KN07 - Future of Indian Aluminium Sector: Challenges and Progress

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Abstract

The global demand for aluminium has experienced a tremendous increase in recent decades, driven by its exceptional physical and chemical properties, lightweight applications, recyclability and abrasion resistance. It has earned the title of "Metal of the future" for various reasons including the potential for carbon footprint reduction. Even after multiple times of recycling, aluminium products can act as resources at the end of their lifecycle without compromising quality. This makes the metal frontrunner in the circular economy.

Aluminium sector plays a crucial role in achieving India's ambitious goal of attaining 5 trillion-dollar economy. In financial year 2022 (FY'22), India catered 4 million tonnes of primary aluminium which is 5.85 % of global aluminium production. Indian Aluminium market is expected to grow at a compound annual growth rate (CAGR) of 8-10 % against world average of 5.6 % and it is anticipated to be driven by the rapid growth of diversified sectors in domestic market, like - automobile, aviation, defence and small-scale industries. The metal commits an important role in the development of downstream sector, fostering MSME (Micro, Small and Medium Enterprises) ecosystem and enhancing the domestic value addition within the country. The recent trend in Indian aluminium industry is hovering over sustainability and green aluminium. Decarbonization, Net Zero emissions, waste management and zero liquid discharge are the main approaches in this endeavour.

Indian smelters have been aligning their strategies with Industry 4.0 to effectively address sustainability challenges in aluminium production in recent years. Extensive R&D efforts are underway to explore the utilization of hazardous wastes generated throughout the entire lifecycle of aluminium. By integrating environmental, social and governance (ESG) principles into the core strategies, like - fostering diversity and inclusivity in workforce, adopting electric vehicle policy and launching of green aluminium, Vedanta is aiming for reduction of carbon footprint and creating long term values for the organization while making a positive impact to achieve India's vision of "AtmaNirbhar Bharat" and Net Zero emissions by 2070. This paper provides an overview of Indian aluminium industry and Vedanta's sustainability practices, market scenario and how the smelters are prioritizing sustainable practices and incorporating ESG considerations into their business strategies.

Keywords: Indian aluminium industry, Sustainable production, Environmental social and governance (ESG), Net zero emissions, AtmaNirbhar Bharat.

1. Introduction

The aluminium industry has long been a key player in the global economy, with its versatile applications spanning various sectors such automobile, power, construction, packaging, and aerospace. The development of innovative and advanced aluminium alloys has opened up a wide range of applications for aluminium in the consumer electronics sector. Additionally, the increasing use of aluminium as a substitute for plastics and steels is driven by its reliability, versatility, high mechanical strength, cost-effectiveness, and lightweight properties, thereby

strengthening the market. The growth of the global aluminium market is further propelled by the expanding applications, growing environmental concerns, and a shift towards the use of recyclable materials. The Asia Pacific region and the America have mature markets, with the Asia Pacific expected to dominate future growth rates. Over the next five years, various countries in the Asia Pacific region and the Middle East are anticipated to witness capacity expansions in aluminium manufacturing [1]. The per capita consumption of aluminium globally has reached an average of 11 kg, while in India; it remains significantly lower, ranging from 2.5 to 2.8 kg [2, 3]. However, it is predicted that the demand for aluminium in India will experience substantial growth in the coming years, primarily due to the projected high GDP growth in the country. The Indian government's ambitious initiatives such as Make in India, 100 % rural electrification, smart cities, the National Infrastructure Pipeline (NIP), and schemes, as FAME (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles) for electric vehicles, along with increased foreign direct investment (FDI), will boost the consumption of aluminium in the country. However, as the industry looks toward the future, it faces a myriad of challenges that require careful examination and strategic planning. Smelters across the globe are trying to develop energy efficient technologies, adopting renewable sources of energy and fostering best operational practices to reduce carbon footprints and integrating best energy management system. This research paper aims to delve into the challenges and progress in the aluminium industry, providing insights into the factors that will shape its trajectory in the coming years.

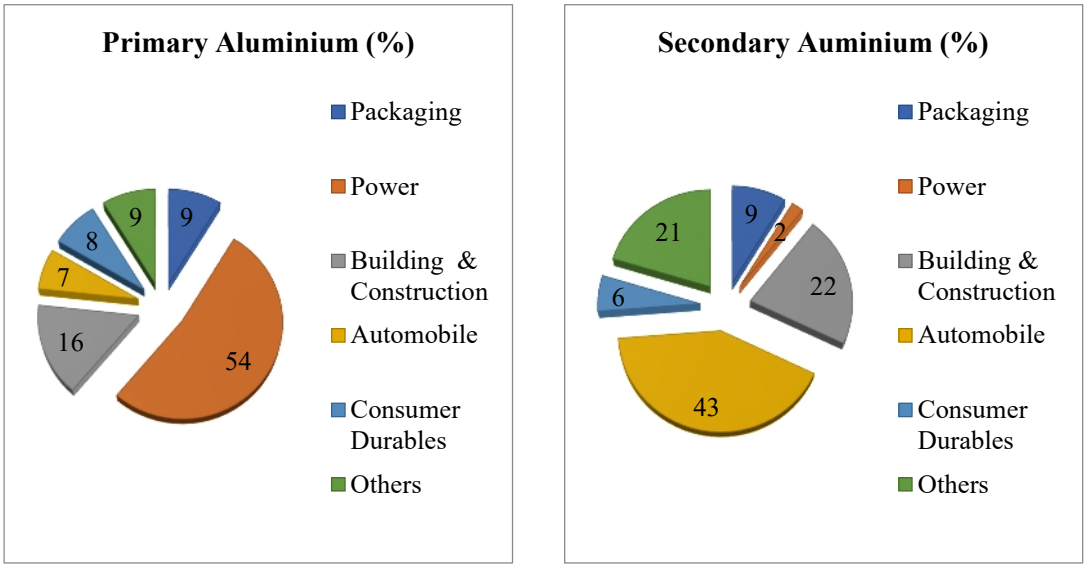

Figure 1. Primary and secondary aluminium usage in different sectors in India [2].

2. Global & Domestic Outlook for Aluminium Market

The Covid-19 pandemic and the ensuing lockdowns had a profound and far-reaching effect on the global aluminium industry during FY'20-21. In the post COVID period the demand of aluminium has shown an uptrend. Aluminium demand is forecast to grow by 33 million tonnes, going from 86 million tonnes in 2020 to 119 million tonnes in 2030. Around 37 % growth is expected to come from China, followed by 26 % other Asian countries and 37 % from rest of the countries [4].

The highest growth in terms of absolute demand will come from the automobile sector after introduction of decarbonization policies and shifting of traditional fossil fuel powered vehicles to electric vehicles (EVs). Followed by automobile sector, the electric and construction sectors are witnessing surge in demand for aluminium. The global market is expected to expand from USD 168.84 billion in 2022 to USD 255.91 billion by 2029. The global aluminium market is expected

to grow at a CAGR of 6.1 % in the forecast period of 2022-2029 supported by the rising demand from end uses [5].

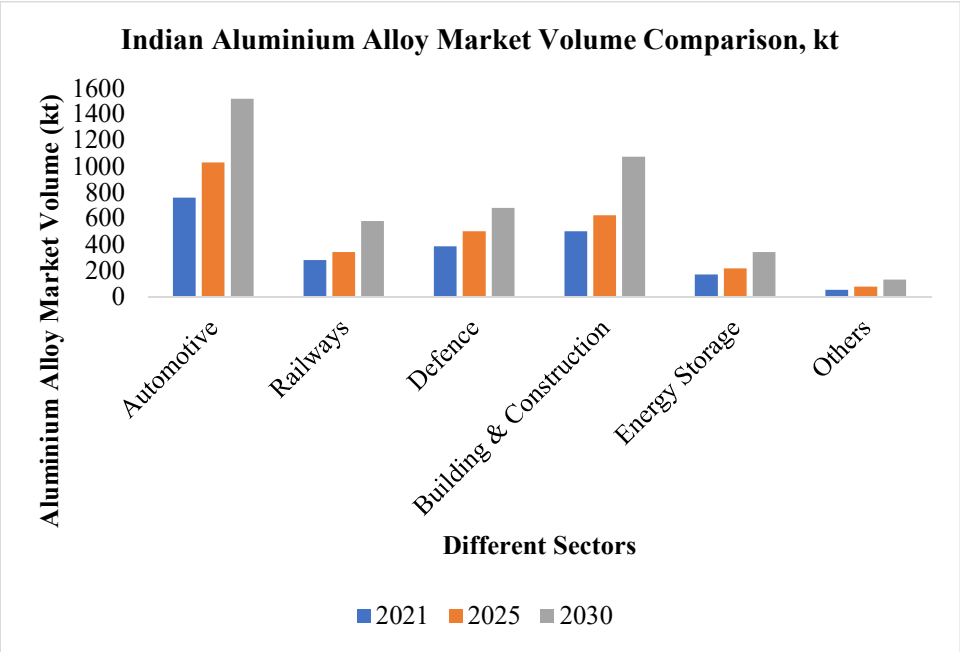

Figure 2. Indian aluminium alloy market volume comparison, kt.

Indian primary aluminium market, with current capacity of 4.2 million tonnes per annum, is expected to deliver ~6 % of global aluminium output in FY'24. Vedanta (Jharsuguda & BALCO together) contributes to 56 % of the country's total primary Aluminium production. India's aluminium demand stands around 4 million tonnes per year [6].

Aluminum's unique combination of lightweight properties, strength, and corrosion resistance makes it an indispensable material in the aerospace and defense industry. Its application in various components and structures contributes to improved performance, fuel efficiency, and overall mission success. The most widely consumed aluminium alloys in aerospace industries are the Al-Cu alloys (2xxx series), Al-Zn alloys (7xxx series) and Al-Li alloys. It is extensively used in aircraft structures, aerospace components, spacecraft and satellites, defense application, missile technology, etc.

Table 1. Production Capacity of Indian Aluminium Smelters [6].

Company	Smelting Capacity (Million Tons Per Annum)	Location
Vedanta Limited	1.8	Jharsuguda (Odisha)
BALCO	0.57	Korba (Chattisgarh)
NALCO	0.46	Angul (Odisha)
HINDALCO	1.35	Renukoot (Uttar Pradesh) Hirakud and Aditya (Odisha) Mahan (Madhya Pradesh)
Total	4.2	India

While the power sector consumes the largest proportion of primary aluminium, the automobile sector is the major driver for secondary aluminium consumption in India [2].

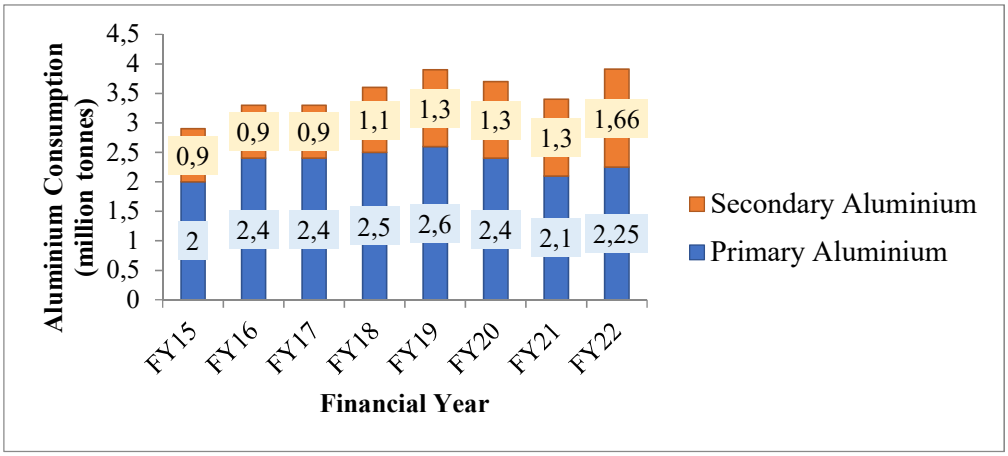

Figure 3. Aluminium demand trend in India [2].

3. Challenges in Aluminium Sector

Aluminium being the second most energy-intensive industry, energy efficiency and greenhouse gas emissions has always been a point of concern. According to 2021 data, aluminium smelting is responsible for 275 million tonnes of direct CO_2 emissions and 1.1 billion tonnes of direct and indirect CO_2e emissions. Primary aluminium production accounts for 95 % of these emissions [7].

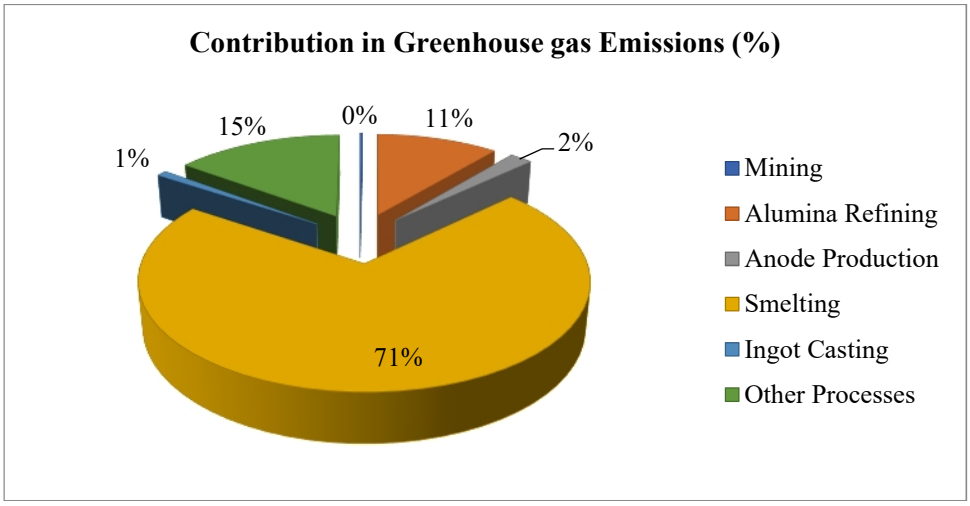

Figure 4. Percentage contributions in greenhouse gas emissions from major processes of aluminium production [8].

The industry presently faces several daunting challenges including rising imports, escalating production and logistics cost. The industry sustainability has also been affected by non-competitive energy cost and severe shortage of coal allotted to the non-power sector. Additionally, raw material quality and carbon pricing are other challenges that aluminium smelters have to face. The primary aluminium-manufacturing firms are expected to face a long-term decline in the real price of aluminium, which will gradually erode their profit margins. This situation will exert pressure on the industry to enhance its return on investment. To extract the metal from ore more efficiently, further advancements in technology are necessary. Apart from that, the aluminium industry will encounter fierce competition from alternative materials like steel and plastics, which serve as substitutes for aluminium.

As the global focus shifts towards eco-friendliness, the industry will face increasing pressure to reduce greenhouse gas emissions and perfluorocarbon (PFC) emissions in the production process. Enhancing energy efficiency in aluminium production becomes imperative. The industry needs to minimize electricity consumption associated with aluminium production. With exponential growth in demand for aluminium from various sectors, particularly the automobile and construction industries, manufacturers must adapt and respond effectively to the changing demands of global customers.

4. Technological Advancement in Global Aluminium Sector

Technology has emerged as a pivotal catalyst in reshaping industries across the globe. The aluminium industry is undergoing significant transformations driven by technological advancements. Technology plays a crucial role in shaping the future of aluminium production, revolutionizing various aspects such as extraction methods, manufacturing processes, recycling capabilities, and energy efficiency. The global aluminium sector has witnessed significant advancements in technology, which have had a revolutionary impact on various aspects of the industry. These technological advancements have not only improved the efficiency and productivity of aluminium production but have also opened new possibilities for innovation and sustainability.

With increasing concerns about the environmental and economic implications of aluminium smelting, smelters worldwide have taken proactive measures to address these challenges. Industry leaders such as Hydro, RUSAL, Alcoa, RioTinto, and Emirates Global Aluminium (EGA) are heavily investing in the development of new technologies that prioritize energy efficiency, optimize the utilization of raw materials and utilities, and minimize environmental risks by reducing hazardous emissions and waste generation.

As part of their transition towards sustainable practices, many smelters worldwide have made the switch from fossil fuel-based energy to renewable energy sources. This shift towards renewable energy is a crucial step in aligning the industry with green initiatives and reducing its carbon footprint.

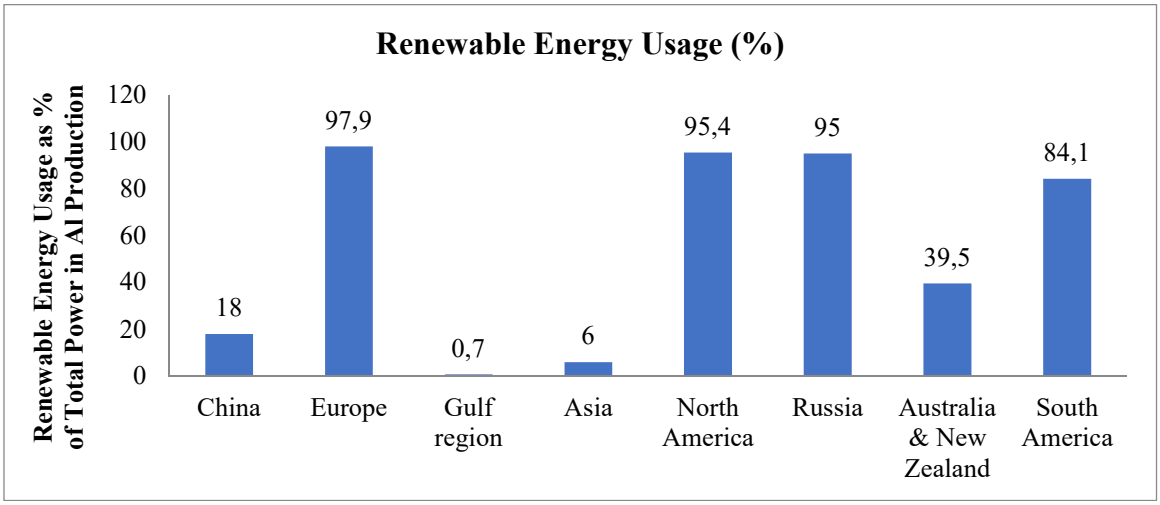

Figure 5. Renewable energy usage (solar, wind, geothermal, hydropower and nuclear) as percentage of total power in aluminium production [7].

Indian smelters are also shifting toward renewable energy utilisation to produce primary aluminium. Vedanta and HINDALCO are pioneering in this vision as Indian smelters. Vedanta Aluminium becomes India's largest industrial consumer of renewable energy with procurement

of about 2 billion units of renewable energy in FY'22 through power exchanges for its aluminium smelter in Jharsuguda, Odisha; thereby reducing Greenhouse Gas emissions intensity at the smelter by more than 1540 kt CO_2e.On the other hand, HINDALCO industries have entered into an agreement with Greenko group to set up green energy plant having capacity of 375-400 MW in Odisha [9].

In India, the Vande Bharat trains, known for their cutting-edge technology and modern design, are set to undergo a significant transformation with the introduction of aluminium coaches. Previously constructed using stainless steel, the shift to aluminium brings forth a range of benefits, including reduced weight, improved energy efficiency, and cost savings. This move marks a historic moment in the Indian Railways' history as it embraces aluminium as a primary material for train manufacturing [10].

Figure 6. Renewable Energy Utilisation.

5. Vedanta's Contribution Towards Green Future

Vedanta Aluminium has implemented a dual strategy to address its carbon footprint, focusing on both mitigation and offsetting measures. In terms of mitigation, the company is actively enhancing its manufacturing processes to achieve higher energy conservation. This includes increasing the utilization of renewable energy sources and transitioning to low-carbon fuels, thereby reducing its overall carbon emissions. By adopting these measures, Vedanta aims to enhance its manufacturing excellence while minimizing its environmental impact.

Vedanta has pioneered the launch of a low-carbon, environmentally friendly aluminium brands named "Restora" and "'Restora Ultra" to cater to the growing demand for metals with a reduced carbon footprint (GHG emission intensity <4 tCO_2e).

Figure 7. Restora & Restora Ultra - low carbon aluminium brands of Vedanta.

Vedanta is committed to achieving excellence in technological advancements within the aluminium smelting industry. As part of its innovative breakthroughs, Vedanta has successfully developed an indigenous Pot Controller and Lining Design. This cutting-edge solution is designed to deliver multiple benefits, including energy savings, reduction in greenhouse gas emissions, and enhanced process control.

Vedanta has achieved 24 % reduction in greenhouse gas (GHG) emissions intensity in FY'22 compared to the 2012 baseline, despite an eight-fold increase in production during the same period. In line with India's vision of net zero carbon emissions by 2070; Vedanta has adopted electric vehicle (EV) policies such as implementation of lithium-ion battery powered electric forklifts.

Implementation of advanced tools like Industrial Internet of Things (IIoT), computational modelling and simulation for optimization of process has resulted in better emissions control and further reduce the carbon footprint.

Vedanta is actively engaged in the development of advanced technologies aimed at reducing specific energy consumption and enhancing process control through advanced control logics. Additionally, the organization has undertaken various waste-to-wealth initiatives, including the utilization of ash, Spent Pot lining (SPL) carbon, and dross. Vedanta has set ambitious targets for these initiatives, with a planned ash utilization of 14.56 Mt by FY'30, SPL carbon utilization of 33.966 kt by FY'30, and dross utilization of 32.53 kt by FY'30.

By closely monitoring the quality of raw materials and implementing strict emission control measures, Vedanta is committed to creating a sustainable future. The company values the importance of continuous value addition and strives to deliver superior quality products consistently. Through these efforts, Vedanta aims to contribute to a greener and more sustainable industry while upholding its core values.

6. Conclusion

Immense demand, affluent consumers, and visible profitability characterize the aluminium industry, creating an impression that numerous companies would eagerly enter the sector. However, the reality is more nuanced. The path to success in the aluminium industry is not as straightforward as it may seem. It requires the ability to establish and effectively manage the complete production cycle, encompassing the extraction of raw materials, the production of alumina, and the reduction of aluminium. Only those capable of efficiently navigating and overseeing this entire process can emerge as leaders in the aluminium industry.

Through the deployment of digital solutions, advanced process control systems, exploration of renewable energy alternatives, strategic sourcing, and the dedication of a young and talented workforce, Vedanta is poised to maintain its position in the first quartile of the cost curve while delivering the highest quality of production in a sustainable manner. With a comprehensive range of products, robust research and development capabilities, and unwavering dedication to customer-technical support, Vedanta is steadfast in its commitment to serving its esteemed global clientele. Simultaneously, the company actively contributes to the national vision of fostering self-reliance and promoting economic empowerment through the 'AtmaNirbhar Bharat' initiative.

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