The Aluminum Association

Powering up American Aluminum:

A Roadmap for Next Generation Supply Chain Resilience

The Aluminum Association and Wittsend Commodity Advisors

May 2025

1.0 Purpose of the Paper

This paper examines the current state of the U.S. aluminum industry and the options for increasing domestic aluminum supply to bolster the nation's economic and energy security while also ensuring an abundant, secure and affordable supply for growing demand across our defense, automotive, aerospace, packaging and critical infrastructure sectors. After providing historical context of how the industry got to its current state, this paper will offer pragmatic assessments of the different options that can be implemented to strengthen U.S. aluminum production.

2.0 Executive Summary

Over the past 30 years, primary aluminum production in the U.S. has declined significantly largely due to two factors: The deregulation of electricity, which increased the market rate for electricity; and oversupply of aluminum imports from China and Russia that undercut the competitiveness of U.S.-manufactured aluminum. Electricity availability and pricing remain significant headwinds to investment and expansion of primary aluminum production. Additionally, access to metal supply as input materials—both imports of primary aluminum and recycled scrap aluminum- have acted to deter domestic primary aluminum investment.

Nevertheless, the overall U.S. aluminum industry is growing due to increased demand in multiple industries including defense, automotive, aerospace and packaging. This growth is attributed to aluminum's value as a lightweight, strong, recyclable and corrosion resistant metal well suited for a variety of applications. In addition, U.S. government intervention to limit unfair trade practices through Anti-Dumping and Countervailing Duties (AD/CVD) cases and Section 301 tariffs that restrict government subsidized oversupply from entering the U.S. at uncompetitive prices have provided support for domestic investment. These investments, predominantly in the recycling and remelting of aluminum products to make new aluminum products, have been generational.

Aluminum is one of only 11 elements on each of the U.S. government's critical minerals lists (USGS, DOE, DOD, DOC). Domestic aluminum manufacturing supports our economic prosperity and our national security interests. In order to ensure our defense and national security production remains healthy and agile, the industry must maintain commercially viable capabilities. In short, to ensure domestic production of defense industrial base items, the industry must be able to competitively produce aluminum sheet, extrusions, castings and forgings today across all the markets served. To meet growing demand, the U.S. aluminum industry will need to increase capacity. There are three methods to expand U.S. capacity:

1) New primary production;
2) Restarting and/or expanding existing primary production;
3) Increasing remelt capacity.

For any expansion of primary production—both new and restart—access to long-term, business-competitive electricity is the inhibiting factor. To expand remelt capacity, metal supply or more specifically, reliable and sufficient supply of recycled scrap metal, is the primary obstacle.

All of these options will be capital intensive, so ensuring the long-term viability of the investment is essential in order to ensure adequate return on investment. In the meantime, the industry's ability to grow will be contingent on collecting more recycled metal and continuing access to imported primary, currently imported mostly from Canada. If the industry is to invest in new or expanded capacity, access to primary imports will be necessary as a bridge between today and future expansion.

3.0 U.S. Aluminum Demand is Healthy

U.S. demand for aluminum products is strong and growing at a 2.5% compound annual rate, approaching 12 million metric tons in 2024.[1] Aluminum products consume both primary aluminum and recycled aluminum for fabrication.

This demand is driven by energized demand for many aluminum products. For example, the wholesale adoption of aluminum in light trucks and automobiles has boosted demand. According to Ducker Carlisle, aluminum demand for the sector will reach 556 pounds per vehicle by 2030 – compared to an aluminum intensity of 120 pounds in 1980. This represents an increase of nearly 3 million metric tons of aluminum needed during this period, and nearly 30% of total aluminum products consumed in the U.S.

Products essential to national security, including aluminum used in aerospace, armor plate, weapons, drone and space applications, are also vital and experiencing growth.

Aluminum shipments to the beverage can market are also accelerating. The aluminum beverage can has seen a renaissance thanks to younger generations embracing highly recyclable aluminum versus Polyethylene Terephthalate (PET) plastic containers. Can shipments in 2023 were 3.088 billion pounds (or nearly 1.4 million metric tons of aluminum consumption annually).

The power industry has ambitious investments to increase U.S. electrical grid capacity. This portends solid growth for aluminum wire and cable. 100% of the U.S. high voltage transmission grid integrates aluminum into its design.

Highly versatile extrusions are an integral part of residential, commercial and institutional construction. Extrusions are found on every commercial truck and trailer produced in the U.S. Nearly 100% of solar panels produced and sold in the U.S. are framed in aluminum extrusions.
Forged aluminum truck wheels are the preferred choice for commercial fleets. The same technology is used in critical commercial aerospace and military applications.

Overall, U.S. aluminum demand has been growing at a compound average growth rate of 2.5%.[2] If the trend continues, aggregate U.S. primary aluminum demand will rise from 4.4 to 5.1 million metric tons by 2029 or nearly the size of 1 modern primary smelter (750,000 metric tons) with recycled aluminum being used to satisfy the remaining aluminum product demand.

U.S. Aluminum Supply Has Changed in the Past 50 Years

The U.S. was once the leading producer of primary aluminum in the world. In 1980, the U.S. produced over 4.65 million metric tons at 33 sites with a nameplate capacity of 4.8 million metric tons. **The deregulation of U.S. electricity prices starting in 1977 led to a drastic increase in industrial electricity rates and was the single most important factor leading to the near total demise of the primary aluminum industry.**

Today, the U.S. has four aluminum smelters remaining, producing 683,500 metric tons. The primary aluminum segment of the aluminum industry is operating at 53% of installed capacity.

Rebuilding domestic total aluminum production is in the industry's best interest to providing supply-chain security for the U.S. and the many downstream manufacturing sectors utilizing aluminum, including those producing for defense and national security applications.

[1] https://www.aluminum.org/news/north-american-aluminum-demand-rebounds-34-2024

[2] https://www.aluminum.org/news/north-american-aluminum-demand-rebounds-34-2024

4.0 Options to Increase Domestic Capacity

This analysis examines three approaches:

1) **Building new primary capacity**
2) **Reopening idle primary capacity**
3) **Expanding secondary capacity**

Developing New Primary Aluminum Capacity

Building new primary capacity in the U.S. faces stiff challenges. Foremost among these is finding competitive, long-term power supply. A contract for at least 20 years at or below $40 per MWh is needed to support such an investment.

Aluminum faces severe competition from data centers and artificial intelligence (AI) for the electricity it needs. Demand from data centers and AI deployment is forecast to rise from 4.4% to 8.8% of total U.S. electricity consumption by 2030. This demand is not sensitive to price, having traded at over $100 per megawatt (MWh). Prices above $40 per MWh are unsuitable for primary aluminum production at current prevailing London Metal Exchange (LME) and Midwest prices and not competitive with industrial electricity rates in other parts of the world.

The industry must also have stable to higher LME and Midwest aluminum prices to ensure a revenue stream to deliver a return on capital. In the modern era, volatility on the LME has been substantial, thereby contributing to the decline in primary aluminum production due to the uncertainty of future profitability.

Efficiency in managing aluminum capital projects in the World (excluding China) has been difficult. Capital costs for a modern, 750,000 metric ton smelter can reach $6 billion or more. Further, securing necessary material and equipment for such projects will be challenging. Lead times for needed electrical equipment, for example, currently exceed five years.

Reviving Idle U.S. Primary Aluminum Capacity

Restarting 601,500 tons of idled domestic primary aluminum capacity shares some of the same challenges as greenfield investments – the need to secure competitively priced electricity. The industry needs $40 per MWh and a 10-year term to amortize the large cost of restarting any of the existing idle smelters or idle potlines at operating smelters.

Restarts are also contingent on stable to higher LME and Midwest aluminum prices to generate the revenue to repay capital invested.

Leveraging Recycling Supply for Greater Recycled Aluminum Production

Secondary aluminum, made from recycled aluminum, represents over 80% of total raw aluminum supply produced in the U.S. today. Since 2016, investors have poured more than $10 billion into the U.S. aluminum industry, much of it directed toward expanding recycling capabilities and increasing secondary production capacity that could double by 2030.

This segment has demonstrated a low capital and energy intensity, while utilizing North American origin recycled metal. Recycled aluminum can be substituted for primary aluminum in most end use cases. As a result, increasing collection of aluminum scrap and keeping scrap in the U.S. for remelting can directly offset primary aluminum imports, decreasing foreign supply chain reliance.

There is substantial growth potential due to large, untapped supplies of domestic recycled metal. Conservative estimates place this at over 1 million tons or the equivalent of 2 world class primary aluminum smelters. As one example, capturing for reuse all of the used beverage cans currently landfilled in the U.S. would offset almost 20% of current U.S. primary aluminum imports.[3]

Increasing U.S. Domestic Supply Must Be Pursued in Parallel Tracks

Building new primary capacity, restarting idle primary capacity and increasing recycled aluminum (secondary) production must be pursued in tandem. Each option has different periods to completion.

The overarching requirement is to ensure that the downstream aluminum sector has sufficient supply to meet its rising demand, regardless of whether it is from a primary or secondary source.

While domestic supply options are pursued, U.S. manufacturers must get metal from somewhere, and the best options remain Canadian primary supply, dramatically increasing domestic post-consumer recycling rates, and limiting aluminum scrap exports – or some combination of all three options.

Canada is A Critical Bridge to U.S. Aluminum Independence

Canada is an important bridge between current strong U.S. demand and limited domestic primary supply. Canadian primary supply ensures that no demand is left unsatisfied due to a lack of primary aluminum supply for the downstream fabrication sector. Founded upon investment from U.S. aluminum companies, it has been a dependable and competitive source of primary aluminum for 125 years and is an integral partner of the United States' growing downstream aluminum industry.

5.0 Historical Perspective on U.S. Primary Aluminum Production

5.1 The 1980 Profile of U.S. Primary Production and Secondary Production

Primary Aluminum

In 1980, there were 33 active primary aluminum smelters in the U.S., operating in the following states:

State	Number of Facilities	Total Capacity (Short Tons)
Alabama	2	322,000
Arkansas	2	193,000
Indiana	1	292,000
Kentucky	2	360,000
Louisiana	2	295,000
Maryland	1	176,000
Missouri	1	140,000
Montana	1	180,000
New York	2	346,000
North Carolina	1	127,000
Ohio	1	250,000
Oregon	2	220,000
South Carolina	1	197,000
Tennessee	2	362,000
Texas	4	649,000
Washington	7	1,237,000
West Virginia	1	163,000
	33	**5,289,000 or 4,808,000 MT**

[3] The sustainable solution for aluminium beverage cans - International Aluminium Institute

Low-cost, long-term electricity contracts and supply options drove the location of these smelters.

Federal and state-owned power supplied 48% of the electricity to the industry. 29% of power was acquired through a long-term purchase agreement with investor-owned utilities or local electric cooperatives. 23% of the power requirements were self-generated.

At the time, aluminum smelters were an attractive customer for any utility. They consumed large blocks of electricity on a 24 hour/7day a week, 365 days a year basis. The smelters represented a base load demand for utilities allowing them to balance their generation versus the high variability in retail demand.

The Emergence of Secondary Aluminum and the Beginnings of Primary Substitution

In 1980, the secondary aluminum industry produced about 1.54 million metric tons of metal derived from pre-consumer (60%) and post-consumer metal (40%).

Used beverage containers (UBC) represented 52% of the post-consumer metal and were collected by integrated producers such as Alcoa and Reynolds Metals. These UBCs were melted and put into new beverage can sheet.

The remaining 48% of post-consumer metals were derived from end-of-life salvage of buildings, automobiles and other industrial products. They typically found new life as diecast products for automotive and other industrial applications.

There is a dichotomy between the primary and secondary trajectories from this point in time to the present. While the primary sector went into decline, the secondary aluminum experienced substantial growth. In 2024, Aluminum Association estimates indicate that recovery from scrap in the United States exceeded 5 million metric tons.

This is not to say that the growth in secondary production somehow contributed to or competed with the domestic primary industry. Rather, the two complemented one another to adjust to changes in electricity supply and continue to meet steady overall growth for aluminum as a production material across industries.

Secondary production more than tripled in size because of two things:

- Pure economics, as recycled material was cheaper than primary metal.
- Technology and metallurgical expertise improved to allow more secondary metal to displace primary metal in some applications such as common alloy sheet, beverage can body stock and aluminum extrusions.

This substitution effect accelerated in the late 1980s when primary aluminum set record nominal prices over $4,000 per metric ton on the LME. As primary prices escalated, previously reluctant consumers of primary aluminum switched to secondary metal. Over subsequent decades, each cycle of high primary prices brought further substitution to secondary metal.

5.2 Root Causes for the Demise of Primary Production

Deregulation of Electricity was the Major Factor

The perfect partnership between aluminum smelters and electricity generators unraveled with a series of actions designed to give states (and consumers) more options in how their local electricity was distributed and sold. Effectively, the retail consumer became a direct competitor to industrial users like the aluminum industry.

Key milestones were:

- **1977** - Federal Energy Regulatory Commission (FERC) created, giving states the power to decide how to supply electricity
- **1992** - National Energy Policy Act created wholesale energy markets and allowed wholesale generators to participate
- **1996** - Order 888 issued by FERC requiring all utilities to file tariffs providing non-discriminatory access to all wholesale users
- **1996** - California creates a deregulated electricity market
- **2000-2001** - Pacific Northwest wholesale prices rose to 10 times their historical average, compelling aluminum smelters to shut their doors and sell their power back to the market, as it was far more profitable than producing aluminum
- **2007** - The Bonneville Power Administration announced the termination of future Direct Service Industry (DSI) power contracts upon their expiration in 2011

The creation of wholesale electricity markets and the ability to transfer power through interregional transmission agreements changed the attitude of power generators. This was pronounced in the Pacific Northwest, where the BPA had been struggling to satisfy the combination of rising local retail demand, the strong California market and its DSI contracts to the aluminum industry. They decided to pull the plug on DSI in 2007. This was the coup de grâce for the Northwest smelters, which had been struggling with weak LME prices from 1990 to 2007, averaging only $1,613 per metric ton. Those anemic revenue returns were a function of Russia and China arriving on the global aluminum scene, as well as the rise of aluminum production in areas with energy cost advantages (e.g., the Middle East).

New Competition Emerges from Russia

The collapse of the Soviet Union on December 26, 1991, proved to be a watershed event for the global aluminum industry. The Soviet Union had hidden its aluminum industry as part of its military-industrial complex. When the political collapse took place, the Russian aluminum industry lost its sponsorship from Moscow. Its aluminum smelters were left with massive inventories of primary aluminum that the military was unable to consume. The reaction was swift. Individual smelters aligned themselves with Western trading companies such as Marc Rich (processor of Glencore) and Transworld Metals. Exports from Russia soared. In 1989, the Soviet Union exported 232,000 metric tons of primary aluminum. In 1992, exports reached 964,000 metric tons and by 1994 were 2,100,000 metric tons. These exports threatened to overwhelm the World (excluding China) supply-demand balance. Demand in 1994 was 16 million metric tons, meaning that Russian exports represented 13% of demand.

To put this into contemporary context, if Russian exports today were comparable to their market share in 1994, Russia would be exporting 9.6 million metric tons (actual 2024 exports 3.2 million metric tons). Reaction to this surge in supply was swift on the LME, with cash prices falling to below $1000 per metric ton.

Western producers considered anti-dumping against the Russians but concluded it would take too long to prosecute the case and delay a solution could have been fatal.

An extraordinary event was convened to combat the threat. Representatives of Australia, Canada, the European Union, Norway, the newly formed Russian Federation and the U.S. met in Brussels in January 1994. This meeting was sanctioned by their respective Justice Departments and led to the Memorandum of Understanding (MOU). The MOU recognized the threat of exceptional disruption to global aluminum supply caused by unexpected political developments in Russia. The parties agree to individually reduce primary aluminum production until LME prices stabilized.

U.S. producers agreed to voluntarily curtail 500,000 metric tons. In the end, 395,000 metric tons were curtailed.

In aggregate, the MOU led to about 1.3 million metric tons of curtailments against promises of 1.8 million metric tons. Although falling short of expectations, the actions did rally LME prices, and the market gradually began to permanently assimilate Russian metal into the Western World supply-demand equation.

China Emerges as the Major Player in Primary Aluminum

China had been producing primary aluminum since the 1950s. In 1980, China was producing 445,000 metric tons of primary aluminum. By 1990, China had begun to ramp up its production thanks to a host of factors:

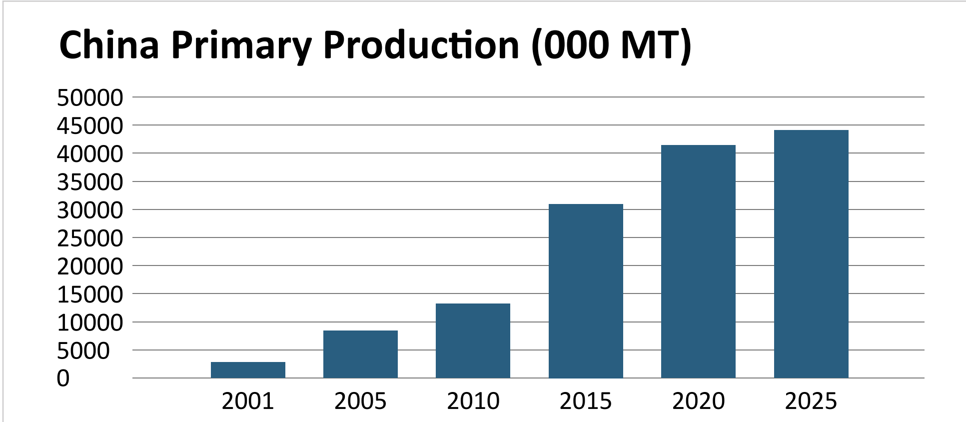
- It developed its own world-class technology, funded by state aid to 3 major technical universities (GAMI-NEUI-SAMI). This technology was licensed at little or no cost to the smelters.
- It tapped into huge domestic coal reserves to provide cheap electricity to smelters.
- Domestic aluminum demand was rising rapidly thanks to a massive rise in private housing construction and huge infrastructure projects such as the national electric grids, high-speed rail networks and institutional buildings.
- An export rebate program for semi-fabricated and fully fabricated products returned the 13% Value-Added-Tax (VAT) applied to domestic metal purchases.
- Permitting and regulatory approvals moved at warp speed. Provincial governments were eager for the jobs and revenues that land sales to smelters provided. Smelters were built in 1 year, bolstering scale effects.
- Environmental standards were lax, with little regulation of things such as fluoride emissions or SO2 and other outputs from coal-fired power stations.
- The Chinese Construction Army built infrastructure at no cost.
- Aluminum smelters benefited from over-capacity in cement, steel, crane equipment and electrical switchgear. Due to the enormous number of projects being built simultaneously, efficient industry supply chains were created to service these multiple projects and the savings passed to the smelters.
- Labor was cheap in the interior regions.

China state-sponsored subsides to the aluminum sector were pervasive and large. A 2019 report by the Organization for Economic Cooperation and Development (OECD) reported that $70 billion in subsidies went to 17 of the largest companies operating in the aluminum value chain, with 5 companies receiving 85% of those subsidies.

The OECD found below-market financing was provided to 32 aluminum companies, comprising up to 7% of their annual revenues.

In 2022, OECD estimated that firms with at least 25% ownership by the Chinese government generated 50% of all revenues by sector.

By 1990, China was producing 750,000 metric tons/year. In the decade 1990-2000, China was adding more annual capacity than the installed capacity in Dubai. In 2000, China was producing 2.8 million metric tons as the 2nd largest producer in the world and within three years it had vaulted to number one. A steady ramp up ensued until 2016-2017 when Beijing began to impose capacity constraints.



China's ability and willingness to build capacity quickly and at low capital cost capped global aluminum prices. The LME primary aluminum contract priced based upon China's low replacement cost. The LME cash price represents about 75% of the total physical aluminum price, with regional premiums, such as the Midwest Transactional Premium, comprising the remaining 25%.

LME prices averaged $1,613 for the period 2000-2007. We saw 1.3 million metric tons of U.S. capacity shut between 2000-2003. Another 1.4 million metrics tons closed between 2005-2015.

China imposed primary production limitations in 2016-2017 by requiring new smelters to acquire operating rights from existing smelters willing to exit the market for a price. This system has worked to purge older, less efficient capacity. China established a 45 million metric ton cap on total primary production.

These actions led to a recovery in LME prices from $1,605 in 2016 to $2,110 during 2018.

These measures slowed primary production growth in China. However, Beijing's generous export rebate program continued to encourage excessive capital investment in aluminum capacity, leading to large annual exports.

2010 saw the beginning of large exports of finished aluminum products, over 6 million metric tons/year. Anti-dumping cases were successfully prosecuted against China from the U.S. and EU to halt these aluminum exports, but the 20+ year Chinese advance in production, stacked on top of a dramatically more expensive U.S. electricity market, had delivered a mortal blow to U.S. primary aluminum production.

5.3 The 2025 Profile of U.S. Primary Aluminum Production

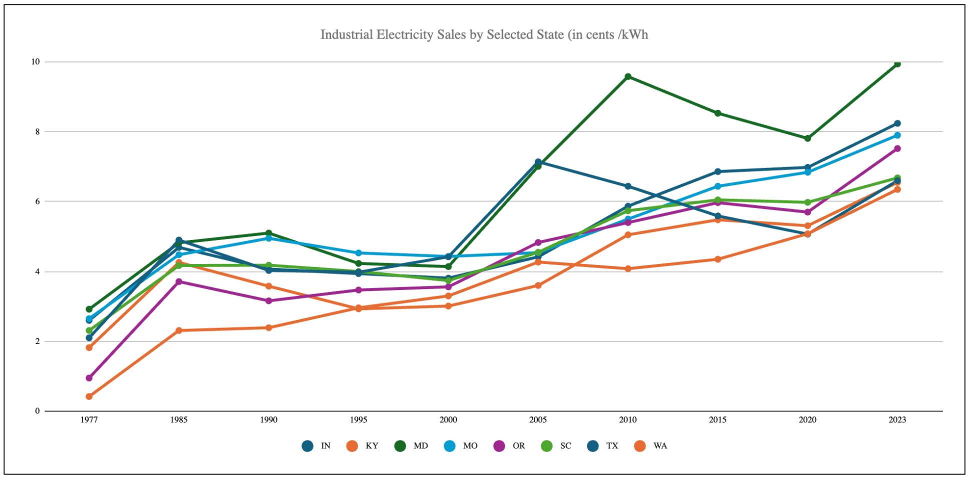
In 2025, the U.S. primary aluminum industry is a shadow of its former self. We have just 6 smelters, with 4 partially or fully curtailed. High electricity prices and subsidized Chinese production gutted the industry. Like parallel developments in magnesium, steel and zinc, China does not operate under normal market restraints faced by U.S. producers. Chinese behavior has been predatory, designed to undercut its overseas competition until they exit the market, leaving China in a dominant position. This is why China now controls over 90% of global production of magnesium and rare earths as prime examples.

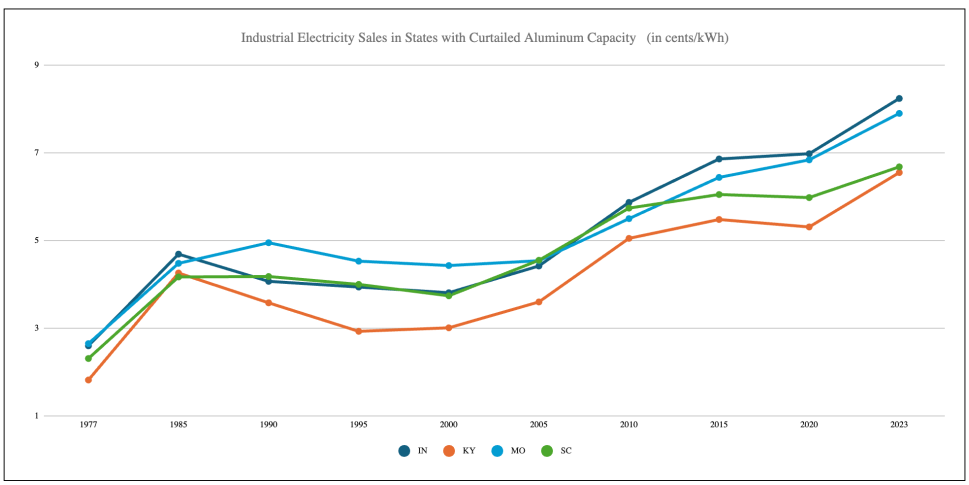
As noted previously, the U.S. primary industry is operating at 53% capacity utilization.

Power Costs Are Problematic for Primary

High electricity costs are the root cause of the current state of the primary aluminum segment of the industry. Century's Hawesville, KY and Magnitude 7's New Madrid, MO smelters closed due to prohibitive costs of day ahead delivery electricity. Both companies were forced into the spot market after failing to secure long-term deals at competitive prices. An analysis of industrial electricity sales prices from 1977 through 2023 highlights the trend.

Below are industrial sale prices for states that lost total primary aluminum production in the period, and states in which idle capacity now exists, based on data from the Energy Information Administration (EIA):





In the states with idled primary aluminum capacity, Indiana power costs in 2023 were \$82.40 per MWh; Kentucky were \$65.50; Missouri were \$79.00; and South Carolina \$66.80 or a simple average of \$73.42 per MWh.

For comparison, the average purchased electricity cost for aluminum smelters in Canada is significantly lower. Canadian smelters pay \$26.50 to \$41 per MWh, thanks to the abundant availability of hydroelectric power. Smelters in other locations in the Western world enjoy similarly or sometimes even lower power prices.

This gap of \$32-46 per MWh in power cost underscores that Canadian aluminum has had a competitive advantage vis-à-vis its U.S. counterparts. It has enabled Canada to bridge the gap between declining U.S. primary production and rising aluminum demand.

However, U.S. imports of Canadian primary should not be viewed as competition to U.S. smelters, rather the import of Canadian primary is the import of energy in the form of aluminum that takes advantage of Canadian lower cost electricity infrastructure, specifically hydropower.

6.0 Alternative Approaches to Increasing U.S. Aluminum Production

6.1 Increasing Existing Primary Production and Building New Capacity

Long-term Power Contracts are Essential

A competitively priced power contract for 20 years would be a minimum requirement to expand capacity. This gives the primary aluminum producer fixed costs for its second largest component of total operating cost. This requirement is well understood by the financial community and is seen as a prerequisite to financing new primary aluminum production.

Structural Challenges with Forward Power Contracting Need to be Resolved

The recently released FERC 2024 State of the Market Report says total electricity demand rose 2.8% in 2024, reaching 3,953 terawatt hours (TWh).

The U.S. is on the cusp of a huge increase in electricity demand for the balance of this decade. Goldman Sach's estimates electricity demand rise at a 2.4% CAGR to 2030. This growth is led by data centers (0.9% CAGR), transportation and residential (0.6% each), industrial and commercial (0.4% each) with non-classified sectors down -0.5%.

The Energy Information Administration (EIA) estimates that by 2030, the U.S. will have an energy deficit of 31 million MWH and 48 million MWH by 2035. We believe these estimates are conservative and may not fully recognize the impact of data center demand and rising electrification of other aspects of the economy that the private sector anticipates, much less the addition of any primary aluminum capacity.

The North American Electric Reliability Corporation (NERC) published its "Long-Term Reliability Assessment" in December 2024. NERC's assertions were that:

- Most bulk power systems (BPS) in North America will face growing capacity challenges over the next 10 years.
- This is a product of surging demand and the retirement of aging thermal generation.
- There is a flood of new solar, battery and hybrid resources in interconnection queues but completions are slow, and their reliability does not match the thermal generation being closed.
- NERC's risk assessment of the 13 area BPS grids of the U.S. shows elevated risk of electricity shortfalls in 8 of the 13, the other 7 having Elevated Risk.

Goldman Sachs estimates that U.S. utilities will invest $50 billion in new generation capacity just to meet data center demand. They will expect a return on that investment.

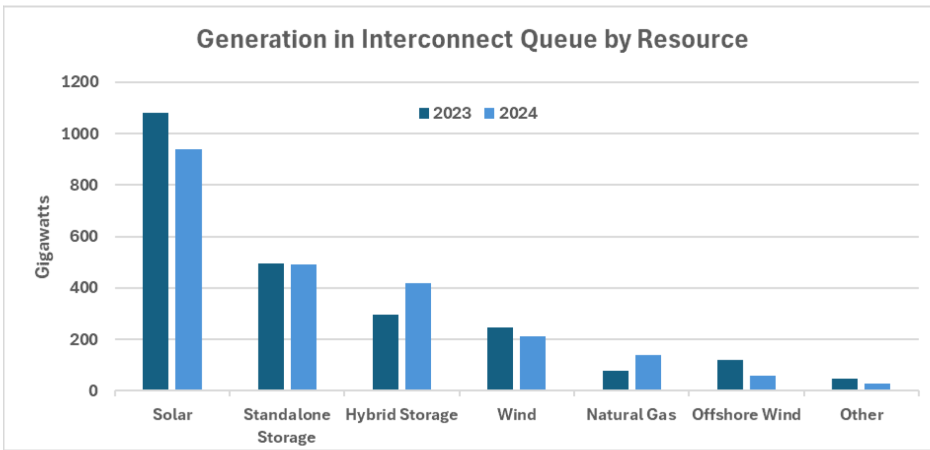
Competition for power between manufacturing and the tech sector illustrates a significant divide in the business orientation for those considering investing in electricity generation. Data center demand is price inelastic. Recent transactions in the market indicate that data centers have no limit on what they are prepared to pay for dependable 24/7 electricity. Constellation Energy's deal with Microsoft to re-open Unit 1 of its Three River Island, Pennsylvania nuclear plant is a telling example. Analysis of the deal suggested that Microsoft conceded up to $115 per MWh. This price is completely untenable for an aluminum smelter at today's LME price. Prices near $40 per MWh are required for an aluminum smelter to operate.

This environment will make it difficult for the primary aluminum sector to secure the power it needs. **The construction of a 1 x 750,000 metric ton smelter will require 11.1 TWh of power. That is the equivalent of more than a year's worth of power consumption for the city of Boston or Nashville.**

If the goal is to build enough domestic aluminum capacity to replace our imports of 4.4 million metric tons/year, we need 65.2 million MWh or more than four Hoover Dams. It equals the annual power consumption of Minnesota or the combined consumption of Idaho, New Hampshire, Hawaii, Rhode Island, Alaska and Vermont.

Stranded Power Generation Needs to be Unleashed to Support Industrial Power Demand

FERC gives us a snapshot of the new generation coming with its Interconnection Queue Report. An interconnection queue is a list of requests from new power generation facilities to connect to the grid. **At the end of 2024, there were 2,289 gigawatts (GW) of generation capacity waiting to connect. 2,289 GW = 15 billion megawatt hours of potential electricity supply not on the grid. Efforts to get this bottlenecked generation capacity into the grid would go a long way toward alleviating upward pressure on industrial electricity pricing.**



Managing Revenue Streams

Securing the right power deal and lowering capital costs are half the battle in rebuilding U.S. primary capacity. Success will equally depend on stabilizing future revenues to justify investment. The case study of Alcoa's Massena Project of 2008-2015 underscores the importance of having the revenue side under control. In that example, Alcoa had signed a long-term contract for power with the New York Power Authority. Then the Global Financial Crisis of 2008-2009 derailed the project as LME prices plunged 37% from their peak in 2007. A short recovery during 2010-2012 was followed by another 33% decline by 2015, at which point Alcoa killed the project.

The lesson was that the successful investor must be extremely agile and opportunistic in selling LME forward contracts and securing attractive forward physical metal sales to lock in prices that deliver a return on capital.

The LME cash price is the global benchmark for setting physical metal prices. The LME price represents between 75% and 85% of the revenue stream. It takes its direction from fundamentals of global supply demand, exchange rates, other commodity movements and pure speculative money flows.

Physical metal sales are comprised of two components:

1) The value of the Midwest regional premium for P1020 standard grade primary aluminum expressed over LME. This premium accounts for time and place utility of metal in the U.S. It also covers direct costs such as freight, handling and tariffs. The Section 232 25% tariff is captured here. Any change in that tariff will have a direct bearing on the premium.

2) The value of value-added products such as billet, foundry alloys, slab, wire rod and high purity primary aluminum. These are products produced in smelter casthouses, which command higher upcharges expressed over the Midwest premium. For example, billet (also known as extrusion ingot) would be expressed as $0.15 cents per pound over Midwest. These value-added upcharges can often be the difference in allowing a smelter to operate profitably when the combination of LME + Midwest premium produces a total price that does not cover direct operating costs.

All primary aluminum producers employ experienced commercial management familiar with the mechanics of how to sell forward LME contracts or “hedge” in the vernacular of the commodity world. To hedge simply means to protect price depreciation as a producer.

All primary aluminum producers also have experienced physical metal sales organizations to optimize sales of P1020 and the value-added portfolios. These sales are driven by achieving higher premiums expressed over the LME. But even these sales must exceed input costs to remain commercially viable, which has been difficult with increasing energy costs.

Solving the Capital Efficiency Problem Inherent to World ex China Aluminum is Necessary to Increase U.S. Primary Aluminum Production

One of the principal causes for the demise of American smelting capacity was China’s ability to build fast and cheap. We discussed their advantages in Section 5.2.

In-country analysis by Western companies such as Alcoa, Hydro and Rio Tinto have taught us what things can be replicated outside China. Replication of these advantages reduces complexity, cuts the time to build and leads to lower costs. That raises the return on investment.

Government assistance can play a role in some areas:

- **Promoting standardized designs and modular construction would lower overhead costs.** Prefabricated parts become the rule. This may run contrary to the interests of labor groups and the contracting community, which favor on-site construction activities. **The Department of Labor and the National Labor Relations Board may be helpful in mediating a fair balance of work rules.**
- **Permitting and regulatory approvals must be fast-tracked.** Time is money and the sooner projects are approved, the faster they can be built. **The Department of Commerce, the Environmental Protection Agency and OSHA can contribute to quicker approvals.** In addition, state and local efforts will also be required to accelerate the consideration and approval of necessary permits.
- **Build within the cycle of our expected technology.** The Chinese smelters are built for a 10-15-year economic life because their technology upgrades came in 5-year cycles. In the West, we tend to do the opposite, building for very long economic cycles. This creates challenges on technological advancement, especially now when new breakthrough technologies like the Elysis inert anode or other decarbonization approaches are in the works.
- **Accelerated depreciation allowances from IRS may be helpful** with any design.
- **Commissioning costs should be treated as operating expenses.** The Chinese do not capitalize start-up costs, they absorb them in operating costs, which gives them incentive to get the smelter up to nameplate capacity faster to reduce operating

expense. The Financial Accounting Standards Board (FASB) is an independent private-sector organization that oversees this. **Consultation with the IRS might provide guidance to companies seeking to stop capitalizing this and move to operating expense.**

- **All options for reliable, affordable, long-term electricity supply for critical mineral primary aluminum production should be explored.** These could include favorable PPA agreements, self-power options including SMR's and fossil fuel power generation, and allocation of power for critical minerals production from new other generation capacity.

Lowering Borrowing Costs

Historically, the primary aluminum industry has not delivered great returns on its smelter projects. This has been a function of cost overruns, delays in commissioning the smelters and weaker than budgeted LME prices. Paybacks have been 12-14 years or 7-8.5% return on initial investment. Returns on capital for leading aluminum producers with existing operating smelters range from 8.2% to 11%. This compared to returns on NASDAQ 100 tech of 27% in 2024, after 2023's 53.8% return.

In a best-case scenario, analysts believe $4,000-5000 per metric ton of installed primary aluminum capacity is achievable. Recent projects in Russia, Indonesia and Iran have come in at $5,000-6,000 per ton. The most conservative estimates are $8,000 or higher. This would put the total capital for 750,000-ton greenfield smelter in the U.S. at between $4 - $6 billion. That is an extremely wide variation in cost to attract capital, and overruns would throw red flags for conservative investors.

Historically, the primary aluminum sector has raised its capital through bank syndication and sovereign wealth funds. Sovereign fund participation is passive government investment in aluminum assets. We have seen direct government investment in many countries, including China. It has not played a role in the U.S. However, the Trump Administration has floated the idea of U.S. sovereign wealth funds. Aluminum could be an early beneficiary of this development. Alternatively, federal loan guarantees could be a means to lower borrowing costs from the private sector.

Bank syndication has often had loan covenants requiring the operators to hedge their future revenue streams on the LME. This has been a customary practice amongst Middle East greenfield smelter projects. The participating banks often have LME trading departments to execute forward sales on behalf of the smelter. This offers the bank the benefit of earning a profit on the LME trade and gives them direct visibility to the revenue stream of the smelter. Similar arrangements in the U.S. would help promote interest in financing smelter construction.

Supply Chain Challenges

Supply chain challenges exist outside of China for new greenfield projects due to infrequent construction of greenfield smelters in the last 15 years. Large electrical equipment needed for projects suffers from extensive lead times. A primary producer recently attempted to purchase new rectifiers (key equipment needed for feeding power into a smelter) from leading Western suppliers and was informed the lead time would exceed five years. Other equipment, such as control devices, suffers from lead times exceeding three years. Orders, however, cannot be entered and deposits paid without planning having been completed and necessary permits secured due to the substantial financial risk. This extends further the timeline needed to complete a new project.

Time is Money for these Large Capital Projects

The challenges to expanding existing capacity (brownfield) and building entirely new

(greenfield) capacity is higher than restarts. This is a function of the much longer planning and execution cycle required to build new capacity outside China.
Historically, this process has been 5-6 years. Success in expanding primary capacity will hinge on speed. This starts at the very beginning, with a permitting and regulatory process that moves quickly.

Summary of Challenges in Building New Capacity

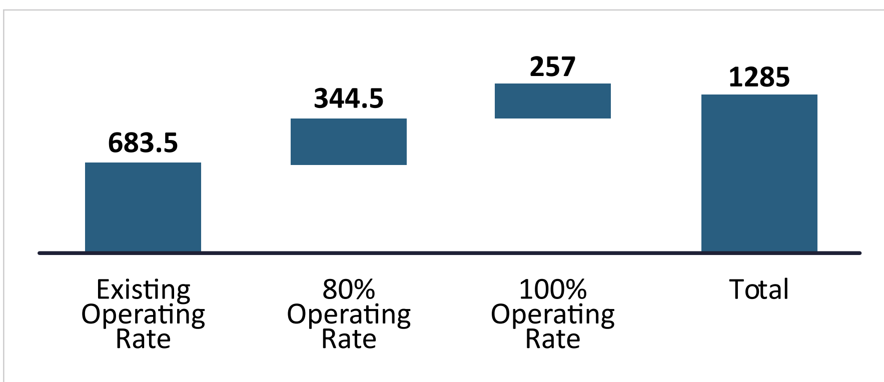
- **A competitive power contract of 20 years at a rate of $40 per MWh.**
- **LME and U.S. regional metal prices remaining at or above current levels to allow amortization of the investment.**
- **Capital investment must be reduced to shorten payback.**
- **Borrowed capital costs must be reduced.**
- **Permitting must be fast-tracked and supply chain constraints relieved.**

6.2 Restarting Idle U.S. Primary Aluminum Capacity

Current Condition April 2025:

	Location	Capacity (000MT)	Operating Capacity	Idle Capacity	Utilization Rate
Alcoa	Massena NY	130	130	0	100%
	Warrick IN	215	161	54	74.9%
Century	Hawesville KY	250	0	250	0%
	Mt. Holly SC	230	172.5	57.5	75%
	Sebree KY	220	220	0	100%
Magnitude 7	New Madrid MO	240	0	240	0%
		1,285	683.5	601.5	53.2%

Bridge to 80% and 100% Capacity Utilization Rates (in 000 MT):



Restarting idle primary capacity is a process that requires reconditioning the pots and electrical systems of the smelter. The reconditioning of the pot consists of relining the cell with new refractory brick and replacing the carbon cathode in the well of the pot. This is labor-intensive and slow. Once completed, the pots must be re-energized in series at the rate of 1-2 pots per day, hence the extended period required to hit nameplate capacity.

Restarts costs will be substantial, as detailed below:

	Location	Idle Capacity (MT)	Restart Costs in Millions	Costs per MT	Elements of Restart Costs
Alcoa	Warrick IN	54	$17.3	$320	Pot Lining-Electrical
Century	Hawesville KY	250	$80	$320	Pot Lining-Electrical-Labor Training
	Mt. Holly SC	57.5	$18.4	$320	Pot Lining
Magnitude 7	New Madrid MO	240	$172	$717	Pot Lining- Carbon Plant-Labor Training
		601.5	**$287.7**	**$478.70**	

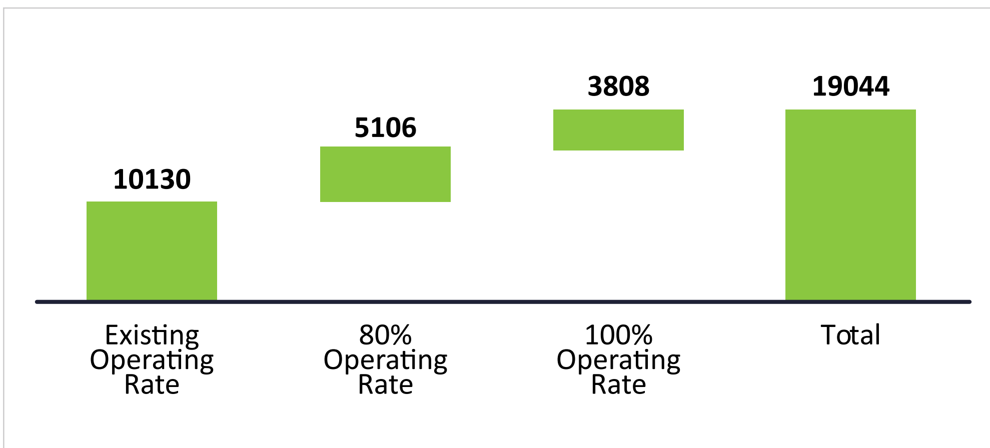
Each of these plants has unique challenges to deal with:

- Alcoa Warrick has two potlines idled. It is believed that one of the two lines has been completely cannibalized and is not fit for restart.
- Century Hawesville has five potlines, and it is believed that one of five lines might require a complete refurbishment that is not in these estimates; labor force has dissipated to other employers in region, requiring a new workforce. The carbon plant also requires some level of refurbishment not included in these estimates.
- Century's Mt Holly plant is the most viable, short-term restart candidate, but must acquire its power from its long-term provider, Santee Cooper, at prevailing market price; this is not consistent with the goal of a long-term deal.
- Magnitude 7 consists of three potlines, of which the third line has not been operated since the facility was acquired and is in very bad condition; the casthouse must be completely replaced and is not in these estimates; the carbon anode plant requires $100 million to build it into operating condition. Workforce availability could also be challenging due to dispersion to other employers.

Securing 10-Year Power

It is essential to secure fixed price electricity for a sufficient term to amortize the investment in the restart. A target price of **$40 per MWh with a term of 10 years** is required for U.S. smelters.

The required electricity consumption bridge looks like this (in MWh):



It takes 14,821 KWh of electricity to produce a metric ton of primary aluminum. That requires 8,914,832 MWh of electricity for a 100% restoration. To put that in perspective, this would be the equivalent amount of electricity consumed by the state of Rhode Island or the city of Atlanta in one year. A comparsion between the aluminum sector and the power requirements of the Loudoun County, VA data center complex helps further illustrate this challenge:

Data Centers vs. Smelting: Competing Demand for Power for Restarts

Century, Hawesville KY

Century, Mt. Holly SC

Versus

Loudoun County Virginia

At Capacity :
Loudoun County consumes 1.8 x power entire Aluminum Sector
Loudoun County consumes 3.9 x power to restore full aluminum capacity
Loudoun County consumes 90% of power encapsuled in Canada imports

Magnitude Seven, New Madrid MO

Alcoa, Warrick IN

Profile	Century Hawesville	Century Mt. Holly	Magnitude Seven New Madrid	Alcoa Warrick	Loudoun County
Current Condition	250,000 MT Idle	57,500 MT Idle	240,000 MT Idle	54,000 MT Idle	300 Data Centers 3,945 MW Capacity
Power Requirement Full Capacity (mWh)	3.7 Million	0.85 Million	3.55 Million	0.80 Million	34.6 Million mWh
Direct Jobs Created	600	115	450	115	12,000
Energy Intensity Per Job (mWh)	6,175	7,410	7,905	6,959	2,880
Aggregate Energy Required to Restart 100% of Idle Capacity	8.9 Million mWh				34.6 Million mWh
Aggregate Energy Required for U .S. Industry at Capacity	19.04 Million mWh				34.6 Million mWh

Challenges and Opportunities to Securing U.S. Aluminum Independence

Source: Datacenters.com, Loudoun County.gov

Securing the Revenue Stream

Another essential step to restarting primary aluminum facilities is **securing the revenue stream.** LME prices at or above current prices for an extended period forward allows the investor to have good line of sight on its cash flows. This provides confidence that restart costs can be recovered and generate positive returns. While production may be sold forward by a producer, this involves costs as the counterparty to the hedge likely will require collateral for such a transaction and a discounted price to secure a margin.

Securing Skilled Labor

Replacing skilled labor to restore and operate the newly restarted capacity may be a problem in the locations with fully idled capacity (Hawesville and New Madrid). In the absence of any assured timeline for restart, much of the workforce will have found other employment in this tight labor market. Further, many of the skilled workers at these facilities were likely at or near retirement age and may be unlikely to return to the workplace. Governmental support for workplace training and development programs would be helpful here.

Alumina and Carbon Sourcing

The ability to secure alumina is critical as it is (depending on power price) the single largest cost component of production. It takes 2 tons of alumina for each ton of aluminum being produced. This material would be sourced overseas due to limited U.S. production capacity and come from Australia, Brazil or Jamaica.

Access to calcined petroleum coke and coal tar pitch is needed to produce the carbon anodes in the Hall-Heroult process. The smelter will require approximately 50% of its nameplate capacity in the form of carbon/coal tar pitch. However, supply chains can adapt to meet this need with planning and time.

Summary of Challenges in Restarting Idle Primary Capacity

- **A competitive power contract of 10 years at a rate of $40 per MWh.**
- **LME and U.S. regional metals prices remaining at or above current levels allow amortization of the restart costs and generate positive free cash flow.**
- **Finding skilled labor to replace prior work forces that dissipated.**
- **Sourcing alumina and carbon in tight market conditions.**

6.3 Increasing Secondary Aluminum Capacity

Secondary recycled aluminum production in the U.S. has a long history of parallel development with primary aluminum. There has been active secondary production in the U.S. for over 125 years. Anytime there is aluminum fabrication, there is pre-consumer recycled metal generated. Similarly, anywhere automobiles are scrapped, beverages are consumed or buildings demolished there is post-consumer recyclable aluminum generated. Over the past decade – and accelerating following Section 232, 301 and antidumping/countervailing duty tariff interventions – U.S. aluminum firms have invested more than $10 billion in domestic manufacturing, supported by secondary production. This has taken the form of secondary casthouse expansions to produce billet, sheet ingot, die-cast alloys and other foundry products, as well as rolling mill and extrusion press expansion to consume the secondary casthouse products.

Current State

Secondary aluminum is produced in multiple business models in the U.S.:

- Standalone plants that buy and toll convert scrap on behalf of customers. These would include firms such as Owls Head Alloys, Real Alloy and Scepter.
- Integrated secondary melting facilities attached to fabrication plants. These would include Aluminum Dynamics, Constellium, Novelis, Service Center Metals and Western Extrusions
- Standalone plants that produce value-added products for sale to fabricators. These would include Ellwood Aluminum, Hydro Aluminum, Matalco, Spectro Alloys/EGA and Vista Metals.

Presently there are over 115 operational secondaries in business today. New standalone facilities are under construction now in Arizona, Kentucky, Minnesota, Ohio, and Tennessee, with more are on the drawing board. Current facilities have also invested to increase remelting and casting capacity.

In 2024, Aluminum Association estimates indicate that recovery from scrap in the United States exceeded 5 million metric tons.

Secondary plants serve a full gamut of a wide cross section of aluminum demand:

- Rolling Mills
- Extrusions
- Rod Mills
- Forging Mills
- Die Casters

Alloys produced by secondary producers are often interchangeable with primary-based alloys and can replace imported primary aluminum in select applications such as extrusion ingot, common alloy building production sheet and beverage can body stock.

U.S. secondary aluminum mirrors U.S. electric arc furnace (EAF) steel mills in that secondary aluminum relies on domestic, recycled metal for its feedstock. It also shares traits of low energy usage and lower capital intensity versus primary production. Alternatively, a primary aluminum plant converts alumina to aluminum and mirrors a steel blast oxygen furnace that converts iron ore to steel.

This growth in secondary production has come in a complementary role to primary aluminum, not as an adversarial one. Secondary expansions have not come at the expense of jobs in the primary sector. Instead, secondary aluminum has met an important task of filling gaps in total aluminum supply as primary smelting has declined since 1980.

Low Energy Requirement

Secondary aluminum production consuming recycled scrap is energy-efficient, consuming only 5% of the energy required to produce primary aluminum. Natural gas in combination with air or oxygen is used to melt the recycled metal. A state-of-the-art natural gas burner system at a secondary smelter uses only 0.8 MWh of electricity equivalent natural gas per MT to melt recycled metal and cast it to finished form. Electricity is not used for melting, but only for auxiliary equipment. This is in contrast to 14.82 MWh per ton for primary aluminum production. Secondary aluminum also has a low carbon footprint. Most secondary aluminum has less than 1 ton of CO^2 per ton of production. This meets growing demand from the automotive, beverage and consumer electronics markets, which desire lower carbon intensity along with higher recycled content in their products.

Capital Efficient

A state-of-the art secondary aluminum facility can be built with capital costs of less than $1,500 per metric ton of installed capacity. The equipment and technology are U.S. or European-derived. These plants can move from concept to completion in 18 months.

The main constraint on secondary production is the availability of recycled metal. The lack of availability is caused by poor post-consumer scrap recycling rates, excessive aluminum scrap exports to the far-East and cyclical/seasonal scrap cycles. There are opportunities to solve these issues.

The issue of scrap availability in the U.S.

The U.S. is increasing its re-melt capacity with at least 14 new investments announced since 2022. These projects are expected to add 2.75 million metric tons of re-melt capacity and significantly impact scrap consumption and recovery rates. When fully operational (estimated 2028-2029), **annual domestic aluminum scrap demand will stand at 6.5 million metric tons, with an anticipated shortfall of 3.5 million tons** after accounting for imports and exports.

The domestic scrap market is also at risk in coming years due to increased international demand for scrap, with China as the main competitor to U.S. operators. China is directing its aluminum industry to ramp-up its re-melt capacity, reported to be three times U.S. capacity in the coming years.

Keeping the scrap in the U.S.

Today, a significant amount of scrap is being exported every year while it could be used by U.S. producers. In 2024, over 2.4 million metric tons of aluminum scrap was exported, an increase of 17% over 2023 exports.

To protect U.S. aluminum supply and ensure long-term scrap availability, we recommend studying potential restrictions on scrap exports to non-market economies (both directly and indirectly) and countries that impose similar restrictions as a matter of reciprocity.

The Opportunity to Increase Recycling of Used Beverage Containers

The aluminum beverage container is one of the best success stories of the aluminum industry. Shipments of these containers are at 108 billion units per year. Unfortunately, the industry has not enjoyed the same success in recycling these containers, known as Used Beverage Containers (UBC). Presently, only 43% are recycled, meaning that about 57% of supply or 800,000 metric tons is being landfilled. This is equivalent to the primary aluminum produced by two average sized smelters. This material is highly sought after by sheet mills producing for the beverage can market.

The failure of the industry to recover these containers is due to:

- Lack of incentives (financial or otherwise) for consumers to change behavior from the status quo of landfilling recyclable materials. Deficiencies in recycling infrastructure for sortation. Even in good curbside collection programs, a substantial amount of aluminum is lost due to mis-sorting at recycling facilities.
- Lack of recycling incentive, infrastructure and sorting technology at Federal and State levels. The U.S. has 10 states that have deposit laws and the recycling rate in those states is higher than in most non-deposit states—approaching 100% in Oregon.
- Access to recycling at the local level. Infrastructure to support voluntary recycling is lacking, especially in rural communities. Funding for collection programs in multi-family settings is also lacking.
- Consumer disbelief that recycling actually works. In this respect, aluminum suffers from 'guilt by association' with the bad image that plastics have in terms of disposal and reuse. Aluminum is infinitely recyclable and the most valuable material in the typical consumer recycling program.

To tap into this supply of valuable metal, state and federal authorities need alignment on the following approaches:

- National and State strategy for collecting and remelting aluminum:
    - Enact Extended Producer Responsibility legislation that mandates producers of beverages fund programs to recover all their materials in the markets they serve, coupled with giving them commercial rights to the material recovery.
    - Deposit legislation should be targeted toward states with high population and generation of UBC. Incumbent providers of curbside services in those states should be entitled to claim the deposits on those units continuing to be placed in curbside bins.
- Tax credits should be extended to municipalities that are investing in recycling infrastructure.

Aluminum Scrap as a By-Product of Steel Shredding

The U.S. recycles about 15 million obsolete automobiles and light trucks each year. These vehicles are recycled by vehicle shredding operations in most states. Shredding vehicles, along with other shredding post-consumer scraps (like used appliances), yield about 4 million metric tons of nonferrous material per year.

The vehicle shredders produce a non-ferrous aluminum shred that is known as Zorba in the trade. Zorba is non "furnace ready scrap" in that it contains only between 70% and 90% aluminum along with copper, stainless steel, brass, nickel, tin, lead and magnesium as well as other metals. Because of these mixed metals, Zorba must be processed again – usually by further shredding combined with manual or mechanical separation (to make a product called, Twitch in the trade). Converting zorba to twitch adds cost. Export markets often will undercut domestic markets by offering more for zorba than what it costs a domestic processor to make twitch. This is due to non-market factors, lower labor rates and ability to use hand sorting of zorba to upgrade the scrap. Continued export of this scrap undermines the U.S. domestic industry as a critical source of scrap. China has announced plans to increase its recycled aluminum production to over 15 million tons by 2027, part of a broader initiative to strengthen its aluminum supply chain and promote sustainable development, according to the Aluminum Industry High-Quality Development Plan (2025-2027).

While most zorba and its twitch derivative are used in the lower-grade aluminum sectors such as die casting, twitch can be further separated into separate aluminum alloys using developing metal separation technology for it to be used in higher grade wrought alloy markets such as rolled, extruded or rod products.

Zorba is the main feedstock for 1.6 million metric tons of secondary aluminum produced annually in the U.S. The Asian market consumes between 1.6 and 2.1 million tons of zorba.

The Opportunity to Upgrade Zorba

Sorting zorba and its twitch derivative more effectively and efficiently will increase the supply of high-grade metal for its higher value use in the rolling mill and extrusion markets. This will further extend our total supply of aluminum as we work toward self-sufficiency in primary aluminum. There is ample demand growth to support both secondary and primary supply increases. Efforts are underway in the U.S. to sort zorba/twitch into discrete alloys that would allow it to be sold at a higher market value. The goal is to sort at speeds that are comparable to the rate at which high grade mills are melting metal.

There are several different sorting technologies being deployed to do this. Laser-Induced Breakdown Spectroscopy (LIBS) and X-Ray Transmission (XRT) are two of the leading approaches. The problem is that the technology is slow, yielding in the most advanced applications only 5 to 8 metric tons/hour. This is inadequate versus the speed at which secondary facilities need to charge their furnaces to optimize production. Ideally, minimum speeds need to be 10-15 tons per hour.

Investments are being made to increase speed, but in the interim, the industry is resigned to installing a series of these sorting machines to boost hourly throughput or utilize the systems to sort more high-value metals such as copper or nickel-bearing alloys.

The aluminum industry would benefit from the government supporting research in sortation technologies and providing tax credits to those firms investing in this next generation of sortation. Aligned with this research would be a priority for expensing R&D costs and providing tax credits for this work. Any efforts in this area would reduce exports of zorba and utilize this aluminum within the U.S. A goal to upgrade 50% of the available zorba could generate an aggregate 800,000 to 1 million tons of annual supply.

Summary of Challenges in Expanding Secondary Production:

- **Ensure that U.S. generated scrap remains in the United States.**
- **Increase recovery of Used Beverage Container recycled metal through investments in recycling infrastructure and supporting legislation.**
- **Accelerate research and invest in recycling technologies, including to advance sortation of automotive scrap.**

7.0 Canada as the Bridge to a New U.S. Aluminum Industry

While the U.S. invests in expanding domestic capacity, regardless of which source, access to primary supply is essential. Built upon U.S. investment, Canada has been a dependable supplier of primary aluminum to the U.S. since 1901. American investment was attracted to Canada for its abundant hydroelectricity and stable political environment. Both qualities persist to this date.

Today, Canada's three producers (Alcoa, Alouette and Rio Tinto) supply about 70% of U.S. imports. This metal flows to the U.S. through reliable barge, rail and truck-based supply chains providing just-in-time arrivals to all major American consumers of primary aluminum. Canadian exports are a mix of standard P1020 remelt ingot, along with value-added casthouse products in the form of billet, foundry alloy, rod and slab. The variety of alloys and forms are unrivaled in the market.

The Canadian aluminum industry has consistently ranked amongst the lowest cost producers in the world. This is a function of the public and private sector investment in low-cost, clean hydroelectricity. 100% of Canadian production is hydro-based and it ranks among the lowest carbon intensity metal in the world. Canadian production has also benefited by continuous reinvestment in state-of-the-art facilities that utilize the latest technology available outside of China.

Importing primary metal from Canada is a smart move for U.S. primary consumers. This conserves U.S. electricity by buying Canada aluminum that has cheaper electricity embedded in it. This extends U.S. generation capacity to other U.S. manufacturing where competitive advantages exist that do not exist in primary aluminum at the present time.

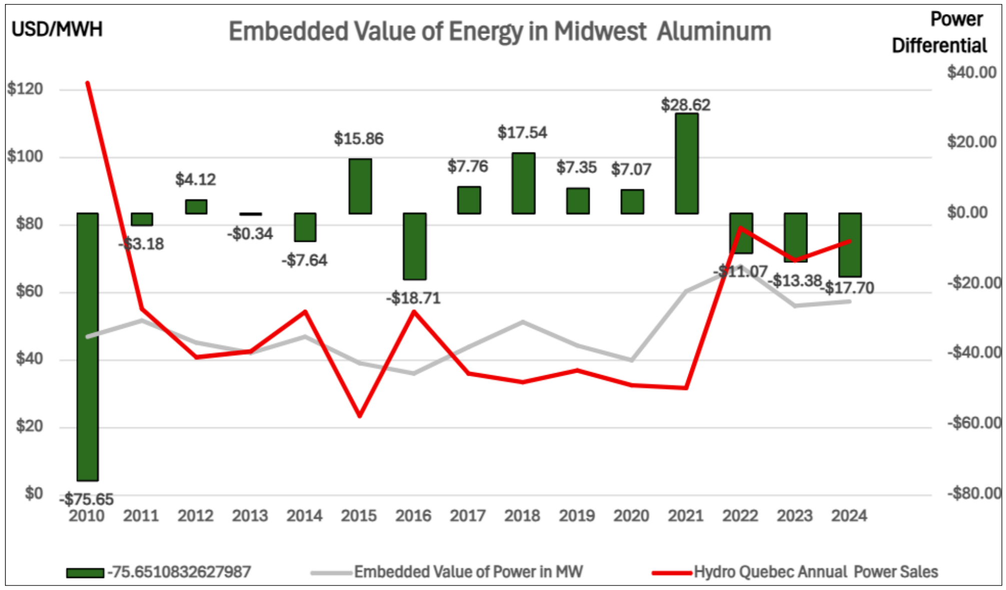
The Electricity Value Embedded in Canadian Aluminum

Cheaper Canadian electricity comes through its value embedded in the aluminum that ships to the U.S. The U.S. physical aluminum market prices on a regional market known as "Midwest Transaction on Price," which is published daily and monthly.

This price represents validated transactions between buyer and seller in the region. The process consists of surveying the physical premium or regional upcharge from these transactions and adding it to the LME cash settlement price for the week or month. This becomes the "Platts Midwest Transaction™".

The metal imported from Canada is sold primarily on this index. We have modeled the embedded value of Canadian electricity in this index using the following methodology:

- We have captured the average annual Transaction Price for the period 2010 through 2024.
- Based upon prevailing power rates in Canada, electricity represents about 30% of the cost of making aluminum. We take 30% of the Transaction Price to compute the implied value of the electricity embedded in the Transaction Price. This value in cents per pound is then converted to dollars per metric ton.
- We then divide the total metric ton value of the embedded electricity by the number of megawatt hours (MWh) required to produce 1 ton of metal. This is 14,821 kilowatt hours (KWh) or 14.821 MWh hours. That gives us the value per MWh of the electricity.
- This number is then compared to average annual export sales of electricity by Hydro Quebec, which is the sole supplier of electricity to those aluminum smelters in Quebec that purchase power for production.



The result of the analysis tells us:

- In **8 of the 15** years in the timeseries, Canadian aluminum was valued at an **average 22% discount to Hydro Quebec** export sales.
- In **3** of the 15 years, Canadian aluminum was valued at a **70% premium to Hydro Quebec** export sales.
- In the remaining **4** years, Canadian aluminum was valued at an **18% premium to Hydro Quebec** export sales.
- **Since 2021, Hydro Quebec power prices have risen sharply, meaning their opportunity costs have risen for power allocated to the production of aluminum in Quebec.**
- **This also coincides to higher Canadian aluminum exports to the U.S., meaning that Canadian electricity has been transferred to the U.S. aluminum market at favorable discounts to the alternative sale as wholesale power to the U.S. Northeast.**
- Given the outlook for power demand over the 2025-2030 period, it is reasonable to expect export prices to remain strong and the opportunity cost to Hydro Quebec to remain high.

The Energy Information Administration (EIA) January 27, 2025 “Today in Energy” report forecasts that power prices in the Northeast U.S. are expected to increase from $47 per MWh to $54 per MWh between 2024 and 2025.

Canadian aluminum has spent 125 years building and preserving its reputation as the United States’ top supplier of primary aluminum, it should be accorded Most Favored Nation status. It is fair to Canada and preserves the relationship between Canadian primary metal and American expertise in advanced aluminum manufacturing.

Every 1 Canadian primary aluminum job supports 13 American aluminum jobs. That is a supply chain that deserves protected status.

8.0 Options to Secure U.S. Aluminum Supply Summarized

Options	New Brownfield or Greenfield Smelter (750,000 MT)	Restart Idle Smelter Capacity (601,000) MT	One Medium Size Secondary Melter Production Facility (345,000) MT
Capital Intensity per MT	High: $5,000-$8,000	Low: $300-$500	Low: $1,500
Total Capital Required	$4-6 Billion	$100-500 Million	$400-600 Million
Raw Materials Requirement Ease of Sourcing	1,500,000 MT Alumina –Hard 250,000 MT Carbon - Medium	1,202,000 MT Alumina- Hard 200,000 MT Carbon- Medium	345,000 MT Aluminum Scrap- Medium to Hard
Electricity or Gas Required	Electricity - 11.1 Terawatt Hours (TWh)	Electricity - 8.9 Terawatt Hours (TWh)	Natural Gas- 0.276 Terawatt Hours (TWh)
Electricity/Gas Contract Term Required	20 Years	10 Years	Annual
Ease of Sourcing Energy	Difficult- Demand from Data Centers	Difficult- Demand from Data Centers	Low- Good Access to Gas
Incremental Direct Job Creation Current Jobs in Sector	800= 20% of Existing Jobs 3,994	1,350= 34% of Existing Jobs 3,994	677 = 6.7% of Existing Jobs 10,109
Energy Intensity Per Job Created	13,895 MWh	6,592 MWh	407 MWh
Productivity Per Job	937 MT	445 MT	510 MT
Time to Execute	5- 6 Years	6-15 Months	12-18 Months

Canada Primary Aluminum as dependable, competitive supply BRIDGE during execution of options

9.0 Summary

- **The U.S. primary industry went into decline due to internal and external forces.**
  - The **deregulation of wholesale electricity was the principal cause due to higher** industrial power prices.
  - The **emergence of Russia as a large net exporter** undermined the economics of U.S. smelting during the period 1990-2000.
  - **China's rapid emergence as a low cost, subsidized producer** of primary metal eroded the value of the benchmark LME aluminum contract.

- **The construction of brownfield and/or greenfield primary capacity** will depend on:
  - Securing **competitive electricity** for a minimum of **20 years at $40 per MWh.**
  - **Reducing capital costs with targets in the $4,500-5,000** per metric ton.
  - **Securing future revenue streams by strategically hedging.**
  - **Lowering borrowing costs through creative financing solutions** such as sovereign wealth fund participation or government load guarantees.
  - **5-6 years to construct at $4-6 billion.**

- **Efforts to restart idle U.S. capacity** will depend upon:
  - **Securing competitive electricity** for a period of **10 years** to justify the investment torefurbish the 601,000 metric tons of currently idled capacity.
  - **Stable LME and Midwest prices long-term.**
  - Finding labor, alumina and carbon.
  - **Total restart costs could range between $100 - $500 million.**

- **Secondary/Recycled aluminum is a complementary solution to primary aluminum:**
  - Capital costs are **$1,500 per ton of capacity and only 0.5 tons of CO^2 per ton.**
  - Only **5% of the energy required** versus primary aluminum.

- **$10B+ invested since 2013** in mid-and-downstream production and recycling capacity, importance of ensuring reliable source of scrap in a tight market.
- Recycling all used beverage containers currently landfilled could yield **800,000 MT of supply.**
- Upgraded Zorba could provide an additional **800,000 MT of supply** of new high-grade supply.

- **Canada has been a dependable, highly competitive supplier to the U.S.:**
    - **Politically stable** environment.
    - A **short lead-time** supply chain.
    - **Lowest carbon footprint** of existing alternatives from seaborne origins.
    - Embedded **electricity value** in the aluminum in the past 3 years has been below that of Quebec's export power alternatives.
    - Canadian imports should have **no tariffs.**

Appendix

A1. 1980 Primary Aluminum Capacities (in 000 Short Tons)

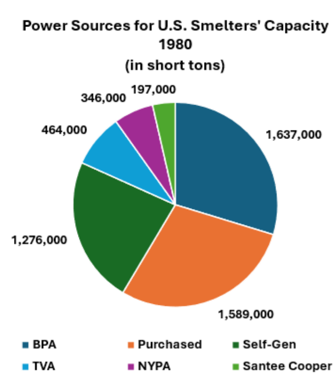
Company (Number of Plants)	Location	Capacity (Short Tons)	Power Source
Alcoa (9)	Warrick IN	292,000	Self-Gen
	Badin NC	127,000	Self-Gen
	Massena NY	220,000	NYPA
	Alcoa TN	220,000	Self-Gen
	Anderson County TX	17,000	Luminant
	Point Comfort TX	176,000	Houston Lighting
	Rockdale TX	342,000	Self-Gen
	Vancouver WA	121,000	BPA
	Wenatchee WA	220,000	BPA
Alumax (3)	Ferndale WA (INTALCO)	265,000	BPA
	Frederick MD (EASTALCO)	176,000	Potomac Edison
	Mt Holly SC	197,000	Santee Cooper
Anaconda (2)	Columbia Falls MT	180,000	BPA
	Sebree KY	180,000	Big Rivers
Consolidated (2)	Lake Charles LA	35,000	Self-Gen
	New Johnsonville TN	142,000	TVA
Kaiser Aluminum (4)	Chalmette LA	260,000	Self-Gen
	Mead WA	220,000	BPA
	Ravenswood WVA	163,000	Ohio Power Co.
	Tacoma WA	81,000	BPA
Martin Marietta (2)	Goldendale OR	120,000	BPA
	The Dalles WA	90,000	BPA
National-Southwire (1)	Hawesville KY	180,000	Big Rivers
Noranda (1)	New Madrid MO	140,000	Assoc.Electric (AEC)
Ormet (1)	Hannibal OH	250,000	AEP
Reynolds Metals (7)	Arkadelphia AR	68,000	Arkansas P & L
	Corpus Christi TX	114,000	
	Jones Mills AR	125,000	Arkansas P & L
	Listerhill AL	202,000	TVA
	Longview WA	210,000	BPA
	Massena NY	126,000	NYPA
	Troutdale OR	130,000	BPA
Revere Copper & Brass (1)	Scottsboro AL	120,000	TVA
Total (33)		5,289,000	

Source: Aluminum: Profile of the Industry, Metals Week Publications 1980

A2. Power Profile of U.S. Primary Producers in 1980

Power Profile of U.S. Primary Producers in 1980

- The 32 smelters operating in 1980 had a mix of power procurement strategies
- The BPA, TVA, NYPA and Santee Cooper were either federally controlled (BPA-TVA-NYPA) or state-controlled (Santee Cooper).
- These government-controlled entities supplied 48% of the industry needs
- Self-generation and purchased power from the private section comprised the other 52%
- The de-regulation of U.S. electricity markets proved to be the financial undoing for much of the industry, as retail-driven pricing saw very limited renewal of long-term pricing agreements for the industrial sector



Challenges and Opportunities to Restoring U.S. Security in Aluminum Supply

A3. Glossary of Terms in the Aluminum Industry

A

Alloys: A metal created by combining two or more metallic elements, usually to provide properties of increased strength, corrosion resistance or malleability. In aluminium, associated with cast house products such as billet, foundry ingot, rod or rolling slabs.
Aluminum Association: The trade association representing primary aluminum producers, fabricators, recycling processors and suppliers within the U.S.
[1]**Alumina:** Aluminum oxide which is produced in the process of refining bauxite.
[2]**Anode:** refers to the carbon block in the smelter pot that facilitates the electrolytic process of extracting aluminum from alumina.
Appreciation: When an asset's value increases over time.
Assay: Certificate of chemical composition of a metal to determine its purity and alloy composition.
Atlantic Basin: A geographical designation for primary aluminium or alumina production originating with the North or South Atlantic Oceans

B

BPA: The Bonneville Power Administration. A federal agency marketing and transmitting power from 31 federal dams and 1 nuclear plant in the Pacific Northwest
Base Metal: Major industrial non-ferrous metals as opposed to precious metal or ferrous metals. Aluminium, copper, lead, nickel, and zinc.
Basis: Used to describe the relationship between physical P1020 or scrap and the London Metal Exchange market. Also referred to as physical premiums.
Bid: The price at which a buyer is prepared to pay.
Bid-Ask Spread: The difference between the bid price at which buyers would purchase and the ask price at which sellers would sell. Typically, the greater the volatility in a market, the wider the spread.

Bill-of Lading: The commercial document representing a physical shipment, accompanied by **certificate of origin, assay certificate or packing slip.**
[3]**Billet:** a circular cross-sectioned cast house product of an aluminum smelter, produced typically in a 6000 series alloy. Most often cast in 200mm to 254mm diameter in length of 711mm to 812mm as "cuts" or supplier as "log" in lengths up 7,620mm. Sometimes referred to as extrusion ingot.
Broker: One who matches buyer versus seller for a fee.
Brokerage: Commission fee charged by a physical or financial broker for executing a transaction.
Brownfield: The process of expanding an existing aluminum production facility, taking advantage of sunk costs already in place for infrastructure.

C

CFTC: The Commodity Futures Trading Commission which governs all commodity futures exchanges in the United Sates
CIF: Cost insurance, and freight. Normally these costs are to the sellers account in physical contracts of delivery. CIF Japan means seller is covering the costs to **Main Japan Port**, with buyer responsible for discharge from vessel.
CME: the Chicago Mercantile Exchange on which U.S. soft and industrial commodity futures are traded. Successor to the NY Mercantile Exchange or "NYMEX"

Carbon Footprint: Refers to the amount of carbon dioxide that is produced in the process of making primary or secondary aluminum. Measured in metric tons per ton of production. Secondary aluminum has a carbon footprint of 0.5 tons of carbon dioxide. Best in class primary smelting is 1.9 tons while worst in class is Indian coal-based production at 16 tons. Middle East gas-based production is around 8 tons.
Carry Charge: The cost of storing and financing a commodity in a warehouse.
Cash: Spot metal price as formally defined by the London Metal Exchange. Cash prices are established 2 days prior to financial settlement, i.e., the Wednesday cash price is established on Monday.
Casthouse: A facility attached to an aluminium **Smelter or downstream fabricator** charged with chilling molten metal from a **Potline** ore remelting recycling metal in value-added cast products for further fabrication:

- **Unalloyed Ingot (see Ingot for visualization)**
- **Billet (see Billet for visualization)**
- **Foundry Alloy (see Foundry Alloy for visualization)**
- **Rolling Slab (see Rolling Slab for visualization)**

Cell: A term used interchangeably with Pot to describe the chamber in which alumina is processed to extract aluminum.
Continuous Casting or Caster: A process of producing aluminum sheet using a belt casting approach that eliminates the traditional hot and cold mill process of progressively reducing the gauge of a rolling slab.
Conversion Fee or Conversion Margin: The processing spread between primary/ secondary raw materials and a semi-fabricated product. Most associated with sheet/coil manufacturing, where **OEM** will **TOLL** their purchased raw materials for an agreed upon conversion fee with a rolling mill.
Cost Curve: A plot of all recognized aluminum smelters' individual costs aggregated in a chart showing lowest to highest costs for total global production.
Creep: The process of adding smaller, incremental production gains to an existing aluminum production plant. This can be done through an increase in electricity amperage and de-bottlenecking of the smelting process.

D

Deficit Region: Any geographic area where domestic or regional primary metal production is less than demand, requiring imports to balance the regional requirements. North Asia, the U.S. and Western Europe are the major deficit regions in the primary aluminium market.
Delivery Date or Prompt Date: The date on which a metal must be delivered to fulfill the contractual terms.
Delivery or Delivery Point: The process of shipping LME-approved brands to an LME-approved warehouse location to satisfy the sale of LME contracts. Delivery point specifies a geographical location listed and approved for issuing LME warrants.
Differentials: The means of describing the price relationship between physical metal and the London Metal Exchange or other terminal market indices. Also used to describe the relationship between P1020 and scrap. This term is used interchangeably with **"premium" or " basis."**
Derivative: A financial contract underpinned by the price of a physical commodity, for example futures or options; traded on derivative exchanges or OTC (over the counter). All physical aluminium players engage in derivative trading on the LME to hedge their exposure to aluminium prices.
Duty Paid: Denotes that all applicable import duties for primary aluminium have been paid to allow metal to be custom cleared into an area. Most used in Europe to describe CIF Rotterdam duty paid metal and in U.S. to describe delivered Midwest duty paid metal.
Duty Unpaid: Denotes that applicable import duties for primary aluminium have NOT been paid to allow metal to be custom cleared into an area.

E

EA: European Aluminium
Elysis: A proprietary breakthrough smelting technology being developed by Alcoa, Apple, the Province of Quebec, and Rio Tinto. Aims to produce a zero-carbon primary aluminum using an inert anode, which does not degrade in the process.
End Consumer: A company in whose hands the identity of the commodity grade metal is lost either as a semi-fabricated product or a finished product.
Equity Metal: Metal supply is allocated to an owner based on capital investment in a smelter or overall ownership stake in a company.


[4]**Extruder:** A fabricator processing a billet into an aluminum profile with an extrusion press:

F

Fabricator: A company which transforms refined metal into semi-fabricated products such as **extrusions, rod, sheet and plate or wire/cable.**
Fast Markets: A well-known trade publication covering ferrous and nonferrous metals. Fast Markets reports on market development as well as published a wide array of physical metal prices and prices.
Financial Intermediary: A bank, Merchant or Trader who takes risk in the physical market for purposes of holding Longs for long term appreciation of premium or price. May also go Short the physical market in anticipation of futures prices falling, buying back at that time to lock in a profit.
Force Majeure: A clause in a physical contract that provides relief to a seller due to events beyond his/her control.
Foundry: A company casting refined metal into die-cast parts. Typically used in automotive and transportation applications, with the aluminum wheel being noteworthy.
Formula Price: The physical regional premium or basis agreed to on physical contract that is then priced using LME reference prices during a Quotational Period basis.
Forwards: Used to describe the prices of metal beyond cash. In the context of the London Metal Exchange, it describes all prices beyond the 3-month contract quotation.


[5]**Foundry Alloy:** A product of an aluminum Smelter or secondary producer that is alloyed into ingot form for sale to die-casting fabricators, most notably OEM automotive wheel producers.
Futures: Another term for forward delivery contracts. Usually thought of as financially settled commodity contracts offered on the London Metal Exchange, Chicago Board of Trade, New York Mercantile Exchange, and Commodity Exchange.

G

GFC: Global Financial Crisis of 2008-2009.
Greenfield: The process of building entirely new primary production at an undeveloped site.
Gulf Region: Geographic term associated with primary aluminum production with the area of the Arabian Sea, consisting of Bahrain, Oman, Qatar, Saudi Arabia, & the United Arab Emirates.

H

Hedge: The act of offsetting financial risk by taking an equal and simultaneous transaction in either the financial or physical market. Commonly applied to the process of buying or selling on the London Metal Exchange A consumer who buys London Metal Exchange contracts against a forward, physical sale of fabricated product is said to have " hedged" his/her transaction.
High Purity: Any grade of primary aluminium that exceeds the standard commercial grade of

- 99.7% or P1020A. These premium grades are designated as follows:
- P0610 which specifies max .06 Silicon and .10 Iron
- P0506 which specifies max .05 Silicon and .06 Iron
- P0404 which specifies max .04 Silicon and .04 Iron
- P0303 which specifies max .03 Silicon and .03 Iron
- P0202 which specifies max .02 Silicon and .02 Iron

Each of these grades commands an upcharge or premium expressed over and above P1020.


6


7


8

I

IAI: The International Aluminium Institute. The world body of primary aluminum producers, which compiles and publishes data on alumina and aluminum production.
Ingot: Primary, unalloyed aluminium 99.7 or P1020 cast into various shapes for ease of transport and subsequent re-melting. These include:

- [6]Standard ingot or "pig" which is typically 22 kilograms or 50 pounds per piece; packed in seaworthy bundles of 1 (one) metric ton each. Most consumed shape within Asia, somewhat less common in North America.
- [7]T-bars which are typically 680 kilograms or 1,500 pounds per piece; packed loose or in unitized bundles of 3 pieces each. First or second most consumed shape within North America.
- [8]Sows which are typically 680 kilograms or 1,500 pounds per piece; packed loose or in unitized bundles of 3 pieces each. First or second most consumed shape within North America.

Integrated producer: A producer of metal who owns mines, refineries, smelters and sometimes fabrication facilities. Examples being Alcoa, Hydro, and Rio Tinto in World ex China and CHALCO in China.

J-K-L

JAA: Japan Aluminium Association.
Kilowatt Hour: Abbreviated as kWh, the standard measure of electricity consumption at the retail level. There is 1,000 kWh in a **Megawatt Hour.**
LIBS: Laser Induced Breakdown Spectroscopy used to sort mixed metals into discrete alloys.
LME: The London Metal Exchange, which is the oldest and largest commodity exchange for trading in base metals. Now owned by the Hong Kong Exchange (HKeX) Trades in cash and 3-month contracts in aluminum, aluminum alloy, copper, lead, nickel, and zinc amongst major contracts. Business is conducted through a series of Rings, Kerbs, and Over-the-Counter markets.
LME Cash Settlement Price: The seller's offered price for cash as established at the close of the 2nd Morning Ring each day. Used to price many physical metal contracts worldwide.
LME Deliverable: Any production brand that has been certified by the LME as eligible for placement into LME warehouse and having warrants issued against it.
Long: A condition describing either a physical or financial position where there is no offsetting sale and owner of the position is holding price risk. Producers are described as "natural longs" as they inherently produce metal each day. Traders and end users of metal are described as "acquired longs" where they elect to purchase metal in anticipation of prices rising in the future.

M

MJP: Main Japanese Port. The standard delivery designation for physical metal being sold into the Japanese market.
MOS: Month of Shipment. Used to describe the Quotational Period for pricing a physical

contract.
MPMOS: Month Prior to Month of Shipment. Used to describe the Quotational Period for pricing a physical contract.
Mark to Market: The process where a pre-existing physical or financial contract is revalued at the prevailing market price or Replacement Value.
Market Maker: A physical or financial participant willing to make a 2-way market in a commodity for purposes of creating liquidity in a market.
Mating Season: A period when buyers and sellers start negotiations on annual supply contracts. Typically launched in September or October of the year prior to contractual shipment.
Megawatt: Abbreviated as MW, the standard convention for measuring power plant capacity. 1 MW - 1,000,000 watts
Example a 1000 MW plant would be the generation capacity of a power plant for 1 hour. To derive the theoretical annual generation of such a plant you would = 1000 x 24 hours x 365 day.
A 1000 MW power plant theoretical capacity is =8,760,000 **megawatt hours**
This number would then be reduced by the effective operating capacity. Most power plants operate at 65-75% effective capacity. In this example, a plant running at 75% efficiency would produce 6,570,000 megawatt hours of electricity.
Megawatt Hour: Abbreviated as MWh, the standard unit of measure when described wholesale power generation, transmission, and pricing of power.
Merchant: A physical trader as opposed to a producer, agent, broker, or end consumer. Acts as a principal, buying and selling with risk of loss.
Metals Week (Platts) Midwest Transaction Price: The sum of the LME Cash Settlement Price weekly average plus the average premium for P1020 in each week or month. As published by Platt's. A copyrighted price index. The average premium is established by taking a representative sampling of leading producers, consumers, and merchants in the U.S. market each week.

N

Netback Calculation: The process whereby exporting producers determine their highest FOB revenue stream by taking the applicable CIF or delivered regional physical premium less direct costs of freight and handling.
Example:

- If the CIF Rotterdam duty paid premium is $200 per ton over LME and the freight from Canada to Rotterdam is $85 per ton, the netback FOB Canadian smelters = $115 FOB.
- If the delivered Midwest premium is $881 per ton over LME and the freight from Canada to Midwest is $90 per ton+ Section 232 duty is $750, the netback = $41 FOB.

In this example, the Rotterdam market offers a higher netback return and Canadian supply should gravitate to Rotterdam.

O

OEM: Original Equipment Manufacturer or end user in the Aluminium Supply Chain.

P-Q

P1020A: Primary Aluminium with impurities no greater than the chemical composition of one of the registered designations:
P1020A in the North American and International Registration Record entitled "International Designations and Chemical Composition Limits for Unalloyed Aluminum" (revised March

2007).
10 refers to the maximum silicon content and 20 refers to the maximum iron content.
The standard commercial grade traded in the World.

Pacific Basin: A geographical designation for primary Aluminium production originating with the Indian and Pacific Oceans, often earmarked for sale into South and North Asia. Also refers to alumina production originating here.
Platt's Metals Week: A leading trade publication reporting market news and publishing physical market prices for major markets such as Europe (Rotterdam), Japan (CIF Japan) and the U.S. (Midwest). Widely used as the reference price for setting physical contract premiums and/or total price. These prices are copyrighted and available by subscription only.
Prebake: Refers to the existing technology used in primary smelting that uses a prebaked carbon **anode** in a **pot** to produce primary aluminum. The process involves the eventual destruction of the anode in 20-30 days after being set into the pot.
Premium: In the context of the physical market, the spread in dollars or cents/lb. between the physical metal price and the LME cash price.
Pricing: The process by which formula-priced or unpriced physical contracts established the final price for commercial invoicing.

R

ReMA: Recycled Materials Association, formerly known as the Institute of Scrap Recycling Industries (ISRI). Changed name in 2024.
Reduction Plant: A term interchangeably used with Smelter. A facility that processes alumina into primary aluminum
Refinery: A facility which processes bauxite into alumina, the feedstock for aluminum.
Replacement Value: Describes the current price or value of any physical or financial contract relative to an existing contract. Used to establish the Mark to Market valuation of an existing body of contracts. If replacement value is less that contractual price, the contract is said to be "out of the money."

[9]**Rolling Slab:** A primary smelter cast house product supplied to aluminium rolling mills to produce sheet, coil, and plate.

S

Secondary Aluminum: Aluminum products produced from either new production or obsolete, post-consumer scrap.
Self-Generation: A primary aluminum smelter which generates its own electricity through an in-situ power plant.
Semi-Fabricator: Same as a fabricator, the principal end user for metal
Sheet, Coil and Plate- One of the principal end use markets for aluminum **Ingot and Rolling Slab**
Short: A open physical or financial sale position in the market that is uncovered.
Smelter: A facility which processes alumina into primary or virgin aluminium. Sometimes referred to as a **Reduction Plant.**
Spot Market: A term used interchangeably with **Cash** to describe the prompt metal price.
Strike Price: The price at which an option is bought or sold.

T

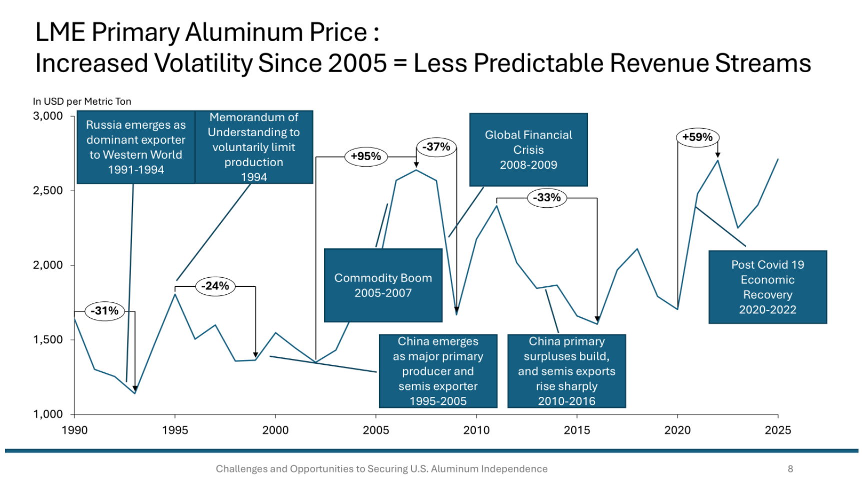
Tennessee Valley Authority: A federal public power corporation generating and distributing power in the Tennessee River Valley.
Terminal Market: Used interchangeably with commodity futures exchange to denote a

market that has been financial and physical settlement capacity. The **LME and SHFE** are terminal markets.
Tolling: A process where an OEM purchases its own primary Aluminium and/or scrap and negotiates a **Conversion Fee** with a fabricator to produce semi-fabricated products. Associated most often with sheet products.
Total Price: The combination of the **Underlying** commodity futures reference price and the regional physical premium. Example, LME cash settlement price plus the CIF Japan premium = total price for Japanese buyers.

U-V-W-X-Y-Z

Underlying: In context of metals, refers to the LME price that underpins all physical metal transactions outside of China.
UBC: Used Beverage Container. Any aluminum container, be it can or bottle which is recovered for reprocessing into new beverage container sheet.
Unpriced: Any physical contract on which the final price has not been established.
VAP: Value Added Product. The same as casthouse products such as **Billet, Foundry Alloy, or Rolling Slab.**
VAT: Value-Added-Tax. Common method of taxation in many countries to tax incremental fabrication revenue. China VAT during 2009-2016 was 16% and was subject to rebate for Chinese semi-fabricators who exported products during this period.
Warrants (LME): A warehouse receipt issued by a listed LME warehouse for metal tendered for delivery. Fully fungible, i.e., has the same value as a bearer bond.
XRT: X Ray Transmission technology is used to sort mixed alloy metals into discrete alloys.
Zorba: The Recycled Materials Association (ReMA) defines this as a shredded mixed non-ferrous metals consisting primarily of aluminium generated by eddy-current separator or other segregation techniques.

A4. LME Primary Aluminum Price



A5. Internal Rates of Returns for Aluminum Primary Smelter Projects

		Power Prices Excluding Transmission Fees in mWh								MISO 2025-2029
		10	15	20	25	30	35	40	45	65.45
Total	3000	13.94%	13.12%	12.29%	11.42%	10.54%	9.62%	8.67%	7.67%	2.90%
CAPEX	4000	10.63%	9.94%	9.24%	8.52%	7.77%	7.00%	6.19%	5.34%	1.65%
In	5000	8.43%	7.83%	7.22%	6.58%	5.92%	5.23%	4.52%	3.77%	0.09%
Billions	6000	6.84%	6.30%	5.74%	5.16%	4.57%	3.94%	3.29%	2.61%	-0.75%
	7000	5.61%	5.11%	4.60%	4.07%	3.52%	2.94%	2.34%	1.70%	-1.41%

To provide perspective, we captured the April 7, 2025, Chicago Mercantile Exchange forward price settlements for the Midcontinent Independent Systems Operator (MISO) Indiana Hub Monthly Price from May 2025 through December 2029. MISO is a not-for-profit organization that manages the distribution of power in 15 states and the province of Manitoba. The average for the period was $65.45 per megawatt hour (MWh).

Internal Rate of Return Calculation on a greenfield 600 MT aluminum smelter at prevailing power prices at the MISO Indiana Hub:

600,000 Metric Ton Smelter	In USD per Metric Ton
Alumina	700
Carbon	300
Power ($65.45 MWh)	858
Power Transmission	131
Labor	295
Other Site Cost	250
Capital Charge	720
Total Cost	**3254**
LME	2650
Midwest Premium	900
Total Revenue	**3550**
EBITDA	296
Annual Total EBITDA	177,531,030
Capital Deployment 2029-2030-2031	$1,666,666,667 x 3 Years = $5,000,000,000
Economic Life	30 Years
Depreciation 30 Year Straight Line	(166,666,667))
Effective Tax Rate of 24%	(2,607,447)
Free Cash Flow	174,923,583
Internal Rate of Return	0.09%

The Aluminum Association