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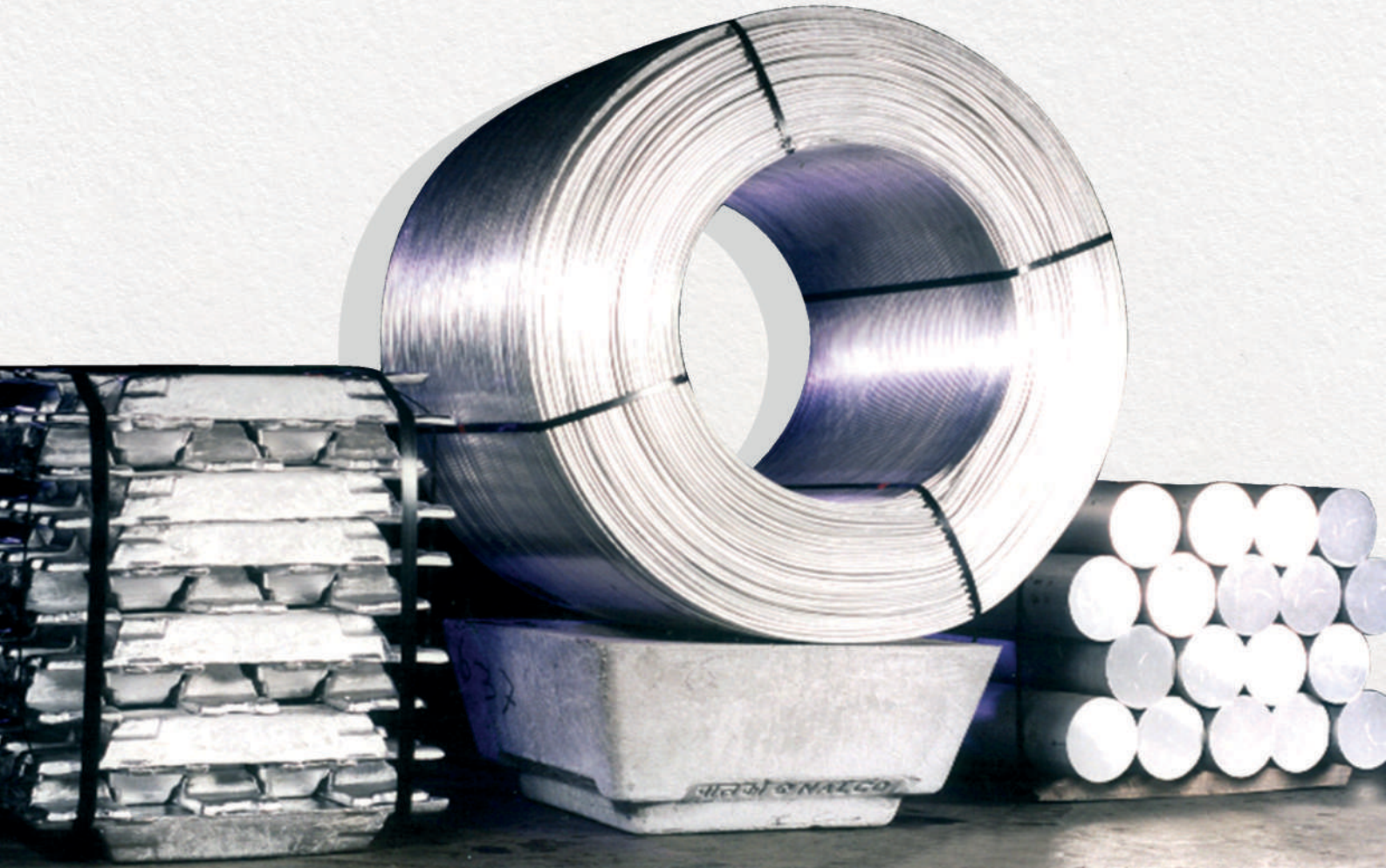
MINISTRY OF MINES

भारत सरकार

GOVERNMENT OF INDIA

Vision Document on Aluminium Sector

2025



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G. Kishan Reddy

सत्यमेव जयते

कोयला एवं खान मंत्री
भारत सरकार
नई दिल्ली
MINISTER OF COAL AND MINES
GOVERNMENT OF INDIA
NEW DELHI

MESSAGE

I am proud to share the vision for India's aluminium sector, a crucial step in realizing Prime Minister Narendra Modi's vision for Viksit Bharat 2047. Aluminium is the backbone of India's economic and technological progress, playing an essential role in infrastructure, transportation, power, electronics, defence, aerospace, and renewable energy. As the world moves towards a future driven by sustainability and advanced manufacturing, aluminium will be at the heart of all emerging industries, from electric vehicles to green hydrogen and space exploration.

Over decades, aluminium consumption has grown significantly, and it is now the second most consumed metal globally. However, per capita consumption in India remains low compared to the global average. As we expand our aluminium sector, we must also address its environmental impact, as production is energy-intensive. India's commitment to sustainable growth is central to our vision for the aluminium sector.

This 'Vision Document' charts a comprehensive roadmap to strengthen India's aluminium industry, including mining, production, and downstream segments, while identifying challenges and forward strategy. By reducing import dependence and fostering domestic innovation, employment, and value addition, India can position itself as a global leader in green and sustainable aluminium production.

This vision requires collective efforts from all stakeholders, including primary and secondary aluminium producers, policymakers, and industry leaders. I am very happy to note that extensive discussions were held on various occasions before the final version of the document was produced.

With a clear strategy and decisive action, India's aluminium sector will power our industrial ambitions and serve as a cornerstone for a self-reliant, sustainable, and globally competitive India. I extend my gratitude to everyone who contributed to this vision, which lays the foundation for a future-ready Atmanirbhar aluminium sector.

(G. Kishan Reddy)

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संदेश

भारत अपनी जनसंख्या और अर्थव्यवस्था के आकार के मामले में एक बढ़ता हुआ देश है। एक विकसित राष्ट्र में बहुउपयोगी धातु - एल्युमिनियम के विविध उपयोग होते हैं। भारत में एल्युमिनियम की मौजूदा प्रति व्यक्ति खपत के कारण इस धातु की मांग में कई गुना वृद्धि होने की गुजांइश है।

भारत ऊर्जा, रक्षा, अंतरिक्ष, अवसंरचना और विद्युत जैसे नवीन क्षेत्रों में, महत्वपूर्ण उपलब्धियां हासिल कर रहा है। उदाहरण के लिए, रक्षा निर्यातों में वृद्धि काफी उत्साहवर्धक रही है। इसरो (ISRO) और डीआरडीओ (DRDO) जैसे हमारे अनुसंधान संगठन मोबाइल अस्पतालों जैसे नए अनुप्रयोग कर रहे हैं, जिन्हें हवाई मार्ग से स्थानांतरित और दूरदराज के स्थानों पर तेजी से स्थापित किया जा सकता है।

उत्पाद नवाचारों के लिए स्टार्ट-अप और एमएसएमई (MSME) क्षेत्र की बड़े पैमाने पर भागीदारी रहेगी और एंड-यूज़ अनुप्रयोगों के लिए बड़ी कंपनियों, शिक्षाविदों और इकोसिस्टम कार्यकर्ताओं को एमएसएमई (MSME) के क्षेत्र में क्षमता निर्माण हेतु सामंजस्यपूर्ण तरीके से कार्य करना होगा, जिससे कि वे भारतीय उपभोक्ताओं की आवश्यकताओं के अनुसार उत्पादन कर सकें।

इस दस्तावेज़ में हितधारकों के एक बड़े समूह से योगदान प्राप्त हुआ है - यथा बड़े और छोटे प्रतिभागी जो इसकी संपूर्ण मूल्य श्रृंखला में समाहित हैं और एक अत्यधिक विविध एल्युमिनियम क्षेत्र का हिस्सा हैं। चूंकि, यह सरकार दृढ़तापूर्वक कार्यों को पूरा करने हेतु समर्पित है, अत: अब यह आश्वासित किया जा सकता है कि एल्युमिनियम क्षेत्र में आत्मनिर्भरता सुनिश्चित करने के लिए कार्यनीतियों को अविलंब कार्यान्वित किया जाएगा।

(सतीश चंद्र दुबे)

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15th April, 2025

MESSAGE

India is on the cusp of a transformation, with the mineral resources sector playing a key role in driving sustainable growth. Aluminium is crucial for the green economy, impacting transportation, infrastructure, and defence manufacturing. It is vital for lightweight transportation, energy-efficient recycling, and as a key material for sectors like space and aerospace.

The Government of India is committed to ensuring the aluminium sector drives economic growth, job creation, and sustainability. While progress has been made, the scale of transformation required for 'Viksit Bharat' is immense. To realize the potential of the Indian aluminium industry, we must understand the opportunity and global competitive landscape.

To enhance resource efficiency and promote sustainable development, the Ministry of Mines introduced the Non-Ferrous Metal Scrap Recycling Framework, 2020, aimed at strengthening the recycling ecosystem for aluminium along with other base non-ferrous metals. To drive this mission forward, the Recycling Promotion Division (RPD) was established under JNARDDC, focusing on technology upgradation, capacity building, research, standardization, and formalizing the recycling industry.

Our vision is clear – to ensure that aluminium not only drives India's industrialization but also contributes significantly to global sustainability efforts. The industry must prioritize technological advancements and strategic actions to meet global challenges.

The Vision document reflects the Ministry of Mines' commitment to the aluminium sector. I thank all those who contributed in shaping this document. We must continue monitoring global trends and keep this Vision document relevant as we progress towards a 'Viksit Bharat'.

(V. L. Kantha Rao)

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Joint Secretary

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भारत सरकार
GOVERNMENT OF INDIA
खान मंत्रालय
MINISTRY OF MINES

Dated: 15.04.2025

MESSAGE

It is with great pride that the Ministry of Mines presents the Vision for India's Aluminium Sector, which is crucial for the country's economic growth.

Aluminium is a strategic metal for India's future, and this Vision Document marks the beginning of its importance in policy-making. India is well-positioned with the resources needed to lead in the Aluminium Sector, but we must recognize the scale of change and collaboration required to bring this Vision to life.

To achieve the enhanced demand for Aluminium, existing players must scale up, diversify, and integrate, while new players enter the market. This ambitious journey will require substantial investment in mining, production, and application development. We must also balance growth with environmental responsibility, adopting a multi-faceted approach to address immediate sectoral issues and long-term goals.

The Government is committed to fostering a supportive environment, promoting R&D, encouraging sustainable practices, and ensuring raw material availability.

We would look forward to the leadership in the Aluminium Sector to contribute their expertise and effort in designing the last-mile result oriented actions.

(Vivek Kumar Bajpai)

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List of Acronyms

AAI	Aluminium Association of India
AAPL	Angul Aluminium Park Private Ltd
ABCAI	Aluminium Beverages Can Association of India
AD	Antidumping Duty
AHSS	Advanced High-Strength Steel
AIM	Aluminium Import Monitoring and Analysis
ALCAN	Aluminium Company of Canada
APS	Announced Pledges Scenario
A/S Ratio	Alumina to Silica Ratio
ASEAN	Association of Southeast Asian Nations
BAU	Business As Usual
BCD	Basic Custom Duty
BIMSTEC	Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation
Bn	Billion
BnT	Billion Tonnes
BPNSI	Biju Patnaik National Steel Institute
BRIC	Brazil, Russia, India, and China
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CBAM	Carbon Border Adjustment Mechanism
CCD	Circumscribing Circle Diameter
CCUS	Carbon Capture Utilization and Storage
CEA	Central Electricity Authority
CEEW	Council on Energy, Environment and Water
CII	Confederation of Indian Industry
CIL	Coal India Limited

CIS	Capital Investment Subsidy
Ckm	Circuit Kilometers
CMPDI	Central Mine Planning & Design Institute Limited
COP	Cost of Production
CPP	Captive Power Plants
CPSE	Central Public Sector Enterprises
CSD	Carbonated Soft Drinks
CSIRO	Council of Scientific and Industrial Research
CSS	Cross Subsidy Surcharges
CVD	Countervailing Duty
CVs	Commercial Vehicles
DFC	Dedicated Freight Corridor
DGCIS	Directorate General of Commercial Intelligence and Statistics
DGFT	Directorate General of Foreign Trade
DISCOM	Distribution Companies
DMF	District Mineral Foundation
DMG	Department of Mines and Geology
DRI	Direct Reduced Iron
EC	Environmental Clearance
EEB	Energy Efficiency Benchmark
EEPC	Engineering Export Promotion Council of India
EGA	Emirates Global Aluminium
EOL	End of life
EOU	Export-Oriented Units
EPR	Extended Producer Responsibility
ERP	Effective Rate of Protection
ERU	Economic Research Unit

ETS	Emissions Trading System
EU	European Union
EV	Electric vehicles
FAME	Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India
FC	Forest Clearance
FDI	Foreign Direct Investment
FRP	Flat Rolled Products
FTA	Free Trade Agreement
FTZ	Free Trade Zones
FY	Fiscal Year
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GWh	Gigawatt hour
HS	Harmonized System
HSLA	High Strength Low Alloy
ICVL	International Coal Ventures Limited
IEA	International Energy Agency
IMEC	India-Middle East-Europe Economic Corridor
IMF	International Monetary Fund
IMFL	Indian Made Foreign Liquor
INSDAG	Institute for Steel Development and Growth
IPP	Independent power producer
ISRI	Institute of Scrap Recycling Industries
ITC	International Trade Centre
JNARDDC	Jawaharlal Nehru Aluminium Research Development and Design Centre
JPC	Joint Plant Committee

JV	Joint venture
kT	Kilo Tonnes
kTPA	Kilo Tonnes Per Annum
kW	Kilo watt
LED	Light Emitting Diode
LME	London Metal Exchange
MCF	Modern Coach Factory
MCL	Mahanadi Coalfields Limited
MECON	Metallurgical & Engineering Consultants (India) Limited
MITI	Malaysian Ministry of International Trade and Industry
MMDR	Mines and Minerals (Development and Regulation) Amendment Act
Mn	Million
MNRE	Ministry of New and Renewable Energy
MoP	Ministry of Power
MoU	Memorandum of Understanding
MRAI	Material Recycling Association of India
MT	Million Tonnes
MTPA	Million Tonnes Per Annum
MTs	Megatrends
MW	Mega Watt
NISST	National Institute of Secondary Steel Technology
NMET	National Mineral Exploration Trust
NRS	Non-regulated Sector
NRTC	National Research and Technology Consortium
NTPC	National Thermal Power Corporation
OEM	Original Equipment Manufacturer
OFB	Ordnance Factory Board

OMC	Odisha Mining Corporation Limited
PET	Polyethylene Terephthalate
PLI	Production Linked Incentive
PPP	Purchasing Power Parity
R&D	Research and Development
RIR	Recycling Input Rate
RoDTEP	Remission of Duties and Taxes on Exported Products
ROPP	Roll-on Pilfer-proof
RPO	Renewable Purchase Obligations
SCOMET	Special Chemicals, Organisms, Materials, Equipment, and Technologies
SECI	Solar Energy Corporation of India Limited
SEZ	Special economic zone
SME	Small and medium enterprise
SRTMI	Steel Research & Technology Mission of India
STEPS	Stated Policies Scenario
T & D	Transmission and Distribution
TUFS	Technology Upgradation Fund Scheme
USD	United States Dollar
USGS	United States Geological Survey
WEF	World Economic Forum

1. Executive Summary

1 Executive Summary

The decision to define a vision for the Aluminium industry in India is a timely one and consistent with the call for establishment of 'Viksit Bharat' by 2047. The Aluminium industry in India started in the 1930s when ALCAN set up its first smelter in Kerala through its subsidiary INDAL. Since then, India has reached a stage where it produces 4.16 MTPA of Primary Aluminium and 1.8 MTPA in the secondary sector. India today stands at the cusp of a major transformation. It has moved on from being called a developing nation to the leader of the Global South to harboring ambitions of becoming a Developed economy by 2047. There are significant implications of this on per-capita income, quality of life and citizen-amenities, not to mention on overall GDP.

Aluminium is catalytic to the transformation we seek in the transportation, infrastructure and defence manufacturing sector. Its importance to the new economy is captured in the points below:

- It is lightweight and its application in transportation, construction etc. can bring down India's oil import bill.
- It is at the core of strategic sectors like space, missile defence, aerospace and is of imperative importance in a world full of increasing strife.
- It melts at about 660^{o}C compared to iron's 1538^{o}C or silica (i.e. glass cullet) at 1700^{o}C thereby making it less energy-intensive to re-cycle.
- Its electrical conductivity makes it the most important ingredient for the upcoming RE grid-connectivity projects, electric mobility etc.

The understanding of the nature of the opportunity and recognition of the global competitive landscape is important for us to realize the potential of the Indian Aluminium industry. Much progress has been made but the nature of transformation that is called for by 'Viksit Bharat' is completely of a different scale. India's GDP today stands at about USD 4 Trillion, seventy years since our Independence. The Government's vision is to take it to USD 30 Trillion[1] in the next 23 years. From its inception till now, Indian per-capita Aluminium consumption has reached about 3.5 Kg (FY24) which is significantly short of the global average of 12 Kg. To achieve even the current global average by 2047, Indian per-capita consumption needs to grow at a CAGR of ~6%. The CAGR will need to be even more if India hopes to touch the per-capita consumption levels of nations like China, USA, France etc. The economic progress of India will inevitably involve more Aluminium consumption than in the past. The incremental demand will come from the following three broad sources –

Table 1: Source of incremental demand[2]

Source of Incremental Annual Demand	Incremental Quantum by FY47 (MT)
Increased population – traditional applications at historical consumption intensity (e.g. electricals, utensils etc.)	1 – 1.5 MT
Traditional applications but at higher consumption intensity (e.g. more airframes for India's growing defence-aviation industry, increased consumption of packaged food and drinks)	15 – 18 MT
New-to-India applications at global average rate of consumption (e.g. greater component penetration in automobiles, transport etc. by Aluminium)	4 – 6 MT

The path to incremental demand will not be one strewn with roses. Cutting corners and compromising on product quality by some producers has resulted in either the discontinuation of aluminum use in certain products or the replacement of these domestic products with imports. For example, there is an urgent need

[1] Indian economy by 2050: In pursuit to achieve the $30 trillion mark, EY-India, Aug 25, 2022, last accessed on 01-Oct-2024
[2] GT Analysis

to enunciate standards relevant to Aluminium in building & construction or e-scooters. Otherwise, these too will earn Aluminium a bad name[3]. There is always competition forthcoming from alternate material from wood to steel to carbon composites. This can only be solved if the MSME sector is enabled to upgrade through professional guidance and aid through research and financial support. Luckily the existing players in the Aluminium industry have the line of sight into which of their MSME business partners are more capable than others. Their wisdom and knowledge base should be tapped to develop key MSME players to become the vanguard of high-quality downstream thrust.

While it will not be a one-way growth story, with competition from other materials, geo-political instability, global growth slow-down etc., it is estimated that India's domestic Aluminium demand will be -

- **Short-term (FY24-FY30):** 8.5 MT by FY30
- **Medium-term (FY31-FY40):** 18 MT by FY40
- **Long-term (FY41-FY47):** 28 MT by FY47

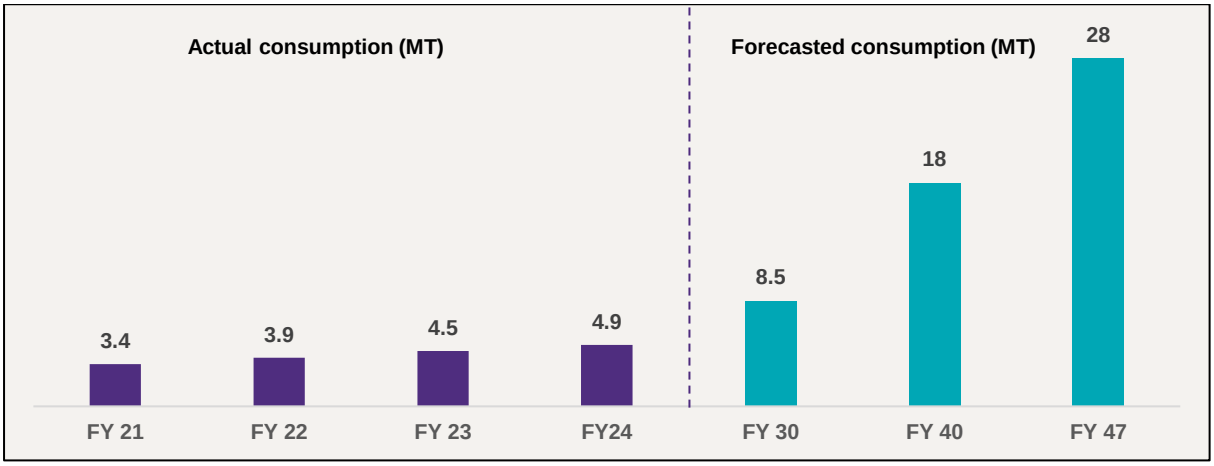

Figure 1: Forecast of India's domestic Aluminium metal consumption.

India's vision in the Aluminium sector should not be restricted to meeting just the domestic demand. Today India is a fringe player in global Aluminium trade of 67 MT with a market share of only 3.8% whereas China has a share of 12.6%. Key competing geographies like China, Russia, North America are partially constrained to meet the future global demand. If India plays its hand well, it is not beyond the realm of possibility to aim to get a 10% market share by FY47. To address this overall demand, India's capacity should scale up to 37 MTPA by FY47.

[3] Industry feedback

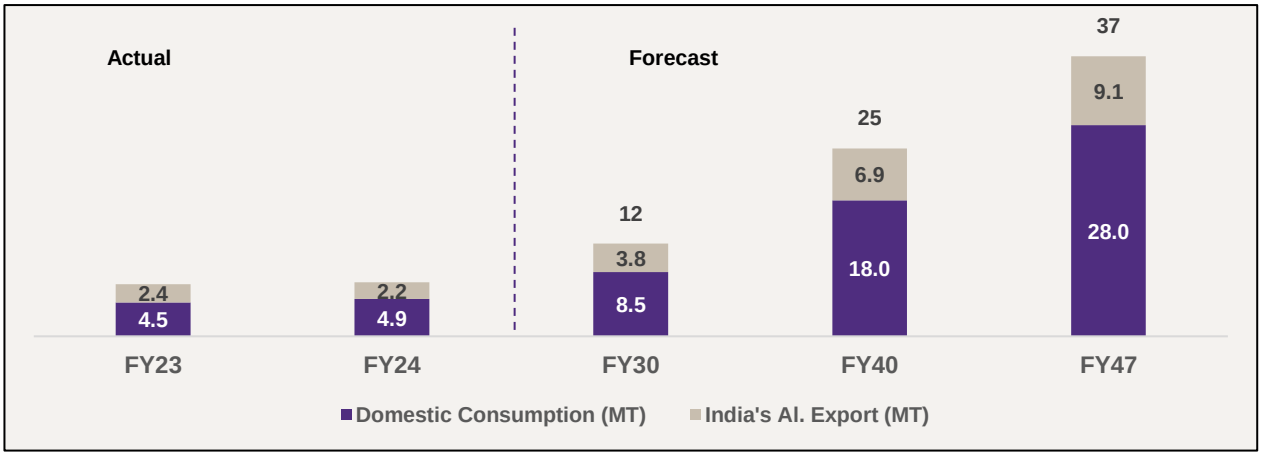

Figure 2: Forecast of India's Aluminium metal consumption and export – potential capacity

This translates into a CAGR of about 7% for domestic demand driven growth and a CAGR of approximately 8.3% of overall capacity growth (including capture of export market share) which has to be covered in a gallop by the suppliers. This is in contrast to how the sector has grown in the past. Indian Aluminium sector growth has followed a step-function with long periods of gap between successive capacity additions. In the last 10 years, the sector has been in wait-and-watch mode. With high-capacity utilization in the last 3 years and in response to the increasing domestic demand, domestic producers have initiated expansion plans for their alumina refineries and Aluminium smelters. NALCO, Hindalco, and Vedanta aim to increase the country's alumina refinery capacity by approximately 10 MT and primary Aluminium smelter capacity by around 3 MT over the next 5 to 6 years.

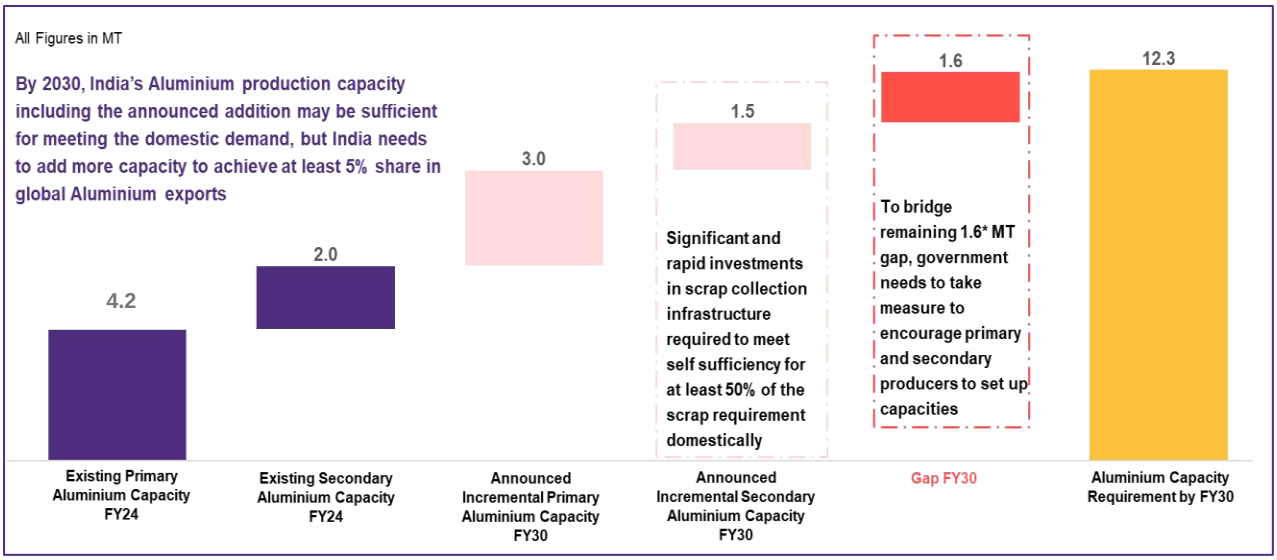

Figure 3: Demand-Supply gap in Aluminium capacity by FY30 (in MT)

However, these additional capacities for primary and Secondary Aluminium producers will not suffice to meet the projected short-term capacity requirement, **leaving India with a shortfall of another ~1.6 MT** of Aluminium production capacity by FY30. Similarly, the secondary sector growth plans are not supported by domestic scrap collection plans. To support India's goal of self-reliance, more scrap collection should be focused upon. These gaps will lead to potential import of Aluminium into the country. Alternatively, the Aluminium industry will go slow in pushing market-development.

Not only in the immediate term, even in the long-run, India will have to literally move mountains to stay '*Atmanirbhar*'. To meet the projected Aluminium demand, India must ensure a robust supply chain for Bauxite and Alumina, alongside sufficient capacity for both primary and secondary Aluminium production. Domestic primary Aluminium production is anticipated to satisfy domestic consumption needs and significantly boost export volumes. However, securing a steady supply of Bauxite is crucial. As per announced capacity by

Primary Producers, Bauxite requirement is projected to reach at least 42 MT by FY30 whereas Alumina requirement is projected to reach 14 MT by FY30.

Also, assuming 85% Aluminium content in scrap (based on scrap import quality standard set by different countries), as per announced Secondary Aluminium Production Capacity, India's scrap demand will be as follows-

Table 2: Projection of India's Scrap demand[4]

Year	Announced Secondary Aluminium Production Capacity (MT)	Scrap demand (MT)
FY30	3.5	4.12

Demand Supply Gap Assessment

India's current domestic self-reliant Aluminium production capacity is 4.2 MT, with secondary capacity of ~2.0 MT is largely dependent on imported scrap. With new bauxite capacity, an additional 3 MTPA of primary Aluminium production can be added. If the rate of mining from existing bauxite reserves can be increased by 50%, another 3 MTPA of primary Aluminium can be supported. Untapped domestic bauxite resources of 4.95 BnT, if proved can support another 14 MTPA of primary Aluminium. By FY47, secondary Aluminium production from domestic scrap is projected to reach an incremental 6 MTPA. However, to meet the projected Aluminium production capacity requirement of 37 MTPA **by FY47, there will still be a shortfall of at least 7 MTPA**, the raw material for which will need to be met from international sources of bauxite or scrap or discovering more bauxite resources within India. Depending on the assumption of a lease-period or life of mine, this gap might even increase. In any case, the process of transitioning 4.95 BnT of resources to proven reserves should happen on a mission-mode to ensure that the pathway to 2047 is clear. This is the biggest chunk of opportunity on which incremental Aluminium capacity can be planned. This is shown in the next graph.

Even the growth from 6.2 MTPA (4.2 primary and ~2.0 secondary) melting capacity to 28 MTPA of domestic demand-justified capacity is not a foregone conclusion. There is no indication from the domestic Aluminium sector that they are planning to put up incremental capacity of the order of magnitude of 20 - 22 MTPA basis their current pronouncements. The Western world will not give India the Aluminium it needs because they are already on a journey towards decarbonizing their economies. Unless India thinks up a way to work around this current conundrum, there is a great likelihood that uncontrolled quality of Aluminium from rest of the geographies will find their way into India or India will just stop short of achieving its potential due to supply-side constraints. The graph below captures the massive supply-side step-up that India needs to perform. Even with massive jumps, some part of the plan is still not baked in. Each of these demand and supply side issues has to be addressed at the micro and macro level.

[4] GT Analysis

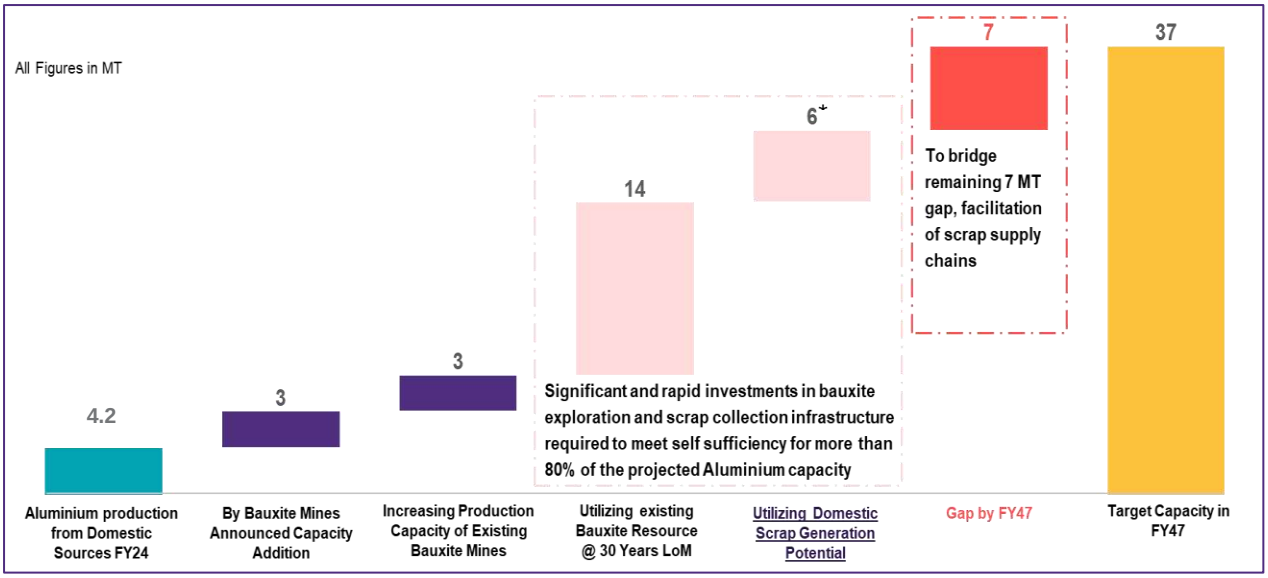

Figure 4: Demand-Supply gap in Aluminium Capacity by FY47 (in MT)

* The existing 2 MT Secondary Steel Capacity which is currently being serviced by imported scrap is included in 6 MT.

As was mentioned earlier, domestic demand growth would be about 7% CAGR and capacity growth required, considering export demand, would need to be about 8.3% CAGR. This is more than what Aluminium sector has achieved in the past 50 years. Also, the long gaps between sequential capacity growth in the sector is directly attributable to very few large-capacity players in the country. This is unlike the steel sector, which has seen continuous capacity growth on account of multiple large capacity players, each on their own track of capacity addition. The main reasons behind low capacity CAGR of Aluminium industry compared to steel are:

- Relatively underdeveloped end-use industry (like Aerospace manufacturing) and low penetration of Aluminium in standard segments (like Automotive) vis-à-vis global standards
- High capex per-tonne of capacity – especially in the primary Aluminium sector compared to steel
- Difficult raw material security scenario (unlike iron ore which has multiple commercial/ merchant miners)
- Lack of clarity around evolving regulations related to energy and carbon transition around the globe and India

The 37 MTPA capacity is not only the need of India but also an opportunity which will get frittered away if the difficult issues impeding the growth of the sector are not addressed in a comprehensive manner. Before delving into the nature of the challenge and its potential solutions, it might be useful to learn from the experience of countries that have been ahead of India in the curve and are of comparative size.

Global Lessons

There are several lessons to be taken from USA's and China's Aluminium sector strategy. In 1980, US primary Aluminium production peaked at 4.65 MT from about 30 smelters. By 2000, USA was down to about 23 primary Aluminium smelters. Currently USA produces less than 1 MT of primary Aluminium in about 4 operating smelters. The rest of the US production of over 4 MT comes from the secondary sector which processes scrap. There is a limit to which scrap based secondary production can go because it is limited by the amount of scrap generated in the first place and then collected. The main reason given by US primary producers behind closure of the smelters has been the high cost of energy. Also, the bauxite for US refineries was predominantly imported. Today, US meets about half of its Aluminium demand from imports. Over half of these imports come in from Canada which enjoys low production cost due to its access to hydropower. It is a matter of great irony because ALCAN of Canada (now part of Rio Tinto) was born out of ALCOA. Between 2018 and 2022, USA has to impose import tariffs and tariff rate quotas on Aluminium and its derivative products to protect whatever little capacity remains in that country. US industry's denouement shows that not

managing raw material availability and energy price led to a situation where the domestic production is in a non-competitive downward spiral compared to imports[5].

On the other hand, China's Aluminium production today is overwhelmingly through the primary route. The Chinese primary Aluminium industry grew from just 0.4 MT in the 1980s to over 40 MT in 2023. This remarkable growth can be attributed to several factors. While the USA shifted its focus away from primary Aluminium, China promoted its primary industry through substantial government support in terms of policies and subsidies. In 2006, China recognized Aluminium as a "Pillar Industry," emphasizing the government's significant role. Investments in infrastructure and energy projects, along with heavy investments by Chinese companies in modernizing production facilities and adopting advanced technologies, increased efficiency and output, making Chinese Aluminium more competitive globally. By focusing on large-scale production, China reduced costs and increased production capacity, allowing its companies to dominate the global market. Additionally, many Chinese Aluminium producers integrated their operations vertically, controlling everything from bauxite mining to Aluminium smelting and processing, which streamlined operations and reduced costs. Since the coal-based power costs in China are also high, they have continuously sought newer manufacturing and digital technologies to reduce the per-ton power consumption. Today when the world looks to become greener, China has accumulated sufficient scrap-worthy Aluminium in its economy which it can use to sustain a shift to secondary route. Still China looks to stay invested in primary Aluminium. All it now needs to do is to retain relevant tax proposals that keeps its Aluminium scrap in the country. China is a good example of a timely and well-thought-through capacity expansion story that will sustain its leadership position in Aluminium for years to come[6].

It can be seen from the debacle of the US Aluminium industry (more in historical context section) how its dependence on scrap based secondary Aluminium and imported bauxite led to a downward spiral. Reliance on scrap can reduce carbon footprint but it puts a limit on production. There is no way any country can produce Aluminium beyond the quantum of scrap available, which itself is less than the quantum of production done previously. This is a vicious cycle. There are only three ways of expanding production:

- Promoting primary Aluminium with domestic resources with progressively increased availability of these resources over time
- Modernizing scrap tracing, collection and re-cycling domestically, popularizing and expanding closed-loop scrap-based production method with progressively greater collection each year
- Mobilize scrap from beyond India – either as unprocessed scrap or as remelt ingots and secure domestic supply chains. It should be easier to pull off than getting green-field mines off the ground in foreign geographies as is being attempted now by several players including government companies. However, the modus operandi for such action should predominantly be private in nature to ensure agility. Support from government may be conceptualized for metal content brought back into India through such registered entities.

Way Forward for Indian Aluminium Sector: Its Strategic Objectives

India cannot emulate China's strategy now. When China grew, fossil fuels were not anathema to regulators, activists and shareholders. As India stands at the cusp of a take-off, it is saddled with this additional burden of carbon-footprint minimization. While NALCO is predominantly owned by Government of India, the other two large players are of an international nature. Global shareholders may prevent those companies from investing in coal-based capacities going forward. India should have more players in the large-capacity segment (> 500 kt) by 2047, if not by 2035. USA had about 14 companies producing ~4.5 MTPA of primary Aluminium in 1980s[7]. China had more than 30 primary Aluminium players in 2016[8]. India on the other hand has only 3 primary producers. With more players, India will not only have a louder voice in policy framing for the country and globally but also foster a competitive market. India will also be able to fire on multiple cylinders

[5] https://crsreports.congress.gov/product/pdf/R/R47294#
[6] The-Development-of-Aluminium-Industry-and-Technology-in-China-1.pdf (international-Aluminium.org)
[7] U.S. Congress, Office of Technology Assessment, Nonferrous Metals: Industry Structure - Background Paper, OTA-BP-E-62 (Washington, d: U.S. Government Printing office, September 1990).
[8] Gao, B., Wang, Z., Shi, Z., & Hu, X. (2017, October). History and Recent Developments in Aluminum Smelting in China. In *Travaux 46, Proceedings of 35th International ICSOBA Conference* (pp. 2-5).

and hustle their way around the global economy. More players with predominantly Indian shareholders may also have greater leeway with regard to fossil-fuel based capacities than current incumbents. However new players will only come in if India can solve for their line-of-sight to raw material and energy security.

In this scenario, India should focus on its innate advantages and follow the path described by our Hon'ble Prime Minister. Accordingly, its Vision and Mission may be articulated and worked upon by all the players in the sector. The demand and supply will not be achieved automatically. It has to be actively guided through policies and other enablement. The sector's vision and mission should be facilitated by the ministry and established in the following suggested tenets:

Key Tenets of Vision	Elements
Viksit Bharat	• Aluminium sector (led by the Ministry) should work on increasing per-capita consumption in India through introduction of newer applications and evangelizing these with potential customer segments. • Indian Aluminium sector should leverage India's standing as a leader of the Global South and 'Design for the World' to solve global problems. Through this, India's Aluminium end-use product export footprint can be expanded

India's vision should be to develop a self-reliant Aluminium industry that stands as a competitive and sustainable global leader. To achieve this, India's mission should be to promote the Aluminium industry for a sustainable future through eco-friendly practices.

Key Tenets of Mission	Elements
Atmanirbharta	Self-reliance in terms of resources to achieve the vision (for both primary and secondary sector)
Ease of Living	Contribute to a better environment through constant efforts to reduce carbon footprint

4 Strategic Pillars of India's Aluminium Vision

	Core Strategic Objectives	Sub-objectives
	**Strengthening Domestic Aluminium Industry to Become 'Atmanirbhar'**	• Increase domestic production capacity to meet 100% of domestic demand by 2047 • Drive domestic demand generation for new & existing applications
	**Self-Sufficiency in Raw Material for Aluminium Production**	• Ensure 100% of India's bauxite and alumina requirements are met domestically by 2035 • Ensure at least 50% of scrap requirements are met domestically by 2047
	**Achieve Carbon Neutrality in Aluminium Production**	• Achieve net-zero emissions in the Aluminium sector, with a 30% reduction in GHG emissions by 2030 compared to the 2023 baseline • Increasing the share of RE to 70% of the total energy used by 2047

		• Target achieving a 56% End-of-Life Recycling Rate for Aluminium by 2047, matching the current global standard
	**Focus on Value Addition and Export growth**	• Maximize the conversion of its primary Aluminium production into value-added/downstream products by 2035 and maximize its export composition towards downstream products by 2047 • Increase India's share in the global Aluminium market volume from 3.8% in 2023 to 10% by 2047

Combining the themes of 'Viksit Bharat', 'Atmanirbharta', 'Ease of Living' mentioned by the Hon'ble PM in his vision, the following inferences may be drawn that are of relevance to the Aluminium sector –

- Countries like US who have relied on scrap and imported resources for Aluminium production have suffered compared to those countries that have managed their access to input materials for primary Aluminium like China. **It is always advisable to leverage domestic resources to the maximum extent** and also have its strategy to retain economical access to global raw materials.
- India's Aluminium sector growth should be based on clean energy to the extent possible. The lack of economical solutions that are simultaneously green is a cause of hesitation for Aluminium companies. Challenges of technical feasibility and financial viability will need to be overcome through newer approaches like
    a. **Group-captive:** Under the Electricity Act, a group captive framework can be created when participants can invest 26% equity in all and consume at least 51% of the power produced. NTPC and MCL have presence in the Aluminium and steel belt of Odisha. Additionally, MCL (or other CIL subsidiaries) have a RE footprint under implementation and also PSP potential which can provide RTC power. This combination of bundled power – both brown and green where bulk of the funding is done by MCL (which should be concerned about its future coal demand) and remaining being shared by the power consumers can be a good way for Aluminium producers to avoid investment in coal-based capacities yet enjoy the benefits of steady power.
    b. **Local green-power corridor**: Hindalco has planned a floating solar power plant in the Hirakud dam reservoir. This is near its Hirakud and Aditya smelter. Such floating solar projects can be considered at the nearest reservoirs of other smelters also; Renukoot (nearest reservoir: Rihand dam), Vedanta (nearest reservoir: Hirakud dam) and NALCO (nearest reservoir: Rengali dam). If floating solar projects prove feasible, then green-power transmission corridors bypassing the state transmission network can deliver power economically to the smelters. It is also suggested to set-up a large green energy park dedicated to Aluminium sector which can provide round the clock power to Aluminium plant. This will boost the investment for setting up capacities for Aluminium and will help industry reducing its carbon emission.
    c. **Ring-fencing green capacities for easier CBAM compliance**: To service the European export market India needs a maximum of 5 MTPA of certified green capacity around the country. The secondary route with end-of-life scrap is relatively green. If the energy is also from a RE source, then the Aluminium CO2 footprint would be very low. However, for easier CBAM compliance these lines may be ring-fenced in a separate physical and logical legal entity that is separately registered, even if these are proximate to the other lines.
    d. **Other Initiatives**: More regulatory changes are required such as allowing green power generated in any part of the country to be counted against RPO obligations. These are captured later in the document.

- Indian per capita consumption must be increased through application evangelization and product innovation. It has been reported for many years now that the number of applications of Aluminium in India are a tenth of the number of its applications world-wide[9]. For instance, ICRA reports[10] that the average quantity of Aluminium used per vehicle in India remains significantly lower (around 40-45kg) compared to the global average of roughly 160-200 kg. As the number of applications increase in India, so will the consumption of primary Aluminium. India will progressively scale the ladder of downstream value-addition and transform into a manufacturer of finished end-use products of Aluminium. With increased product innovation, India can channelize its developed design talent to solve the problems of the world. For this **an INSDAG kind of organization that works in the steel sector, would be recommended for the sector for expanding use of Aluminium applications in India.**

- **MSMEs** that are within the ambit of DPIIT are critical to the success of application development. Yet they do not have significant exposure to the potential opportunities. Their entrepreneurial spirit along with some support in R&D and finance can allow them to ride on the work done by INSDAG like organizations (for Aluminium) and create that bridge between the end-consumer and the Aluminium producers. The large-capacity Aluminium producers can play an important role in catapulting their MSME business partners into a higher orbit by introducing them to Private Equity funds and other professional agencies that can strengthen their governance and enable them to grow bigger.

- In his Independence Day speech of 2024[11] from the ramparts of the Red Fort, our Hon'ble Prime Minister mentioned a few points of relevance. Some of the new messages one could distill are 'Design in India, Design for the World', 'State-level Investment Competition' and 'Indian Standards as Global Benchmarks'. The Hon'ble Prime Minister called upon Indians to strive to be the skill and manufacturing hub of the world during his 78th Independence Day speech on 15th August 2024. Clearly this will contribute to India's GDP and upliftment of its people. In keeping with the call by the Hon'ble PM, the Aluminium sector should participate in India's export ambition and meet a reasonable proportion of the global demand of Aluminium products. It can be hoped that India will transform itself into an exporter of end-use products made out of Aluminium rather than a predominant exporter of upstream and semi-finished products. It should be realized that accessing export markets in the future may need Indian manufacturers to enhance their quality and carbon-emission standards to an extent where they can navigate through potential non-tariff barriers. **A taskforce under the relevant ministry to work on establishing standards for various Aluminium products and input materials** is the need of the hour**.**

- The resources required to maximize India's per-capita consumption and also participate reasonably in the global marketplace for end-use Aluminium products, should be controlled and easily accessible to the sector. Today access to resources is not easy. New entrants in the sector do not have access to large Bauxite deposits. Even if the Bauxite issue is resolved the Coal issue remains. To resolve bauxite block paucity, regulations need to be changed to enable

    a. **Combined auction of multiple leases as a single block:** Regulations should be changed to allow non-contiguous leases to be auctioned as a single block so that a refinery of suitable size can be planned against this. This is possible in Odisha where a lot of blocks of small size are available, but these are individually not attractive.

    b. **Proving indicated resources in mission mode:** There is a serious need of expediting detailed exploration to prove indicated resources of bauxite which stands at 4.95 BnT as on date. GSI should be given targets to expedite bauxite exploration, specially in Andhra Pradesh, Chhattisgarh and Odisha.

    c. **Closed-loop domestic scrap recycling:** India has accumulated significant Aluminium in its economy over the last 50 years. A portion of this already scrapped indiscriminately in landfill. Some

[9] Tomotia, S K (2002) *Aluminium and Its Usage.* In: Proceedings of Seminar on Resurgence of Metallic Materials the Current Scenario(ROMM-2002), 24-25, October 2002, National Metallurgical Laboratory (CSIR), Jamshedpur.

[10] Primary Aluminium Industry, ICRA, Aug 2023, last accessed on 03-Oct-2024

[11] Prime Minister Shri Narendra Modi Sets Ambitious Vision for India's Future in 78th Independence Day Address, PIB Delhi, 15-Aug-2024; last accessed on 01-Oct-2024

of it is in use and some of it, even though not in use, are untraceable within a bigger application that has been surveyed off or scrapped. To make the most out of the scrap that is lying in the Indian economy, it is important to ensure that individual applications return to the specific remelt site so that the chemistry is preserved. Empty beverage cans should return to beverage can manufacturers and automotive parts should return to auto-cluster Aluminium ancillaries. This calls for more specificity in the ESR with responsibilities on the user of the product as well as greater use of technology and GST system to maintain traceability of Aluminium parts as they diffuse into the economy.

d. **Facilitating scrap value-chain outside India**: India itself has a net shortage of about 7 MTPA by FY47 on the supply side. Even now there is a gap, which is why it is importing indifferent quality scrap from wherever available. Increasingly the developed nations like USA and Europe may stop scrap moving out of the country. India recognized many years back the merit of creating entities to ensure raw material security for its mineral dependent industries. It is time now to promote Indian companies to participate in scrap value chain outside India and bring in either unprocessed scrap or remelted and refined ingots.

   In this regard, an agency or agencies may be created/ mandated that shall set up large scale state-of-the-art scrap segregation plants at the point of ingress to provide collective service to secondary Aluminium / Recycling Industry to create economies of scale. Government may identify the requirement for providing support / incentive for setting up such units in India / abroad for collection, and segregation of Aluminium scrap which can be provided to recycler maintaining the quality of scrap.

e. **Other Initiatives** like early operationalization of Coal and Bauxite blocks through ministerial interventions should be a standard operating practice for the states; solving logistics issues in key districts to enable movement by railway through a proper masterplan are very important initiatives.

f. Aluminium being a power intensive, even if the issue of the main raw material is solved, the issue about allocation of rakes to the non-power sector remains in the near-term. Many nations that focus on exporting minerals and mineral concentrates are often said to be suffering from resource curses. In the case of Aluminium, exporting upstream products tantamount to exporting energy whereas exporting downstream and end-use products is a proper reflection of value-addition through skill and manufacturing prowess. **Recognizing Aluminium as a core sector may enable preferential or focused treatment of the sector in matters related to rake-allocation, anti-dumping issues etc**.

- Secondary players who are low energy and carbon footprint companies are important contributors in India's net-zero ambition. To remain profitable and sustain over the long run, they should look at **value-capture through forward integration into applications on the one hand as well as back-ward integration into scrap value chain** in India and abroad. Measures such as incentivising recycling plants and liberalising financing for MSMEs may be implemented to promote domestic scrap collection, establish recycling and downstream plants, and reduce reliance on imported scrap.

- Further, to boost downstream Aluminium production, impetus should be given to existing proposed/ new **Aluminium Parks** to bring them into operation as early as possible as it would not only help in value addition but also help in employment generation. This will require the primary Aluminium players to take initiative for developing downstream players in and around their plant by providing land, hot metal, amenities, and other support to such players. Efforts should be made to adequately publicise such parks to attract investors/ MSMEs to set up value addition plants.

- Indian manufacturers should collaborate and devise a **common minimum program** that aims to address the Hon'ble PM's concerns around 'Ease of Living'. In the Coal sector, under the call of 'Ease of Living' first-mile connectivity of Coal mines to rail-lines was mechanized through CHPs and silos. This was done to reduce the environmental and traffic-hazard faced by people living in the Coal-fields due to heavy truck movement. The primary Aluminium sector has to deal with issues such as emissions from their CPPs, red-mud disposal, ash-pond breaches, fluoride pollution etc. causing significant strain on their managerial

capacity as well as posing a constant risk to people in the vicinity. **It may make sense for them to increasingly become mixed players with both primary and secondary (re-melt) production facilities.** This would be a pragmatic step given the direction being taken by the EU to impose CBAM. There may be ways that can be found to get the upstream players to support down-stream or end-use applications in ways more evolved than just creating industrial parks near their smelters. This will enable incremental capacity addition in India to be in the greenest possible mode. There are other ways of collaboration too which are discussed later in this document. Some platforms, initially developed for the steel industry (like MSTC or mjunction) can also be leveraged to **drive collaborative efforts for Aluminium (e.g. collective buying/ import of fluoride or calcined pet-coke)**.

In addition to these initiatives, several other short-term actions are needed to make the industry tide over the short-term challenges. it is expected to face in the short-term from the standpoint of trade, skills, technology etc. These are discussed at some length in the document. Following immediate measures are required to help the industry navigate short-term challenges-

- **Skill Development:** Developing skills in fabrication, precision manufacturing, and Aluminium metallurgy through specialized courses in ITIs, polytechnics, and packaging institutes is crucial for a robust Aluminium ecosystem. Emphasizing non-ferrous extractive metallurgy, circular economy, and continuing collaboration with the Indian Iron and Steel Skill Council will further support this sector.
- **Quality Standards:** A detailed set of standards for Aluminium products is essential to prevent the import of sub-standard items and improve the global perception of Indian downstream products. Stricter enforcement and new standards are needed across various sectors, including packaging, construction, and recycling, to ensure quality and performance.
- Relevant tariff items should be reviewed in FTAs in case of import from ASEAN countries and bilateral safeguard clauses should be strengthened. Appropriate trade remedial measures should be taken on a case-by-case basis where there is proof of dumping of Aluminium articles in Indian market.
- Coal Cess revenue to be dedicated to the development of renewable energy and clean environment technologies.
- Aluminium industry's Captive Power Plants (CPPs), which are notably energy-intensive, should be relieved from the Electricity Duty
- Allowing Calcined Pet Coke (CPC) imports as per the Aluminium capacity
- Rationalizing Logistics costs of critical raw materials and wastes (Fly ash, Red mud) by reducing railway freight in a revenue neutral manner
- NRS Linkage Auctions with sufficient offer to meet increasing demand to distribute coal in the proportion of 75% for power and 25% for non-power sectors
- CIL should apply the latest Central Electricity Authority (CEA) norms to calculate Coal Requirement for CPPs.
- The implicit taxes which are already being paid by Indian Aluminium industry, are required to be recognized as effective carbon taxes
- A Production Linked Incentive Scheme can be provided for the focus product segments in the downstream sector to reduce import dependency of products like can stock, hard alloy plates, alloy wheels etc. and support the demand from growing sectors like marine, aerospace & defence etc. The list of these products has been provided in chapter 9.3[12].

[12] Industry Sources

- Additionally, the following sector-specific measures can be implemented to promote Aluminium usage:

Key areas to be addressed	Interventions
Building & Construction Sector	
• Lack of comprehensive standards for Aluminium doors, windows and facades resulting in low quality, sub-standard product flooding the market. • Absence of Energy ratings for doors, windows and roofing sheets.	• Creation of a National Fenestration Rating Council of India (NFRC India) in similar lines of USA, to create norms and testing standards. • Implementing a standard for fenestration in India • Preference for use of formwork in government building projects, affordable housing projects, smart city projects, Pradhan Mantri Awas Yojana etc. may be considered.
Packaging	
• Pharmaceutical and packaged food industry prefer sourcing primary Aluminium foils to avoid any contaminations • Lack of standards/ lesser compliance to existing guidelines.	• Strict compliance with BIS guidelines for Aluminium house foil / semi-rigid containers for food packaging. • Suitable regulations for ensuring adequate strength in semi-rigid containers for avoiding contamination or spillage of food. • A cluster-based strategy could be employed to support foil converting MSMEs in supplying to the pharmaceutical industry. They can be given training on standards, technology upgradation support, working capital solutions etc. • Encouraging large companies to procure from foil converting MSMEs on spot payment basis.
Transport	
Railways: Capability gap for manufacturing of large CCD (24") extrusions with length of 25 m	• Strong push for adoption of indigenous Aluminium in wagons, semi high-speed trains and metros.
Two wheelers/ Passenger Vehicles / Commercial Vehicles • Weaker emission control targets and enforcement • Less stringent passenger safety and control regulations	• Strong push for light-weighing of vehicles • Stricter emission norms for HDVs in line with rest of the world • Mandating efficiency norms for electric vehicles (EVs), such as power consumption per ton-kilometre • Stricter axle-load regulations for Commercial Vehicles like European regulations mandates lightweighting passenger vehicles- a legal weight restriction of 3.5 metric tons, including passengers and cargo[13].

[13] Alumobility White-Paper_All-Vehicles-Should-Be-Made-From-Aluminium_July2022.pdf

Key areas to be addressed	Interventions
	• Capability developments via technology tie-ups by domestic players specially in Brakes and Suspension (ABS) and Crash Management Systems (CMS) • Strong push for adoption of Aluminium in govt. buses / e-buses • Driving adoption of Aluminium by OEMs in Crash Management Systems (CMS), body structures and EV battery housing • Standards for driving adoption of Aluminium based front / rear underbody protection devices in heavy goods carrier
Electrical, Machinery & Equipment	
Lack of domestic capability to manufacture large Aluminium sections	• Domestic companies to develop abilities for manufacturing large profiles (for Welding machines up to 400 mm CCD, for UPS / Invertors up to 400 mm CCD) • Domestic companies should focus on enhancing their capabilities in cold rolling and indirect pressing to achieve improved tolerance requirements and superior surface finishes.

How to make it happen

Many things need to fall in place before all the actions can begin, leave alone, start bearing fruit. For starters, while primary metal is within the ambit of the Ministry of Mines, demand generation will need support from the Ministry of Trade and Commerce. Energy will need the support of MNRE, Power, Coal etc. Even states need to come on board for some of the solutions to fall in place.

Aluminium is a strategic mineral now for India. Maybe it was not as strategic between the World Wars till the advent of the green age. It needs specialization as well as focus. Since Aluminium value chain straddles multiple domains (from mining, chemicals, Industries, MSME etc.) the Ministry may want to implement institutional reforms needed to support this transformation. The following institutions are proposed in line with the experience of the steel sector:

- Creation of an "**Investment Promotion and Aluminium Strategy Implementation Cell**" **(IP&ASIC)** in the Ministry led by a JS/ Senior Director Level Officer who sets timelines and monitors progress of implementation actions – this Cell should debrief the Secretary every fortnight about progress. This cell will
    - Coordinate with primary and secondary players regularly to understand the on-ground difficulties being faced by them in the implementation of the strategy.
    - Coordinate with State Govts. / Central Institutions for timely support to industry after MoU signing.
    - This cell will also Identify and take decisions on measures like reduction of GST, other duties and taxes for Primary, Secondary and Downstream, PLI, treating CPPs at par with IPPs, Public Procurement preference, and other incentives to promote capacity addition across value chain.

- The cell would organise Investment Promotion Roadshows/ Conferences/ Seminar for Aluminium industry for increasing downstream capacity addition and attract metallurgical OEMs to setup manufacturing base in India.
- Arrange funding for setting up of Aluminium Data collection and Publication Unit and Institute for Aluminium Application Growth
- Coordination with all taskforces, setting milestones & timelines and monitoring progress of implementation actions
- Policy formulation support can be provided by the Cell by deploying specialized resources.

- Looking at the experience of steel sector, the following dedicated institutions are needed for Aluminium sector to promote collaboration, data sanctity across Aluminium value chain and application evangelization
  - **Aluminium Data collection and Publication Unit (ADCPU)** on the lines of Joint Plant Committee (JPC) under the Ministry of Steel. The board members/ management committee of the entity can be drawn from PSUs and Private sector organizations. The organization can be headed by an Executive Secretary who can be drawn from the industry. This organization should be responsible for collating survey based or officially collected periodic data from different agencies across value chain players and consolidating the same for the Ministry. This unit can serve as the custodian of official data of the Ministry. The data from primary/ secondary producers, recyclers, special groups like extruders etc. can all be brought under one umbrella. The JPC also has an Economic Research Unit (ERU) within itself. However, the decision to have an ERU within the ADCPU is a function of what tasks are determined for the ERU by the IP&ASIC and whether the right team members are found to perform such sector-oriented commercial and economic research work. Some of the residual team members of the taskforces (described later in the document), post implementation of their mandates can also be assimilated into the ERU. If the ERU is constituted here, then the policy formulation assistance role of the IP&ASIC should be devolved to the ERU.
  - **Institute for Aluminium Application Growth (IAAG)** on the lines of INSDAG under Ministry of Steel may be set up. INSDAG is a not-for-profit, member-based organization established by the Government of India (Ministry of Steel) and Major Steel Producers of the Country as a “Society”. It is engaged in development of advanced and cost-effective design methodologies, technical and institutional marketing by expanding applications of steel in different segments of the construction industry, up-gradation of technical skills and know-how, creation of awareness amongst potential users and communicating the benefits of steel vis-à-vis other competitive materials etc. INSDAG is also involved actively in formulation and revision of codes and standards for steel use in construction based on latest developments with Bureau of Indian Standards (BIS) and Indian Roads Congress (IRC). The IAAG should aim to bring in global knowledge of innovative as well as standard applications and work with regulators and potential buyers to create an ecosystem more receptive to the use of Aluminium.

- The Aluminium sector in India does not have a technology advisory organization of global repute and clientele of the nature that is enjoyed by RITES (railways) or EIL (O&G) or MECON (steel) or even CMPDIL (coal nationally). These organizations have such heft that they can influence specifications for projects globally. While NRTC and ABSTC own various patents in the Aluminium sector and have done significant research work it would serve the sector well if JNARDDC should evolve into a center of excellence to such an extent that it can earn significant part of its revenue from its research and consulting experience. It may embark on a journey specializing in research and development and work on aiding the development of downstream products/ end-use applications for the MSME sector through their research capabilities.

- In addition to these institutions there is a need to create 3 taskforces to enumerate micro actions for the sector. The deliverable of the taskforces can be program-manage by the IP&ASIC. The IP&ASIC should draft the detailed terms of reference and tenure of the taskforces. The taskforces may include knowledge partners to help in the collation effort. The following taskforces are envisaged:

Table 3: Taskforces Needed

Taskforce Name	Primary Mandate	Constitution of the Taskforce (In addition to MoM representative)
Resource Security Taskforce	• Chalk-out detailed action plans to amend various rules and laws at the central and state level or impute tasks and duties to various organizations to help development of bauxite resources and improve scrap collection • To dissolve on completion of their deliverable	Representative of NITI Aayog; Representative of DSM, Govt of Odisha; Representatives of other relevant state DMGs; Representative of AAI; Representative of MSTC, MRAI etc.
Applications Development & Demand Generation Taskforce	• Develop strategic plans to promote Aluminium usage in sectors like automotive, transport, construction, packaging, electronics etc. • To draft standards to ensure that the quality of all Aluminium products and inputs (imported and domestic) meets global standards • Decision on the product coverage (finished Aluminium products or even input materials) of Quality Control Order • Identify various research areas in collaboration with the Downstream Development Taskforce, prepare budgets, plans for any capital lab/ pilot plant-equipment purchase etc. and work on those research topics with MSMEs and large players. • Will merge into IAAG on completion of the mandates	International Aluminium marketing and sales experts; Indian Aluminium sector marketing & sales representatives from primary, secondary and downstream sectors; Representative of EEPC/ DPIIT, Knowledge partners etc. Representative of JNARDDC, NRTC, ABSTC; Representatives of trade bodies like AAI/ ASMA/ MRAI etc.; SMEs as relevant Representative from CSIR (DML, NML, IMMT etc.); Invitees from International Research Organizations (like CSIRO); Invitees from pioneering academic institutions (IIT BHU etc.); Representatives of Global OEMs like Fatahunter, ACT, Hycast, Warwick, Hencon etc.; Representatives of Process Automation & Digital players like Siemens, ABB etc.
Green Transition Taskforce	• Chalk-out detailed plans to create sufficient green capacity at a landed cost that is competitive for the Aluminium sector • Evaluation of RPO obligations, Carbon Credit purchase etc. in the context of carbon-tax like levies • Definition of Green Aluminium • To dissolve on completion of their deliverable	Representative of MNRE and Ministry of Power (MoP); Representatives AAI and ASMA; Representative of World Bank/ GIZ/ JICA etc.; Representatives of CIL/ NTPC/ SECI etc.; Green Project Developers like Greenko / O2 etc.

Immediate high-impact initiatives:

To address the immediate requirement of Aluminium Sector, following strategic initiatives need to be adopted at earliest:

Rationalizing the electricity duty on Aluminium CPP plants (especially in Odisha and Chhattisgarh) to allow the Aluminium industry to be more cost-competitive globally

Considering Aluminium CPP equivalent to IPP for equal priority in the allocation of rakes

Expediting exploration and auction of larger bauxite blocks through amalgamation or auction of multiple non-contiguous mining leases as a single block

Supporting MSME development in Aluminium clusters/parks with the help of primary Aluminium players

Creating/mandating an agency with government support to establish large-scale, state-of-the-art scrap segregation plants at the point of scrap ingress

Conclusion

The Executive summary captures only the key actions that are of strategic importance. There is a slew of other initiatives needed to help the sector tide over near-term issues (like upcoming FTAs). These are discussed in appropriate sections of the report.

Aluminium is a very strategic metal for India's future, and it should earn its place of importance in terms of policy making by the Government. India is blessed with all the resources that are necessary for it to take a leap into the future. However, it would not be wise to underestimate the scale of change required or the extent of hand-holding that would be necessary for the vision to fructify into reality.

It is a statement of fact that outside the IT sector, Indian or Indian-owned multi-national companies are visible at large-scale only in the metals and mining sector. It is equally true that the scale of international presence of Indian metals and mining companies, is far short of the extent of multi-national presence developed by global metals and mining conglomerates such as Anglo American, Rio Tinto, BHP, Vale, Glencore Xstrata etc. One of the features of metals and mining giants around the world is that they have presence across multiple minerals. Aditya Birla Group's Hindalco is the only Indian Aluminium multinational that operates at scale outside India through its acquisition of Novelis and Aleris. It is important for the growth of Indian Aluminium sector to consider such players with their global footprint as part of the Indian Aluminium sector so that we may learn from their capabilities (such as recycling from Novelis and aerospace grade alloy-metallurgy from Aleris). Vedanta's Aluminium presence is limited to India but on the whole, Vedanta, at the group level, is present across multiple minerals and geographies. Like Vedanta, NALCO's Aluminium presence is also limited to India, but is one of the lowest cost producers of bauxite and alumina. Both Vedanta and NALCO are predominantly upstream players in comparison to Hindalco's global footprint. As the world approaches a period of strife and nationalization, the window of opportunity on multi-national corporations in the metals and mining domain seems to be closing. Amidst this turmoil there are examples of hectic forays by global players to control the mineral economy of the world through diversification and strategic tie-ups. We are already seeing companies without any presence in Aluminium, express their interest in this sector in India at this time. Indian players have found it difficult securing bauxite resources outside India vis-à-vis competition from China. It is the aspiration of the industry that the country should have multiple India-Headquartered multi-national resource-based companies with presence in Aluminium by 2047 who on the basis of their entrepreneurial spirit will carve out a path for India to realize its Vision.

2. Overview of Aluminium Industry

2 Overview of Aluminium Industry

2.1 Aluminium as a Metal

The earth's crust constitutes 1% of the earth's volume. Nearly 8% of the earth's crust contains Aluminium and it is the 3rd most abundant element, following oxygen and Silicon.

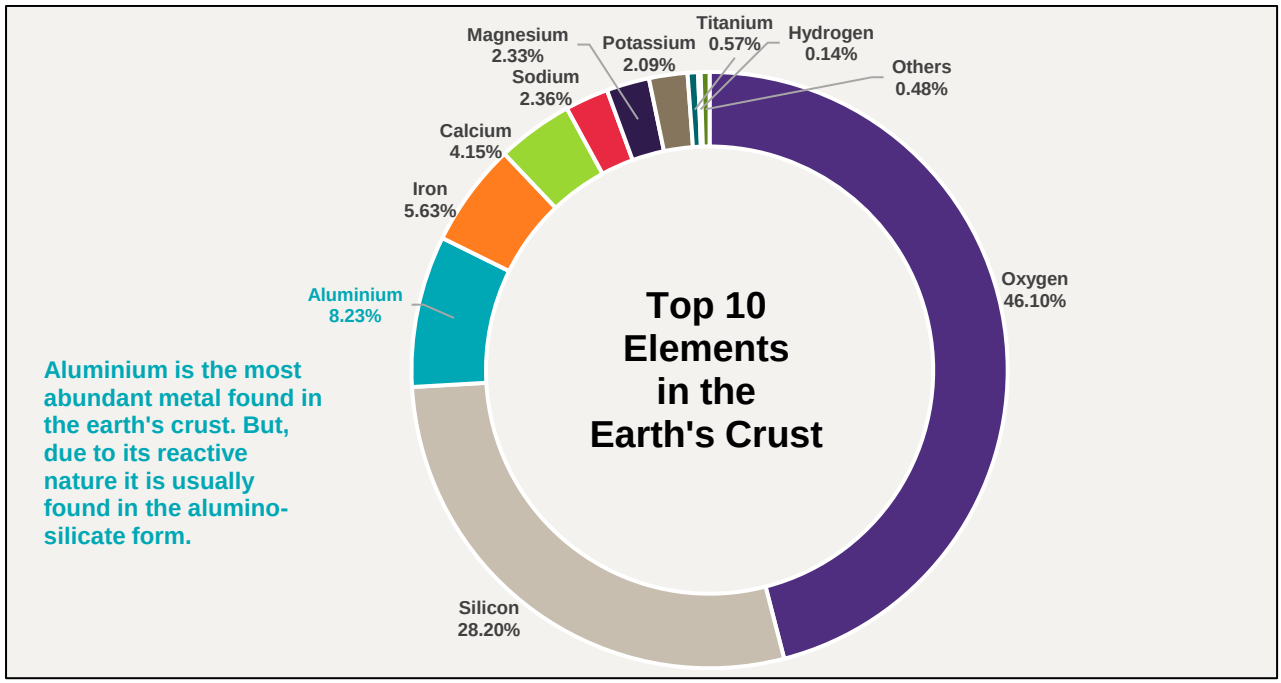

Figure 5:Top 10 Elements in the Earth's Crust

In the last 60 years the consumption of Aluminium has grown more than 20-fold, making it one of the fastest growing metals in terms of consumption[14] [15]. Its unique properties- lightweight, recyclability, conductivity, non-corrosiveness, and durability make it the 2nd most consumed metal in the world after steel with an annual consumption of 97.8 MT in 2023. Due to its versatility, Aluminium is a metal of choice across different sectors like automobiles, construction, packaging, electrical, machinery and equipment and consumer durables for various applications.

2.2 Historical Perspective

Alum (a compound of Aluminium) was used from time immemorial. However, modern scientists were able to isolate this metal only in 1825. It was originally considered difficult to refine and until the middle of the Nineteenth century, its price remained higher than gold. Production of the metal grew from 6,800 tonnes in 1900 to 2.8 MT in 1954, when Aluminium surpassed copper to become the most produced non-ferrous metal. As on date, Aluminium production exceeds those of all other non-ferrous metals combined. While total Aluminium production in 2022 stood at 108 MT, the production of Copper, the 2nd most produced non-ferrous metal, stood close to 26 MT.

While many scientists and engineers were instrumental in the development of this industry, engineers Paul Heroult (later associated with Pechiney) and Charles Martin Hall (later associated with Alcoa) independently improved the electrometallurgical process in the latter half of the nineteenth century, that industrialized the process of extracting Aluminium from Alumina. Around that time, Carl Joseph Bayer was successful in producing Alumina from Bauxite at scale. Aluminium prices remained high till the turn of the century. The initial uses of Aluminium were in jewelry, optical instruments, and cookware. In the early days of the Twentieth

[14] Past and Prospective Trends In The World Aluminium Industry, International Bank For Reconstruction And International Development Association, 31-May-1968, last accessed on 04-Oct-2024
[15] Industry Sources

century, Aluminium alloys added versatility to the physical properties and expanded the use of Aluminium in marine and aviation sector. During the first world-war, the use of Aluminium had extended heavily into the power sector and coinage in addition to sky-rocketing demand in airframe manufacturing. After the war prices rationalized over time. However, demand for Aluminium remained strong in traditional houseware applications and new applications in surface transport (like freight cars) and construction sector developed between the two wars. At this time, Carl Wilhelm Soderberg innovated on the process of anode manufacturing that gave a fillip to the cost of production of Aluminium.

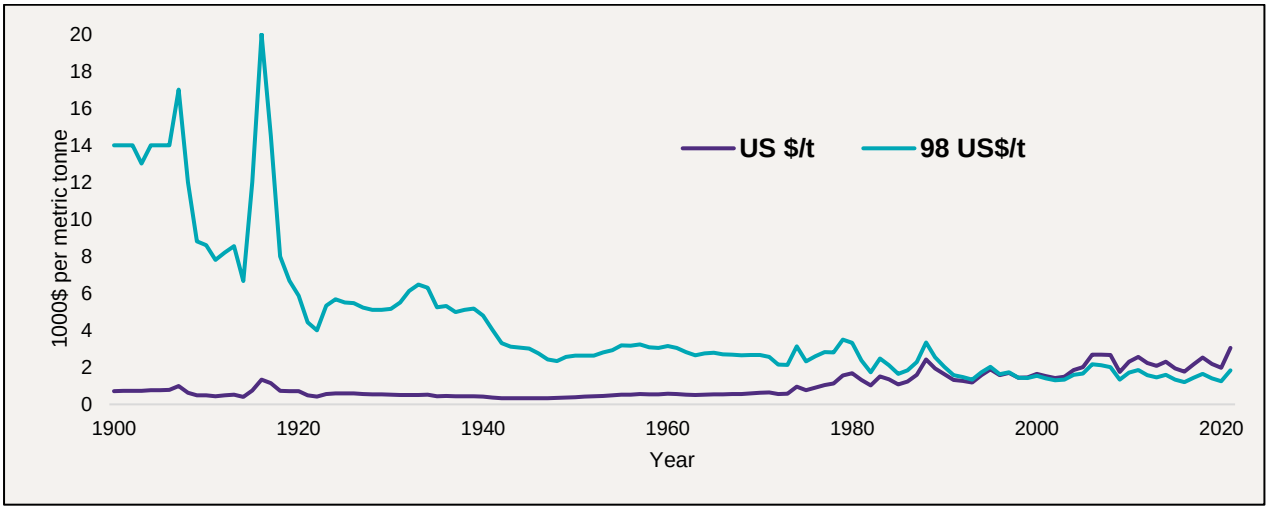

Figure 6: Historic trend of the real and nominal price in USD of a metric ton of apparent consumption of Aluminium

Note:

1. Unit Value (US$/t): Unit value is defined as the value of 1 metric tonne (t) of Aluminium. It is calculated using the "Annual Average Primary Aluminium Price," in USD, as reported in the Mineral Yearbook.
2. Unit Value (98 US$/t): The Consumer Price Index conversion factor, with 1998 as the base year, is used to adjust unit value in the current USD to unit value in constant 1998 USD.

Recycled Aluminium was considered inferior to primary Aluminium because of poor removal of dross and other impurities. Recycling grew but remained in the shadow of primary production. As electric energy prices declined in the West in the late 1930s, energy-intensive primary Aluminium again started dominating recycling. However, by the time of the second-world war, recycling had taken hold. The second world war saw Aluminium manufacturing increase heavily in Europe. After the Second world war, growth in civil aviation, advent of the space age, high-speed rail sector and increased consumerism by baby-boomers led to a very high CAGR of the Aluminium sector for several decades.

As the growth of global Aluminium use increased in the 1960s and the 1970s, it faced environmental scrutiny (which among other things led to a shift in the anode making process). With the increased Aluminium production and demand, the exchange trade for metal contracts started on the LME in 1978. Till this time Aluminium production globally was dominated by USA, Europe (incl. USSR) and Japan. However, since the early 1970s, there has been a geographic shift in the production of Bauxite, Alumina, and Aluminium. In Bauxite, Guinea, Australia, Brazil, China, India and Indonesia overtook the traditional geographies of Jamaica, Russia etc. Global Alumina production too has shifted to China, Australia, Brazil and India from Russia, Jamaica, Suriname etc. Some analysts prefer to show the shift of Bauxite and Alumina as one from the Western block to the BRICS block. If only the four BRIC countries are considered, their real GDP relative to the world equivalent more than doubled from 11% in 2000 to 26% in 2023. Using GDP measured at PPP, the BRIC share exceeded 33% in 2023 as compared to 18% in 2000. Improvement has been particularly impressive for countries such as China (second largest share of global GDP measured at PPP) and India (third on the same scale).[16] The impact of the BRIC economies on the global primary Aluminium industry has been even more significant, not only in terms of surging demand but also on the supply side of the market.

[16] World Development Indicators | DataBank (worldbank.org), last accessed on 10-Aug-2024

While raw material, energy, and capex account for about a third each of total Aluminium production costs, energy cost varies the most among different countries. It is due to low energy cost that the Middle East has emerged as a significant producer in the global Aluminium market. Countries like Bahrain and UAE look at Aluminium export as just another form in which to export energy.

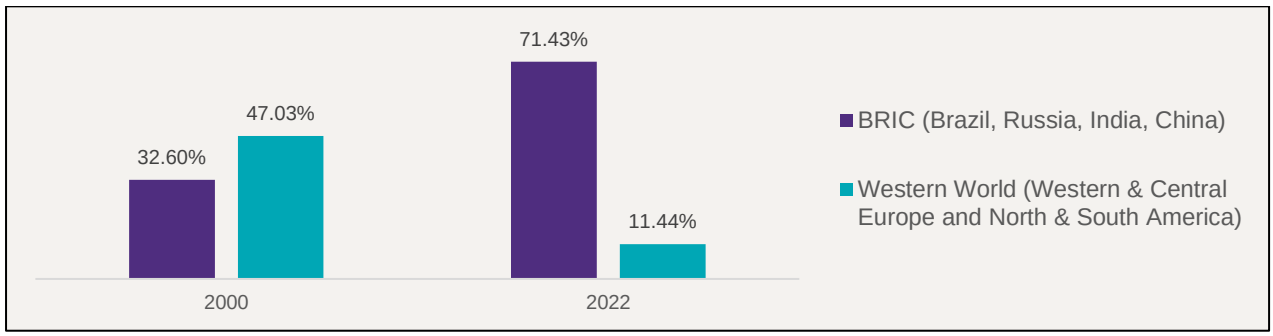

Figure 7: Share of Developed & BRIC Economies in Global Primary Aluminium Production

Historically, India's primary Aluminium sector has seen four waves of growth. It is captured in the table below:

Period	Companies	Smelters	India's Aluminium production[17]
Pre-Independence	• INDAL (a subsidiary of ALCAN) • Aluminium Corporation of India	• Alupuram (1938) • Jaykaynagar (1942)	(included under the British production)
During Post-Independence Industrialization	• INDAL • Hindalco • MALCO • BALCO	• Hirakud (1957-58) • Renukoot (1958) • Mettur (1965) • Korba (1965)	• 0.018 MTPA
Pre-liberalization	• INDAL • NALCO	• Belgaum (1970) • Angul (1981)	0.185 MTPA
21st Century	• Vedanta • Hindalco	• Jharsuguda (2008) • Mahan, Aditya (2013)	4.16 MTPA

The Aluminium sector in India has undergone significant changes over the years, including divestment by original owners, capacity expansions at existing smelter locations, and various regulatory shifts, especially in the energy sector. These changes have influenced both the primary and secondary Aluminium industries. Domestic Aluminium production began after the discovery of the Hall-Heroult process, with the establishment of the Indian Aluminium Company in 1943, boasting an installed capacity of 2,500 tonnes per annum (TPA). Later, key players like HINDALCO (1962), MALCO (1965), and BALCO (1965) entered the market, with BALCO now owned substantially by Vedanta. The public sector unit NALCO was established in 1981 with an installed capacity of 218,000 TPA. Today, India's installed capacity for primary Aluminium production stands at 4.2 MT, and the country was the second-largest Aluminium producer globally in 2023. From producing just a few thousand tonnes per annum in the 1950s, India's Aluminium production has grown to 4.16 MT annually.

The secondary and downstream Aluminium segment in India has also seen rapid growth since the 1980s, with Aluminium Industries Ltd. (ALIND) and India Foils Limited leading the initial efforts. Today, this segment has a cumulative processing capacity of close to 4 MTPA, represented by the Aluminium Secondary Manufacturers' Association (ASMA). The sector primarily relies on Aluminium scrap rather than Bauxite ore/

[17] Minerals yearbook 1990 Year 1990, Volume 2 1990 - Full view - UWDC - UW-Madison Libraries (wisc.edu)

Alumina, making India the largest importer of Aluminium scrap. This reliance is due to the high capital, energy, and raw material costs associated with primary Aluminium production.

The history of the Aluminium sector is closely linked with the power and Bauxite mining sectors. Post-independence, smelters like MALCO, Hirakud, and Renukoot were conceptualized alongside large hydro-power projects. However, the lag in power generation capacity compared to energy demand growth led to a transition to Coal-based captive power in the 1990s. Aluminium players then sought captive Coal mines for energy security, but this was disrupted in 2014 with the deallocation of Coal mines. High premiums were bid for Coal mines, and now, with energy security issues settling, the sector is shifting towards renewable energy, affecting the energy mix. The state-owned power transmission and distribution sector, a significant consumer of Aluminium, has limited affordability to absorb high prices due to financial constraints. MALCO was sold to Vedanta Resources as its Bauxite reserves dwindled, and its plant remains non-operational. BALCO continues to struggle with patchy deposits. India's Alumina refining growth has partially relied on the patchy Bauxite deposits of the Chhota Nagpur plateau and Central India. Most of the large blocks in Maharashtra and other central Indian states have nearly exhausted, making Vedanta Aluminium dependent on imported Bauxite. A refinery in Andhra Pradesh remains inoperative due to a lack of Bauxite[18]. Odisha boasts the largest share in India's Bauxite reserves and resources. The rich deposits in the Eastern Ghats remain largely inaccessible, even though the state mining player OMC has been allocated more blocks through government dispensation. OMC continues to auction its Bauxite while maintaining price fixation. The recent Supreme Court ruling about the right of states to impose taxes on mining companies, for mining rights and mineral bearing lands, on retrospective basis will impact Bauxite mines and Coal-buying Aluminium companies in Odisha immediately. Retrospective taxes on Odisha mines will impact NALCO and Hindalco the most and also Vedanta Aluminium if MCL passes on any of these taxes' impositions to the customers. If Jharkhand and other states also start imposing retrospective taxes, then primary Aluminium sector will be severely impacted.

There are several lessons to be taken from USA's and China's Aluminium sector strategy. In 1980, US primary Aluminium production peaked at 4.7 MT from about 30 smelters. By 2000, USA was down to about 23 primary Aluminium smelters. Currently USA produces less than 1 MT of primary Aluminium in about 4 operating smelters. The rest of the US production of over 3 MT comes from the secondary sector which processes scrap. There is a limit to which scrap based secondary production can go because it is limited by the amount of scrap generated and collected. The main reason given by US primary producers behind closure of the smelters has been the high cost of energy. Also, the bauxite for US refineries was predominantly imported. Today, US meets about half of its Aluminium demand from imports. Over half of these imports come in from Canada which enjoys low production cost due to its access to hydropower. Between 2018 and 2022, USA imposed import tariffs and tariff rate quotas on Aluminium and its derivative products to protect whatever little capacity remains in that country. US industry's denouement shows that not managing raw material availability and energy price led to a situation where the domestic production is in a non-competitive downward spiral compared to imports[19].

On the other hand, China's Aluminium production today is overwhelmingly through the primary route. The Chinese primary Aluminium industry grew from just 0.4 MT in the 1980s to over 40 MT in 2023. This remarkable growth can be attributed to several key factors. While the USA shifted its focus away from primary Aluminium, China promoted its primary industry through substantial government support in terms of policies and subsidies. In 2006, China recognized Aluminium as a "Pillar Industry," emphasizing the government's significant role. Investments in infrastructure and energy projects, along with heavy investments by Chinese companies in modernizing production facilities and adopting advanced technologies, increased efficiency and output, making Chinese Aluminium more competitive globally. By focusing on large-scale production, China reduced costs and increased production capacity, allowing its companies to dominate the global market. Additionally, many Chinese Aluminium producers integrated their operations vertically, controlling everything from bauxite mining to Aluminium smelting and processing, which streamlined operations and reduced costs. Since the coal-based power costs in China are also high, they have continuously sought newer manufacturing

[18] Andhra Pradesh to present arguments in bauxite case in London court next week, Indian Express, 25-Sept-2021, last accessed on 04-Oct-2024
[19] U.S. Aluminum Manufacturing: Industry Trends and Sustainability, Congressional Research Service, 26-Oct-2022

and digital technologies to reduce the per-ton power consumption. Today when the world looks to become greener, China has accumulated sufficient scrap-worthy Aluminium in its economy which it can use to sustain a shift to secondary route. Still China looks to stay invested in primary Aluminium. All it now needs to do is to keep relevant tax proposals that retains its Aluminium scrap in the country. China is a good example of a timely and well-thought-through capacity expansion story that will sustain its leadership position in Aluminium for years to come[20].

Indian Aluminium sector growth has followed a step-function with long periods of gap between successive capacity additions. This is unlike the steel sector, which has seen continuous production growth. The main reasons behind low capacity CAGR of Aluminium industry compared to steel are –

- Relatively under-developed end-use industry (like Aerospace manufacturing) and low penetration of Aluminium in standard segments vis-à-vis global standards
- High capex per-tonne of capacity
- Difficult raw material and energy security scenario
- Increasingly lack of clarity around the evolving energy and carbon footprint of the country is making it difficult to commit capacities

Indian regulations with respect to energy and raw material have dominated the mind space of Aluminium CEOs in India. Indian secondary sector's dependence on imported scrap on account of higher price of domestic primary Aluminium coupled with the lack of proper scrap recycling environment in the country is likely to become a source of risk for the sector in the event of a global supply chain challenge. The learnings from history can now be summarized:

1. India is today the second largest producer of primary Aluminium in the world. However, there is no guarantee of staying a permanent leader in the global pecking order unless the factors of production and the conditions of sale remain stable, predictable, and efficient.
2. Some policies have at times, perhaps inadvertently, created situations where the source of competitive advantage of Indian Aluminium has been put under stress. Policy making should be cautious and well thought-through so that adverse unintended consequences do not play out to the disadvantage of the sector. Also, policy clarity and policy stability are crucial for the sector to make meaningful decisions. Downstream sector development is heavily reliant on various fiscal and non-fiscal policies (industrial, land, power policies etc.) of the central and state governments and the longevity of any policy dispensation is crucial.
3. Aluminium is a metal of geo-strategic significance. Smooth and economic availability can help a country sustain through tough times.
4. Aluminium has faced continuous challenge of substitution throughout its history and a proper supportive environment that balances the needs of the primary and secondary sector can ensure sustenance of the sector.

2.3 Value Chain and Industry Structure[21,22]

The Aluminium industry is divided into two main segments: upstream and downstream. The upstream sector focuses on extracting Aluminium from Bauxite ore to produce primary, or unwrought Aluminium, typically in the form of ingots, billets, or slabs. Conversely, the downstream sector transforms Aluminium into semi-finished products like rods, bars, rolled products, castings, forgings, and extrusions, using primary Aluminium or recycled Aluminium (secondary production), or a combination of both:

[20] The Development of Aluminum Industry and Technology in China, International Aluminium Institute, last accessed on 04-Oct-2024
[21] The Aluminium value chain and implications for CBAM design, ERCST, Jun-2021
[22] Aluminiumleader.com, last accessed on 10-Aug-2024

1. **Bauxite Mining**: Bauxite, the mineral ore that contains Aluminium, is extracted through opencast mining. The mined ore is mostly sent directly to an Alumina refinery.
2. **Alumina Refining**: Bauxite undergoes the Bayer process to extract Alumina. This involves dissolving it in caustic soda, separating impurities, and calcining Aluminium hydroxide to produce pure Alumina. It leaves behind bauxite residue (red mud). Approximately 6-7 tonnes of Bauxite ore is required to produce 2 tonnes of Alumina.
3. **Primary Aluminium Production**: The Hall-Heroult process converts Alumina into molten Aluminium through electrolysis in a cryolite bath. The molten Aluminium is then alloyed and cast into semi-finished products, with 2 tonnes of Alumina producing 1 tonne of Aluminium.
4. **Secondary Aluminium Production**: Aluminium products can be disposed of or recycled back into the supply chain. Scrap Aluminium is collected, melted down, and resold. Recycling involves re-melting and molding, and some smelters specialize in processing scrap Aluminium, while others handle both Alumina and scrap. This process uses only 1/20th of the energy needed for primary Aluminium production.

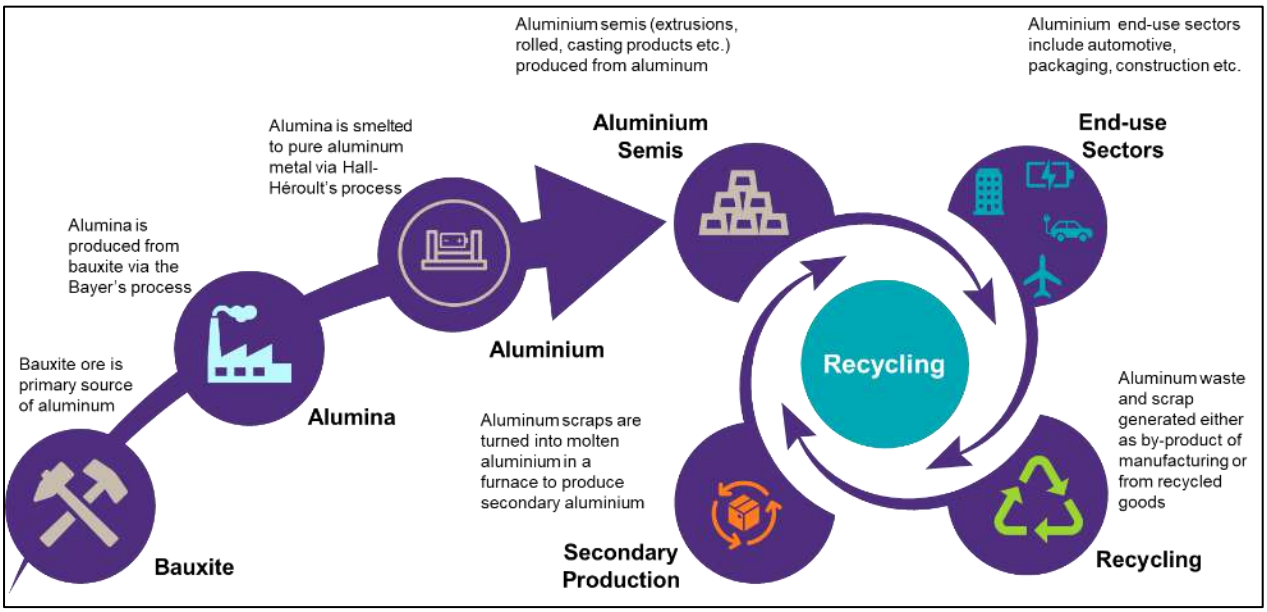

Figure 8: Aluminium Value Chain

5. **Aluminium Semis:** The downstream sector transforms primary Aluminium into value-added products. Molded products like billets and slabs are converted into semi-fabricated products such as flat-rolled products, extrusions, and castings for manufacturing use.
    - **Extrusion:** Aluminium billets are heated and forced through a die to create profiles for various applications.
    - **Rolling**: Aluminium ingots are rolled into sheets, foils, or plates for diverse uses.
    - **Casting**: Molten Aluminium is poured into molds to create complex shapes for various industries.
6. **End-use:** Semi-fabricated Aluminium products are usually delivered to industrial customers for final fabrication into finished items such as cans, cables, window frames, automobile parts, and aircraft components. Fabrication involves the use of machining, pressing, shaping etc. These finished products are utilized by various consumers for numerous applications.

Table 4: Application of Aluminium in different end-use sectors

#	Sector	Applications
1	Packaging	Aluminium foil, aerosol cans, beverage can body and end, caps & closures, collapsible tubes

#	Sector	Applications
2	Transportation	Bus body, commercial vehicles, Trucks, passenger cars, rail coach, two wheelers, marine and aircraft
3	Building & Construction	Cladding, portioning, composite panels, curtain rod, doors and window, facades, false ceiling, rolling shutters, roofing, siding, formwork, scaffolding, ladder
4	Electrical	Transmission and distribution lines, solar panel frames, electrical fans, lamp caps, luminaires, bus bars
5	Machinery & Equipment	Cladding, ducting, lithographic plates, machinery, motor body, solar panels, ventilation etc.
6	Consumer Durables	Kitchen cabinet fittings, Furniture, Pressure cooker, non-stick cookware, pots & pans, Air Conditioners, refrigerator, Washing machine
7	Others	Defence & aerospace application

Global Dominance across the Value Chain

Bauxite Reserves (World: 30 BnT)	Bauxite Production (World: 400 MT)	Alumina Production (World: 137.5 MT)	Primary Aluminium Production (World: 70.6 MT)	Downstream Products Exports (World: 26.7 MT)
• Guinea (25%) • Vietnam (19%) • Australia (12%) • Brazil (9%) • Jamaica (7%)	• Australia (25%) • Guinea (24%) • China (24%) • Brazil (8%) • India (6%)	• China (60%) • Australia (14%) • Brazil (7%) • India (5%) • Russia (2%)	• China (59%) • India (6%) • Russia (5%) • Canada (4%) • UAE (4%)	• China (30%) • Germany (9%) • USA (7%) • Turkey (4%) • Italy (4%)

Figure 9: Bauxite to Aluminium: Top five – across the chain, 2023

Despite possessing only 2.4% of global Bauxite reserves, China has been a significant, or rather the largest, contributor across the value chain. It is not only the largest producer of Aluminium but also the largest consumer. India, on the other hand, is a significant contributor to Bauxite, Alumina, and primary Aluminium production but lags behind in downstream production capabilities.

The Aluminium industry's value chain is a testament to the intricate processes involved in transforming raw material into a versatile product. The sector's sustainability and efficiency are increasingly important considerations as it evolves to meet global demands.

2.4 Importance as a Strategic Sector[23]

The Aluminium industry has solidified its position as a strategic industrial backbone for numerous nations worldwide. This strategic designation is a testament to its critical role in defense, national security, critical infrastructure, and economic growth. Governments across the globe have recognized the Aluminium industry's potential to drive technological advancement and foster sustainable development. Consequently, they have implemented a range of supportive policies, including financial incentives, tax breaks, research and development funding, and infrastructure investments.

[23] Op-Ed: Our National Security Depends on a Healthy Aluminium Industry | U.S. Department of Commerce

China's early recognition of Aluminium's strategic importance, designating it as a "pillar industry," has propelled its dominance in global production and processing.[24] As per the US National Strategic and Critical Minerals Production Act of 2013, strategic and critical minerals are defined as necessary for national defense and security requirements, energy infrastructure (including pipelines, refining capacity, electrical power transmission and generation, and renewable energy production), domestic manufacturing, agriculture, housing, telecommunications, healthcare, and transportation infrastructure, as well as the nation's economic security and balance of trade. Russia, with its abundant resources, leverages Aluminium as a strategic asset for its defense industry. In Europe, the EU has outlined a long-term vision for the non-ferrous metals sector, aiming to maintain a competitive and sustainable Aluminium industry. Canada, with its hydroelectric power and Bauxite reserves, is a major producer.[25] South Korea and Taiwan, early adopters of Aluminium as a strategic sector, continue to have a strong presence in Aluminium processing. Emerging economies like Malaysia, Indonesia, and the UAE[26] have also identified Aluminium as a key driver of industrial growth.

The notion of 'strategic minerals' or 'critical minerals' is relatively new to policymakers in India compared to other major economies. According to the Council on Energy, Environment, and Water's (CEEW) report on non-fuel minerals in 2016, Aluminium was classified under Zone III with low economic importance and low supply risk (least critical).[27] Despite this, India recognized Aluminium as a vital metal in wartime[28]. However, strategic importance of Aluminium for India today spans economic growth, infrastructure development, defense, transportation, sustainability, and global competitiveness. Its versatile applications and alignment with national priorities make it a critical material for India's development and strategic interests.

Government policies are instrumental in shaping the Aluminium industry's trajectory. Financial incentives, tax breaks, research and development funding, and infrastructure investments are common tools used to stimulate growth and innovation. Trade policies, environmental regulations, and energy policies also significantly influence the industry's competitiveness and sustainability. The global shift towards a low-carbon economy presents unprecedented opportunities for Aluminium. Its lightweight properties make it a crucial material for electric vehicles, renewable energy infrastructure, and energy-efficient buildings. Moreover, its infinite recyclability aligns perfectly with the circular economic principles.[29] To capitalize on these opportunities, countries must invest in research and development, promote sustainable practices, focus on creating new demand through product innovation and build resilient supply chains.

Aluminium's strategic importance is undeniable. It is a versatile metal that underpins numerous sectors and drives economic growth. By adopting comprehensive policies nations can harness Aluminium's full potential and contribute to a greener and more prosperous future.

[24] Li, S., Zhang, T. The Development Scenarios and Environmental Impacts of China's Aluminium Industry: Implications of Import and Export Transition. J. Sustain. Metall. 8, 1472–1484 (2022). https://doi.org/10.1007/s40831-022-00582-0
[25] Quebec Budget 2024: Business Funding for a Strong Economy (mentorworks.ca)
[26] Dubai seeks to become industrial hub in line with Dubai Industrial Strategy 2030 vision - The Economic Times (indiatimes.com)
[27] India's Critical & Strategic Non-Fuel Minerals for Manufacturing Sector (ceew.in)
[28] 82-85.PDF (nmlindia.org)
[29] New IAI Study Reveals Environmental Benefits of Increased Global Aluminium Can Recycling - International Aluminium Institute (international-Aluminium.org), last accessed on 10-Aug-2024

3. Present Scenario of Global Aluminium Industry

3 Present Scenario of Global Aluminium Industry[30]

3.1 Per-capita Consumption In India & Global[31,32,33]

Often dubbed as the "metal of the future," Aluminium is a critical material in modern industries due to its unique properties, including lightness, strength, corrosion resistance, and recyclability. Known for its adaptability and wide range of applications, Aluminium is an essential metal in many sectors, including packaging, aircraft, and transportation in addition to building and construction. Gaining insight into the demand for Aluminium consumption in various nations might help one better understand their industrial, technological, and economic development. In this regard, the amount that different countries use Aluminium in their daily lives can be determined by looking at per capita Aluminium consumption. This section compares India and the top nations based on per capita use of Aluminium to provide insight into how they use this essential metal and the effects it has on their industrial sectors and economy.

In the figure below, developed nations, where sectors like automobiles, construction, and aerospace are mature, have the highest per capita Aluminium consumption. With a per capita consumption of 42.76 kg of Aluminium, South Korea is currently the world's largest Aluminium consumer. Bahrain and Germany, with a per capita Aluminium consumption of 32 kg and 31 kg, respectively, come right after South Korea.

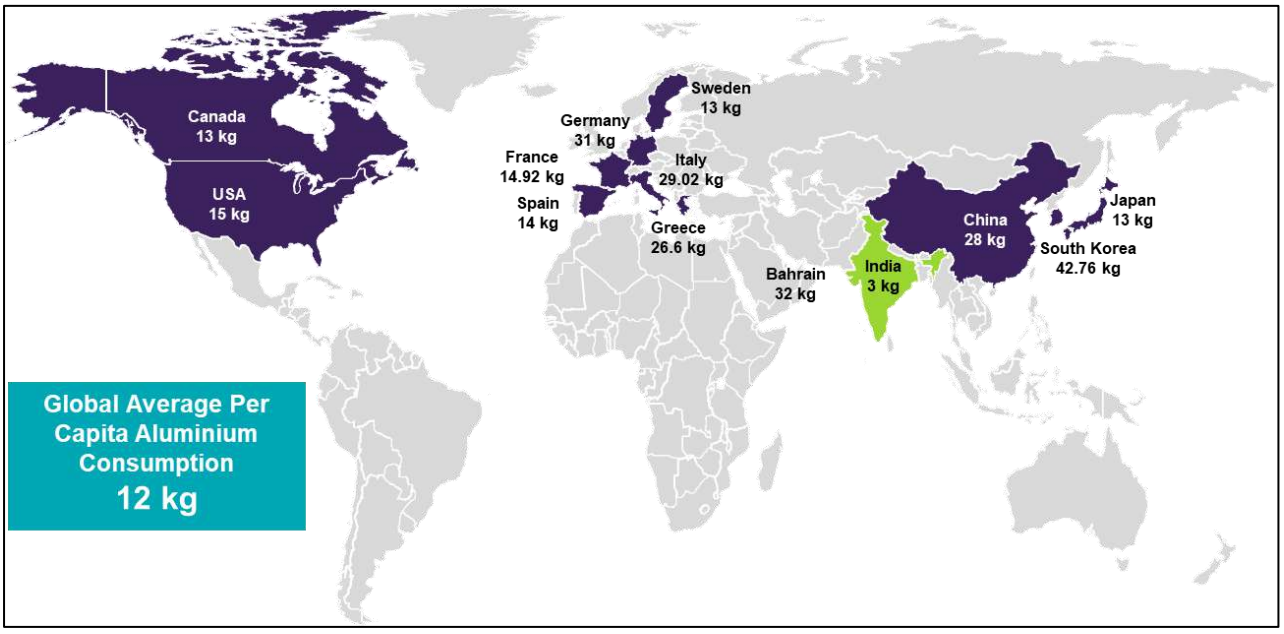

Figure 10: Country wise Per Capita Aluminium Consumption, 2022

South Korea (Per capita consumption: 42.76 kg)

Owing to its expansive and export-oriented automobile and electrical sectors, South Korea's per capita Aluminium consumption was the highest globally in 2022. However, since South Korea is not one of the top Aluminium producers, it depends on imports to meet its metal requirement. In 2023, the country's Aluminium imports were USD 8.20 billion, with primary Aluminium (46%) accounting for most of the total Aluminium imports, followed by Aluminium scraps (20%) and plates, sheets & strips (16%).

[30] Note: In this report, the import and export data of ITC Trademap has been averaged to demonstrate trade of Aluminium Commodities
[31] https://www.alcircle.com/news/2022-per-capita-Aluminium-consumption-ranking-the-world-s-top-10-countries-96308
[32] ITC Trademap, last accessed on 10-Aug-2024
[33] Mineral Commodity Series, USGS

Bahrain (Per capita consumption: 32 kg)

Aluminium consumption in Bahrain is significantly influenced by Aluminium firms operating in the kingdom, especially Aluminium Bahrain (Alba), which is one of the biggest smelters of Aluminium worldwide. Bahrain produced 1.6 MT of Aluminium in 2023, making it self-sufficient in Aluminium. Infrastructure, technological, and human resource investments, among other government initiatives and policy support, have contributed to the growth of Bahrain's Aluminium sector.

Germany (Per capita consumption: 31 kg)

Due to the low level of Aluminium production in the nation, a sizable portion of the need for Aluminium comes from imports. With USD 22.89 billion of Aluminium imports, Germany was the 2nd largest importer in 2023. Germany's Aluminium imports are dominated by primary Aluminium, followed by downstream Aluminium products and scraps. This reliance on imports underscores the importance of Aluminium for Germany's automotive and construction industries markets. Consequently, the dynamics of international trade have a big influence on Germany's industrial output and economic growth. Germany was also the 2nd largest exporter of Aluminium in 2023 majority of which comprised downstream products and nearly 10% of the exports comprised scraps.

Italy (Per capita consumption: 29 kg)

Italy is the 6th largest importer and 5th largest exporter of Aluminium by value. The country imported Aluminium worth USD 8.52 billion in 2023, of which primary Aluminium (39%), plates, sheets & strips (14%) and Aluminium scraps (12%) accounted for nearly 65% of the total Aluminium imports. Such consumption reflects the nation's booming manufacturing industries, which include construction, packaging, automobile, and electronics industries. Italy exported USD 8.69 billion worth of Aluminium mostly consisting of downstream products.

China (Per capita consumption: 28 kg)

China is the world's largest Aluminium consumer, driven by its vast population and 5th highest per capita Aluminium consumption, indicating a substantial demand for this non-ferrous metal within the populous nation. China mostly relies on domestic sources for this demand, with its annual Aluminium production reaching an impressive 41 MT in 2023. However, China was also the 3rd largest Aluminium importer with USD 12.35 billion of imports. Primary Aluminium (49%) constituted nearly half of its total imports, followed by scraps (28%). China was also the largest exporter of Aluminium (USD 34.98 billion). More than 90% of China's Aluminium exports consisted of downstream products.

Greece (Per capita consumption: 26.6 kg)

Because of its very low production, Greece mostly depends on imports to meet its high per capita Aluminium consumption requirement. Greece's Aluminium imports were USD 1.58 billion in 2023, more than 86% of which constituted primary Aluminium (64%) and scraps (22%).

USA (Per capita consumption: 15 kg)

In 2022, the USA was the 2nd largest consumer of Aluminium metal with 4.76 MT and was ranked 7th in per capita Aluminium consumption. Most of the country's Aluminium demand is met through secondary Aluminium production, imports and some through domestic primary Aluminium production. This is ironic because Charles Martin Hall, one of the pioneers of Aluminium electro-metallurgy and an early Director at Alcoa, championed primary Aluminium production in this country. The USA was the largest importer of Aluminium with USD 28.30 billion of imports, most of which constituted primary Aluminium. The country also produced nearly 3.3 MT of secondary Aluminium in both 2022 and 2023. USA was the 3rd largest Aluminium exporter (USD 14.28 billion) and the largest exporter of Aluminium scrap (USD 3.74 billion) in 2023.

France (Per capita consumption: 14.92 kg)

France ranked 8th in per capita Aluminium consumption, mainly due to its expanding and popular automobile sector. Like many top Aluminium consumers, France is dependent on imports to meet its demand due to limited domestic production capability. This again is ironical because Paul Heroult, the pioneer of primary

Aluminium production was instrumental in starting on the earliest Aluminium producing companies in the world, Pechiney, in France. In 2023, France imported USD 8.52 billion worth of Aluminium, mainly comprising downstream products. France also exported Aluminium worth USD 6.5 billion mostly consisting of downstream products.

Spain (Per capita consumption: 14 kg)

Spain is also dependent on imports to meet its Aluminium demand. In 2023, Spain ranked 16th in Aluminium imports (USD 5.02 billion) and 15th in exports (USD 5.22 billion). The country mainly imported primary Aluminium and scraps and exported downstream products.

Canada (Per capita consumption: 13 kg)

Canada's Aluminium demand is primarily met through its domestic primary Aluminium production. It produced nearly 3 MT of primary Aluminium in 2023. Canada ranked 4th in Aluminium exports (USD 12.61 billion) and 15th in Aluminium imports (USD 5.10 billion). The country mostly imported downstream products and exported primary Aluminium and scraps. ALCAN which started out as a subsidiary of Alcoa with most of its non-American assets, was at one time the largest Canadian company. ALCAN's end as an independent company in 2007 through a bidding war between Alcoa and Rio Tinto, which Rio Tinto eventually won, is a case study in itself about multi-national operations in metals and mining sector.

Japan (Per capita consumption: 13 kg)

Japan, the fourth-largest economy in the world[34], depends on imports of Aluminium to meet the demand because of lack of domestic resources. Owing to its advanced automobile industry's requirements, the country imported USD 8.2 billion worth Aluminium in 2023.

Sweden (Per capita consumption: 13 kg)

Sweden was ranked 10th in per capita Aluminium consumption in 2022, but its overall Aluminium demand is very low owing to the small population of the country.

India (Per capita consumption: 3 kg)

Despite being the fifth largest economy in 2022, India's per capita Aluminium consumption of 3 kg is well below the global average of 12 kg. India needs to increase its Aluminium consumption more than five-fold to achieve the global average at current levels.

The top ten per capita Aluminium consuming countries are an example of the global demand and dependence on this versatile metal. From tall skyscrapers to complex machines, Aluminium plays a central role in shaping the modern world. As these countries prioritize sustainability, innovation and economic growth, their steady consumption of Aluminium is a testament to its irreplaceable value. Together, they form a collective force, paving the way to a brighter, Aluminium-rich future.

3.2 Current Scenario on Aluminium Production and Trade

3.2.1 Global Aluminium Production[35,36]

Historical Trend of Aluminium Production

Since the beginning of this century, global Aluminium production has nearly tripled over the past 22 years, from 36.7 MT in 2001 to 108.2 MT in 2022. However, owing to the environmental benefits, secondary Aluminium (5.5% CAGR) production has outpaced the growth of primary Aluminium (4.8% CAGR).

[34] https://www.forbesindia.com/article/explainers/top-10-largest-economies-in-the-world/86159/1
[35] International Aluminium Institute, last accessed on 10-Aug-2024
[36] Mineral Commodity Series, USGS

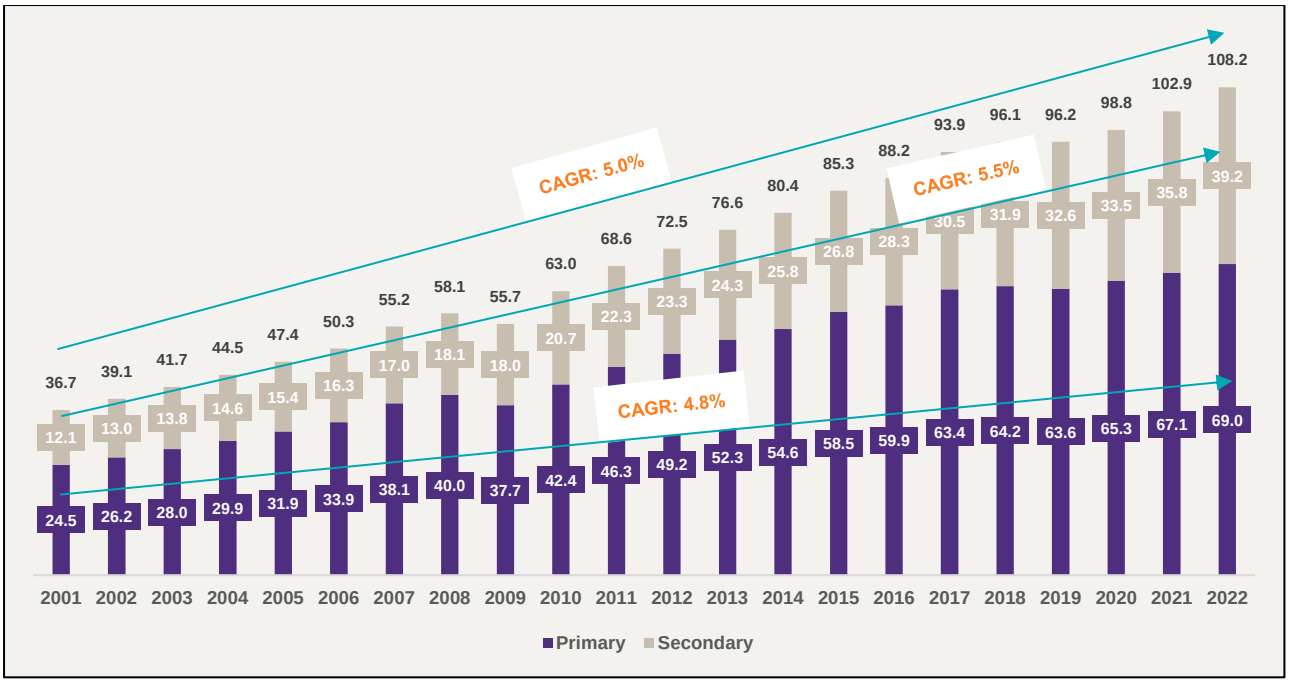

Figure 11: Global Primary Aluminium Production, 2001-2023 (MT)

Back in 2001, Aluminium production was concentrated in the regions of North and South America, Europe, and Russia. These regions contributed to more than 60% of the global Aluminium production. However, due to the soaring global demand for this versatile metal, largely driven by economic powerhouses like China and India, the production has shifted to Gulf and Asian nations like UAE, Bahrain, India, and China.

While the contribution to primary Aluminium production in 2023 from Gulf and Asian countries has surged to over 74%, a remarkable increase from the mere 23% recorded in 2001, the share from the regions of North and South America, Europe, and Russia has dwindled to a mere 17% in 2023, down significantly from the 60% in 2001. Similarly, for secondary Aluminium, the share of Gulf and Asian countries has double in 2021 to 58% from 29% in 2001. However, owing to the growing climate concerns and low availability of Bauxite reserves, North America and Europe still accounted for nearly 31% of the secondary Aluminium production in 2023.

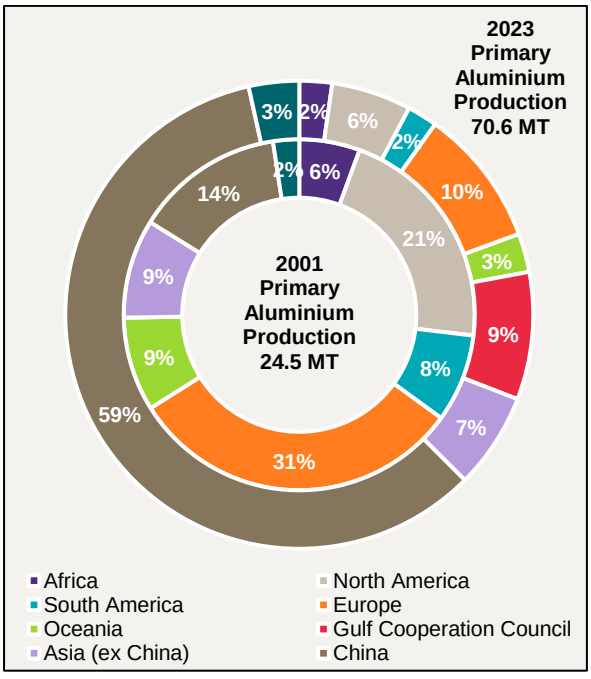

Figure 12: Global Primary Aluminium Production Distribution Change, 2001 and 2023

Figure 13: Global Secondary Aluminium Production Distribution Change, 2001 and 2021

China's share of global primary Aluminium production increased from 3.37 MT in 2001 to 41.67 MT in 2023, with a CAGR of 11.55%. Gulf countries produced no Aluminium in 2001, increasing to 6.62 MT in 2023. Overall, excluding China, Asian countries have shown an increase in Aluminium production at a CAGR of 3.26%. However, India's production has increased at a significantly higher CAGR of 8.68% from 2001-02 (0.60 MT) to FY24 (4.16 MT), making it the second fastest growing country in terms of Aluminium production.

Country wise Primary Aluminium Production, 2023

In 2023, China was the largest producer of primary Aluminium, accounting for 59% of global production. It was followed by India and Russia, which contributed 6% and 5% respectively, bringing the total contribution of these three countries to nearly 70% of global production. Including these countries, the top 10 Aluminium-producing countries accounted for 87.5% of global production.

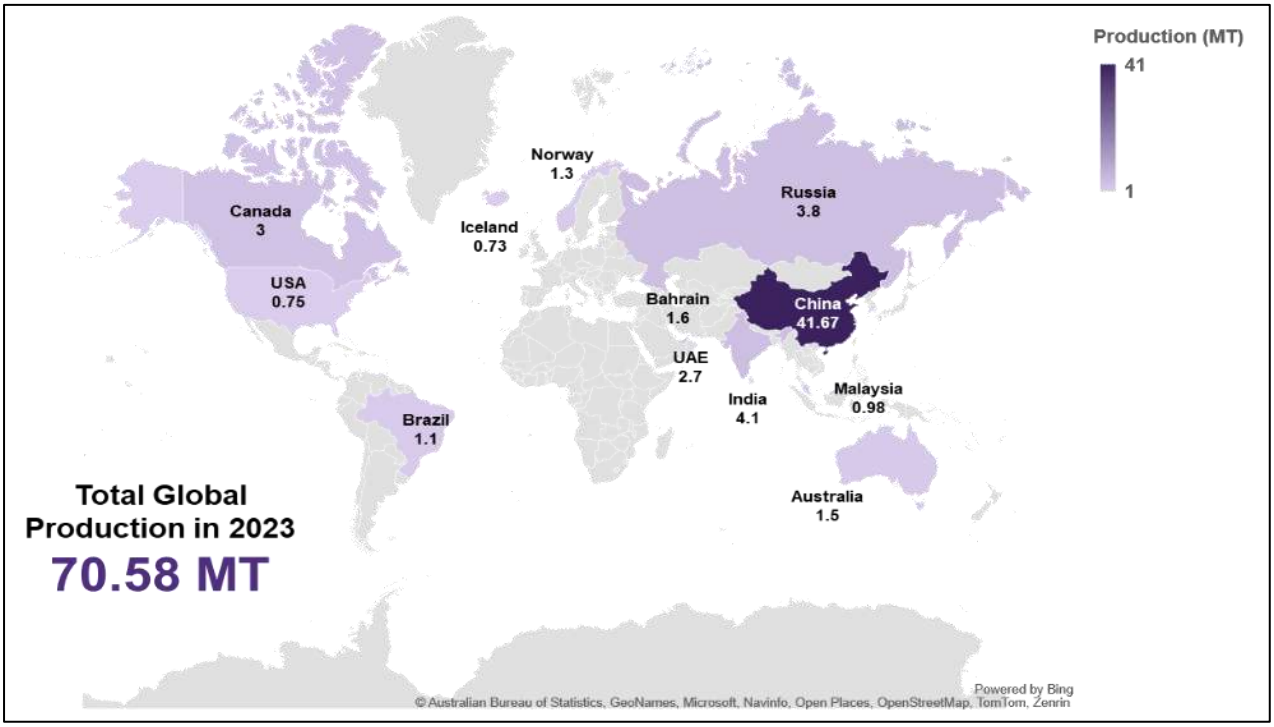

Figure 14: Global Primary Aluminium Production 2023 (MT)

3.2.2 Top Aluminium Producers[37]

Primary Aluminium Producers

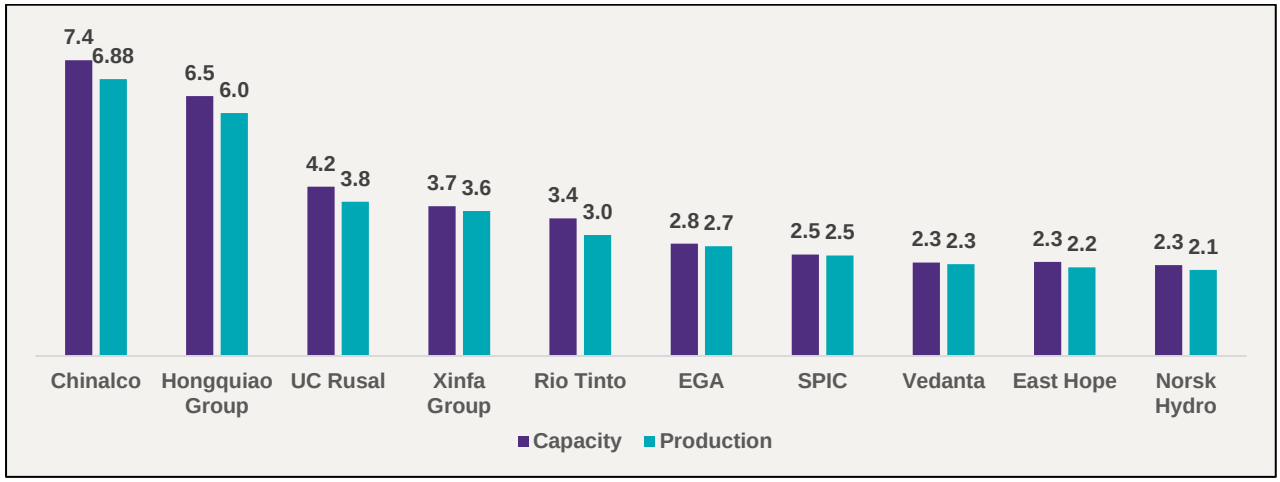

Figure 15: Top 10 Primary Aluminium Producers, 2022 (MT)

[37] Companies Annual Reports and Websites, last accessed on 10-Aug-2024

The top 10 producers alone contributed to 51.5% of the global primary Aluminium production in 2022, with the Chinese companies' contribution amounting to 31%. UC Rusal was the largest Aluminium producer (excluding the Chinese producers) in 2022, followed by Rio Tinto, EGA, Vedanta and Norsk Hydro. The average utilisation of the Aluminium smelters of the top 10 producers was 95%.

Secondary Aluminium Producers[38]

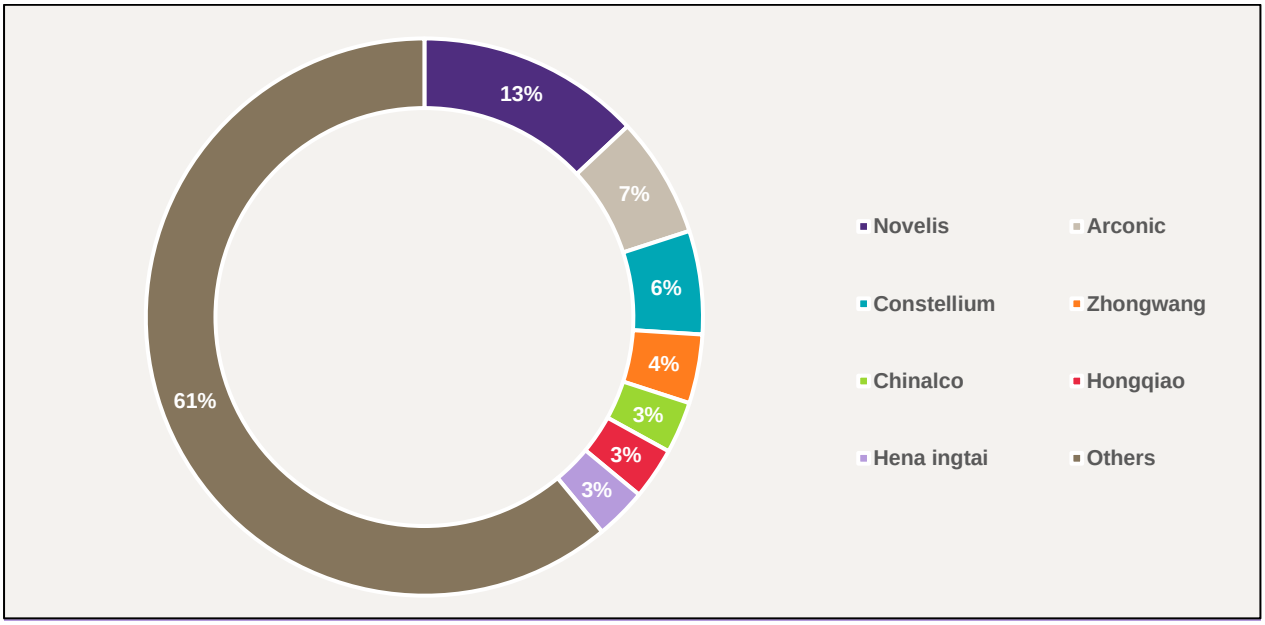

Figure 16: Secondary Aluminium Production

Novelis stands as the global leader in Aluminium recycling with 14 recycling facilities across four continents. The company pioneered the first and largest closed-loop recycling systems for automotive Aluminium. Each year, Novelis recycles over 82 billion used beverage cans. Novelis plans to expand its recycling capacity to more than 2.9 MT by FY27 from current capacity of 2.2 MT.

Hydro operates 21 recycling facilities across Europe, North America, and South America, with a combined annual capacity of approximately 1.4 MT. Currently, about 0.17 MT of post-consumer scrap are utilized in their recycling operations. Hydro aims to increase its post-consumer scrap recycling capacity to between 0.85 MT and 1.2 MT by 2030. In 2023, Hydro recycled 0.44 MT of post-consumer and 1.05 MT of pre-consumer Aluminium scrap. Additionally, Hydro sold 51 kt of Hydro CIRCAL, a brand of recycled Aluminium containing at least 75% post-consumer scrap and boasting a carbon footprint of 1.9 kg CO_2 per kg of Aluminium.

Constellium's recycling capacity stood at 0.65 MT in 2023 and aims to achieve at least half of Aluminium from recycled sources by 2030. They have also set an intermediate goal of achieving 0.75 MT recycled Aluminium input by 2026.

3.2.3 Global Trade of Aluminium[39]

Aluminium is being traded globally in many forms like unwrought Aluminium, Aluminium scraps (raw materials for secondary Aluminium) and downstream products like Aluminium plates, rods, bars, wire, foil, tubes, pipes, cans etc. In 2023, Total trade of Aluminium products stood at USD 233 billion. The global trade for the Aluminium products were down by nearly 16% from 2022 levels. This drop was mainly attributed to factors like global economic slowdown, geopolitical tension and volatility in the Aluminium market.

By value, unwrought Aluminium (HS Code: 7601) was the most traded product, constituting nearly 31% of the global Aluminium trade. The other Aluminium products plates, sheets and strips of Aluminium (HS Code: 7606), Aluminium scrap (HS Code: 7602), bars, rods and profiles of Aluminium (HS Code: 7604), Aluminium

[38] Hindalco Industries – Capacity expansion, sizing downstream to drive margins, Anand Rathi Research
[39] ITC Trademap, last accessed on 10-Aug-2024

foil (HS Code: 7607), Aluminium structures and parts of structures (HS Code: 7610) and articles of Aluminium-like nails, bolts, grills etc. (HS Code: 7616) added another 59% of the global Aluminium trades.

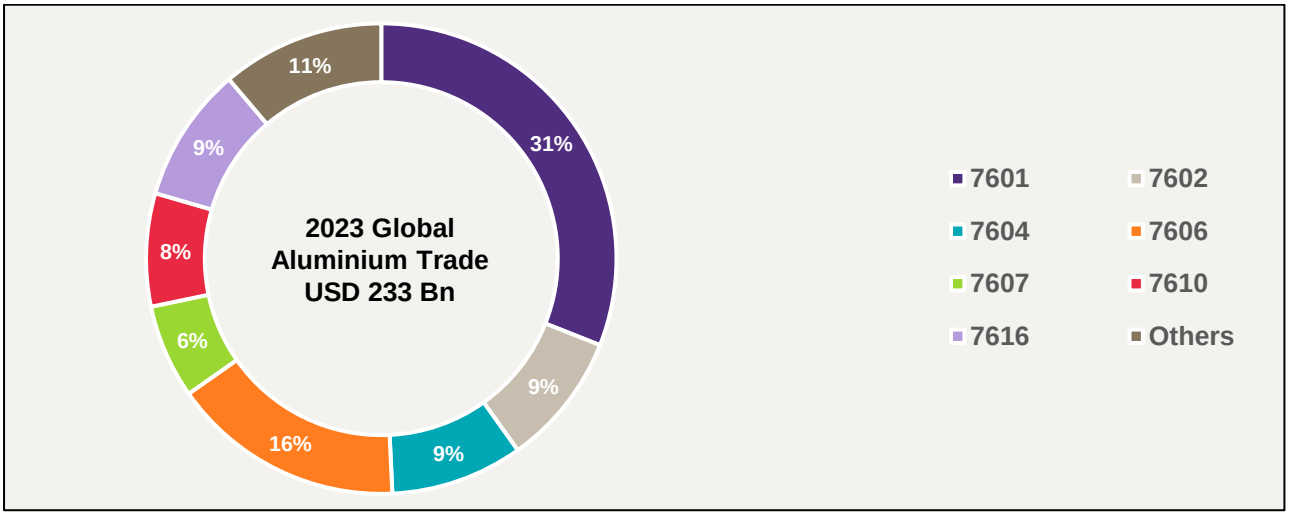

Figure 17: Product wise Trade of Aluminium Products by Value, 2023

Global Unwrought Aluminium Trade (HS Code: 7601)

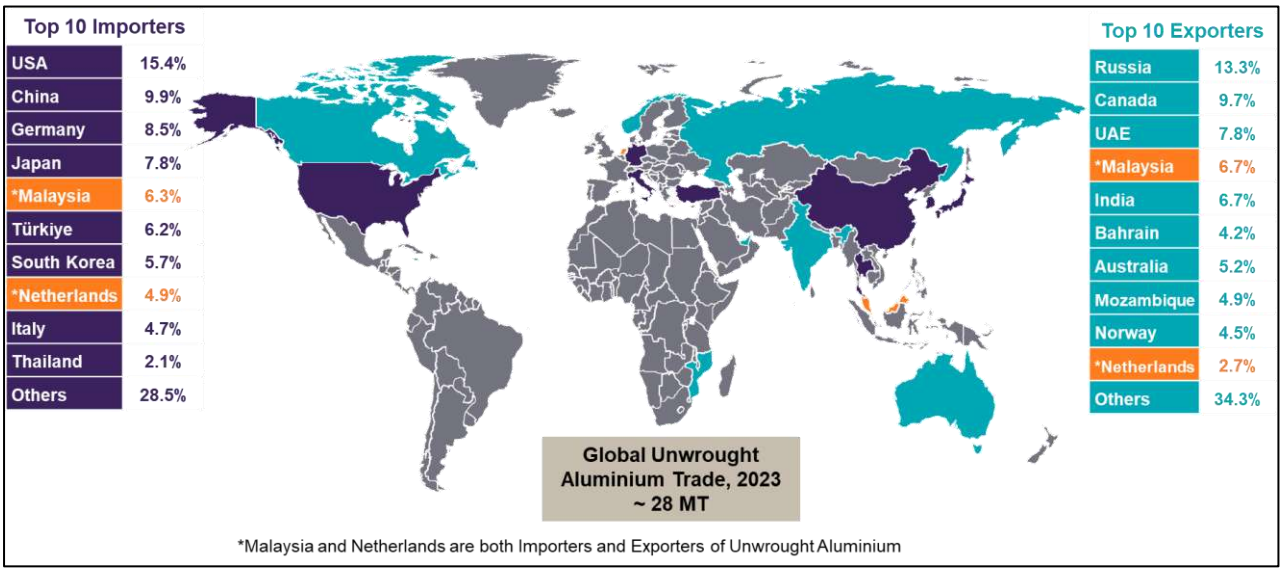

Figure 18: Global Trade of Unwrought Aluminium by Volume, 2023

In 2023, the top 10 nations accounted for nearly 71.5% and 65.7% of the world's imports and exports of unwrought Aluminium, respectively. All the top 10 nations except China, have low or no Bauxite reserves and import unwrought Aluminium to meet their Aluminium demand. Russia was the largest exporter of unwrought Aluminium with nearly 4 MT of exports. Despite having low Bauxite resources, countries like Canada, UAE, Bahrain, Mozambique and Norway contributed to more than 31% of the global unwrought Aluminium exports.

Today, China dominates both the upstream (primary and secondary Aluminium) and downstream Aluminium market. India needs to develop its recycling and downstream sectors, as well as enhance its primary Aluminium capabilities to achieve self-reliance.

3.3 Raw Material Scenario[40,41,42]

Globally, Aluminium is produced through two routes, primary and secondary route. While the primary route requires Bauxite and Alumina as raw materials, the secondary route requires Aluminium scraps.

3.3.1 Bauxite and Alumina

Primary Aluminium production involves the extraction and processing of raw materials, which are primarily Aluminium-bearing minerals. The main raw materials used in the Aluminium sector are Bauxite and Alumina. Bauxite is the primary source of Aluminium for primary Aluminium production. It is a mixture of hydrous Aluminium oxides, Aluminium hydroxides, quartz, hematite, clay minerals, magnetite, goethite and siderite.

Bauxite is commonly extracted through open-pit mining method and then refined through the Bayer process to produce Alumina (Aluminium oxide). Alumina is then used as a feedstock for Aluminium production.

Global Bauxite Reserves

Global Bauxite reserves were 29.76 BnT in 2023, with Guinea holding nearly 25% of the world's reserves. Vietnam (19.49%), Australia (11.76%), Brazil (9.07%) and Jamaica (6.72%) were other top 5 nations blessed with nearly 47% of the Bauxite reserves.

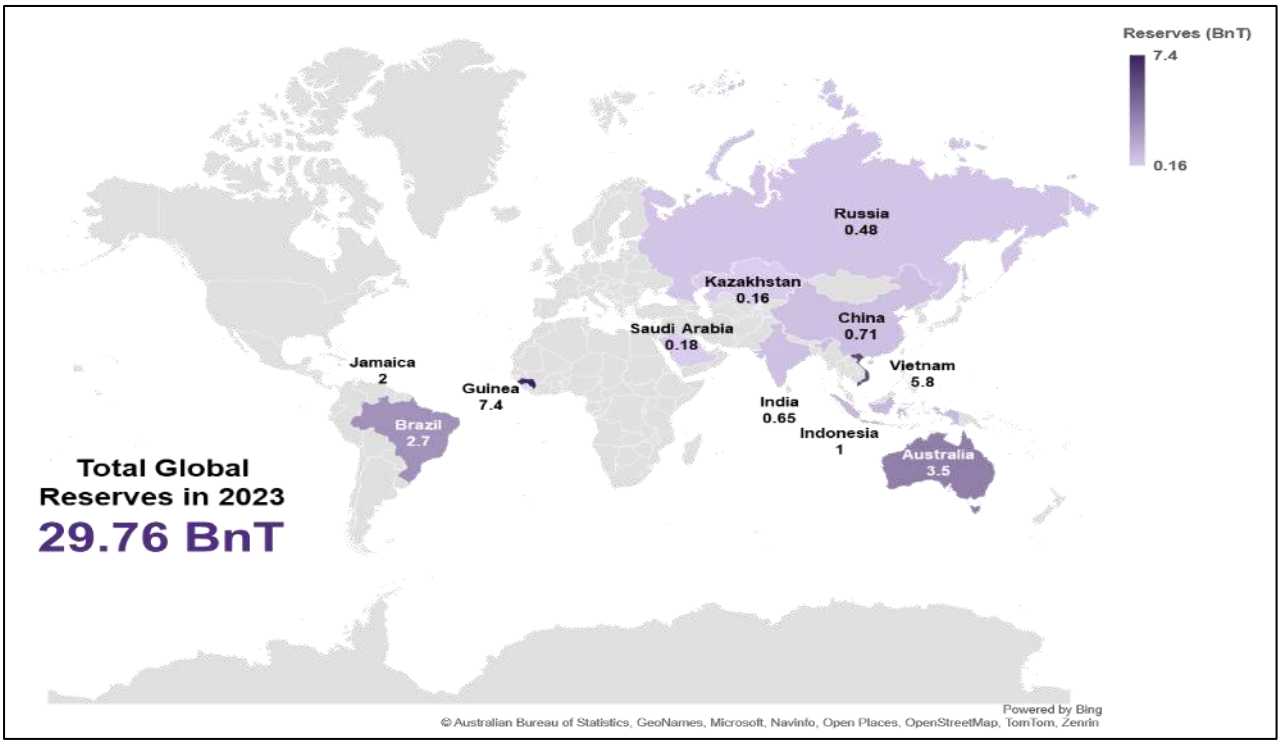

Figure 19: Global Bauxite Reserves Distribution, 2023 (BnT)

[40] Mineral Commodity Series, USGS
[41] International Aluminium Institute, last accessed on 10-Aug-2024
[42] ITC Trademap, last accessed on 10-Aug-2024

Global Bauxite and Alumina Production

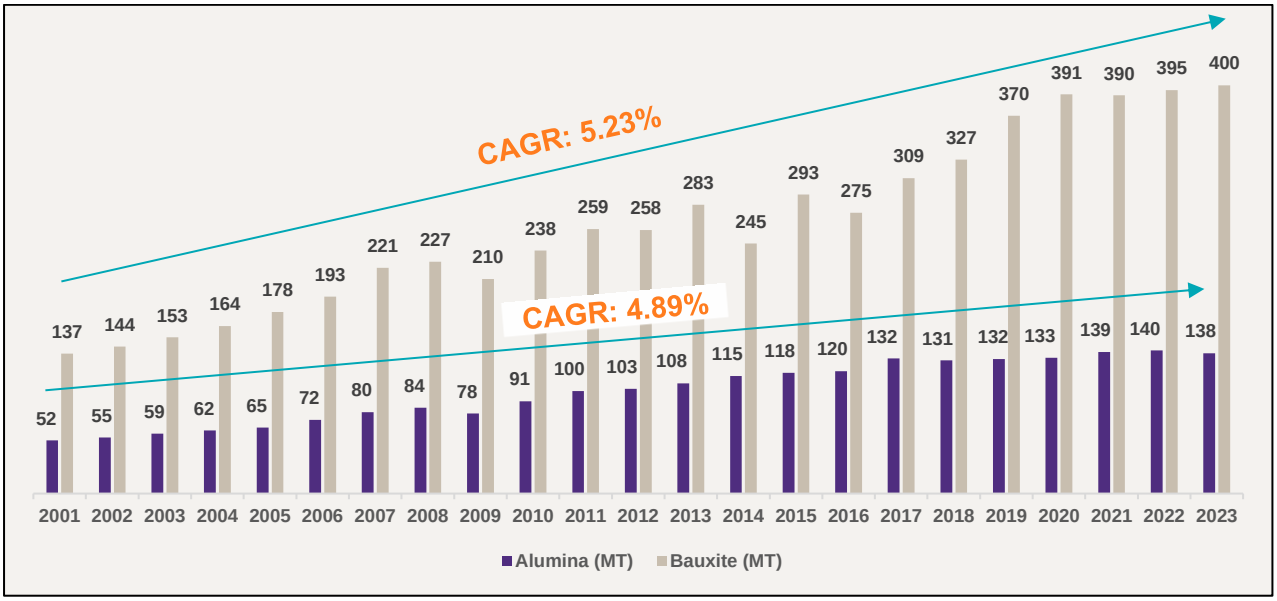

Figure 20: Global Bauxite and Alumina Production, 2001-2023 (MT)

World Bauxite and Alumina production increased at a CAGR of 5.23% and 4.89%, respectively, from 2001 to 2023. In 2023, Australia (98 MT) was the largest Bauxite producer closely followed by Guinea with 97 MT Bauxite production. Over the years, to decrease its dependence on raw materials, China's production of Bauxite and Alumina has grown exponentially and has emerged as one of the largest producers of both Bauxite and Alumina. Despite holding only 2.4% of the global reserves, the country's Bauxite production has increased nearly 9.5 times from 9.8 MT in 2001 to 93 MT in 2023. Also, from having zero Alumina production till 2002, China reached 82 MT of Alumina production in 2023, contributing to 60% of the global Alumina production. Australia, Brazil, and India along with China accounted for 86% of the global Alumina production in 2023. On the other hand, although, production of Bauxite and Alumina from India, Australia and Brazil have increased over the years, their share in global production has either remained constant or decreased.

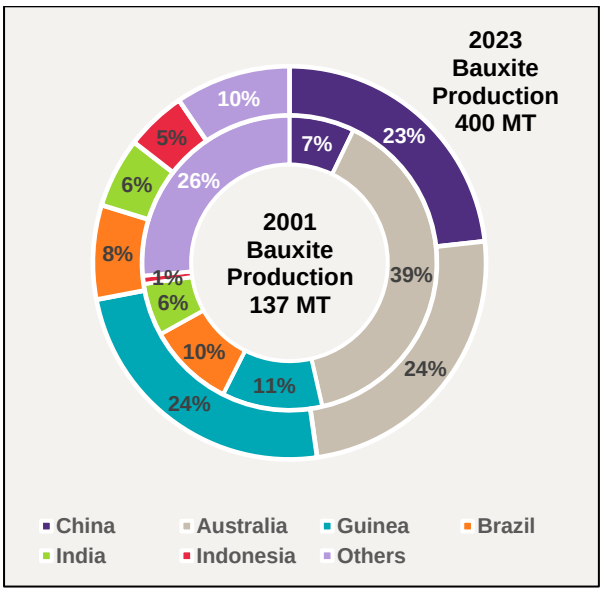

Figure 21: Global Bauxite Production Distribution Change, 2001 and 2023

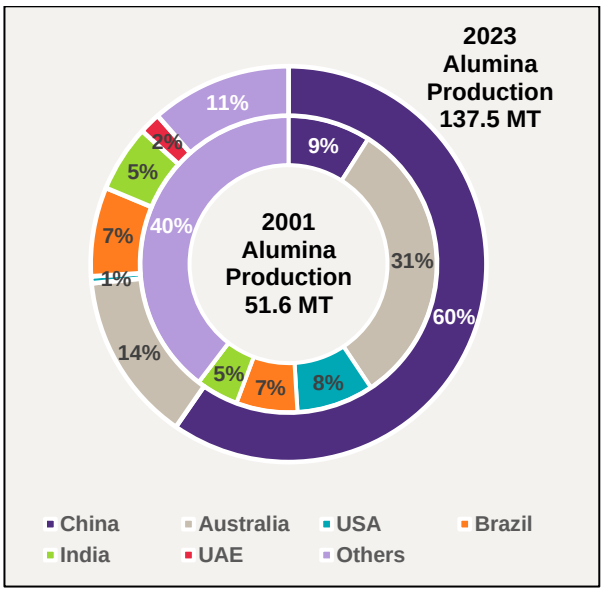

Figure 22: Global Alumina Production Distribution Change, 2001 and 2023

Global Bauxite and Alumina Consumption Trend for Aluminium Production

Global consumption for Bauxite and Alumina for Aluminium production was estimated to be around 372 MT and 141 MT, respectively in 2023. Both Bauxite and Alumina consumption has nearly increased 1.5 times from 2001 levels.

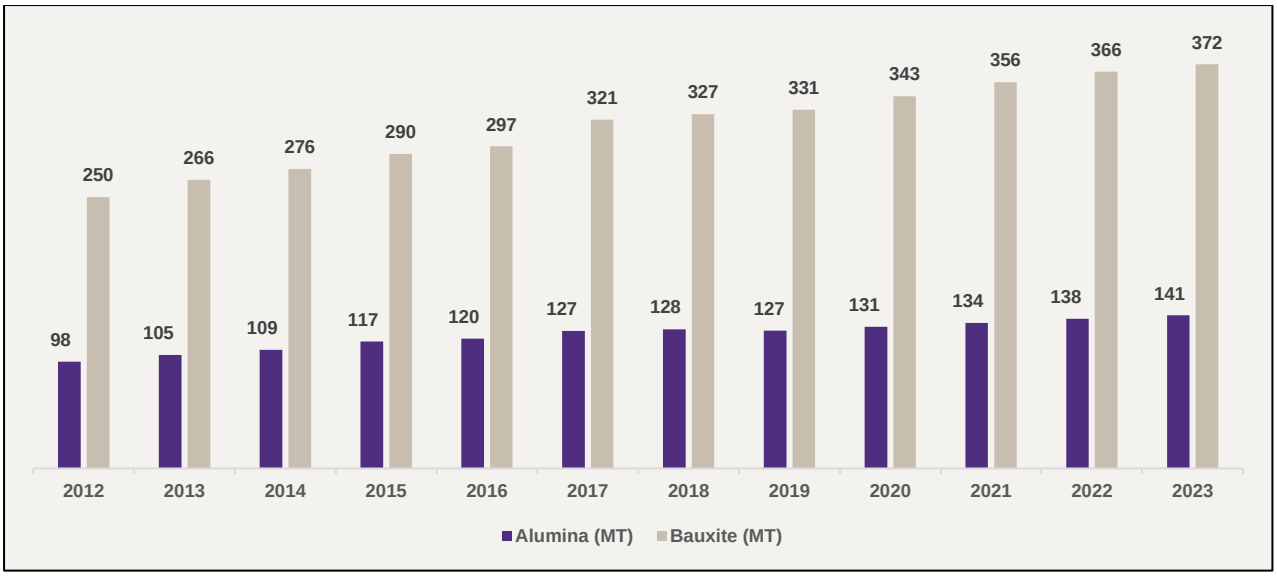

Figure 23: Global Bauxite and Alumina Consumption Trend for Primary Aluminium Production, 2012 - 2023 (MT)

Global Trade Scenario for Bauxite and Alumina

Global Bauxite Trade

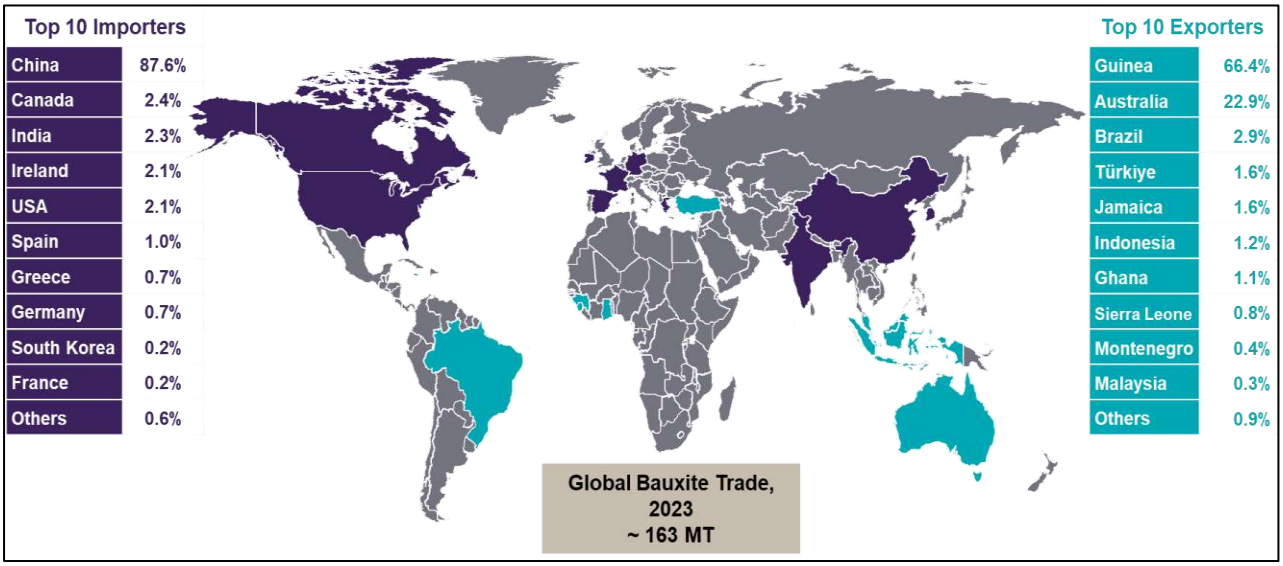

Figure 24: Global Trade of Bauxite by Volume, 2023

In 2023, the top 10 countries accounted for 99.1% and 99.4% of the global Bauxite exports and imports, respectively. Guinea and Australia, being the top producers of Bauxite and due to lower domestic demand for Bauxite, were the top 2 exporters of Bauxite, accounting for nearly 89.3% of total exports. Despite being one of the largest producers of Bauxite, China imported nearly 141.57 MT of Bauxite, accounting for 87.6% of the global Bauxite imports to fulfil the demand of its Alumina refinery. Canada (3.83 MT), India (3.78 MT), Ireland (3.43 MT), and the USA (3.37 MT) are the other nations among the top 5 importers. While the imports of Canada, Ireland, and the USA can be attributed to the lack or low availability of resources, the Bauxite imports of India are mainly attributed to the growing demand for the mineral to support its growing Aluminium consumption and the slow pace of the addition of new Bauxite mining capacities.

Global Alumina Trade

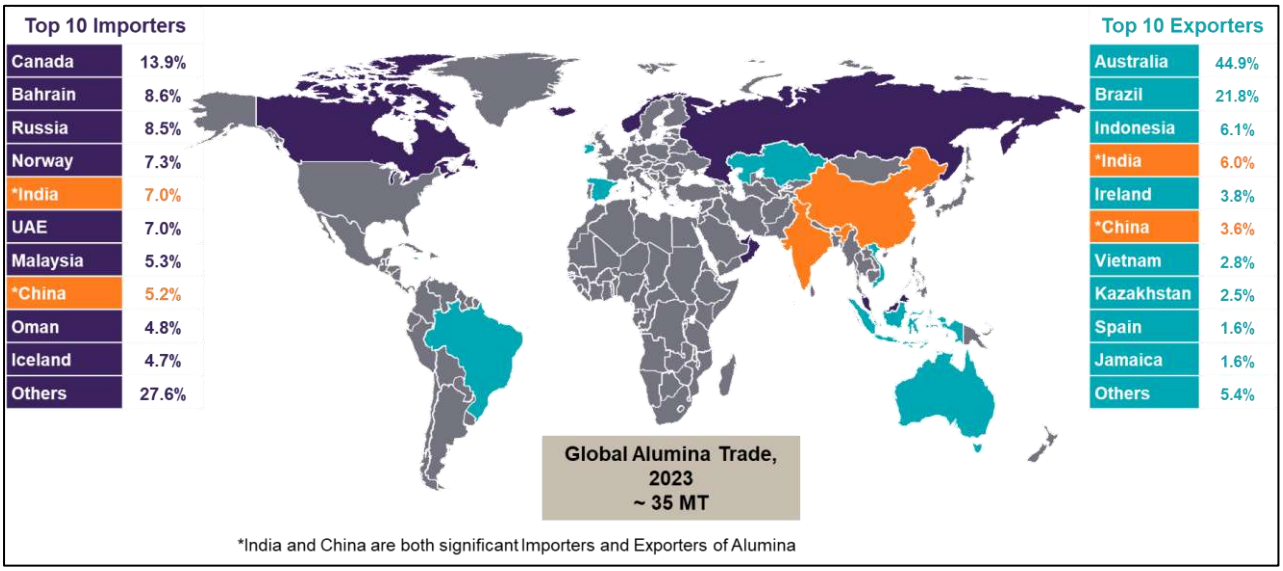

Figure 25: Global Trade of Alumina by Volume, 2023

Global Alumina trade volume was estimated to be ~35 MT in 2023, of which, the top 10 countries accounted for 72.4% and 94.6%, respectively of the total imports and exports. Of the top 10 exporters of Alumina, except Spain and Ireland, all other nations are having abundant Bauxite reserves and are also among the top producers of Bauxite. Both, India and China are among the top 10 importers as well as exporters for Alumina. However, they are net importers of Alumina.

3.3.2 Aluminium Scrap

Considering the fact that nearly one-third of the Aluminium produced globally is secondary Aluminium, Aluminium scraps become an important raw material along with Bauxite and Alumina required. The Aluminium scrap required for secondary Aluminium production is categorized into two types i.e. new scrap and old scrap. New scrap generally refers to the scrap generated within the Aluminium and manufacturing industries. Old scrap originates from the end-of-life final products like beverage cans, cars, demolished buildings, old electrical cabling etc.

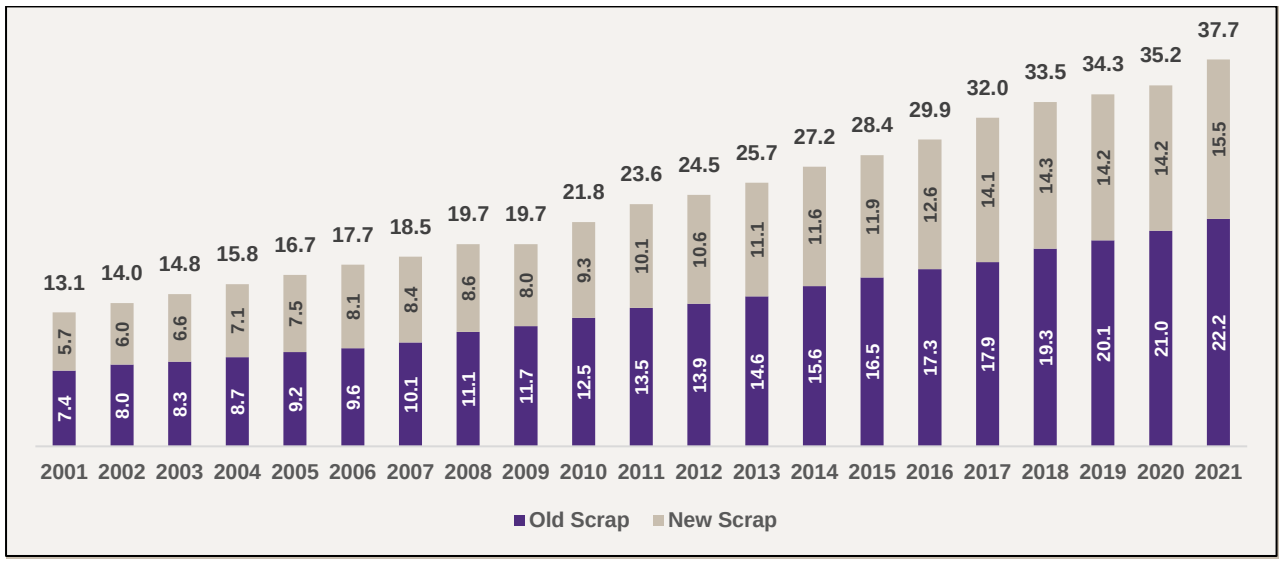

Figure 26: Global Old and New Scrap Generation Trend, 2001-2021 (MT)

The world generated 37.7 MT of Aluminium scrap in 2021 up 2.9 times from 2001. In 2021, China was the largest Aluminium scrap generator, having 33% share in the globally generated scrap, followed by North America (21%) and Europe (18%).

Global Aluminium Scrap Trade

Globally, more than 12 MT of Aluminium scrap was traded in 2023. The top 10 countries together accounted for 68.8% and 58.7% of the total scrap imports and exports, respectively. India and China were the top 2 importers of Aluminium scrap in 2023 with nearly 1.83 MT and 1.75 MT scrap imports, respectively. While India's large imports of Aluminium scrap can be attributed to the low availability of domestic scrap, China's high imports of scrap are mainly due to the high consumption of the metal in the country. Other countries like South Korea and Italy mostly depend on recycled Aluminium for meeting their Aluminium demand. USA was the largest exporter of Aluminium scrap, followed by Germany and Canada, demonstrating the maturity of the established recycling industry in these countries.

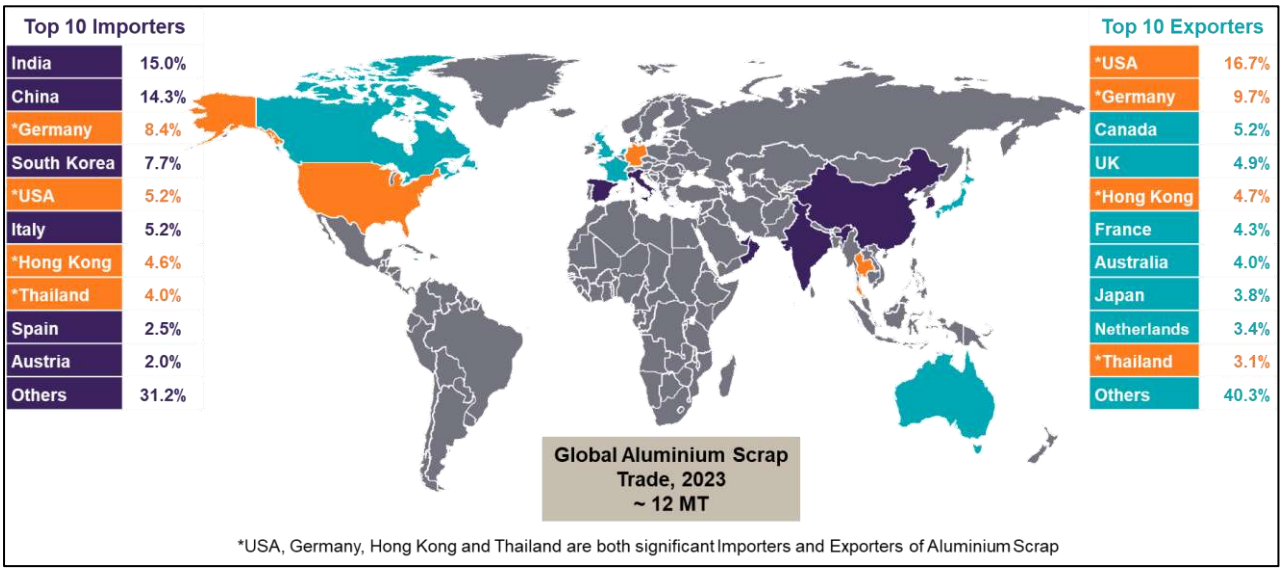

Figure 27: Global Trade of Aluminium Scrap by Volume, 2023

More than 80% of the global Bauxite reserves, over 96% of Bauxite production, and more than 94% of Alumina production are concentrated in the top 10 countries, giving them substantial control over the supply of essential raw materials for primary Aluminium production, potentially influencing prices and availability. Additionally, considering the need for secondary Aluminium production for the greater good, the Aluminium scrap industry needs to be strengthened outside China, North America, and Europe.

3.4 Downstream Products

Whether in the US or countries like India, relying solely on primary Aluminium manufacturing is becoming increasingly challenging. Consequently, companies are shifting their focus to value addition and downstream manufacturing to capitalize on the rising Aluminium demand.

The downstream segment of the Aluminium industry involves processing Aluminium into semi-finished goods such as extrusions, rolled products, foils, castings, wire rods etc. These products can be made from primary Aluminium, secondary (recycled) Aluminium, or a combination of both, depending on the specifications of the final product.

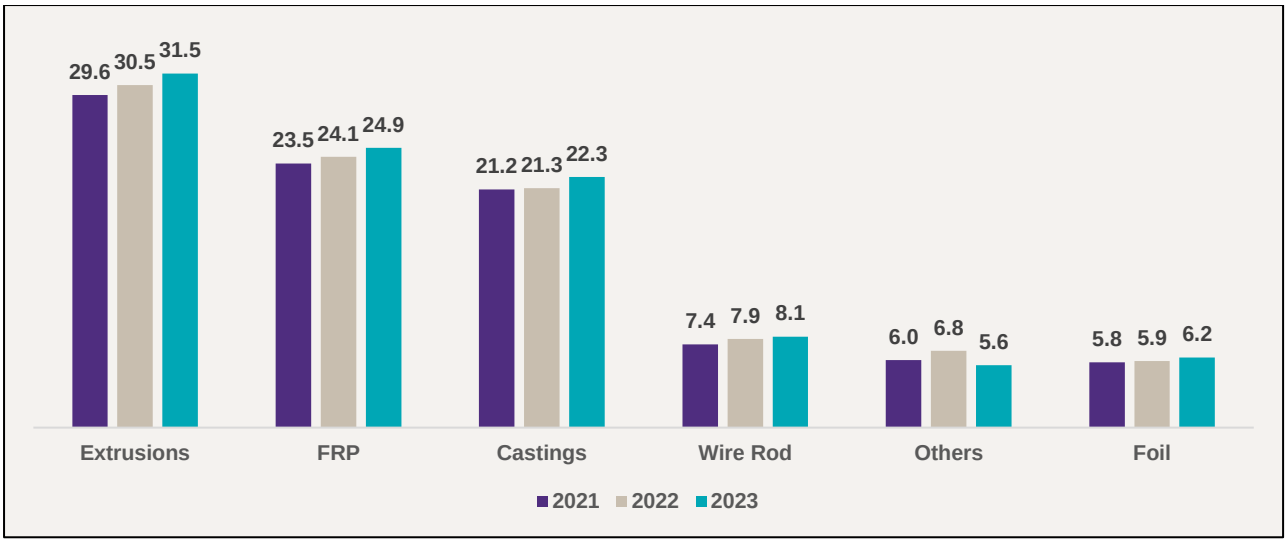

Figure 28: Global Aluminium Downstream Products Consumption (MT)

Globally, Aluminium extrusions are the most consumed downstream product, constituting nearly 32% of the global downstream products consumption, followed by (flat rolled products) FRP (25%), Castings (22%), wire rods (8%) and foils (6%). While, Aluminium castings are predominantly used in the transportation sector, FRP and foils are mostly used in the packaging industry. Extrusions find their major application in the building and construction sector and wire rod is almost used entirely in the electrical sector.

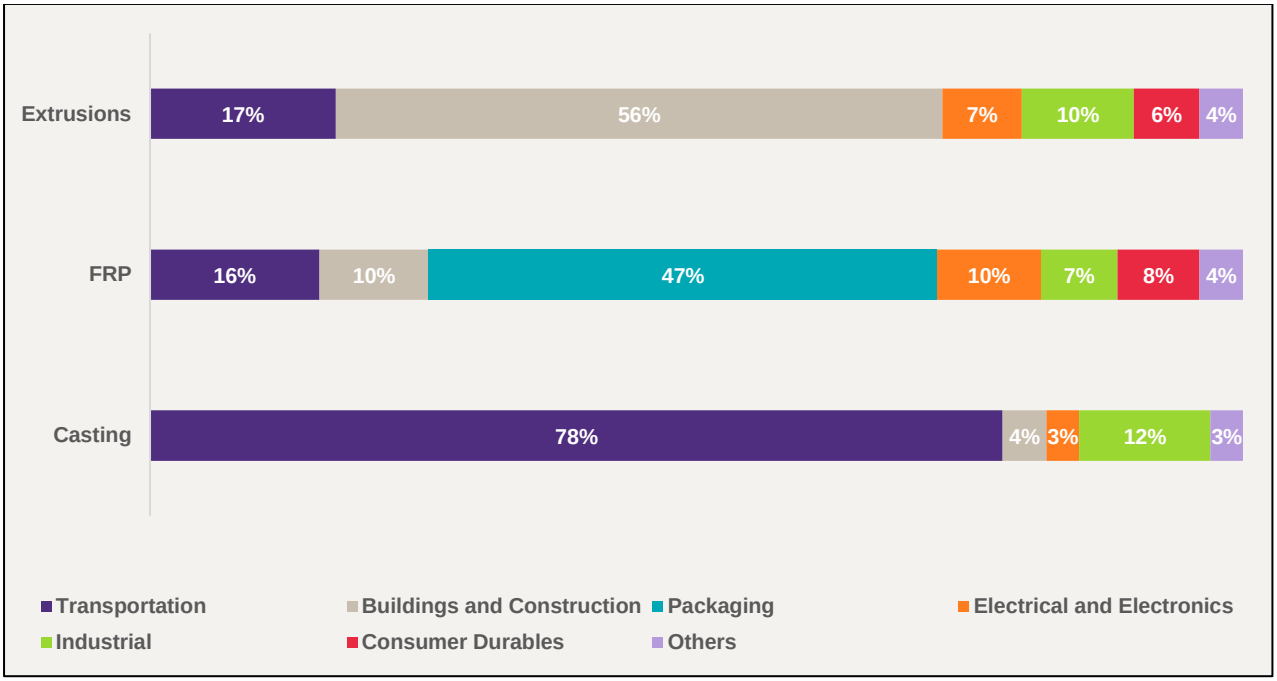

Figure 29: Sector wise Consumption of Aluminium Downstream Products, 2023[43]

Global Aluminium Downstream Products Trade (HS Code: 7603 to 7616)[44]

In 2023, the global trade of Aluminium downstream products stood close to 27 MT. China's dominance in the downstream sector is demonstrated with 30.3% share in the global Aluminium downstream products exports. USA and European countries like Germany, France, Italy and Netherlands were both the importers and exporters of downstream products. While USA, France and Netherlands were net importers, Germany and Italy were net exporters of the downstream products.

[43] Aluminium Industry Outlook 2024, Al Circle
[44] ITC Trademap, last accessed on 10-Aug-2024

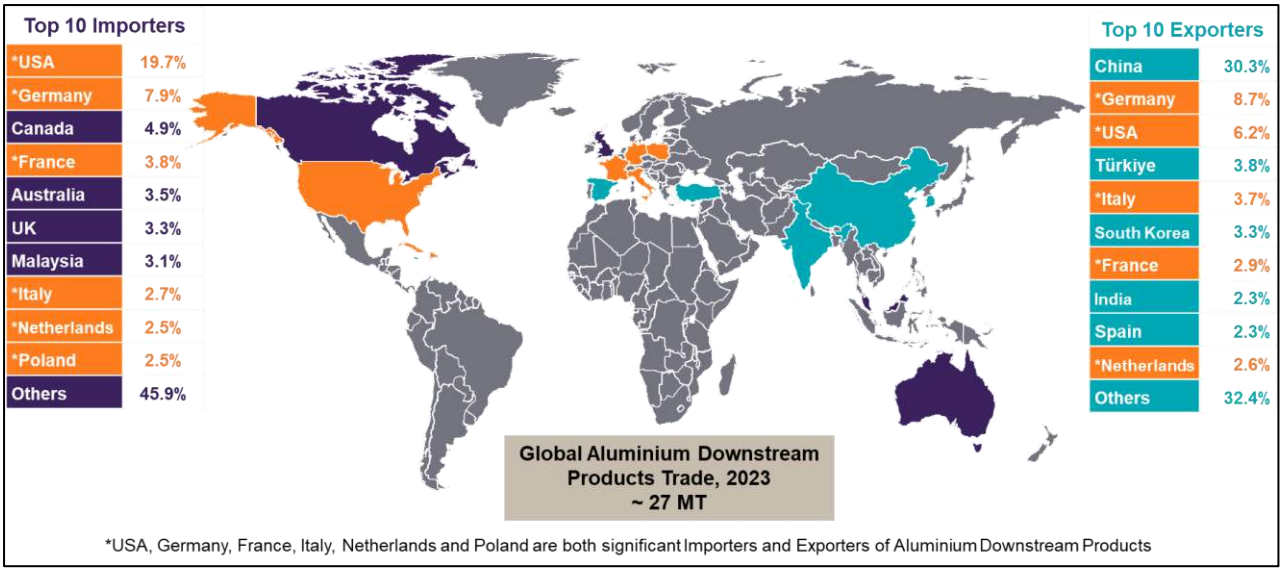

Figure 30: Global Trade of Aluminium Downstream Products by Volume, 2023

Aluminium Alloys[45]

Certain specialised applications of Aluminium necessitate alloying to attain the specific product characteristics needed for use in those industries. In the Aluminium industry, the 1xxx, 2xxx, 3xxx, 4xxx, 5xxx, 6xxx, 7xxx, and 8xxx series represent different categories of Aluminium alloys, each with unique properties and applications. These series are part of a classification system created by the Aluminium Association, which organizes Aluminium alloys based on their primary alloying elements.

Aluminium Alloy	Main Alloying Element	Characteristics	Applications
1xxx	Minimum 99% Aluminium content	High corrosion resistance, excellent workability, and high thermal and electrical conductivity	Packaging, Building product, Electrical conductors, chemical equipment, and food processing
2xxx	Copper	High strength, good machinability, but lower corrosion resistance	Aerospace, Defence, Space and high-performance applications
3xxx	Manganese	Good corrosion resistance, moderate strength, and good workability	Beverage can, Building product
4xxx	Silicon	Lower melting point, good wear resistance, and good fluidity	Castings, Cladding on brazen sheet, Welding wire, brazing alloys, and automotive components
5xxx	Magnesium	High strength, good corrosion resistance, and good weldability	Marine, pressure vessels (LNG carrier) and automotive parts.

[45] Material Properties I.pptx (uc.edu)

Aluminium Alloy	Main Alloying Element	Characteristics	Applications
6xxx	Magnesium and Silicon	High strength, good corrosion resistance, and good weldability	Structural applications, architectural components, and auto structural sheet
7xxx	Zinc	Very high strength, good fatigue resistance, but lower corrosion resistance	General Engineering, Aerospace, sporting equipment, and high-stress components
8xxx	Others	Varies widely depending on the specific alloying elements used	Auto body sheet, Specialized applications like lithium-containing alloys for aerospace

Top Downstream and Value-Added Products Manufacturers[46]

Novelis

Novelis, a subsidiary of Hindalco Industries Limited, is a global leader in the Aluminium rolling and recycling sector. It is a premier provider of sustainable Aluminium solutions for the aerospace, automotive, beverage packaging, and high-end specialty products markets. Novelis is also the largest single producer of Aluminium flat-rolled products for the beverage can and automotive industries worldwide. Novelis' shipped 3.67 MT FRP shipments to its customers around the world in FY24.

Hindalco's Novelis completed the acquisition of Aleris, global leader in Aluminium rolled products and specialty alloys supplying to diverse industries including aerospace, automotive, building and construction, commercial transportation and industrial manufacturing, in April 2020.

Hydro Norsk

Hydro Extrusions is the global leader in Aluminium extrusion-based solutions, boasting 71 production sites across 40 countries. This extensive reach is supported by a blend of local expertise, a robust global network, and cutting-edge research and development capabilities. Hydro has an annual extrusion capacity of 1.3 MTPA and in 2023, the company achieved 1.1 MT of extrusion products sales. This performance secured a market share of 17% in Europe and 20% in North America, while also maintaining strong positions in South America and Asia.

Zhongwang Holdings Limited

China Zhongwang Holdings Limited, along with its subsidiaries, is one of the largest developer and manufacturer of industrial Aluminium extrusion products. The Group primarily focuses on lightweight development in the transportation, machinery and equipment, and electric power engineering sectors by providing high-quality processed Aluminium products.

Constellium

Constellium, a global leader in Aluminium transformation, designs and manufactures innovative, high value-added Aluminium products and components. These are primarily tailored for the aerospace, automotive, and packaging markets.

Constellium developed advanced alloys for the aerospace market, Airware®, which first ventured into space in 1998, was used for cryogenic components of the space shuttle's external tank. Airware® 2195 offered enhanced damage tolerance and corrosion resistance and substantially increasing its payload capacity. Its diverse range of products also include 3xxx, 5xxx, and 6xxx Aluminium sheet solutions for battery enclosures,

[46] Companies Websites, Annual Reports and Investor Presentations, last accessed on 10-Aug-2024

including the cladded cooling plates that help maintain batteries in their optimal temperature range. The company shipped 1.49 MT downstream and value-added products in 2023.

Arconic

Arconic provides a diverse range of highly differentiated Aluminium sheets, plates, and extruded products for the aerospace, automotive, commercial transportation, brazing, and industrial markets. They are also a key supplier to the building and construction sector, offering innovative products and systems that assist architects, builders, and project teams in realizing their vision for modern, beautiful, and high-performing buildings. Arconic is also a market leader in Aluminium-lithium extrusions, holding a prominent role in the production of components for the Airbus A380, Airbus A350, and Gulfstream G650.

Kaiser Aluminium

Kaiser Aluminium is a leading producer of fabricated Aluminium products for aerospace, high-strength, general engineering, automotive, and custom industrial applications. Their extensive Aluminium product range includes plates, sheets, extrusions, rods, bars, tubes, forge stock, and wire. Their diversified portfolio features Aluminium alloys from the 1xxx to 7xxx series. In total, they shipped over 0.5 MT of downstream and value-added products to customers across various sectors.

3.5 Demand Analysis: Growth Drivers and Consumption Pattern across Downstream Product Segment, Key Sectors and Regions

Aluminium ranks 2nd in terms of metal consumption worldwide. However, the demand for Aluminium is 1/18th that of steel. Although the consumption of Aluminium is way behind that of steel, it still is way ahead of other metals in consumption.

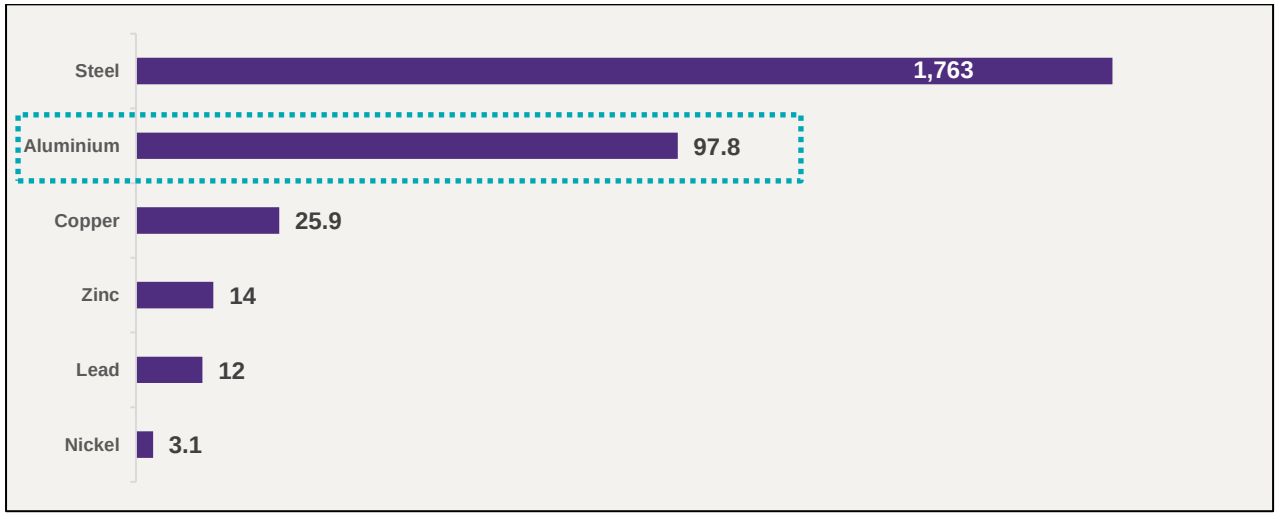

Figure 31: Global Metal Consumption, 2023 (MT)[47,48,49,50]

Globally, Aluminium consumption has grown at a CAGR of 4.3% from 46 MT in 2005 to 98 MT in 2023. In 2023, primary and secondary Aluminium contributed to 71% and 29% of the global demand, respectively.

Aluminium Growth drivers in the Current World

The ubiquity of Aluminium makes it an essential commodity for almost all the sectors. The global consumption of Aluminium has seen a significant rise across various sectors. Leading this growth is the automotive sector, where technological advancements, including the development of electric and lightweight vehicles, have

[47] https://worldsteel.org/media/press-releases/2024/world-steel-in-figures-2024-now-available/
[48] Al Circle
[49] https://www.iea.org/data-and-statistics/data-tools/critical-minerals-data-explorer
[50] Industry Sources

driven a substantial increase in Aluminium demand. The increased focus on sustainability is driving the demand growth for Aluminium across various sectors. Some key factors contributing to this trend are:

- **Recyclability:** In recent years, propelled by environmental concerns, rising demand, and technological advancements, the secondary Aluminium market is gaining traction. Its sustainability, requiring just 5% of the energy needed to produce virgin Aluminium, positions it as a key player in combating climate change. This, combined with growing demand in sectors like transportation, construction, and packaging, creates a positive feedback loop. Investments in enhanced sorting and processing technologies broaden its applicability, making recycled Aluminium increasingly appealing. Supportive government policies and heightened consumer awareness further accelerate this trend, while cost-effectiveness in certain cases adds to its allure. These factors collectively boost collection rates, diversify applications, and promote tighter circular economy models. With ongoing research and development, the future of secondary Aluminium looks promising, heralding a more sustainable and resource-efficient global economy[51].
- **Decarbonization:** Many industries are moving towards low-carbon solutions, and Aluminium production is increasingly using renewable energy sources like hydroelectric power to reduce greenhouse gas emissions. Technological advancements are making Aluminium production more energy efficient. Innovations such as inert anode technology are being developed to further cut emissions during the smelting process. Some Aluminium producers are also exploring carbon capture and storage (CCS) technologies to safely capture and store CO2 emissions from the production process. Supportive government policies and regulations are driving the shift towards low-carbon Aluminium production, with incentives, subsidies, and carbon pricing mechanisms encouraging the adoption of renewable energy sources. This transition aligns with the global decarbonization goals of both producers and consumers. By adopting these low-carbon solutions, the Aluminium industry is making significant progress towards a more sustainable and environmentally friendly future, benefiting both producers and consumers and contributing to the global fight against climate change.
- **Transportation:** Aluminium is widely used in the automotive industry to reduce vehicle weight. Lighter vehicles consume less energy, resulting in better fuel efficiency and lower emissions. The increasing production of electric vehicles has further driven the demand for Aluminium. Lightweight materials like Aluminium are crucial for enhancing the energy efficiency of EVs, extending battery life, and increasing the vehicle's range per charge. In the aerospace sector, Aluminium is prized for its high strength-to-weight ratio, essential for building strong yet lightweight aircraft, which improves performance and fuel efficiency. The development of advanced Aluminium alloys has further improved the material's properties, making it even more suitable for transportation. These alloys offer enhanced strength, durability, and corrosion resistance. All these factors contribute to a shift towards using Aluminium, benefiting both the environment and the economy.
- **Renewable Energy:** Aluminium is crucial in the renewable energy sector due to its lightweight and durable properties. It is extensively used in solar panels for structural support and reflective surfaces, enhancing efficiency. In wind turbines, Aluminium is used in components like nacelles and rotor blades, reducing weight and improving performance. Its corrosion resistance is vital for offshore installations. Aluminium's excellent conductivity and cost-effectiveness make it ideal for electrical transmission lines, essential for expanding renewable energy generation. Its recyclability supports sustainability and the circular economy. The growing demand for renewable energy drives the need for Aluminium, with ongoing innovations further enhancing its role in this sector, benefiting both the environment and the economy.
- **Sustainable Packaging:** The packaging industry is increasingly adopting more sustainable solutions. Aluminium is at the forefront of the packaging industry's shift towards sustainability due to its infinite recyclability. Its excellent barrier properties and durability help maintain product quality and reduce waste. Widely used in beverage cans for its lightweight and recyclable nature, Aluminium is also favored in food packaging for its versatility and safety. Growing consumer demand for sustainable solutions and

[51] AI Circle

regulatory pressures are driving its adoption. Economically, Aluminium's recyclability and durability offer long-term cost savings and enhance brand image, making it an ideal choice for sustainable packaging.

- **Construction:** The construction sector is increasingly adopting sustainable practices, with Aluminium playing a pivotal role due to its strength, durability, and corrosion resistance. Widely used in structural components like beams and frames, Aluminium ensures long-lasting structures, reducing the need for frequent repairs. Its natural resistance to corrosion makes it ideal for harsh weather conditions, lowering maintenance costs and environmental impact. Rapid urbanization and infrastructure development in Asia, especially in China and India, are driving Aluminium demand for skyscrapers, bridges, and public transport. Aluminium's recyclability and energy efficiency support sustainable urban environments, while its design flexibility and energy efficiency make it a favorite for eco-friendly buildings. The use of recycled Aluminium contributes to green building certifications and economic benefits, including job creation in production and recycling industries.

Product wise Aluminium Consumption Trend[52] [53]

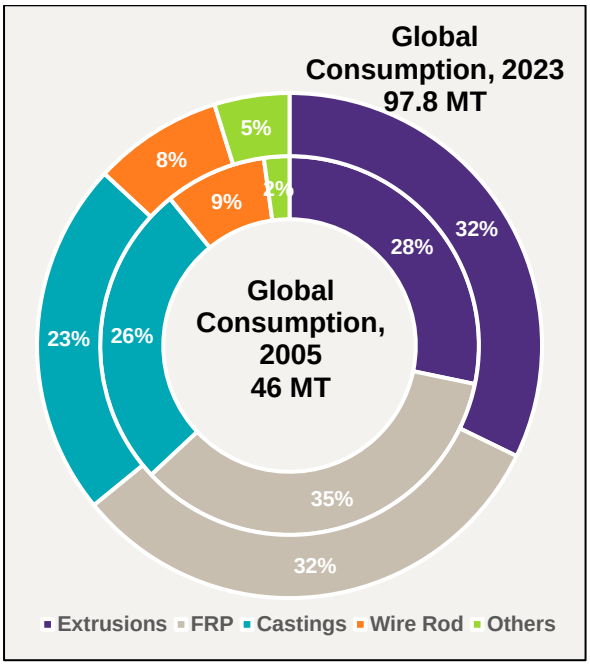

Figure 32: Product wise Aluminium Consumption (MT)

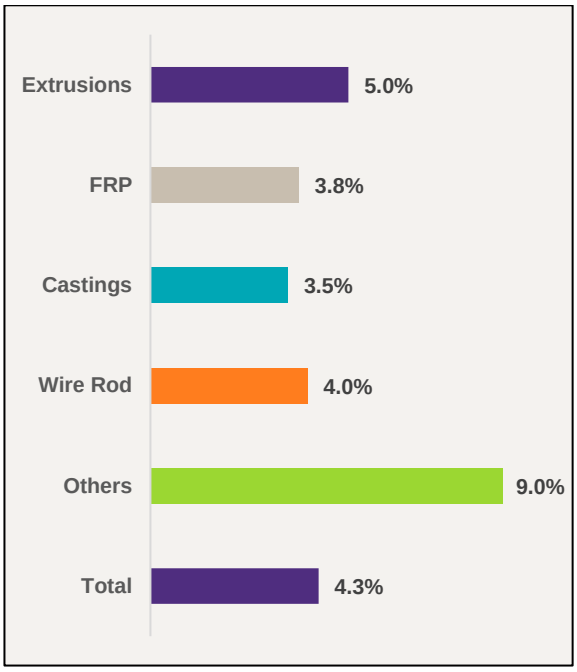

Figure 33: Product wise Aluminium Consumption Growth CAGR (2005 – 2023), (%)

Global consumption is dominated by rolled products, extrusions and casting which together account for ~87% of the total demand in 2023. From 2005 to 2023, overall Aluminium consumption grew at a CAGR of 4.3%. Extrusions registered the fastest growth (5% CAGR), followed by wire rod, castings and FRP.

[52] Industry sources
[53] Aluminium Industry Outlook, Al Circle

Sector wise Aluminium Consumption[54]

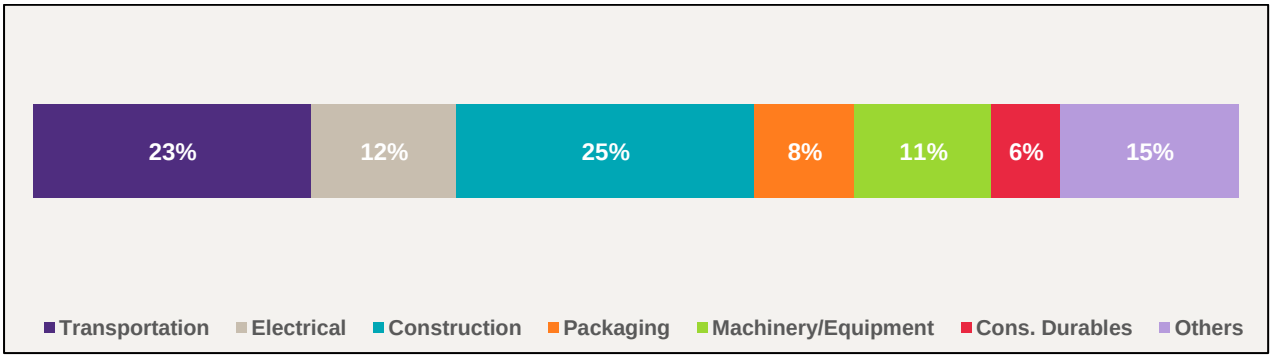

Figure 34: Sectoral share of Global Aluminium demand (2020)

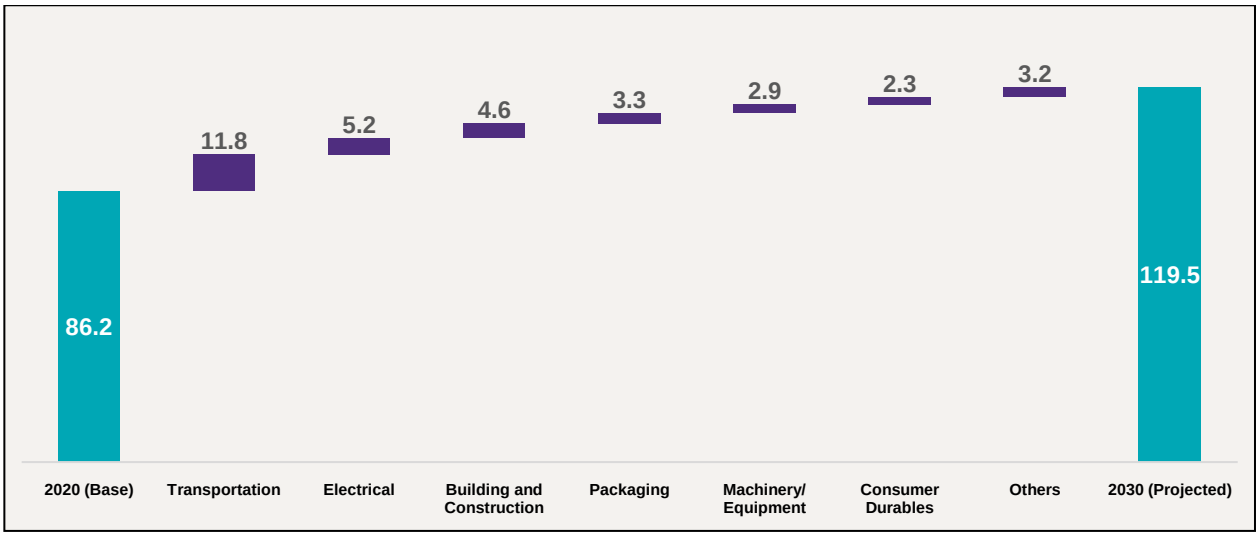

Figure 35: Sector wise Consumption forecast on Aluminium (2020 vs 2030)

Decarbonization policies and the shift towards sustainability are set to significantly impact Aluminium demand. The rise of renewable energy, electric vehicles (EVs), and sustainable solutions in packaging and construction will create major opportunities for the Aluminium industry. Aluminium consumption is projected to increase from 86.2 MT in 2020 to 119.5 MT by 2030, a growth of 33.3 MT.

Approximately 75% of this demand growth will come from the transportation (35%), electrical (16%), construction (14%), and packaging (10%) sectors. The transportation sector will see increased Aluminium demand due to the shift towards EVs. The electrical sector will drive demand through the expansion of renewable energy and power grids. Although the construction sector's move towards sustainability has had limited success, it still contributes to Aluminium demand. The packaging sector will benefit from Aluminium's high recyclability and the growing popularity of circular economy policies.

Demand Scenario across major Aluminium Consuming Regions

China

China has been the largest consumer of Aluminium for over a decade. It accounts for more than half of the global demand. The broad range of end-use applications positions Aluminium demand favorably for future growth. By 2030, China's Aluminium demand is projected to increase by ~12 MT from 2020 levels. A significant portion of this growth, over one-third, is expected to come from the transportation sector, driven by the rapid adoption of electric vehicles (EVs). In the electrical sector, the expansion of renewable energy installations in remote areas and the subsequent power transmission projects will contribute to more than one-fifth of the increased Aluminium demand. The shift away from physical infrastructure and heavy industry is anticipated to result in slower growth in Aluminium demand from the construction and machinery &

[54] Opportunities for Aluminium in a post-Covid economy, CRU, 2022

equipment sectors. Although packaging will remain the smallest end-use sector in China, it is expected to experience the fastest relative growth among all sectors, primarily due to the shift from glass to canned beers.

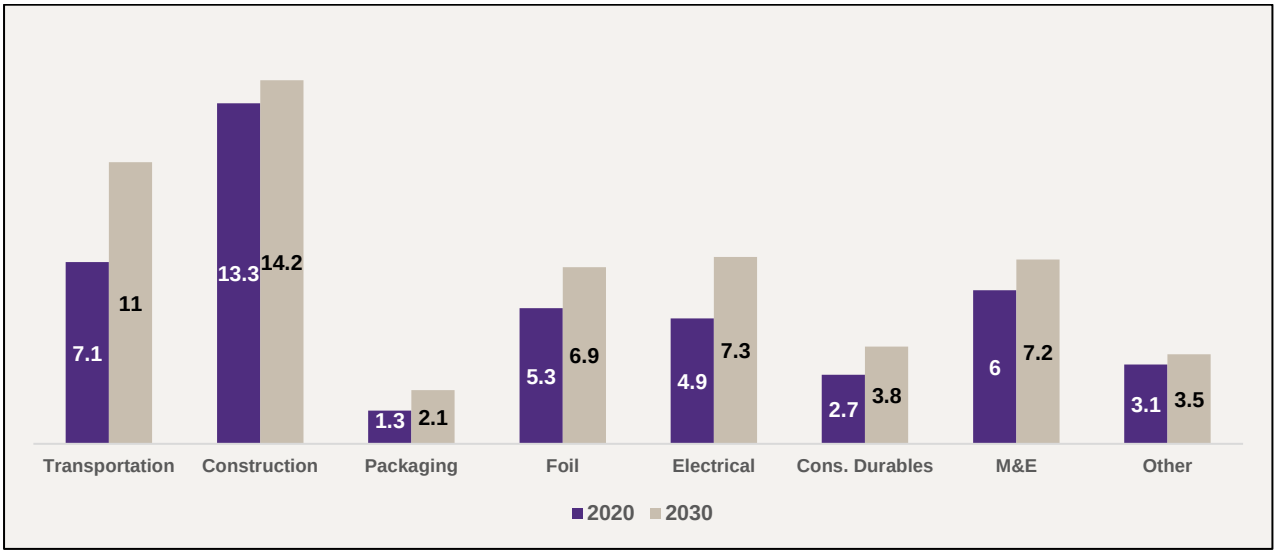

Figure 36: China's Aluminium Demand, Million Tonnes, 2020 Vs 2030

Asia ex-China

India, Japan, South Korea and Middle Eastern countries like Bahrain are key consumers of Aluminium in the region and are anticipated to drive Aluminium demand growth. The region is projected to have the fastest growth in Aluminium consumption, growing at 4.8% CAGR from 2020 to 2030. This growth in demand will primarily be driven by the transportation, construction, and electrical sectors, which together are expected to account for nearly 70% of the region's consumption growth over the next decade. In India, the increase in Aluminium demand will be largely fueled by population growth, urbanization trends, government focus on infrastructure development, the transition to renewable energy sources, and the adoption of electric vehicles (EVs). In Japan and South Korea, the rise in Aluminium consumption will be significant due to the country's auto manufacturing industry, which are among the top 5 auto manufacturers. In the Middle East, the growth in Aluminium demand will mainly be driven by the construction sector and efforts to develop the downstream Aluminium sector.

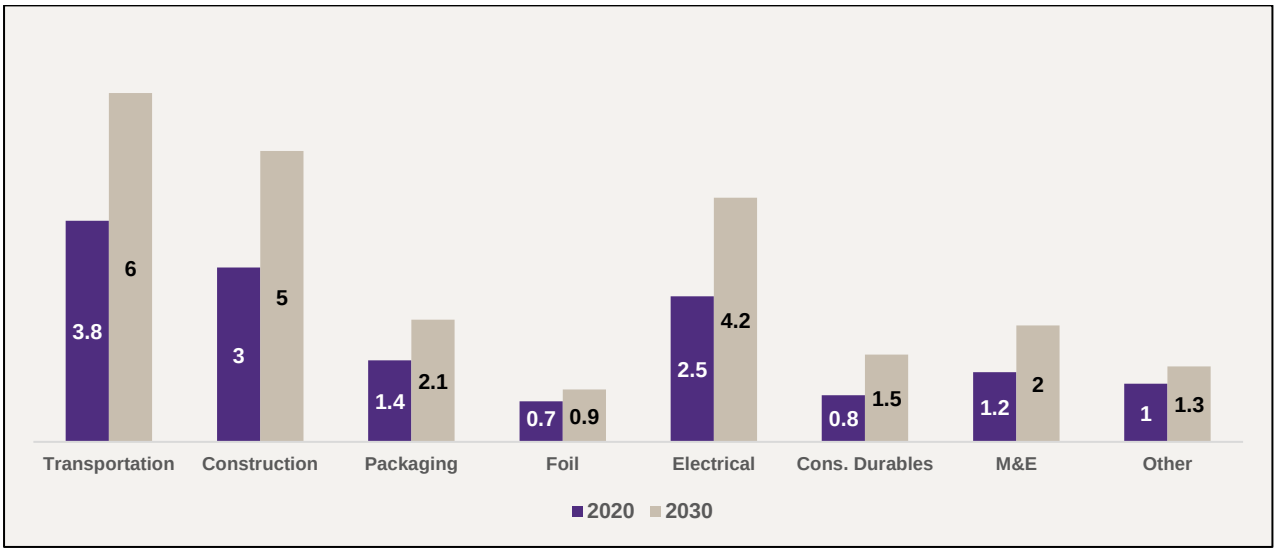

Figure 37: Asia ex-China's Aluminium Demand, Million Tonnes, 2020 Vs 2030

Europe

European countries like Germany, France, Spain, and Italy are major centers for Aluminium consumption in the region. The high demand for Aluminium is primarily due to the developed automobile sector, which accounted for 33% of the region's total demand in 2020. The transportation sector is expected to remain the

main driver of Aluminium demand, with its share increasing to 37% by 2030. Aluminium demand from the automobile and electrical sectors will be bolstered by the EU's climate strategy, which aims for nearly one-third of energy to come from renewables by 2030 and net-zero greenhouse gas emissions by 2050. Policies like the European Green Deal is expected to encourage a shift from high-carbon to low-carbon Aluminium consumption but will not significantly impact Aluminium demand in the region.

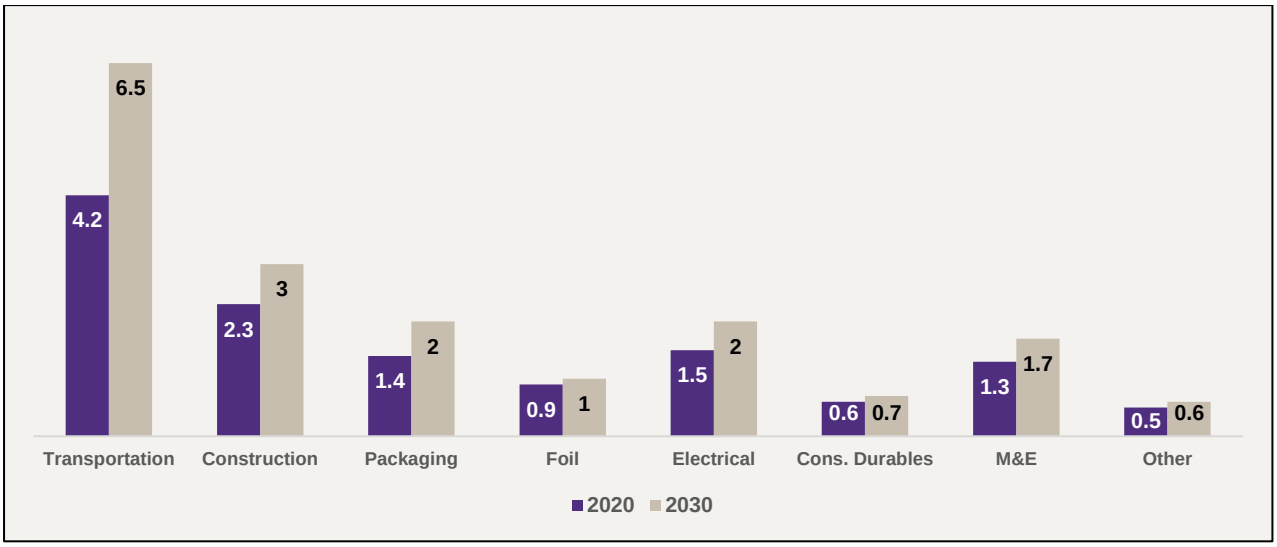

Figure 38: Europe's Aluminium Demand, Million Tonnes, 2020 Vs 2030

North America

Similar to Europe, North America's transportation sector accounted for the largest share of Aluminium consumption in 2020, representing 37% of the region's demand. Due to its consumer-driven economy, North America is unique among developed regions in that the Aluminium demand from the Packaging sector is more than the Construction sector. The region's Aluminium demand is projected to reach 16.6 MT by 2030, from 11.5 MT consumed in 2020. Similar to Europe, 49% of this growth is expected to come from the Transportation sector alone, as the region becomes a key EV production market.

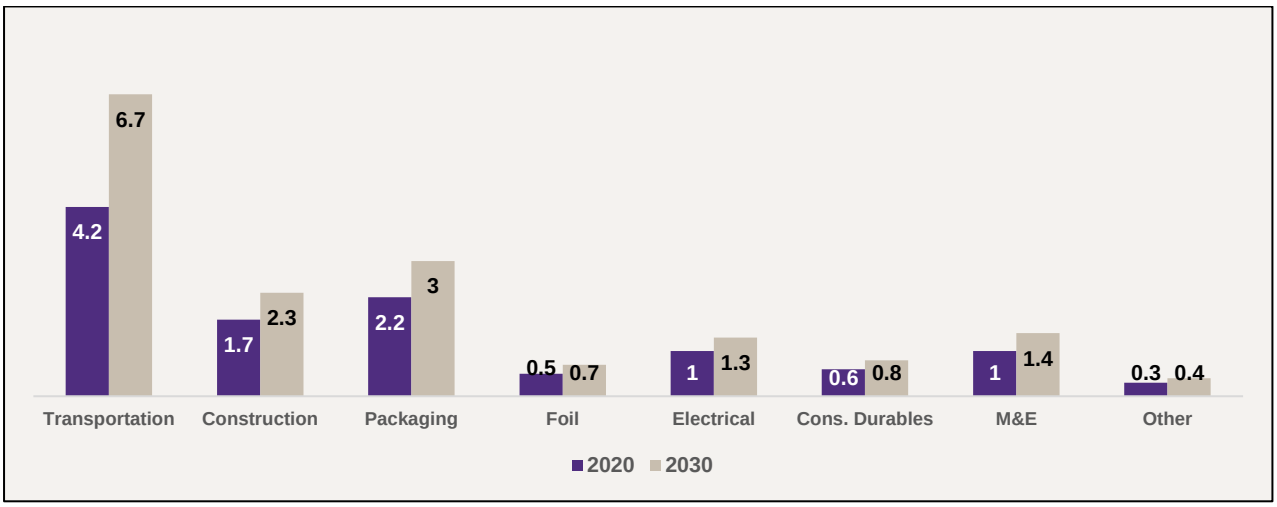

Figure 39: North America's Aluminium Demand, Million Tonnes, 2020 Vs 2030

Overall, the global Aluminium demand is expected to grow in both short-term and long-term owing to the global focus on climate change and Aluminium's significant role in achieving net-zero.

4. Aluminium and India

4 Aluminium and India

The Indian Aluminium industry is advancing rapidly, expanding in both primary and secondary metal production and downstream sectors. With ongoing economic growth, the demand of Aluminium is expected to rise significantly. The downstream processing industry in India is poised for remarkable progress in the coming years, driven by the growth in Aluminium consumption through value-added products. Aluminium consumption in India has increased from 3.20 MT in FY16 to 4.95 MT in FY24. However, per capita Aluminium consumption in India remains at 3.5 Kg (FY24), compared to the global average of 12 kg and 28 kg in China[31].

There is substantial potential for increasing Aluminium consumption due to government initiatives such as Make in India, Smart Cities, Housing for All, rural electrification, freight corridors, bullet trains, power to every household, energy-efficient/electric automobiles, Aluminium wagons, and more. Aluminium is set to play a crucial role in India's industrial development, serving as a fundamental input for various industries and as a strategic metal.

In everyday life, Aluminium is found in numerous applications, from household utensils to space vehicles. Modern engineering demands materials that are lightweight, strong, corrosion-resistant, and aesthetically pleasing. Aluminium, with its unique properties, meets these requirements, making it an ideal choice for many applications. It can be alloyed with copper, magnesium, zinc, silicon, manganese, and more to create various cast, rolled, extruded, forged, and drawn products.

4.1 Current Scenario on Aluminium Demand, Production, Export and Import

Production[55]

India's Aluminium industry is experiencing an upward trajectory, positioning the country as the world's second-largest primary producer and third-largest consumer of Aluminium[56]. Domestic primary Aluminium production has grown at a CAGR of ~7% from FY16 onwards till FY24. Meanwhile, total domestic consumption of Aluminium has been growing at a CAGR of ~5.6% from FY16 to FY24[57] with primary Aluminium demand growing at a CAGR of just ~2%.

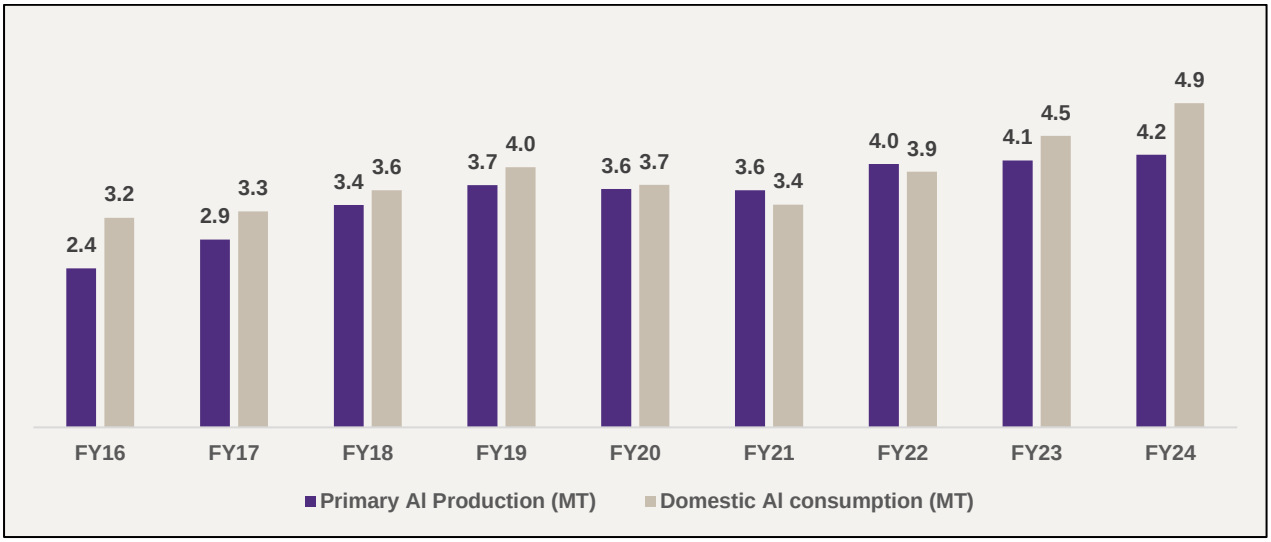

Figure 40: India's production of primary Aluminium and consumption of Aluminium (MT)

On the other hand, the demand for secondary Aluminium has surpassed the growth rate of primary Aluminium, achieving a CAGR of ~10.7%, rising from 0.85 MT in FY16 to 1.73 MT in FY23. The better cost economics and environmental advantages of secondary Aluminium have enabled it to secure nearly 39% of

[55] Indian Minerals Yearbook 2022, Indian Bureau of Mines
[56] India: Aluminium sector surging in India, but hampered by labour shortages: Hindalco exec - The Economic Times (indiatimes.com)
[57] Industry Sources

the domestic Aluminium market, marking a 12% increase from FY16 levels.

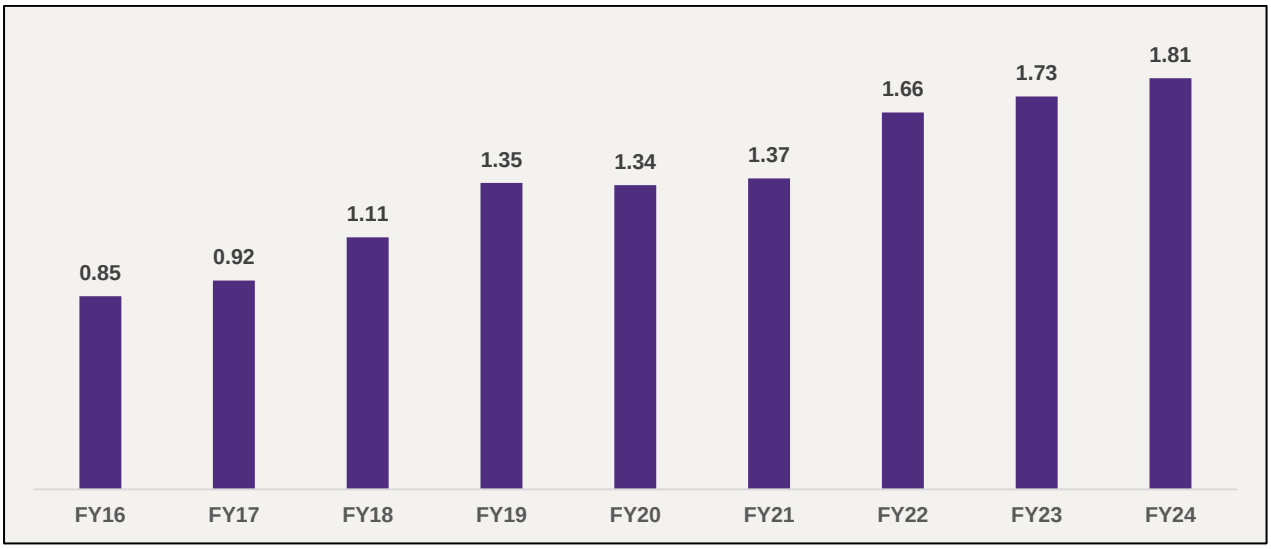

Figure 41: India's Secondary Aluminium Consumption Trend (MT)[58]

Despite the global market's slow recovery in 2023, India's Aluminium demand remained robust, setting it apart from the rest of the world. This growth is largely driven by government initiatives like "Make in India," which have boosted Aluminium demand in sectors such as power and construction. Significant investments in infrastructure, including railways and airports, along with the booming housing construction and automotive industries, are key factors contributing to this increased demand. The country's thriving Aluminium sector underscores its potential transition from a growing economy to a major global player.

Trade Structure of Indian Aluminium Industry[59]

In India, both exports and imports have been rising rapidly over the past few years, as illustrated in the figure below. From 2014 to 2023, exports grew at a CAGR of 12%, while imports have increased at a CAGR of 7%.

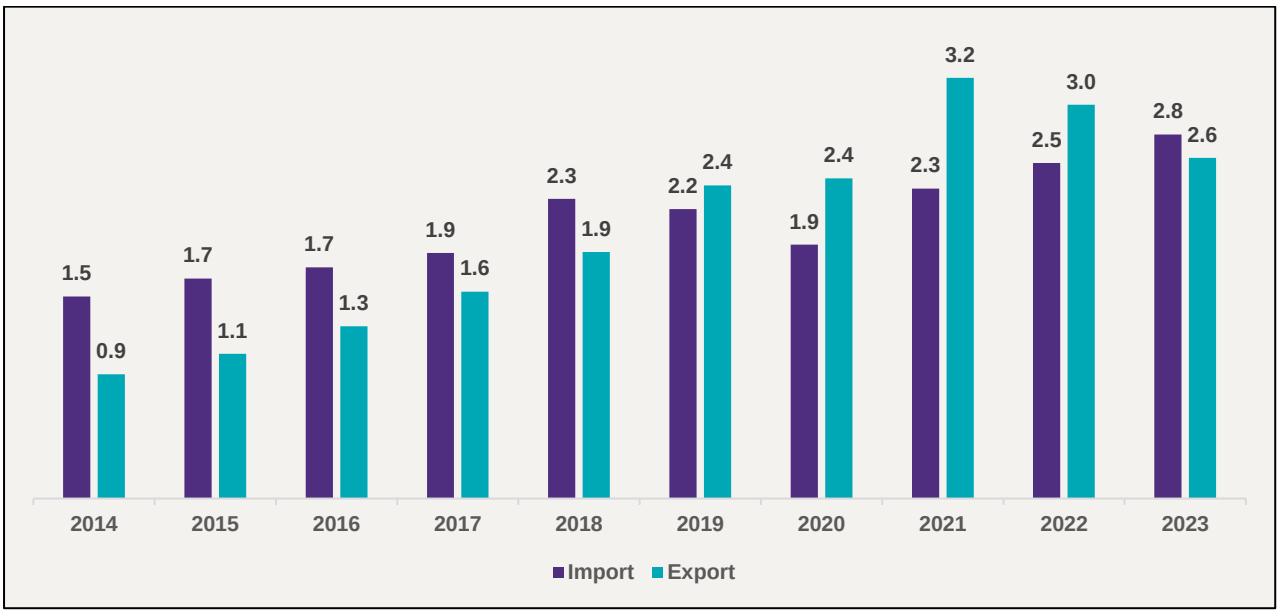

Figure 42: India's Trade of Aluminium and Articles Thereof, MT (HS Code:76)

As imports are also increasing, it is necessary to specify the group of products that have contributed to this growth. HS codes of the 76 group are segregated at the 4-digit level for the analysis, where 7601 is in the category of unwrought primary Aluminium sector, 7602 is Aluminium waste and scrap, and HS codes from 7603 to 7616 are in the category of downstream Aluminium sector.

[58] AI Circle
[59] ITC Trademap, last accessed on 10-Aug-2024

We can observe the trend and share of imports of primary and downstream sectors in the figure below. According to ITC Trademap data, imports of the primary Aluminium sector corresponding to HS code 7601 were 0.34 MT in 2014, which decreased to 0.26 MT in 2022, representing a drop of 25%. On the other hand, for the same period, imports of downstream Aluminium products have been steadily growing from 0.34 MT in 2014 to 0.53 MT in 2022, increasing by 53% despite the decrease in 2020 due to COVID-19 lockdowns and disruptions. It is noteworthy that imports of primary Aluminium decreased, while those of the downstream sector have experienced an increasing trend, as the share of downstream Aluminium products imports has increased quite rapidly.

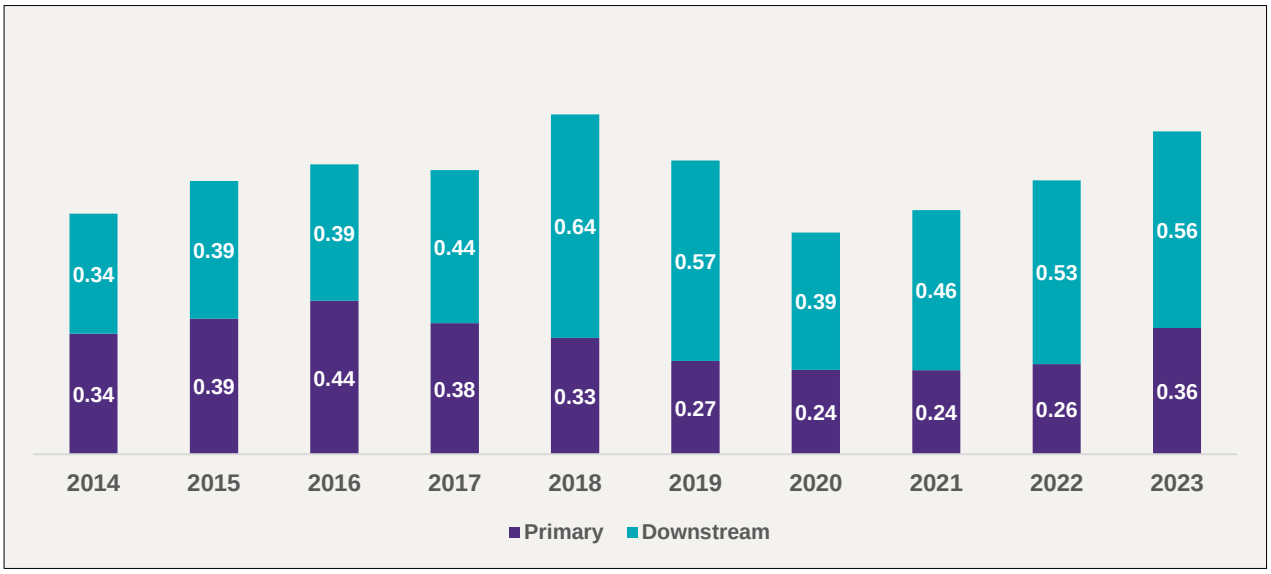

Figure 43: India's import of primary and downstream Aluminium (MT)

Additionally, we can see that the import of waste and scrap has been increasing, resulting in scrap being the largest component in the import of Aluminium and its articles. The import of scrap is mainly from the USA, UK, UAE, Saudi Arabia, etc. India's import duty on Aluminium scrap stands at a mere 2.5%, which is significantly lower than the 7.5% levied on primary Aluminium. This tariff disparity, creating significant price undercutting in recycled Aluminium production, is a driving factor for the uptick in the import of scrap.

Due to the increase in scrap import, the ratio of total import of Aluminium to Domestic sales increased from ~40:60 in FY 12 to 60:40 in FY 22. Aluminium imports cater to ~60% of domestic demand, growing at a CAGR of 9% in the last decade (FY 11 to FY 23). India's Aluminium share through scrap route has increased with a CAGR of 11% from 0.47 MT in FY 11 to 1.73 MT in FY 23 years due to policy measure taken by other importing countries like China & Malaysia to restrict metal scrap imports into their respective nations.[60]

[60] Import Export databank, Ministry of Commerce and Industry, Govt. of India

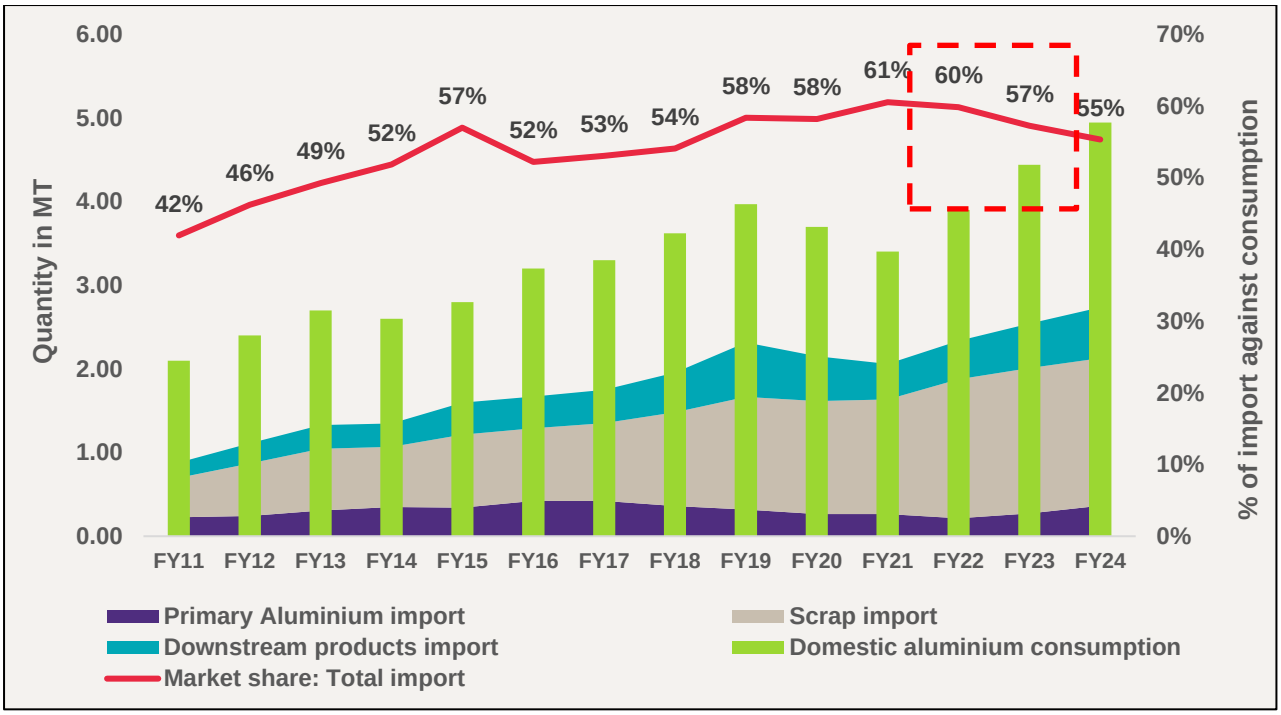

Figure 44: Share of imports of Aluminium in domestic consumption

India exported approximately 72% of its primary Aluminium production in FY22. According to ITC Trademap data, imports of primary Aluminium (HS code 7601) were 0.35 MT in 2014, which decreased to 0.26 MT in 2022, representing a 25% drop. However, during the same period, India's primary Aluminium exports more than quadrupled, rising from 0.6 MT in 2014 to 2.4 MT in 2022. In 2023, India exported Aluminium and Aluminium products worth USD 7.3 bn, out of which USD 4.8 bn or 65% was unwrought or primary Aluminium and 35% were downstream Aluminium products.

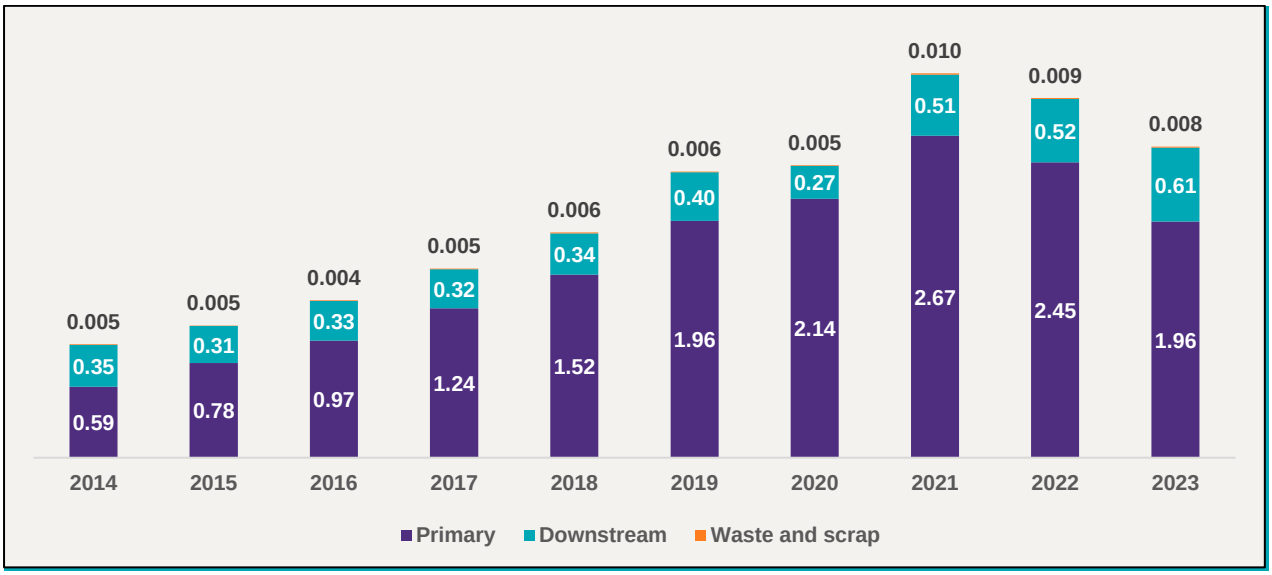

Figure 45: Sectoral Share in India's Export of Aluminium and its products (MT)

Primary Aluminium is mainly exported to Malaysia, South Korea, Japan, Mexico, and the Netherlands. In 2023, Malaysia accounted for around 23% of India's overall primary Aluminium exports, followed by South Korea (17%) Japan (9%) and Mexico (7%). Malaysia was also the largest exporter of unwrought Aluminium to India, but it was much lower compared to its import from India. In 2023, India imported 0.36 MT of Primary Aluminium, of which the top 10 countries accounted for 93% of the total imports with Middle East Countries alone accounting for 61%.

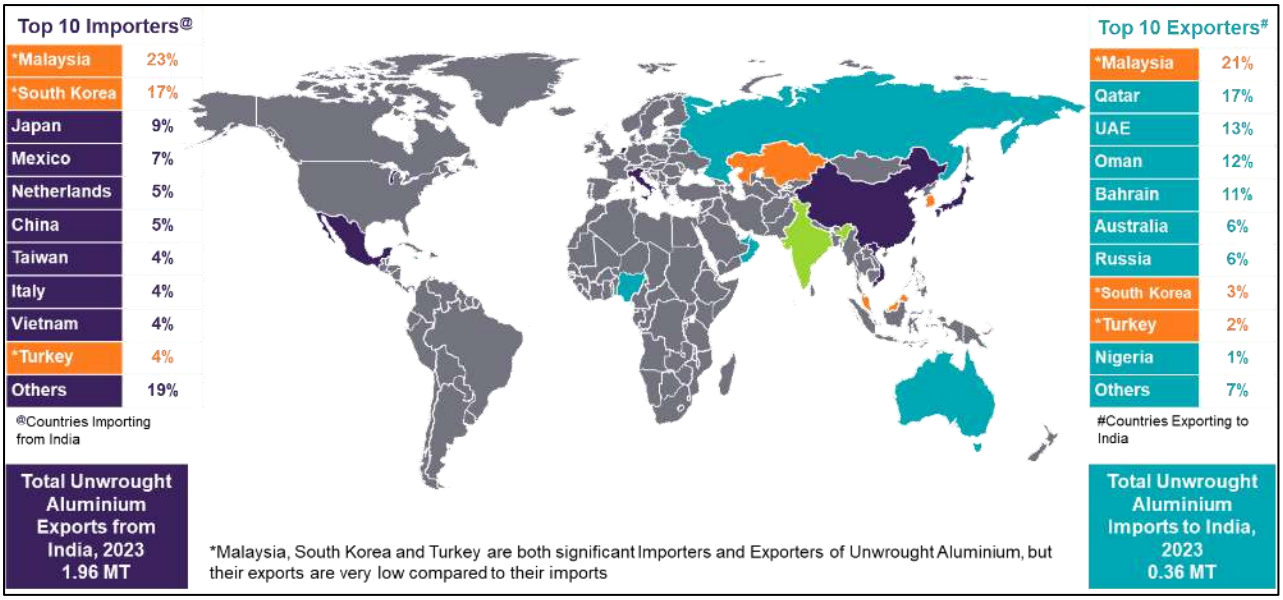

Figure 46: India's Trade of Unwrought Aluminium, 2023 (HS Code: 7601)

On the other hand, imports of the downstream Aluminium products since 2014 have been steadily growing from 0.34 MT in 2014 to up to 0.56 MT in 2023, increasing up to 64% despite the decrease in 2020 due to covid-19 lockdowns and disruptions. It is noteworthy that imports of the primary Aluminium decreased, and the share of downstream Aluminium products imports have increased quite fast.

4.2 Raw Material Scenario – Alumina and Bauxite: Capacity, Production, Export and Import[61,62]

4.2.1 Bauxite

Bauxite Reserves

India is the eighth largest country in terms of Bauxite reserves and is naturally endowed with large deposits of gibbsitic Bauxite[63]. Bauxite is primarily used for the production of Alumina. Other than that, it is also used in refractories, abrasives, chemicals, aluminous cements, and miscellaneous products like proppants.

Bauxite ore reserves in India are limited, and their quality is deteriorating over time. Additionally, government norms are likely to change to include low-grade materials as Bauxite ores. The globally accepted terminology for classifying Bauxite reserves into high and low grade is based on the ratio of Total Alumina to Total Silica content in the Bauxite sample, also known as the A/S ratio. High-grade Bauxites have an A/S ratio greater than 10, while Bauxites with an A/S ratio less than 10 are classified as low-grade ores.

Only 646 MT (13%) Bauxite are under (proved & probable) category and balance 4,312 MT are yet to be fully explored out of 4958 MT Bauxite resources[55]. Traditionally, Bauxite reserves in India are mainly concentrated in the Western Ghats, Central, and Eastern Ghats regions, with significant differences in quality regarding SiO_2 content and Al_2O_3 content. India possesses substantial quantities of metallurgical grade Bauxite (approximately 76% of total resources), primarily located in five states: Odisha, Maharashtra, Jharkhand, Chhattisgarh, and Gujarat. Resources of cement, chemical, refractory, and abrasive grade Bauxite are limited and mainly found in Gujarat, Jharkhand, Madhya Pradesh, and Maharashtra. The East Coast is a prime area with high (Tri Hydrated Alumina) Bauxite.

[61] Indian Minerals Yearbook 2022, Indian Bureau of Mines
[62] ITC Trademap, last accessed on 10-Aug-2024
[63] Draft Strategy on Aluminium Resource Efficiency, NITI Aayog, December 2018

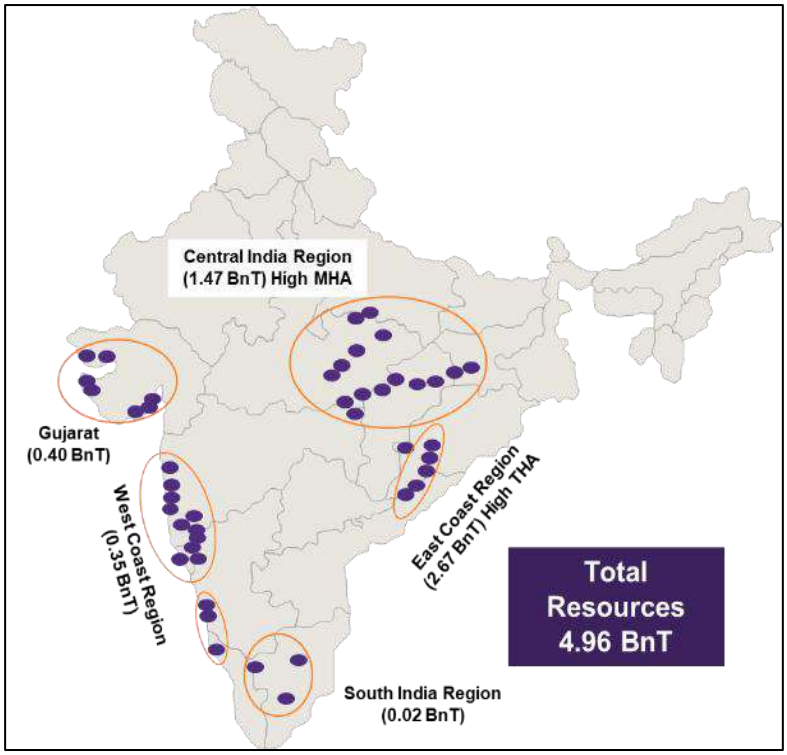

Figure 47: Bauxite Resource Distribution in India

Odisha holds the largest share of Bauxite reserves and resources in India, with over 63% of the total reserves and 41% of the total resources. While the Resource to Reserve conversion rate is minimal in Andhra Pradesh (0%) and Chhattisgarh (2%), it is relatively higher in Gujarat (25%) and Odisha (20%). Despite this, the conversion rates remain low, indicating significant potential for India to enhance exploration activities and expand its reserve base.

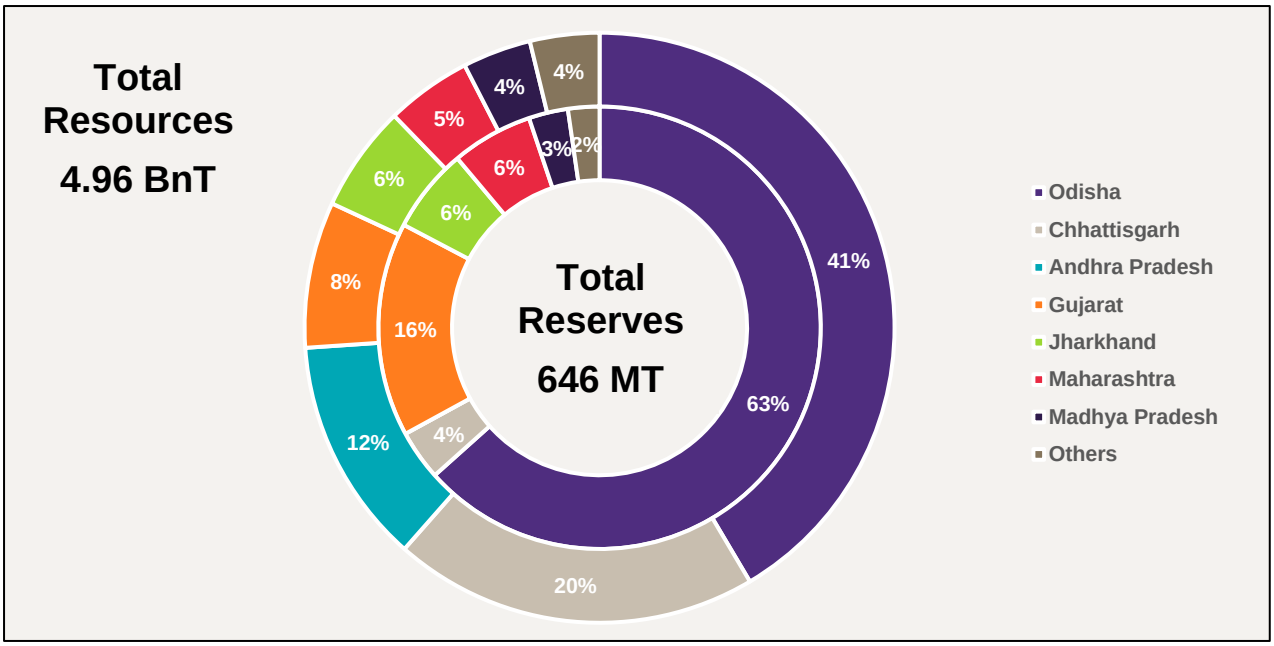

Figure 48: State wise Bauxite Resource and Reserve Distribution as on 01.04.2020

More than 80% of India's Bauxite reserves and 75% of resources are of metallurgical grade, an essential raw material for producing smelter grade Alumina and ultimately Aluminium. This provides an edge over many countries, as it has a large resource base to support the development of Aluminium industry in India.

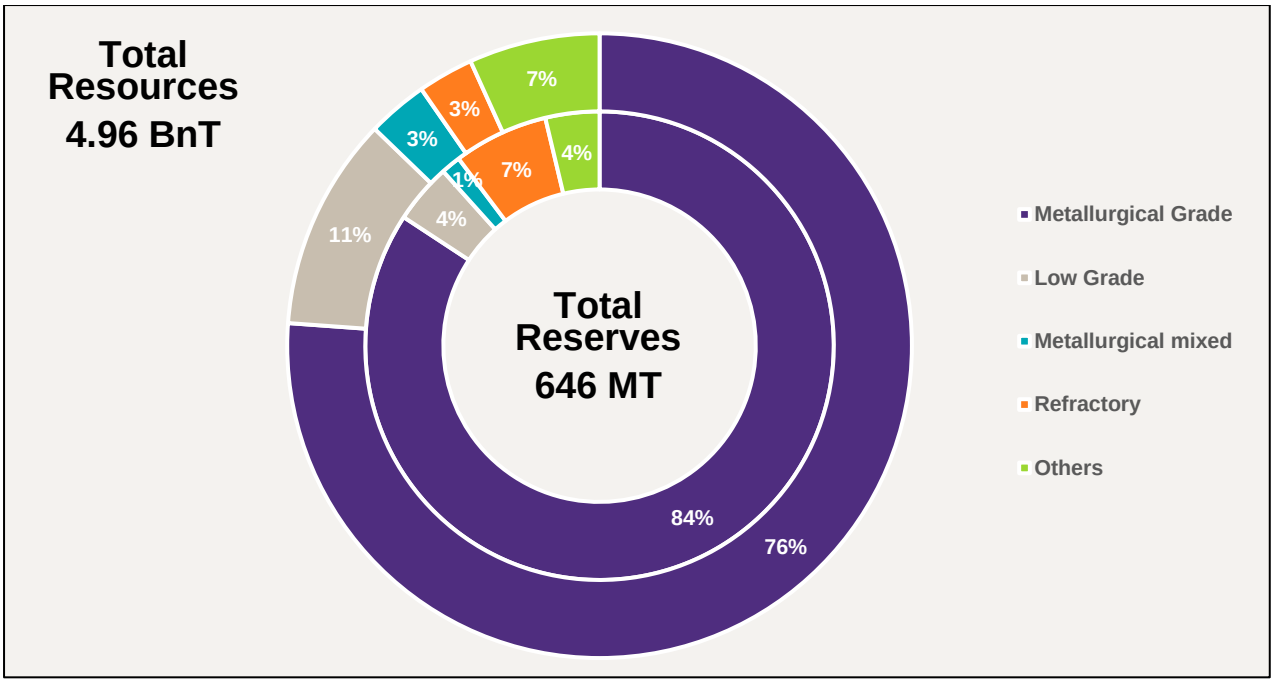

Figure 49: Grade wise Bauxite Reserve and Resource distribution, on 01.04.2020

Bauxite Production

Production of Bauxite has been around 22-23 MTPA since FY14 except it reached 28.1 MT in FY16. According to Indian Bureau of Mines there are reported 226 Bauxite mines in FY24. State of Odisha (17.6 MT) ranks 1st in production of Bauxite and is followed by Jharkhand (2.0 MT), Gujarat (1.6 MT), Maharashtra (1.0 MT), Chhattisgarh (1.0 MT), and Madhya Pradesh (0.6 MT).

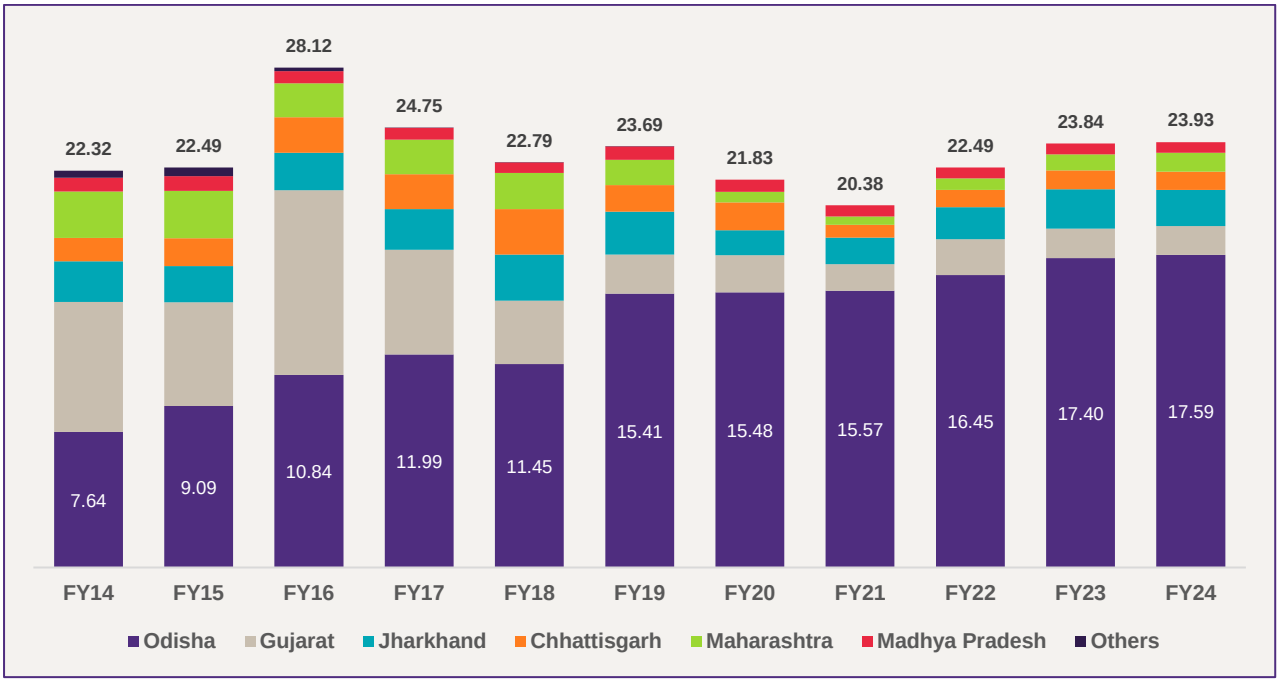

Figure 50: State Wise Bauxite Production (MT)

Till 2016 India was consuming around 70%-80% of the Bauxite produced domestically, while the rest of the commodity was being exported. In recent years, due to the rise in the demand of Aluminium in the domestic markets, the exports have dropped rapidly from 1.7 MT in 2017 to just 0.1 MT in 2023.This increased demand for Aluminium and in turn Bauxite has led to the rise in the import of Bauxite which has more than doubled from 1.6 MT in 2014 to 3.8 MT in 2023. More than 95% of India's Bauxite imports comes from Guinea.

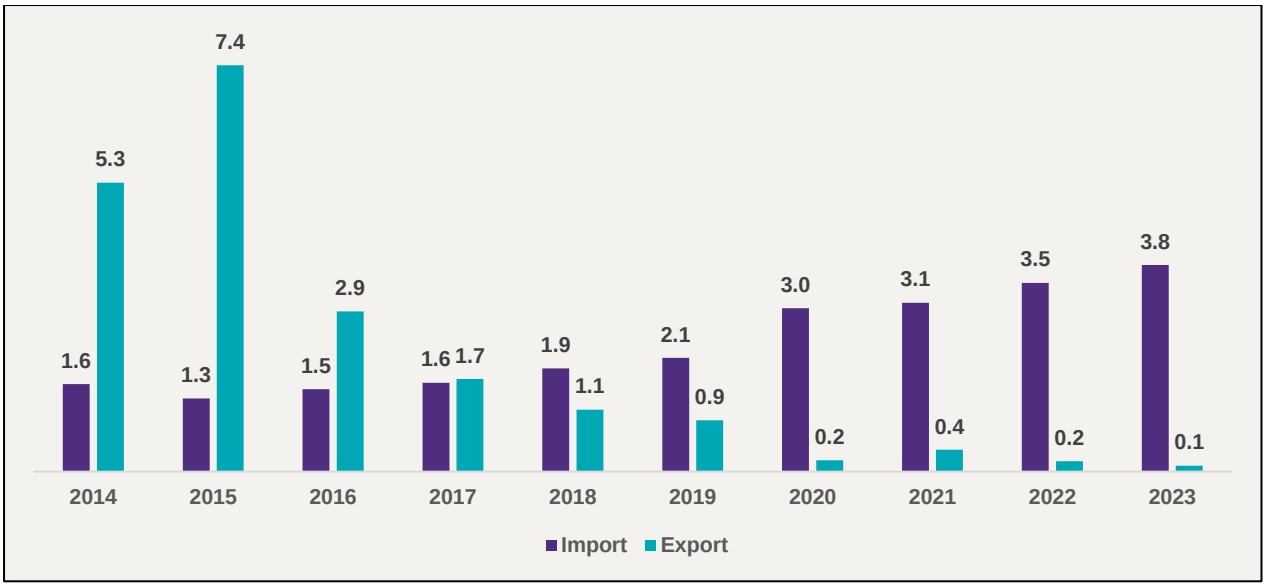

Figure 51: India's Bauxite Trade (HS Code: 260600) (MT)

4.2.2 Alumina

According to the recent USGS report, India ranks 4th in terms of production of Alumina contributing to nearly 5% of the world production. Domestic Alumina plants are owned by the dominant three players of the Aluminium industry of the country i.e. National Aluminium Company Limited (NALCO), Hindalco Industries Limited (Hindalco) & Vedanta Limited.

Domestic Alumina production increased at a growth rate of 7.2% CAGR from FY14 to FY24. Most of the Alumina produced is used for domestic consumption i.e. by the respective companies which manufacture it, for the manufacturing of Aluminium metal.

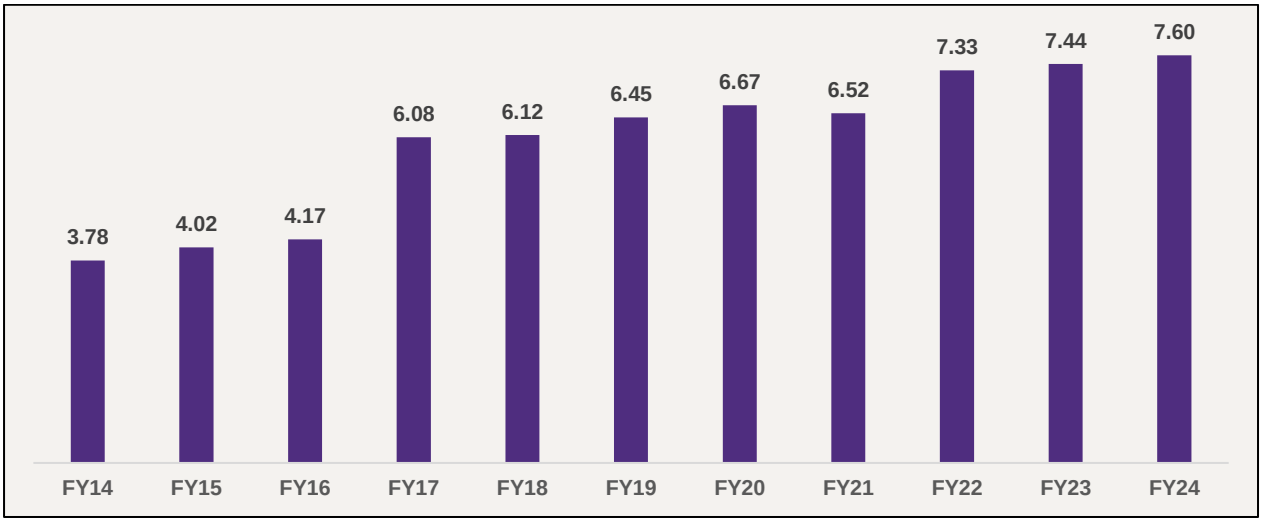

Figure 52: Alumina Production in India (MT)

India is a net importer of Alumina. While the imports of Alumina increased at a CAGR of 13% from 0.8 MT in 2014 to 2.5 MT in 2023, exports have increased at a much slower growth rate of 3.8% CAGR. This is mainly attributed to the increased demand of Alumina (~7 to 8 Million Tonnes) for domestic Aluminium production.

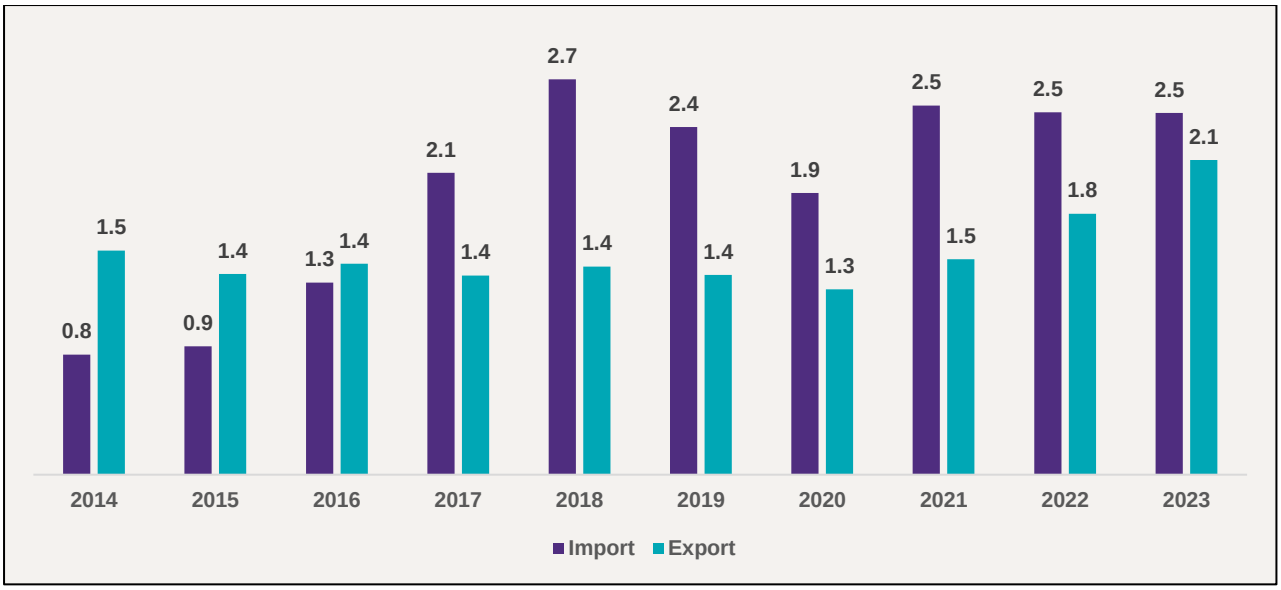

Figure 53: India's Trade of Alumina (MT) (HS Code: 281820)

In 2023, India's imports of Alumina were mainly from Indonesia (41%), Australia (30%), Vietnam (20%), Saudi Arabia (5%) and China (4%). Exports were mainly to Oman (39%), Russia (23%), United Kingdom (16%), United Arab Emirates (15%) and China (3%).

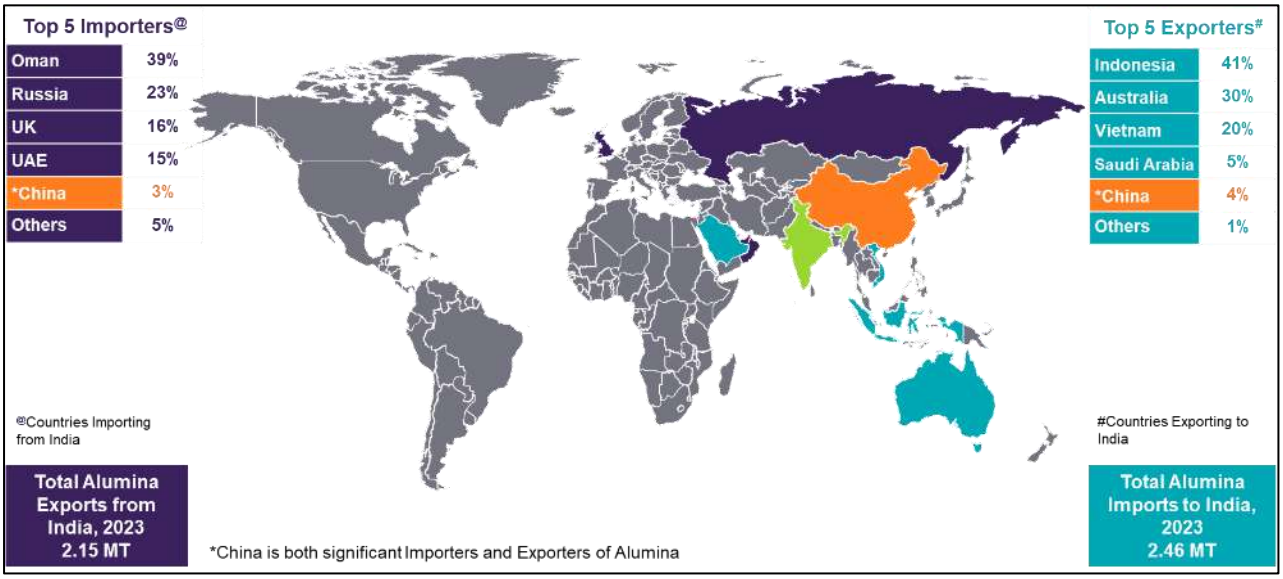

Figure 54: India's Alumina Trade, 2023 (HS Code: 281820)

4.2.3 Aluminium Scrap

India depends on imports for meeting nearly 85%-90% of its scrap requirement. India's import of Aluminium scrap has been increasing at a CAGR of 7.9% from 2019 to reach 1.83 MT in 2023. This increase in the imports is the testament of the country's historically low consumption of the metal and also the underdeveloped scrap generation and collection system. India's export of scrap metal has been negligible compared to the imports. The top 10 exporters of Aluminium scrap constituted nearly 72% of India's total imports with USA (27%) being the largest exporter of the scrap metal to India. European (more than 20%) and Middle East (more than 17%) countries also export significant volume of Aluminium scrap to India.

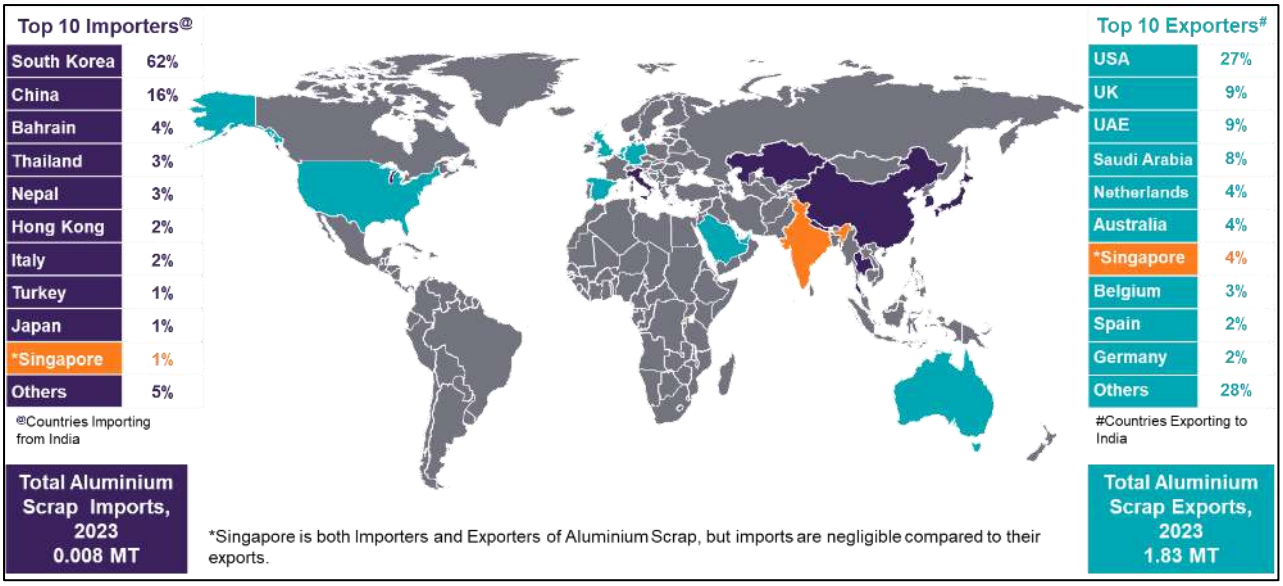

Figure 55: India's Trade of Aluminium Scraps, 2023 (HS Code: 7602)

4.3 Overview of Major Players: Current Capacity and Production[64]

The Aluminium sector in India features a diverse range of companies, from fully integrated firms to product specialists, with both horizontal and vertical extensions. While the secondary Aluminium sector is highly fragmented due to low entry barriers & capital costs, the capital-intensive primary upstream sector is dominated by three major players: NALCO, Hindalco, and Vedanta, with a production capacity of 4.2 MT. The secondary Aluminium sector has nearly 10 medium sized players and more than 150 to 200 small players. The downstream segment includes over 150 large and mid-sized companies, along with a significantly larger base of smaller and unorganized players[65].

Primary Aluminium Producers

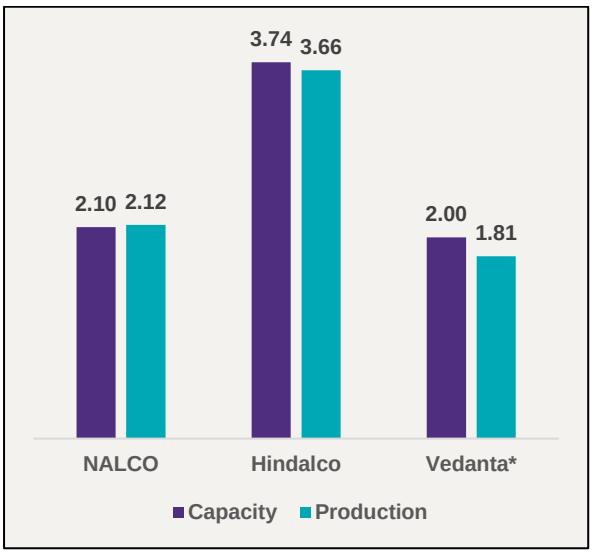

Figure 56: Indian Companies' Alumina Capacity and Production, FY24 (MT)

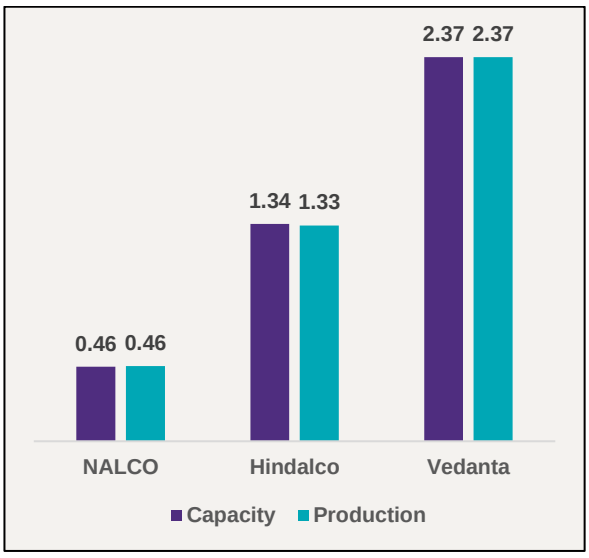

Figure 57: Indian Companies' Primary Aluminium Capacity and Production, FY24 (MT)

*Vedanta's current alumina refinery capacity is 3.5 MTPA

[64] Companies' Website, Annual Report and Investor Presentation, last accessed on 10-Aug-2024
[65] Need for an Aluminium Policy in India, Niti Aayog 2017

While the primary Aluminium smelter capacity in India has remained mainly constant over the past years, the smelter's capacity utilisation has risen from 59% in FY16 to 101% in FY24. This increase in capacity utilisation is mainly attributed to the growing Aluminium demand in India.

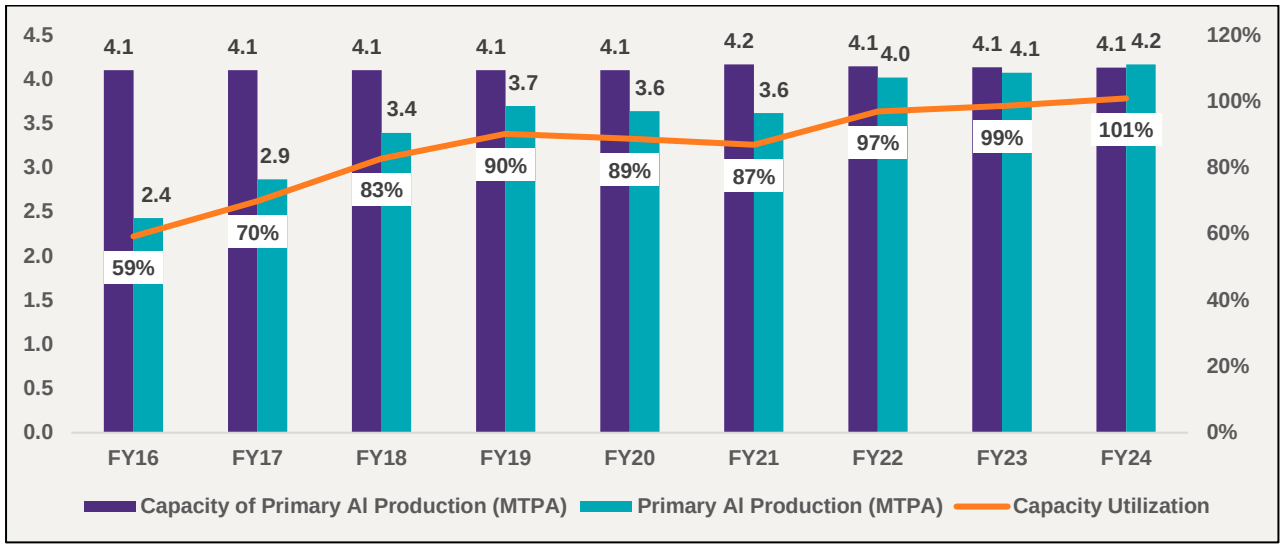

Figure 58: Primary Aluminium capacity and production in India (MTPA)

4.3.1 National Aluminium Company Limited (NALCO)

NALCO, a scheduled 'A' Navratna CPSE was incorporated in 1981. It is third largest integrated primary Aluminium producer in India, covering the entire value chain from Bauxite mining to downstream products. NALCO operates extensive facilities in Odisha, including a 6.83 MTPA Bauxite mine, a 2.1 MTPA Alumina refinery, a 0.46 MTPA Aluminium smelter, and a 1,200 MW captive power plant as of FY24.

NALCO is the lowest cost producer of Bauxite and Alumina in the World. NALCO also has a competitive advantage w.r.t alumina due to its backward integration in terms of bauxite mines. It is also the lowest cost producer of Aluminium in India, giving it a competitive edge across the Aluminium upstream value chain compared to other domestic producers like Vedanta and Hindalco.

Products: NALCO offers a wide range of products across various categories.

i. **Alumina:** Calcined Alumina, Alumina Hydrate, and Specialty Hydrates.

ii. **Aluminium and Downstream:** Standard Ingots, Sow Ingots, T-Ingots, Wire Rods, Billets, and Flat Rolled Products.

Backward Integration:

i. NALCO collaborated with Gujarat Alkalies & Chemicals Limited (GACL) to set up a 0.27 MTPA Caustic Soda Plant along with 130 MW Captive Power Plant at Dahej in Gujarat to meet the Caustic Soda requirement of Alumina Refinery, as a part of raw material securitisation. The plant was commissioned in May 2022.

ii. Pottangi Bauxite Mine, with a capacity of 3.5 MTPA and reserves of 111 MT, has been reserved in favor of NALCO by the government. This will help meet the Bauxite requirement for the additional 1 MT Alumina Refinery currently under expansion.

iii. NALCO has been allocated the Utkal-D and Utkal-E Coal blocks having 175 MT reserves which will provide raw material security to the existing operational Units at Captive Power Plant (CPP) and future expansion

Expansion Plans:

i. Refinery: Capacity expansion plan from 2.1 MTPA to 3.1 MTPA (Expected completion by June 2026)

ii. Aluminium smelter: Capacity expansion by 0.5 MTPA by FY30

iii. Downstream:

a. Value-added product portfolio i.e. further capacity addition in FRP, wire rod, Extrusions, casting and foils etc.

b. It has established a JV named 'Angul Aluminium Park Private Ltd' (AAPPL) with Odisha Industrial Infrastructure Development Corporation (IDCO) to enhance ancillary, upstream, and downstream products in the Aluminium industry.

4.3.2 Hindalco[66,67]

Hindalco Industries Limited, the flagship entity of the Aditya Birla Group, ranks among Asia's largest integrated primary Aluminium producers. The company boasts a comprehensive presence across the entire Aluminium value chain, encompassing Bauxite mining, Alumina refining, Aluminium smelting, and downstream processes such as rolling, extrusions, and recycling. Hindalco has positioned itself as a low-cost producer of primary Aluminium in its domestic operations and stands as one of the world's largest producers of recycled Aluminium through its overseas operations, spearheaded by its subsidiary Novelis. On April 14, 2020, the company closed the acquisition of Aleris through its subsidiary Novelis. Hindalco's acquisition of Aleris Corporation has made it one of the world's largest Aluminium companies, with 49 advanced manufacturing facilities across North America, Europe, and Asia.

Hindalco runs captive Bauxite mines in Jharkhand, Chhattisgarh, Maharashtra, and Odisha with a cumulative EC capacity of 15 MTPA against the current requirement of 10-11 MTPA. The Utkal Alumina refinery in Odisha is a world-class facility known for its globally competitive cost structure. The company operates Aluminium smelters with captive power plants in Madhya Pradesh, Uttar Pradesh, and Odisha. Key smelters include those at Renukoot (Uttar Pradesh), Hirakud and Aditya (Odisha), and Mahan (Madhya Pradesh), of which Aditya and Mahan smelters employ advanced AP36 technology.

Products: Hindalco's product portfolio includes:

i. **Alumina:** Chemical Alumina and hydrates used in industries like water treatment, refractories, and ceramics

ii. **Aluminium and Downstream:** Ingots, billets, wire rods, rolled products, extrusions, and foils

Backward Integration:

i. Hindalco has entered into a MoU with OMC to secure a long-term raw material supply for its upcoming 2 MTPA Alumina refinery project.

ii. To ensure long-term raw material security, Hindalco aims to reduce its dependency on external sources for Coal procurement. It has recently acquired the Chakla and Meenakshi Coal mines, which have a combined mining capacity of 12.5 MTPA. Apart from this, Hindalco also has three Coal mines- Meenakshi West, Gare Palma IV/4 (GP-4) and Kathautia. These acquisitions have further strengthened the Coal supply chain and are expected to drive cost synergies leading to lower cost of production.

Expansion Plans:

i. Refinery: Capacity expected to surpass 5.8 MT with addition of 2 MTPA refinery Kansariguda, Rayagada district by FY27.

ii. Aluminium smelter: Capacity expansion up to 1.5 MTPA by FY27.

iii. Downstream:

   a. To enrich its downstream products portfolio and to expand this business, Hindalco has allocated around USD 0.68 billion towards domestic capex to enhance domestic downstream Aluminium capacity by ~39% to over 0.6 MT by FY26.

[66] Hindalco Industries – Capacity expansion, sizing downstream to drive margins, Anand Rathi Research
[67] Hindalco-Novelis completes acquisition of Aleris

b. Hindalco has established an India's first automated robotics plant in Chakan, Pune, Maharashtra, to manufacture battery enclosures for the EV segment having an annual capacity of 164,000 units.

c. To meet the demand of Aluminium battery foil in India, primarily due to the exponential growth of gigafactories involved in advanced cell manufacturing Hindalco has allocated ₹800 crore to establish a new plant near Jharsuguda in Odisha. Initially, this facility will produce 25,000 MT of Aluminium battery foil, essential for both Lithium-ion and Sodium-ion cells.

d. Hindalco has planned a CAPEX of USD ~ 5 billion to enhance Novelis' FRP capacity by ~21% to over 4.9 MT and recycling capacity by ~33% to 2.9 MT.

4.3.3 Vedanta

Vedanta is a major player in the global Aluminium industry and the largest producer of Aluminium in India. The company has a comprehensive presence across the Aluminium value chain, from Alumina refining to Aluminium smelting and downstream value-added products. The Company has also recently acquired bauxite mines to become an integrated Aluminium producer.

Vedanta meets its Bauxite requirement through imports and domestic procurement and its Alumina refinery and Aluminium smelter capacity stands at 3.50 MT and 2.37 MT, respectively making it the largest primary Aluminium player in the country and 8th largest in the world. Vedanta operates some of the largest Aluminium smelters in the world. The Jharsuguda smelter in Odisha has a capacity of 1.8 MTPA, making it one of the largest single-location Aluminium smelters globally. Additionally, the Bharat Aluminium Company (BALCO) in Korba, Chhattisgarh, has a smelting capacity of 0.57 MTPA. Together, these facilities contribute significantly to Vedanta's total Aluminium production capacity of 2.37 MTPA

Products: Vedanta's product portfolio includes:

i. Aluminium and Downstream: Ingots, billets, wire rods, Rolled products, and alloys.

ii. Specialty Products: Low carbon 'green' Aluminium product branded as "Restora", which is used in sectors like automotive and aerospace.

The refinery has recently expanded its capacity to 3.5 MTPA and plans to further increase it to 5 MTPA. This expansion is part of Vedanta's strategy to achieve 100% vertical integration and reduce dependency on external sources for Alumina.

Backward Integration: Vedanta has planned for 100% backward and forward integration to fulfil the requirement of its Alumina refinery and Aluminium smelter:

i. Vedanta won Sijimali Bauxite mine having 300 MT resource and mining capacity of 12 MT. This will be capable to supply nearly 67% of the future Bauxite demand of Vedanta's Aluminium refinery. The remaining Bauxite requirement shall be sourced from OMC/other miners.

ii. Vedanta has recently acquired 5 Coal mines with a total resource of 950 MT and mining capacity of 40 MTPA to ensure uninterrupted and low-cost power supply for its Aluminium operations.

Expansion Plans:

i. Refinery: Vedanta has planned to increase its Alumina refinery capacity to 5 MTPA by 2025 and 6 MTPA by 2026.

ii. Aluminium smelter: Vedanta aims to achieve 3.1 MTPA Aluminium smelter capacity post expansion.

iii. Downstream:

a. In the downstream sector Vedanta has set a target to achieve 2.5 MT downstream/value added products production capacity from current levels of 1.4 MT.

b. Vedanta, in collaboration with the Odisha Industrial Infrastructure Development Corporation (IDCO), is setting up a state-of-the-art Aluminium Park near its smelter in Jharsuguda, Odisha. Inaugurated in December 2022, this park aims to attract downstream industries by offering direct access to hot metal (molten Aluminium) from Vedanta's smelter.

Secondary Aluminium Producers[68],[69]

While the primary Aluminium market is dominated by only three players, the secondary Aluminium industry is highly fragmented and divided into small and medium players, and large players, with the latter having an annual capacity of 40,000 tonnes or more. The recycling market relies heavily on small and medium players, who cater to 55-60% of the total market demand. The large players, characterised by superior economies of scale, an extensive client base, mechanized operations, technological advancements, and enhanced productivity, contribute the remaining 40-45%.

Large players, such as CMR Group, Daiki Aluminium, and Sunalco, have a diversified geographical presence with multiple plants, allowing them to mitigate regional demand fluctuations and potentially achieve better growth. These large players are notably present in key automotive clusters.

CMR Group is a major player in the recycling segment, along with Daiki Aluminium, Sunalco, and Namo Alloys. Aluminium scrap recovery is mainly handled by small and medium enterprises, serving the utensil and casting industries.

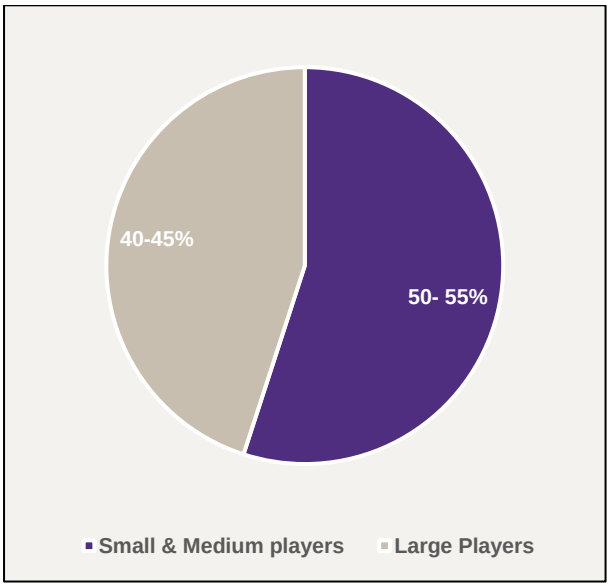

Figure 59: Capacity distribution of Secondary Aluminium based on Players (for FY 21)

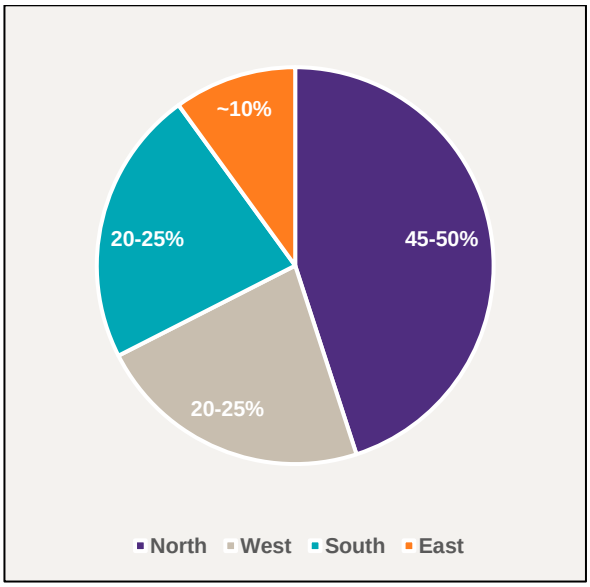

Figure 60: Region wise distribution of installed secondary capacity in India

Table 5: Leading Secondary Aluminium players in India

#	Leading Secondary Aluminium Players	Capacity (kTPA)
1.	**CMR Green Technologies**	382
2.	**Sunalco**	75-100
3.	**Daiki Aluminium Industry India Pvt Ltd.**	70-110
4.	**IMAC Alloy Casting**	30-50
5.	**Sree Sumangala Metals**	30-40
6.	**SBA**	30-90
7.	**GR Metalloys**	25-40

[68] Source: Aluminium recycling in India, February 2022, CRISIL
[69] Industry sources

#	Leading Secondary Aluminium Players	Capacity (kTPA)
8.	**Century NF**	50-70

Secondary Aluminium production capacity in India is expected to grow from ~2 MT in FY24 to 3.5 MT by FY30. CMR plans to add 100 kTPA, to increase its capacity to 482 kTPA by FY26. Other players such as Namo and Samyak are expected to add 8.4 kTPA, 30 kTPA, respectively.

Northern India holds 45-50% of the country's secondary Aluminium recycling capacity, primarily due to its proximity to the National Capital Region (NCR) auto cluster with key OEMs such as Hero Motocorp, Maruti Suzuki, Tata Motors, Bajaj Auto, etc. located in the region. The western and southern regions each account for 20-25% of the capacity, serving the automotive, building & construction, and consumer durables industries. The eastern region, with about 10% of the capacity, mainly caters to the deoxidizer segment and utensil manufacturing.

4.4 Downstream and Value-Added Products[70]

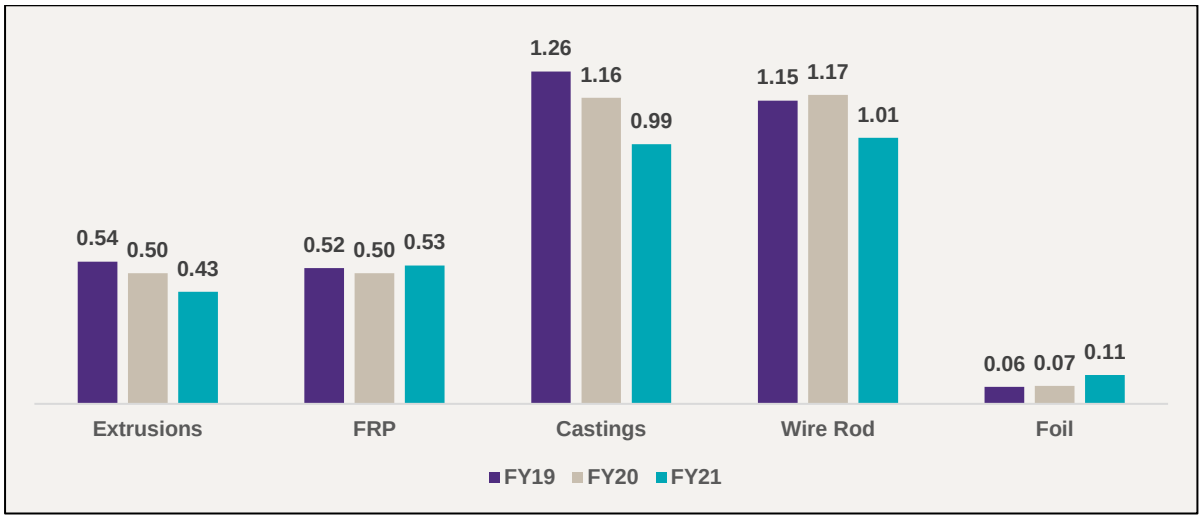

Figure 61: India's Production of Downstream Products (MT)

India's downstream Aluminium production capacity stood at 3.9 MT in 2020[71] and needs to more than double by FY30 and grow nearly tenfold by FY47 to achieve India's aim of self-reliance in the Aluminium sector. The most consumed and produced downstream products in India are Aluminium castings and wire rods, followed by FRP and extrusions. Due to the impact of COVID-19, the consumption and production of downstream products in FY20 and FY21 decreased from FY19 levels. However, with the recovery of the Indian economy, the demand for Aluminium products has picked up again. Currently, Aluminium demand stands at 4.95 MT in FY24.

[70] Al Circle
[71] https://www.entrepreneur.com/en-in/growth-strategies/how-downstream-Aluminium-can-facilitate-the-way-for/359560

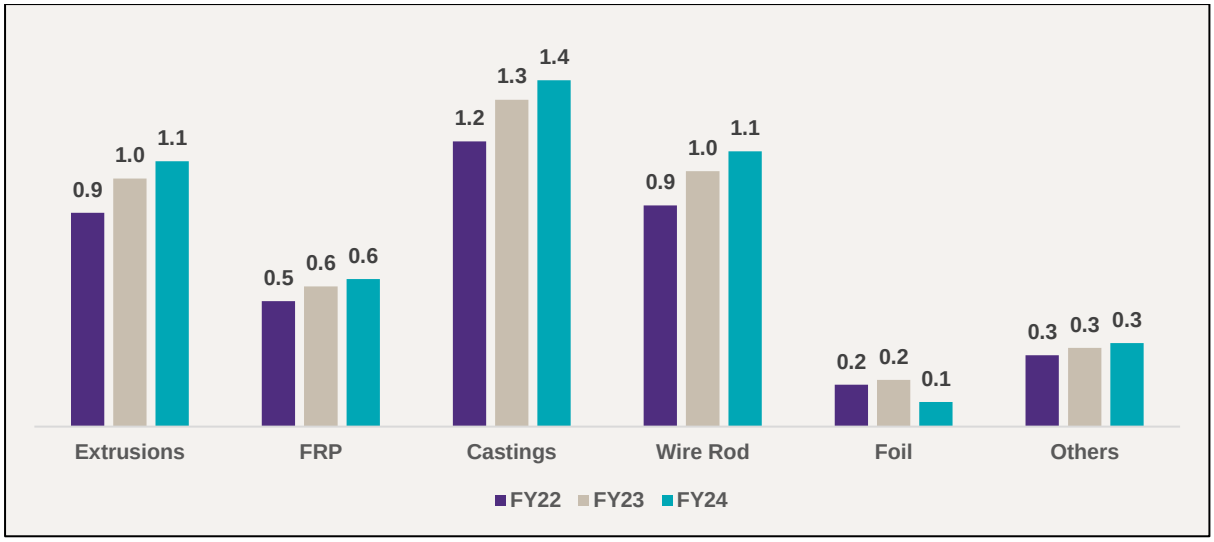

Figure 62: India's Consumption of Downstream Products (MT)

In India, extrusions find their application mainly in the building and construction, transportation and electrical and electronics sector. While castings are mostly in the transportation sector, FRP and foils are majorly consumed in the packaging industry. FRP also finds its application in the automotive, electrical & electronics and consumer durables industry. On the wire rods is almost entirely consumed in the electrical and electronics sector.

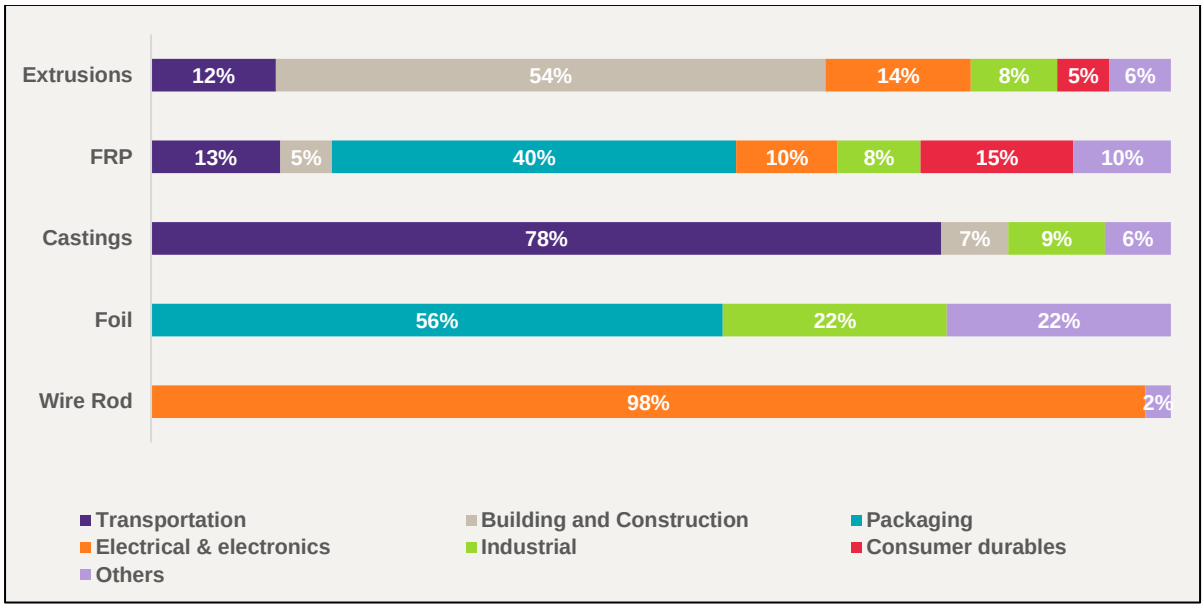

Figure 63: Sector wise Consumption of Aluminium Downstream Products, FY21[72]

Primary producers like Vedanta, Hindalco and NALCO are also major players in the downstream Sector in India. Other major players include Jindal Aluminium, Century Extrusions, Apar Industries, Manaksia etc. These companies offer a wide range of Aluminium alloys.

- Jindal's wide range of alloys (1xxx, 3xxx, 5xxx and 8xxx) are well accepted all across the globe in diverse alloy combinations for segments such as Aviation, Architectural, Transport, Electronics, Defence, Solar, Roofing, Cladding, Insulation, Closure stock, Foils etc.
- Hindalco-Almex Aerospace Limited (HAAL), a JV between Hindalco Industries and Almex USA Inc., focuses on manufacturing high-strength Aluminium alloys for the aerospace, sporting goods, and

[72] Outlook for Indian Aluminium Industry, Al Circle

surface transport industries. Its 12,000 TPA uses state-of-the-art technologies in casting, homogenizing, machining and ultrasonic testing for manufacturing Aluminium hard alloy billets and slabs in a wide range of 2xxx, 6xxx and 7xxx alloy series.

- Vedanta also produces different downstream products of different alloys of 1xxx, 3xxx, 4xxx, 5xxx and 6xxx series. In collaboration with VSSC-ISRO, BALCO has installed a Novelis Casting Station along with Heat Treatment, Stretching, and Polishing equipment to commercially produce various grades of aerospace alloys. The alloys produced by BALCO for VSSC include AA2014, AA2219, AA7075, and AA6063.
- NALCO produces diverse rolled products like sheets and coils of 1xxx, 3xxx, 5xxx and 8xxx series.
- Century also produces different alloys (1xxx to 6xxx and 8xxx series) catering to building and construction, transmission & distribution sector.

Table 6: Application of different Aluminium Alloy

Aluminium Alloy	Applications
1xxx	Packaging, Building product, Electrical conductors, chemical equipment, and food processing
2xxx	Aerospace, Defence, Space and high-performance applications
3xxx	Beverage can, Building product
4xxx	Castings, Cladding on brazen sheet, Welding wire, brazing alloys, and automotive components
5xxx	Marine, pressure vessels (LNG carrier) and automotive parts.
6xxx	Structural applications, architectural components, and auto structural sheet
7xxx	General Engineering, Aerospace, sporting equipment, and high-stress components
8xxx	Auto body sheet, Specialized applications like lithium-containing alloys for aerospace

Table 7: Major Aluminium Downstream Producers in India

Product Segment	Major Players
Extrusions	Alom Extrusions Ltd. MAAN Aluminium Ltd. Jindal Aluminium Ltd. Hindalco Industries Ltd. Century Extrusions Ltd. Valco Industries Ltd.
FRP	Hindalco Industries Ltd.

Product Segment	Major Players
	Vedanta Ltd. (BALCO) Jindal Aluminium Ltd. Nalco Virgo Aluminium Ltd. Manaksia Aluminium Co. Ltd
Castings	Alicon Castalloy Ltd Ashley Alteams India Caparo India Endurance Technologies Jay Hind Industries Ltd Minda Industries Ltd
Wire Rod	Vedanta Group Hindalco Nalco Gupta Power Cabcon India KVJ Alloy Conductors Apar Industries
Foil	Hindalco Industries Ltd Jindal India Ltd. PG Foils Ltd Raviraj foils Ltd. Paragon Industries

Table 8: Major Aluminium Downstream Producers Capacity[73]

Producer/Product	Annual Installed capacity (Tonnes)
Hindalco Industries Ltd[74].	
Rolled product	295,000
Extrusions	115,000
Aluminium foils	40,000
Total	**450,00**
NALCO	

[73] Indian Mineral Yearbook 2022, IBM
[74] 386-24 -24 Hindalco Extrusions Brochure Revision, last accessed on 01-Oct-2024

Producer/Product	Annual Installed capacity (Tonnes)
Aluminium wire rods	100,000
Aluminium billets	30,000
Rolled products	45,000
Total	**175,000**
Vedanta[75]	
Primary Foundry Alloy	140,000
Rolled products	45,000
Billets	580,000
AlSi	85,000
Aluminium wire rods	555,000
Total	**1,405,000**
JINDAL ALUMINIUM LTD[76]	
Extrusions	180,000
Rolled Products	75,000
Total	**255,000**

India's Trade of Downstream Products

In 2023, India ranked 12th and 8th in global downstream Aluminium imports and exports, respectively. More than 2/3rd of the downstream Aluminium imports came from China, with Thailand and South Korea being the other top 3 exporters to India. USA, Saudi Arabia and UAE were the top 3 export destinations for India's downstream products accounting for close to 45% of India's export.

[75] Vedanta Investor Presentation 2024
[76] Jindal Aluminium, Nov 2024

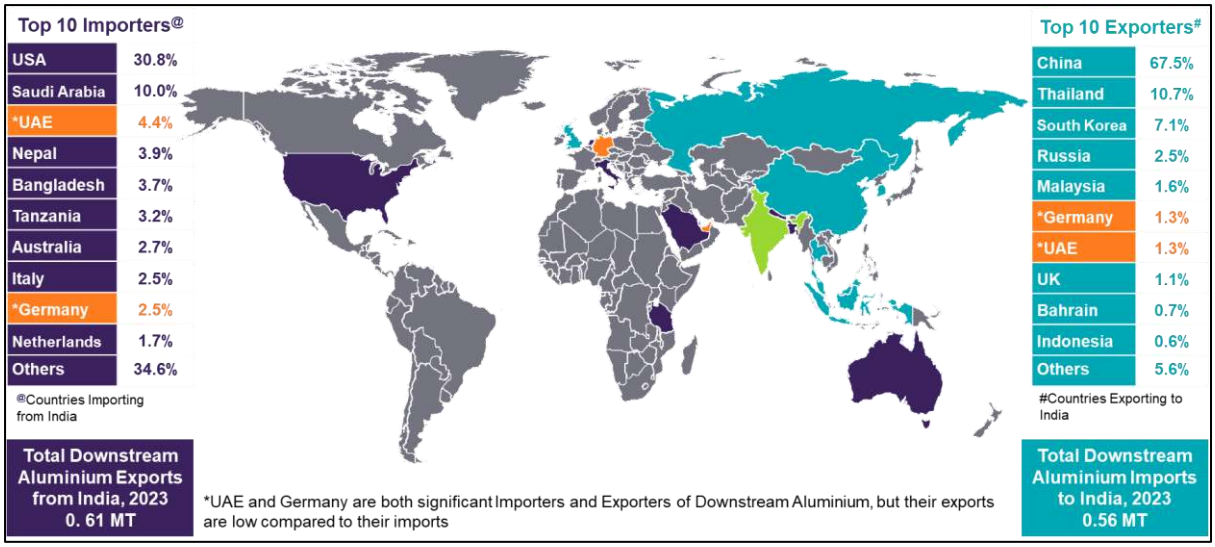

Figure 64: India's Trade of Aluminium Downstream Products (HS Code: 7603 to 7616)

While India is heavily dependent on imports for Aluminium foils, plates, rods and structures, it is one of the major exporters of Aluminium wire, stranded wire and cables.

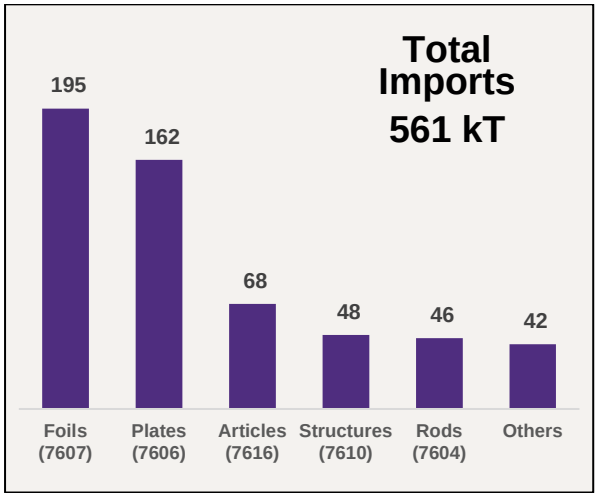

Figure 65: India's Product wise Imports of Downstream Aluminium (kT), 2023

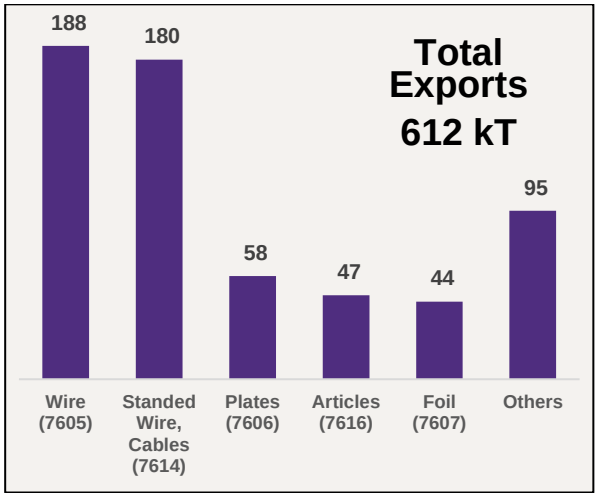

Figure 66: India's Product wise Exports of Downstream Aluminium (kT), 2023

4.5 Aluminium Cost of Production Assessment[77]

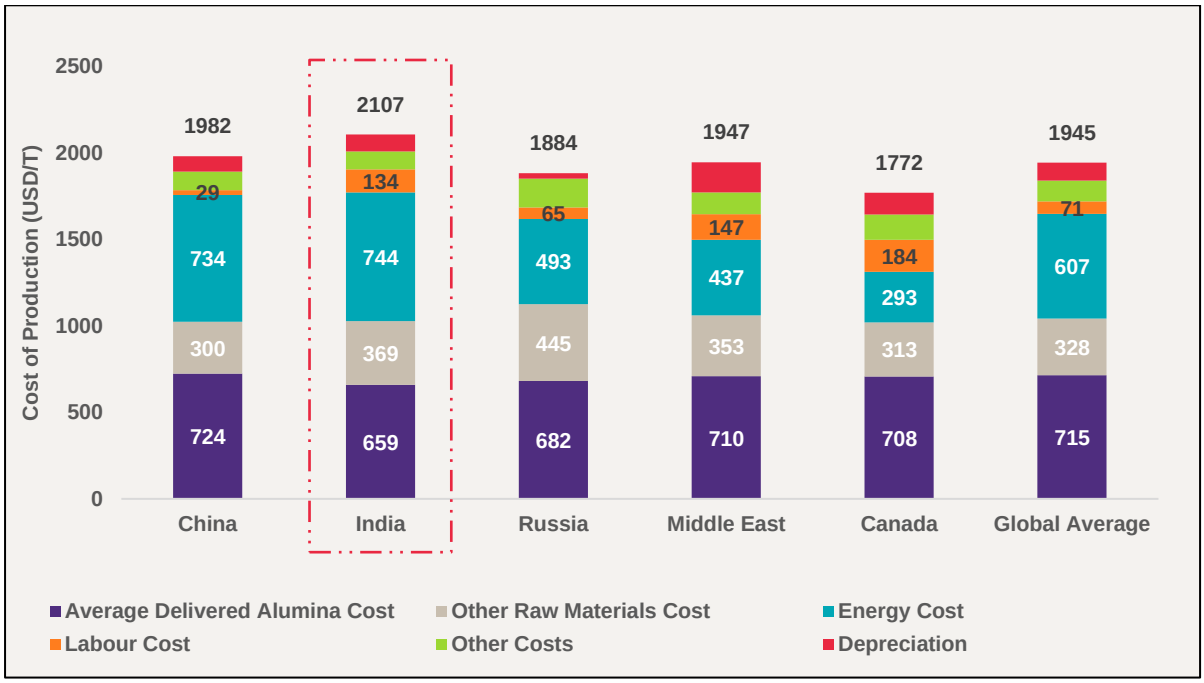

Figure 67: Cost of Production of Aluminium (USD/T): India vs. Other Countries/Regions

Note: Global Average includes major Aluminium producing countries like China, Russia, Canada and Middle East Countries top Aluminium smelters cost and excludes Indian Aluminium Smelter's cost

India has the highest Aluminium production costs among major producers such as China, Russia, Canada, and Middle Eastern countries like the UAE and Bahrain. The total cost of producing Aluminium in India is USD 2107 per tonne, while the global average is USD 1945 per tonne, which is 8% lower than India's production cost. Alumina and energy cost makes up 55%-75% of the total cost of production of Aluminium.

The cost of production of Aluminium in India is influenced by several factors, including the cost of raw materials (such as Bauxite and Alumina), energy costs, labour etc.

- The average delivered Alumina cost in India is USD 659 per tonne of Aluminium, whereas the global average delivered Alumina cost is USD 715 per tonne of Aluminium. India's lower average delivered Alumina cost is mainly because India has positioned itself as the lowest cost producer of Alumina in the world as the Alumina producers in India have integrated Bauxite mines. On the other hand, countries like China, Canada and Middle East Countries have significant dependence on imports for Bauxite sourcing leading to higher Alumina cost for their smelters.
- Power is a critical input for the Aluminium industry, accounting for almost 30% - 40% of the cost of production globally. The energy cost in India is USD 745 per tonne of Aluminium, whereas globally it is USD 607 per tonne of Aluminium. While China has the highest energy cost per tonne of Aluminium produced after India, countries like Canada, Russia, and Middle Eastern nations have much lower energy costs compared to India, ranging from 30% to 60% of the energy cost of Indian Aluminium smelters. Canada being the lowest cost Aluminium producer has lowest energy cost of USD 293 per tonne of Aluminium, accounting for just 17% of the total cost. Canada's low energy cost is as a result of the adoption of hydropower for its smelters. Coal subsidies in China, natural

[77] Industry Sources

gas subsidies in Russia, and subsidized power in the Middle East and various Aluminium-producing countries give them a competitive edge over Indian players.

4.6 Primary vs Secondary Aluminium – Present Scenario[78,79]

Resource efficiency and a circular economy in the metal industry are crucial for sustainable growth. With rising demand and consumption, recycling key base metals like Aluminium is increasingly emphasized. The growth rate of secondary Aluminium has surpassed that of primary Aluminium, driven by better cost economics compared to primary Aluminium, environmental advantages, and low capital investment requirements.

Key Advantages of Secondary Aluminium

- ✓ **Lower Capital Intensity:** Producing Aluminium through the primary route involves capital and energy-intensive processes like bauxite mining, refining, and smelting. Establishing a green-field refinery and smelter of minimum economic size (1 MTPA for a refinery and ~0.5 MTPA for a smelter) with a captive power plant requires an investment in excess of INR 30,000 Crores (excluding mines and other associated infrastructure). In contrast, the recycled route, which includes sorting, melting, re-alloying, and casting scrap into ingots, is significantly less costly due to lower energy requirements. Setting up a fully mechanized recycling unit with a 1 MTPA capacity typically requires an investment of INR 1,500-2,000 Crores.
- ✓ **Low Cost of Production Compared to Primary Aluminium:** One of the key benefits of recycling Aluminium is its lower production costs compared to the primary manufacturing route. This cost advantage is primarily due to the significantly reduced energy requirements for recycling. Additionally, the presence of necessary alloyed elements in Aluminium scrap further decreases alloying costs (since it is pre-alloyed to meet specific end-use requirements when in scrap form).
- ✓ **Eco-friendly Alternative:** The production of primary Aluminium requires substantial natural resources. Industry estimates indicate that producing 1 tonne of Aluminium via the primary route in India consumes 6-7 tonnes of bauxite, 20-22 cubic meters of water, and approximately 14,000 kWh of power. In contrast, manufacturing 1 tonne of Aluminium through recycling uses Aluminium scrap as the main raw material, conserving natural resources and requiring only 5-7% of the energy needed for primary Aluminium production, thus being more energy efficient. Additionally, each tonne of Aluminium ingot produced via the secondary route emits 95% less CO_2. The primary Aluminium production process also generates significant solid waste, approximately 2-2.5 tonnes per tonne of Aluminium produced, which negatively impacts the environment. In contrast, secondary Aluminium production results in minimal solid and liquid waste.

Demand Segregation across Primary and Secondary Aluminium

Although the power sector is the largest consumer of primary Aluminium in India, the more favorable cost economics of secondary Aluminium and the strong demand for non-ferrous castings from the automotive sector, which is the biggest user of secondary Aluminium, are the primary drivers of secondary Aluminium demand in the country. The secondary Aluminium also finds an additional demand from packaging, consumer durables, and construction sectors.

[78] Assessment of secondary Aluminium industry in India, 2022, CRISIL
[79] AL Circle

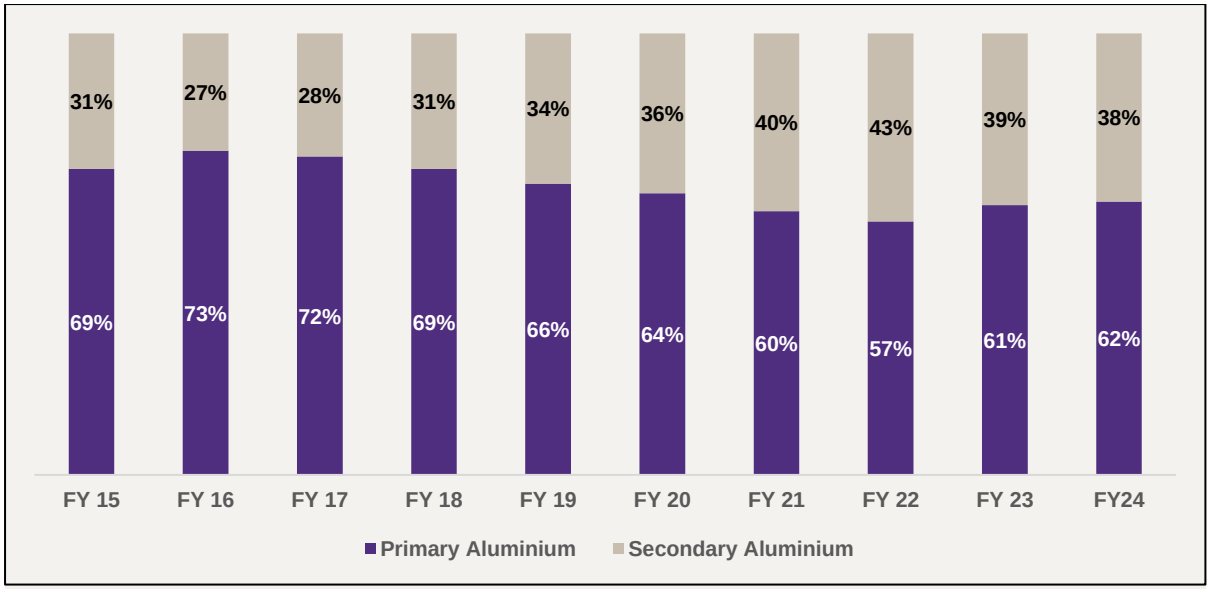

Figure 68: Primary and Secondary Aluminium share in domestic Aluminium consumption

Owing to its specific characteristics, usage of primary and secondary Aluminium across different sectors also varies significantly. While the primary Aluminium dominates the usage in power sector, the share of secondary Aluminium is very low. On the other hand, secondary Aluminium usage share is higher in transportation, packaging and construction sector.

The automotive sector consumes 40-45% of secondary Aluminium in India, while the building and construction sector, which uses 21-22%, has seen increased demand due to the rising use of recycled extrusions, especially in window frames. The packaging segment also experienced faster growth, driven by the food, beverage, and pharmaceutical industries.

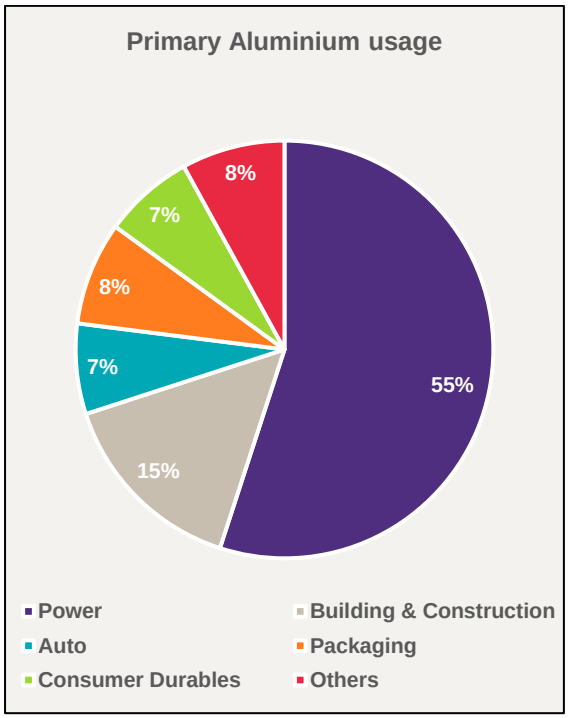

Figure 69: Primary Aluminium Usage Distribution across end-use Sectors

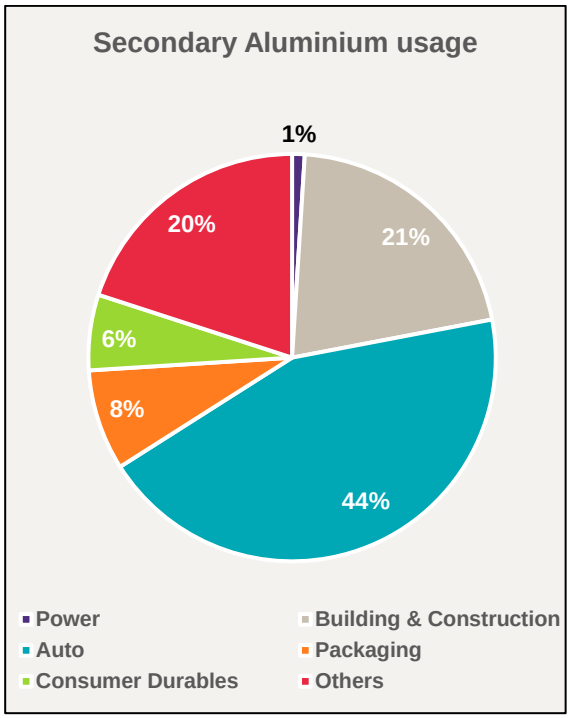

Figure 70: Secondary Aluminium Usage Distribution across end-use Sectors

Although the share of secondary Aluminium consumption in India has increased over the years, the availability of domestic scrap and sourcing scrap from other nations have been challenging. The

industry heavily depends on imports, with scrap imports accounting for 85-90% of raw material needs, exposing recyclers to risks like currency fluctuations, global scrap price volatility, upfront cash payments, and longer turnaround times. Additionally, the lack of automation in scrap recycling activities such as sorting, cleaning, and segregation poses a challenge in setting up large capacity plants. The industry is labour-intensive and lacks full automation in recycling activities, leading to lower productivity and quality control compared to larger players. Furthermore, impurities in secondary Aluminium pose risks to major end-use industries like packaging, automobiles, building and construction, and consumer durables.

To overcome the challenges facing the domestic Aluminium industry, India needs a collaborative effort between the industry and the government. Significant investment in scrap collection and processing infrastructure is essential for sustainable development. Implementing advanced technologies for sorting, cleaning, and segregating scraps can enhance productivity and quality control. Policies that encourage the use of recycled Aluminium across various sectors will drive demand, while forming alliances among recyclers can facilitate the sharing of best practices and pooling of resources. Additionally, investing in research and development to improve recycling processes and develop new applications for secondary Aluminium will spur industry growth. Stringent quality control processes are crucial to minimize impurities in secondary Aluminium, ensuring it meets industry standards.

Organizing the recycling business by integrating scrap collectors, aggregators, and rag pickers into the formal system is essential. A robust scrap metal recycling industry will significantly contribute to establishing a circular economy in the Aluminium sector, generating substantial employment opportunities and aiding in mitigating climate change by adhering to COP21 commitments and achieving sustainable development goals (SDGs).

5. Net Zero Pathway for India's Aluminium Sector

5 Net-Zero Pathway for India's Aluminium Sector

5.1 Sustainability: Global Initiatives and India's Commitments Towards Climate Change

5.1.1 World's Climate Change Goals

The collective aim of the world is that greenhouse gas (GHG) emissions need to be reduced by 45% of its 2010[80] levels which was 43.44 BnT of CO_2 equivalents[81] . In the global scale the goal also is to attain net-zero carbon emissions by 2050[80].The following are the net-zero emission goals of different countries of the world.[82]

Region	2030 greenhouse gas reduction targets	Net-zero greenhouse gas emission target
USA	To reduce the emissions by 50-52% from 2005 levels which was 6,350[83] MT of CO_2 equivalents.	The country aims to achieve net-zero greenhouse gas emissions by 2050.
European Union [EU]	To reduce emissions by 55% from 1990 levels which was about 4,284 MT of CO_2 equivalents.	The EU aims to achieve net-zero greenhouse gas emissions by 2050.
China	The target is to increase the share of non-fossil energy consumption to around 20% by 2030. Achieve peak CO_2 emissions by 2030.	The country aims to achieve net-zero greenhouse emissions by 2060.
Japan	Japan aims to reduce its greenhouse emissions by 46% in 2030 from its 2013 levels which was about 1300 MT of CO_2 equivalents.	The country aims to achieve net-zero greenhouse emissions by 2050.
Canada	Canada aims to reduce its greenhouse emissions by 30% in 2030 from its 2005 levels which was 686.29 MT of CO_2 equivalents.	The country aims to achieve net-zero greenhouse emissions by 2050.
South-Korea	South Korea aims to reduce its greenhouse emissions by 24.4% in 2030 from its 2017 levels which was 708.76 MT of CO_2 equivalents.	The country aims to achieve net-zero emissions by 2050.
Brazil	Brazil aims to reduce its greenhouse emissions by 43% from its 2005 levels which was 898.79 MT of CO_2 equivalents.	The country aims to achieve net-zero greenhouse emissions by 2050.

[80] Carbon neutrality by 2050: the world's most urgent mission, António Guterres, 11-Dec-2020, last accessed on 01-Oct-2024
[81] Total greenhouse gas emissions (kt of CO2 equivalent) | Data (worldbank.org), last accessed on 01-Oct-2024
[82] The Carbon Space Implications of Net Negative Targets, CEEW, Nov-2021, last accessed on 01-Oct-2024
[83] Greenhouse gas emissions - Our World in Data, last accessed on 01-Oct-2024

5.1.2 India's Climate Change Goals

India aims to reduce its greenhouse gas emissions intensity by GDP from 2.40 MT of CO_2/ USD billion in 2005 (The GDP of India in 2005 was USD 820[84] billion and the greenhouse gas emissions was 1970[85] MT of CO_2 equivalents) by 45% to 1.32 MT of CO_2 / USD billion in 2030[86] .India has already managed to lower the emissions intensity by GDP by 33% from its 2005 number in 2019[87]. India also aims to power 50% of its energy from renewable energy sources by 2030. By 2023 India has achieved a capacity of 43.8% energy from non-fossil energy sources[86]. India also aims to achieve net-zero greenhouse gas emissions by 2070.

5.1.3 Aluminium's role in a Net-Zero World

Aluminium's unique properties make it an indispensable material in the fight against climate change and is the key in the transition to a sustainable, low-carbon future. Its versatility and recyclability not only help reduce emissions but also support sustainable development across various sectors like transportation, construction, packaging and electrical. In this section, we have highlighted how Aluminium is contributing to a net-zero world:

Transportation: Due to its lightweight nature, the world is increasingly using Aluminium in the automotive and aerospace industries. Vehicles made with Aluminium are lighter, which improves fuel efficiency and reduces greenhouse gas emissions. To achieve its net-zero ambitions, the world's rapid transition to EVs has led to increased consumption of Aluminium in the automotive industry, as it also benefits from Aluminium by helping extend battery life and range.

Construction: The construction industry is at a pivotal moment, facing growing demands for sustainable practices and materials. In this context, Aluminium stands out as a significant contender, providing a blend of durability, flexibility, corrosion resistance, and environmental advantages. Along with other benefits, its thermal and reflective properties contribute to reduced cooling costs and energy savings when used in windows, doors, roofing, cladding, and facades.

Packaging: Aluminium can be utilized in various packaging formats, such as cans, foils, and pouches. Its recyclability and flexibility make it an ideal material for the packaging industry, enabling innovative designs that cater to diverse products and industries. Additionally, recyclable Aluminium packaging helps reduce the reliance on non-environmentally friendly materials like single-use plastics, promoting a more sustainable future.

Renewable Energy: Renewable energy sources such as solar, wind, hydro, and geothermal generate electricity without emitting greenhouse gases, making them crucial in the global push towards a net-zero world. Aluminium plays a key role in these technologies, being used in the frames of solar panels and the structures of wind turbines. Its lightweight and strong properties make it perfect for these applications, aiding in the production of clean energy.

Decarbonising Production: Aluminium is one of the most emission-intensive metals, accounting for nearly 2% of global man-made emissions. However, given its crucial role in achieving a net-zero world, there is a pressing need to decarbonize the Aluminium sector. The industry is actively working to reduce its carbon footprint by transitioning to renewable energy sources for smelting and refining processes, thereby further contributing to a net-zero future.

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[84] GDP (current US$) - India | Data (worldbank.org), last accessed on 10-Aug-2024
[85] India: CO2 Country Profile - Our World in Data, last accessed on 10-Aug-2024
[86] Non-fossil fuel sources account for nearly 44 per cent of India's total installed electricity generation capacity, PIB Delhi, 06-Dec-2023, last accessed on 01-Oct-2024
[87] Annual Report, FY24, MoEF&CC

To maximize these benefits, collaboration across industries and governments is essential. Policies that promote recycling, investment in clean technologies, and consumer awareness are all crucial in leveraging Aluminium's potential to achieve a net-zero future.

5.1.4 Contribution of Aluminium in Total Greenhouse gas emissions Globally

In 2023, the total greenhouse gas emissions were 52.96 BnT of CO_2 equivalents. The industrial combustion sector in particular emitted 6.45 BnT of CO_2 equivalents. The following is the sector wise breakup of the greenhouse gas emissions.

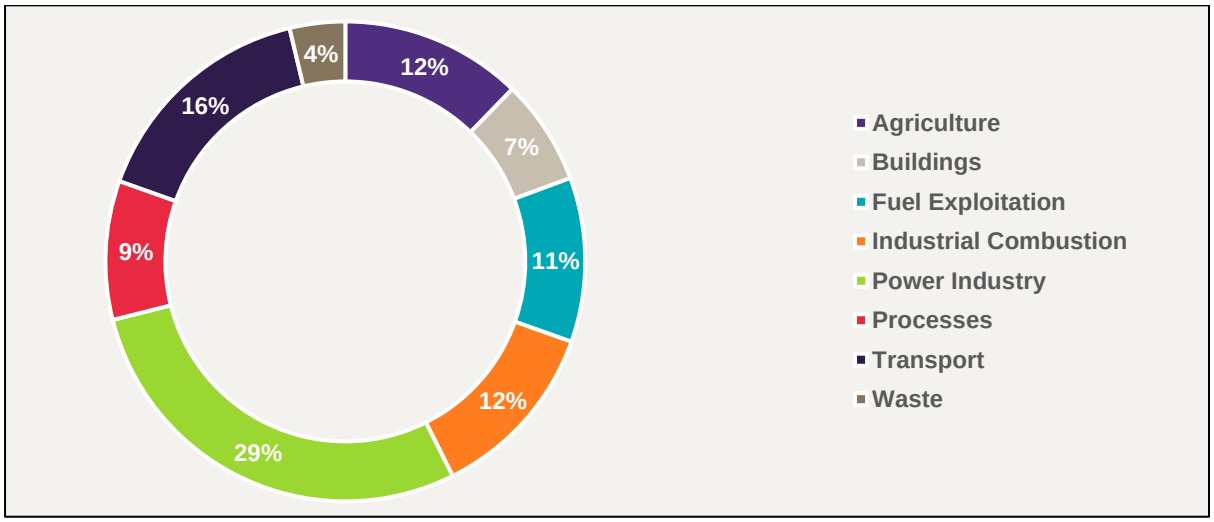


Figure 71: Sector Wise Green House Gas Emissions Worldwide (2023)

In 2023 the greenhouse gas emissions by the Aluminium sector accounted for 2% of the total greenhouse gas emissions worldwide. The Aluminium sector emitted 1.12 BnT of CO_2 equivalents while the total greenhouse gas emissions was 52.96 BnT of CO_2 equivalents.[88]

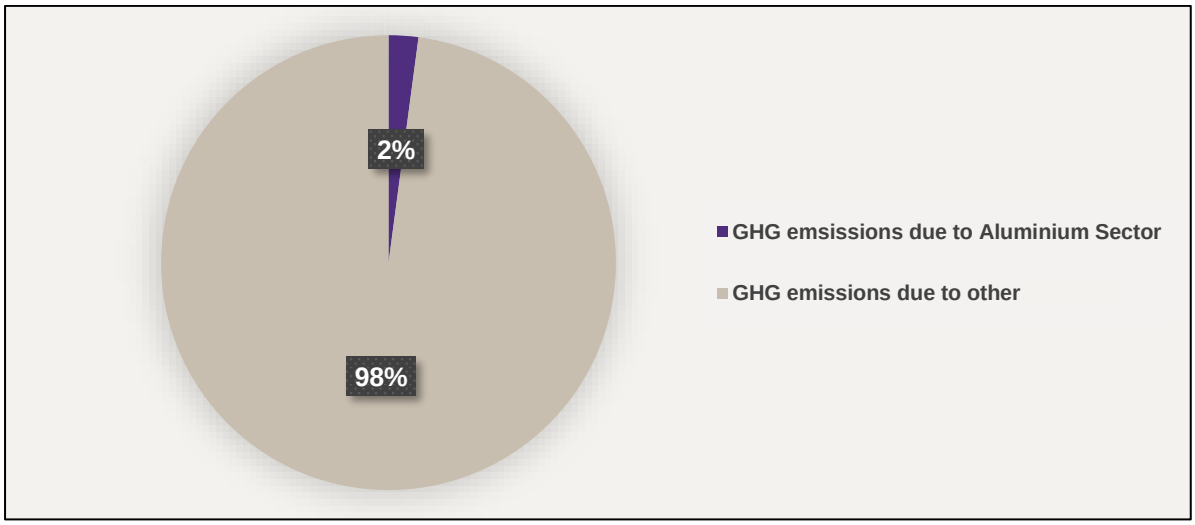


Figure 72: Contribution of Aluminium in greenhouse gas emissions worldwide

Note: Aluminium Sector includes All processes from mine (primary route) and end of life product collection (recycling route) to semis fabrication including ancillary processes, transport and electricity production

[88] Greenhouse Gas Emissions – Aluminium Sector - International Aluminium Institute, last accessed on 10-Aug-2024

5.1.5 Contribution of Aluminium in Total Greenhouse gas emissions for India

In the Indian scenario the greenhouse gas emission intensity of the Aluminium sector is 18 tonnes of CO_2 equivalents/tonne of Aluminium produced in the year 2023[89]. In 2023 India emitted 4.13 BnT of CO_2 equivalents and the industrial combustions had emitted 628.55 MT of CO_2 equivalents[90]. The total GHG emission of Indian aluminium industry was estimated as 82 MT of CO_2 equivalents in 2023.

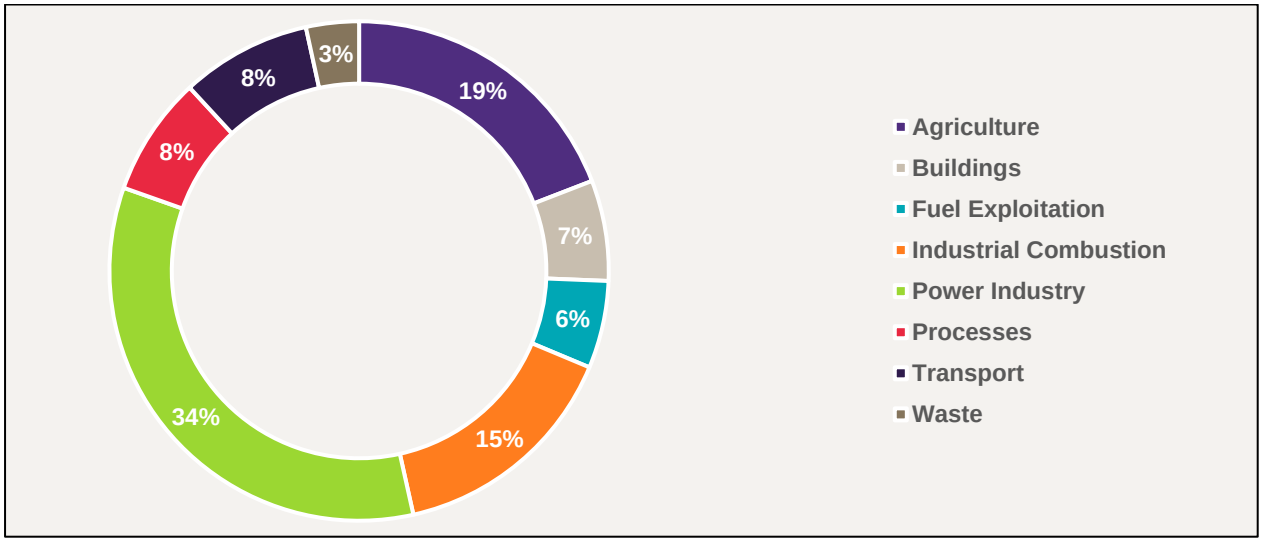


Figure 73: Sector wise greenhouse emissions in India (2023)

5.1.6 Greenhouse gas emissions scenario for Aluminium Sector.

In 2023 the greenhouse gas emissions intensity in the Aluminium sector (globally) was 14.8 tonnes of CO_2 equivalents/ tonne of Aluminium. The following is the historical data of the greenhouse gas emission intensity in the Aluminium sector from 2005-2023.[91]

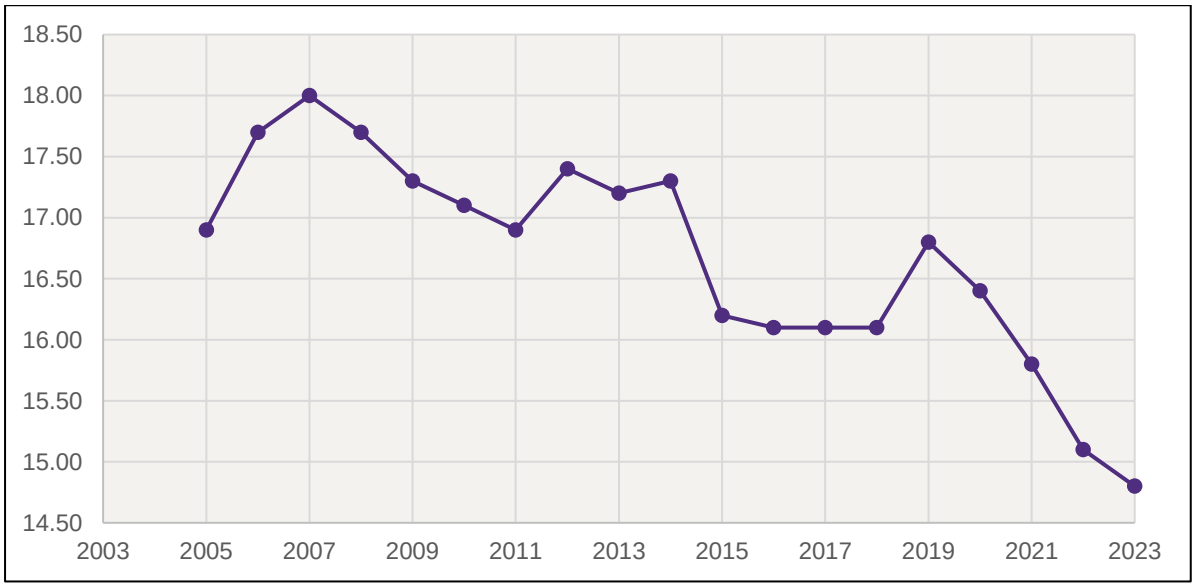


Figure 74: Greenhouse gas emission intensity in the Aluminium sector (worldwide)

[89] https://jmkresearch.com/wp-content/uploads/2025/04/Green-Power-Procurement-by-Aluminium-Sector-in-India_JMK-Research.pdf
[90] EDGAR - The Emissions Database for Global Atmospheric Research
[91] Greenhouse Gas Emissions – Aluminium Sector - International Aluminium Institute, last accessed on 10-Aug-2024

Greenhouse gas emission intensity growth in the Aluminium Sector

Future projections of greenhouse emission intensity in the Aluminium sector assumes two scenarios. The first scenario is the 2050 net-zero emissions scenario which would result from decarbonization efforts such as applying inert anode technologies, using carbon capture storage technologies, switching to renewable energy sources for electricity generation etc. The second scenario is the 2050 Business as usual (BAU) scenario which assumes no significant decarbonization initiatives.[92]

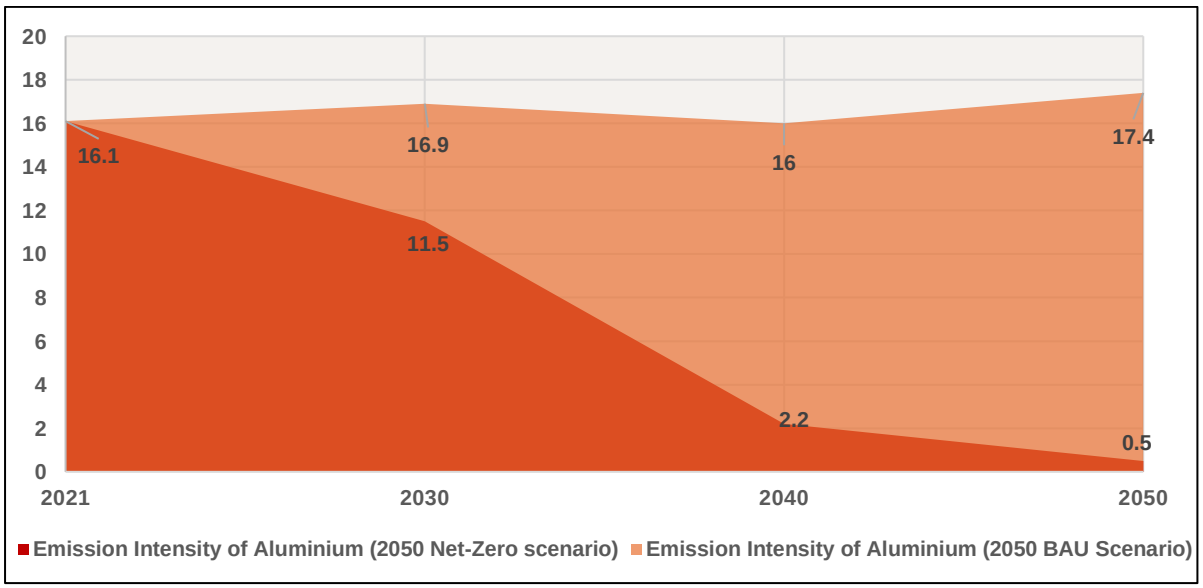


Figure 75: Future projections of greenhouse emissions in the Aluminium sector

5.1.7 Pathway for carbon neutrality in the Global Aluminium Industry

Decarbonizing the power supply:

Almost 70% of the carbon emissions during the Aluminium production are released from the electricity consumption during the smelting process as the only commercial process for Aluminium production is the Hall-Heroult process, where smelter grade Alumina is produced from Bauxite in the Bayer process. Direct electric current is passed through prebaked carbon anodes and predominantly CO_2 is formed as a by-product. The decarbonization of the power supply can be achieved in the following ways.

1. Transitioning to renewable energy sources such as hydropower, geothermal, nuclear etc.
2. Using Carbon Capture Utilization and Storage (CCUS) technologies to capture CO_2 by separating it from other gases and either being transported to a suitable site for geological storage or injected deep underground.

Decarbonizing process emissions:

Process emissions refer to the emissions released during industrial processes and on-site manufacturing. Anode consumption in 2018 approximately accounted for 10% of sectoral emissions. and the burning of fuel was responsible for 15–20% of them. The production of primary Aluminium generates direct emissions from the electrolysis of Alumina using a carbon anode during smelting and from fuel combustion during unit processes to produce heat and steam. This can be achieved in two ways.

1. Development of a non-carbon anode. Replacing carbon anodes with an inert anode eliminates direct emission from electrolysis.

[92] Net-Zero Industry Tracker 2023 Edition, World Economic Forum, Nov 2023

2. Transitioning to replace the use of fossil fuels. Using fossil fuels during refining can be replaced by using green-hydrogen, solar water heaters etc.

Increasing scrap recovery:

The production from scrap only requires 5% of the energy compared to the production of primary Aluminium. If 14.25 MT of scrap can be recycled it would result in the savings of an estimated 250 MT of CO_2 emissions per year. Scrap Aluminium has a great demand in the manufacture of automotive parts, building materials, packaging (such as cans and foil), and consumer goods. Scrap Aluminium can be better collected by improving collection and sorting systems for Aluminium waste also by increasing public awareness about the benefits of recycled Aluminium.

Some of the initiatives being undertaken by global and domestic producers for the decarbonisation of the Aluminium industry have been provided in Annexure 3.

5.1.8 Pathway for carbon neutrality in the Indian Aluminium Industry[93]

The Indian Aluminium industry emits 20.88 tonnes of CO_2 per tonne of Aluminium in 2021 (18 tonnes of CO_2 per tonne of Aluminium in 2023). The following are the pathways for the net zero greenhouse gas emissions in the Indian Aluminium industry.

1. Power sourced from renewable energy sources would reduce about 49% of the total greenhouse gas emission intensity. As Aluminium production requires large amount of reliable supply of electricity, we consider that 30% of the electricity demand still has to be met through captive power plants.
2. Using Carbon Capture Technologies would help in capturing the CO_2 emissions and storing them to geological locations, thereby reducing 21% of the total greenhouse gas emission intensity.
3. Increasing energy efficiency during the Aluminium smelting process and during the Alumina extraction process would reduce 30% of the total greenhouse gas emission intensity.

The following is the graphical representation of net-zero greenhouse gas emission intensity pathway in the Aluminium sector.

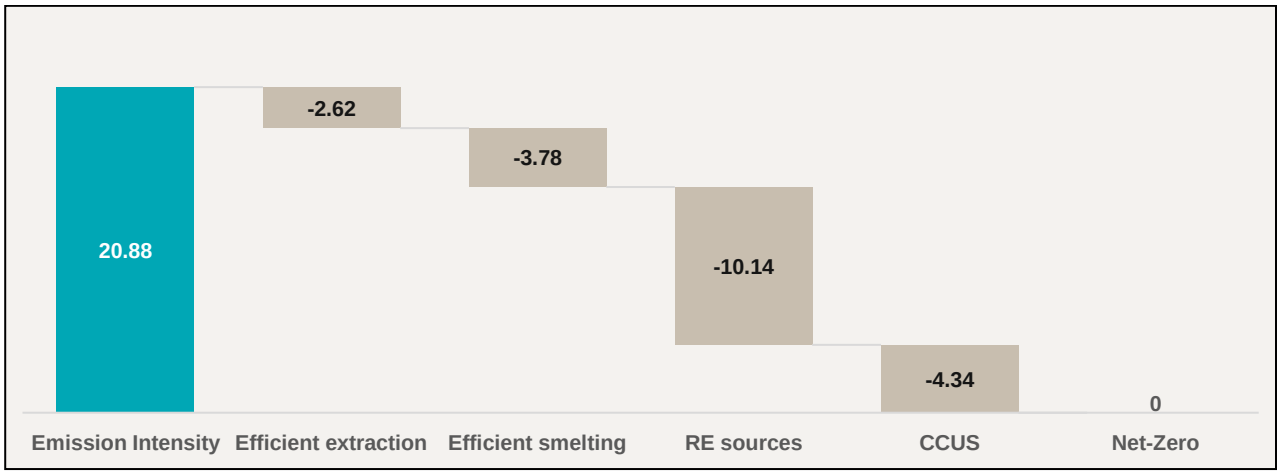


Figure 76: Emission mitigation pathway for Alumina refining and Aluminium smelting (tonnes of CO_2/tonne of Aluminium)

[93] Evaluating Net-zero for the Indian Aluminium Industry, CEEW, April 2024

5.2 CCUS in Aluminium Sector[94]

The urgent need to decarbonize the Aluminium industry is evident. While various techniques and alternative fuel sources aim for net zero by 2050, carbon capture stands out as a mature technology already used in other energy-intensive sectors. This process can significantly reduce global warming.

Carbon Capture, Storage and Utilisation is a three-step process involving capturing the carbon dioxide produced by power generation or industrial activity, transporting it and then it is stored deep underground in porous rock layers or transferred via pipeline for reuse.

In most industries, CCUS is mature, but in the Aluminium sector, it is still in the early stages. Despite this, it holds great potential for reducing the industry's carbon footprint.

Although CCUS seems plausible, its adoption in the Aluminium Sector faces some challenges. The primary challenge is the low CO_2 Concentration. Aluminium smelters' off-gas contains only about 1% CO_2, while existing carbon capture technologies are designed for higher concentrations (around 4%). Also, the off-gas pollutants are incompatible with current carbon capture technologies.

One of the leading Aluminium producers, Norsk Hydro, has made significant advancements in CCUS. In 2021, Hydro partnered with Verdox, investing USD 20 million to develop an all-electric carbon capture technology. This technology, tested in Hydro's primary Aluminium smelter, shows promise and aims for industrial-scale implementation by 2030.

CCUS is relatively new in India but is gaining traction. IIT Guwahati and NTPC are developing an energy-efficient system for capturing CO_2 from power plants, consuming up to 11% less energy than current methods. IICT Hyderabad has developed a process to convert CO_2 into high-purity hydrogen from non-fuel grade bioethanol.

As these technologies mature, top Aluminium producers in India are expected to adopt carbon capture to effectively reduce emissions thus contributing to the decarbonisation of the sector in India.

5.3 Green Aluminium: The Sustainable Metal-Key Trends

5.3.1 What is Green Aluminium?

Due to its production power source—hydroelectric, geothermal, nuclear, etc.—or proportion of recycled content, environmentally friendly Aluminium is also known as "Green-Aluminium." Due to its significantly lower carbon footprint than conventional Aluminium production methods, it is frequently referred to as low-carbon or zero-carbon Aluminium. In particular, it includes delivering Aluminium with emissions of less than 4 metric tonnes of CO_2 per metric ton of Aluminium on a cradle to gate basis. This includes emissions from the smelter all the way to the product's end of life.[95]

5.3.2 Benefits of Green Aluminium

1. Mining, refining, and smelting are necessary steps for primary Aluminium production which are energy intensive, but secondary Aluminium production does not require as much energy. Aluminium scrap is collected, shrunk, separated, and melted during the secondary Aluminium production process. As a result, recycling Aluminium only requires 5.0 to 7.0% of the energy required to produce Aluminium from ore.

[94] The Aluminium industry and carbon capture utilization & storage, Al Circle, 2-Mar-2023, last accessed on 01-Oct-2024
[95] Aluminium Research, Analysis & Consulting | HARBOR Aluminium

2. Recycling of Aluminium makes it a green metal as it utilizes considerably less energy as compared with primary Aluminium, emits less harmful gases, generates minimal waste, requires less water, and does not cause deforestation.
3. Recycled Aluminium will help in achieving zero land degradation goals by restoring land that was degraded by 2030. Primary Aluminium manufacturing process results in generation of hazardous waste and red mud that results in soil pollution.
4. It limits deforestation and conserves biodiversity.
5. Recently there has been an increasing demand in green Aluminium products especially in the luxury automobiles section. This trend presents an opportunity for Aluminium producers to differentiate their offerings and seize a competitive edge in the emerging green economy.[96]

5.3.3 World's Initiative towards Green Aluminium

Europe

Europe has the highest Aluminium recycling rate efficiency at 81%. Additionally, according to the European Aluminium Association, the landmass has the highest per capita Aluminium re-use rate. In fact, recycled Aluminium accounts for more than half of all Aluminium produced in Europe. Likewise, end-of-life Aluminium recycling rates are high in Europe, at more than 90% in the construction and automotive sector and 60% in the packaging sector. Europe also aims to increase the recycling rate to ensure 100% recycling and availability of scrap. In fact, the region is targeting to implement improved waste collection systems, better sorting and Aluminium recovery infrastructure, and end-user engagement to achieve 100% Aluminium beverage can recycling by 2030.

Norway's Norsk Hydro's has a carbon footprint below 4 tonnes of CO_2/kg of Aluminium. Their primary Green Aluminium product, called Hydro-Reduxa, uses at least 70% renewable energy sources such as wind, solar and hydro power. The secondary Green Aluminium product called Hydro-Circal, which takes in at least 75% of post-consumer scrap has a carbon footprint of 1.9 tonnes of CO_2/ tonne of Aluminium. Also, they are currently in the process of researching a way to replace liquid natural gas with green hydrogen in the recycling of post-consumer scrap. Hydro has also collaborated with PADNOS to start commercial operation of an advanced scrap sorting technology for processing complex post-consumer scrap and achieve higher scrap recovery.

Asia

In China the percentage of energy used by hydropower sources in Aluminium smelters increased from 10% in 2015 to 19% in 2024. In China majority of Carbon emissions from Aluminium are scope-2 emissions. The scope 2 carbon emissions by Aluminium smelters in Yunnan is around 0.7 tonnes per tonne of Aluminium. In December 2022, Non-ferrous metals society of China and China Non-ferrous Metals Industry association (CNIMA) published a guide so that Green-Aluminium can be distinguished from Aluminium produced using thermal power thus satisfying the demands of downstream products of the consumers. China produces more than 10 MT of scrap Aluminium each year, accounting for over 30% of the annual global total.

Middle East

The UAE was apparently the first country in the world to produce Aluminium using the power of the sun according to a 2021 report Dubai Electricity and Water Authority (Dewa) and Emirates Global Aluminium (EGA) released. Dewa is the supplier of EGA's smelter with 560,000 megawatt hours of solar power yearly from the Mohammed bin Rashid Al Maktoum Solar Park. The energy is sufficient to make 40,000

[96] Industry Sources

tonnes of Aluminium in the first year with the potential for significant expansion. EGA will supply solar power-based Aluminium to global customers under the new product name, CelestiAL.

North America

According to IAI, North America has the world's highest RIR (Recycling Input Rate) which is a metric used to quantify the proportion of recycled material used as the input for production of new materials or products with 57% of the metal produced in the region originating from scrap.

5.3.4 India's Initiative towards Green Aluminium

Recycling Technologies

In India, Aluminium scrap import follows International Scrap Recycling Institute (ISRI) specifications. To ensure that the imported scrap does not have any hazardous element, the Aluminium scrap is checked by Customs for ISRI-based specifications, and radioactive elements and explosives. Scrap Aluminium is processed for return to the market in a series of steps: pre-processing, melting, alloying, refining, and casting. At present Indian recyclers have implemented following technologies.

1. Automatic segregation and sorting equipment such as eddy current separator, washing table, heavy media separation, color sorters, and others.
2. Shredder / shearing machines to cut large scraps into required sizes.
3. Smelting furnaces.
4. Automatic casting and stacking system, cyclone separators, scrubbers for emissions such as dust and gas/fumes to ensure eco-friendly processing.
5. Auto chargers for feeding raw material into furnaces
6. Regenerative burners to achieve better combustion efficiency, reduced fuel consumption and reduced emission of CO and CO_2 into the environment
7. Dross processing to minimize or avoid solid waste.

5.4 Enabling the Circular Economy with Aluminium[97,98,99]

The circular economy is a sustainable model designed to minimize waste, reduce emissions and maximize resource use. Unlike the traditional "take-make-dispose" approach, it focuses on keeping products, materials, and resources in use for as long as possible. Key principles include designing products to be durable, repairable, and easy to disassemble, promoting reuse and refurbishment. When items reach the end of their life, they are recycled or repurposed, closing the material loop.

The circular economy aims to separate economic growth from resource use and environmental harm. It promotes sustainable practices that benefit the environment and offer economic advantages, such as lower production costs, new opportunities in recycling and remanufacturing, and greater resilience to resource scarcity and supply chain disruptions. Governments, businesses, and organisations worldwide are increasingly adopting circular economy principles to address these challenges and create a more sustainable and resilient global economy.

In an era where environmental sustainability is of utmost importance, Aluminium plays a crucial role in this model due to its high recyclability. It can be recycled indefinitely without losing its properties, making

[97] Innovation action plan for Aluminium in a circular economy, Dr. Christopher Pilgrim, last accessed on 01-Oct-2024
[98] IAI study highlights vital role of Aluminium cans in a circular economy, International Aluminium Institute, last accessed on 01-Oct-2024
[99] How Aluminium is leading the circular economy recycling revolution, Al Circle, 14th Oct 2023, last accessed on 01-Oct-2024

it a key driver in India's climate-neutral and circular economy ambitions. Recycling Aluminium uses only 5% of the energy required to produce new metal, significantly reducing CO_2 emissions.

For example, Aluminium cans are widely used in the beverage industry and are an environmentally responsible choice due to their recyclability. Today, Aluminium cans are the most recycled beverage containers globally. Once collected, they have an unrivaled sorting, reprocessing, and remelting efficiency rate of 90%, compared to 67% for glass and 66% for PET.

However, challenges remain. Improving the collection and sorting of Aluminium products, raising consumer awareness about recycling, and investing in advanced sorting technologies and recycling infrastructure are essential to fully realize Aluminium's potential in the circular economy.

By embracing a circular economy framework and fostering collaborative communities based on three key principles: Circular Design, Circular Business Models, and Circular Recovery; we can inspire industry members to unite in reducing environmental impact and achieving Net Zero goals.

- **Circular Design:** From choosing materials to evaluating how products and services interact with people and systems, and considering end-of-life disposal, design is a fundamental pillar of circular economy systems. The Aluminium sector can reduce its environmental impact by improving design practices.
- **Circular Recovery:** Focusing on retaining assets throughout value chains and procurement policies can reduce the need for new feedstocks, lower costs, and mitigate supply chain risks. This is particularly important for Aluminium, where primary production has a significant environmental impact.
- **Circular Business Models:** Circular business models define how an organization creates and delivers value to stakeholders while eliminating waste and environmental harm as materials and products circulate through the economy. Aluminium has the potential to lead in setting environmental standards, enhancing the value of domestic production, and achieving more with fewer resources.

For a Circular Economy to be truly effective, it must operate as a closed-loop system. This requires Aluminium product manufacturers to collaborate closely with end-user industries to enhance scrap collection and sorting, minimizing the mixing of alloys. By returning scrap to the original manufacturer rather than repurposing it or selling it to scrap dealers, the loop can be closed. Recycling within the same alloy family is crucial for achieving closed loop circularity. Mixing different alloys makes the resulting metal difficult to reuse for its original purpose and often necessitates adding large amounts of new metal.

For example, if scrap from an Aluminium uni-alloy car door is sent back to a rolling mill and recycled in a closed-loop process, it can be continuously remanufactured into material for new car doors. However, if Aluminium alloys are mixed with other alloy families during the scrap sorting process, they may no longer be fit for use to produce wrought materials, such as car doors. Instead, they will be utilized in a different value stream, representing a significant missed opportunity for circularity and resulting in a loss of CO_2 savings[100].

Brazil exemplifies an effective closed-loop recycling system, particularly for Aluminium beverage cans. In 2022, the country achieved a remarkable milestone by recycling 100% of the Aluminium cans consumed domestically. Aluminium cans are collected from various sources including homes, businesses and public spaces through a well-organized network of collectors and recycling centers. It has initiatives like "Garimpeiro Urbano" (Urban Mining), which involve extensive networks of collection centers working with local suppliers, cooperatives, and municipalities to gather recyclable materials. It

[100] Closed Loop Aluminum Recycling is a Key Driver in the Sustainable Cars of the Future, Light Metal Age, April 25, 2024, last accessed on 03-Oct-2024

employs state-of-the-art automated sorting systems to separate Aluminium from other materials. Advanced sorting technologies in Brazil can separate Aluminium scrap based on density and chemical composition. At recycling facilities, the cans are sorted to remove contaminants and compressed into bales for easier handling and transportation to reprocessing plants where the Aluminium is shredded, de-coated, melted, and cast into ingots. Finally, the ingots are rolled into fresh Aluminium sheets, ready to be used in manufacturing new beverage cans[101].

Companies like Novelis and Constellium collaborated with end-user industries to establish closed-loop circular systems for Aluminium, ensuring high-quality standards and significantly reducing emissions.

5.5 Comparison of India as against global Aluminium recycling rates

5.5.1 Aluminium life Cycle

Aluminium production starts with the mining of Bauxite. Bauxite is then refined using the Bayer process to extract Alumina. Alumina is then broken down by electrolysis to produce primary Aluminium. The primary Aluminium is then fabricated to make finished products.

After their usage the products reach a stage after which they are no longer useful, this stage is called End of life products. From the end-of-life products a certain portion is recovered for recycling. This portion is often contaminated, and it requires extensive sorting, cleaning and remelting to recycle the scrap to produce secondary Aluminium.

5.5.2 Different metrics for Aluminium Recycling Rates

There are various metrics for Recycling Rates of Aluminium. The two most significant one are[102]:

End of Life Recycling Rate (EOL-RR):

The End-of-Life Recycling rate is defined as the ratio of Recycled End of Life metal to the End-of-Life metal products. It depends on two factors, which are the old scrap collection rate and recycling rate efficiency. Their product gives the End-of-Life Recycling Rate. The EOL-RR for India for Aluminium is around 30%[103] while the global EOL-RR is around 56% as the old scrap recovery rate for Aluminium for the world is about 74% and the recycling rate efficiency for Aluminium globally is 76%[104].The old scrap recovery rate of China is quite high at over 80% as per 2021 figure. The highest recycling efficiency rate of Aluminium is of Europe which is at 81% which makes their EOL-RR at about 64% as their old scrap recovery rate is about 79%[105]

Recycling Input Rate (RIR):

The Recycling Input Rate refers to the fraction of scrap metal in the total input of metal production. The RIR for India is around 25% while the global average RIR is around 35% as per 2021 figure. Europe and North America both have RIR of around 60%

5.5.3 Reasons for India's low Recycling rate of Aluminium

The low recycling rates of Aluminium in India can be attributed to several factors:

Infrastructure and Technology Limitations:

[101] Pioneering and the point of reference in Aluminium recycling, LATASA Brazil, last accessed on 03-Oct-2024
[102] Recycling Rate of Metals, A Status Report, UNEP
[103] National Non-Ferrous Metal Scrap Recycling Framework, Ministry of Mines, 2020
[104] Aluminium Recycling, International Aluminium Institute, 2021, last accessed on 03-Oct-2024
[105] Public Access - International Aluminium Institute (world-Aluminium.org), last accessed on 03-Oct-2024

The recycling infrastructure in India is underdeveloped compared to other countries. Limited access to advanced recycling technologies hampers the efficiency and profitability of recycling operations. Consequently, the recycling rates remain low because many recyclers are unable to invest in or access the necessary technology.

Lack of Awareness and Segregation at Source:

There is insufficient public awareness about the importance of Aluminium recycling. Coupled with inadequate waste segregation practices at the source, a large portion of Aluminium scrap ends up in landfills instead of being recycled. This issue is compounded by the informal nature of the recycling sector in India, which often lacks the resources and organization to efficiently collect and process Aluminium waste.

Market Dynamics:

Fluctuations in global Aluminium prices, especially on the London Metal Exchange (LME), also affect recycling rates in India. When prices drop, the incentive to recycle decreases because the economic returns are lower, leading to reduced recycling activity

These factors collectively contribute to the relatively low recycling rates of Aluminium in India, despite the growing demand for the metal. Addressing these issues will be crucial for improving the sustainability of the Aluminium industry in the country.

Ultimately, Aluminium stands out as a key commodity in the circular economy due to its exceptional recyclability and versatility. As environmental responsibility becomes more crucial, Aluminium's importance will grow. By enhancing recycling practices and embracing this metal, we can work towards a greener, more sustainable future with conserved resources, minimized waste, and a thriving circular economy.

6. Demand Forecast 2030 and 2047

6 Demand Forecast 2030 and 2047

6.1 Megatrends likely to Affect Aluminium Industry

Megatrends (MTs) are affecting nearly every facet of human life. Trends like rapid urbanisation, climate change, and shifting economic power are transforming markets, disrupting supply chains, and altering global manufacturing demographics. These megatrends are currently driving the growth in Aluminium demand globally and in India and it will play a crucial role in determining the industry's future demand trajectory.

Several megatrends (MTs) exhibit overlapping effects. For instance, population growth and urbanisation contribute to rising energy demand. This increased energy demand intersects with other megatrends, such as climate change, particularly in the expansion of renewable energy sources.

6.1.1 Growing Population and Urbanization

The history of humanity is one of urbanization and the swift expansion of cities. The world population is estimated to have surpassed 8 billion in 2022, with 56.9% of the global population living in urban areas, up from 30% in 1950. By 2050, the UN forecasts that 68% of the world's population, which is projected to be 9.67 billion, will live in cities. India's population is estimated to be 1.67 billion in 2050, with nearly 53% living in urban areas.

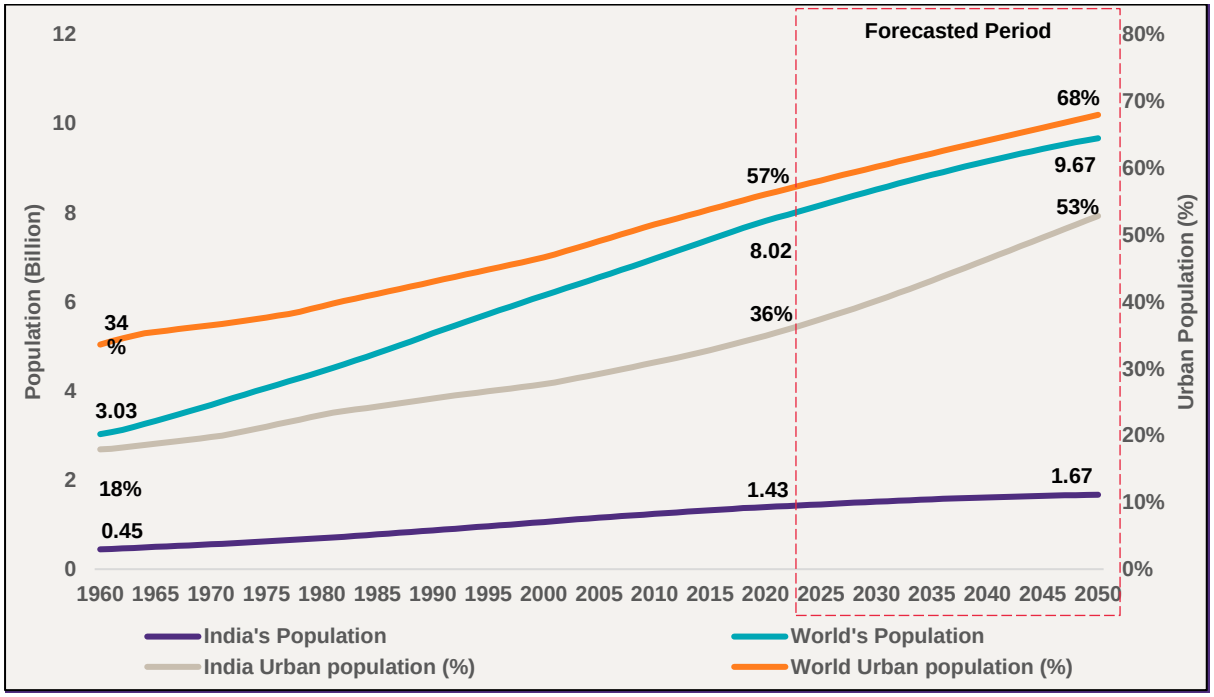


Figure 77: World and India Population and Urban Population (%)

Increasing population and urbanization naturally create more Aluminium demand, particularly in construction, electrical grid expansion, infrastructure, and transport. With urbanization rates growing fastest in Asia (especially in India and China) and Africa, stronger growth is forecast in these regions.

6.1.2 Energy Demand and Sources

Urbanization, characterized by the rapid expansion of cities and dynamic economic development, particularly in emerging economies, is driving a continuous rise in energy demand. Due to climate change commitments, the world is increasingly adopting cleaner methods of electricity production. Achieving these targets, including net zero goals, has significant implications for future pathways. Clean

electrification, enhanced efficiency, and a transition to lower- and zero-carbon fuels are crucial strategies for emerging and developing economies to meet their national energy and climate objectives.

India leads the world in energy demand growth, surpassing Southeast Asia and Africa. The country is entering a dynamic new phase in its energy development, characterized by a long-term net zero emissions goal, advanced regulatory measures, a focus on clean energy deployment, and the establishment of domestic clean energy technology supply chains. Recognizing the potential to transform its energy sector, reduce fossil fuel imports, and lower CO_2 emissions, India has set a net zero emissions target for 2070 and implemented policies to scale up clean energy supply and technology manufacturing. India is expected to achieve its 2030 target of having half of its electricity capacity from non-fossil sources well before the end of the decade. If the new solar PV module manufacturing capacity under the PLI program becomes fully operational by 2026, it will significantly advance India's solar PV module manufacturing capacity, exceeding the requirements for the end of this decade in both the STEPS (Stated Policies Scenario) and APS (Announced Pledges Scenario) scenarios. While the World's electricity generation is estimated to grow at a CAGR of 2.24% and 3.02% by 2050 in the STEPS and APS scenarios respectively, India's electricity generation is expected to grow at a much faster pace. India's electricity generation is estimated to grow at a CAGR of 4.27% and 4.82% by 2050 in the STEPS and APS scenarios respectively.

Electricity transmission has long been a significant and established market for Aluminium. It is also essential for the renewable energy sector, including solar and wind systems, representing a strong growth area. The World Bank estimates that Aluminium demand in this sector will reach 5.5 MT by 2050. Bloomberg NEF forecasts that, to achieve a net-zero world, global transmission lines will nearly triple by 2050, from about 6 million kilometers in 2020. India's Green Energy Corridor project aims to create transmission capacity to integrate an increasing share of variable renewable power. The transmission plan targets the integration of 500 GW of renewable capacity by 2030. As of October 31, 2022, the total circuit kilometers (ckm) of transmission lines in India was 463,758 ckm, and by 2030, an additional 50,890 ckm will be required to integrate the additional renewable energy capacity[106].

On one hand, growing demand is expected to boost Aluminium consumption. However, since electricity is a major cost factor in Aluminium production, rising energy prices could negatively impact demand. Recently, the surge in energy prices across Europe, fueled by the Russia-Ukraine war, has led to higher production costs and reduced Aluminium output. In China, stringent energy consumption policies and efforts to reduce carbon emissions have caused power shortages and increased energy costs. Similarly, in the Middle East, rising energy prices have affected the cost of Aluminium production, impacting their competitiveness in the global market.

Overall, the Aluminium demand will continue to grow driven by the energy demand and other megatrends like population growth, urbanisation, and economic growth.

[106] Transmission System for Integration of over 500 GW RE Capacity by 2030, Central Electricity Authority, Dec-2022, last accessed on 01-Oct-2024

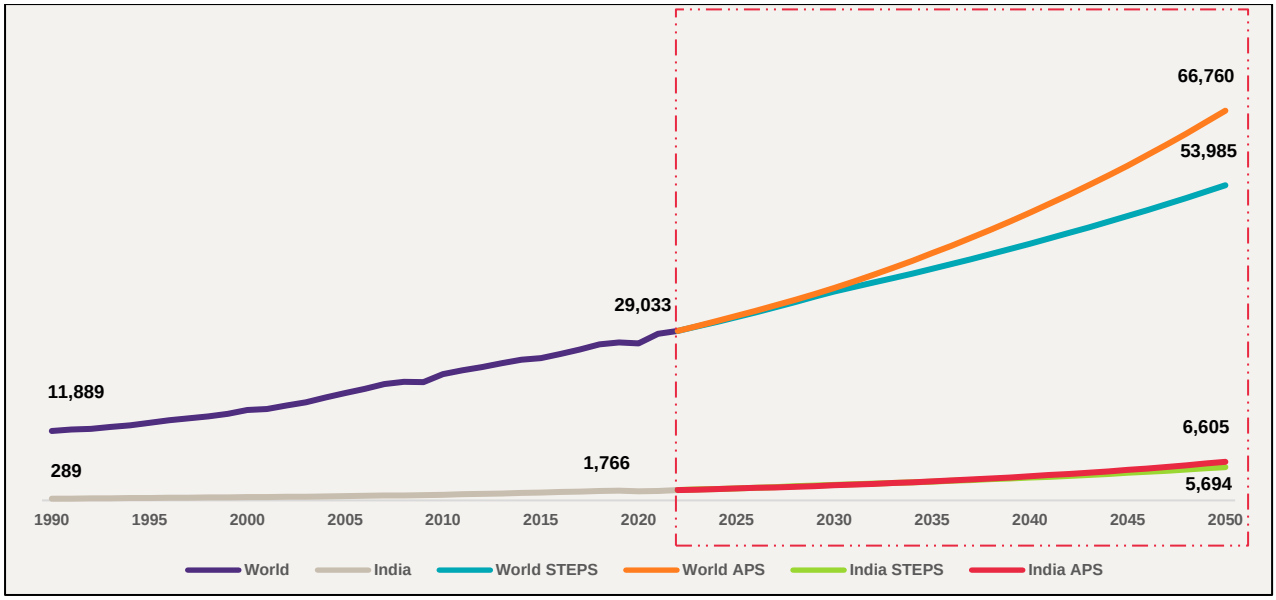


Figure 78: World and India Electricity Generation Estimates (TWh)[107]

6.1.3 Technology Disruptions[108]

Technological advancements are accelerating, and their impacts are increasingly significant. These changes will greatly influence Aluminium demand, though predicting specific outcomes is challenging. Technological disruptors could either increase or decrease Aluminium demand. For instance, a new low-cost Aluminium smelting process could make Aluminium more cost-competitive against substitutes, while new materials could reduce its competitiveness.

New Aluminium alloys could open up new applications and markets, whereas alternative materials like high-strength wood products and lightweight ceramics might capture market share from Aluminium. Research is ongoing into high-strength power cable alloys that could reduce the volume of Aluminium needed to carry the same current.

Aluminium batteries are also a very active research area with the potential to significantly boost demand. Aluminium demand is also expected to increase with innovations in sectors such as automotive, aerospace, and electronics which need high-performance materials. On an average, 40-45 kg of Aluminium is used per vehicle in India compared to the global average of 160-200 kg. The focus on vehicular weight reduction to improve fuel efficiency will also result in higher Aluminium consumption in India[109]. It is worth studying how global vehicles with more Aluminium content still perform better in crash-tests compared to Indian automotives.

The Aluminium demand for EVs is expected to rise significantly, with global EV sales projected to reach 62 million units by 2050 with nearly 700 million units on roads.[110] Nearly 14 million new electric cars were registered globally in 2023. As per projection on the basis of the data from Vahan portal and NITI Aayog's sales projections, EV stock in India will become 3.49 Crores in 2030 from 0.40 Crores in 2024 and rise to 15.19 Crores in 2050, while the EV battery market is expected to grow the same timeframe.

The substitution of Aluminium by carbon fiber is a significant threat across various industries. Carbon fiber composites, made from carbon fibers and resin, are leading the charge in replacing traditional Aluminium parts. These composites have an exceptional strength-to-weight ratio, being up to five times

[107] World Energy Outlook 2023, International Energy Agency
[108] An Assessment of Global Megatrends and Regional and Market Sector Growth Outlook for Aluminium Demand, CM Group, 2020
[109] Primary Aluminium Industry, ICRA, Aug 2023, last accessed on 03-Oct-2024
[110] 700 million electric vehicles will be on the roads by 2050, Wood Mackenzie, Feb 08, 2021, last accessed on 03-Oct-2024

lighter than steel and much lighter than Aluminium. This weight reduction enhances fuel efficiency in vehicles, lowers energy consumption in machinery, and increases payload capacity in aerospace. The shift from Aluminium to carbon fiber is already evident in many sectors, showcasing clear benefits.[111]

New research from Cranfield University's Sustainable Manufacturing Systems Centre has found that switching from Aluminium to zinc alloys in automotive parts can significantly enhance their longevity and sustainability. The study highlights that zinc alloys are more sustainable and offer higher performance compared to Aluminium.[112]

Despite the potential for disruptions due to adverse technological changes, it is believed that technological advancements in the Aluminium and associated sectors will have an overall positive impact on Aluminium demand growth.

6.1.4 Climate Change

Despite efforts to reduce carbon emissions, greenhouse gas levels in the atmosphere continue to worsen. This is leading to rising global temperatures and an increase in the frequency and severity of extreme weather events which are increasingly affecting every aspect of human life. According to a press release by World Meteorological Organisation, Global temperature is likely to exceed 1.5°C above pre-industrial level temporarily in next 5 years[113]. This underscores the need for urgent measures to achieve more rapid cuts in GHG emissions.

Aluminium plays a crucial role in combating climate change, primarily through light-weighting in transportation, especially in vehicles, as well as in renewable energy infrastructure and power cabling. The demand and supply of Aluminium are closely linked through the primary production process. The carbon footprint is becoming a key quality attribute for all materials. Primary Aluminium production is highly CO_2-intensive when fossil fuels are used for electricity, which harms its long-term reputation and suitability as a preferred material. The Aluminium industry must decisively reduce average CO_2 emissions to avoid significant demand challenges, driven by consumer backlash and stringent government restrictions on high CO_2 emitters.

Sustainability reports from Aluminium companies increasingly outline plans to achieve zero carbon by 2050. In the coming years, with the transition to renewable energy sources, implementation of CCUS technologies, improving energy efficiencies, increased recycling and adoption of low carbon technologies, the Aluminium industry is expected to address CO_2 emissions during primary production, leading to substantial long-term growth.

6.1.5 Changing Geopolitical Landscape

Aluminium industry forms the foundation of modern manufacturing and infrastructure, essential for everything from automobiles and electronics to green energy and even soda cans. Most importantly though, Aluminium industry is the backbone of aerospace sector which has strategic significance. However, this market is being impacted by the significant transformations taking place in the geopolitical landscape. Understanding these dynamics is crucial for navigating the challenges and opportunities it presents for the Indian Aluminium industry.

Traditional alliances are being tested and reconfigured. The rivalry between the United States and China is a central feature of the changing geopolitical order. This competition influences global alliances, trade policies, and military strategies. The interactions between these two nations are pivotal

[111] Upgrading to the Future: Replacing Aluminium parts with Carbon fibre, Carbon Parts, 01-Aug-2023, last accessed on 01-Oct-2024
[112] Switching from aluminium to zinc alloys could make cars more sustainable, IMECHE, 09- Jun- 2020, last accessed on 01-Oct-2024
[113] Global temperature is likely to exceed 1.5°C above pre-industrial level temporarily in next 5 years, World Meteorological Organization, 05-Jun-2024, last accessed on 01-Oct-2024

in defining the international landscape. China + One is a clear positive outcome of this stress which is benefiting Indian manufacturing sector growth. The United States' focus on internal issues has allowed other global powers, such as China and Russia, to assert more influence. The European Union is also striving for greater strategic autonomy, particularly in defense and trade.

Recent geopolitical crises, including the Russia-Ukraine- NATO conflict, Israel-Hamas-Hezbollah-Iran conflict, the Red Sea shipping crisis, rising tensions in the South China Sea, and protectionism, (not to mention COVID) are sending shockwaves through global supply chains. These events are disrupting global prices, production, and trade. Western European nations like Germany, which relied heavily on Russian Aluminium imports, are facing supply shortages and high prices. This adds stress to the region's industry, already grappling with an energy crisis and looming recession.

These flashpoints have created a complex web of sanctions, tariffs, and quotas, disrupted established trade routes and created uncertainty. Trade wars between major producing countries like USA, China, Russia, and Europe, have affected the market, creating both opportunities (for other producing countries like India, Indonesia, Brazil etc.) and risks (for import dependent nations like South Korea, etc.). Lessons may be drawn from the Indian steel sector which is fighting dumping from East Asia on the one hand, whereas on the other it is at the receiving end of potential anti-dumping action from Europe. The fine-line between free-trade and protectionism is becoming increasingly difficult to navigate.

Another growing concern is the rising trend of resource nationalism, where governments increase control over their natural resources. This is reshaping the Aluminium supply chain, with implications for mining regulations, taxation, and trade. Many countries like Guinea are trying to increase their control over Bauxite deposits, by demanding higher taxes and greater local ownership.

Rising shipping costs, driven by security threats in key shipping lanes, add to the challenges. Delays in shipments due to vessel rerouting are disrupting supply chains, leading to higher transport costs and insurance rates. The disruption of Red Sea routes and threats in the South China Sea are compounding these issues, straining the Aluminium supply chain.

Amidst this complex game, India is making strategic moves of its own. India's foreign policy is characterized by a balance between strategic autonomy and engagement with multiple global powers, reflecting its aspirations in a multipolar world. Over the past decade, India's geopolitical alliances have evolved significantly. India has strengthened its alliances, particularly with the US, Japan, and Australia through the Quad, while maintaining strong ties with Russia.

The US-India relationship has deepened, particularly through the Quadrilateral Security Dialogue (Quad) with Japan and Australia, focusing on a free and open Indo-Pacific. This partnership has grown in response to China's assertiveness in the region. India and Japan have strengthened their strategic partnership, focusing on economic cooperation, infrastructure development, and regional security. This includes collaborations on projects like the Mumbai-Ahmedabad High-Speed Rail.

Despite closer ties with the US, India has maintained a strong relationship with Russia, including defense cooperation and energy partnerships. The two countries have signed multiple agreements, including a 10-year military cooperation pact.

India has enhanced its engagement with the EU, focusing on trade, investment, and climate change. The EU-India Strategic Partnership has seen renewed vigor, especially in areas like digital cooperation and sustainable development. India's relationships with Middle Eastern countries, particularly the UAE and Saudi Arabia, have grown, focusing on energy security, trade, and investment. The India-Middle East-Europe Economic Corridor (IMEC) is a significant initiative aimed at enhancing connectivity and economic integration between Asia, the Persian Gulf, and Europe. Given the cost of energy is the least in the middle east, and given its proximity to the Europe, it makes sense for Indian industry to evaluate distributed supply chains, sustainability concerns permitting. There was a time when the Indian Government was actively evaluating a smelter in Iran. Given the potential in India's defence

manufacturing sector and its good relationship with the GCC, it is possible to imagine a joint venture between India and any suitable GCC state to work on special grade alloys based on high grade primary Aluminium from Alba/ EGA and supply it to the world along with India.

Through initiatives like the Act East Policy, India has continued to strengthen its ties with ASEAN and BIMSTEC countries, aiming to enhance economic and security cooperation in Southeast Asia. Notwithstanding this, the geo-political environment in India's immediate periphery is unstable. This might require the government to divert funds otherwise meant for development to protect national security interests.

The "China Plus One" strategy has gained increasing importance due to shifting global dynamics and the uncertainties associated with over-reliance on Chinese manufacturing. Although many companies had been considering this approach since the mid-2010s, the US-China trade war and the supply chain disruptions caused by the COVID-19 pandemic compelled them to act. This has benefitted India positioning it as a key player in the global manufacturing landscape.

These partnerships support India's strategic interests and drives domestic Aluminium consumption supported by India's government initiatives, like infrastructure development and green energy projects and are boosting Aluminium demand. In 2023, India was a standout player in Aluminium production and consumption, even as the global market faced a slow recovery.

In summary, it is difficult to conclude whether the current instability across the world will negatively impact demand for Aluminium (in the construction, transportation sectors) or increased use (in space and military aircraft making) in the medium to long term.

6.1.6 Emerging Economic Power

China has long been a driving force in the global economy. In 2022, it was the second biggest economy after the USA. Meanwhile, India has made remarkable progress, climbing from the 13th spot in 2000 to the 5th largest economy in 2022. Forecasts from organizations such as Goldman Sachs, the IEA, and the IMF suggest that India will be the fastest-growing economy in the coming years, potentially becoming the third-largest economy by 2050.

India is on its path to becoming a developed economy by 2047 under the Viksit Bharat vision. The government is focusing on economic policies that encourage investment, foster innovation, and promote sustainable growth. Key programs like Make in India, Digital India, and Startup India demonstrate the commitment to creating a business-friendly environment and generating employment. Large-scale infrastructure projects, including roads, railways, ports, and urban development, are being launched. Initiatives like Pradhan Mantri Awas Yojana, Bharatmala, Sagarmala, and the Smart Cities Mission highlight the focus on building livable, sustainable cities, enhancing connectivity, and providing affordable housing. The introduction of Vande Bharat trains and the UDAN initiative has made travel more convenient for citizens. Additionally, the expansion of metro networks ensures smooth travel within cities.[114] This rapid economic growth is expected to position India as a key driver of Aluminium demand, not just in Asia, but globally.

However, the global economy is on the verge of a recession, driven by a combination of economic factors such as a global slowdown and high inflation rates, as well as geopolitical factors including rising tensions and conflicts among nations worldwide. While the global recession presents challenges, India's economic fundamentals, proactive government policies, and strong domestic market position it to navigate these difficulties better than many other economies. Continued focus on infrastructure, and strategic international partnerships will be crucial for sustaining growth.

[114] Viksit Bharat: The Vision of PM Modi (narendramodi.in), 24-Feb-2024, last accessed on 01-Oct-2024

Table 9: World's Largest Economies Ranking[115]

Ranking	1980	2000	2022	2050
1	USA	USA	USA	China
2	Japan	Japan	China	USA
3	Germany	Germany	Japan	India
4	France	United Kingdom	Germany	Indonesia
5	United Kingdom	France	India	Germany
6	Italy	China	United Kingdom	Japan
7	China	Italy	France	United Kingdom
8	Canada	Canada	Canada	Brazil
9	Argentina	Mexico	Russia	France
10	Spain	Brazil	Italy	Russia
11	Mexico	Spain	Brazil	Mexico
12	Netherlands	Korea	Korea	Egypt
13	India	India	Australia	Saudi Arabia
14	Saudi Arabia	Netherlands	Mexico	Canada
15	Australia	Australia	Spain	Nigeria

The attractiveness of the Indian Aluminium sector has generated interest from new players who have previously not had any footprint in the sector. This can be evidenced from their participation in Bauxite block auctions and various other tenders they have been floating to evaluate their entry into the Aluminium sector.

6.2 Growth Drivers and Demand Forecast for Domestic Aluminium Consumption in Short Term (FY30) and Long Term (FY47)

6.2.1 Approach for demand forecasting

To forecast India's domestic Aluminium demand for FY30 and FY47, the GDP elasticity of Aluminium demand across the end-use sectors have been considered-

1. **Data Collection:** Last 20 years historical data on India's GDP and Aluminium demand in each of the end-use sectors- packaging, transportation, building & construction, electrical, machinery & equipment, consumer durables & others (defence, aerospace) were collected.

[115] The Path to 2075 — Slower Global Growth, But Convergence Remains Intact, Goldman Sachs, 06-Dec-2022, last accessed on 01-Oct-2024

2. **Calculation of GDP Elasticity of Aluminium demand**: The GDP elasticity of Aluminium demand for each sector was determined by analyzing how Aluminium demand has changed with respect to changes in GDP over time. While doing this exercise, outlier data or data of years known to have issues (e.g. COVID years) were removed.

3. **Projection of GDP Growth**:

India's growth is largely predicated by its domestic economic health. Owing to its large population and large land area it is possible for India to be reasonably insulated from global events. While a turnaround is visible in domestic capex in real estate, power, steel etc. sectors, increasingly India's neighbourhood is also turning out to be a drain on its budget, not to mention the high energy and fertilizer costs around the world. India's fiscal deficit is in control but that is also the reason for a tight monetary regime preventing unfettered growth.

Economic forecasts by different agencies (namely Goldman Sachs, IMF etc.) across different horizons were referred to project India's consensus GDP growth up to 2030 and 2047. GDP forecast by various agencies considered is shown in a table below:

Table 10: GDP Growth Projection by Different Agencies

Report Name	GDP Growth Projections		
	Short Term	Medium Term	Long Term
The Path to 2075, Goldman Sachs	2024-2029: 5.8%	2030-2039: 4.6%	2040-2049: 3.7%
Economy Watch, Monitoring India's Macro Fiscal Performance, EY India[116]	2026-2030: 7.0%	2031-2035: 6.2% 2036-2040: 5.3%	2041-2045: 4.8% 2046-2050: 4.4%
International Monetary Fund, World Economic Outlook Database, April 2024	2024-2029: 6.5%	-	-
Focus Economics Consensus Forecast, April 2024	2023-2025: 6.7% 2026-28: 6.5%	-	-

The approach being taken for determination of Aluminium demand and consequently capacity, is a top-down approach. It must be met by bottom-up actions. The risk of assuming high GDP rates and thereby a high demand for Aluminium may lead to creation of capacities ahead of actual demand fructifying. India has already seen the consequences of unbridled capex and credit growth in the steel sector and the subsequent turn of events between 2014 until IBC came through. A prudent approach should be one which provides additional land to entrepreneurs to expand capacity beyond the core line that is set up. After all the world is not in a very good place and India's continuous

[116] Indian economy by 2050: In pursuit to achieve the $30 trillion mark, EY-India, Aug 25, 2022, last accessed on 01-Oct-2024

insistence on its insulation from the global economy can sometimes fall flat depending on the scale of global machinations. After all, in this year's Independence Day speech the prime minister mentioned that – "Challenges are abundant, both internal and external. As we grow stronger and gain more attention, these challenges are bound to increase. External challenges, in particular, are likely to escalate, and I am well aware of this. However, I want to convey to such forces that the development of Bharat does not mean a threat to anyone. Even in the past, when we were prosperous, we never dragged the world into wars. We are the land of Buddha, and war is not our path. Therefore, the world need not worry. As Bharat progresses, I urge the global community to understand Bharat's values and its thousands of years of history. Do not perceive us as a threat. Do not resort to strategies that might make it harder for a land capable of contributing to the welfare of all humanity."

It would be naïve to think that India's Consumption and Investment growth is a sheer function of domestic factors. The proposed hydro-projects in Arunachal Pradesh are already being opposed. The metals sector has seen the way in which Sterlite copper at Tuticorin and Niyamgiri bauxite reserves in Odisha have stalled. Hence the numbers assumed have been largely conservative, especially in the long run.

4. **Adjustment of GDP elasticity:** Calculated GDP elasticity of Aluminium demand for each sector were adjusted considering any known future policies, market trends, or technological advancements that could significantly affect Aluminium demand.
5. **Forecast sector-wise Aluminium demand**: The adjusted GDP elasticity of Aluminium demand for each end-use sector were multiplied with the projected GDP growth to estimate the future growth rate of Aluminium demand for each sector. The growth rate was used to forecast end-use sector wise Aluminium demand.
6. **Aggregate Demand forecast:** The forecasted demand across all sectors were summed up to get the total Aluminium demand for the forecast years.

6.2.2 Demand Forecast in Short Term (FY30) and Long Term (FY47)

Scenarios	Actual Consumption (MT)									Forecasted Demand (MT)		
	FY 04	FY 08	FY 12	FY 16	FY 20	FY 21	FY 22	FY 23	FY 24	FY 30	FY 40	FY 47
Scenario 1	0.55	1.69	2.40	3.20	3.71	3.40	3.90	4.45	4.95	**8.4**	**15.7-17**	**23.5-24.7**
Scenario 2										**8.7**	**19.3**	**32**
Scenario 3										**8.5**	**18**	**28**

India's Aluminium demand has been forecasted using end-use sector wise historic GDP elasticity of demand. This analysis considers two scenarios:

i. **Scenario 1:** Demand projection basis consensus (Industry feedback, projections by different economists etc.) Real GDP growth forecast for short-term, medium-term and long-term.

ii. **Scenario 2:** Demand projection basis GDP growth to achieve a USD 30 trillion economy in line with India's Vision@2047. The reason for taking this scenario is that self-fulfilling prophecy also plays a role in achieving apparently stretch-targets. When 300 MTPA target was taken for steel production

by 2030-31, many were skeptical. However, the industry has rallied around this vision and appears to be well-set to come close to this number.

iii. Scenario 3: Average of Scenario 1 and Scenario 2

The forecasting methodology involves analyzing the historic GDP elasticity of demand for Aluminium across various sectors. This elasticity measures the responsiveness of Aluminium demand to changes in GDP. By applying these elasticities to the projected GDP growth rates under the two scenarios, future Aluminium demand has been estimated.

Scenario 1: Demand projection basis Real GDP growth Forecast

Under the Real GDP growth forecast[117], India's Aluminium demand is projected to grow steadily. The demand is expected to align with the GDP growth rates, reflecting a consistent increase in Aluminium consumption across various sectors. Under this scenario:

- **Short-term (2024-2030):** India's Real GDP is projected to grow at an annual rate of 6.5% during this period and the anticipated domestic Aluminium demand is estimated to be 8.4 MT by FY30.
- **Medium-term (2031-2040):** India's Real GDP is projected to grow at an annual rate of 4.6% during this period. Given the GDP growth projection of 4.5-5.0%, the anticipated domestic Aluminium demand is estimated to be between 15.7 and 17 MT by FY40.
- **Long-term (2041-2047):** India's Real GDP is projected to grow at an annual rate of 3.7% during this period. Given the GDP growth projection of 3.5-4.0%, the anticipated domestic Aluminium demand is estimated to be between 23.5 and 24.7 MT by FY47.

Scenario 2: Demand projection basis GDP growth to achieve a USD 30 trillion economy in line with India's Vision@2047

India's ambitious vision to become a USD 30 trillion economy by 2047 presents a more aggressive growth scenario. In the context of achieving a USD 30 trillion economy by 2047, GDP growth rate needs to be aggressive[118] and the Aluminium demand is anticipated to surge significantly. This scenario assumes accelerated economic activities and infrastructure development, leading to a higher demand for Aluminium.

- **Short-term (2024-2030):** With a projected GDP growth rate of 7%, the expected domestic Aluminium demand is approximately 8.7 MT by FY30
- **Medium-term (2031-2040):** With a projected GDP growth rate of 5.8%, the expected domestic Aluminium demand is approximately 19.3 MT by FY40
- **Long-term (2041-2047):** With a projected GDP growth rate of 4.8%, the expected domestic Aluminium demand is approximately 32 MT by FY47

Conclusion

The domestic Aluminium demand forecast for India under both scenarios indicates robust growth, with Scenario 2 presenting a more optimistic outlook. By averaging the projections from both scenarios, accounting for both base-case and aggressive growth estimates, a slightly stretch-case Aluminium demand projection which amounts to a third scenario, which is given below-

- **Short-term (2024-2030):** 8.5 MT by FY30
- **Medium-term (2031-2040):** 18 MT by FY40

[117] The Path to 2075 — Slower Global Growth, But Convergence Remains Intact, Goldman Sachs, 06-Dec-2022, last accessed on 01-Oct-2024
[118] Indian economy by 2050: In pursuit to achieve the $30 trillion mark, EY-India, Aug 25, 2022, last accessed on 01-Oct-2024

- **Long-term (2041-2047):** 28 MT by FY47

According to the CRISIL report on 'Aluminium recycling in India', the demand for Aluminium in India is expected to reach 7.3 MT by 2030[119]. On the other hand, the Confederation of Indian Industry (CII) projects the demand to be 8 MT by 2030[120]. Our forecast aligns well with these estimates, indicating a robust growth trajectory for Aluminium demand in the country. By considering both CRISIL's and CII's projections, our balanced forecast of 8 MT by 2030 reflects that the projection is realistic.

According to the Aluminium demand forecast, India's per capita Aluminium consumption is expected to see significant growth over the coming decades. Starting from 3.5 kg in FY24, it is projected to increase to 5.6 kg by FY30. This upward trend is anticipated to continue, with per capita consumption reaching 11.2 kg by FY40 and further rising to 16.9 kg by FY47. This substantial increase reflects the growing demand for Aluminium in various sectors and the country's focus on expanding its Aluminium production capabilities.

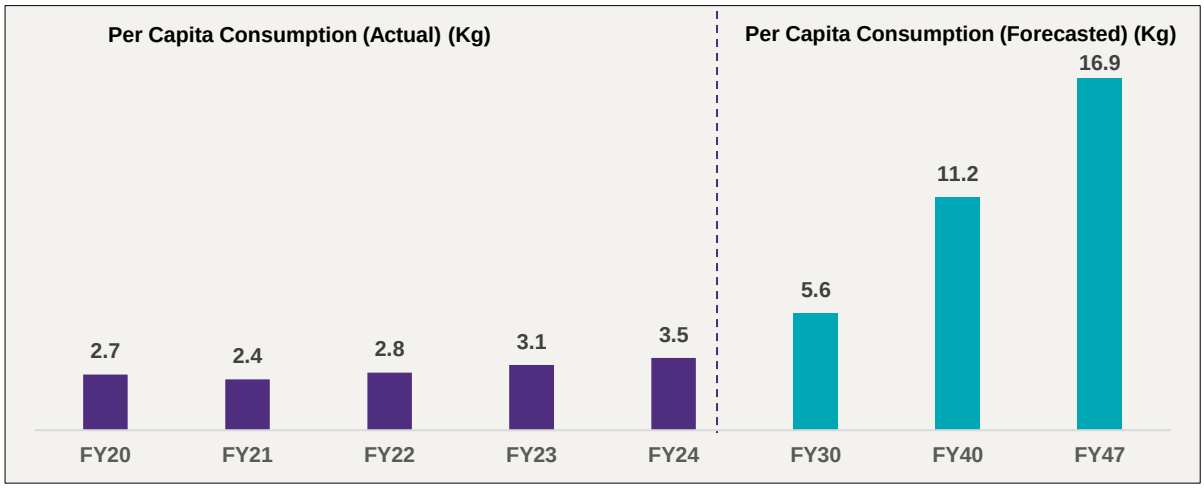


Figure 79: Per capita Aluminium consumption forecast

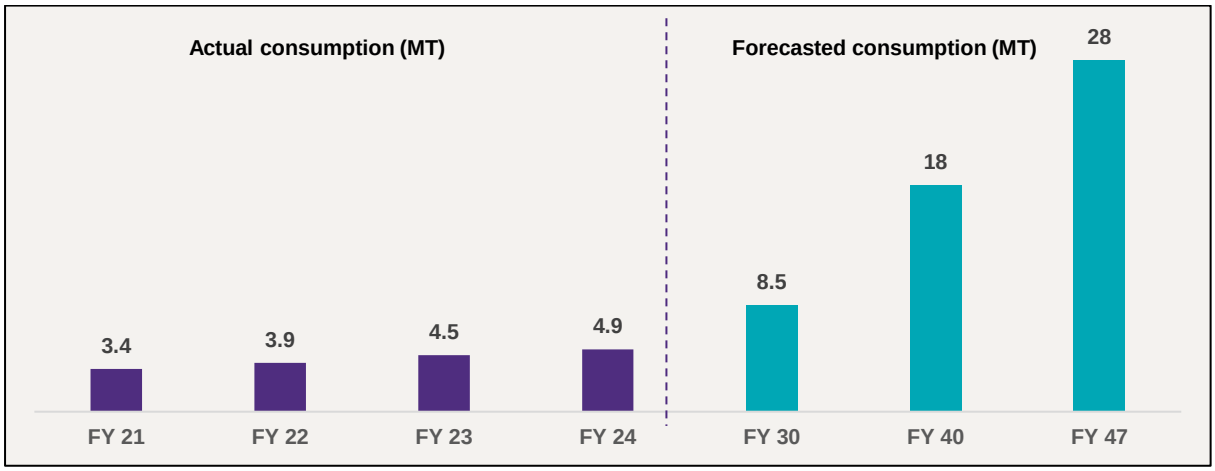


Figure 80: Domestic Aluminium consumption forecast

Assumptions

i. Outlier data or data of years known to have issues (e.g. COVID years) were removed for calculation of average sector wise GDP elasticity of Aluminium demand.

[119] Aluminium recycling in India, CRISIL, Feb 2022
[120] Vision and Strategy for the Indian Aluminium Sector, Confederation of Indian Industry

ii. For high growth potential sectors like transportation & electricity, the GDP elasticity of Aluminium demand will increase in the long term.

iii. No major disruptions that could drastically alter Aluminium demand are considered.

iv. The analysis assumes a supportive policy environment that encourages industrial growth and infrastructure development.

v. The global Aluminium market remains stable, with no significant supply chain disruptions or price volatility.

6.2.3 Growth Drivers[121]

Total domestic consumption of Aluminium is growing at a CAGR of ~7% from FY09 onwards till FY24, from 1.7 MT to 4.95 MT. Product innovations, the introduction of new alloys, emerging new technologies in product markets, shift from other metals to Aluminium in various applications, have all favored the growth of Aluminium industry.

Electrical is the major user of Aluminium products accounting for 48% of total usage followed by transportation at 16% at FY24. Other key segment users include building & construction, packaging, consumer durables & machinery & equipment.

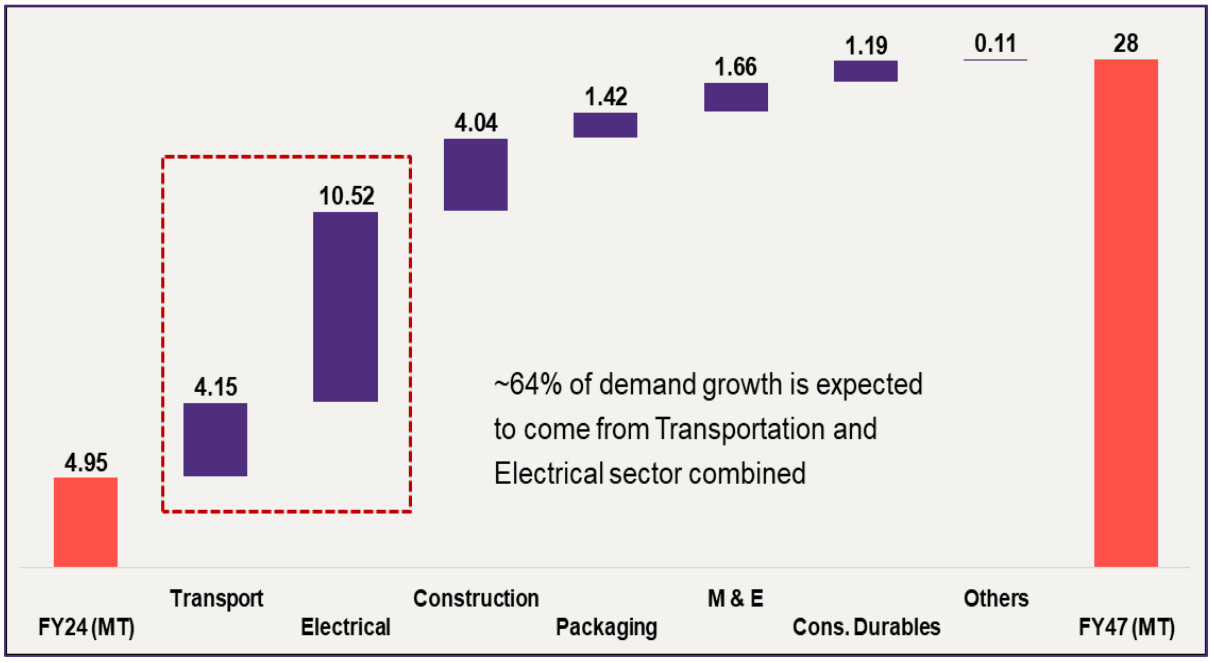


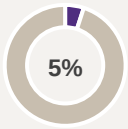
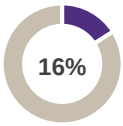
Figure 81: Aluminium demand growth by sectors (MT)

By FY47, Transportation and Electrical sectors will be major growth drivers accounting for 64% of demand growth from FY24 to FY47. Building & Construction (B & C), Packaging sector will contribute to 22% of demand growth. Rest of the demand growth will be contributed by Consumer durables, Machinery & Equipment (M & E) and other end-use sectors.

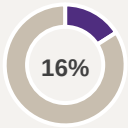
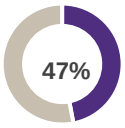
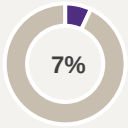
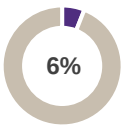
The Critical growth drivers for the increase in the Aluminium demand are (details provided in Annexure 5):

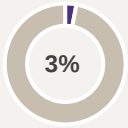
[121] Outlook for the Indian Aluminium Industry, AL Circle

Table 11: Sector-wise growth drivers

End-use sector	Aluminium consumption share (2023)[122]	Al. demand growth potential	Drivers for growth in Aluminium consumption
Packaging		**Medium**	The usage of Aluminium in the packaging sector is projected to grow from 0.2 MT in FY24 to 0.4 MT in FY30 and 1.7 MT in FY47, with a growth rate of 10% from FY24 to FY30 and 12% from FY30 to FY47. The Indian packaging market, expected to reach USD 204 billion by 2025, registering a CAGR of 26% from 2020 to 2025, has seen a 200% increase in consumption over the past decade due to rising consumer markets in processed food, beverages, personal care, and pharmaceuticals. This growth is further driven by government initiatives to phase out single-use plastics, aligning with consumer demand for sustainable packaging.
Transport		**High**	The transportation sector's Aluminium consumption is projected to grow from 0.70 MT in FY24 to 1.4 MT in FY30 and 4.9 MT in FY47. India, a major player in heavy vehicle production, has a diverse auto industry driven by two-wheelers and passenger cars, with the market value expected to grow from USD 126.67 billion in 2024 to USD 187.85 billion by 2029. Despite a dip in manufacturing post-FY19 due to economic challenges and the COVID-19 pandemic, the industry has rebounded strongly. The sector is poised for significant growth, with substantial investments and a focus on increasing vehicle exports. The automotive industry's shift towards lightweight materials for better fuel efficiency and the increasing production of electric vehicles (EVs) are also significant factors. The government's FAME scheme to promote EV adoption is also a key driver. Also, boosting Aluminium usage through projects like lightweight Aluminium-bodied trains, metro rail networks, and energy-efficient wagons may further drive the demand.

[122] AL Circle estimates

End-use sector	Aluminium consumption share (2023)[122]	Al. demand growth potential	Drivers for growth in Aluminium consumption
Building & Construction		**Medium**	Aluminium consumption in this sector is projected to grow from 0.8 MT in FY24 to 1.4 MT in FY30 and 4.8 MT in FY47. Rapid urbanization and infrastructure development, including smart cities and modernization projects, are creating substantial demand for Aluminium in construction due to its durability and versatility. The Indian government's infrastructure initiatives, such as the National Infrastructure Pipeline, Smart Cities Mission, and 100% FDI in construction projects, are expected to significantly boost Aluminium demand.
Electrical		**High**	Aluminium usage in India's electrical sector is projected to grow from 2.4 MT in FY24 to 4.0 MT in FY30 and 12.9 MT in FY47. Its high structural integrity, lightweight nature, and excellent conductivity make it essential for electrical cables, busbars, transmission lines, motors, and more. The power sector's Aluminium demand is driven by transmission and distribution lines, renewable energy projects, and infrastructure development. Additionally, Aluminium is crucial in LED lighting and electric fans, with significant market growth expected in these areas due to its desirable properties.
Machinery & Equipment		**Low**	Aluminium usage in the Machinery & Equipment sector is projected to grow from 0.4 MT in FY24 to 0.6 MT in FY30 and 2.0 MT in FY47. Offset printing, a major user of Aluminium plates, maintains its relevance within the industry, but its growth may be impacted as digital methods gain popularity. The demand for extrusions is expected to rise from Ventilator industry.
Consumer durables		**Low**	Aluminium usage in the Consumer Durables sector is projected to grow from 0.3 MT in FY24 to 0.50 MT in FY30 and 1.5 MT in FY47. The growing middle-class population and rising disposable incomes are leading to increased consumption of consumer durables, which often contain Aluminium components. The cookware market is driven by increased consumer spending and population growth, while the refrigerator and washing machine markets benefit from urbanization and rising incomes. The air conditioner market is expanding

End-use sector	Aluminium consumption share (2023)[122]	Al. demand growth potential	Drivers for growth in Aluminium consumption
			due to construction demands, and the electronics sector is growing with the 'Make in India' initiative, all boosting Aluminium demand.
Others (Aerospace, Defence)		**Low**	Aluminium usage in the Others (Aerospace, Defence) sector is projected to grow from 0.14 MT in FY24 to 0.2 MT in FY30 and 0.3 MT FY47. The sector's growth is driven by increased air travel, a wealthier middle class, and the 'Make in India' campaign, which boosts domestic production and investment in aerospace and defence, reducing reliance on foreign procurement. The aerospace and defence sectors in India are set to boost Aluminium consumption due to the metal's critical role in aircraft and military hardware manufacturing. With India's increasing focus on self-reliance in defence production, the demand for Aluminium in these industries is expected to rise significantly.

6.3 Supply Forecast in Short Term (2030) and Long Term (2047)

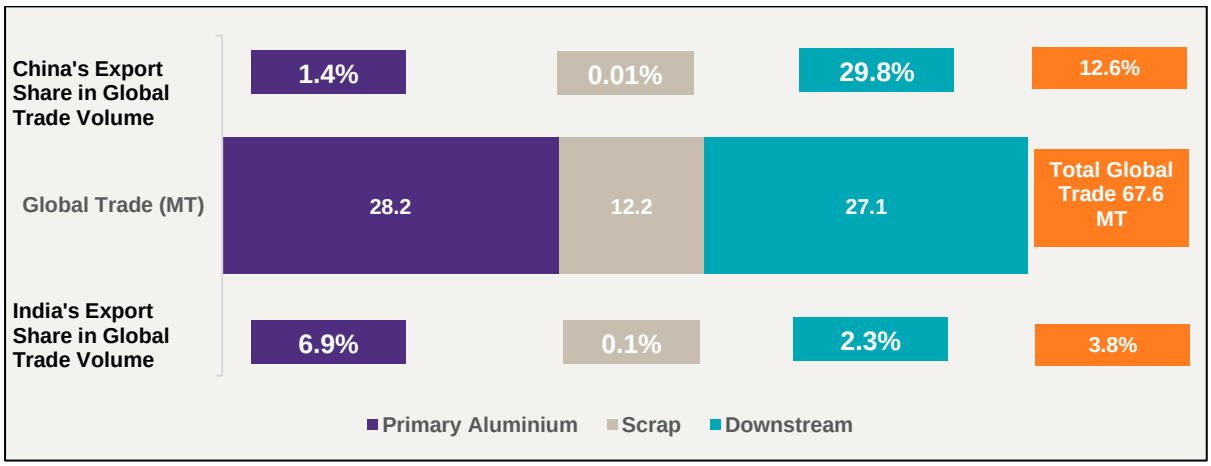


Figure 82: Global Aluminium Trade Scenario, 2023 (Volume wise)

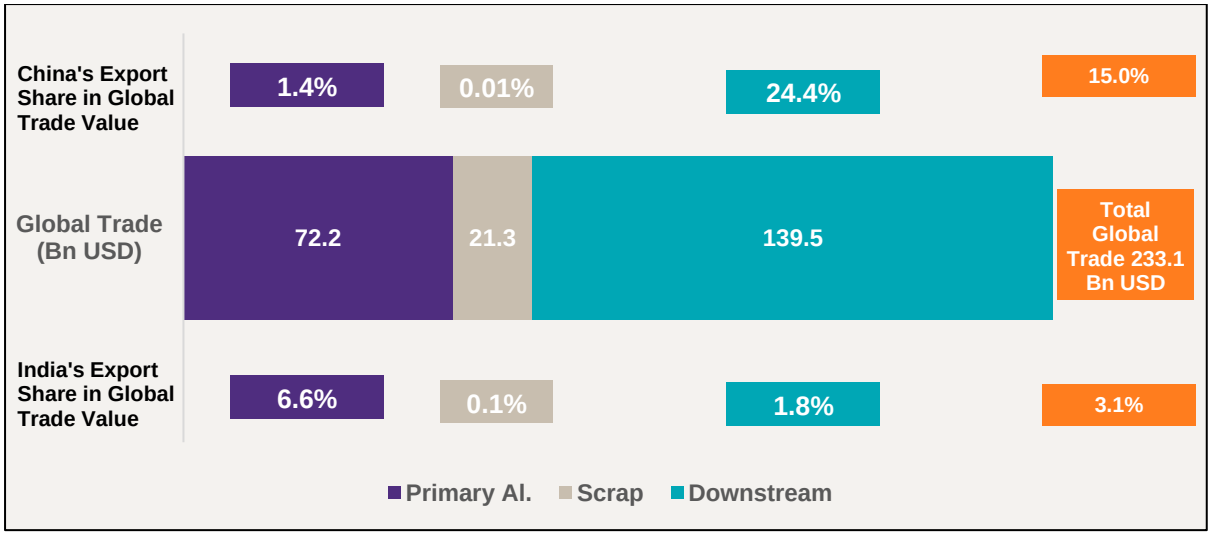


Figure 83: Global Aluminium Trade Scenario, 2023 (Value Wise)

As of 2023, China commanded a significant 12.6% share of the global Aluminium trade volume, which totaled 67.6 MT for the year. In contrast, India's export market share stands at 3.8% of the total global Aluminium trade volume. Notably, 76% of India's Aluminium exports volume consist of primary Aluminium, with only 24% being downstream products. Conversely, China's export composition is 5% primary Aluminium and 95% downstream products. In terms of value, India and China exported Aluminium and Aluminium products worth USD 7.3 billion and USD 35 billion, respectively in 2023. The focus of China on downstream exports makes the imbalance even more stark in terms of value.

Considering contribution of other developed economies to grow in the future Aluminium trade, India's projected share in Global trade volume in Aluminium can be considered to 10% by 2047. To achieve a 10% volume share in 2047 from 3.8% at 2023, in the global Aluminium market by 2047, India Aluminium export is projected to be 3.8 MT by FY30, 6.9 MT by FY40 and 9.1 MT by FY47. Correspondingly, India's Aluminium metal production capacity should be 12 MT, 25 MT and 37 MT by FY30, FY40 and FY47.

To meet its export targets, India may explore the Aluminium market in emerging African economies such as Nigeria and Egypt, projected to be the 5th and 7th largest economies by 2075, respectively[123]. In 2023, African nations accounted for approximately 4% of global downstream product imports, a figure expected to rise due to limited downstream production capacity in the region.

[123] The Path to 2075 — Slower Global Growth, But Convergence Remains Intact, Goldman Sachs, 06-Dec-2022, last accessed on 01-Oct-2024

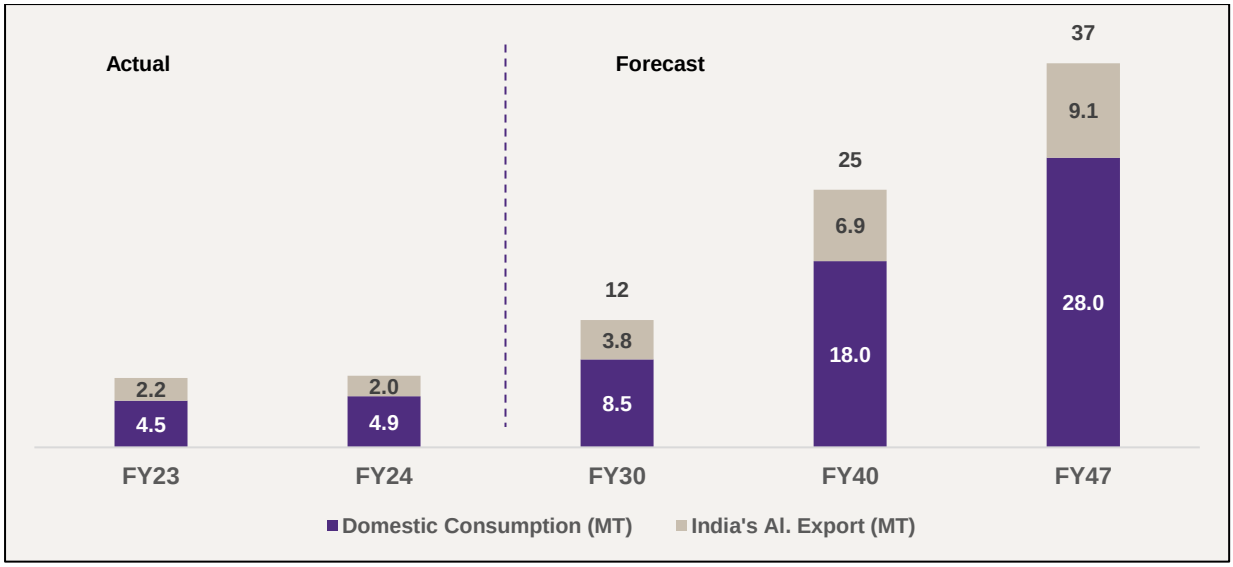


Figure 84: Forecast of India's Aluminium metal consumption and export

Focusing on emission reduction, increased scrap recycling is a key lever. The International Energy Agency forecasts that the share of secondary Aluminium production in total Aluminium production globally will reach 56%[124]. India's Aluminium consumption is currently at 4.5 MT. Though, the demand for Aluminium is growing, driven by sectors like construction, automotive, and packaging, the supply of scrap Aluminium might not be keeping pace with this demand, leading to potential shortages.

Not only in the immediate term, even in the long-run, India will have to literally move mountains to stay '*Atmanirbhar*'. To meet the projected Aluminium demand, India must ensure a robust supply chain for Bauxite and Alumina, alongside sufficient capacity for both primary and secondary Aluminium production. Domestic primary Aluminium production is anticipated to satisfy domestic consumption needs and significantly boost export volumes. However, securing a steady supply of Bauxite is crucial. As per announced capacity by Primary Producers, Bauxite requirement is projected to reach at least 42 MT by FY30 whereas Alumina requirement is projected to reach 14 MT by FY30.

Also, assuming 85% Aluminium content in scrap (based on scrap import quality standard set by different countries), India's scrap demand as per announced secondary Aluminium production capacity will be as follows-

Table 12: Projection of India's Scrap demand[125]

Year	Announced Secondary Aluminium Production Capacity (MT)	Scrap demand (MT)
FY30	3.5	4.12

In addition to bauxite, alumina and scrap requirement, by FY30, the Indian Aluminium industry will need at least 15 – 18 GW of power to meet the production requirement.

Assumptions

i. For 1 ton of primary Aluminium production, 6-7 tonnes of Bauxite is required. However, for estimation 6 tonnes of bauxite requirement has been considered.

ii. For 1 ton of primary Aluminium production, 2 tonnes of Alumina is required.

iii. Capacity utilization has been considered at 100% since the demand estimation has taken a reasonably cautious view of medium-to-long-term demand growth to avoid over-capacity.

iv. Considering contribution of other developed economies to grow in the future Aluminium trade, India's projected share in Global trade volume in Aluminium is considered to be 10% by 2047 from current level of 3.8%. For reference China's current share in global trade is 12.6%.

v. Aluminium content in scrap is considered to be 85% (based on scrap import quality standard set by different countries)

vi. Global Aluminium demand has been considered as per International Aluminium Institute production data.[126]

vii. Global trade volume of Aluminium may reach 55% of Global Aluminium demand for that year from the current level of 60%, considering significant increase in global demand.

viii. The ratio of primary to secondary Aluminium in total domestic production is likely to be 70:30 in FY 30, given adequate implementation of the measures outlined in this vision document.

ix. 100% of domestic end-use Aluminium demand is likely to be met from domestic production.

x. 1000 MW generation capacity required for 0.5 MT Aluminium smelter.

xi. Aluminium production via secondary route consumes 95% less energy compared to primary

[124] Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach, International Energy Agency, 2023
[125] GT Analysis
[126] Global Cycle - International Aluminium Institute, last accessed on 03-Oct-2024

xii. The analysis assumes a supportive policy environment that encourages industrial growth and infrastructure development.

xiii. The global Aluminium market remains stable, with no significant supply chain disruptions or price volatility.

Demand Supply Gap Assessment

In response to the increasing domestic demand for Aluminium, domestic producers have initiated expansion plans for their alumina refineries and Aluminium smelters. NALCO, Hindalco, and Vedanta aim to increase the country's alumina refinery capacity by approximately 7 MT and primary Aluminium smelter capacity by around 3 MT over the next 5 to 6 years.

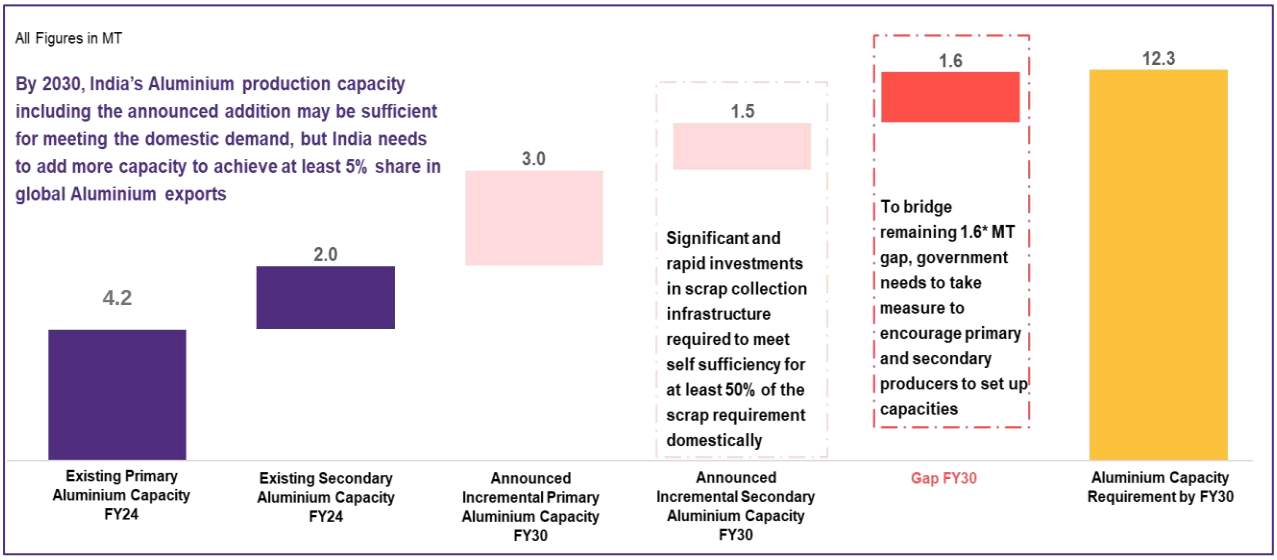


Figure 85: Demand-Supply gap in Aluminium capacity by FY30 (in MT)

However, these additional capacities for primary and Secondary Aluminium producers will not suffice to meet the projected short-term demand, **leaving India with a shortfall of another ~1.6 MT** of Aluminium by FY30. Similarly, the secondary sector growth plans are not supported by domestic scrap collection plans. To support India's goal of self-reliance, more scrap collection should be focused upon. These gaps will lead to potential import of Aluminium into the country. Alternatively, the Aluminium industry will go slow in pushing market-development.

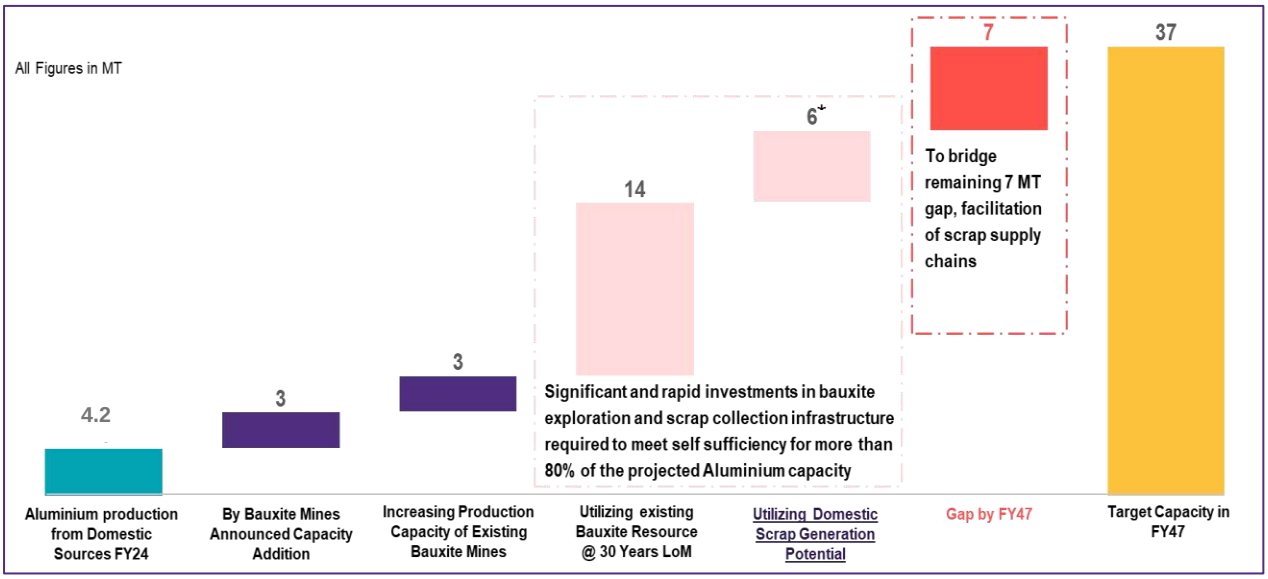


Figure 86: Demand-Supply gap in Domestic Aluminium in FY47 (in MT)

* The existing 2 MT Secondary Steel Capacity which is currently being serviced by imported scrap is included in 6 MT.

India's current domestic self-reliant Aluminium production capacity is 4.2 MT, with secondary capacity of 2.0 MT is largely dependent on imported scrap. With new bauxite capacity, an additional 3 MTPA of primary Aluminium production can be added. If the rate of mining from existing bauxite reserves can be increased by 50%, another 3 MTPA of primary Aluminium can be supported. Untapped domestic bauxite resources of 4.95 BnT, if proved can support another 14 MTPA of primary Aluminium. By FY47, secondary Aluminium production from domestic scrap is projected to reach an incremental 6 MTPA. However, to meet the projected demand of 37 MTPA by FY47, there will still be a shortfall of 7 MTPA, the raw material for which will need to be met from international sources of bauxite or scrap or discovering more bauxite resources. In any case, the process of transitioning 4.95 BnT of resources to proven reserves should happen on a mission-mode to ensure that the pathway to FY47 is clear.

Assumptions

i. 50% production capacity may be enhanced from the operational Bauxite mines.

ii. Out of 4.95 Bn Tonnes of Bauxite resources, 70% may be converted to Reserve with 75% Metallurgical grade Bauxite.

iii. 30 years of life of mine have been considered for the new Bauxite mines.

iv. Aluminium content in scrap is considered to be 85%

v. Half of the Aluminium consumed annually is assumed to have a 20-year lifespan, while the other half is expected to last 40 years. Additionally, 10% of the current consumption is considered for immediate recycling.

vi. No addition in existing Bauxite resource has been considered.

7. Opportunities and Threats

7 Opportunities and Threats

7.1 Opportunities and Future Growth Prospects for Indian Aluminium Industry

7.1.1 Rising demand for Aluminium products

By 2030, India's Aluminium consumption is going to double. This surge in demand will create numerous opportunities across various sectors, including automobiles, urban infrastructure, pharmaceuticals, and air conditioning.

7.1.2 Building downstream capability[127]

India has the potential to significantly boost its export earnings by expanding its production capacity of downstream Aluminium products. Despite a notable increase in primary Aluminium production over the past decade, the rate of value addition within the country remains low. This can be improved by developing new products and applications through increased investments in R&D activities, which are currently limited.

Primary Aluminium producers in India are focusing on enhancing their downstream production capabilities in value-added products such as flat rolled products, extrusions, foils and light gauge products. There is also, significant demand of Aluminium frames for solar panel. These products have applications in various sectors, including packaging, cans, foils, food and beverages, aerospace, automotive, electronics, transportation, building and construction, and other industrial segments.

To capitalize on this potential, India needs to develop its capabilities and capacities in value-added downstream Aluminium products. Currently, the downstream sector is dominated by China, which benefits from a robust manufacturing ecosystem and infrastructure, despite rising costs. As companies shift their supply chains away from China, India has an opportunity to benefit from the 'China-plus-one' strategy by creating a manufacturing ecosystem with skilled labor, particularly in the Aluminium downstream sector. Compared to China, India's midstream and downstream capacities are still in their early stages, presenting significant growth potential.

For instance, in FY23, India exported Aluminium and Aluminium products worth USD 7.3 billion. Of this, USD 4.8 billion (65%) was unwrought or primary Aluminium, while 35% were downstream Aluminium products. In contrast, China exported Aluminium and Aluminium products worth USD 35 billion, with only 3% being primary Aluminium and 97% being downstream Aluminium products. This indicates that China captures a high share of the value-added in the supply chain before exporting.

Therefore, there is a substantial opportunity for India to create further downstream capacity domestically, enhancing its export earnings and capturing more value within the country.

7.1.3 Increasing demand from Automobile sector for lightweight materials and the expanding electric mobility

Automobile manufacturers are increasingly substituting heavier materials like steel and iron with Aluminium to increase fuel efficiency, improve performance, reduce carbon emissions, and lower vehicle weight, especially in electric vehicles. Aluminium's durability, strength, and light weight make it an attractive alternative.

7.1.4 Beverage Packaging Market

Aluminium is becoming the preferred material for beverage packaging due to its sustainability and recyclability. The shift from materials like glass, steel, and Polyethylene Terephthalate or PET plastic to Aluminium, along with the introduction of new beverage products such as energy drinks, canned cocktails, spiked seltzers, and sparkling waters, is driving demand for Aluminium packaging.

[127] ITC Trademap, Company Annual Reports, last accessed on 10-Aug-2024

7.1.5 Material Substitution Trends

While carbon fiber and plastics are other lightweight options, their high cost and limited recyclability make Aluminium a more competitive choice. This trend is boosting the demand for flat-rolled Aluminium products across various industries.

7.1.6 Production Linked Incentive Scheme for White Goods[128]

The Production Linked Incentive (PLI) scheme for white goods in India aims to boost domestic manufacturing and attract significant investments in the production of air conditioners (ACs) and LED lights. The Government has sanctioned the Production Linked Incentive (PLI) Scheme for White Goods, specifically targeting air conditioners and LED lights, to be executed from FY22 to FY29, with a financial allocation of INR 6,238 crores. High Value Intermediates products of Acs made with Aluminium Foil are also covered under the scheme. Under the PLI scheme, companies like Hindalco Industries Ltd. are developing products like coated AC fins which will boost the Aluminium demand.

7.1.7 Recycling and circular economy

Due to its excellent recycling properties, Aluminium could become a cornerstone of the circular economy. As consumption is expected to grow, the amount of post-consumer Aluminium will also increase. Utilizing recycled metals will help satisfy consumer demand while decreasing the need for virgin metals. Companies such as Hindalco are working on establishing a can recycling facility.

7.1.8 Emerging applications for the specialty Alumina

Specialty Alumina is increasingly in demand due to evolving industry requirements, leading to the development of advanced products in both existing and emerging markets. It is used to produce high performance refractory materials, advanced ceramics components, flame retardants. Also, the demand for high-purity Alumina has been on the rise, driven by new applications such as lithium-ion batteries and semiconductors.

7.2 Major Issues Faced by Indian Aluminium Industry

7.2.1 Rise in import of Aluminium scrap poses problem for primary Aluminium players

Aluminium scrap is being imported by more than 1000 odd traders/ importers into India. There has been significant import of Aluminium scrap for the last 3-4 years due to policy measure taken by other importing countries like China & Malaysia to restrict metal scrap imports into their respective nations[129]. As on today, India is the largest importer of Aluminium scrap in the world, importing major tonnages from countries like USA, UK, UAE, Saudi Arabia etc. Due to the increase in scrap import, the ratio of total import of Aluminium to Domestic sales increased from ~40:60 in FY 12 to 60:40 in FY 22. Aluminium imports cater to ~60% of domestic demand, growing at a CAGR of 9% in the last decade (FY 11 to FY 24)[130]. India's Aluminium share through scrap route has increased with a CAGR of ~11% from 0.47 MT in 2010-11 to 1.77 MT in 2023-24. This is due to policy measure taken by other importing countries like China & Malaysia to restrict metal scrap imports into their respective nations and the supply diversion has been towards India.

[128] Production Linked Incentive Scheme (PLI) for White Goods (Air Conditioners and Led Lights) Manufacturers in India, e-gazette notification, dated 16th April 2021, DPIIT, Ministry of Commerce and Industry
[129] China, Malaysia's scrap metal U-turn a golden opportunity for India – official, Eileen Soreng and Mai Nguyen, 24-Nov-2021, last accessed on 03-Oct-2024
[130] Import Export databank, Ministry of Commerce and Industry, Govt. of India, last accessed on 10-Aug-2024

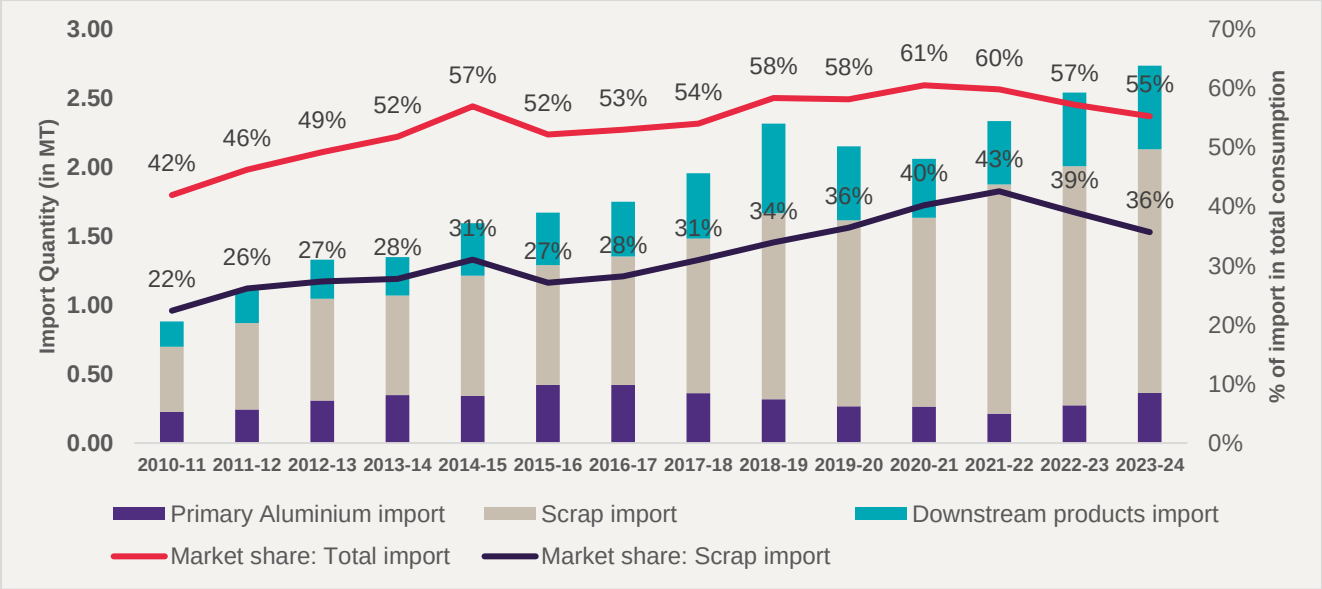


Figure 87: Market share of scrap import in India's Aluminium consumption

Secondary Aluminium is derived from recycled Aluminium scraps, which can originate from sources like old soda cans and car parts. In India, the import duty on Aluminium scrap is currently only 2.5%, significantly lower than the 7.5% duty imposed on primary Aluminium. This creates an incentive for importing scrap.

7.2.2 High incidence of taxes and duties leading to higher input cost for Aluminium industry[131]

India stands out as the most expensive producer of Aluminium among major global players, including China, Canada, Russia, the Middle East, and Norway. This cost disparity can be attributed to several factors, such as high cost of power due to rising Coal prices, significant Coal Cess, increased Electricity Duty, an inverted duty structure for essential raw materials, and elevated logistics expenses.

The Aluminium industry faces significant challenges due to the heavy burden of duties and taxes, which can account for as much as 14% of production costs. This substantial financial impact affects Aluminium producers.

Table 13: Impact of taxes/ duties/ cess on Primary Aluminium production cost

Particulars	Tax/ Cess/ Duty	Sp. Consumption/ ton of Al	Impact on Aluminium COP (USD/ton of Al)	Remarks
GST compensation cess of Coal	INR 400/ tonne	12 tonnes	58	Huge disadvantage to highly power intensive industries like Aluminium (applicable on domestic sales)
Royalty, NMET and DMF on Coal	Royalty -14%, NMET-2% of Royalty, DMF-10% of Royalty	12 tonnes	39	Representative price (May 2024) of G13 grade Coal- INR 1710/ ton of Coal
Electricity duty	INR 0.55/ kWh[132]	14,500 kWh	96	Electricity duty is INR 0.55/ kWh for CPP in Odisha

[131] Industry sources
[132] Odisha hikes electricity duty for captive power plants, Sujit Kumar Bisoyi, 11-May-2017, last accessed on 03-Oct-2024

Particulars	Tax/ Cess/ Duty	Sp. Consumption/ ton of Al	Impact on Aluminium COP (USD/ton of Al)	Remarks
				(Increased from INR 0.30/ kWh to INR 0.55/ kWh in 2017 for CPPs in Odisha)
Higher Coal prices for non-power sector	INR 163/ ton of Coal	12 tonnes	24	For G13 grade Coal, price difference is INR 163/ ton .CIL notified price (dated 31st May 2023) is INR 827/tonne for power sector and INR 990/tonne for non-power sector
Royalty, NMET & DMF on Bauxite	USD 3.3/ tonne of Bauxite	6 tonnes	20	Avg. LME price of Al for FY 23-24 is USD 2202/ton Avg. Al_2O_3 % in Bauxite- 42.5% Royalty= 0.6%*52.9%* Avg. Al_2O_3 % in Bauxite* Avg. LME price of Al DMF=10% of Royalty NMET=2% of Royalty
Evacuation Facility Charges on Coal by Coal India	INR 60/ tonne of Coal	12 tonnes	9	INR 60/ton of Coal from August 2021
Import Duty on Calcined Petroleum (CP) Coke	Basic Custom Duty (BCD): 7.5% and social welfare cess: 10% of BCD	383 kg	19	Average of available price of CP coke for FY 23-24 is INR 50,847 per ton
Import duty on Aluminium Fluoride	Basic Custom Duty (BCD): 7.5% and social welfare cess: 10% of BCD	19 kg	2	Average of available price of Aluminium Fluoride for FY 23-24 is INR 1,09,530 per ton
Renewable Purchase Obligation (RPO)	29.91% RPO	14,500 kWh	17	RPO for 2024-25 is 29.91%. INR 0.33/ kWh cost considered based on avg. traded price of Renewable Energy Certificate (REC) at Indian Energy Exchange during Jan-Mar 2024
Total impact of taxes/ duties/ cess on Primary Aluminium production cost			**284**	**14% of Cost of Production**

Particulars	Tax/ Cess/ Duty	Sp. Consumption/ ton of Al	Impact on Aluminium COP (USD/ton of Al)	Remarks
				Considering COP of USD 2010/ ton of Aluminium (excluding depreciation)[133]

Note-

- USD to INR exchange rate considered 82.78 INR/ USD which is average exchange rate for FY 23-24
- Specific consumption of Raw materials and prices of Calcined Petroleum coke and Aluminium Fluoride is taken from Industry sources
- Cost of Renewable Energy Certificate might increase further as the demand increases

Impact of New Tax Regulations on Aluminium Production Costs

Recent Developments

The recent Supreme Court ruling has empowered Indian states to impose taxes on mining activities. This decision has significant implications for the mining sector, particularly in states like Odisha and Jharkhand, which are rich in mineral resources.

ORISED Act, 2004[134]

Under the Orissa Rural Infrastructure and Socio-Economic Development (ORISED) Act, 2004, the tax on mineral-bearing land is capped at 20% of the annual value of the land. This tax is aimed at generating revenue for rural infrastructure and socio-economic development in Odisha. However, the ORISED Act needs to be reinstated by the Supreme Court before Odisha Govt. can start collecting the tax.

Jharkhand Mineral-Bearing Land Cess Bill, 2024[135]

The Jharkhand Mineral-Bearing Land Cess Bill, 2024, that will come into effect after the publication of its notification in the Official Gazette, introduces a new cess based on the weight of the minerals extracted. The cess rates are:

- **Coal:** INR 100 per metric ton
- **Bauxite:** INR 70 per metric ton

Impact on Aluminium Production Costs

The new tax regulations under the ORISED Act and the Jharkhand Mineral-Bearing Land Cess Bill are set to increase the cost of Aluminium production in India as the cost of production of coal and bauxite will increase with the imposition of the taxes. While these measures aim to generate revenue for socio-economic development, they present significant challenges for the Aluminium industry, which must navigate these additional costs to remain competitive.

Comparison of Taxes across nations[136]

Implementation of taxes/levies on coal such royalty, DMF, putting undue burden on industry. A schedule of cross-country comparison of royalty duties (coal and bauxite) is given below-

Table 14: Royalty and Taxes as percentage of ex-mine coal cost

Country	Royalty & taxes as % of ex-mine coal cost

[133] Aluminium Smelter Costs League 2023, Wood Mackenzie
[134] The Orissa Rural Infrastructure and Socio-economic Development Act, 2004
[135] खनिज-धारित-भूमि-उपकर-2024, Jharkhand Vidhan Sabha
[136] Need for an Aluminium Policy in India, NITI AAYOG, 2017

India	25-31%
Indonesia	12%
South Africa	0-7%
Australia	7%

Table 15: Royalties and Taxes on Bauxite

Country	Royalties and Taxes (Rs/Ton)
India	230
Guinea	50
Brazil	90
Australia	120

Table 16: Present Basic Custom Duty (BCD) of Critical raw materials required for Aluminium production

Commodity	HS Code	Current Basic Custom Duty
Calcined Petroleum Coke	2713 12 10	7.5%
Raw Petroleum Coke	2713 11 10	10%
Caustic Soda Lye	2815 12 00	7.5%
Aluminium Fluoride	2826 12 00	7.5%
Green Anode/ Pre-Baked Carbon Anode	8545 19 00	7.5%
Calcined Alumina	2818 20 10	5%

7.2.3 Raw material supply shortages[137,138,139]

7.2.3.1 Coal

Insufficient quantity allocation for Non-Regulated Sectors

The Ministry of Coal circular for Auction of Linkages, dated 15th February 2016, specifies that Coal should be distributed in the proportion of 75% for power and 25% for non-power sectors. This directive aims to ensure a balanced supply of Coal to different sectors, considering their importance and contribution to the country's infrastructure and economy. But this directive is not being followed properly, and the Non-regulated sector is facing issues with coal availability.

There have been instances where industries like the Aluminium sector have faced critical shortages due to Coal supply policies. For example, in 2021, Coal India Ltd. took decision for stopping/reducing Coal supplies and rakes for non-regulated sector (NRS), leading to severe Coal shortage situation for Captive Power Plants (CPPs) of Aluminium producers. A power interruption lasting two hours or longer can cause the molten

[137] Aluminium manufacturers write to CIL for resuming coal supplies, Bhavya Dilipkumar (Economic Times), 21-Sept-2021, last accessed on 03-Oct-2024
[138] Aluminium industry stares at critical coal shortage, Construction Week, 30-Aug-2021, last accessed on 03-Oct-2024
[139] Industry Sources

Aluminium within the pots to solidify. This situation necessitates a shutdown of the Aluminium production facility for a minimum of six months, incurring substantial financial losses and significant costs associated with restarting operations. Moreover, after resuming production, it typically requires about a year to achieve the targeted level of metal purity, given that the industry relies on a continuous, power-intensive process.

Pricing disparity

Also, there is huge disparity in allocation/ pricing of Coal for Power and Non-Power Sector. CPPs pay ~20% higher for Coal as compared to IPPs leading to differential pricing for different consumers of the same commodity. For example, in case of G13 grade Coal, the price difference is INR 163/ ton exists .CIL notified price (dated 31st May 2023) for G13 grade Coal is INR 827/ton for power sector and INR 990/ton for non-power sector.

Outdated consumption norms[140,141]

Latest consumption norms issued by the Central Electricity Authority (CEA) dated 20.07.2021 consider GCV losses due to stocking, extra moisture and in-transit pilferage. CIL however continues to use the old norms which do not consider these losses. Hence, the outdated Norms for calculation of Coal requirement for CPPs leads to significant quantity Loss in calculation of Annual Contracted Quantity (ACQ).

The table below shows that for 1000 MW CPP the Annual Contracted Quantity is 0.4-0.5 MTPA less according to the existing CIL Scheme Document for Coal Linkage for CPP, 2024.

Grade of Coal	CEA Notified Norms, 2021		CIL Scheme Document for Auction of Coal Linkage for CPP, 2024		Difference in Coal Requirement (MTPA)
	GCV (kcal/kg)	Coal Requirement for 1000 MW CPP (MTPA)	GCV (kcal/kg)	Coal Requirement for 1000 MW CPP (MTPA)	
G10	4,004	**4.9**	4,300	**4.5**	**0.4**
G11	3,719	**5.2**	4,000	**4.8**	**0.4**
G12	3,434	**5.7**	3,700	**5.2**	**0.5**

Note: For calculation of Coal requirement Unit Heat Rate considered for 100 MW to 200 MW units

The coal consumption norms issued by the CEA in 2021 which provided for additional eligibility on account of the following losses:

- Loss in stock – 85 kcal/kg, as per CERC Tariff Regulations 2019
- Loss due to moisture: 5%, due to difference in GCV (Eq) and GCV (ARB)
- Loss in transit: 0.8%, for non-pit head plants

7.2.3.2 Calcined Petroleum Coke

Low Sulphur Anode Grade Calcined Petroleum Coke is not available in India in adequate quantity. Domestic demand is 1.7 MTPA from Aluminium and Steel plants, whereas domestic supply is only 0.3 MTPA.

Also, according to Notification No. 68/2023-DGFT dated March 7, 2024, the total permissible import for 2024-25 is 1.9 MT of Raw Petroleum Coke (RPC) for manufacturing Calcined Petroleum Coke (CPC) and 0.5 MT of CPC for the Aluminium industry. From 2025-26 onwards, the permissible import will be 1.9 MT of RPC for

[140] Central Electricity Authority Notification No. 219/GC/BO/TPPD/CEA/2021/224, dated 20.07.2021
[141] Scheme Document for Auction of Coal Linkages in the CPP Sub- Sector Under Tranche VII, CIL, January 2024

manufacturing CPC and 0.8 MT of CPC for the Aluminium industry. This import restriction is creating hinderance in smelter capacity expansion.

7.2.3.3 Caustic Soda Lye

Aluminium industry is a bulk consumer of Caustic Soda, highly dependent on imports and not able to meet its demand through domestic sources due to several constraints related to quantity, infrastructure and logistics. Also, PSUs are not allowed to import Caustic soda as per GoI procurement policy. (Majority of Caustic Soda production is in Western region (Gujarat, Maharashtra, Rajasthan) while major Alumina producers are in Eastern region (Odisha, Chhattisgarh, Andhra Pradesh, Uttar Pradesh), resulting in high logistics costs.

7.2.3.4 Aluminium Fluoride

Domestic demand of Aluminium Fluoride is 70,000 TPA from Aluminium producers, whereas domestic supply is only 25,000 TPA. 60-70% of requirement of Aluminium Fluoride is imported by Aluminium manufacturing Plants in India

7.2.4 High logistics cost and unavailability of rakes

Aluminium smelting facilities operate on a continuous process system, necessitating a steady and reliable provision of essential raw materials. The production of one ton of Aluminium necessitates the transport of approximately 20 tonnes of these materials[142]. The scarcity of available railway rakes has led to a significant accumulation of pending deliveries and elevated logistical expenses, primarily due to increased railway freight charges for crucial commodities. This situation underscores the critical need for consistent material supply chains to maintain the smelting operations without incurring excessive costs.

As per Goods Tariff No. 45 (w.e.f. 01.04.2007)[143] , Bauxite has been classified as Base Class 160 and Alumina as 180. Due to this classification, higher freight charges are applicable on Bauxite and Alumina which are critical raw materials for Aluminium industry.

For example, for 160 Class Train load, Railway freight of Bauxite is INR 843/ ton for 500 km distance, whereas for 145 Class Train load and for same distance Railway freight of Dolomite is INR 764/ ton. So, due to higher classification, the freight rate is ~10% more.

Also, primary producers are being forced to take coal through road mode which is costly and also not environment friendly.

7.2.5 Rising import of primary Aluminium, downstream products

Rising import of primary Aluminium

The import of primary Aluminium saw a significant increase of 31% year-on-year, rising from 214 thousand tonnes in the fiscal year 2022 to 279 thousand tonnes in the fiscal year 2023. The Middle East was the primary source of this growth, contributing about 61% of the total increase. Notable exporters included Qatar at 21%, Bahrain at 17%, Oman at 11%, and the UAE also at 11%. The Middle East's considerable excess production capacity, which is due to its low-cost electricity and production that exceeds local demand (with a total capacity of 5.3 MT against a consumption of only 0.8 MT), leads to a part of this excess being exported and subsequently dumped in India.[144]

[142] Industry sources
[143] Goods Tariff No.45 Pt. I (Vol. II), Indian Railways, 02/03/2007, last accessed on 03-Oct-2024
[144] Industry sources

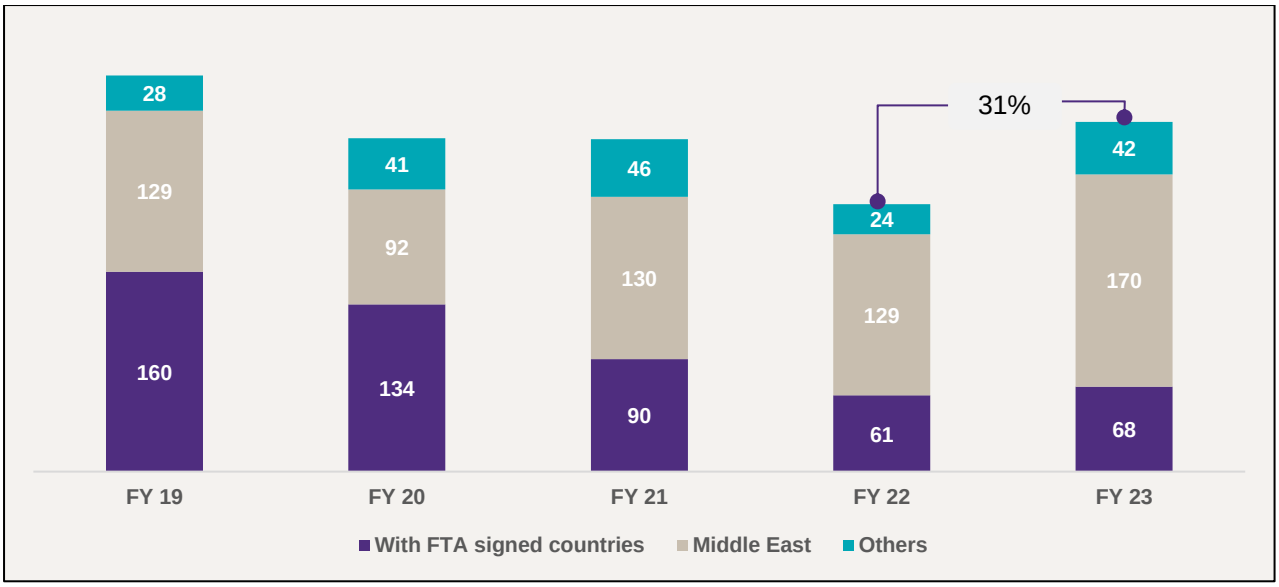


Figure 88: India's primary Aluminium import in kT

The rising import of primary Aluminium in India presents challenge for domestic primary Aluminium producers like increased competition in domestic market.

Pricing of unwrought Aluminium poses significant challenge for the Indian downstream Aluminium industry[145]

Over 60% of value addition in the Indian Aluminium industry occurs at the downstream sector level, which also contributes significantly to the industry's output and employment. This sector encompasses a diverse group of producers who manufacture a wide range of products, including Aluminium extrusions, flat rolled products, castings, foil, wire, slugs, powder, lacquers, and other processing applications. These semi-finished Aluminium products are then sold to various customers who use them in further manufacturing processes. However, the downstream sector has been facing challenges due to the rising costs of its primary raw material, unwrought Aluminium, which has been increasing in value and, as a result, reducing the sector's competitiveness.

The cost of raw Aluminium significantly impacts the competitive edge of India’s downstream Aluminium sector. The sector’s main challenge is the inflated cost of primary Aluminium used to create higher-value products. Local primary Aluminium manufacturers set their domestic prices based on import parity, factoring in a 7.5% Basic Custom Duty (BCD) and an additional 0.75% social welfare surcharge (which is 10% of the BCD). This pricing strategy leads to extra income for primary producers through Indian import tariffs, while the downstream industry pays more for the essential raw materials, resulting in excessive expenditure. In the year 2022, the downstream sector in India paid around 470 million USD more than necessary to Indian primary producers. This financial anomaly bolstered the profits of the smelters at the expense of the downstream sector’s growth and investment. Downstream manufacturers, who focus on producing higher-value products, face financial strain due to the necessity of purchasing primary Aluminium at these elevated import parity prices, contributing to their profit decline.

On the other hand, due to volatility in the LME prices, have at many times reduced the margins for primary Aluminium players also. Huge investments are required for setting up primary Aluminium smelters. Any change in pricing will discourage the primary producers. It may not be right to interfere in the play of market forces by artificial price controls or fiscal interventions. In the previous section it can be seen that there are only 3 primary producers in India compared to China, Brazil and USA in its heydays. As more primary players come into the sector, this will automatically bring in competition and ensure moderate pricing of primary Aluminium to the secondary and downstream sector.

[145] Assessing The Impact of CBAM and Tariffs in the Indian Aluminium Industry, IIFT, June 2023

The calculation of overpayment can be shown with an illustration-

i. Primary Aluminium producers add USD 20-30 per ton of Aluminium as premium

ii. Import duty on primary Aluminium is 8.25% (7.5% basic tariff + 0.75% of social welfare surcharge) which constitutes to USD 182 per ton of Aluminium (considering avg. LME price of Aluminium for FY 23-24 is USD 2202/ton)

The excess payment by downstream manufacturers varies with the fluctuating London Metal Exchange (LME) Aluminium prices. The presence of import tariffs on primary Aluminium allows for an increase in the domestic selling price of Aluminium. The cost of primary Aluminium represents a significant portion- up to 60% of the total production costs for finished Aluminium goods in the downstream sector. This high-cost component renders the end products less competitive both in local and international markets.

Rising import of downstream products[146]

As per the data from ITC Trademap, there has been a consistent rise in the import of downstream Aluminium products to India since 2014, growing from 343 thousand tonnes in 2014 to 562 thousand tonnes in 2023, marking a 64% increase. This growth persisted despite a temporary dip in 2020 due to the disruptions caused by the COVID-19 pandemic. The proportion of downstream Aluminium product imports has seen a rapid surge. A significant portion of this, ~70%, is attributed to imports from China, with **Aluminium foil and plates** making up about 65% of total downstream imports. This influx of imports has posed challenges to India's domestic Aluminium industry. The Indian domestic downstream industry is losing its market share steadily due to rising imports of Aluminium products.

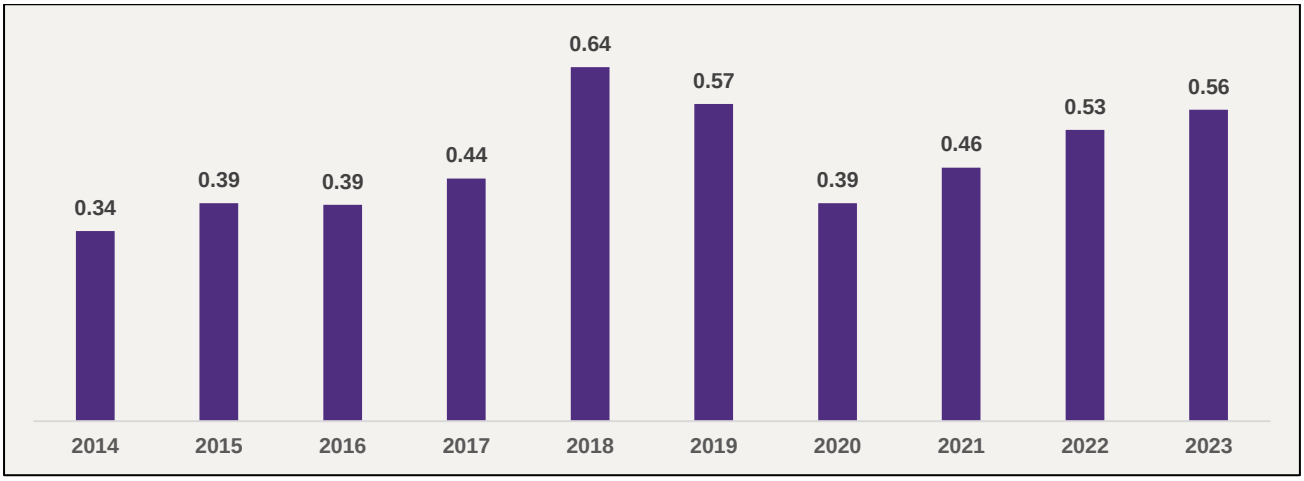


Figure 89: Rising import of downstream Aluminium products in India (MT)

Rising import of Aluminium Articles from ASEAN[147,148]

India is encountering multiple challenges in its Aluminium trade with ASEAN countries under the existing Free Trade Agreement (FTA). The agreement has predominantly favored ASEAN nations, creating a notable trade imbalance. India's import of Aluminium from ASEAN nations have risen swiftly.

A significant issue for India is the potential misuse of the trade agreement. There have been cases where goods from non-ASEAN countries are routed through ASEAN nations to India, bypassing the intended benefits of the FTAs. This practice undermines the trade advantages that India is supposed to gain.

In the FTA, India placed all items in the Normal Track except for 760110 (Unwrought Aluminium, unalloyed). However, Malaysia has imposed excessively high Most Favoured Nation (MFN) duties, ranging from 25% to 30%, on tariff lines between 7604 and 7608. This high duty structure severely restricts the ability of India's downstream industry, particularly Micro, Small, and Medium Enterprises (MSMEs), to export their products.

[146] Assessing The Impact of CBAM and Tariffs in the Indian Aluminium Industry, IIFT, June 2023
[147] In trade renegotiation with ASEAN, India eyes higher exports, lower deficit, Policy Circle, 11-Mar-2024, last accessed on 03-Oct-2024
[148] Industry Sources

Similarly, Indonesia has placed downstream Aluminium products under the Sensitive Track, making it difficult for Indian exporters to access the Indonesian market. These tariff lines should be reviewed to allow better market access for India's downstream industry.

Furthermore, Indonesia is on a massive expansion spree in manufacturing primary Aluminium, with production capacity increasing from 261 kTPA to 636 kTPA between 2018 and 2023 and plans to expand further to 1.5 MTPA by 2027. Malaysia has also increased its production capacity of primary Aluminium from 760 KTPA to 1.1 MTPA during the same period. With increased supply of primary Aluminium from these countries, it might be challenging for Indian Aluminium producers to compete.

Table 17: Major Imports from Malaysia, Indonesia and Thailand

Country	Product	HS Code	Import in FY 16 (Tons)	Import in FY 24 (Tons)	Increase in Import
Malaysia	Primary Aluminium (not alloyed)	760110	1,012	5,565	5.5x
	Primary Aluminium (alloyed)	760120	63,239	83,502	1.3x
	Scrap	760200	11,420	32,749	2.9x
Thailand	Scrap	760200	4,867	6,032	1.2x
	Aluminium plates, sheet	760612	124	12,468	101x
Indonesia	Aluminium Wire	760511	0	2529	-
	Aluminium plates, sheet	760612	86	252	3x
		760692	34	1861	55x

Table 18: Current Basic Custom Duty on Aluminium articles

HS Codes	Description	Current Basic Custom Duty
7601	Primary Aluminium	7.5%
7603-7607	Downstream Aluminium Products	7.5%
7608-7616	Downstream Aluminium Products	10.0%

7.2.6 Impact of CBAM on domestic industry[149,150]

In May 2023, the European Union (EU), which is the second-largest consumer of Aluminium globally, adopted the Carbon Border Adjustment Mechanism (CBAM). This mechanism imposes a tax on imports like Aluminium, electricity, cement, fertilizer, hydrogen, and iron and steel products into the EU, based on the carbon emissions produced during their manufacture. Starting from January 1, 2026, the CBAM will mandate that importers of specific goods that consume a lot of energy, such as Aluminium products, pay a tax that

[149] EU carbon tax to have limited Impact on India's Aluminium exports, Saurav Anand (Economic Times), 09-Apr-2024, last accessed on 03-Oct-2024
[150] India's Aluminium exports to European Union set to become unviable on CBAM dent, ET Energy World, 13-Jun-2023, last accessed on 03-Oct-2024

reflects the embedded carbon cost equivalent to the EU Emissions Trading System (ETS) emissions permit prices. This may adversely impact primary Aluminium more than secondary Aluminium sector.

In the fiscal year 2023, India exported approximately 0.7 MT of primary Aluminium to European Union, representing approximately 29% of India's total merchandise exports to the EU, which are valued at approximately USD 75 billion. The anticipated carbon taxes under CBAM are expected to range from USD 50 to 140 per tonne of Aluminium from 2026 to 2034, amounting to about 2-6% of the price of Aluminium. These projections do not consider indirect emissions, which make up about 80% of the total emissions from producing primary Aluminium in India. If indirect emissions were to be factored into the tax calculations, the impact could be drastic, potentially constituting around 27-30% of the Aluminium price. The cost impact is calculated based on current carbon prices; cost impact may increase up to 70% of Aluminium price. This is because India's Aluminium sector heavily depends on Coal-powered plants, in contrast to the EU, which mainly uses hydroelectric power. Thus, India's primary Aluminium export will be hit hard by CBAM regulation once it is fully implemented by EU. This will result in the diversion of exports to other markets leading to further competition in those markets. India is currently devising its own carbon border tax mechanism which may help on the hand and complicate matters on the other if other countries start devising their own means.

7.2.7 Challenges in securing Round-the-clock Renewable power[151]

Aluminium smelters are required to meet Renewable Purchase Obligations (RPOs) to support the country's renewable energy goals. The RPO Trajectory published dated 22nd July 2022 mandates that 29.91% of the total energy consumed by these smelters must come from renewable sources and this percentage will increase to 43.33% by 2030[152]. The Indian Aluminium industry faces several significant challenges in transitioning to renewable power sources. These challenges stem from the unique operational requirements of Aluminium production, geographical constraints, and economic factors. Here is a detailed overview:

Continuous Power Supply Requirement

Aluminium production is highly energy intensive. Unlike steel production, Aluminium smelting requires a continuous, 24*7 power supply without voltage fluctuations. Any power outage, even for a short duration, can lead to significant operational disruptions and prolonged recovery times, sometimes extending up one to two years. Wind and solar power are inherently variable, depending on weather conditions and time of day. This intermittency makes it difficult to ensure a constant power supply to high energy-sensitive sectors.

PPA Related Disputes

Some primary Aluminium producers have already set up RE projects in states like Andhra Pradesh and Rajasthan. However, the signing of PPAs is often delayed due to approval issues from regulatory commissions, pending court cases, and unviable tariffs offered by discoms

Lack of Perennial sources for Hydro Power

Unlike regions such as the EU and Canada, India lacks perennial sources of large hydro power, which are reliable and consistent renewable energy sources. If India could divert greener sources of power (such as hydro power etc.) towards industries and use Coal-based power primarily for the domestic sector, it could help India's price competitiveness.

Land Acquisition for Solar Parks

Setting up large solar parks in India faces significant challenges due to land acquisition issues. Unlike China, where land acquisition is more streamlined, India's regulatory and social landscape makes it difficult to acquire large tracts of land for solar projects.

Limitations of Wind Power

Wind power in India suffers from low-capacity utilization and erratic generation patterns, making it unreliable for the continuous power needs of Aluminium smelters.

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[151] Industry sources
[152] Renewable Purchase Obligation (RPO) and Energy Storage Obligation trajectory till 2029-2030, Government of India, Order No.: F. No. 09/13/2021-RCM, 22-Jul-2022, last accessed on 03-Oct-2024

High Capital Costs for Storage Solutions

Pump storage and battery plants, which could provide backup power, are highly capital-intensive. This adds to the already large capital expenditure required for Aluminium production.

Nascent Stage of Alternative Technologies

Technologies like hydrogen power and other alternative energy sources are still in the early stages of development and are not yet viable for large-scale industrial use.

Location Disparities

Solar parks are predominantly located in northern India, and wind farms are situated in the western regions or along coastlines. In contrast, Aluminium smelters are typically based near mineral reserves in eastern India, leading to logistical challenges in power distribution.

Economic Unviability of Power sourcing from different sources

DISCOMs (Distribution Companies) charge Cross Subsidy Surcharges (CSS) when consumers opt for open access to purchase electricity from sources other than the local DISCOM. Thus, scheduling different sources of power is economically unviable due to high cross-subsidy surcharges imposed by DISCOMs, along with transmission and other scheduling charges. These additional costs make it difficult for Aluminium producers to switch to renewable energy sources.

7.2.8 Substitution Threat to Aluminium

When evaluating substitutes for Aluminium, several key characteristics are considered. Factors such as availability, cost, quality, and technological advancements play a crucial role in selecting the best alternatives.

Steel: Steel surpasses Aluminium in terms of tensile, compressive, and yield strength. It is also more cost-effective. For instance, High Strength Low Alloy (HSLA) steel and Advanced High-Strength Steel (AHSS) provide greater strength at a lower cost than Aluminium. Technological advancements, such as Direct Reduced Iron (DRI) using hydrogen instead of carbon, significantly reduce CO_2 emissions. This “green steel” is becoming increasingly attractive to industries focused on sustainability. Consequently, sectors like construction and automotive are actively turning to steel[153].

Copper: Factors such as higher electrical conductivity, thermal conductivity (60% higher than Aluminium), superior durability and reliability, and greater tensile strength make it a viable substitute for Aluminium. These properties make it ideal for commercial wiring, as it can carry more current with less resistance and energy loss. Additionally, it is suitable for plumbing and roofing applications, as well as industrial machinery like heat exchangers. [154,155]

Carbon Fiber: It boasts a superior strength-to-weight ratio and excellent fatigue resistance, maintaining integrity through repeated loading cycles. This makes it highly suitable for high-performance applications in aerospace and sporting goods. The strength of carbon fiber is not uniform; it varies with the fiber’s orientation, allowing for customization of component strength by adjusting the fiber weaving. This directional strength is advantageous for parts subjected to multidirectional forces. Additionally, its corrosion resistance makes it ideal for use in marine vessels.[156]

Titanium: Its superior strength-to-weight ratio, corrosion resistance, temperature tolerance, and biocompatibility make it a better substitute than Aluminium. These properties make it ideal for applications in aerospace, automotive, marine, jet engines, industrial processes, medical implants and prosthetics. [157,158]

[153] Aluminium vs steel strength weight and applications compared, Endura Steel Website, last accessed on 10-Aug-2024
[154] Copper Wire vs. Aluminium Wire - Aluminium Magazine, last accessed on 10-Aug-2024
[155] Aluminium and Copper – Comparison – Properties, Material Properties, last accessed on 10-Aug-2024
[156] Carbon Fiber vs Aluminium: Strength & Weight Debate, 22-Feb-2024, last accessed on 03-Oct-2024
[157] Titanium vs. Aluminium: Which Metal Is Better? – PROTO, last accessed on 10-Aug-2024
[158] Aluminium and Titanium - Comparison - Properties, Material Properties, last accessed on 10-Aug-2024

Magnesium alloys: It is 33% lighter than Aluminium, offers superior corrosion resistance, and has better machinability, which reduces costs and time. Additionally, it absorbs energy more effectively under dynamic loading. These advantages lead to its widespread use in automotive, aerospace, and electronics, including laptops and smartphones. [159,160]

7.2.9 Geopolitical Risks[161]

The Russia-Ukraine war caused a significant shock to the global economy, particularly affecting energy and food markets by tightening supply and driving prices to unprecedented levels. For instance, the price of Aluminium on the London Metal Exchange soared to an all-time high of USD 4,000 per metric ton in early March 2022, compared to a monthly average of USD 3,224 in February 2022. This price surge led many Aluminium producers to restart or increase their production capacities, potentially resulting in an oversupply in the market in the coming months. The unusually high Aluminium prices also negatively impacted demand, as consumers began seeking alternative materials.

Additionally, the war has caused a sharp increase in the price of imported Coal, leading to excessive demand for domestic Coal in India and creating shortages for Aluminium producers. This situation could disrupt power supply to Aluminium smelters, forcing production cuts.

The spike in oil prices due to the Russian military operations affected not only Aluminium prices but also the prices of all commodities. The Brent Crude Oil Index rose from around USD 80 per barrel at the beginning of 2022 to about USD123 per barrel by March 7, 2022. Similarly, supply chain disruptions caused by the invasion increased the overall cost of shipping operations. The Clark Sea Daily Rate Charter Index showed a rise in shipping rates from ~ USD 30,000 per 40-foot container at the end of January 2022 to over USD 40,000 in March 2022. Any further escalation of geopolitical tensions, such as the Russia-Ukraine war or potential US-China conflicts, could lead to high volatility in Aluminium supplies and prices, global inflation, and disruptions in trade and supply chains.

[159] Magnesium alloys - uses, applications and benefits, Keronite, 12-Apr-2022, last accessed on 03-Oct-2024
[160] Magnesium Alloys: An Alternative for Aluminium in Structural Applications, Scientific.Net, last accessed on 03-Oct-2024
[161] Annual Report, NALCO, FY23

8. Policies and Regulations

8 Policies and Regulations

8.1 Existing Policies: World vs India

In this chapter we have compared the policies and regulations of key Aluminium consuming/producing countries which can provide valuable insights for increasing Aluminium consumption in India sustainably. Understanding how other countries have boosted their Aluminium industries can help India create policies that stimulate economic growth, attract investments, and create jobs. By aligning with international standards and practices, India can enhance its competitiveness in the global market, making its Aluminium products more attractive to international buyers.

8.1.1 China

China is the world's leading Aluminium producer, generating around 41 MT each year, which represents 58.8% of the global annual output. Over the years, Chinese Aluminium Industry has been greatly supported by policies in various end-use segments. In transport, policies like the Auto Industrial Policy (2000), Light Duty Fuel Consumption standards (2004), scrappage programs (2008, 2011), and the NEV (New Energy Vehicle or Zero Emission Vehicle) mandate (2018) were aimed at optimizing fuel consumption, reduce emissions and in turn promoted Aluminium use in vehicles. Consumer durables saw increased Aluminium demand due to subsidy programs (2009-2012) for energy-saving products. Packaging benefited from laws like the Prevention and Control of Environmental Pollution by Solid Waste (2007) and the Food Safety Law (2009), which encouraged recyclable and non-toxic materials. The electrical sector's Aluminium demand was boosted by the Wind Power Development Plan (2014) and standards for low-voltage Aluminium alloy cables (2015). In construction, initiatives like the affordable urban housing focus (2011), the Belt and Road Initiative (2013), the National Plan on New Urbanization (2014) and the Code for Acceptance of Energy Efficient Building Construction (2015) has encouraged the use of green building material like Aluminium which has significantly driven Aluminium consumption.

In addition to the classification of Aluminium as one of the strategic minerals and policies stated above, the country has, in recent years, implemented various initiatives to support the sustainable growth of its Aluminium industry and decarbonize the sector. Some of the measures taken by China has been mentioned below:

Capacity Swap Scheme[162]**:** Since 2017, China has capped Aluminium production capacity at 45 MTPA with an aim to control overcapacity and decarbonize its energy-intensive sectors. This policy requires the retirement of old capacities for any new Aluminium smelter project to proceed, ensuring capacity addition by an equivalent amount. Consequently, less efficient old smelters have been closed, reducing overall emissions and energy consumption, thereby increasing the efficiency of Aluminium plants. As a result of this policy, Chinese companies have begun establishing Aluminium production capacities in hydropower-rich areas within China from Coal-reliant regions and outside of China, in resource-rich countries like Indonesia (known for its Bauxite reserves) and regions with low energy costs such as Saudi Arabia, to ensure the sustainable growth of their Aluminium industry.

The swaps are not expected to significantly impact Aluminium production levels in the near term, as most of the planned capacity quotas were from plants already idle due to high operating costs. However, in the long term, utilization rates are anticipated to increase and production costs to decrease as more efficient, low-cost replacement capacities come online.[163]

China's National Development and Reform Commission (NDRC)[164]: Like many other countries, the Chinese government is implementing policies to encourage industrial decarbonization. They are increasing the cost of carbon-intensive Coal power and promoting the use of more affordable, low-carbon grid power.

[162] China's green policies push aluminum smelters to step up overseas investment, Avery Chen (S& Global), 09-May-2023, last accessed on 04-Oct-2024
[163] China Aluminium Market to Reach Capacity Ceiling on Swap Policy, Fitch Ratings, 20-Aug-2019, last accessed on 04-Oct-2024
[164] China's 2024-25 Energy Conservation and CO2 Reduction Plan – Compliance Considerations for Businesses, Arendse Huld (China Briefing), 17-Jun-2024, last accessed on 04-Oct-2024

Additionally, the government is encouraging Aluminium plants to relocate to the southwestern region, where there is an abundance of hydropower resources and a significant energy cost advantage.[165] With an aim to decarbonize its Aluminium sector and promote green power Aluminium, NDRC proposed a plan for the Aluminium industry with following criteria by the end of 2025:

- 30% of the production capacity of China's Aluminium industry should be above government's 'energy efficiency benchmark' (EEB)
- The proportion of renewable energy used in production should be more than 25%
- Output of recycled Aluminium should reach 11.5 MT.

Imported Scrap Quality Control Measures[166]: Since 2020, the Chinese government has implemented quality standards for specific categories of scrap metal imports.

- Copper, brass, and Aluminium scrap are required to meet a minimum purity level of 99.1%.
- Additionally, upon arrival at Chinese ports, these materials must undergo and pass inspections conducted by Chinese customs authorities.
- Furthermore, waste materials destined for import into China must be accompanied by a pre-shipment inspection certificate, which should be issued by inspectors recommended by The China Certification & Inspection Group.

Other Measures: In addition to the measures stated above, China has since long, been providing several commercial benefits to its Aluminium producers:

- Export taxes on upstream Aluminium products, such as scrap, primary, and secondary Aluminium, have been designed to discourage the export of these non-downstream products and to promote the domestic downstream industry. While the export of primary Aluminium was discouraged by imposing a 15% export tax, the export of semi-fabricated and fabricated Aluminium products was favoured with a VAT rebate of 13%-15%[167].
- Low-cost financing, reduced land use fees, cheaper electricity, and tax benefits have been helping Aluminium producers lower their production costs, making them more cost competitive in the global market.

8.1.2 USA

USA is among the top 10 consumers of Aluminium by volume. Recognizing its importance to economic growth, the USA has classified Aluminium as a 'Critical Mineral' on the USGS list of 50 identified minerals[168]. Over the past decade, the Aluminium industry has invested more than USD10 billion in US manufacturing to meet the growing demand for the metal[169]. Also, US policies focused on EVs, new emission norms for vehicles and discouraging plastic use has greatly helped the growth of Aluminium demand. To support its domestic Aluminium industry, USA has taken several measures which have been stated below:

Section 45X Production tax credit[170]: Section 45X of the 'Inflation Reduction Act, 2022' offers a 10% credit on eligible production costs, including labor, electricity, depreciation, and overhead. The primary goal of this tax credit is to support the domestic Aluminium industry, reducing reliance on imports and enhancing the competitiveness of the US Aluminium sector. Additionally, the tax credit is encouraging many Aluminium companies to restart idled production capacities and helping existing smelters become more energy-efficient and less polluting, thereby boosting global competitiveness.[171]

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[165] How China is decarbonizing the electricity supply for Aluminium, Jorgen Sandstrom (World Economic Forum), 21-Apr-2022, last accessed on 04-Oct-2024
[166] How to export recyclable materials to China? Reyes Lopez (Scrap ad), 03-Aug-2022, last accessed on 04-Oct-2024
[167] What Caused the Aluminum Industry's Crisis?, Thomas Bradtke, (BCG), 24-Jun-2023, last accessed on 04-Oct-2024
[168] What Are Critical Materials and Critical Minerals?, Department of Energy, last accessed on 04-Oct-2024
[169] U.S. Aluminum Drives Modern Manufacturing with $10+ Billion Invested, The Aluminium Association, last accessed on 04-Oct-2024
[170] Federal Tax Credits for Solar Manufacturers, Department of Energy, last accessed on 04-Oct-2024
[171] US Aluminium industry welcomes clarification on Section 45X, Yasemin Esmen (Fast Markets), 20-Dec-2023, last accessed on 04-Oct-2024

The act allocates over USD 50 billion for new grants, loans, and tax credits to support clean manufacturing and promote solar, wind, and battery production, allowing these sectors to benefit from tax credits for five years. It aims to incentivize the production and sale of domestically produced clean energy components, such as PV modules and their subcomponents, inverters, tracking system components, and batteries. This initiative is expected to generate new demand for Aluminium[172].

Antidumping Duties (AD) and Countervailing Duties (CVD)[173]: In October 2023, to protect U.S. Aluminium businesses from unfair competition, resulting from unfair pricing by foreign companies and unfair subsidies to foreign companies by their governments, the U.S. Department of Commerce announced the initiation of these duties for Aluminium extrusions from countries such as China, Colombia, Ecuador, India, and Indonesia. The AD rates for Chinese Aluminium extrusions range from 32.79% to 86.01%, while the CVD rates span from 7.37% to 216.61%. A similar antidumping duty was imposed in 2018 for certain Aluminium foil imported from China which were used in F&B and pharma packaging, fins in AC's and industrial insulations. In 2019 US imposed antidumping duty on imports of Aluminium wires and cables from China.

Aluminium Import Monitoring and Analysis (AIM): The system, managed by the Department of Commerce, gathers and disseminates early warning data on Aluminium product imports. Through the import monitor, AIM offers an early indication of Aluminium imports by publishing near real-time aggregate data on imports into the United States. This system enables users to monitor potential unfair trade practices and analyze evolving import trends that affect their specific markets and help industry to better prepare for market fluctuation and competitive pressures [174].

8.1.3 European Union (EU) Council

In June 2023, the EU Council designated Bauxite, Alumina, and Aluminium as strategically important raw and critical materials. To strengthen the domestic Aluminium industry, the EU aims to ensure that by 2030, its processing and recycling capacities will cover at least 50% and 20%, respectively, of its annual consumption of these strategic raw materials[175]. Other steps taken by the EU include:

Temporary State Aid Framework, 2022[176]: To tackle the high electricity prices driven by economic, regulatory, and geopolitical factors, the EU Council proposed grants of EUR 400,000 per undertaking. Specifically for Aluminium production facilities, a maximum aid of EUR 50 million was allocated to cover up to 70% of eligible energy costs and 80% of operating losses. This initiative has helped stabilize the Aluminium market, preventing disruptions, ensuring a steady supply of Aluminium products in the EU, and limiting production curtailments at Aluminium plants.

CBAM (Carbon Border Adjustment Mechanism)[177]: The EU's Carbon Border Adjustment Mechanism (CBAM) is the EU's tool to put a fair price on the carbon emitted during the production of carbon intensive goods that are entering the EU, and to encourage cleaner industrial production in non-EU countries. This also includes Aluminium which would encourage the import of highly decarbonized Aluminium in the EU nations. By ensuring that a price has been paid for the carbon emissions embedded in the production of certain goods imported into the EU, the CBAM will ensure that the carbon price of imports matches the carbon price of domestic production. This measure will not only ensure a level playing field for the domestic low carbon producers but also help maintain the EU's climate objectives without being compromised. This will also encourage the existing idled Aluminium plants to operate with full capacities.

EU Innovation Fund[178]: To meet EU's GHG emission reduction targets, the EU Innovation Fund allocates EUR 40 billion to be invested by 2030 in advancing clean, low-carbon, and innovative technologies. A special

[172] FACT SHEET: Clean Manufacturing Investments in the Inflation Reduction Act, Bluegreen Alliance, Jun-2022, last accessed on 04-Oct-2024
[173] Inflation Reduction Act creates new tax break for US critical minerals, Camellia Moors (S&P Global), 15-Aug-2022, last accessed on 04-Oct-2024
[174] https://www.trade.gov/Aluminium-monitors
[175] European Council adds bauxite, alumina, aluminum to strategic materials, S&P Global, last accessed on 6th Oct 2024
[176] Reconciling growth and decarbonisation amidst the energy crisis, European Aluminium Reaction to the Repower EU Plan, May-2022, last accessed on 04-Oct-2024
[177] Carbon Border Adjustment Mechanism, europa.eu, last accessed on 04-Oct-2024
[178] Discover the Innovation Fund, one of the world's largest funding programmes, with €40 Billion funding, euinnovationfund.eu, last accessed on 04-Oct-2024

allocation of EUR 1.4 billion is designated to enhance industrial manufacturing capacity, including the Aluminium sector. This will help generate new domestic demand for Aluminium and ensure sustainable growth of the domestic Aluminium industry.

In addition to the policies stated above, Europe's packaging recycling targets (2017) which aim for 65% by 2025 and 70% by 2030 and European Strategy for Plastics in a Circular Economy (2018) promote recyclable Aluminium packaging. The 2019 initiative to phase out internal-combustion engines by 2040 in several countries increases Aluminium demand in the transport sector. Additionally, policies reducing the total ownership cost of EVs, such as subsidies and tax exemptions in Norway, the Netherlands, the UK, and France, further drive Aluminium demand in the automotive industry.

8.1.4 Russia

Russia is third largest primary Aluminium producer in the world with a contribution of ~5% to the world's Aluminium production[179]. With a strong emphasis on efficiency and technological innovations in the sector, Russia has also identified Aluminium as 'strategic metal' for defence. Here are some policies of Russia which are key enablers for growth of domestic Aluminium industry:

"Aluminium Valley" Special Economic Zones (SEZ)[180]: The establishment of the "Aluminium Valley" SEZ in Siberia is a strategic initiative by the Russian government to boost Aluminium production and consumption. Companies operating within these zones are guaranteed protection from unfavorable changes in taxes and duties for up to 49 years. This long-term stability is crucial for attracting and retaining investment. Investors in the SEZs receive a series of tax benefits, customs preferences and infrastructure support. These incentives reduce the overall cost of production, making the zones more attractive to both domestic and international investors.

Export Tariff on scrap, primary and secondary Aluminium: To discourage exports of upstream products, Russia has placed tariffs on exports of such products. On the other hand, to promote value addition within the country, in 2021, Russian Government set the export duty on Aluminium alloys at 0%[181].

Government Support for Aviation Industry: In the aviation sector, the formation of the Unified Aircraft-Building Corporation (UABC) in 2006 consolidated aircraft manufacturing activities, enhancing efficiency and production. The Aviation Industry Development Plan 2013-2025, coordinated by multiple ministries, aimed to boost global competitiveness and production volumes. Additionally, significant government support announced in 2014, with plans to invest $28 billion by 2025, further strengthened the aviation industry, driving Aluminium demand in this sector.

8.1.5 Middle East

Middle Eastern countries benefit from some of the lowest electricity and natural gas costs globally and are significant Aluminium producers outside of China. The UAE and Bahrain are the leading Aluminium producers in the region, collectively contributing nearly 6% of the world's primary Aluminium production. Key initiatives promoting the growth of the Aluminium industry in the Middle East include:

Dubai Industrial Strategy 2030[182]: The strategy aims to transform Dubai into "an international hub for knowledge-based, innovative, and sustainable industrial activities." This will be achieved by enhancing industrial coherence and integration with other key economic sectors, particularly strategic ones, and by creating an attractive investment environment through various initiatives and incentives.

Six industrial subsectors have been targeted in this strategy, with Aluminium & Fabricated Metals being one of them. Dubai is a leading global producer of fabricated metals, particularly Aluminium. While this leading position is currently based on the manufacturing of upstream primary products, the strategy aims to enhance the Emirate's competitiveness and expand its production base to include downstream finished products. The

[179] Mineral Commodity Series 2023, USGS, last accessed on 04-Oct-2024
[180] https://www.aluminas.ru, last accessed on 10-Aug-2024
[181] Government approves zero duties on Aluminium alloys, 28-Oct-2021, Government Decisions - The Russian Government, last accessed on 10-Aug-2024
[182] Dubai Industrial Strategy 2030

growth of other five sectors targeted in this strategy will also contribute to significantly to the domestic Aluminium demand.

Free Trade Zones[183]: These FTZs provide a plethora of incentives for the investors to set up the upstream and downstream value chain in Dubai. Businesses established in these zones benefit from 100% foreign ownership, providing full control to investors. One of the key attractions is the exemption from corporate and personal tax for an extended period, typically up to 50 years. This tax holiday serves as a powerful incentive for foreign companies looking to establish a presence in Dubai.

Invest Aluminium Bahrain Program[184]: This program, initiated by Bahrain's Ministry of Finance and the Ministry of Industry and Commerce, aims to develop the country's downstream Aluminium industry. It focuses on creating more job opportunities for Bahrainis, boosting export earnings, and achieving greater value addition. The project plans to provide the necessary infrastructure to establish a downstream zone near the Aluminium Bahrain factory, attracting both local and foreign investment and enhancing exports in this dynamic sector.

8.1.6 Indonesia[185]

Indonesia's Bauxite reserves stand at 1 BnT and is also the sixth largest producer of Bauxite. A key component of Indonesia's 20-year development plan, the "2045 Golden Indonesia Vision," is to elevate the country to the world's fifth-largest economy. A crucial aspect of achieving this goal is the development of an integrated metals supply chain, with a focus on downstream processing of key commodities such as Bauxite, nickel, and copper. Indonesia has taken several measures to promote the domestic Aluminium industry:

"Pioneer" Industry Status for Aluminium[186]: In line with the 2045 vision, Indonesia has granted "Pioneer" industry status to Aluminium subject to fulfilment of criteria like substantial investment, creating significant employment using raw materials and contributing to export. This status offers several commercial benefits to encourage investment and development of the domestic Aluminium industry. Some of the benefits include tax holiday of 100% of the corporate income tax due for 5 to 20 years, for project value more than IDR 500 Bn depending on the scale of investment and 50% reduction in tax due for 5 years for project value ranging between IDR 100 to 500 Bn.

Ban on Bauxite Export: To further develop its downstream domestic metals sector, Indonesia announced a ban on Bauxite exports in 2021, which was confirmed in May 2022 and officially took effect on June 10, 2023. This ban is expected to remain in place for the foreseeable future. Previously, Indonesian Bauxite accounted for a significant portion of China's imports. However, with the ban in place, China is now exploring opportunities to establish Aluminium production capacities within Indonesia.

Restrictions on Scrap Imports[187]: In 2019, the Indonesia announced it would restrict waste imports to those with a threshold of 0.5% impurities. However, in July 2021 it eased its restrictions and now permits import of pre-export inspected recycled commodities with up to 2% impurities.

8.1.7 Malaysia[188]

Malaysia is a significant player in the global Aluminium market and accounted for nearly 2.5% of the global Aluminium trade in 2023 (by value). To achieve its Low Carbon Aspiration 2040 initiative, Malaysian government launched the National Energy Policy 2022-2040 to develop a low-carbon economy with focus on EV penetration, increased capacity and usage of renewable energy sources, alternative low carbon fuels for transportation etc.[189]. These measures are expected to boost the Aluminium demand in Malaysia.

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[183] Free trade zones and public-private cooperation to boost Dubai industry, UAE: Dubai | Industry, Oxford Business Group, last accessed on 04-Oct-2024
[184] Aluminium Downstream Zone – Invest in Bahrain, last accessed on 04-Oct-2024
[185] Indonesia vows to invest more in Aluminium supply chain in strategy for critical metals, Laura Roberts (Fast Markets), 20-Jun-2024, last accessed on 04-Oct-2024
[186] Investing in Indonesia – 2023: Industrial Incentives & Zones, OOSGA, 31-Oct-2023, last accessed on 04-Oct-2024
[187] Indonesia to allow waste imports with 2% contamination limit, Corin Williams (MRW), 19-Jul-2021, last accessed on 04-Oct-2024
[188] Guidelines for Importation and Inspection of Metal Scrap, sirim-qas.com.my, last accessed on 04-Oct-2024
[189] Malaysia: Malaysian National Energy Policy 2022-2040, Baker Mckenzie, 26-Sept-2022, last accessed on 04-Oct-2024

Aluminium Scrap Import Regulation: To prevent import of low-quality Aluminium scrap, The Malaysian Ministry of International Trade and Industry (MITI) released guidelines for the Importation of Metal Scrap that became effective since 2022. The guideline states criteria for waste and scrap of ferrous, copper and Aluminium to be allowable to import. The key points are-

- It is to be ensured that the imported metal scrap is not contaminated with any scheduled waste, hazardous materials, or other impurities
- For Aluminium waste or scrap (HS Code 7602) following criteria should be met-

Criteria Grouping	Requirement (% by weight)
Solid Non-Ferrous	Minimum: 94.75%
Solid Ferrous	Maximum: 5.0%
Solid Plastics	Maximum: 0.25%
Scheduled waste including electrical and electronic	0%
Other Impurities	0%

- Pre-shipment inspection by accredited inspection body for each consignment to ensure that metal scrap conforms to the criteria set.

8.2 India – Need to Emulate the Global Growth Blueprint

India is currently among the top three producers and consumers of Aluminium globally. However, its per capita consumption lags significantly behind the world average of 12 kg. Factors such as taxes and duties on Coal and electricity and an inverted duty structure on raw materials pose challenges to the growth of the domestic Aluminium sector. Additionally, India lacks a direct policy supporting the Aluminium industry.

Nevertheless, various government initiatives, such as the PLI scheme for large-scale electronics manufacturing, white goods production, high-efficiency solar PV modules, automobiles and auto components, the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME India) Scheme, and the Green Energy Corridor Initiative, have created a favorable environment for domestic manufacturing. These policies promote the adoption of products that use Aluminium as a key component, thereby driving demand for Aluminium.

To sustain and exponentially expand its Aluminium demand while remaining competitive with leading Aluminium producing countries, India can take cue from the major Aluminium producers/consumers.

Globally, major economies have recognized Aluminium as a strategic metal, classifying it as a core or pillar industry and a strategic sector in their long-term industrial growth strategies.

Countries such as China, those in the Middle East, Russia, Canada, Norway, and Iceland offer various incentives to support their domestic Aluminium industries. These incentives include concessions and subsidies, availability of raw materials, cheaper power through long-term agreements, preferential gas allocation, tax benefits, export tax incentives, and low-interest rate loans.

Additionally, countries like the USA, China, the EU, Australia, and Turkey have implemented several safeguard measures, such as high customs duties and stringent standards, to mitigate the threat of imports and protect their domestic industries.

By formulating policies and reforms tailored to the Indian Aluminium industry India can ensure cost competitiveness in terms of raw material security for critical inputs, Coal, power, and logistics. This support will boost the domestic Aluminium industry and help them stay competitive globally and help India achieve self-sufficiency by reducing import dependency, thereby creating a level playing field and attracting more investments.

9. Aluminium Sector Vision

9 Aluminium Sector Vision

India's vision for the Aluminium sector should align with the goals of 'Atmanirbhar Bharat' and 'Viksit Bharat'. Launched in 2020 by Prime Minister Narendra Modi, 'Atmanirbhar Bharat' aims to make India self-sufficient by developing domestic production capabilities, crucial for the Aluminium industry.

The Indian Aluminium sector can play a crucial role in achieving the ambitious goals[190] of the Viksit Bharat 2047 vision-

- **Economic Growth**

  The Aluminium industry contributes 2% of India's manufacturing sector GDP, which is expected to grow substantially[191]. The Aluminium sector can significantly contribute to achieving a USD 30 trillion economy by 2047 by enhancing domestic production and focusing on high-quality Aluminium products to boost exports.

- **Boosting Indigenous Industry and Innovation**

  Aluminium is essential for various industries, including automotive, electrical, aerospace, and construction. By investing in R&D and innovation, the sector can enhance the quality and competitiveness of Indian products.

- **Self-Reliance in Defence and Space**

  Aluminium's lightweight and durable properties make it ideal for defence and space applications. Developing indigenous capabilities in these sectors can reduce dependency on imports and strengthen national security.

- **Green Growth and Climate Action**

  Aluminium is infinitely recyclable, which supports sustainable practices. Increasing the use of recycled Aluminium can reduce carbon emissions and energy consumption. Additionally, Aluminium is crucial for renewable energy technologies like solar panels. The role of Aluminium in light-weighting in the transportation sector can also play a significant role in bringing down India's oil-import bill.

- **Empowering Youth with Skills and Education**

  The Aluminium industry is a significant source of employment. It directly and indirectly generates employment of 20,500 for per Million Tonne of Aluminium Production[192]. It includes jobs in the upstream sector i.e. Bauxite mining, Alumina refinery and Aluminium production. For every direct employment, Aluminium industry has the capacity to generate indirect employment of 3.7 times. The Aluminium sector can collaborate with educational institutions to provide specialized training and skill development programs. This can prepare the workforce for advanced manufacturing and technological roles.

The Aluminium sector should focus on enhancing domestic production, reducing import dependency, and fostering innovation. By investing in advanced technologies and sustainable practices, India can boost the competitiveness of its Aluminium industry. This includes developing high-quality products for critical sectors like aerospace, defense, and infrastructure, enhancing recycling, and reducing carbon emissions. Strengthening the Aluminium sector will support economic growth, create job opportunities, and contribute to a resilient and self-sufficient economy. India's vision should be to develop a self-reliant Aluminium industry that stands as a competitive and sustainable global leader. To achieve this, India's mission should be to promote the Aluminium industry for a sustainable future through eco-friendly and sustainable practices.

[190] Vision India@2047: Transforming the Nation's future, LAARDIS, December 2023
[191] Need for an Aluminium Policy in India, NITI AAYOG, 2017
[192] Employment in the Global Aluminium Industry, 2019, International Aluminium Institute; May 2021

9.1 Overall Strategic Objectives

9.1.1 Strengthening Domestic Aluminium Industry to Become 'Atmanirbhar'

It is crucial to meet 100% of domestic demand for primary and downstream Aluminium products through domestic production to become 'Atmanirbhar'. As of FY24, India's domestic primary Aluminium production capacity stands at 4.2 MTPA, with imports accounting for 55% of total domestic Aluminium consumption. To minimise this dependency on imports and capture a reasonable share of global trade, the metal Aluminium production capacity must be expanded to 12 MTPA by FY30, 25 MTPA by FY40, and 37 MTPA by FY47. Increasing the per capita consumption of Aluminium in India is another vital goal. Currently, the per capita consumption is 3.5 Kg (FY24), which is significantly lower than the global average of 12 kg. By 2047, India aims to surpass this global average. This can be achieved by enhancing the application and product innovation of Aluminium. It has been reported that the number of Aluminium applications in India is only a tenth of the global average. As the number of applications increases, so will the consumption of Aluminium.

Amongst the top 10 manufacturers globally, all predominantly primary aluminium producers, China boasts 5 companies. Overall, China has close to 60 smelters. USA also has several companies, such as Arconic, Alcoa, Century, and Kaiser, each with a turnover exceeding USD 1 billion, though these include both primary and secondary producers. USA had about 15 primary Aluminium smelters most of which are closed or have their potlines curtailed today. Europe also has close to 20 primary Aluminium smelters. Russia has close to 10 smelters. Clearly, India has scope for higher number of alumina refineries and smelters.[193]

In summary, the Indian Aluminium industry must focus on expanding its production capacity and increasing per capita consumption through innovation and application. Achieving these targets will not only make India self-sufficient in Aluminium production but also position it as a major player in the global Aluminium market.

9.1.2 Self-Sufficiency in Raw Material for Aluminium Production

Bauxite: India's Bauxite production reached 24 MT in FY24. The increasing demand for Aluminium has led to a significant rise in Bauxite imports, which have more than doubled from 1.6 MT in 2014 to 3.8 MT in 2023.

Alumina: In the fiscal year FY24, India's Alumina production was 7.6 MT, with imports and exports amounting to 2.5 MT and 2.1 MT, respectively in 2023. Despite not being self-sufficient in Alumina production, a considerable quantity is exported. However, the capacities of NALCO and Vedanta are being increased and the Alumina imports will reduce significantly.

Scrap: India is currently dependent on imported scrap for meeting 85%-90% of the domestic scrap requirement.

To address the growing demand for Aluminium and ensure adequate Alumina supply, India should aim to meet 100% of its Bauxite and Alumina requirements from domestic sources by 2035. India will also need to participate in the global supply chain for scrap to ensure consistent availability of raw material for secondary route. This will also contribute significantly to India's ambition to reduce carbon footprint. This strategic move will not only reduce dependency on imports but also strengthen the country's position in the global Aluminium market.

9.1.3 Achieving Carbon Neutrality in Aluminium Production

The Indian Aluminium industry is responsible for over 3% of the country's total greenhouse gas emissions. While primary Aluminium producers have set a target to reach net-zero emissions by 2050, the sector, as a whole should aim to reduce Greenhouse Gas emissions from Aluminium production by 30% by 2030 compared to 2023 baseline to achieve net-zero. For this India will need to plan low carbon intensity green line dependent on RTC RE and scrap.

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[193] Primary Aluminum Producers, Light Metal Age Magazine, 24 November 2023, last accessed on 03 October 2024

9.1.4 Focus on Value Addition and Export growth

Notably, 76% of India's Aluminium exports volume consist of primary Aluminium, with only 24% being downstream products. Conversely, China's export composition is 5% primary Aluminium and 95% downstream products. In terms of value, India exported Aluminium and Aluminium products worth USD 7.3 billion in 2023. Of this, USD 4.8 billion (65%) was unwrought or primary Aluminium, while 35% were downstream Aluminium products. In contrast, China exported Aluminium and Aluminium products worth USD 35 billion, with only 3% being primary Aluminium and 97% being downstream Aluminium products. This highlights China's strategic focus on capturing a high share of the value-added in the supply chain before exporting. To enhance its position in the global Aluminium market, India should adopt a strategic approach focusing on increasing the production and export of value-added downstream Aluminium products. India should aim to maximize the conversion of its primary Aluminium production into value-added products by 2035 and should maximize its export composition towards downstream Aluminium products by 2047.

In 2023, China accounted for a significant 12.6% of the global Aluminium export market, with a total export volume of 67.6 million tonnes for the year. In comparison, India's export share was 3.8% of the global Aluminium trade volume. Aluminium exports from India represented 1.7% of the country's total export value, with cumulative merchandise exports reaching USD 431 billion in 2023[194]. India aims to achieve USD 1 trillion in merchandise exports by 2030.

To increase its share in the global Aluminium market volume from 3.8% in 2023 to 10% by 2047, India needs to boost its Aluminium metal export volume to 3.8 MT by FY30, 6.9 MT by FY40, and 9.1 MT by FY47.

9.2 Functional Objectives

9.2.1 Renewable Energy Usage

In accordance with the Renewable Purchase Obligation (RPO) Trajectory set forth by the Ministry of Power, it is mandated that by 2030, 43.33% of the total energy consumed by Aluminium smelters must be sourced from renewable energy. To align with this directive and further our commitment to sustainable practices, we should set ambitious targets for the integration of renewable energy in our Aluminium production processes. Given that Aluminium production necessitates a substantial and reliable electricity supply, it is improbable that renewable energy alone can fulfill the entire demand. Therefore, it is anticipated that 30% of the electricity requirement will continue to be met by captive power plants (CPP)[195]. India should target to increase the share of renewable energy to 70% of the total energy used in Aluminium production by 2070.

9.2.2 Increasing Aluminium Recycling Rate

India's vision for an Atmanirbhar Bharat (self-reliant India) highlights the need for a robust domestic Aluminium industry that leverages both primary and secondary Aluminium production. Currently, India's End-of-Life Recycling Rate (EOL-RR) for Aluminium stands at approximately 30%, compared to the global average of around 56%. This indicates significant potential for improvement in scrap collection and metal recovery. To align with global standards, India should aim to achieve the current global EOL-RR for Aluminium by 2047.

9.2.3 R&D Investment

In developed countries, Aluminium has over 3,000 applications, whereas the no. of applications is close to 300 in India[196]. To bridge the gap between no. of applications in developed countries and India, Indian Govt. should focus on R&D in Aluminium focusing on downstream sector.

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[194] India | Imports and Exports | World | Aluminium and articles thereof | Value (US$) and Value Growth, YoY (%) | 2012 - 2023 (trendeconomy.com), last accessed on 03-Oct-2024
[195] Evaluating Net-zero for the Indian Aluminium Industry, CEEW, April 2024
[196] Need for an Aluminium Policy in India, NITI AAYOG, 2017

9.2.4 Technology and Digital Interventions

As of 2023, no Aluminium plants globally have been recognized as Industry 4.0 Lighthouses by the World Economic Forum (WEF). In contrast, two steel plants in India have achieved this certification, showcasing their advanced adoption of Fourth Industrial Revolution technologies. A total of 15 manufacturing plants in India have been certified as Lighthouses in 2023, highlighting the country's progress in integrating cutting-edge technologies to enhance productivity and efficiency. So, adoption of Industry 4.0 technologies such as AI, IoT, smart manufacturing technologies to be leveraged to transform Indian Aluminium industry.

9.2.5 Quality Certification

100% of Aluminium products to meet international quality standards by 2030. 100% of Aluminium scrap imported into India should be refined and certified as free of inimical elements before being cast into other downstream products.

9.2.6 Skill development

Develop a skilled workforce by training in Aluminium production techniques and safety standards by 2030.

9.2.7 Product diversification

High-performance Aluminium alloys for various applications, such as automotive, aerospace, and construction to be developed in India.

9.3 Key enablers

9.3.1 Key Enablers to Strengthen India's Aluminium Industry and Achieving Self-Sufficiency in Raw Material Production

9.3.1.1 Classifying Aluminium as 'Core' Industry[197]

India's core sector encompasses eight crucial industries: Coal, crude oil, natural gas, refinery products, fertilizers, steel, cement, and electricity. However, unlike Steel, the Aluminium Industry in India has not been accorded 'Core' status, despite being a vital component of the nation's economy. Aluminium is indeed of strategic importance for several reasons, particularly in driving the government's agenda in various new-generation and sunrise industries like Electrical Vehicles, Wind Turbines, Solar panels, Packaging etc. The Aluminium sector accounts for almost 2% of India's manufacturing GDP, a figure that is anticipated to rise alongside consumption growth. Moreover, the industry is a significant source of employment, directly and indirectly generating approximately 800,000 jobs. Also, these statistics highlight the critical role of the Aluminium industry in the broader manufacturing sector and its influence on India's economic landscape. Consequently, it is advocated that the Aluminium Industry be designated as a "Core Industry", and it has also been recommended in a report published by NITI Aayog. It will help the industry to get preferential allocation of energy, rakes, PLI, government procurement support, protection from dumping, FTAs etc.

9.3.1.2 Expediting exploration and auction of Bauxite blocks[198]

Aluminium, due to its role in electric vehicles and aerospace industry, is of strategic importance to the world and India as it faces an uncertain energy transition and geopolitical scenario. As discussed earlier in the document, the expansion of Aluminium sector of any country cannot be driven through the secondary route as it is limited by the ability of the economy to generate scrap. Secondary route may be less energy-intensive, but it can only maintain status quo. Primary route can be the only basis for expansion of the industry. The inability to see this link led to the downfall of the US Aluminium industry. ALCAN, now part of Rio Tinto but originally an offshoot of ALCOA, is today the largest exporter of Aluminium to USA in an ironical turn of events. Primary Aluminium needs energy and access to bauxite. Of all the leading Aluminium producing countries in

[197] Need for an Aluminium policy in India, NITI AAYOG, 2017
[198] Why import bauxite when you can mine, Financial Express, March 18, 2021, last accessed on 03-Oct-2024

the world only India and Russia have these necessary ingredients. It would be unfortunate, if India despite possessing these resources, is unable to capitalize on the same.

Despite having the resources and a robust market, India's efforts to auction limited number of Bauxite mines is impeding its potential to emerge as a global manufacturing leader. Notably, even with India's vast Bauxite resources, which are among the world's largest at nearly 4.9 BnT, the nation still imports Bauxite for its Aluminium needs. The inability to utilize these resources has led to a substantial foreign exchange loss, estimated at over USD 1.1 Bn[199] in the past five years. This financial drain is likely to persist if India doesn't manage to auction Bauxite mines successfully and boost existing mine production by at least 50%.

Getting bauxite linkage has proved to be difficult for Indian alumina refineries. The Lanjigarh investment of Vedanta struggled for many years and even today awaits finalization of bauxite pricing methodology. The best quality bauxite in the Eastern Ghats is claimed by local tribals on account of their hereditary rights of worship. On the other hand, only 13% of India’s bauxite resources are classified in reserve category. Even the blocks auctioned so far, were won at very highly premiums, reducing the profitability of the aluminium producers. The following actions are needed –

Expediting exploration of Bauxite blocks[200]

Considering the quality of Indian Bauxite, 3 tonnes of Bauxite is required to producing 1 ton of Alumina and 2 tonnes of Alumina is required for producing 1 ton of metal Aluminium. Therefore, for 1 ton of metal Aluminium there is requirement of 6 tonnes of Bauxite. It indicates that for development of Aluminium sector in India, there is huge requirement of Bauxite as well as refining facilities of Bauxite for preparing Alumina. India has huge potential of Bauxite, however, most of the resources are yet to be explored to convert the ‘indicated’ resources as ‘proved or probable’ category.

Central Govt. through MMDR Act, 2015 has created National Mineral Exploration Trust to create fund for exploration activities and the National Mineral Policy now facilitates for FDI investment in mineral exploration. Govt. needs to take active role in attracting private sector in exploration. Also, deposits beyond the Eastern Ghats should be unlocked through expeditious proving of resources and auction of Composite License. This initiative should be taken up on a mission mode by a designated taskforce.

GSI should be given targets to expedite bauxite exploration, specially in Andhra Pradesh, Chhattisgarh and Odisha.

Auctioning larger bauxite blocks

The proving of large sized leases (having more than 100 MT resources) should be prioritized over smaller leases. The lack of clarity on potential pipeline of large deposits makes it difficult for large players to plan alumina refining capacities. Where leases are smaller in size, a cluster of those within a reasonable radius, amounting to over 70 – 80 MT resource, may be offered as a single license at one go, for the purpose of auction so that an alumina refinery may be planned against the same. Such leases may be identified in Chhattisgarh, Jharkhand and Odisha. This initiative should be taken up on a mission mode by a designated taskforce. State Governments should exercise the power vested in them vide Section 6 (1) (c) of MMDR Act for auctioning of non-contiguous mining leases. Visibility of a sufficient pipeline of leases can also instil confidence in bidders and prevent them from unreasonable bidding aggression.

Govt. of Odisha has already identified ~40-45 nos. of bauxite blocks in Koraput, Rayagada, Kalahandi, Kandhamal districts some of which are already explored or under exploration. Resource quantity in many of these blocks are less than 5 MT. State Govt. may consider amalgamation of the smaller size blocks, wherever possible, and put up for auction as bigger blocks to attract serious investors. Similar such small blocks may be found and clubbed for auction purposes in other Bauxite rich states. Any changes in rules, if necessary, need to be done.

[199] ITC Trademap, last accessed on 12-Aug-2024
[200] Development of Aluminium and Copper industries in the Country, 31st Report of the Standing Committee on Coal, Mines and Steel (17th Lok Sabha), 22-Mar-2022

New players (other than NALCO, Vedanta, and Hindalco) are waiting in the wings. Odisha and AP Government may consider award of land parcels for setting up green-field refinery along with attached mining lease and create efficiency parameters even for the development of the alumina refinery on the lines of MDPA for mining leases. This can be secured through higher performance bank guarantee.

A railway master plan is required for the bauxite mining areas to ensure that railway lines are laid and the movement of bauxite rakes and BTAP rakes are facilitated.

9.3.1.3 Early operationalization of Coal and Bauxite blocks[201]

The production of Aluminium is a complex and energy-intensive process, with several major cost components. Alumina, other raw materials, and the energy cost account for up to 88% of total cost of production. While Alumina alone accounts for ~33% of total cost of production mainly due to significant energy consumption and cost of caustic soda, energy costs for the electrolysis process can account for ~37% of the total production costs. While bauxite is required for Alumina production, coal is consumed in the thermal CPPs.

To ensure cost competitiveness, timely operationalization of captive Coal blocks is necessary. Out of 107 Coal blocks auctioned till date, only 11 Coal blocks have been operationalized successfully.[202] Land acquisition and obtaining statutory clearances like Environmental Clearance (EC), Forest Clearance (FC) are major bottlenecks for mine operationalization.

It is crucial that industries, upon being granted Coal and Bauxite mining rights, encounter no administrative or legal obstacles while bringing these mines into operation. In this regard the following support measures are advocated:

- The government may ensure that the major statutory clearances (Environment, Forests, and miscellaneous) should be available with the blocks put up for auction.
- Alternatively, Environmental Clearance (EC) and Forest Clearance (FC) may be granted in one single step within a specified timeline. Also, the industries may be allowed to self-certify compliances, with the condition of imposing substantial penalties by the Govt. for any breaches.

9.3.1.4 Regulating tariffs and revisiting FTAs

It is required to implement a balanced approach to tariff regulations keeping in mind the importance to protect the domestic Aluminium industry form overpricing of primary Aluminium due to import parity price & unrestricted import of downstream products and at the same time ensuring the competitiveness of the downstream industry. Therefore, a two-pronged strategy could be considered:

Revisit FTAs

In the India-ASEAN FTA, India placed all items in the Normal Track except for 760110 (Unwrought Aluminium, unalloyed). However, Malaysia's high MFN duties (25%-30%) on tariff lines 7604 to 7608 severely restrict India's downstream industry, especially MSMEs, from exporting their products. Similarly, Indonesia's placement of downstream Aluminium products under the Sensitive Track hinders Indian exporters' access to the Indonesian market. These tariff lines should be reviewed to **include the downstream products under 'Normal Track'** to allow Indian downstream industry to access these markets.

Indonesia and Malaysia are significantly expanding their primary Aluminium production capacities. Indonesia's capacity has grown from 261 kTPA in 2018 to 636 kTPA in 2023, with plans to reach 1.5 MTPA by 2027. Malaysia's capacity increased from 760 kTPA to 1.1 MTPA over the same period. This surge in supply from these countries could present competitive challenges for Indian Aluminium producers. Hence, to shield Indian producers from the competitive pressures posed by the increased supply of Aluminium from Indonesia and Malaysia, relevant tariff items should be reviewed, and bilateral safeguard clauses should be strengthened.

[201] Industry sources
[202] Coal Ministry to Launch 10th round of Commercial Coal Block Auction, PIB Delhi, 14th Jun 2024, last accessed on 03-Oct-2024

Several strategic adjustments to the Rules of Origin (RoO) like implementing Product Specific Rules for countries like Indonesia, Malaysia, and Thailand are required. Specifically, for primary Aluminium, the RoO should require “Refining & Smelting at the country of Export,” ensuring that only primarily produced Aluminium enters India. For downstream products, the RoO may be reviewed to prevent Aluminium value-added products made from scrap from entering the Indian market while allowing genuine products from ASEAN countries. The current FTA also has cumulative value addition criterion RoO norm which should be removed to include minimum value addition required in one member nation to export at preferential tariff level. This measure will prevent re-routing of Aluminium products.

Also, ensuring a level playing field for the domestic Aluminium industry is crucial during the FTA negotiations with the Russia-led Eurasian Economic Union (EAEU) as industry has raised concern about the potential influx of Aluminium articles from Russia.

Conditional FTAs for Technology Transfer

To strengthen the Indian Aluminium sector, India may consider negotiating conditional Free Trade Agreements (FTAs) with technologically advanced countries like Canada, Russia that include provisions for technology transfer. These agreements should specifically focus on facilitating the transfer of advanced technologies related to refining and smelting. By incorporating clauses that mandate technology transfer, India can gain access to cutting-edge processes and innovations, which can significantly enhance the efficiency and competitiveness of its Aluminium industry.

Such FTAs can include provisions for technical cooperation, research and development partnerships, and the sharing of best practices in Aluminium manufacturing. This will not only help Indian companies adopt more efficient and sustainable production methods but also foster innovation and skill development within the industry.

By leveraging these conditional FTAs, India can modernize its Aluminium sector, reduce production costs, and improve the quality of its products, making them more competitive in the global market. This approach will also support the broader goal of industrial growth and economic development in India. One classic example can be the India-European Free Trade Association (EFTA) Trade, where similar provisions were kept.

Trade remedial measures

Approximately 70% of downstream imports come from China, with Aluminium foil and plates making up about 65% of total downstream imports. Appropriate trade remedial measures should be taken on a case-by-case basis where there is proof of dumping of Aluminium articles in Indian market.

The Indian Aluminium industry already pays taxes like coal cess, electricity duty, while the imported Aluminium articles are often cheaper because other countries may not have similar taxes, giving their products a price advantage. A taxes like Border Adjustment Tax (BAT) would level the playing field between domestic producers and foreign competitors, ensuring that the environmental costs are accounted for in the price of imported goods.

Protecting Domestic Industry from Unilateral Restrictions like CBAM under FTAs

The EU's Carbon Border Adjustment Mechanism (CBAM) aims to prevent carbon leakage by imposing a carbon price on imports from countries with less stringent climate policies. To protect the domestic Aluminium industry from such unilateral restrictions, India should seek exemptions or special considerations for its Aluminium industry to mitigate the impact of CBAM and similar mechanisms during FTA negotiations.

Focus on Research and Development

Research and Development (R&D) should be more focused on development of new high-performance alloys for aerospace sector, expanding the applications of recycled Aluminium by management of impurities.

9.3.1.5 Technological upgradation

Alumina

Indian Bauxite contains 5 to 14% of boehmite (mono hydrated Alumina) and the rests are gibbsite (trihydrate Alumina). In general, a low digestion temperature (~ 150° C) is employed for gibbsitic Bauxite while a high temperature (~ 250° C) is used for boehmitic Bauxite. In India most of the refining plants are having facilities of single stage digestion (for extracting gibbsite), excepting Muri and Renukoot Alumina plant of Hindalco. In single stage digestion plant the boehmitic Bauxite is being wasted as a part of red mud. As a result, there is a gap of 7 to 9% between TA% (Total Alumina content) and TAA% (Total Available Alumina content). Ideally this gap should be reduced to 2 to 3% if the Bauxite will be refined under double digestion process. Therefore, it is advisable to convert to / construction of Alumina plant with facilities of double digestion to produce more Alumina and in turn more metal Aluminium. Some of the technological advancements in alumina refining and red mud utilisation/treatment have been mentioned in Annexure 2.

Aluminium

India currently lacks advanced technology for Aluminium smelters, making it reliant on global technology providers such as Rio Tinto Alcan and GAMI for setting up new plants and upgrading existing ones. This dependency increases the cost of both upgrading and establishing new facilities. An overview of the smelter technologies is provided in Annexure 2. To enable sustainable development of its domestic Aluminium industry, India could leverage its relationships with countries that host the latest Aluminium smelting technologies for economical technology imports.

9.3.1.6 Providing institutional support to the Aluminium Sector[203]

In both Aluminium and steel, India is ranked second in the world in terms of production. The difference is, however, in the quantum of steel produced in MTPA and the number of players in the industry classified into various categories. Also, steel sector predates Aluminium sector globally and in India. There is a whole Ministry dedicated to steel due to its large economic value unlike Aluminium. While the Aluminium industry has its JNARDDC, there are some lessons to be taken from the ecosystem of institutional structures and common platforms available to the steel industry that play a role in its development.

Core Ministry of Steel (Mos) driven bodies

a. **Joint Plant Committee –** A body which is charged with data collection related to the sector, conducting various initiatives (e.g. rural consumer demand assessment) and issuing publications of authenticated Government data. The Apex Committee of the JPC comprises senior Ministry of Steel officials, representatives of top steel producers, representatives of various industry associations, representatives of Ministry of Mines, Railways and Statistics. It also houses an Economic Research Unit (ERU) that conducts specialized research on the steel-based economy. JPC does reasonably good work as a centralized data bank of the industry.

b. **Biju Patnaik National Steel Institute (BPNSI)** – A wholly owned MoS body, the Institute was set up as a center of excellence that will provide technology and skilled / trained manpower to the steel industry with special focus on the emerging technologies and industry practices. As the steel sector is gearing up

[203] Ministry of Steel and its affiliated institution websites.

towards Industry 4.0 and De-carbonization, the BPNSI is playing a significant role in conceptualizing the building the skill inventory of India to participate in the process.

c. **National Institute of Secondary Steel Technology (NISST)** – This too is a body like the BPNSI but focused on secondary steel. It also has a Research & Development mandate. The Institute is managed by a Board of Governors consisting of members from industry, Educational Institutions, Industrial Associations & Ministry of Steel.

Industry bodies sponsored by the Ministry

a. **INSDAG** – The Institute for Steel Development and Growth was mandated primarily to create awareness amongst potential users about benefits of steel use. It provides advisory service on materials, construction practices, interpretation of code etc. so that steel is not placed worse against competitive materials for want of data/ information. INSDAG has played a phenomenal role in promoting newer applications of steel such as crash-barriers on Ghat roads, sound mufflers on city flyovers etc.

b. **SRTMI** – The platform, "Steel Research & Technology Mission of India" (SRTMI) was set up to facilitate R&D programs of national importance, create state of art facilities to conduct cutting edge research, develop expertise and skill development, manage human resources and bolster a tripartite synergy among industry, national R&D laboratories and academic institutes. Indian steel mills continue to import capex items from European and Chinese OEMs. It was envisaged that SRTMI would drive synergies across the IITs, CSIR Labs, NITs etc. and make India self-sufficient in steel technology. This is a relatively recent body and has much more to achieve to prove its utility.

Joint Ventures between public and private sector bodies

Steel Ministry has been a pioneer in championing joint ventures between the public and private sectors. Some organizations like mJunction (a JV between SAIL and Tata Steel) have been more successful compared to others like S&T Mining. ICVL is a JV of public sector entities that is trying to solve India's coking Coal problem. India recently tried to drive collective negotiation and import of coking Coal, but it fell through. However, these attempts reflect the desire of driving synergies between individual organizations.

JNARDDC: Technology Centre of Excellence Across Aluminium Value Chain

JNARDDC should be conceptualized as a technology center of excellence and support the growth of not only primary Aluminium but also downstream sector. With the support of the Department of MSME, programs could be run that help JNARDDC transition from a centralized organization to one where it can provide R&D support to the distributed downstream Aluminium clusters that shall develop going forward. This may require JNARDDC to re-evaluate its role. The following potential exists:

- Assist the Downstream Applications Development taskforce to bring in the technical capacity to produce them in the country. This may need JNARDDC to invest in equipment that enables more innovative means of production technologies.
- There are no international Aluminium sector consulting firms in India of the stature of GAMI (now part of Chinalco) or Innoval (now part of Danielli). Even the steel sector in India has MECON, Railways sector has RITES, O&G sector has EIL etc. These agencies have achieved such levels of penetration across the world that they can influence technical specifications for their respective sectors. It is imperative that JNARDDC fills this vacuum and rediscovers itself to play this role.
- To play these roles it may need to give up non-core areas that it might be engaged in. Such as data collection for the Ministry or some role in economic policy making. As such a different organization like JPC for the steel sector, is proposed to be replicated in Aluminium to play such a role.

9.3.1.7 Correcting duties and rectifying the inverted duty structure on critical raw materials

To make the domestic Aluminium producers cost competitive, Govt. can take the following corrective measures-

Coal GST compensation cess Reimbursement as Incentive

The Coal Cess, initially introduced at INR 50/MT in 2010, has seen successive increases over recent years:

- Raised to INR 100/MT in 2014-15
- Further increased to INR 200/MT in FY16
- Doubled to INR 400/MT in the Union Budget FY17

The introduction of a considerable Coal Cess significantly increases the financial strain on industries that consume a lot of power. The GST compensation cess on coal should be reimbursed to the purchasers of coal for CPPs as an incentive for establishing downstream capacities. This incentive could be proportional to the installed downstream capacities. Such a measure would significantly lower production costs and enhance the cost competitiveness of the aluminium industry. A similar incentive is already being considered by Ministry of Coal for setting up coal gasification units.

Utilization of revenue generated from coal cess[204]

The coal cess, previously known as the "Clean Energy Cess" and "Clean Environment Cess" was introduced in India to generate funds specifically for renewable energy initiatives through the National Clean Energy and Environment Fund (NCEEF). Between FY10 and FY18, India collected INR 86,440 crore from this cess. However, not all of this revenue was allocated to the NCEEF. For instance, in FY16, only 24% of the coal cess revenue was directed towards the NCEEF to support clean energy and environmental projects. There is a need for a larger portion of the coal cess revenue to be dedicated to renewable energy and clean environment technologies.

Revision/exemption of electricity duty

In Odisha, which houses three-quarters of India's Aluminium production capacity, the Electricity Duty on Captive Power Plants (CPPs) increased from ₹0.30/kWh to ₹0.55/kWh in 2017. This hike has resulted in a significant escalation of manufacturing expenses for Aluminium industry. It is advised that the Aluminium industry's Captive Power Plants (CPPs), which are notably energy-intensive, should be relieved from the Electricity Duty. Alternatively, it is suggested that the Electricity Duty be adjusted back to the initial rate of ₹0.30/kWh.

Revision of inverted duty structure and high basic custom duties on raw materials

The presence of an inverted duty regime and elevated basic custom duties on critical raw materials significantly hampers the competitiveness of local Aluminium manufacturers who rely on imports for their inputs. Hence, it is recommended to reduce the present Basic Custom Duty of 7.5% on the critical raw materials like Calcined Petroleum Coke, Aluminium Fluoride, Caustic Soda Lye.

Allowing CPC imports as per the Aluminium capacity

According to Notification No. 68/2023-DGFT dated March 7, 2024, the total permissible import for 2024-25 is 1.9 MT of Raw Petroleum Coke (RPC) for manufacturing Calcined Petroleum Coke (CPC) and 0.5 MT of CPC for the Aluminium industry. From 2025-26 onwards, the permissible import will be 1.9 MT of RPC for manufacturing CPC and 0.8 MT of CPC for the Aluminium industry. Removing these import restrictions could significantly boost the domestic Aluminium industry. By allowing greater imports of RPC and CPC, Indian Aluminium producers would have more consistent and reliable access to essential raw materials and this would enable them to plan for expansion in smelting capacity.

9.3.1.8 Resolving infrastructural and logistics issues

To address the critical need for consistent raw material supply chains to maintain the Aluminium smelting operations without incurring excessive costs, the following measures can be taken-

[204] The Evolution of the Clean Energy Cess on Coal Production in India, IISD

Dedicated freight corridor development[205]

Development of Dedicated Freight Corridors (DFCs) in India can significantly boost the Aluminium industry in several ways. The introduction of electrified rail lines is set to enable freight trains to operate at triple the speed and haul larger cargoes. This enhanced speed, affordability, and dependability in transporting goods are expected to play a significant role in diminishing the elevated expenses associated with logistics. The advancements will assist India in lowering its disproportionately elevated logistics expenses, which currently stand at about 13-15% of its GDP. This initiative is aimed at achieving the goal of reducing these costs to 8%, thereby aligning India's logistics expenditures closer to the international norms.

Modification in Preferential Traffic Order

As per the Preferential Traffic Order issued from time to time, traffic is classified into four categories viz., A, B, C and D. Commodities registered in the higher categories have preference over those registered in the lower categories. As per the Preferential Tariff Order for allotment of wagons (General Order 98, dated 26.03.2024) by Ministry of Railways, Coal, Iron ore, Salt, Fertilizer and POL are included in Priority 'C'. It is recommended to include Aluminium & its Raw materials in Category– "C" from existing Category– "D" in Railway's Preferential Traffic Order.

Rationalizing Logistics costs of critical raw materials and wastes by reducing railway freight in a revenue neutral manner

As per Goods Tariff No. 45 (w.e.f. 01.04.2007)[206] , Bauxite has been classified as Base Class 160 and Alumina as 180. Due to this classification, higher freight charges are applicable on Bauxite and Alumina which are critical raw materials for Aluminium industry. It is recommended to re-classify Bauxite from class 160 to lower class 145, and Alumina from class 180 to lower class 170. Also, the waste materials like Red mud and Fly Ash which are classified as Base class 110, 120A, may be offered by Railways to be transported at discounted rate. These reductions in railway freight can be done in a revenue neutral approach where Railway provides reduced freight rates in exchange for a certain offtake pledge from the producer's side. This could also help in reducing the environmental impact of these waste materials by promoting their reuse and recycling. Such agreements could be structured to ensure that the Railways do not incur losses while supporting industrial producers in managing their waste more effectively.

9.3.1.9 Ensuring consistent supply of Coal to CPPs

Ensuring a consistent supply of Coal for Captive Power Plants (CPPs) is crucial for the Aluminium industry, which is highly dependent on continuous and intensive power to maintain the production process. To mitigate the risks of Coal supply shortage to CPPs the following measures can be taken-

Conducting regular NRS Linkage Auctions with sufficient offer to meet increasing demand

The allocation of Coal dispatches should be followed as per the Ministry of Coal circular for Auction of Linkages, dated 15th February 2016, specifies that Coal should be distributed in the proportion of 75% for power and 25% for non-power sectors. This directive aims to ensure a balanced supply of Coal to different sectors, considering their importance and contribution to the country's infrastructure and economy.

- These policy guidelines are not being complied fully. The quantity allocation of Coal in linkage auction should consider a bottom-up approach which should consider the open demand for all the CPPs in Non-regulated sector.
- The disparity in non-coking Coal prices for power and non-power sector should be removed. The notified price of Coal by CIL for the non-power sector should be at par with that of the power sector.

[205] India Takes a Quantum Leap in Building New Freight Corridors, World Bank, January 21, 2021, last accessed on 03-Oct-2024
[206] Goods Tariff No.45 Pt. I (Vol. II), Indian Railways, 2nd Mar 2007, last accessed on 03-Oct-2024

Applying the latest norms of CEA for calculating linkage eligibility

The latest consumption norms issued by CEA consider GCV losses due to stocking, extra moisture and in-transit pilferage. CIL however continues to use the old norms which do not consider these losses. CIL should apply the latest CEA norms to calculate Coal Requirement for CPPs.

Resolving rake pendency issue

Despite the commendable efforts from the Ministry of Coal (MoC) and Coal India Limited (CIL), the issue of linkage rake pendency from different subsidiaries of CIL remains a significant challenge. To address this, MoC and CIL should consider several strategic measures. Firstly, they could allow the shifting of pending linkage rakes to other subsidiaries that are better positioned to handle the demand. This flexibility would ensure a more efficient distribution of resources and reduce delays in coal supply.

Additionally, offering a change of mode of transportation without any additional premium could be highly beneficial. This would enable consumers to switch to more efficient or available transportation modes without incurring extra costs, thereby facilitating smoother and faster delivery of coal. Lastly, providing special priority for consumers owning General Purpose Wagon Investment Scheme (GPWIS) rakes would be a crucial step. These consumers have already invested in infrastructure to support coal transportation, and prioritizing their needs would enhance the overall efficiency of the supply chain. Implementing these measures could significantly alleviate the current challenges and improve the reliability of coal supply to the industry.

Digitalization of activities

Ministry of Coal, Coal India Ltd. may extend digitalization initiatives to other areas like Delivery Order issuance, financial reconciliation etc.

9.3.2 Key Enablers for Achieving Carbon Neutrality in Aluminium Sector

9.3.2.1 Focus on domestic scrap recycling

India's aspiration for an Atmanirbhar Bharat (self-reliant India) underscores the importance of a strong domestic Aluminium industry. Achieving this goal requires a well-balanced strategy that harnesses the advantages of both primary and secondary Aluminium production. Recycling Aluminium is significantly more energy-efficient, consuming 95% less energy compared to producing it from raw Bauxite.

Compared with manufacturing through the primary route, recycling of Aluminium consumes significantly less power (5-7% of the total energy requirement for primary Aluminium). Each tonne of Aluminium manufactured through recycling results in saving of 5-6 tonnes of Bauxite, 20-25 tonnes of water and ~14000 kWh of energy (~90-95% of energy savings as per International Aluminium Institute). Also, 1 tonne of Aluminium manufactured through the recycling process results in savings of ~3,500 kg of CO_2 emission.[207]

Scrap usage in India is diffused and not regulated through standards or end-use restrictions with heavy reliance on imports. To align with global standards, India should aim to achieve the current global EOL-RR i.e. 56% for Aluminium by 2047 and enhance job creation opportunities.

To create a sustainable Aluminium ecosystem, it's crucial to promote higher domestic scrap generation while strategically managing imports to fill any gaps. Achieving this goal requires a multifaceted strategy. Taking cue from Brazil's success, India can establish its own closed-loop Aluminium recycling ecosystem. This would not only reduce India's reliance on scrap imports but also maximize the potential of domestically generated scrap.

Ensuring the quality of Aluminium scrap entering the ecosystem

Some countries Like Malaysia, China and Indonesia have already taken stringent measures to ensure the quality of scrap entering their country's ecosystem. India, aiming to align with global best practices and its commitment to the UN Sustainable Development Goals, particularly Goal 12, should consider developing

[207] Assessment of secondary Aluminium industry in India, CRISIL, September 2022

comprehensive guidelines for the import of Aluminium scrap. These guidelines could be modeled after international standards, such as those recently implemented by the Malaysian Ministry of International Trade and Industry (MITI), while also considering India's unique environmental, social, and industrial needs. The decision regarding the implementation of quality control on aluminum scrap imported by India may be made by the designated taskforce, which is proposed to be established in this Vision Document (Section 9.4.2).

In this regard, an agency or agencies may be created/ mandated that shall set up large scale state-of-the-art scrap segregation plants at the point of ingress to provide collective service to secondary Aluminium / Recycling Industry to create economies of scale. Government may identify the requirement for providing support / incentive for setting up such units in India / abroad for collection, and segregation of Aluminium scrap which can be provided to recycler maintaining the quality of scrap.

Govt. can consider developing comprehensive guidelines on based on the recommendation of Resource Security Taskforce-

- **Quality Standards:** India should establish clear criteria for the quality of Aluminium scrap, including minimum percentages of Aluminium content and maximum levels of nonmetallic impurities. Also, implementing stringent quality checks is required based on international classification guidelines like Institute of Scrap Recycling Industries (ISRI) is essential.
- **Certification Requirement:** Indian should make a mandate that all imported Aluminium scrap is accompanied by a certification from the exporting country, verifying compliance with the established quality standards.
- **Inspection and Monitoring:** India should implement a robust inspection regime at designated ports of entry to ensure that all imported scrap meets the guidelines. This could involve both document verification and physical inspection of shipments.

EPR with closed loop system

The Ministry of Forest, Environment and Climate Change (MoEF&CC) has released a draft of the Hazardous and Other Wastes (Management and Transboundary Movement) Second Amendment Rules, 2024. This draft, issued on August 14, 2024, aims to implement an Extended Producer Responsibility (EPR) framework specifically for non-ferrous metals. The proposed new rules require producers of non-ferrous metals to register with the Central Pollution Control Board (CPCB) and meet their Extended Producer Responsibility (EPR) duties by ensuring their products are collected, recycled, or refurbished.

But it lacks the regulation on closed loop system of scrap collection. The draft should also mandate the Aluminium product manufacturers to collaborate closely with end-user industries to enhance scrap collection and sorting, minimizing the mixing of alloys. By returning scrap to the original manufacturer rather than repurposing it or selling it to scrap dealers, the loop can be closed. Recycling within the same alloy family is crucial for achieving closed loop circularity as mixing different alloys makes the resulting metal difficult to reuse for its original purpose and often necessitates adding large amounts of new metal. Some traceability solutions are required to be implemented in the recycling industry to monitor the recycled materials journey.

Strengthening domestic scrap collection and processing infrastructure

- Ministry of Mines issued a National non-ferrous metal scrap recycling framework, 2020, but the aim should be to develop a comprehensive National Non-Ferrous Metals (Aluminium and Copper) Scrap Recycling Policy to address collection, segregation, and recycling in sustainable manner.
- Developing a mechanism for registration of authorized collection centers, segregators, recycling centers through a national directory.
- Recyclers should be Recycling Industry Operating Standards (RIOS) certified
- Adopting best practices for collection, processing & value addition in recycling process
- Develop or acquire process technologies to separate metals and materials from complex products
- Recycling parks can be created for a specific End-of-life product category

- Introducing recycling-based tax incentives for both industries and public for effective scrap recovery/collection and remelting in consultation with Ministry of Commerce and Industry
- Setting up of recycling plants should be incentivised.
- Financing of recycling and downstream projects should be liberalised for MSMEs.
- Developing indicators for monitoring and reporting mechanism
- Maintain the record of flow of scrap and recycled metal including finished goods, energy use, water use and environmental emissions etc.
- Raising customer awareness about environmentally friendly waste management techniques and providing specific incentives on new products in exchange or scrapping EOL products.
- Creating public awareness program on disposal, handling & recycling schemes.
- Publicity of the policies of MoM concerning the recycling of Non-ferrous metals.
- Alignment with ferrous scrap recycling majors (E.g. MSTC, Tata Steel, Ship-breaking yards etc.) to leverage their network to obtain separated non-ferrous scrap from combined metal scrap (E.g. automobile scrap, ship-breaking scrap)

9.3.2.2 Support by Govt. for transition towards Round-the-clock Green Power[208]

The transition to Round-the-clock renewable power sources for the Indian Aluminium industry is fraught with challenges. Addressing these issues requires a multifaceted approach, including policy support, technological advancements, and significant investments in infrastructure. Collaborative efforts between the government, industry stakeholders, and research institutions will be crucial in overcoming these hurdles and achieving a sustainable energy transition.

Ensuring Round-the-Clock Energy Supply for Aluminium Smelters through Group Captive Power Projects[209]

Aluminium smelters along with PSUs can set up Group Captive Power Projects (GCPPs) with pumped storage projects integrated with renewable energy sources like solar and wind. Group Captive Power Projects (GCPPs) may offer a viable solution for Aluminium smelters seeking a stable and sustainable power supply. Unlike traditional captive plants, GCPPs are owned by multiple users. Such captive user(s) shall hold at least 26% of the ownership in the generating plant. This shared ownership model makes it easier to meet the 51% captive consumption criteria, where power is sourced in proportion to each shareholder's equity.

Companies involved in GCPPs can benefit from various state and central government incentives, such as accelerated depreciation, tax holiday benefits, and exemptions from regulatory levies like Cross Subsidy Surcharge (CSS) and Additional Surcharge. These incentives can significantly reduce the overall cost of power. Also, GCPPs provide a stable cost of power, protecting companies from the frequent tariff changes imposed by Distribution Companies (Discoms). This stability is crucial for Aluminium smelters, which require a consistent and reliable power supply for their energy-intensive operations.

To facilitate the successful implementation of Group Captive Power Projects (GCPPs) and ensure a stable, round-the-clock renewable energy supply for Aluminium smelters, the government can play a pivotal role by establishing a clear and supportive policy framework that encourages the development of GCPPs. This includes simplifying the approval processes and providing clear guidelines for setting up and operating these projects.

[208] Industry sources
[209] Renewable Energy Certificate Mechanism in India, Power System Operation Corporation Limited

Revenue neutral swap contracts

India generates approximately 275 TWh of renewable power annually, while Aluminium smelters require around 70-80 TWh per year. To mitigate the impact of the Carbon Border Adjustment Mechanism (CBAM), one effective measure would be to introduce revenue-neutral swap contracts. These contracts would allow Aluminium smelters to swap renewable power from the grid while selling power from their coal-based captive power plants (CPPs) back to the grid. This arrangement would enable smelters to utilize renewable energy for their operations, thereby reducing their carbon footprint and aligning with global sustainability goals.

In the current scenario, double electricity would be charged on sale of electricity generated through coal and purchase of electricity generated through renewable sources. Additionally, Aluminium producers would need to pay transmission charges. Hence, to facilitate this initiative, an amendment to the current regulations, would be necessary. This amendment would enable the legal framework for implementing swap contracts, ensuring that the transactions are seamless and beneficial for both the smelters and the grid. By enabling Aluminium smelters to swap renewable power from the grid while selling coal-generated power back to the grid, this measure would support the industry's green transition. It would also contribute to India's broader goals of increasing renewable energy usage and reducing carbon emissions, making the Aluminium sector more competitive and sustainable in the global market.

Renewable Power Transition Strategies for Aluminium Smelters

Transitioning to renewable power is crucial for the sustainability of the Aluminium industry. One effective strategy involves linking Aluminium smelters with hydropower stations and developing floating solar projects on nearby water bodies, along with storage systems. These renewable energy sources can create a dedicated green power line, ensuring a consistent and sustainable energy supply. Additionally, integrating scrap remelting facilities with these renewable power sources can further enhance the environmental benefits.

Hydropower stations provide a reliable and continuous source of renewable energy, which is essential for the energy-intensive Aluminium smelting process. By establishing direct linkages with these stations, smelters can secure a stable power supply while significantly reducing their carbon footprint. Floating solar projects on water bodies near smelters offer another innovative solution. These projects not only generate clean energy but also optimize the use of available space, making them a practical addition to the renewable energy mix.

Furthermore, the Nuclear Power Corporation of India Limited (NPCIL) can play a pivotal role in this transition by developing Small Modular Reactors (SMRs) of 220 MW units specifically for large Aluminium smelters. With central allocation or Viability Gap Funding (VGF), NPCIL can ensure the financial feasibility of these projects. SMRs provide a reliable and low-carbon power source, complementing the renewable energy initiatives and ensuring a continuous power supply even when renewable sources are intermittent.

It is suggested to set-up a large green energy park dedicated to Aluminium sector which can provide round the clock power to Aluminium plant. This will boost the investment for setting up capacities for Aluminium and will help industry reducing its carbon emission.

Policy and administrative support from Government

The potential for renewable energy (RE) generation varies across different regions of the country. To support Aluminium producers, RE generation anywhere in the country should be recognized as power used for Aluminium production. Policy interventions are needed to ensure the seamless and timely flow of RE power to Aluminium smelters.

Simplifying procedures for faster inter-state Open Access transactions is crucial. This would allow Aluminium smelters to use RE power generated in other states for captive use, enabling immediate decisions on power usage if state discoms do not continue Power Purchase Agreements (PPAs).

Some primary Aluminium producers have already set up RE projects in states like Andhra Pradesh and Rajasthan. However, the signing of PPAs is often delayed due to approval issues from regulatory

commissions, pending court cases, and unviable tariffs offered by discoms. Long-pending PPA disputes need to be resolved out of court, with the Government of India acting as a facilitator, to encourage RE power producers and ensure a stable power supply for Aluminium smelters.

Designation of Aluminium smelters as deemed distribution licensee

Aluminium smelting operations require a constant and reliable energy supply. The shift from thermal to renewable energy sources, including a mix of wind, hydro, and solar, is impeded by the financial challenges posed by cross-subsidy surcharges, transmission fees, and other related costs levied by Distribution Companies (DISCOMs). At present, the transmission fees for acquiring renewable energy via long-term market agreements are triple the fees charged for thermal power, due to the comparative inefficiency of renewable technologies. It is critical to designate Aluminium smelters as 'Deemed Distribution licensees' to avoid these additional charges for renewable energy.

Partial Exemption of electricity duty

An exemption from the electricity duty for the use of renewable energy in Aluminium smelters should also be implemented. Additionally, Aluminium producers should be allowed direct and unrestricted access to the interstate transmission network, bypassing the losses associated with state transmission systems.

Production Linked Incentive (PLI) Scheme for Aluminium Smelters to Adopt Green Energy

Implementing a PLI scheme specifically for Aluminium smelters can incentivize the adoption of green energy. This scheme would provide financial incentives to smelters that invest in renewable energy sources such as solar, wind, and hydro power.

Research & Development (R&D) Grants for New Technologies

Providing R&D grants for the development of modern technologies such as hydrogen energy and pump storage systems can drive innovation in the Aluminium industry. These grants can support-

- Development of hydrogen as a clean energy source for smelting processes, which can drastically cut down emissions.
- Investment in pump storage technology to store excess renewable energy, ensuring a stable and reliable power supply for smelters.

Preference to low carbon indigenous Aluminium in Public Procurements

Giving preference to low carbon indigenous Aluminium in public procurement policies post 2030 can create a strong market demand for sustainably produced Aluminium. This can be achieved through:

- Implementing policies that require public sector projects to prioritize the use of low carbon Aluminium produced from domestic scrap/ bauxite or alumina.
- Providing incentives for companies that comply with green procurement standards, thereby promoting the adoption of sustainable practices across the industry.

9.3.2.3 Assistance for encouraging coordinate/participating in Global scrap supply chains

While primary Aluminium is a great opportunity for India, scrap is undeniably the best method to reduce energy and carbon intensity of Aluminium production. Also new scrap or process scrap can bring in desirable alloying elements that makes them a cost-effective source of alloys. Under the threat from CBAM, primary manufacturers may look at the secondary route actively. In the future it is quite likely that primary players will also have green energy powered secondary line. The primary players also have the financial heft to ring-fence the reverse supply chain of scrap domestically. This can be evidenced in the way Tata Steel has planning to go ahead with regional ferrous scrap-based EAF facilities.

Globally countries are increasingly realizing the importance of scrap and imposing export duty on it to keep it in the country. Also, there are closed supply chains for new-scrap and special grade alloy scrap that is controlled by large players like Boeing and Novelis. At the same time, there are many countries that have reasonable Aluminium production, scrap generation and yet an unorganized scrap collection system. Scrap

will be the future battleground, and Indian players are several years away from generating any meaningful quantity of scrap domestically. Indian secondary players need to adapt and secure their future.

While there are a few examples of scrap dealers making it big in primary metals in India, it is not possible for all the secondary players to play that role since per unit capex in primary Aluminium is very high. Therefore, it is imperative for India to capture the Aluminium scrap generation across the globe, starting with easy to work-in countries with reasonable amount of scrap generation. While the actual initiative may be taken by members of MRAI and ASMA or even members of AAI or existing players like MSTC, it is important for Government to incentivize this. The taskforce that is set up for raw material security should examine the following topics –

1. Whether this initiative be taken up at the level of Aluminium scrap or non-ferrous scrap or all metal scrap?
2. The nature of knowledge and advice that needs to be provided to Indian players and the method to deliver the same with the help of local embassies.
3. Whether the business plan would include collection of scrap and then transfer to India or should the scrap be processed, segregated, remelted and refined
4. How can Government incentivise these initiatives – through a minority stake or through negative duty on imported metal of a certain quality made from end-of-life scrap and new/ process scrap
5. Certifications that will enable this scrap or the metal processed from this scrap to be treated as ‘green Aluminium’

9.3.3 Key Enablers for Value Addition and Export growth

9.3.3.1 Improving domestic manufacturing capabilities of downstream products and promoting exports

The Aluminium downstream sector in India is predominantly made up of micro, small, and medium enterprises (MSMEs), with over 150 large and mid-sized companies and around 3,500 MSMEs[210]. Currently, only about 1.36% of India's MSMEs are engaged in exporting, indicating a gap between the country's export growth and the internationalization of its MSMEs[211].

To unlock the potential of the downstream sector, it is essential to encourage Aluminium industry players to enhance their production capabilities and focus on exporting value-added Aluminium goods. Promoting the export of these value-added products offers significant benefits to the country. The pricing of these products is less affected by market fluctuations due to the extensive processing, refinement, or transformation they undergo. This differentiation and branding provide greater pricing stability. Additionally, higher value-added manufacturing contributes to increased employment opportunities within the country. The downstream sector has the potential to generate 2.5 – 3 times more employment compared to the primary sector.

Multiple steps can be taken in partnership with the private sector to achieve these goals and fully realize the potential of the Aluminium downstream sector.

Production Linked Incentive Scheme[212]

There is a significant opportunity to expand domestic downstream capacity, particularly in flat rolled products and extrusions. Emerging applications include lightweighting for both conventional and electric vehicles in commercial and personal mobility, Aluminium freight wagons for railways, and can body stock. In the EV sector, there are specific uses for battery foil, casing, and cooling plates. Additionally, strategic applications in Aerospace and Defence, as well as passenger coaches for Railways, highlight the urgent need to develop these capabilities within the country. Based on key parameters like Market size and potential growth, Import substitution, Export potential and value addition, key product segments have been identified where

[210] Assessing The Impact of CBAM and Tariffs in the Indian Aluminium Industry, IIFT, June 2023
[211] VIKSIT: An approach for India to achieve USD 1 trillion exports, PwC, August 2024, last accessed on 03-Oct-2024
[212] Industry inputs

implementing a Production Linked Incentive (PLI) program can render investments more financially feasible, to bolster the replacement of imports with domestic products and boost Aluminium usage.

It should be kept in mind that PLI should be given on component of products instead of assembled products. For example, the current PLI scheme focuses on promoting the manufacturing of complete EVs rather than their individual components. This approach can indeed lead to increased imports of components, with local manufacturers primarily engaging in assembling. Shifting the focus of the PLI scheme to incentivize the production of EV components can shift the entire value chain of EV manufacturing to India.

Also, policy stability for longer duration is crucial for the success of schemes like the PLI. Consistent and predictable policies help build investor confidence, encourage long-term investments, and allow manufacturers to plan and scale their operations effectively.

Table 19: Focus Product Segments for Development of Downstream sectors

For import substitution	For increasing Aluminium usage	For Strategic application areas
Flat Rolled Products – Auto Fin stock/ Clad – Foil Stock – Hard Alloy – Circles – AC Fin **Extrusions** – Solar Frames – Metro 3rd Rail – Formwork	**For lightweighting of** – Commercial vehicles (Bulkers, Trailers, Bus) – Personal Mobility (EVs, Two wheelers, E-Bicycles) – Railway (Aluminium wagons) **Electric Vehicles** – Battery Foil – Battery Casing – Cooling plates **Can body stock for Aluminium cans**	**Aerospace and Defence grade** – Plates – Sheets – Rods **Railway Passenger coaches** – Extrusions – Shell fabrication

Table 20: Focus Downstream Aluminium Products

Focus Downstream Products	Capex for setting up manufacturing plant of 10 kT (USD Mn)	Size of Domestic Market (kT)	Remarks
Flat Rolled Products			
Can Stock	20-30	30-50	Import dependency ~90%
Aluminium Composite Panel	20-30	30-50	Import dependency ~50%
Hard Alloy Plates for Aerospace & Defence Sector	20-30	15-25	Import dependency ~70%
Coil/ Litho	20-30	20-40	Import dependency ~50%
Packaging (Foil for Pharma & Food)	20-30	110-120	Pharmaceutical and packaged food industry

Focus Downstream Products	Capex for setting up manufacturing plant of 10 kT (USD Mn)	Size of Domestic Market (kT)	Remarks
Pharma (Blisters& strips and Aluminium foil) Food packaging (Aseptic and Lidding foil)			prefer sourcing primary Aluminium foils to avoid any contaminations
Extrusion			
Solar Frame (Extrusion Press for Anodized Aluminium Panel)	25-35	190-250	Solar Module import of 2 Bn$ in H1 CY24
EV (2-Wheeler & Passenger Vehicle) (Extrusion Press: 5" - 10" for Handlebar, Battery Enclosure, HVAC Piping etc.) For MHCV (Extrusion up to 13")	25-35	280-320	-
Railways: Vande Bharat Train/Freight Coach (Long extrusion press, Size 13")	30-40	10-15	Majorly imported. Govt. has future plan for manufacturing of 1 Lakh Wagons & 200 Vande Bharat trains
Casting			
Auto: Alloy Wheels (A356.2 grade)	30-40	340-360	Import dependency ~50%
Alloys			
2XXX, 6XXX, 7XXX, AA2XXX for Aerospace and Defence sector	-	50-60	Demand is expected to grow @10% CAGR
2XXX, 5XXX, 7XXX for Marine sector	-	70-80	Demand is expected to grow @10% CAGR
Others			
Aluminium Powder	-	40-50	Demand is expected to grow @5% CAGR
Aluminium Foam	-	10-15	Demand is expected to grow @9% CAGR

Scheme for Technology upgradation

A scheme like 'Technology Upgradation Fund Scheme' (TUFS) that was rolled out for textile industry, can be launched for MSMEs of Aluminium downstream sector. The Capital Investment Subsidy (CIS) under such schemes can provide financial assistance for the adoption of advanced technologies, which can indirectly result in substantial cost savings.

Incentive for setting up Downstream Production Capacities

Liberalised financing and incentives in the form of capex subsidy for MSMEs may promote addition of new downstream capacities thus generating demand for primary and secondary Aluminium and also reducing reliance on downstream imports.

Enhanced RoDTEP rates[213]

The Remission of Duties and Taxes on Exported Products (RoDTEP) scheme aims to refund exporters for taxes, duties, and levies that arise during the manufacturing and distribution of goods, which are not compensated by any other state, central, or local mechanisms. The RoDTEP rates applicable to Aluminium smelters in Domestic Tariff Areas (DTAs) have been notified. However, the rates for Special Economic Zones (SEZs) and Export-Oriented Units (EOUs) have not been announced yet. Together, SEZs and EOUs account for 30% of India's total Aluminium exports. Announcing rates for these zones is expected to provide a significant boost to the nation's Aluminium industry.

Development of Aluminium Park

More Aluminium parks can be established close to Aluminium smelters, allowing downstream Aluminium producers to set up their plants nearby. The government can offer land, water, and electricity at reduced rates. These nearby downstream facilities can receive hot metal directly from the smelters, significantly cutting down on energy consumption.

To boost downstream Aluminium production, impetus should be given to the existing proposed/ new **Aluminium Parks** to bring them into operation as early as possible as it would not only help in value addition but also help in employment generation. This will require the primary Aluminium players to take initiative for developing downstream players in and around their plant by providing land, hot metal, R&D support, centralized tool room facilities, training facilities, competitive power and other amenities and support to such players to make it more feasible. Efforts should be made to adequately publicise such parks to attract investors/ MSMEs for setting up value addition plants.

Skill development

Developing skills is essential for establishing a robust Aluminium ecosystem.

- Programs aimed at enhancing skills in fabrication and precision manufacturing should be implemented. Industrial Training Institutes (ITIs) and Polytechnics (Diploma) can run specialized courses for fabrication, assembly and installation of Aluminium doors/ windows/ facades/ roofing collaboration with national skill development corporation.
- Institutions can offer specialized courses in facade engineering as part of their civil engineering, mechanical engineering, architecture and diploma programs.
- Offering specific Pharma Foil Conversion courses in various packaging institutes to ensure the availability of specific skilled labour for this sub-sector.
- Additionally, introducing courses focused on Aluminium metallurgy at the collegiate level would be beneficial. It's also important to emphasize non-ferrous extractive metallurgy and circular economy in educational curriculums to further support this sector.
- The current collaboration of Aluminium sector with Indian Iron and Steel Skill Council is commendable and should be continued.

[213] Aluminium industry seeks govt intervention to notify rates for SEZs, Economic Times, Oct 16, 2023, last accessed on 03-Oct-2024

Revisiting SCOMET Guidelines

The Special Chemicals, Organisms, Materials, Equipment, and Technologies (SCOMET) list categorizes items that are subject to export controls, and it includes specific categories of Aluminium products that have potential military applications. Aluminium products that fall under the SCOMET list need proper authorization for export, require declaration of end-use, and end-user information. Revisiting these guidelines may encourage export of Aluminium products.

Acknowledging existing implicit taxes on coal and fuel as effective carbon taxes to address CBAM

The Aluminium industry is already paying carbon taxes in lot of implicit ways like

- GST compensation cess of INR 400 per ton of coal
- Cost incurred due to Renewable Purchase Obligation (RPO)
- Electricity duty
- Taxes on petrol, diesel, and other fuels

The implicit taxes are required to be recognized as effective carbon taxes being paid by Indian Aluminium industry. Thus, India can better align with the EU's CBAM requirements, demonstrating that Indian industries are already subject to carbon costs and also align with India's upcoming Carbon Credit Trading Scheme (CCTS).

Considering Total Cost of Ownership in Government Projects

The government's decision-making process, particularly in projects like the Vande Bharat Express with Aluminium coaches, often focuses on upfront costs rather than the Total Cost of Ownership (TCO). While the initial investment in Aluminium coaches is higher due to the cost of materials and advanced manufacturing processes, this approach overlooks the long-term economic and operational benefits. Aluminium coaches, despite their higher upfront costs, offer significant advantages in terms of durability, reduced maintenance, and energy efficiency. They are more resistant to corrosion, which lowers maintenance expenses over time, and their lighter weight results in substantial energy savings during operation. Additionally, the longer lifespan of Aluminium coaches can further offset the initial investment, making them more cost-effective in the long run. By considering TCO in decision-making for public procurements, Government can make more informed decisions that account for these long-term benefits, leading to more sustainable and economically viable solutions.

9.3.3.2 Sector wise interventions required for promoting Aluminium usage

Table 21: Sector wise interventions for promoting Aluminium usage

Key areas to be addressed	Interventions
Building & Construction Sector	
• Lack of comprehensive standards for Aluminium doors, windows and facades resulting in low quality, sub-standard product flooding the market. • Absence of Energy ratings for doors, windows and roofing sheets.	• Creation of a National Fenestration Rating Council of India (NFRC India) in similar lines of USA, to create norms and testing standards. • Implementing a standard for fenestration in India • Preference for use of formwork in government building projects, affordable housing projects, smart city projects, Pradhan Mantri Awas Yojana etc. may be considered.
Packaging	

Key areas to be addressed	Interventions
• Pharmaceutical and packaged food industry prefer sourcing primary Aluminium foils to avoid any contaminations • Lack of standards/ lesser compliance to existing guidelines.	• Strict compliance with BIS guidelines for Aluminium house foil / semi-rigid containers for food packaging. • Suitable regulations for ensuring adequate strength in semi-rigid containers for avoiding contamination or spillage of food. • A cluster-based strategy could be employed to support foil converting MSMEs in supplying to the pharmaceutical industry. They can be given training on standards, technology upgradation support, working capital solutions etc. • Encouraging large companies to procure from foil converting MSMEs on spot payment basis.
Transport	
Railways: Capability gap for manufacturing of large CCD (24") extrusions with length of 25 m	• Strong push for adoption of indigenous Aluminium in wagons, semi high-speed trains and metros.
Two wheelers/ Passenger Vehicles / Commercial Vehicles • Weaker emission control targets and enforcement • Less stringent passenger safety and control regulations	• Strong push for light-weighing of vehicles • In India medium and heavy-duty vehicles account for only 2% of the vehicles on road but contribute to 40% of the total emissions from road transportation[214] • Stricter emission norms (Comparison of Emission Norms given in Annexure 8) for HDVs in line with rest of the world • Mandating efficiency norms for electric vehicles (EVs), such as power consumption per ton-kilometre • Stricter axle-load regulations for Commercial Vehicles like European regulations mandates lightweighting passenger vehicles- a legal weight restriction of 3.5 metric tons, including passengers and cargo[215]. • Capability developments via technology tie-ups by domestic players specially in Brakes and Suspension (ABS) and Crash Management Systems (CMS) • Strong push for adoption of Aluminium in govt. buses / e-buses • Driving adoption of Aluminium by OEMs in Crash Management Systems (CMS), body structures and EV battery housing

[214] Why zero-emission trucks are the future of clean transportation in India, Climate Works Foundation, 9-Mar-2023, last accessed on 01-Oct-2024
[215] All Vehicles Should be Made from Aluminum, Alumobility, July 2022, last accessed on 03-Oct-2024

Key areas to be addressed	Interventions
	• Standards for driving adoption of Aluminium based front / rear underbody protection devices in heavy goods carrier
Electrical, Machinery & Equipment	
Lack of domestic capability to manufacture large Aluminium sections	• Domestic companies to develop abilities for manufacturing large profiles (for Welding machines up to 400 mm CCD, for UPS / Invertors up to 400 mm CCD) • Domestic companies should focus on enhancing their capabilities in cold rolling and indirect pressing to achieve improved tolerance requirements and superior surface finishes.

9.3.3.3 Quality Standards for Aluminium

Detailed set of standards for Aluminium products is necessary for prevention of import of sub-standard products. Also, there is a need for change of perception on the quality of Indian downstream products. Indian primary Aluminium is recognised as quality product in global export market, but downstream products are not being recognised as quality products worldwide. Industry needs to work with BIS on suggestions related to all products generated from Primary and secondary Aluminium covering foreign material content, mechanical properties (tensile strength, hardness), hazardous material, free from defects, dimension tolerances, sampling & testing etc. For downstream industry, especially in packaging, Building & Construction there should be emphasis on stricter enforcement on existing guidelines and new standards in areas where they don't exist. For example, BIS guidelines by FSSAI for Aluminium house foil/ semi rigid containers in packaging. Also, there exists lack in comprehensive standards for Aluminium doors, windows and facades due to which low quality products are flooding the domestic market. So, there is a need for standardization on performance criteria for fenestration in the Building & Construction sector.

Also, Quality standards should be developed for utensils and extrusions where target consumers are unaware of quality issues. Products manufactured from recycled Aluminium should be certified from NABL accredited laboratory. There is a need for quality standards in cycles being produced in India. The current cycles being used are of such poor quality that they will be scrapped sooner than later and they will go to landfills.

9.3.3.4 Establish Cluster Based Research and Development Facilities[216]

Research & Development (R&D) drives the development of new Aluminium alloys and products, enhancing their properties such as strength, durability, and corrosion resistance. This innovation is essential for meeting the evolving demands of industries like automotive, aerospace, and construction. Also, Research in the downstream sector can focus on improving recycling processes and reducing the carbon footprint of Aluminium production. In developed countries, Aluminium has over 3,000 applications whereas in developing economies like India, the usage is limited[217]. R&D enables the exploration of new applications for Aluminium, opening up additional markets and increasing the material's versatility. Hence, Govt. should increase the expenditure focusing on R&D of Aluminium downstream sector.

Cluster-based R&D facilities for Aluminium sector can be developed in India along with focus on Aluminium parks. These facilities will bring together experts from different fields to work on interdisciplinary projects and

[216] Industry sources
[217] Need for an Aluminium Policy in India, NITI Aayog, 2017

will help to collaborate among industry partners, academic institutions, and research organizations. Following clusters in the downstream sector across states may be considered for development of R&D facilities-

i. **Rajkot Aluminium Foundry cluster, Gujarat-** Around 60 foundry units are situated in the industrial areas surrounding Rajkot city. These units manufacture precision components for use in automobiles, machinery, engineering, and electrical equipment through casting and extrusion processes.

ii. **Ahmedabad Aluminium Foundry cluster, Gujarat-** The Ahmedabad cluster hosts approximately 500 medium and large industries, along with over 23,000 micro, small, and medium enterprises (MSMEs). The primary products manufactured here are used in textiles, agro machinery, and pumps & valves. Notable foundries in this cluster include TKT High-tech Cast, C M Smith & Sons, Bhagwati Autocast, and Ahmedabad Induction Alloys.

iii. **Pune Aluminium Casting cluster, Maharashtra-** The Pune cluster comprises around 50 Aluminium casting and allied units. Most of these units serve the automotive sector, as well as other sectors such as electrical and electronics.

iv. **Chennai Aluminium casting cluster, Tamil Nadu-** Chennai, the capital of Tamil Nadu, hosts over 200 Aluminium casting units in Thirumudivakkam and Ambattur. This cluster primarily serves large automobile industries. The die-casting units produce various products, including automotive components such as oil pumps, gearboxes, water pumps, starter motors, motor covers, assorted engineering equipment, and various utensil products.

v. **Faridabad mixed Engineering cluster, Delhi/NCR-** The Faridabad industrial cluster began developing in the 1950s with the establishment of several large-scale industries producing tractors, auto parts, shoes, and more. Numerous MSMEs were subsequently set up to support these large plants with products and processes such as castings, auto components, electroplating, and heat treatment. The cluster now includes an estimated 12,015 MSME units.

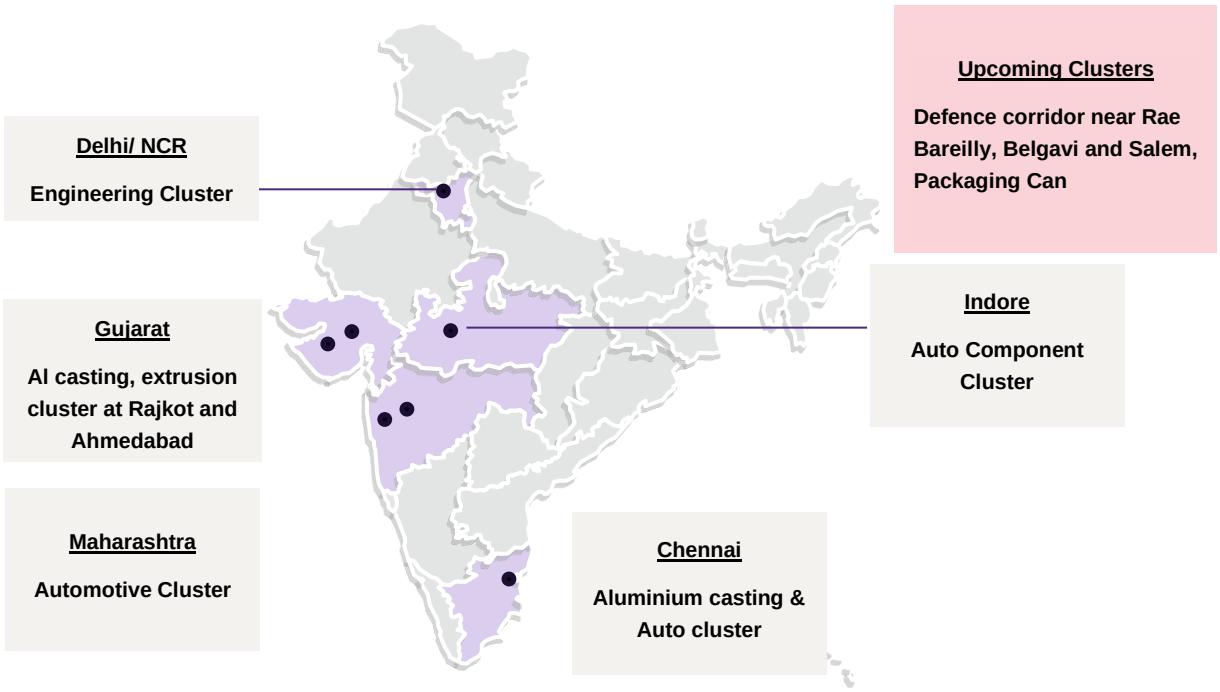

Figure 90: Potential Aluminium clusters for R&D facility development

In addition to R&D in Aluminium applications, India should also invest in developing in-house Aluminium smelter technologies to lower the CAPEX investment required for setting up new smelters.

9.4 Recommended Institutions and Taskforces

Aluminium is a strategic mineral now for India which needs specialization as well as focus. Since Aluminium value chain straddles multiple domains (from mining, chemicals, Industries, MSME etc.), the Ministry may want to implement institutional reforms needed to support this transformation. The following institutions are proposed in line with the experience of the steel sector:

a. Creation of an "**Investment Promotion and Aluminium Strategy Implementation Cell**" **(IP&ASIC)** in the Ministry led by a JS/ Senior Director Level Officer who sets timelines and monitors progress of implementation actions – this Cell should debrief the Secretary every fortnight about progress. This cell will

   i. Coordinate with primary and secondary players regularly to understand the on-ground difficulties being faced by them in the implementation of the strategy.

   ii. Coordinate with State Govts. / Central Institutions for timely support to industry after MoU signing.

   iii. This cell will also Identify and take decisions on measures like reduction of GST, other duties and taxes for Primary, Secondary and Downstream, PLI, treating CPPs at par with IPPs, Public Procurement preference, and other incentives to promote capacity addition across value chain.

   iv. The cell would organise Investment Promotion Roadshows/ Conferences/ Seminar for Al and attract metallurgical OEMs to setup manufacturing base in India.

   v. Arrange funding for setting up of Aluminium Data collection and Publication Unit and Institute for Aluminium Application Growth

   vi. Coordination with all taskforces, setting milestones & timelines and monitoring progress of implementation actions

   vii. Policy formulation support can be provided by the Cell by deploying specialized resources.

b. Looking at the experience of steel sector, the following dedicated institutions are needed for Aluminium sector to promote collaboration, data sanctity across Aluminium value chain and application evangelization

   i. **Aluminium Data collection and publication unit (ADCPU)** on the lines of Joint Plant Committee (JPC) under Ministry of Steel. The board members/ management committee of the entity can be drawn from PSUs and Private sector organizations. The organization can be headed by an Executive Secretary who can be drawn from the industry. This organization should be responsible for collating survey based or officially collected periodic data from different agencies across value chain players and consolidating the same for the Ministry. This unit can serve as the custodian of official data of the Ministry. The data from primary/ secondary producers, recyclers, special groups like extruders etc. can all be brought under one umbrella. The JPC also has an Economic Research Unit (ERU) within itself. However, the decision to have an ERU within the ADCPU is a function of what tasks are determined for the ERU by the IP&ASIC and whether the right team members are found to perform such sector-oriented commercial and economic research work. Some of the residual team members of the taskforces (described later in the document), post implementation of their mandates can also be assimilated into the ERU. If the ERU is constituted here, then the policy formulation assistance role of the IP&ASIC may be devolved to the ERU.

   ii. **Institute for Aluminium Application Growth (IAAG)** on the lines of INSDAG under Ministry of Steel may be set up. INSDAG is a not-for-profit, member-based organization established by the Government of India (Ministry of Steel) and Major Steel Producers of the Country as a "Society". It is engaged in development of advanced and cost-effective design methodologies, technical and institutional marketing by expanding applications of steel in different segments of the construction industry, up-gradation of technical skills and know-how, creation of awareness amongst potential users and communicating the benefits of steel vis-à-vis other competitive materials etc. INSDAG is also involved actively in formulation and revision of codes and standards for steel use in

construction based on latest developments with Bureau of Indian Standards (BIS) and Indian Roads Congress (IRC). The IAAG should aim to bring in global knowledge of innovative as well as standard applications and work with regulators and potential buyers to create an ecosystem more receptive to the use of Aluminium.

iii. The Aluminium sector in India does not have a technology advisory organization of global repute and clientele of the nature that is enjoyed by RITES (railways) or EIL (O&G) or MECON (steel) or even CMPDIL (coal nationally). These organizations have such heft that they can influence specifications for projects globally. While NRTC and ABSTC own various patents in the Aluminium sector and have done significant research work it would serve the sector well if JNARDDC should evolve into a center of excellence to such an extent that it can earn significant part of its revenue from its research and consulting experience. It may embark on a journey specializing in research and development and work on aiding the development of downstream products/ end-use applications for the MSME sector through their research capabilities.

iv. In addition to these institutions, there is a need to create 3 taskforces to enumerate micro actions for the sector. The deliverable of the task forces can be program-managed by the Investment Promotion and Aluminium Strategy Implementation Cell (IP&ASIC). The IP&ASIC should draft the detailed terms of reference and tenure of the task forces. The task forces may include knowledge partners to help in the collation effort. To propel India's Aluminium industry to new heights, the establishment of the following task forces is recommended-

9.4.1 Resource Security Taskforce

Objective/ Deliverable

To ensure a stable and secure supply of raw materials for the Aluminium industry.

- Achieve **50 MTPA** bauxite production by FY30 and **150 MTPA** by FY47
- Accelerated exploration program for proving **4.9 BnT** of Resources; **1 BnT** incremental proven reserve by FY30
- Achieve domestic Scrap Collection of **2 MTPA** by FY30 and **7 MTPA** by FY47

Activities

- Develop plans for resource acquisition and management.
- Engage with mining companies, suppliers, and government agencies.
- Organize discussions on resource security and supply chain management.
- Promote rapid decision-making and resource allocation.
- Identify and mitigate risks related to resource scarcity and supply disruptions.
- Identification of Suitable clusters and noncontiguous leases of Bauxite for auction as single blocks
- Coordination with State Govt.
- Changes in Laws/Act/Rules e.g. Bauxite pricing, auction of linked ML with greenfield refinery/smelter, etc.
- Target setting for State DMGs / MECL / NEAs and monitoring exploration
- Setup PMU for exploration activities
- Set Target for bauxite rich state e.g. Odisha, Andhra Pradesh, Chhattisgarh and Jharkhand
- Incentives and schemes for scrap generation
- Expediting operationalisation of bauxite blocks.

- Framing norms for construction, electrical and transport sectors

9.4.2 Applications Development & Demand Generation Taskforce

Objective

To enhance the use of Aluminium in diverse downstream applications, uphold quality standards within the Aluminium sector, and promote innovation and technological progress in the Aluminium industry.

- Increase consumption intensity (e.g. Aerospace / defence / Auto / packaged food and drinks)
- Introduce New-to-India applications
- Achieve **8 MT** and **37 MT** Downstream Aluminium Capacity by FY30 and FY47, respectively

Activities

- Setting up of institutions like Institute for Aluminium Application Growth (IAAG) for Demand generation
- Bringing new product application ideas from international markets
- Develop strategic plans to promote Aluminium usage in sectors like automotive, construction, packaging, and electronics.
- Engage with industry players, government bodies, and research institutions to foster collaboration.
- Identifying schemes/ incentives/ measures to achieve downstream capacity addition.
- Organize forums and workshops to discuss innovations and market trends.
- Encourage rapid development and implementation of new applications.
- Identify and address challenges in the adoption of Aluminium in downstream sectors.
- Formulate guidelines and standards for quality control of all Aluminium articles (imported and domestic)
- Collaborate with customs, importers, and quality assurance agencies
- Conduct meetings to discuss quality issues and improvements.
- Decision on the product coverage (finished Aluminium products or even input materials) of Quality Control Order
- Monitor and address any discrepancies in the quality of imported materials.
- Develop a roadmap for R&D projects focusing on new technologies and processes.
- Partner with research institutions, universities, and tech companies.
- Host conferences and seminars to share research findings and technological advancements.
- Accelerate the adoption of cutting-edge technologies.
- Identify and resolve technical challenges in the industry.

9.4.3 Green Transition Taskforce

Objective

To promote sustainable practices and reduce the environmental impact of the Aluminium industry.

- Reducing carbon intensity for Al sector progressively -
    - Current Global Average: **16 tCO_2/T**

- Current EU Average: **6 – 7 tCO_2/T**

- Generating local demand for Green Aluminium
- CO_2 intensity milestone compliance to reach **10% global trade** share by **2047**

Activities

- Definition of Green Aluminium
- Create strategies for reducing carbon emissions and enhancing energy efficiency.
- Work with environmental agencies and industry leaders.
- Evaluate establishment of Green Energy Parks for RTC power for Aluminium smelters.
- Facilitate discussions on green technologies and sustainable practices.
- Encourage swift implementation of eco-friendly initiatives.
- Evaluation of RPO obligations, Carbon Credit purchase etc. in the context of carbon-tax like levies
- Creating/ mandating an agency or agencies that shall set up large scale state-of-the-art scrap segregation plants at the point of ingress to provide collective service to secondary Aluminium / Recycling Industry to create economies of scale.
- Address environmental concerns and regulatory compliance issues.
- Devising strategies for generating domestic demand for Green/ low-carbon Aluminium

9.4.4 Suggested Constitution of Taskforces

The Aluminium sector in India holds significant potential for economic growth and industrial advancement. To harness this potential, it is crucial to establish well-structured taskforces dedicated to addressing the unique challenges and opportunities within the sector. These taskforces should be composed of experts from various fields, including industry leaders, policymakers, researchers, and environmental specialists. Their collective expertise will be instrumental in formulating strategies that promote sustainable development, enhance production efficiency, and ensure global competitiveness. By fostering collaboration and innovation, these taskforces can drive the Aluminium sector towards a more prosperous and sustainable future for India.

Resource Security Taskforce	Application Development & Demand Generation Taskforce	Green Transition Taskforce
Chair – NITI Aayog or MoM	Chair – Former office-bearer of INSDAG or Ministry of Steel / NITI Aayog	Chair – NITI Aayog / MoM
Representative from State Govt. (DMGs)	Representative of EEPC / DPIIT or other such bodies as relevant	Representative of MNRE, Ministry of Power (MoP), DGCIS
Representative of MoM, MoC&I, Finance	Representative of CSIR, JNARDDC, NRTC, ABSTC	Representatives AAI and ASMA
Representatives of AAI, MRAI, ASMA, FAIUMA, MMTC, etc.	Representative of ASMA, International Aluminium Association	Representative of World Bank/ GIZ/ JICA etc.
Representatives from Exploration agencies e.g. GSI, MECL, etc.	International Research Organizations (like CSIRO), Prominent academic institutions, etc.	Representatives of CIL/ NTPC/ SECI etc.

Resource Security Taskforce	Application Development & Demand Generation Taskforce	Green Transition Taskforce
SMEs as relevant	Representatives of Global OEMs like Fatahunter, ACT, Hycast, Warwick, Hencon etc.	Green Project Developers like Greenko/ O2 etc.
Knowledge Partner as relevant for report compilation	SMEs as relevant from other sectors (like steel)	SMEs as relevant from other sectors (like steel)
	Knowledge Partner as relevant for report compilation	

Annexures

Annexures

Annexure 1: HS Code

HS Code	Description
7601	Unwrought Aluminium
7602	Waste and scrap, of Aluminium
7603	Powder and flakes, of Aluminium (excl. pellets of Aluminium, and spangles)
7604	Bars, rods and profiles, of Aluminium
7605	Aluminium wire
7606	Plates, sheets and strip, of Aluminium, of a thickness of > 0,2 mm
7607	Aluminium foil, "whether or not printed or backed with paper, paperboard, plastics or similar backing materials", of a thickness "excl. any backing" of <= 0,2 mm
7608	Aluminium tubes and pipes (excl. hollow profiles)
7609	Aluminium tube or pipe fittings "e.g., couplings, elbows, sleeves"
7610	Structures and parts of structures "e.g., bridges and bridge-sections, towers, lattice masts, pillars and columns, roofs, roofing frameworks, doors and windows and their frames and thresholds for doors, shutters, balustrades", of Aluminium
7611	Reservoirs, tanks, vats and similar containers, of Aluminium, for any material (other than compressed or liquefied gas), of a capacity of > 300 l, not fitted with mechanical or thermal equipment, whether or not lined or heat-insulated
7612	Casks, drums, cans, boxes and similar containers, incl. rigid or collapsible tubular containers, of Aluminium, for any material (other than compressed or liquefied gas), of a capacity of <= 300 l
7613	Aluminium containers for compressed or liquefied gas
7614	Stranded wire, cables, plaited bands and the like, of Aluminium
7615	Table, kitchen or other household articles, sanitary ware, and parts thereof, of Aluminium, pot scourers and scouring or polishing pads, gloves and the like, of Aluminium
7616	Other Articles of Aluminium

Annexure 2: Technological Advancements across Aluminium Value Chain

Technological Advancements in Alumina Refining and Red Mud Utilisation/Treatment

Alcoa- Refinery of the future[218]

Alcoa's "Refinery of the Future Project" aims to achieve zero-carbon alumina refining. Traditionally, the final stage of the alumina refinery process, calcination, relies on fossil fuels like natural gas to heat alumina hydrate crystals and remove water molecules. At Alcoa's Pinjarra refinery in Western Australia, electric calcination is being tested as a direct replacement for this method. This pilot project will use renewable energy to power the calciner, eliminating carbon emissions and capturing residual energy typically lost as steam. This approach will also eliminate the need for steam venting stacks and lead to significant water savings.

Vedanta-Reuse of Slurry Water[219]

Vedanta, in collaboration with the Indian Institute of Technology Kharagpur, has developed a process to extract and recycle the entire volume of water from red mud waste for operational use. This process reportedly reduces bauxite residue by 30% by removing iron content, while also increasing alumina yield and lowering the total organic content during the alumina refining process.

EGA[220]

In 2023, Emirates Global Aluminium (EGA) started building an innovative pilot plant to convert bauxite residue, a byproduct of alumina refining, into manufactured soil. The plant will use EGA's proprietary technology to rapidly neutralize caustic bauxite residue, transforming it into an environmentally safe raw material within hours, instead of the natural process that takes decades. This optimized red mud will serve as the primary component for the manufactured soil.

Rio Tinto-Pacific Operations Hydrogen Program[221]

In 2021, Rio Tinto conducted a technical feasibility study to explore replacing natural gas with green hydrogen for primary decarbonization. The study also examined the potential reuse of steam produced from hydrogen combustion and alumina calcination for secondary decarbonization at the refinery. Concluded in 2023, the findings confirmed that hydrogen is a viable substitute for natural gas without compromising quality.

NALCO[222]

Currently, NALCO recycles wastewater from bauxite residue, significantly reducing freshwater consumption. Additionally, they recover soda from caustic red mud ponds. NALCO has also initiated a project with BARC to use red mud in constructing core catchers, devices designed to contain molten core material in the event of a nuclear meltdown.

JNARDDC[223]

JNARDDC under the NITI Aayog Initiative along with other players are conducting research and development for feasible options for metal extraction and rare earth element enrichment from red mud. It is conducting a project to transform red mud into cost-effective, high-energy shielding blocks for X-rays and gamma rays,

[218] Refinery of the Future, Alcoa, last accessed on 03-Oct-2024
[219] Advances in Processing Alumina Refinery Bauxite Residue Waste, Light Metal Age, Feb 27, 2024, last accessed on 03-Oct-2024
[220] EGA begins construction first-of-its-kind pilot plant to convert bauxite residue into manufactured soil, EGA, 23 Nov 2023, last accessed on 03-Oct-2024
[221] Rio Tinto pacific Operations Hydrogen program, Rio Tinto, 15 Nov 2022
[222] Annual Report, FY24, NALCO
[223] Annual Report, FY23, JNARDDC

making them ideal for constructing radiation therapy bunkers, nuclear power plants, and food sterilization facilities.

Smelter Technology Overview

Several leading technology providers are driving advancements in Aluminium smelting technology worldwide. An overview of few of the technologies is given in the table below[224]:

Cell Technology	SY-660	NEUI-600	AP-60	RA-550
Technology Group	SAMI	NEUI	RTA	Rusal ETC
Company	Xinfa Group	Weiqiao	Rio Tinto Alcan	UC Rusal
Location	Liaocheng smelter, Shandong, China	Weiqiao smelter, Shandong, China	Arvida smelter, Jonquière, Quebec, Canada	Sayanogorsk smelter, Russia
Current (kA)	600 - 660	600	570-600	550
No. of Operating Lines (No. of cells)	3 lines (630)	3 lines (558)	Demonstration line (38)	Pilot test group (5-8)
Start-up date	2015	2014	2013	2016
Production (t Al/cell/day)	5	4.6	4.4	4.2
Production (t Al/cell/potline)	365	309	N/A	7.6
Production (kt Al/year/smelter)	1150	900	60	N/A
Current Efficiency (%)	94	94.3	94.6	94.5
Cell Volts (V)	3.85	3.85	4.15	3.8
Energy Consumption (MWh/kg)	12,205	12,166	13,072	12,000

The leading global producers are also developing latest low carbon technologies to achieve net-zero in Aluminium production. Some of these technologies are:

HalZero[225]

HalZero, an advanced Aluminium smelting technology developed by Norsk Hydro, involves chlorinating alumina to produce Aluminium chloride. This process generates carbon dioxide, which is recycled in a closed-loop system to produce oxygen, released into the atmosphere instead of CO_2. In late 2023, the construction

[224] Super-high amperage prebake cell technologies in operation at worldwide Aluminium smelters by Alton Tabereaux, Alcoa Inc
[225] https://www.hydro.com/Document/Doc/Integrated%20Annual%20Report%202023_ENG.pdf?docId=594088

of a HalZero test facility was approved, moving the project from laboratory-scale testing to small-scale industrial trials. Hydro aims to scale this up to a full industrial pilot by 2030.

Elysis[226]

Elysis, a joint venture between Rio Tinto and Alcoa, is supported by the governments of Quebec and Canada. Rio Tinto intends to implement this emission-free technology at its Arvida smelter in Quebec. By replacing carbon anodes with inert anodes in the smelting process, the technology emits oxygen instead of CO_2. Elysis requires approximately 13,000 kWh of electricity and 0.4 tons of high-quality carbon material to produce one ton of primary Aluminium through conventional electrolysis.

EX Reduction[227]

EX-reduction technology, the successor to DX+ ultra technology, consumes 11,500 kWh of electricity. It is expected to achieve a production rate of 3,765 kg per pot per day.[228] Emirates Global Aluminium (EGA) plans to construct ten pilot EX reduction cells at its Al Taweelah smelter to test and validate their performance, aiming to industrialize the technology by 2028.

Aluminium Cast house

Almex USA[229]

For over 25 years, the company has been an independent provider of high-performance aerospace, hard alloy, and soft alloy Aluminium casting systems and related equipment. Their expertise spans advanced Aluminium alloy processes, including melt treatment, casting, rolling, extrusion, and specialty thermo-mechanical processes, which enhance their core competency in casting. A standout feature of Almex's offerings is their "Furnace to Finish™" Solutions. The company holds the record for casting both the world's largest billet and slab in conventional and high-performance hard alloys.

MQP[230]

MQP is a leading provider of advanced Aluminium casthouse technology, specializing in high-efficiency grain refiners. Their flagship product, Optifine, is renowned for significantly improving the quality and cost-efficiency of Aluminium alloy production. With over 20 years of research and development, MQP serves major casthouses worldwide, helping them produce high-quality Aluminium for various applications, including automotive and packaging industries

Hycast[231]

Based in Sunndalsøra, Norway, Hycast is a leading provider of advanced Aluminium casthouse technology. Founded in 1990 as a spin-off from Hydro R&D, Hycast specializes in delivering state-of-the-art, fully automated casting lines. Their expertise includes melt treatment, purification, and vertical DC-casting of Aluminium alloys. With over 30 years of innovation, Hycast has established a global presence, providing comprehensive casthouse solutions that ensure high-quality billets and slabs.

RIA Casthouse Engineering[232]

RIA Casthouse Engineering, based in Germany, is a renowned provider of advanced Aluminium casthouse technology. Specializing in tailor-made, rail-bound charging and skimming equipment, RIA focuses on reliability, durability, and safety. Their innovative solutions, including AI-driven charging and skimming systems and in-furnace dross processing, enhance operational efficiency and metal recovery. With over 20

[226] https://informaticsjournals.com/index.php/jmmf/article/download/45481/30415/94327
[227] https://Aluminiumtoday.com/news/ega-completes-design-phase-of-next-generation-smelting-technology-readies-pilot-reduction-cells
[228] https://www.ega.ae/media/ewvh4qin/ega-2022-sustainability-report.pdf
[229] Technology - Almex USA - Aluminium Casthouse Solutions
[230] About - MQP Ltd | High efficiency grain refiners
[231] Who we are | Hycast
[232] RIA Cast House Engineering About (ria-casthouse-engineering.de)

years of experience, RIA has become a trusted partner for Aluminium billet and sheet ingot cast houses worldwide, supplying over 80 machines to major Aluminium producers.

Aluminium Heat Treatment Furnaces & Ancillary Equipment

SECO/WARWICK[233]

SECO/WARWICK is a global leader in heat treatment furnaces and ancillary equipment, serving industries such as automotive, aerospace, energy, medical, and defense. They offer a wide range of solutions, including vacuum heat treatment, Aluminium and atmosphere thermal processing, and controlled atmosphere brazing. Their innovative technologies are designed to enhance efficiency, safety, and environmental sustainability. With a strong focus on customization, SECO/WARWICK tailors each project to meet specific client needs, ensuring optimal performance and reliability.

Hencon[234]

Hencon is a prominent technology provider across the Aluminium value chain, offering specialized mobile equipment designed to enhance efficiency and safety in Aluminium production. Their innovative solutions include automated vehicles for transporting hot metal, vacuum systems, and integrated mobile solutions for cast houses, rolling mills, and extrusion plants. Hencon's commitment to sustainability and cutting-edge technology ensures that their equipment meets the highest standards of productivity and reliability. With a global presence, Hencon continues to support the Aluminium industry by providing robust, custom-made solutions tailored to the unique needs of their clients.

Aalberts[235]

Aalberts Surface Technologies is a leading provider of Aluminium metal heat treating services, offering state-of-the-art solutions to enhance the strength, ductility, uniformity, and longevity of Aluminium products. Their advanced heat treatment processes, including solution heat treatment, aging, and hot isostatic pressing (HIP), are designed to meet the stringent requirements of various industries such as aerospace, automotive, and defense. With a strong focus on technical expertise and quality, Aalberts ensures that their services not only improve material properties but also optimize production efficiency and reliability.

Jones Metal Products[236]

Jones Metal Products is a distinguished provider of Aluminium heat treatment technology, offering a comprehensive range of services to meet the stringent demands of industries such as aerospace and defense. Their capabilities include aging, air quenching, hot and cold-water quenching, glycol quenching, annealing, hardening, solution treatment, and stress relieving. With NADCAP accreditation and approvals from major aerospace companies like Lockheed Martin and Rolls Royce, Jones Metal Products ensures the highest standards of quality and precision. Their state-of-the-art facilities and experienced team enable them to deliver reliable and efficient heat treatment solutions tailored to specific customer requirements.

[233] Heat treatment furnaces by SECO/WARWICK GROUP (secowarwick.com)
[234] Casthouse Solutions – Hencon
[235] Heat Treatment for Metals | Aalberts Surface Technologies (aalberts-ht.us)
[236] UNDERSTANDING ALUMINIUM HEAT TREATING – Jones Metal Products (jmpforming.com)

Annexure 3: Initiatives Taken by the Global and Domestic Producers for Decarbonization of Aluminium Sector[237]

The major Aluminium industry players of the world have taken the following initiatives for the decarbonization of the Aluminium sector.

Initiatives undertaken by Global Producers

UC Rusal [Russia]

Progress and greenhouse gas emission reduction goals

In 2018 the Company produced 41.9 MT of gross greenhouse gas emissions (Scope1, Scope2 and Scope3). In 2023, the gross greenhouse gas emissions came down to 39.5 MT, a reduction of 6.7%. The company aims to reduce its gross greenhouse gas emissions by at least 23% from its 2018 figure by 2030. The company aims to achieve net-zero greenhouse gas emissions by 2050.

To fulfil its decarbonization and net-zero goals the company has taken up the following initiatives:

Reduction of process emissions:

Switching to EcoSoderberg Technology

The company has already shifted to EcoSoderberg technology from the traditional Soderberg process as EcoSoderberg technology enhances the traditional Soderberg process by the usage of improved anode paste formulations. Thus, lower levels of impurities lead to reduced GHG emissions.

Using Pre-Baked Anodes

Further the company is improving the conductivity of the anodes used in the Aluminium smelting process by using pre-baked anode technology where anodes will be manufactured separately in a controlled environment before being used in the electrolytic cells. By 2035, the company aims to use pre-baked anode technology for all its smelting operations. Pre-baked anodes provide a more stable and consistent performance during electrolysis, leading to better overall process efficiency in Aluminium smelting. Pre-baked anodes minimize the generation of volatile compounds like pitch and tar during the baking process, thereby reducing emissions. They have also Implemented energy-efficient electrolysers used during electrolysis of Alumina in year 2021 which has resulted in electricity savings of 471 million kWh within 2 years.

And now company is developing electrolysers that will reduce electricity consumption by 2,500 kWh/tonne of Aluminium metal which is currently 13,500 kWh/tonne of Aluminium Metal.

Decarbonizing the power supply

Using Renewable Energy Sources

Currently, the company uses 98.99% hydropower energy for its smelting operations which it aims to increase further.

Switching to LED Lights

The total reduction in energy consumption following the implementation of energy efficiency improvement measures in 2023 amounted to 271,577 GJ. The power saved in Windalco, a subsidiary of UC Rusal, by replacing its older lights with LED equipped with motion sensors that switch on only when needed.

Increased Scrap Recovery

[237] Companies' Annual Reports, last accessed on 10-Aug-2024

The company aims to improve the extraction of scrap Aluminium which will be done by the ultra-high energy efficient electrolysers that is projected to have an extraction rate of recycled Aluminium of 70%.

Hongqiao [China]

Progress and greenhouse gas emission reduction goals

The company aims to keep on reducing its carbon emissions from 2025 to attain its goals of net zero carbon emissions by 2050.

To fulfil its decarbonization and net-zero goals the company has taken up the following initiatives:

Reduction of process emissions:

Reduced Emissions during Electrolysis:

The company nearly eliminated the occurrence of undesirable interruptions in the electrolysis process which occurs when the concentration of Aluminium in the electrolyte drops too low. To achieve that the company upgraded the online system of anode-current distribution in electric baths and adopted technology such as single point precise feeding which helps in maintaining the optimum concentration of Aluminium during electrolysis. These processes helped the company achieve near-zero anode effect thereby reducing 750,000 tonnes of CO_2 emissions per year.

Energy efficiency improvement initiative:

Shandong Hongtuo Industrial Co. Ltd, an indirect subsidiary of the group along with a consortium of universities and organizations developed a technology for Aluminium electrolysis that enhances the cathode's performance in the electrolytic cell. Technology involves using composite material for the cathode that integrates copper and carbon which helps in current efficiency and provides the necessary mechanical strength and stability. The integration of this technology led the group to save 100 million kWh of power and 100,000 tonnes of carbon emissions since its onset in 2021. This technology is called "Aluminium Electrolysis Integrated Copper-Carbon Composite Cathode (RuC) Technology Development and Application.

Switching to Electric Vehicles:

The company along with Shandong Transportation is planning to purchase nearly 1000 pure electric trucks to be used in cargo transportation. This is estimated to reduce Carbon emissions by 120000 tonnes per year.

EGA [UAE]

Progress and goals in decarbonization of Aluminium

In 2021 the greenhouse gas emission intensity for the company was 8 tonnes of CO_2/tonne of Aluminium produced and in 2022 the greenhouse gas intensity reduced by 4.4% to 7.65 tonnes of CO_2/tonne of Aluminium. However, the overall CO_2 emissions increased from around 20 MT of CO_2 to 20.27 MT of CO_2 due to higher quantity of Aluminium produced. The company aims to achieve its net-zero greenhouse gas emission goal by 2050.

To fulfil its decarbonization and net-zero goals the company has taken up the following initiatives:

Decarbonizing the Power Supply

Increasing energy efficiency

The company improved the energy efficiency of the electrolysis process by incorporating the DX+ ultra reduction cell technology which operates at higher amperage levels of 500kA thereby allowing more Aluminium to be produced from the same number of reduction cells. The company also has reduced its energy consumption in Aluminium smelting by 2.23kWh/kg earlier which was 16.10kWh/kg. With the adoption of new technology, it is further projected to reduce an additional 2.37kWh/kg.

Switching to renewable energy sources:

EGA signed a power purchase agreement with Dubai Electricity and Water Authority (DEWA) to source 50% of its electricity from a solar park.

Reduction of Process Emissions

Boiler Electrification

EGA aims to replace traditional fossil fuel boilers with electric boilers to provide heating for steam generation. The company aims to switch from Natural gas to green hydrogen to meet the thermal energy requirements. Green hydrogen is produced by electrolyzing water using renewable sources of energy. Adopting green hydrogen in place of natural gas produced by burning fossil fuels would drastically cut down on greenhouse gas emission. In 2022 the company used 81000 MWh of solar power to produce more than 57000 tonnes of Aluminium.

Increasing energy efficiency

EGA has undertaken various energy efficiency projects such as modernizing its equipment to high-efficiency motors and advanced control systems, to reduce energy consumption. The company has installed heat recovery systems that capture and reuse waste heat from its processes, reducing additional energy input.

Hydro [Norway]

Progress and goals in decarbonization of Aluminium:

The company aims to reduce its carbon emissions by 10% in 2025 compared to 2018 baseline which was about 10 MT of CO_2 equivalents emissions. (Scope 1 and Scope 2 emissions). In 2023 the number was 9.35 MT of CO_2 equivalents, a 6.5% decrease. The company aims to reduce its carbon emissions by 30% from the 2018 baseline by 2030. The company aims to achieve net zero carbon emission goals by 2050.

To fulfil its decarbonization and net-zero goals the company has taken up the following initiatives.

Decarbonization of the power supply:

Switching to renewable energy sources:

The company operates 40 hydropower plants with a combined output of 13.7 TWh renewable electricity in a normal year. This ensures that 70% of its electricity used for the production of primary Aluminium is based on renewable energy**.**

Increasing energy efficiency:

During 2023, the company replaced the lighting systems at its five Aluminium smelters in Norway with LED lights equipped with motion sensors that switches on based on needs. This combined with various other measures saves up to 100 GWh of energy annually.

Changing fuel-type:

The company aims to install several electric boilers for steam generation at its Alumina refinery in Alunorte in Brazil. This will reduce greenhouse gas emissions by 700,000 tonnes of CO_2 equivalents when completed. Already one electric boiler has been installed. Two more electric boilers will be installed by the end of 2025 which has the potential to reduce emissions by 400,000 tonnes of CO_2 equivalents.

Reducing Process Emissions:

Decarbonizing the electrolysis process:

The company aims to replace it's CO_2emissions with oxygen emissions during electrolysis by integrating Hal-Zero technology by 2030. In the Hal-Zero process Alumina becomes chlorinated and this process also produces CO_2. Instead of releasing them to the atmosphere, it is recycled back in the process and reused in a closed loop. The only by product of the process is oxygen.

Changing fuel-type:

In 2023, the company implemented actions to replace fossil energy in the cast houses with biomethane in its plant at Sunndal, which will cut emissions by 20,000 tonnes of CO_2 equivalents each year.

Recycling the post-consumer scrap:

The company has already produced its green Aluminium product Hydro CIRCAL which is a certified recycled and low-carbon product of more than 75 percent post-consumer scrap. Hydro CIRCAL has a carbon footprint of 1.9 tonnes of CO_2/tonne of Aluminium produced. At Hydro's recycling plant in Clervaux in Luxembourg, the company has also produced 130 tonnes of near-zero carbon Aluminium with 100 percent post-consumer Aluminium scrap, Hydro CIRCAL 100R, with a carbon footprint below 0.5 tonnes of CO_2/tonne of Aluminium.

Alcoa [USA]

Progress and goals in decarbonization

In 2015 the greenhouse gas emission intensity was 7.1 tonnes of CO_2/tonne of Aluminium produced. By 2025 the goal of the company is to reduce the emission intensity by 30% from this 2015 baseline. By 2030 the goal is to reduce the emission intensity by 50% from the 2015 baseline. The goal of the company is to achieve net-zero emissions by 2050.

To fulfil its decarbonization and net-zero goals the company has taken up the following initiatives:

Reduction of Process emissions

De-carbonization of the smelting process:

The company aims to replace the carbon anodes with inert anodes for its smelting operations by integrating Elysis inert anode technology which is a joint venture between Alcoa and Rio Tinto with support from several government and private institutions. Instead of CO_2 only oxygen will be released as a by-product during smelting. To facilitate the process Alcoa is building 450 ka commercial scale trial smelter pots in Quebec, Canada**.**

Increasing Scrap Recovery

The company has developed a technology to purify post-consumer scrap to high purity Aluminium called Astrea. The technology addresses the challenge of recycling contaminated Aluminium scrap which traditionally can't be used for high value applications due to impurities.

Rio-Tinto [Canada]

Progress and goals in decarbonization:

In 2018 the scope1 and scope2 emissions for the company were 34.68 MT of CO_2 equivalents. In 2023 the reduction in scope1 and scope2 emissions was 6% below the 2018 baseline which was 32.6 MT of CO_2 equivalents. In 2025 the goal is to reduce the emissions by 15% relative to 2018 levels. The goal is to reduce scope 1 and scope 2 emissions by 50% compared to the 2018 baselines. The company aims to achieve its net zero emission goals by 2050. To fulfil its decarbonization and net-zero goals the company has taken up the following initiatives:

Decarbonization of the Power Supply:

Increasing energy efficiency:

The company aims to reduce its overall energy consumption per ton of Aluminium production by investing USD 1.01 billion to equip its Aluminium smelter at Complexe Jonquiere in Saguenay, Canada with AP 60 electrolysis technology. The technology is designed to operate at higher current densities and produce up to 60% more Aluminium as compared to traditional smelting cells.

Switching to renewable energy sources:

Rio Tinto signed Purchase Power Agreements to buy 1.1 GW of energy from the Upper Calliope Solar Farm project where solar energy would be used. This energy would be used to re-power three of the company's

production assets. The company Approved, subject to regulatory approvals, a 12.4 MW solar photovoltaic system and a 2.1 MWh battery storage system via long term PPA for Amrun operations. The company has constructed a 5 MW solar plant pilot project at Kennecott Copper, USA.

Reduction of Process Emissions:

In pilot stage of incorporation of the Elysis Technology jointly developed by Alcoa and the company with support from various government and private bodies. The technology will release oxygen instead of CO_2 during smelting operations.

Initiatives Undertaken by the India Producers

NALCO [India]

Progress and goals in decarbonization

In the financial year FY23 the company produced emissions of 11.186 MT of CO_2 equivalents (Scope 1 and Scope 2 emissions) which is 2.5% lower than its emissions of the financial year FY22 which was 11.47 MT of CO_2 equivalents. NALCO has set its goals for net-zero emissions by 2050.

To fulfil its decarbonization and net-zero goals the company has taken up the following initiatives.

Decarbonization of the Power Supply:

Generating renewable energy:

NALCO has operational wind power projects are in Gandikota, Andhra Pradesh (50.4 MW), Luderva, Rajasthan (47.6 MW), Devikot, Rajasthan (50 MW), and Jath, Maharashtra (50.4 MW). The Company has installed 850 kWp roof top Solar Power Plants at its premises.

Reduction in energy consumption:

NALCO aims to improve its Aluminium smelting efficiency by carrying out the AP2XN technology on its pilot scale. The technology improves smelting efficiency via optimized cell design which uses enhanced materials such as fully graphitized cathode linings and slotted anodes also real time monitoring and control systems to adjust operational parameters. (Already implemented in 15 pots where a saving of 150 kWh/MT has been made). The company has saved 4,77,000 kWh through installation of 5,350 LED systems in place of conventional light fittings since 2021.The company has also replaced old motors with 374 energy efficient IE3 Motors (ranging from 0.37 kW to 55 kW) in FY23 leading to energy savings of 10,25,515.34 kWh/annum.

Reduction of Process Emissions:

De-carbonizing the electrolysis process:

As fully graphitized cathode linings have a lower carbon consumption rate, it is used to replace the semi-graphitized cathode linings. (916 out of 955 are already running with 44 in progress). Slotted anodes are being used in all smelter pots as the slots in the anodes facilitates better gas release, particularly oxygen, during the electrolysis process. This helps in the maintenance of a more stable electrolyte surface and reduces the risk poof gas bubbles overall which improves efficiency of anode, leading to more efficient Aluminium production with less CO_2 emission. (1st slot cutting machine is in operation and 2nd slot cutting machine is under installation).

Vedanta [India]

Progress and goals in decarbonization:

In the year 2021 the company produced 60.24 MT of greenhouse emission of CO_2 equivalents. In 2023 the greenhouse emission increased to 65.9 MT of CO_2 equivalents. It is expected that the company will have its carbon peak by 2026 or 2027. By 2030 the target is to reduce greenhouse emissions to 25% from the 2021 baseline. The company aims to achieve its net-zero emission goals by 2050.

To fulfil its decarbonization and net-zero goals the company has taken up the following initiatives.

Decarbonization of the Power Supply:

Switching to renewable energy sources:

Vedanta Aluminium entered into long-term power delivery agreements to source 1,335 MW of renewable energy, comprising both solar and wind power. This renewable energy will support its operations in Odisha and Chhattisgarh, enabling the company to significantly reduce its greenhouse gas emissions. By doing so, Vedanta Aluminium aims to cut approximately 3.2 MT of CO2 annually, marking a substantial step in its decarbonisation efforts[238].

Switching to low-carbon/zero-carbon fuels.

The company uses biomass briquettes which are essentially compressed compounds made from green waste and other organic materials for power generation at its Alumina refinery in Lanjigarh, Orrisa. This initiative helps reduce greenhouse gas emissions by over 10000 tonnes of CO_2 annually. The goal is to use 5% biomass briquettes for power generation by 2025.

Reduction of Process Emissions:

De-carbonizing the electrolysis process:

As fully graphitized cathode linings have a lower carbon consumption rate, so it is used to replace the semi-graphitized cathode lining. The goal is to achieve 100% graphitization of its cathode linings by 2030.

Hindalco [India]

Progress and goals in decarbonization:

In 2023 the greenhouse gas emission intensity of the company was 19.26 tonnes of CO_2/ tonne of Aluminium down by 20.08% from its greenhouse gas intensity of 2011-12 baseline which was 24.1 tonnes of CO_2/tonne of Aluminium produced. By 2025 the company aims to reduce its greenhouse gas emission intensity by 25% from its 2011-12 baseline. The company aims to achieve its net-zero emission goals by 2050.

To fulfil its decarbonization and net-zero goals the company has taken up the following initiatives.

Decarbonization of the Power Supply:

Switching to renewable energy sources:

Hindalco and Greenko are working together to develop 375-400 MW of solar and wind power capacity. Greenko will design, construct and partly own and operate the solar and wind facilities. This endeavor is expected to reduce carbon emissions by 68000 tonnes/year.

The biomass boiler at Belgavi, Karnataka is to generate 4 MW of power. The company has a 5 MW wind power plant at Taloja, Maharashtra. The company has a 7.5 MW of Solar Plant at Mouda, Maharashtra with battery storage.

Reduction of Process Emissions:

Increasing energy efficiency:

A trial was conducted in the Aditya smelter in Sambalpur, Orissa to test a new design for the collector bar lining which is used to collect electricity. The aim was to validate the ideas of copper insert in the collector bar that would improve electrical conductivity and can enhance the efficiency of current collection. It can achieve a reduction of 70 kWh/MT of Aluminium.

A 400-kA low energy hipot design is in the pilot stages in the Mahan smelter at Singrauli, Madhya Pradesh. It refers to the design of a new pot (electrolysis cell) that operates at a high current of 400 kA thereby reducing energy consumption. An Aluminium smelter digital twin is being equipped in the Aditya smelter which is a virtual replica of the physical smelter, encompassing its processes, systems and operations. This digital

[238] Vedanta.indd (Aluminiumtoday.com)

model is continuously updated with real-time data from the physical smelter enabling advanced monitoring thereby optimizing energy consumption.

Increasing Scrap Recovery:

Recycling:

Novelis Hindalco's subsidiary recycles over 74 million beverage cans each year. The company also specializes in closed loop recycling in the automotive sector. Which is essentially is a process in which materials from end-of-life vehicles are recovered and reused in the manufacturing of new vehicles. The company's alloys 3015, 3004 and 3005 which are used for building and construction are up to 99% recycled.

Annexure 4: Data Tables

Global Aluminium Production

Table 22: Global Primary Aluminium Production Distribution Change, 2001 and 2023

Region	2001 (MT)	2023 (MT)
Africa	1.37	1.59
North America	5.22	3.90
South America	1.99	1.47
Europe	7.61	6.73
Oceania	2.12	1.88
Gulf Cooperation Council	0.00	6.22
Asia (ex-China)	2.23	4.67
China	3.37	41.67
Others	0.59	2.46
World	**24.51**	**70.58**

Table 23: Global Secondary Aluminium Production Distribution Change, 2001 and 2023

Region	2001 (MT)	2023 (MT)
North America	3.51	5.45
South America	0.75	1.75
Europe	2.74	5.55
Oceania	0.12	0.03
Middle East	0.19	0.55
Asia (ex-China)	1.87	7.36
China	1.42	12.77
Others	1.54	2.38
World	**12.14**	**35.85**

Global Aluminium Trade

Table 24: Product wise Trade of Aluminium Products by Value, 2023

Product (HS Code)	2023 (USD Billion)
7601	72
7602	21
7604	21
7606	37
7607	15
7610	18
7616	22
Others	26
Total	**233**

Note: Note: In this report, the import and export data of ITC Trademap has been averaged to demonstrate trade of Aluminium Commodities

Table 25: Global Trade of Unwrought Aluminium by Volume, 2023

Top 10 Importers	Imports (MT)	Top 10 Exporters	Exports (MT)
USA	4.16	Russia	3.91
China	2.68	Canada	2.86
Germany	2.31	UAE	2.28
Japan	2.11	Malaysia	1.97
Malaysia	1.70	India	1.96
Turkey	1.69	Bahrain	1.24
South Korea	1.53	Australia	1.54
Netherlands	1.31	Mozambique	1.45
Italy	1.27	Norway	1.31
Thailand	0.56	Netherlands	0.79
Others	7.72	Others	10.08
World	**27.05**	**World**	**29.38**

Global Bauxite and Alumina Production

Table 26: Global Bauxite and Alumina Production Distribution Change, 2001 and 2023

Country	Bauxite Production (MT)		Alumina Production (MT)	
	2001	2023	2001	2023
Australia	53.80	98.00	16.31	19.00
Guinea	15.10	97.00	0.64	0.33
China	9.80	93.00	4.65	82.00
Brazil	13.03	31.00	3.45	10.00
India	7.86	23.00	2.40	7.30
Indonesia	1.24	20.00	0.00	1.20
Jamaica	12.37	6.00	3.54	1.50
Russia	4.00	5.80	3.05	2.40
Saudi Arabia	0.00	4.60	0.00	1.80
Kazakhstan	3.69	4.30	1.23	1.30
Others	16.11	12.50	16.33	10.67
World	**137.00**	**395.20**	**51.60**	**137.50**

Global Bauxite Trade

Table 27: Global Trade of Bauxite by Volume, 2023

Top 10 Importers	Imports (MT)	Top 10 Exporters	Exports (MT)
China	141.57	Guinea	109.13
Canada	3.83	Australia	37.70
India	3.78	Brazil	4.73
Ireland	3.43	Turkey	2.64
USA	3.37	Jamaica	2.58
Spain	1.68	Indonesia	1.92
Greece	1.14	Ghana	1.74
Germany	1.10	Sierra Leone	1.24
South Korea	0.29	Montenegro	0.66

Top 10 Importers	Imports (MT)	Top 10 Exporters	Exports (MT)
France	0.29	Malaysia	0.56
Others	1.04	Others	1.44
World	**161.53**	**World**	**164.34**

Global Alumina Trade

Table 28: Global Trade of Alumina by Volume, 2023

Top 10 Importers	Imports (MT)	Top 10 Exporters	Exports (MT)
Canada	4.87	Australia	15.94
Bahrain	3.02	Brazil	7.73
Russia	2.99	Indonesia	2.15
Norway	2.54	India	2.15
India	2.46	Ireland	1.34
UAE	2.46	China	1.26
Malaysia	1.87	Vietnam	1.01
China	1.83	Kazakhstan	0.87
Oman	1.67	Spain	0.56
Iceland	1.65	Jamaica	0.55
Others	9.65	Others	1.93
World	**35.01**	**World**	**35.50**

Global Scrap Trade

Table 29: Global Trade of Scrap by Volume, 2023

Top 10 Importers	Imports (MT)	Top 10 Exporters	Exports (MT)
India	1.83	USA	2.03
China	1.75	Germany	1.18
Germany	1.02	Canada	0.63
South Korea	0.94	United Kingdom	0.60
USA	0.64	Hong Kong	0.58
Italy	0.63	France	0.52
Hong Kong	0.56	Australia	0.48
Thailand	0.49	Japan	0.46
Spain	0.30	Netherlands	0.41
Austria	0.25	Thailand	0.38
Others	3.81	Others	4.90
World	**12.23**	**World**	**12.18**

India’s Alumina Trade

Table 30: India’s Trade of Alumina by Volume, 2023

Top 5 Importers	Imports (MT)	Top 5 Exporters	Exports (MT)
Oman	0.84	Indonesia	1.01
Russia	0.49	Australia	0.73
UK	0.34	Vietnam	0.48
UAE	0.31	Saudi Arabia	0.13

Top 5 Importers	Imports (MT)	Top 5 Exporters	Exports (MT)
China	0.06	China	0.09
Others	0.11	Others	0.03
Total Exports from India	**2.15**	**Total Imports by India**	**2.46**

India's Scrap Trade

Table 31: India's Trade of Scrap by Volume, 2023

Top 10 Importers	Imports (MT)	Top 10 Exporters	Exports (MT)
South Korea	0.0050	USA	0.49
China	0.0013	UK	0.16
Bahrain	0.0003	UAE	0.16
Thailand	0.0002	Saudi Arabia	0.15
Nepal	0.0002	Netherlands	0.07
Hong Kong	0.0002	Australia	0.07
Italy	0.0002	Singapore	0.07
Turkey	0.0001	Belgium	0.05
Japan	0.0001	Spain	0.04
Singapore	0.0001	Germany	0.04
Others	0.0004	Others	0.51
Total Exports from India	**0.008**	**Total Imports by India**	**1.83**

India's Unwrought Aluminium Trade

Table 32: India's Trade of Unwrought Aluminium by Volume, 2023

Top 10 Importers	Imports (MT)	Top 10 Exporters	Exports (MT)
Malaysia	0.45	Malaysia	0.08
South Korea	0.33	Qatar	0.06
Japan	0.18	UAE	0.05
Mexico	0.14	Oman	0.04
Netherlands	0.10	Bahrain	0.04
China	0.10	Australia	0.02
Taiwan	0.08	Russia	0.02
Italy	0.08	South Korea	0.01
Vietnam	0.08	Turkey	0.01
Turkey	0.08	Nigeria	0.00
Others	0.37	Others	0.03
Total Exports from India	**1.96**	**Total Imports by India**	**0.36**

Annexure 5: Sector wise Growth Drivers

Packaging[239]

The usage of Aluminium in the packaging sector is projected to grow from 0.2 MT in FY24 to 0.4 MT in FY30 and 1.7 MT in FY47, with a growth rate of 10% from FY24 to FY30 and 12% from FY30 to FY47.

Packaging stands as one of the rapidly expanding industries in India. The India Packaging Market is expected to reach USD 204 billion by 2025, registering a CAGR of 26% during the period of 2020 to 2025. Forecasts suggest that the overall revenue is projected to experience a growth rate of 26.1% from 2022 to 2027. As per Indian Institute of Packaging, over the past ten years, packaging consumption in India has escalated by almost 200%. This growth can be attributed to the significant rise in consumer markets, particularly in processed food, alcoholic beverages, personal care, and pharmaceutical industries. Increased Aluminium demand in this sector is reinforced by the government's initiative to phase out single-use plastics, which is in harmony with consumer demand for products packaged in a sustainable manner.

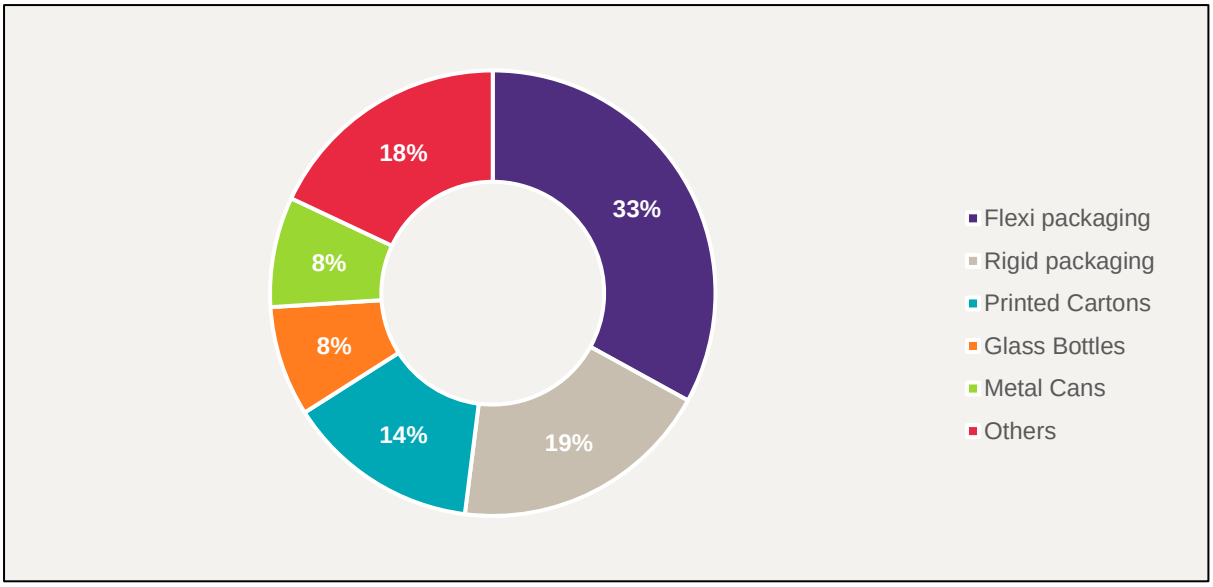

Figure 91: India's packaging market by type

Metal Cans accounts for 8% of Indian packaging industry. Aluminium sheets and foils are widely used in the packaging industry and some of the key applications include-

User segment	Key applications
Aluminium sheets	• Aluminium closures (Roll-on Pilfer-proof (ROPP) Caps, lug caps) • Aluminium beverage cans • Aluminium aerosol cans • Collapsible tubes & bottles
Aluminium foil	• Packaging for various applications including food, beverages, pharmaceutical, personal care • Semi-rigid containers • Household foil • Lidding foil, cigarette foil, etc.

Approximately 78% of Aluminium foil produced is utilized in sectors that directly serve consumers, including packaging materials and everyday household items. In India, the demand for Aluminium foil has seen significant growth, particularly driven by its use in packaging for pharmaceutical products and various household purposes.

[239] India- packaging industry positive outlook, Care Edge Analytics & Advisory, February 2024

Recent trends show that the Aluminium foil market is continuing to expand, with innovative uses in flexible packaging that offer benefits such as extended shelf life and product protection. The focus on sustainability has also led to the development of recyclable and reusable Aluminium foil products, catering to the increasing consumer demand for eco-friendly options. The industry is expected to maintain its upward trajectory, propelled by these advancements and the rising awareness of Aluminium foil's versatile applications.

Aluminium Beverage cans

Aluminium cans are predominantly used for packaging carbonated soft drinks (CSD) and beer, which are the primary market segments. Recently, other beverages like spring water, wine, and spirits have also begun to be packaged in Aluminium cans. In the fiscal year FY21, the Indian market for Aluminium beverage cans was estimated to be around 2 billion units, with CSDs making up about 60% of this figure. Noteworthy recent developments in this sector include:

- The formation of the 'Aluminium Beverages Can Association of India' (ABCAI) by major industry players such as Hindalco Industries, Ball Beverage Packaging (India), and Can Pack India, aimed at promoting the adoption of Aluminium cans for beverages in India.
- A policy initiative by the Uttar Pradesh government in March 2020 to replace glass bottles with Aluminium cans for the sale of Indian Made Foreign Liquor (IMFL).

The surge in the Indian market for Aluminium cans is primarily fueled by the escalating demand within the food & beverage industry, driven by changing consumer habits, and a spike in the need for personal care items. Also, the preference for ready-to-eat meals has also elevated the sales of products in cans, thereby significantly raising the usage of Aluminium aerosol cans. Moreover, government-led initiatives like 'Make in India' and 'Swachh Bharat Abhiyan' have catalyzed domestic production, leading to a rise in consumer goods packaged in Aluminium containers, including aerosol cans. Additionally, the increasing consumer consciousness regarding the health advantages of packaged foods is expected to further boost the industry's growth in the coming years.

Aluminium aerosol cans

India is the second largest producer of Aluminium aerosol cans in Asia after China. In the fiscal year FY20, the Indian market for Aluminium aerosol cans was approximately 400 million units. India Aluminium aerosol cans market was estimated to be worth INR 2,400 crore in 2020.[240] These Aluminium aerosol products are predominantly utilized in various segments such as:

- Home care: Common products are air fresheners for rooms and cars, insect repellent sprays, sprays for rust prevention, butane refills for lighters, spray paints, and sprays for shoe care.
- Personal care: This includes items like deodorants, perfume sprays, shaving creams, hair dyes, and breath fresheners.
- Pharmaceuticals: They are used for packaging metered-dose inhalers and sprays for pain relief.

ROPP (Roll on pilfer proof) Caps:

Roll-On Pilfer-Proof (ROPP) caps are utilized across various types of containers made of glass, plastic, and metal. They are particularly prevalent in sectors like alcoholic beverages and pharmaceuticals. While the competition from plastic caps has impacted their growth to a degree, Aluminium ROPP caps maintain a competitive advantage in certain areas, notably in the alcoholic beverages and pharmaceutical industries. There is also an increasing trend in the use of ROPP caps for wine bottles.

It is evident that ROPP caps are essential in ensuring product safety and integrity, especially for sensitive products like pharmaceuticals and alcoholic beverages. Moreover, the inherent tamper-evident design of ROPP caps provides added security against product tampering, which is crucial for consumer safety. These factors contribute to the sustained demand and growth of Aluminium ROPP caps in these sectors.

[240] India Aluminium Aerosol Cans Market (2021 - 2027) | Trends, Outlook & Forecast, 6wresearch, last accessed on 01-Oct-2024

Recent Developments[241]

In 2020, Technocap, a prominent player in the global metal packaging industry based in Italy, formed a strategic partnership with Oricon, an Indian enterprise, to venture into the Aluminium packaging market of India. The joint venture, known as Technocap Oriental, is focused on producing lug caps and operates out of Mumbai.

Technocap Oriental is part of Tecnocap's broader strategy to penetrate the Indian and Far Eastern markets, marking a significant step in their international expansion plans. The joint venture is set to control 75% of the share capital through the acquisition of Oricon's metal lug business, with Oricon retaining a 25% stake. This collaboration is expected to leverage mutual synergies and capitalize on market growth opportunities, delivering high-quality products and services. The establishment of Technocap Oriental underscores the growing importance of Aluminium packaging solutions in India, reflecting the industry's shift towards sustainable and innovative packaging practices.

Also, a recent study by Toxics Link, an environmental research organization found microplastics in Indian salt and sugar samples[242]. Plastics used in packaging are a source of microplastic in food. Govt. can implement policy measures to ban use of plastics and mandates use Aluminium can packaging to prevent microplastic contamination in food.

Transportation[243,244]

The automobile sector in India is a significant consumer of Aluminium. Currently, Indian vehicles use much less Aluminium, around 40-45 kg, compared to the global average of 160-200 kg per vehicle. As the industry focuses on reducing vehicle weight to improve fuel efficiency, it's anticipated that the use of Aluminium per vehicle will rise. Additionally, the transition to electric vehicles, which use a substantial amount of Aluminium, is expected to boost the demand for this metal even more.

The transportation sector's Aluminium consumption is projected to grow from 0.70 MT in FY24 to 1.4 MT in FY30 and 4.9 MT in FY47.

India holds a prominent place in the international market for heavy vehicles, being the top producer of tractors, the second largest in bus production, and the third in heavy truck manufacturing globally. The Indian auto industry is categorized into four main divisions: two-wheelers, three-wheelers, passenger cars, and commercial vehicles. The market is predominantly driven by two-wheelers and passenger cars. The value of India's automobile market is projected at USD 126.67 billion for the year 2024, with an expectation to surge to USD 187.85 billion by 2029. This growth trajectory represents a CAGR of 8.20% over the five-year period from 2024 to 2029.[245]

Automobile manufacturing in India saw a consistent rise until the fiscal year FY19, after which it began to fall due to a variety of reasons such as economic downturn, escalating fuel prices, and the emergence of the COVID-19 pandemic at the start of 2020. However, post-pandemic, the Indian automotive industry has recovered robustly, showing significant expansion in the fiscal years 2023 and 2024.

Table 33: Indian automobile industry: production trends ('000 units)[246]

Category	FY19	FY20	FY21	FY22	FY23	FY24
Passenger Vehicles	4028	3425	3062	3651	4587	4902
Commercial Vehicles	1112	757	625	806	1036	1066

[241] Tecnocap reaches the Indian market with Tecnocap Oriental, Tecnocap Website, last accessed on 01-Oct-2024
[242] Your salt and sugar packets contain harmful microplastics: Iodised salt has the highest, rock salt lowest, study finds, Economic Times, Aug 14, 2024, last accessed on 03-Oct-2024
[243] Primary Aluminium Industry, ICRA, Aug 2023, last accessed on 03-Oct-2024
[244] Indian Automobiles Industry Analysis, IBEF, Aug-2024, last accessed on 03-Oct-2024
[245] Indian Automobile Industry Size & Share Analysis - Growth Trends & Forecasts (2024 - 2029), Mordor Intelligence, last accessed on 03-Oct-2024
[246] Society of Indian Automobile Manufacturers Website, last accessed on 01-Oct-2024

Category	FY19	FY20	FY21	FY22	FY23	FY24
Three Wheelers	1269	1133	615	759	856	993
Two Wheelers	24500	21033	18350	17821	19459	21469
Grand Total	**30909**	**26347**	**22652**	**23036**	**25937**	**28430**

India's auto industry aims to quintuple its vehicle exports in the decade from 2016 to 2026. The country's automotive market has significant expansion potential, especially when compared to developed areas such as the US, China, and Europe, where car ownership rates are between 80-90%, in stark contrast to India's 8%. The sector has seen substantial investment inflows, with the Indian government anticipating USD 8-10 billion in domestic and international investments by 2023. From April 2000 to December 2023, the industry has already attracted around USD 35.65 billion in cumulative equity foreign direct investment (FDI).

Passenger cars

India has firmly positioned itself as a key player in the international automobile market. The market value of Indian passenger cars stood at USD 32.70 billion in 2021 and is projected to climb to USD 54.84 billion by 2027, with a CAGR exceeding 9% from 2022 to 2027. The Indian market has attracted numerous global car manufacturers. Key industry participants include international brands like BMW, Ford, Honda, Hyundai, and Volkswagen, as well as Indian companies such as Mahindra & Mahindra, Maruti Suzuki, and Tata Motors. Prominent auto-component producers include Behr India, Brakes India, Visteon, Subros, Tata Toyo, Taco, Sanden Vikas, and Pranav Vikas. Global firms like Kia Motors and Volkswagen have redesigned their products to appeal to India's vast middle-class demographic, intensifying competition with local manufacturers in this dynamic sector.

Two-wheeler[247]

The two-wheeler sector in India is experiencing a surge in popularity due to several factors: the cost-effectiveness and fuel efficiency of these vehicles, the burgeoning population, traffic congestion, limited parking, and inadequate transport infrastructure. Electric two-wheelers are especially appealing for their lower emissions. This segment leads the market in sales volume, fueled by a growing middle class and a predominantly youthful demographic. Seasonal festivals and auspicious days from August to November typically boost two-wheeler purchases. Additionally, rural areas, home to about two-thirds of India's populace, contribute to over half of the two-wheeler sales. There's also an increasing trend of using two-wheelers for long-distance travel.

Commercial Vehicles

Tata Motors and Ashok Leyland are at the forefront of India's commercial vehicle production. The sector also includes manufacturers like AMW Motors, Daimler, Eicher Motors, SML Isuzu, Force Motors, Mahindra & Mahindra, and Volvo. Additionally, there's a diverse range of bus and truck coach builders across India, with JCBL Group, Sutlej Buses, Global TVS, and Ruby Coaches being some of the key names, alongside various state-run transport companies.

A notable recent development in this segment is Hindalco's foray into the truck and trailer market, capable of producing 20,000 units annually, with the launch of Aluminium trailers and bulkers in December 2019. These vehicles, designed to carry cement, chemicals, grains, and other bulk materials, are constructed from a robust Aluminium alloy. The 34-foot Aluminium trailer is significantly lighter, weighing 2.5 tonnes less than its steel counterpart, offering a 50% reduction in weight. Initially, Hindalco will supply these Aluminium trailers to Ultratech Cement, a company within its own group.

[247] Indian Automobile Industry Size & Share Analysis - Growth Trends & Forecasts (2024 - 2029), Mordor Intelligence, last accessed on 03-Oct-2024

Electric Vehicles (EV)[248]

India is pivoting towards electric vehicles (EVs) as a strategy to cut down on emissions. Aluminium, known for being both lightweight and strong, is being increasingly used in EVs for parts like battery enclosures, motors, electronics, and cooling systems. Its ability to dissipate heat, coupled with its lightness and resistance to corrosion, contributes to reducing the overall weight of EVs, enhancing their efficiency and driving range.

According to the International Aluminium Institute's 2022 report on lightweight automotive materials, the average amount of Aluminium used in EVs is expected to rise from 360 kg per vehicle in 2021 to 430 kg by 2025. This trend is motivated by the benefits of lighter EVs, which include extended range. The Aluminium Association also emphasizes the significant benefits of Aluminium in EV batteries and parts, noting that it can lead to a vehicle weight reduction of as much as 20%, which can substantially increase the vehicle's range-up to 6% for every 10% reduction in weight.

In a notable achievement, India saw the sale of 1,325,112 EVs in the fiscal year 2024 up to January. The previous year, FY23, witnessed the sale of 1,183,422 EVs, marking a year-over-year sales growth of ~11% in FY24. As per projection on the basis of the data from Vahan portal and NITI Aayog's sales projections, EV stock in India will become 349 Lakhs in 2030 from 40.1 Lakhs in 2024 and rise to 1519 lakhs in 2050, while the EV battery market is expected to grow the same timeframe. EV stock in India will grow at a CAGR of 15% during 2024 to 2050 period. With these growth rates, India is well on its way to becoming the world's largest EV market by 2030, presenting an investment opportunity exceeding USD 200 billion in the coming 8-10 years.

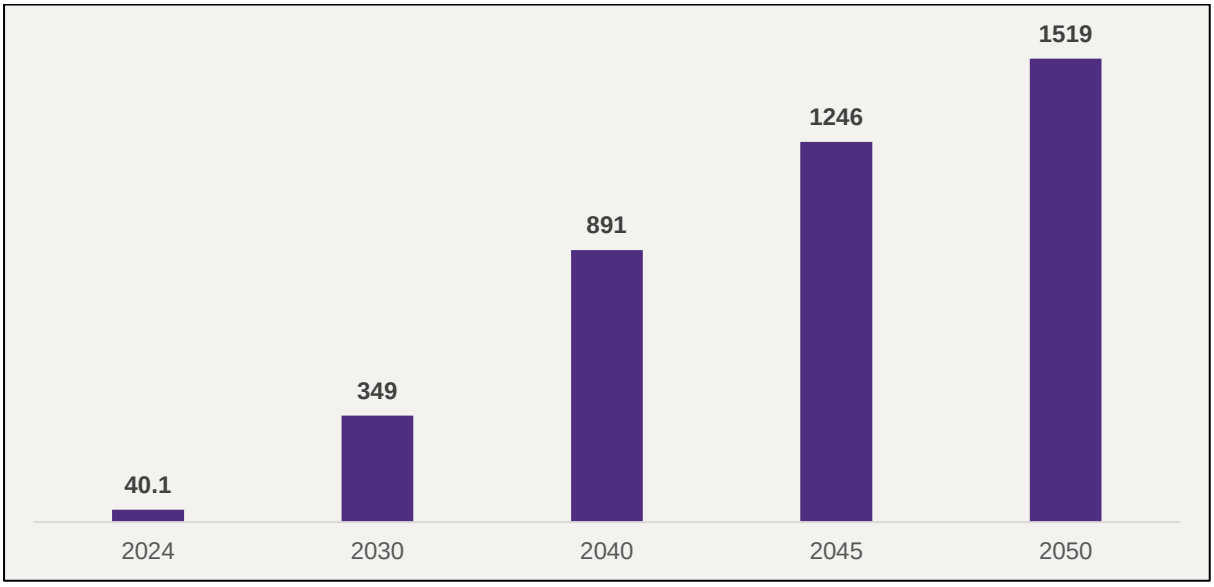

Figure 92: EV Stock forecast in India (Lakhs)

Recent advancements in India's electric vehicle (EV) sector include:

- The FAME (Faster Adoption and Manufacturing of Electric Vehicles) scheme in India is designed to boost the adoption of electric vehicles (EVs) through a series of strategic measures like providing subsidies to lower the upfront cost of EVs, making them more affordable for consumers.[249]
- VinFast and the Tamil Nadu Government inked a MoU in January 2024, pledging a USD 2 billion investment for an EV initiative in Thoothukudi, with USD 500 million allocated for the initial phase, aiming for an annual production of 150,000 units.

[248] Engineered aluminium: Driving force behind EV efficiency, A.S Ganesan (Economic Times), 08-Dec-2023, last accessed on 03-Oct-2024
[249] How will the government's decision on the FAME 3 initiative impact EV adoption in India?, Dr. Anshul Gupta (Economic Times), 17-Apr-2024, last accessed on 03-Oct-2024

- Tata Passenger Electric Mobility Ltd. (TPEM) and Bharat Petroleum Corporation Limited (BPCL) agreed in December 2023 to set up 7,000 public EV charging stations across the country to improve customer experience.
- Hero MotoCorp joined forces with Ather Energy in December 2023 to create a widespread fast-charging network, planning to span 100 cities with over 1,900 charging points.
- SAIC Motor and JSW Group declared a strategic partnership in November 2023, focusing on the advancement of eco-friendly mobility.
- Mahindra & Mahindra announced a substantial investment of INR 10,000 crore (about USD 1.2 billion) in December 2022 for a new EV manufacturing facility in Pune.
- In November 2022, Mahindra & Mahindra formed alliances with Jio-bp, Statiq, and Charge Zone to provide comprehensive charging solutions for their EV lineup.
- The Indian government unveiled the country's first electric double-decker bus in Mumbai in August 2022, signaling a commitment to revamp the transportation system with a focus on urban mobility and a smaller carbon footprint. This is part of a broader effort to encourage the adoption of EVs in response to the demand for cleaner transport options.

With the automotive industry's emphasis on reducing vehicle weight to enhance fuel efficiency and the anticipated shift towards EVs in the next decade, the demand for two-wheelers and passenger vehicles in India is expected to significantly boost Aluminium consumption.

Railways

Across US, EU and China, the share of Aluminium in structures of High-speed trains (>200kmph) is 100%; in Semi high-speed trains (100kmph-200kmph) is 50%-60% and in metro trains is 50%-80%. India stands as a major player in the global railway industry, with a yearly requirement of 5,500 coaches. The railway sector is poised to boost its Aluminium usage due to various projects and advancements:

- **Aluminium-Bodied Trains[250]:** The launch of lightweight Aluminium-bodied trains, such as the “Vande Bharat” express, is a key factor in increasing Aluminium use. These trains are built with Aluminium to cut down on weight, thereby improving their speed and energy efficiency. The Indian government issued a tender in 2022 to procure 100 Vande Bharat trains with Aluminium coaches. However, they are now reconsidering this decision due to high costs and the unavailability of domestic technology.
- **Metro Rail Networks:** The growth of metro rail systems in numerous Indian cities includes incorporating Aluminium in the construction of stations and the trains themselves.[251]
- **Wagons and Coaches:** Research indicates that new Aluminium wagons could slash energy consumption by up to 60%, as Aluminium halves the weight of a railcar. Each wagon uses about 5 tonnes of Aluminium, reflecting significant consumption in rolling stock. The Indian government has approved Aluminium for future trains, following the example of Japan and several European countries that have been using Aluminium coaches for over a decade and a half.[252]
- **100% Electrification plan in Railways[253]:** The target to achieve 100% electrification in Indian Railways is set to significantly increase the Aluminium consumption. The electrification of Railway lines involves installation of OHE systems which include Aluminium components such as conductors, wires, cantilever and other fittings.

Some of the recent developments in Indian Railway sector include-

[250] Why Indian Railways is unlikely to go for aluminium-bodied Vande Bharat trains, Economic Times, 14-Aug-2024, last accessed on 03-Oct-2024
[251] Primary Aluminium Industry, ICRA, Aug 2023, last accessed on 03-Oct-2024
[252] The use of Aluminium in Railways, Pragun Jindal Khaitan (Construction Times), 02-Dec-2022, last accessed on 03-Oct-2024
[253] Indian Railways on course to 100 per cent electrification, becoming world's largest green network, Economic Times, 08-Apr-2024, last accessed on 03-Oct-2024

- The Indian Railway has put out a tender to construct 100 “Vande Bharat Express” trains, marking a shift from stainless steel to Aluminium, which promises lighter, more energy-efficient trains at a reduced production cost. This marks the first instance of Indian Railways using Aluminium to build trains.[254]
- Alstom Transport India is broadening its manufacturing capabilities at Sri City, Andhra Pradesh, aiming to triple its output to 300 train cars annually. Alstom, which has absorbed Bombardier, secured a deal to deliver 234 coaches for Mumbai’s Metro Line 4 and its extension.
- A technology transfer agreement has been signed by the Modern Coach Factory (MCF) in Rae Bareli with a Korean firm, enabling the production of high-quality Aluminium coaches. This agreement covers the creation of eight different types of passenger coach prototypes, design, manufacturing, and testing, with mass production set to occur at MCF.

These initiatives underscore the railway sector’s vital contribution to the rise in Aluminium demand in India, in line with the nation’s infrastructure and eco-friendly goals.

Building & Construction

Aluminium ranks as the metal most frequently used in construction, second only to steel. It's a key component across various building segments, from commercial structures to residential homes. The primary applications include window frames, roofing materials, external wall cladding, curtain walls, and structural glazing. It's also prevalent in prefabricated structures, architectural fixtures, heating and ventilation systems, interior design, and partitioning. Additionally, Aluminium finds extensive use in industrial equipment, as well as in ladders and scaffolding for its durability and ease of handling. The construction industry commonly employs two main types of Aluminium alloys: the 5000 series, which are magnesium alloys known for their increased strength through work-hardening, and the 6000 series, which are magnesium-silicon alloys that can be heat-treated to enhance their properties.[255]

Aluminium consumption in this sector is projected to grow from 0.8 MT in FY24 to 1.4 MT in FY30 and 4.8 MT in FY47.

The Indian government’s focus on the infrastructure sector is expected to significantly increase Aluminium consumption in the country due to several key initiatives and developments-

- **National Infrastructure Pipeline (NIP)[256]:** With an estimated capital expenditure of INR 111 Crore for the period FY20-FY25, the NIP is set to drive infrastructure sector with flagship schemes like AMRUT, Gati Shakti, Sagarmala, Bharatmala and others. These projects necessitate the use of Aluminium due to its lightweight, durability and corrosion resistance.
- **Pradhan Mantri Awas Yojana-Urban 2.0:** This scheme aims to address the housing needs of one crore urban poor and middle-class families. It also includes provisions for interest subsidies to facilitate loans at affordable rates.[257]
- **Smart Cities Mission:** The ‘Smart Cities Mission’ launched by Govt. of India focus on creating 100 smart cities across the country, which will feature modern construction materials. As India continues to urbanize, the demand for modern housing and public infrastructure will contribute to increased Aluminium consumption.
- **Foreign Direct Investment (FDI) Policy:** 100% FDI through automatic route is allowed in construction development projects which encompasses a wide array of projects such as the creation of townships, building of homes and commercial spaces, and the construction of essential infrastructure like roads, bridges, as well as establishments like hotels, resorts, hospitals, schools, and leisure facilities. Additionally, it includes the development of urban and regional infrastructure and townships. The

[254] Indian Railways Invites Tenders To Build All-Aluminum Coaches For Vande Bharat Trains, News 18, 27-Feb-2023, last accessed on 03-Oct-2024
[255] Use of Aluminium In Building Construction, Prof. Madhuri K. Rathi, 01-Apr-2013, last accessed on 03-Oct-2024
[256] Budget 2024: Economic development through infrastructure investment, The Indian Express, 22-Jul-2024, last accessed on 03-Oct-2024
[257] Budget 2024: Interest subsidy returns under PM Awas Yojana 2.0 (Urban), Hindustan Times, 23-Jul-2024, last accessed on 03-Oct-2024

automatic route simplifies the investment process, encouraging greater international investment and contributing to the country's development.

- **The Real Estate (Regulation and Development) Act (RERA), 2016:** This Act seeks to protect homebuyers as well as help boost investments in the real estate industry.

Electrical

Aluminium usage in India's electrical sector is projected to grow from 2.4 MT in FY24 to 4.0 MT in FY30 and 12.9 MT in FY47.

Power sector in India

Aluminium and its alloys are essential to the power industry due to their high structural integrity, lightweight nature, excellent electrical conductivity, great malleability, and lack of magnetic interference. These materials are crucial in a variety of applications such as electrical cables, conductive busbars, aerial transmission lines, electric motors, foil coil windings, capacitors for energy storage, components for heating, and devices for thermal management, among others. Their versatile properties make them a key component in numerous electrical and electronic applications. The power sector in India consumes Aluminium primarily in the following ways:

- **Transmission and Distribution (T&D) Lines:** Aluminium is extensively used in the power T&D sector due to its excellent conductivity and lightweight properties. Aluminium stands out for its remarkable adaptability and excellent electrical conductivity. It is second only to copper in terms of conductivity among common metals. To carry the same amount of current, an Aluminium wire requires a cross section that is approximately 1.5 times larger, yet it remains twice as light and resistant to corrosion from environmental factors. This makes Aluminium wire rods ideal for use in transmission lines. Their reduced weight is particularly beneficial in preventing the sagging of transmission lines, which is crucial for maintaining reliable power distribution across extensive distances.
- **Aluminium Wire Rods:** India is one of the largest consumers of Aluminium-based wires and cables, with an annual consumption of 1.04 MT Aluminium wire rods[258]. This is crucial for the electrical infrastructure across the country.[259]
- **Renewable Energy Projects:** With the government's ambitious target to achieve 500 GW of renewable energy capacity by 2030, there will be substantial capacity additions in transmission lines, which will further drive the demand for Aluminium in the power sector[260].

India aims to reach a solar power capacity of 280 gigawatts (GW) by 2030[261]. As of June 2024, the country's installed solar energy capacity stands at 85 GW[262]. To meet this target, India will need to add approximately 32.5 GW of solar capacity each year.

Aluminium plays a crucial role in this expansion, with 72% of the total Aluminium input used in construction and mounting structures, 22% in panel frames, and 6% in inverters. Specifically, developing 1 GW of solar power capacity requires about 20 kilo tonnes (kT) of Aluminium solely for panel frames[263]. So, 650 kTPA of Aluminium will be required only for frames and total ~4 MT of Aluminium is required to produce frame for the 280 GW solar power.

- **Infrastructure Development: As per t**he National Electricity Plan (NEP) 2022-32 worked out by the Central Electricity Authority (CEA), the total capacity addition during the period 2022-27 is expected to

[258] AL Circle Website, last accessed on 10-Aug-2024
[259] Aluminium is the Metal of the Future for the Electrical Sector, P. K. Chatterjee, 12-Aug-2021, last accessed on 03-Oct-2024
[260] Economic Survey 2024: Renewable energy investments to fuel India's green transition, aiming for 500GW by 2030, Saurav Anand (Economic Times), 22-Jul-2024, 03-Oct-2024
[261] India is marching ahead in the Renewable Energy Sector, PIB Mumbai, 30-Jul-2023, last accessed on 03-Oct-2024.
[262] Invest India Website, last accessed on 10-Aug-2024
[263] Vedanta AL, October 2020 Edition, last accessed on 03-Oct-2024

be 211,819 MW and capacity addition requirement is projected to be 291,802 MW during 2027-32.[264] This expansion is expected to boost Aluminium consumption in the power sector[2].

In summary, the power sector's demand for Aluminium is driven by the need for efficient and durable materials for electrical transmission and distribution, and the sector's growth will push for consumption of Aluminium.

Electrical Lighting

The electrical lighting market in India is evolving rapidly- moving from conventional lamps to LED and Aluminium an indispensable material in the design and function of LED lighting. Market demand for Aluminium LED channels is experiencing significant growth. The market value of LED lighting in India is projected to be USD 4.70 billion in the year 2024. It is anticipated to expand to USD 6.77 billion by the year 2030. This represents a growth trajectory with a CAGR of 6.29% over the period from 2024 to 2030.[265]

Electric Fans[266]

Aluminium's ability to conduct heat and its lightweight properties make it ideal for use in the coils and blades of electric fans. Ceiling fans are a popular choice in India, with sales reaching around 41 million units each year, ranking them as one of the most purchased cooling devices. The market for electric fans in India was estimated at USD 1.94 Billion in 2024 and is projected to grow at a CAGR of 11.5% until 2030, potentially reaching USD 3.72 Billion. The increasing demand for cost-effective cooling options among the expanding middle class is driving fan sales, which, in turn, is expected to elevate the demand for Aluminium.

Machinery & Equipment

Aluminium usage in the Machinery & Equipment sector is projected to grow from 0.4 MT in FY24 to 0.6 MT in FY30 and 2.0 MT in FY47.

Offset printing

The offset printing industry is one of the major users of Aluminium plates. The printing industry in India is fragmented with over 250000 small, medium and large printers operating in the market. Major printing clusters are present in Amritsar, Delhi and Faridabad in North; Ahmedabad and Mumbai in west; Bangalore, Coimbatore, Chennai, Sivakasi, Hyderabad and Vijaywada in South. Demand for offset plates has been growing, in line with the new offset printing machine installations in the country. TechNova has manufacturing facilities in Mumbai and has technology tie-up with Agfa to manufacture offset plates.

Even as digital methods gain popularity, offset printing maintains its relevance within the industry, recognized for its ability to produce bulk print runs efficiently and economically. The expansion of this market is propelled by ongoing needs for office supplies, marketing items, and packaging across diverse sectors. In 2023, the commercial printing sector in India was valued at USD 34.5 Billion. Projecting ahead, the IMARC Group forecasts that this sector will grow to USD 45.3 Billion by 2032, with an expected CAGR of 3% from 2024 to 2032.[267]

Ventilator

Amid the COVID-19 pandemic, the demand for ventilators fabricated using Aluminium extrusions in India surged. Domestic ventilator production increased from 2,500 in February 2020 to an estimated 5,500-5,750 in March 2020. The Indian ventilator market is currently valued at USD 103.5 million in 2023 and is expected to grow at a 5.12% CAGR through 2029.[268] In the future, as hospitals adopt more advanced ventilator technology, the demand for extrusions is expected to rise from this sector.

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[264] India's power generation sector requires Rs 33 lakh crore investment, 3.78 million professionals by 2032: Economic Times, last accessed on 03-Oct-2024
[265] India LED Lighting Market Size & Share Analysis - Growth Trends & Forecasts Up To 2030, Mordor Intelligence, last accessed on 03-Oct-2024
[266] India Electric Fans Market Size, Share and Forecast 2030F, TechSci Research, last accessed on 03-Oct-2024
[267] India Commercial Printing Market Size, Share, Trends, Report 2024-2032, IMARC, last accessed on 03-Oct-2024
[268] India Ventilator Market By Size, Share and Forecast 2029, TechSci Research, last accessed on 03-Oct-2024

Consumer Durables

Aluminium usage in the Consumer Durables sector is projected to grow from 0.3 MT in FY24 to 0.50 MT in FY30 and 1.5 MT in FY47.

Cookware

Aluminium's properties of conducting heat well, being durable, and lightweight make it a favored choice for manufacturing various kitchen appliances like pressure cookers, toasters, mixing bowls, kettles, and pans. The cookware market in India has seen a steady rise and is anticipated to continue its upward trajectory, spurred by an increase in consumer spending, higher per capita income, and population growth across the country. The lockdowns during the Covid-19 pandemic saw a surge in home cooking and sharing culinary creations online, leading to increased cookware purchases as restaurants were closed. Moreover, the growing preference for quality branded products in rural India, where nearly 70% of the population resides, is also fueling market growth. This trend is expected to further boost the demand for Aluminium in the cookware industry.

Refrigerators[269]

Aluminium's superior heat transfer capabilities, resistance to corrosion, and lightness make it a key material in refrigerator manufacturing. It is particularly utilized in components like evaporator and condenser coils that require efficient heat conduction.

The refrigerator sector in India is on an upward trajectory, with expectations to expand at a 10.2% CAGR from 2023 to 2031, potentially reaching a valuation of USD 9,988 Million by 2031, up from USD 4602 Million in 2023. The surge in urban populations and rising income levels are fueling the demand for refrigerators. This, in turn, is boosting the need for Aluminium in their production. Furthermore, initiatives like 'Make in India' and other governmental policies are spurring local manufacturing, which includes refrigerator production and, by extension, Aluminium usage.

Washing Machine[270]

Aluminium's robustness, resistance to wear, and lightness are key reasons for its integration into washing machines. It's employed in crafting parts like alloy belt pulleys and motor wiring, leveraging its mechanical strength and conductive properties. Additionally, Aluminium is chosen for certain structural elements to lighten the appliance's overall mass.

The market for washing machines in India is projected to swell from USD 4.44 billion in 2024 to USD 6.27 billion by 2029, advancing at a CAGR of 7.14% over the five-year period. Urban regions are the primary market for these appliances, driving a significant portion of the sales. The trend towards intelligent washing machines is expected to gain momentum, spurred by the rapid urbanization and changing consumer lifestyles. The burgeoning urban demographic, especially those with higher incomes, is poised to bolster washing machine sales in the coming years, which, in turn, will amplify the demand for Aluminium.

Air conditioners[271]

Aluminium plays a crucial role in the manufacturing of air conditioner coils, contributing to their enhanced performance and longevity. In 2023, the valuation of the air conditioner market in India stood at USD 3.15 billion. It is forecasted to grow at a 7.78% CAGR from 2024 to 2032, with expectations to reach USD 6.15 billion by the end of the forecast period. The surge in demand for air conditioners is attributed to the increasing construction of commercial and residential spaces needing effective cooling systems. This growth trajectory in the air conditioning sector is anticipated to propel the demand for Aluminium in India as the industry continues to flourish.

Electronics Hardware

[269] India Refrigerator Market Analysis - Industry Report, Astute Analytica, last accessed on 03-Oct-2024
[270] Washing Machine Market in India Size & Share Analysis - Growth Trends & Forecasts (2024 – 2029), Mordor Intelligence, last accessed on 03-Oct-2024
[271] India Air Conditioner Market Report and Forecast 2024-2032, Expert Market Research, last accessed on 03-Oct-2024

Aluminium's ability to manage heat and its low weight make it a popular choice for use in electronic devices like televisions, laptops, and smartphones. As one of the rapidly expanding markets for electronic hardware globally, India sees a high volume of imports for these products. However, with the government's 'Make in India' campaign aimed at enhancing local production, the demand for Aluminium within the country's manufacturing sector is anticipated to rise.

Others

Aluminium usage in the Machinery & Equipment sector is projected to grow from 0.14 MT in FY24 to 0.2 MT in FY30 and 0.3 MT FY47.

Mainly Aluminium extrusions are used in these sectors for manufacturing of structural works such as frames, rivets, ribs and I&L sections. Apart from this, Aluminium extrusions in commercial aircrafts are used for interiors, seats, lighting fixtures, overhead cabins, window panels, brackets etc.

Also, high strength Aluminium alloys are used in military aircrafts, ammunition hardware, missiles and rockets. 41 Ordnance factories across India erstwhile the Ordnance Factory Board (OFB) are the largest producer of Aluminium profiles for the defence industry. OFB produces solid, hollow and tube sections for Defence and Aerospace sectors.

The expansion of the Indian Aluminium industry is being propelled by its growing use in the aerospace and defence sectors. Increased air travel and a wealthier middle class with greater spending power are opening up strong prospects in the aerospace field. Meanwhile, the 'Make in India' campaign is spurring on domestic investments and production, which is likely to bridge the current divide between local output and the worldwide supply of premium Aluminium alloy extrusions, essential for aerospace and defence uses. Furthermore, India has made considerable strides in its Defence sector, evidenced by a reduction in foreign defence procurement spending from 46% in FY19 to 36.7% as of December 2022.

Annexure 6: Key Regulatory Change Requirement

Measures to be Taken to Promote Domestic Aluminium Industry	Regulatory Change Required	Responsible Stakeholders
Classifying Aluminium as a Core Industry The aluminium industry is crucial for India's growth, driving sectors like EVs, wind turbines, and solar panels. It contributes nearly 2% to India's manufacturing GDP and generates around 800,000 jobs. Recognizing its strategic importance, it is recommended to designate aluminium as a core industry to secure benefits like energy allocation and protection from dumping.	Inclusion of Aluminium in the Core Industry list through the Office of the Economic Adviser, under the Department for Promotion of Industry and Internal Trade (DPIIT), Ministry of Commerce and Industry. Currently Coal, Steel, Cement, Natural Gas, Electricity, Crude Oil, Fertilisers and Refinery Products are designated as Core Industry.	Ministry of Commerce and Industry
Revenue Neutral Swap Contracts India generates ~275 TWh of Renewable power every year. Aluminium Smelters need 70-80 TWh per year. One measure to mitigate the impact of CBAM therefore would be to introduce **revenue neutral swap contracts** wherein Aluminium Smelters are allowed to swap renewable power from the grid while they sell power from their coal CPPs to the grid. This will also help smelters to continue operating coal CPPs as back up to grid power in case of exigencies, which is something that the smelters highlight as a key hurdle to green transition.	Amendment in Electricity Act, 2003 and respective state government rules.	Ministry of Power and respective State Government Ministries
Reduction/Exemption of Electricity Duty Electricity is the largest cost factor in aluminium production. Consequently, higher electricity duties increase production costs, deterring investors from establishing new capacities. Reducing or exempting electricity duties will enhance the profitability of primary producers, thereby encouraging them to establish new aluminium smelters.	Amendments in Electricity Act 2003, and respective state electricity duty acts like Chhattisgarh Electricity Duty Act 1949 and Odisha Electricity Duty Act, 1961.	Ministry of Power and respective State Government Ministries

Measures to be Taken to Promote Domestic Aluminium Industry	Regulatory Change Required	Responsible Stakeholders
Stricter Emission Norms for HDVs Stricter emission norms for HDVs in line with rest of the world would lead to increased aluminium consumption for light-weighting of vehicles.	Revision of Bharat Stage Emission Standards (BSES) to ensure stricter emission norms.	Ministry of Environment, Forest and Climate Change
Revision of inverted duty structure and high basic custom duties on raw materials The inverted duty regime and high basic custom duties on critical raw materials hinder the competitiveness of local aluminium manufacturers. Reducing the Basic Custom Duty on essential inputs like Calcined Petroleum Coke, Aluminium Fluoride, and Caustic Soda Lye is recommended to alleviate this issue.	Review and amend the Customs Tariff Act, 1975.	Ministry of Commerce and Industry
Enhanced RoDTEP rates[272] The RoDTEP scheme rates for Special Economic Zones (SEZs) and Export-Oriented Units (EOUs) need to be announced as SEZs and EOUs account for 30% of India's total Aluminium exports. Announcing rates for these zones is expected to provide a significant boost to the nation's Aluminium industry.	Amendments to RoDTEP rates	Ministry of Commerce and Industry
GST compensation cess Reimbursement as Incentive for setting up Downstream Capacities Aluminium production requires 24 X 7 continuous power supply which is currently achieved through thermal power. Therefore, GST Compensation Cess on coal reimbursement proportionated to the installed downstream capacity will lead to lower cost of electricity generation thus encouraging aluminium producers to invest in downstream sector.	NA	Ministry of Coal
PLI Scheme for Key Aluminium Product Segments	NA	Ministry of Commerce and Industry

[272] Aluminium industry seeks govt intervention to notify rates for SEZs, ET Infra (indiatimes.com)

Measures to be Taken to Promote Domestic Aluminium Industry	Regulatory Change Required	Responsible Stakeholders
To encourage investment in downstream sector and reduce import dependence PLI for key aluminium product segments may be given.		
Agency for Facilitating Global Scrap Supply Chain for Import Similar to KABIL, India can setup an agency to gain control over the global scrap supply chain to ensure raw material security.	NA	Ministry of Commerce and Industry

Along with the above changes, Institutional Infrastructures and Taskforces to support the domestic Aluminium Industry have to be constituted by Ministry of Mines to realise the goals set forth in this vision document.

Annexure 7: Stakeholder Views

Stakeholder	Views / Support Required from Government
AAI (NALCO, Hindalco and Vedanta)	1. Classification of Aluminium Industry as a “Core” Industry. This will facilitate the Aluminium companies for getting priority in coal and railway rake allotments. 2. As a matter of policy, primary Aluminium sector should be focused due to higher domestic value addition (and employment generation) and limited scrap availability. 3. Increasing the custom duty on import of Aluminium Scrap. 4. Preferential allocation of coal blocks for new Aluminium Industries. 5. GST Compensation Cess of INR 400/tonne on coal should be removed. 6. Reduction in custom duty of basic raw materials like caustic soda, CP coke, Aluminium Fluoride. 7. RPO obligation for Aluminium Industry to be re-looked. 8. Efficiency norms for EV should be mandated by Govt. like Power consumption/ ton km 9. PLI should be given on component of products instead of assembled products. For example, PLI scheme of EV instead of EV components is increasing import of components and only the assembling is being done in India. 10. BIS standard needs to be implemented for all downstream and end-use products and BIS should aim at reaching global standard. 11. In Packaging, Building & Construction Extended Producer Responsibility (EPR) should be implemented along with ensuring closed loop of scrap recycling. Closed loop is important from quality perspective. 12. Aerospace and Semiconductor new emerging industries in India, EPR can be mandated for these industries from the beginning. 13. For transition to Aluminium based products Government is taking decision based on upfront cost (e.g.: Vande Bharat Aluminium coach) while they should consider Total cost of ownership.
MRAI	1. Reduce custom Duty on Import of Non-Ferrous Scrap to NIL. 2. In light of the proposed CBAM and the potential ban on the export of scrap to non-OECD countries, the Government of India should engage with the EU to ensure the continued inflow of scrap into India. 3. PLI Scheme for Secondary Non-Ferrous Industry 4. Reduce GST on post-consumer scrap to Nil. Since the scrap already includes the GST suffered at the component stage. Recyclers should be allowed to take performa credit of 18% of their scrap purchase value. They will then be required to charge GST on their product at the rate of 18% as applicable.
ASMA	1. Duty of scrap import may be reduced from present duty of 2.5% 2. Duty of primary Aluminium import may be reduced from present duty of 7.5% 3. Duty on downstream Aluminium products, specially Flat Rolled Products may be increased to 12.5% from present duty of 7.5% 4. RoDTEP rates for primary Aluminium export is slightly higher compared to the downstream export. The rate for downstream export should be higher compared to primary Aluminium 5. RoDTEP rates to be enhanced to previous MEIS rates 6. Cluster based R&D facilities can be developed for product innovation

Stakeholder	Views / Support Required from Government
	7. GST on domestic Aluminium scrap may be reduced to 5% from current GST of 18%. It would be a step in developing an organized scrap collection sector. 8. Setting up of recycling plants should be incentivised. 9. Financing of recycling and downstream projects should be liberalised for MSMEs. 10. Quality control should be on the end products rather than input materials. 11. Cluster manufacturing unit establishment through government/private player in PPP mode to allow smaller players to use it as a shared unit.
JNARDDC	1. Increased Funding from the government to support R&D projects and innovation and encourage private sector involvement in those projects. 2. Simplifying regulatory processes to facilitate R&D activities and reduce bureaucratic barriers. 3. Investing in state-of-the-art research facilities and equipment to support advanced R&D. 4. Promoting joint research projects between industry and academic institutions to drive innovation

Annexure 8: Comparison of Emission Norms[273]

Category	Recent Emission Standard Pollutants	USA		Japan	Australia (ADR79/04)	Europe (EURO 6)	India (BS-VI)
		USA (Tier 3)	California (LEV III)				
PCs (referred as LDVs in USA and California)	CO HC	0–2.610 –	0.621–2.610 –	0.63 (1.15) –	(1.0) (0.1)	0.5 (1.0) – (0.10)	0.5 (1.0) – (0.1)
	NOx	–	–	0.15, 0.05	(0.06)	0.08 (0.06)	0.08 (0.06)
	HC + NOx	–	–	–	–	0.17 (–)	0.17 (–)
	HCHO	0 –0.002	0.002	–	–	–	–
	NMHC	–	–	0.024 (0.1)	(0.068)	–	– (0.068)
	NMOG + NOx	0–0.099	0.012–0.099	–	–	–	–
	PM	0–0.002	0.006	0.005	0.0045	0.005	0.0045,
	PN	–	–	–	–	6×10^{11}	6×10^{11}
LDVs	CO	0–2.610	0.621–2.610	0.63, 1.15–4.02	–	0.5–0.74 (1.0–2.27)	0.5–0.74, (1.0–2.27)
	HC	–	–	–	–	– (0.1–0.16)	– (0.1–0.16)
	NOx	–	–	0.15–0.24, 0.05–0.07	–	0.08 –0.125 (0.06 – 0.082)	0.08–0.125, (0.06–0.082)
	HC + NOx	–	–	–	–	0.17–0.215 (–)	0.17–0.215 (–)
	HCHO	0–0.002	0.002	–	–	–	–
	NMHC	–	–	0.024, 0.1–0.15	–	– (0.068–0.108)	– (0.068–0.108)
	NMOG + NOx	0–0.099	0.012–0.099	–	–	–	–
	PM	0–0.002	0.006	0.005–0.007, 0.005–0.007	–	0.005	0.0045
	PN	–	–	–	–	6×10^{11}	6×10^{11}
	Recent emission standard/ pollutants	Tier 3	LEV III	–	ADR80/ 03	Euro VI	BSVI

[273] Singh, S., Kulshrestha, M. J., Rani, N., Kumar, K., Sharma, C., & Aswal, D. K. (2023). An overview of vehicular emission standards. *Mapan*, *38*(1), 241-263.

Category	Recent Emission Standard Pollutants	USA		Japan	Australia (ADR79/04)	Europe (EURO 6)	India (BS-VI)
		USA (Tier 3)	California (LEV III)				
HDVs	CO	0–4.536	1.988–4.536	2.22, (16)	1.5–4.0	1.5	4.00
	HC	–	–	–	0.46–0.55	0.13	–
	NOx	–	–	0.4, (0.7)	2.0	0.4	3.50
	HCHO	0–0.004	0.004	–	–	–	–
	NMHC	–	–	0.17, (0.23)	–	–	0.55
	NMOG + NOx	0–0.391	0.093–0.391	–	–	–	–
	CH4	–	–	–	–	–	1.10
	PM	0–0.006	0.037–0.075	0.01, 0.01	0.02–0.03	0.01	0.03
	PN	–	–	–	–	8×10^{11}	–

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