Legislative Analysis for The U.S. Aluminum Industry

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SAFE | CENTER FOR Strategic Industrial Materials

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KEY TAKEAWAYS

- Aluminum is caught in the middle of the clean energy transition—it is a crucial component enabling economy-wide decarbonization, but at the same time is one of the highest emitting industrial materials.
- This clean energy paradox requires equivalent supply and demand-side policies to simultaneously reduce power and transportation sector emissions and emissions of aluminum production.
- Beyond mitigating climate change, a carbon-free aluminum sector creates a lifeline for this vital domestic industry and, thus, preserves U.S. national and economic security.
- Decarbonizing technologies in aluminum smelting can decrease operational costs by 15 percent. Clean energy use in primary production can also reduce electricity costs, as well as shield industry from global energy price volatility.
- Despite the important role aluminum plays and the link between energy, environment, and economic viability of smelters, policy efforts have been unable to address this core challenge; aluminum's ability to decarbonize requires clean energy technologies, but these technologies require cheap and affordable aluminum.
- New U.S. policies on climate, supply chains, and infrastructure increase manufacturing of goods that need aluminum at home. Unfortunately, these demand-side drivers for aluminum outpace the few supply-side investments these policies provide smelters.
- With trillions allocated to transition the U.S. economy away from fossil fuels, U.S. industry will inevitably fill demand for aluminum from somewhere. Whether demand is met with affordable, sustainable, and secure aluminum produced at home or in allied countries, remains up to U.S. policymakers.
- A series of additional reports, examining trade policy options and international best practices, will be produced to guide U.S. policy makers to better access carbon-free aluminum at home and from allied countries.

CONTEXT

The U.S. aluminum industry is at a tipping point. Aluminum has a crucial role to play in the clean energy transition, yet carbon emissions from primary aluminum production detract from this potential. At the same time, long-term challenges to the domestic aluminum industry persist. Chinese primary overproduction suppresses aluminum prices, making it harder for all forms U.S. aluminum to compete. Simultaneously, a lack of abundant, stable, and affordable energy for U.S. smelters is pushing them into decline. SAFE's Center for Strategic Industrial Metals (C-SIM) released a report, *Aluminum's Energy Problem and Energy Solution*, which elucidates how the U.S. clean energy transition is a make-or-break moment for this once thriving domestic industry.

As a global commodity used across multiple industries, aluminum's problems are not stagnant. They evolve with changes to domestic policies and international trade. U.S. policies, actively being rolled out, are shifting the backdrop of the aluminum challenges, and not always for the better. All the while, other aluminum producing countries are dealing with the same China and energy problems, testing different policy responses. C-SIM therefore is putting out a series of reports on how aluminum's energy problem and energy solution are playing out overseas and within a new policy landscape at home. These reports aim to answer the following questions:

- **Legislative Analysis for the U.S. Aluminum Industry** Now with an infrastructure law, a climate law, and other laws clearly linking commodity supply chain weak points to national security threats, where does U.S. aluminum stand? Do these new laws help or hurt the aluminum energy problem?
- **Political Tailwinds: Can Trade Policy Assure U.S. Aluminum Viability?** Domestic politics have sept into aluminum trade policy for the last three administrations. How will the *Global Arrangement on Sustainable Steel and Aluminum* learn from previous attempts to use to trade to remedy these complex issues? Will this trade mechanism provide relief from the energy cost problem and China price problem?
- **Global Insights: Environmental & Energy Aluminum Solutions** How are other countries able to produce aluminum in the face of these shared challenges? What unique energy and climate policies can the United States learn from to help sustain its much-needed primary sector?

The answers to these questions will help industry and government determine an effective pathway forward—a pathway that ensures domestic industry can sustain the sustainability transition. As huge transformational investments shift supply chains and decrease manufacturing and power emissions, it is paramount component parts, like aluminum, are not overlooked. Aluminum is the foundation of our current economy and the fuel for its future energy sources and technologies of the future. The United States needs aluminum, whether it is made here or not. These reports aim to inform how government and industry can come together to ensure the former.

Introduction

SAFE's Report, *Aluminum's Energy Challenge and Energy Opportunity*, sounds the alarm on the growing disparity between U.S. aluminum demand and the ability to ensure existing and future sources of supply are secure. Secondary and imported aluminum will continue to be an important part of the U.S. mix to meet demand. However, more domestic primary is needed to maintain economic and national security, especially as the United States hustles to decarbonize the economy, increasing demand for clean technologies that rely on aluminum.

Unlike other critical minerals necessary for the clean energy transition, primary aluminum has a long history of processing and manufacturing in the United States. However, in the last two decades, U.S. primary production fell from first to ninth globally. Futhermore, the world's top producer, China, now generates 45 times more primary aluminum than the United States. While the United States is not overly reliant on primary processed in China (currently imports of all types of Chinese aluminum sit around six percent), China's overproduction of primary suppresses prices, making it harder for domestic smelters to compete—effectively undercutting downstream and secondary aluminum production in the United States. Less domestic production across segments increases supply chain inefficiencies, as the U.S. market benefits from having the largest customer market at home. Outside the North American market, the next largest countries for U.S. imports are Russia and the United Arab Emirates (UAE).[1]

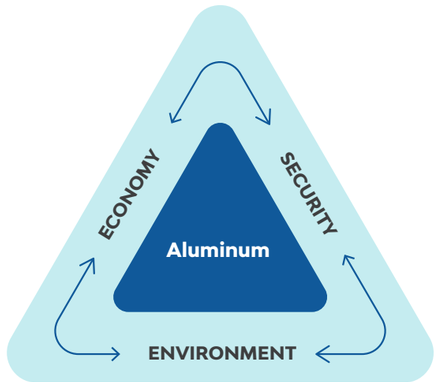
Underlying this geopolitical hurdle of Chinese market distortion, the root of the primary challenge at home is energy. Primary aluminum needs stable, abundant, and affordable sources of energy to ensure smelter viability and economic competitiveness. Countries with ample and cheap energy, like Iceland, Canada, the UAE, and Russia have been able to sustain and even grow primary production in the face of Chinese market flooding. The shift to renewable energy sources, which is accelerating demand for aluminum, can be a source of stable, abundant, and affordable sources of energy for smelters—if the right policies are in place.

Given aluminum exists within an economic, security, and environment prism, policies impacting aluminum crosscut these sectors. This report looks at recently passed laws, specifically the *Inflation Reduction Act* (IRA), the *Infrastructure Investment and Jobs Act* (IIJA), the *CHIPS Act*, and the increased spending authority under the *Defense Production Act Title III* (DPA Title III), in those laws and others. Within these laws, provisions related to climate change, grid deployment, defense, semiconductors, and innovation all impact aluminum. Impacts on aluminum can be divided into two camps: supply-side and demand-side. Demand-side policies are widened beyond direct policies. The IRA domestic content bonus for clean energy tax credits is one example of a direct demand-side policy for aluminum production. From the aluminum use-case perspective, demand-side policies include investments in built infrastructure, funding programs for energy storage, and incentives for domestic clean manufacturing, just to name a few. Because aluminum is widely used in those end products, its demand will grow in turn. The laws examined in this report are filled with demand-side policies for aluminum as a component.

There are some supply-side policies for aluminum production in these laws. These policies include manufacturing tax credits and grants for metals and minerals production and processing. However, the support they provide is contingent on decarbonization and funding is highly competitive. All the while, U.S. smelters struggles to stay afloat due to the cost of electricity. The domestic industry is entangled in a clean energy paradox where it cannot deliver on new demand for solar panels, electric vehicles (EVs), and grid

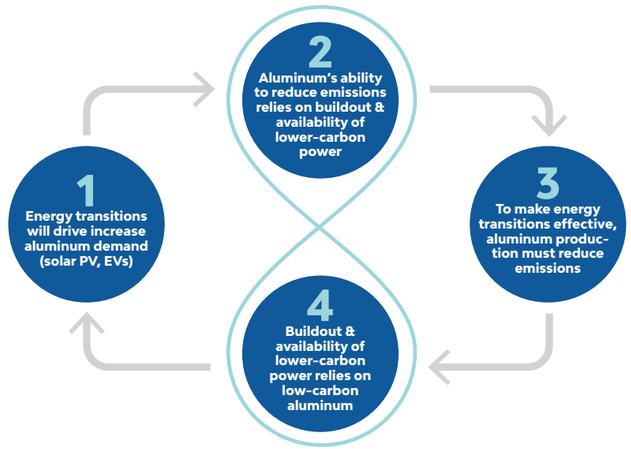
The United States is the largest customer market for aluminum products.

Figure 1 Aluminum's Role



Source: SAFE Analysis.

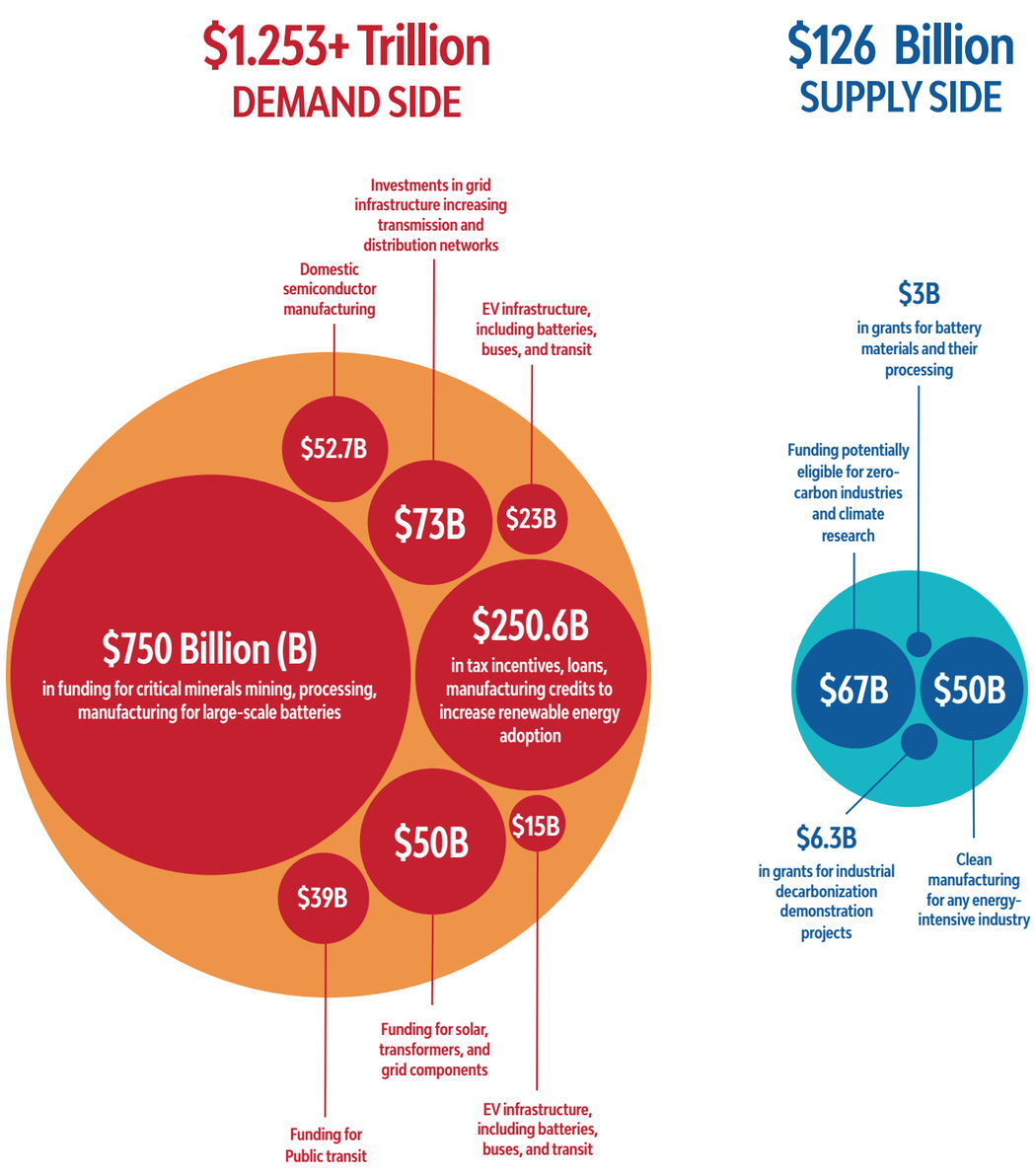
Figure 2 Aluminum's Energy Transition Circularity



Source: Wood Mackenzie, 2021.

1 USGS, Minerals Commodities Summaries 2022 - Aluminum, January 31, 2022.

Figure 3 Demand- Versus Supply-Side Opportunities in Recent U.S. Legislation



Sources: SAFE analysis based on the provisions of the Inflation Reduction Act of 2022 (H.R. 5376), CHIPS Act of 2022 (H.R. 4346), and Infrastructure Investment and Jobs Act of 2021 (H.R. 3684).

The 117th Congress passed major legislative packages with cross-sectoral impacts on aluminum.

infrastructure, because the cost of its own production—namely energy use—is too high.

The United States must reconcile that the current policy framework, while increasing resilient, domestic, and low-carbon supply chains, threatens to leave its own aluminum industry behind. The current approach neglects to recognize aluminum's clean energy transition circularity; the rate at which the aluminum industry can reduce emissions at scale is a function of the buildout and availability of lower-carbon energy sources, which itself, is a function of the use of low-carbon aluminum (Figure 2). By setting the decarbonization conditionality for supply-side support and simultaneously increasing demand across multiple sectors, the United States entraps itself in this cycle. There is hope the United States can produce clean and competitive aluminum with the right policies in place. With a resilient primary sector powered by green energy, the United States also ensures the security, efficiency, and sustainability of its grid, EV market, and defense products.

Figure 3 emphasizes the asymmetry between the many policies increasing aluminum demand and the few aiding U.S. aluminum's production challenges. C-SIM's seminal report, *Aluminum's Energy Problem and Energy Solution,* stresses the need for policymakers to view aluminum holistically in terms of its contributions to a transitioning economy. *Legislative Analysis for the U.S. Aluminum Industry* goes onto prove current domestic policies only widen the chasm between the nation's need for aluminum and access to secure supply.

Supply-side policies here are policies directly related to aluminum's primary production phase in the United States. Whereas demand-side policies are predominately indirect policies driving up the need for aluminum in its use-case. They can be supply-side policies for other domestic manufactured goods that need aluminum as a component part.

Evaluation of Recent U.S. Domestic Policy Actions

The Biden-Harris administration confronted several supply chain, economic, and environmental challenges since entering office and have since signed into law nearly $2 trillion in domestic-focused policies to address these problems. Given its cross-sectoral criticality, aluminum is impacted by policies in the IRA, IIJA, recent DPA Title III authorizations, and CHIPS Act.

Figure 4 Recent United States Domestic Policy Actions

IRA	IIJA	DPA Title III	CHIPS
Inflation Reduction Act of 2022	Infrastructure Investment & Jobs Act of 2021	Defense Production Act Title III, 2022 Invocations	CHIPS and Science Act of 2022
$369B	$1.2T	$750M	$278B

Source: SAFE Analysis.

With almost $370 billion in spending, the IRA predominately tackles the climate crisis.[2] The IRA begins to tackle the primary aluminum energy challenge, providing supply-side and demand-side opportunities. This law also touches upon aluminum's China problem, with certain requirements to wean out Chinese minerals mined and processed for electric vehicles (EVs).

The IIJA injects the economy with $1.2 trillion for transportation, buildings, energy production, grid modernization, and more.[3] Like the IRA, the IIJA contains clean energy provisions, which will drive aluminum demand and aid production. As new and revitalized built infrastructure is rolled out, more supply-side aluminum policies will be needed to meet demand.

In response to growing concerns over secure domestic supplies, President Biden invoked DPA Title III on two separate occasions in 2022, once for critical minerals for batteries[4] and once for multiple clean energy technologies.[5] While aluminum is a critical mineral used in batteries and a major input in several clean energy technologies, the DPA Title III has not been leveraged expressly for aluminum since the 1950s. However, through legislative vehicles like the *National Defense Authorization Act* (NDAA), Congress has considered the DPA Title III path for aluminum.

Alleviating global supply chain pressures from the semiconductor shortage was the main impetus of the 2022 passage of the CHIPS Act. Yet, this reshoring effort exposes new supply chain hurdles. As the $57.2 billion in funding to catalyze domestic production of semiconductors is allocated, new U.S. producers will need stable access to input materials, like high-purity aluminum.[6] Beyond catalyzing domestic semiconductor manufacturing, the law expands R&D and commercialization of new technologies, including clean energy.[7] Given the similarities between semiconductors and aluminum in terms of the recent fall of domestic production and the resulting impacts on economic and national security, it could be considered a model for revitalizing the aluminum sector.

2 SAFE analysis based on the provisions of the Inflation Reduction Act of 2022 (H.R. 5376), 2022.

3 Ibid.

4 Congressional Research Service, "2022 Invocation of the Defense Production Act for Large-Capacity Batteries: In Brief," May 27, 2022.

5 The White House, "FACT SHEET: President Biden Takes Bold Executive Action to Spur Domestic Clean Energy Manufacturing," June 6, 2022.

More supply-side aluminum policies will be needed to meet growing aluminum demand.

Inflation Reduction Act

The Inflation Reduction Act bears opportunities for the U.S. aluminum sector. Several provisions enable stronger domestic supply and demand. The law includes billions of dollars for new grants, loans, and tax credits that could help U.S. aluminum smelters cut costs, boost efficiency, reduce emissions, and increase global competitiveness. At the same time, the law boosts demand through driving growth in solar power, EVs, batteries, etc. that use clean U.S. aluminum.[8]

While IRA policies hit at the core of aluminum's clean energy paradox, generating clean technologies that need aluminum while concurrently enabling aluminum's decarbonization, they are not a panacea. There are limits to aluminum's ability to capture all the benefits the IRA presents. Further, the availability of clean energy does not necessarily equate to clean energy use for smelters. Additional government to industry coordination and support is needed.

6 Vishnu Kannan and Jacob Feldgoise, "After the CHIPS Act: The Limits of Reshoring and Next Steps for U.S. Semiconductor Policy," Carnegie Endowment for International Peace, November 22, 2022.

7 McKinsey & Company, "The CHIPS and Science Act: Here's what's in it," October 4, 2022.

8 See, e.g., Inflation Reduction Act of 2022 (H.R. 53760), August 16, 2022.

Supply-Side Policies

The IRA has more than $50 billion for clean manufacturing. This funding includes a new manufacturing production tax credit (45X), an expanded investment tax credit (48C), and a new program for emissions-reductions at energy-intensive industrial facilities.

Production Tax Credit for Advanced Manufacturing

The IRA's 45X tax credit encompasses advanced manufacturing for solar, wind, batteries, and critical minerals. The critical minerals portion of this production tax credit directly impacts aluminum supply. The next section will touch on 45X's use for solar, wind, and batteries, which drive demand for aluminum.

High-purity aluminum, which is a grade of aluminum with limited impurities, is eligible for the 45X credit.[9] As such, high-purity producers can receive a credit for 10 percent of production costs starting in 2023. If applied, this tax credit could help alleviate the United States' cost disadvantage in the aluminum sector.

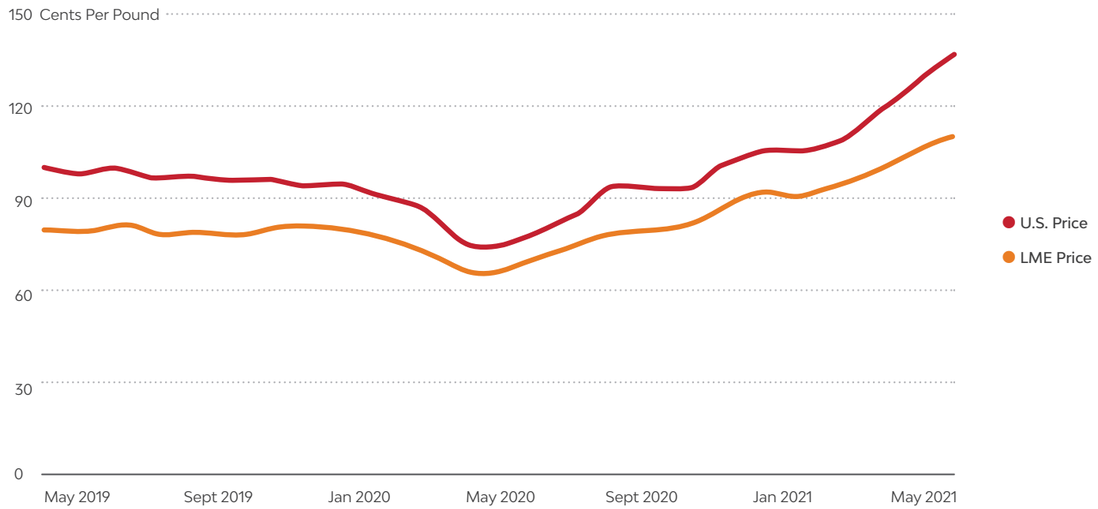
Cutting production costs are particularly critical given the 15-25 percent sustained premium U.S. aluminum endures (see Figure 5).[10] Due to higher electricity costs, which account for 40 percent of primary costs, U.S. production is more expensive. In the United States it costs about $1,600 to produce one ton of aluminum, compared to about $1,500 per ton in China.[11] U.S.-produced aluminum is priced higher than aluminum produced elsewhere in the world.

9 Bloomberg Tax, "Sec. 45X. Advanced Manufacturing Production Credit."

10 USGS, Mineral Commodity Summaries 2021, January 31, 2021.

11 Bloomberg New Energy Foundation, "Decarbonizing Aluminum: Technologies and Costs," 2021.

Figure 5 Average Price of Aluminum (U.S. cents per pound)



Source: USGS, 2021

While the 45X credit is permanent for aluminum, it has limitations. This specificity of high-purity aluminum confines access to certain producers; only one U.S. smelter produces high-purity currently, and it is curtailed due to high energy costs.[12] Further, it does not get at the crux of primary's challenge. It cuts costs but it doesn't alleviate the reason costs are high: energy.

Expanded Investment Tax Credit & Industrial Emissions Reductions Program

In addition to creating the Advanced Industrial Facilities Deployment Program within the U.S. Department of Energy, the IRA includes the 48C expanded investment tax credit. Together these provisions can generate supply-side relief for energy-intensive industrial facilities. 48C can cover up to 30 percent of investment costs of smelters incorporating energy efficiency and emissions reductions technologies.[13] The IRA's Advanced Industrial Facilities Deployment Program includes $5.8 billion in loans and grants for transformational technologies to decrease emissions.[14] With aluminum production contributing to roughly 2 percent of global greenhouse gases, it is no surprise this statute includes aluminum.[15]

Support to upgrade smelters is critical since smelter age is another reason why U.S. primary production lags and faces higher costs. The average smelter age in the United States is 62 years, compared to China's much younger and energy efficient fleet built out over the last two decades. Innovative emissions-reduction technologies have been proven to cut operations costs. One example is a process called ELYSIS, which leverages an inert anode, made of ceramic material, instead of the traditional carbon-based anode in the smelting process. As a result, oxygen is emitted instead of instead of carbon dioxide in the electrolysis process.[16] Beyond reducing primary production emissions by 13 percent, these inert anodes have a longer lifespan and thereby can decrease primary production costs by 15 percent.[17] ELYSIS is a prime example of the type of innovations the emissions reductions program is targeting.[18]

There are impediments to leveraging these policies. The $10 billion for 48C, casts a wide net for eligibility. Fuel cells, microturbines, grid modernization equipment, and any facility producing energy from sun, water, wind, or geothermal deposits, can access this credit—making 48C more like a competitively awarded grant than a credit. Almost half of these funds target coal communities, leaving less room for aluminum producers to access the credit (three out of seven smelters are in coal communities). These stipulations limit an even smaller pot of funding to reduce emissions in the aluminum sector. Including electricity emissions, aluminum's decarbonization is priced at $1 trillion globally.[19]

Additionally, even though technologies like inert anodes are well aligned with the emissions reductions program, the United States is not the priority destination for deployment of these technologies. Canada has been driving investment in R&D for ELYSIS, so Rio Tinto's Alma smelter in Québec will be the first installation site to deploy an inert anode at commercial scale.[20] U.S. smelters use more fossil fuels than Canadian smelters, which rely exclusively on hydroelectricity.[21] While all types of smelters can theoretically be retrofitted with the inert anodes, their application in older inefficient smelters still reliant on coal and natural gas is counterintuitive. Domestic primary producers should first reduce emissions from their energy use to then attract this decarbonizing technology for their smelting process and be able to fully capitalize on any green premiums for aluminum on the global market.

Electrolysis

Aluminum is created through the Hall-Heroult (electrolysis) process involving alumina and anodes. First, alumina is dissolved in a cryolite bath inside carbon-lined cells, called pots. Then, an electric current run through the bath, separating aluminum metal from the chemical solution. Carbon is emitted.

Source: American Chemical Society, 2001

12 Century Aluminum, "Century Aluminum to Temporarily Idle Its Hawesville Smelter Due to Soaring Energy Prices; Issues WARN Notice to Employees," June 22, 2022.

13 BlueGreen Alliance, "Summary of Key Policy Provisions: Clean Technology Manufacturing."

14 John Larsen et al., "US Decarbonization Priorities in the Wake of the Inflation Reduction Act," Rhodium Group, February 9, 2023.

15 William A. Reinsch and Emily Benson, "Decarbonizing Aluminum: Rolling Out a More Sustainable Sector," Center for Strategic & International Studies, February 25, 2022.

16 American Chemical Society National Historic Chemical Landmarks, "Production of Aluminum: The Hall-Héroult Process," November 2, 2001.

17 ENPOT (2020), Aluminum Production Pathway to Zero Carbon 2050, p.13.

18 Bloomberg New Energy Foundation, "Decarbonizing Aluminum: Technologies and Costs," 2021.

19 Congressional Research Service, U.S. Aluminum Manufacturing: Industry Trends and Sustainability, October 26, 2022.

20 Anthony Everiss, "Emission Control Accelerates Pace of Inert Anode Development," CRU Group, July 12, 2021.

21 Investissement Québec, "The Greenest Aluminum in the World," 2022.

Low Carbon Aluminum

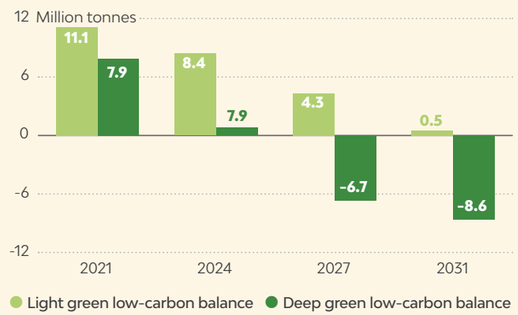
Green premiums are not a market reality currently, but aluminum companies are positioning themselves for a future where they reign. Analysis from the CRU Group shows low-carbon aluminum branding is on the rise. Marketing campaigns to distinguish between underlying carbon-profiles of an otherwise homogenous metal is a response to emissions reductions goals of end users. CRU found the packaging and automotive sectors, which represent the 29 and 16 percent of global aluminum demand respectively, were the most committed to emissions reduction goals.[22] As a result, low-carbon aluminum surpluses are diminishing. Figure 6 forecasts two scenarios—a deep green low-carbon aluminum demand scenario and a light green low-carbon balance scenario. In both cases, low-carbon aluminum supply decreases due to rising demand. The introduction of carbon tariffs and carbon border adjustments will further reward cleanly produced aluminum.[23]

Despite the low-carbon aluminum trend and the supply-side opportunities in the IRA, decarbonization is a luxury at this point for U.S. smelters. Struggling with high and volatile electricity costs, skilled labor shortages, and aging facilities, U.S. aluminum producers' priority is maintaining business as usual. In this current reality, highly competitive emissions programs and complex incentives may take a backseat.

22 Guillaume Osouf, "Consultation for a proposed low carbon premium methodology," CRU Group, June 2022. and Natural Resources Canada, "Aluminum Facts," February 24, 2023.

23 Guillaume Osouf, "Consultation for a proposed low carbon premium methodology," CRU Group, June 2022.

Figure 6 Low Carbon Aluminum Remains in Surplus Globally, But This Is Changing Quickly



Source: The CRU Group, 2022

Demand-Side Policies

The IRA's incentives for domestic clean energy manufacturing, electricity, and transportation will contribute to major demand growth for aluminum. From its reflexivity to its light weight, this metal contains several qualities vital to these technologies. Therefore, as IRA incentives drive production and use of solar PV, energy storage, and battery electric vehicles (BEVs), aluminum's demand will grow commensurately. Global demand forecasts for aluminum are highest in the transportation (35 percent) and electrical sectors (16 percent) and the shift away from internal combustion engine (ICE) vehicles and fossil fuels for electric power are cited as the major reasons for those increases (see Figure 7).[24]

Electricity Incentives

The IRA reintroduces and rebuffs production tax credits for renewable electricity production and investment, specifically through Sec. 45's production tax credit and Sec. 48's investment tax credit. These credits are collectively worth over $127 billion but cannot be layered. Through incentivizing clean electricity, they boost demand for clean energy technologies that need aluminum. Producers also can gain bonus credits if projects meet wage and apprenticeship requirements, are in energy communities, and use domestic iron and / or steel. These credits remain in effect until 2032 or when CO_2 emission targets are achieved.[25]

24 The CRU Group, "Opportunities for aluminium in a post-Covid economy," January 28, 2022.

25 Dentons, "Inflation Reduction Act at a Glance—Everything You Need to Know," August 10, 2022.

The global consulting firm, ICF's Climate Center, found the IRA's Sec. 45 and Sec. 48 credits make clean energy more cost competitive. Solar's levelized cost is expected to decrease 20-35 percent by 2030 and wind's 38-49 percent.[26] Lower relative clean energy costs are a boon for aluminum. The World Bank predicts the vast majority (87 percent) of clean energy-related aluminum demand by 2050 comes from solar PV.[27] Wind and energy storage will play a role in spurring demand growth, accounting for 9.7 percent and 1.2 percent of clean energy-related aluminum demand by 2050 respectively.[28]

An important caveat, transmission build out, which depend on aluminum, must keep pace with renewable energy deployment for the IRA to reach its full emissions reduction potential. The U.S. high-voltage transmission network needs to grow 2.3 percent a year to meet IRA CO_2 reduction goals and achieve the wind, solar, and energy cost reductions the ICF report lays out.[29] If successful, transmission build out will drive aluminum demand. The final version of the IRA did not include a transmission tax credit, but it did include $2 billion for loans for electric transmission facilities if they receive a special designation.

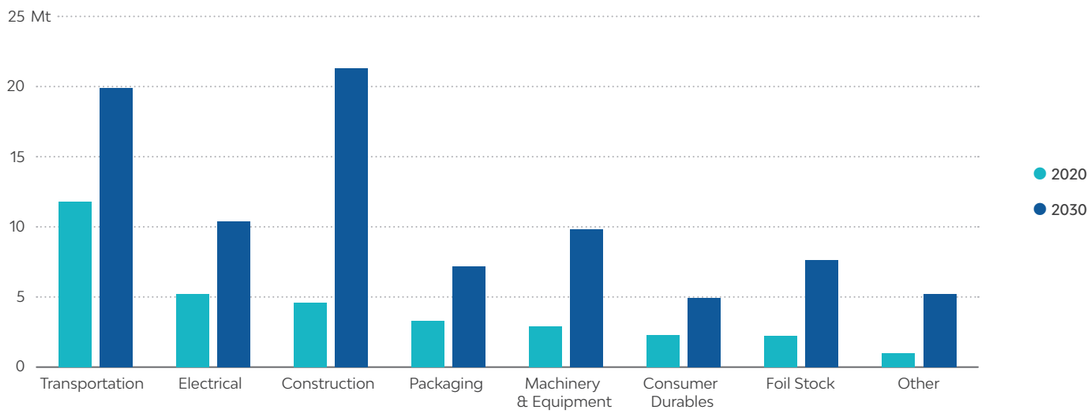
26 Ian Bowen et al., "How Clean Energy Economics Can Benefit from the Biggest Climate Law in US History," ICF Climate, September 16, 2022.

27 Kirsten Hund et al., Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition, World Bank Group, 2020.

28 Ibid.

29 Jesse Jenkins et al., "Electricity Transmission is Key to Unlock the Full Potential of the Inflation Reduction Act," REPEAT Project, September 2022.

Figure 7 Aluminum Semi-Finished Products Consumption, 2020 vs. 2030, Mt



Source: The CRU Group, 2022

Production Tax Credit for Advanced Manufacturing

Returning to 45X, aluminum demand will grow indirectly through the increased domestic manufacturing of clean technologies. Table 1 highlights aluminum's use in all these components. It is for this reason the World Bank considers aluminum a "high-impact and cross-cutting mineral."[30]

Table 1 Aluminum Uses in 45X Eligible Components

45X eligible component	Aluminum use
Solar	• In frames and inverters, making up 85 percent of solar PV components • 87 percent of energy-related aluminum demand
Batteries / Energy Storage	• In cathode of nickel-cobalt-alumina batteries, aluminum-ion batteries in development • 1.2 percent of energy-related aluminum demand
Wind Energy	• In the tower platform components and turbines • 9.7 percent of energy-related aluminum demand

Source: World Bank, 2020 and The Aluminum Association, 2022.

Clean Vehicle Tax Credits and Grant for Heavy Vehicles

The clean vehicle tax credits and grant for clean heavy vehicles have a similar story in driving aluminum demand as a component part. EVs use 42 percent more aluminum per vehicle (643 pounds) than non-EVs (459 pounds), while all-electric buses are estimated to use 230 percent more aluminum per vehicle than traditional buses.[31] New EVs are incentivized through a $7,500 credit (30D) and old EVs through a $4,000 credit (25E).[32] In addition to passenger vehicles, the law provides a 30 percent credit for new clean commercial EVs (45W) and creates a $1 billion grant for clean heavy-duty vehicles.[33]

Uniquely, 30D considers where extraction, processing and/or manufacturing of key material inputs takes place. It introduces provisions not only stimulating North American and allied production of these EVs, their batteries, and battery components,

30 Ibid.

31 Jinlong Wang, "Geared for Growth," Recycling Today, May 2021; Muyi Yang, "As Aluminium Surges in China, so Do Carbon Emissions," Ember, February 7, 2021.

32 Dentons, "Inflation Reduction Act at a Glance—Everything You Need to Know," August 10, 2022.

33 Ibid.

Foreign Entity of Concern

The IRA and other laws include provisions excluding foreign entities of concern from accessing credit benefits. A foreign entity of concern is defined as a foreign entity that is:

- Designated as a foreign terrorist organization;
- Included on the list of specially designated nationals or blocked persons;
- Owned by, controlled by, or subject to the jurisdiction or direction of a government of a foreign country that is a covered nation;
- Alleged to be involved in activities for which a conviction was obtained; or
- Determined to be engaged in unauthorized conduct that is detrimental to U.S. national security or foreign policy.

Source: Cornell Law, 2022

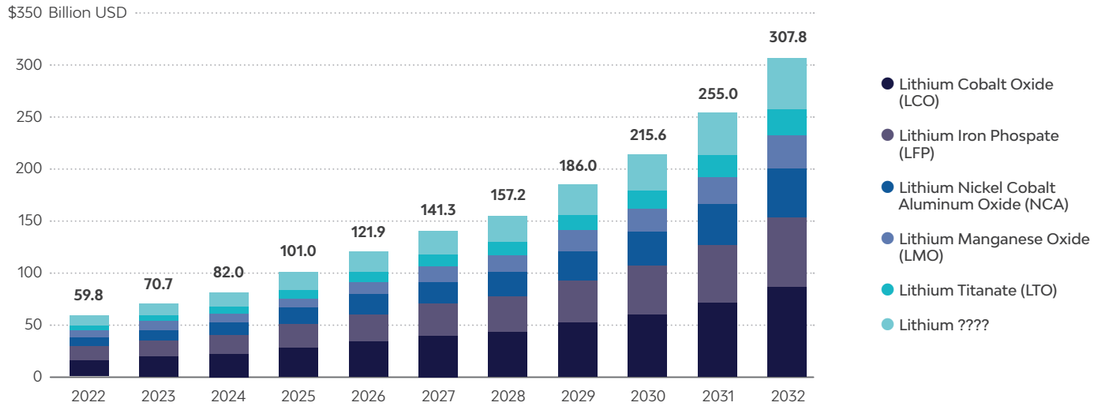
but also deterring sourcing from adversarial countries across the EV supply chain. More specifically, the credit is bifurcated into $3,750 for vehicles satisfying domestic content requirements for critical minerals in the batteries and $3,750 for vehicles satisfying domestic content requirements for battery components.[34] These domestic content requirements include countries with which the U.S. has a Foreign Trade Agreement and exclude "foreign entities of concern." Recognition of the implicit security and economic challenges of U.S. overreliance on non-allies in the clean energy transition is an important step towards reconciling today's aluminum's challenges.

Aluminum is used in some battery chemistries—namely the cathode in a nickel-cobalt-aluminum oxide (NCA) battery—and thereby directly eligible to benefit from the 30D credit. Aluminum's use here over manganese, which is used in the more common nickel-cobalt-manganese battery, is said to increase the battery lifespan. Energy-dense NCA batteries have been around for over a decade, used in older Tesla models, and are expected to modestly grow in market share going forward (see Figure 8).[35]

34 SAFE analysis based on the provisions of the Inflation Reduction Act of 2022 (H.R. 5376), 2022.

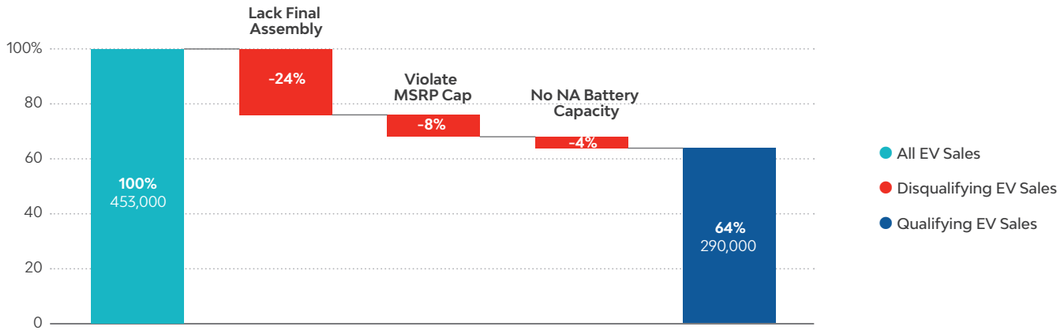
35 Henry Man, "What are LFP, NMC, NCA Batteries in Electric Cars?," February 19, 2023

Figure 8 Global Lithium Ion Battery Market, size, by product 2022-2023



Source: Market.US, 2023

Figure 9 1H 2023 Qualifying EV Sales Under IRA Credits



Source: BloombergNEF, 2022.

Indirectly, aluminum demand correlates with EV adoption; EVs leverage aluminum's light weight largely in other vehicle parts, such as doors, hoods, etc. Lighter vehicles help maximize heavy battery range. With the U.S. EV market expected to accelerate by 20 percent from the IRA, aluminum demand will grow in turn.[36]

The picture is not all bright. Because of the credit's domestic sourcing stipulations, few vehicles currently qualify for the credit; BloombergNEF estimates 64 percent of vehicles sold in the first half of 2023 would qualify, but only for a portion of the credit (see Figure 9).[37] It will take time for supply chains to reroute to the United States and allied countries and for the workforces in those countries to develop expertise needed to process eligible minerals and build batteries. 80 percent of U.S. imports of lithium-ion batteries came from China in the fourth quarter of 2021.[38] This reliance emphasizes the grip China has on the current battery manufacturing market. China is a covered nation under the "foreign entity of concern" definition, meaning companies affiliated with China are actively excluded from these tax credit benefits.

36 Bloomberg New Energy Foundation, "Zero-Emission Vehicles Fact-book," November 2022.

37 Bloomberg New Energy Foundation, "Zero-Emission Vehicles Fact-book," November 2022.

38 Panjiva, Garrett Hering, "US Lithium-ion Battery Imports Surge as Auto, Energy Sectors Race to Meet Demand," S&P Global Market Intelligence, February 25, 2022.

Infrastructure Investment and Jobs Act

The $1.2 trillion IIJA, with $550 billion in new funding, made history as the nation's largest infrastructure package. It is also notable for qualifying the grid as traditional infrastructure for the first time and infusing climate policy in what is typically a surface transportation package. Similar to the IRA, it includes both supply- and demand-side impacts for aluminum. The IIJA has an industrial decarbonization opportunity supporting supply, whereas the demand-side is strongly linked to transmission build out and electrification of transport.

Supply-Side Policies

Creation of the Office of Clean Energy Demonstrations

The IIJA provides $6.3 billion dollars in grants to establish demonstration projects that reduce industrial emissions.[39] Again, aluminum, which producing one ton of emits more carbon than burning five tons of oil, is listed as eligible for these grants.[40] The benefits and challenges of this grant are the same as those mentioned in the Advanced Industrial Facilities Deployment Program (see previous section). Here aluminum producers are competing with iron, steel, cement, concrete, glass, pulp, paper, chemicals, and industrial ceramics.[41] Table 2 stresses how much more investment is needed to decarbonize all these sectors globally. Further, Figure 10 exposes aluminum's smaller sliver of emissions, compared to other eligible materials.

Eligible materials, while in some cases contributing more to emissions, are not facing the same economic challenges as the domestic aluminum sector. With one U.S. smelter fully closing and two curtailing in 2022 due to energy price increases and labor shortages, it is clear how vulnerable domestic industry is presently. U.S. producers are trying to survive another year, making it harder to capitalize on grant opportunities.

Battery Material Processing Grant Program

With $3 billion in grants for battery materials and their processing, the IIJA presents a highly competitive opportunity for aluminum and alumina producers. As mentioned in the previous section, some EVs leverage the precursor to aluminum, alumina or aluminum oxide, in the cathodes of their lithium-ion batteries. For example, Tesla previously shifted to nickel-cobalt-aluminum oxide cells to reduce cobalt usage in batteries, as cobalt mining has been linked to unsafe working conditions and child labor in the Democratic Republic of Congo.[42] Though, in 2021 Tesla took the pivot away from cobalt a step further and committed

39 Office of Clean Energy Demonstrations, "Industrial Decarbonization Program," 2021.

40 Archy de Berker, "Understand Your Aluminum Emissions," Carbon Chain, 2022.

41 See, e.g., Jesse Jenkins et al., "Electricity Transmission is Key to Unlock the Full Potential of the Inflation Reduction Act," REPEAT Project, September 2022.

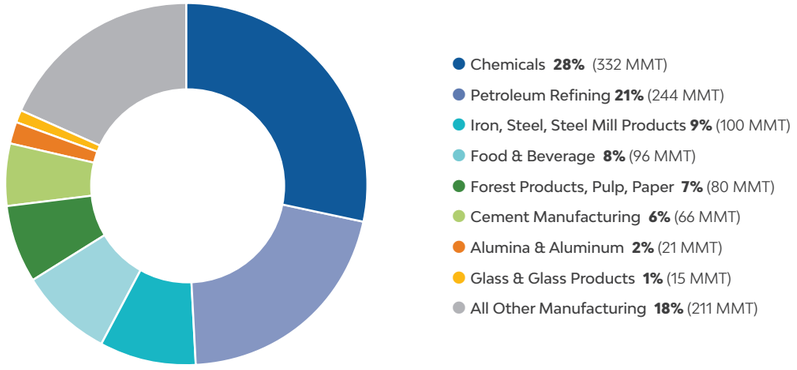
42 Scott K. Johnson, "Here's What Tesla Will Put in its New Batteries," Ars Technica, September 24, 2020.

Table 2 Competition Amongst Eligible Materials for IIJA Decarbonization Program

Eligible Materials	Cost of Global Decarbonization (USD)	Percent Global CO_2 Emissions	Global CAGR (2022-2030)
Aluminum	$1 trillion[i]	2-3%[ii]	5.6%[iii]
Steel & Iron	$1.4 trillion[iv]	11%[iv]	5.1%[v]
Cement / Concrete	$410 billion[vi]	7-8%[vii]	4.7%[viii]
Glass	N/A	0.3%[ix]	5.2%[x]
Pulp & Paper	N/A	0.8%[xi]	4%[xii]
Chemicals	$759 billion[xv]	2% [xiii]	5.6%[xiv]

Sources: i.Eric Onstad, "Aluminum sector needs $1.5 trillion to decarbonise power," Reuters, October 26, 2021. ii.Ali Hasanbeigi, "Steel Climate Impact," Global Efficiency Intelligence, April 7, 2022. iii.Precedence Research, "Aluminum Market—Global Industry Analysis, Size, Share, Growth, Trends, Regional Outlook, and Forecast 2022-2030," September 2022. iv.Malan Wu et al., "Pedal to the Metal: Iron & Steel's $1.4 Trillion Dollar Shot at Decarbonization," Wood Mackenzie, September 2022. v. Grand View Research, "Iron And Steel Market Size, Share & Trends Analysis Report By Application, By Region, And Segment Forecasts, 2022—2030," 2023. vi.Ankit Kalanki and Dongyi Wang, "Bringing Low-Carbon Cement to Market," Third Derivative, June 30, 2022. vii.WTTW, "Cement Carbon Dioxide Emissions Quietly Double in 20 Years," June 22, 2022. viii.Precedence Research, "Aggregates Market—Global Industry Analysis, Size, Share, Growth, Trends, Regional Outlook, and Forecast 2022-2030," June 2022 ix.Coenraad D. Westbroek et al., "Global material flow analysis of glass," 2021. x.Grand View Research, "Glass Manufacturing Market Size, Share & Trends Analysis Report By Application, By Region, And Segment Forecasts, 2022-2030," 2023. xi.Precedence Research, "Pulp and Paper Market—Global Industry Analysis, Size, Share, Growth, Trends, Regional Outlook, and Forecast 2022-2030," June 2022. xii. Wenke Bengtsson et al., "Decarbonizing the chemical industry," McKinsey & Company, April 12, 2023. xiii. Acumen Research and Consulting, "Chemical Distribution Market Forecast, 2022-2030," February 15, 2023.

Figure 10 U.S. Primary Energy- and Process-Related Emissions (MMT CO_2e) for Manufacturing Product Industries



Source: U.S. DOE Energy Information Administration, 2018

to deploying cobalt-free lithium-iron-phosphate (LFP) batteries in their standard vehicles.[43]

Aluminum has key functions beyond the cathode of the battery. It can be used as battery housing or cell casing. Use of aluminum alloy here can reduce the weight of a battery pack by 10-30 percent compared to steel.[44] This feature is critical to cost reductions and efficiency gains for EVs, to be discussed further in the next section. Aluminum and steel are also used as current collectors in the battery. Together with its roles encasing the batteries and collecting the current and along with aluminum oxide's use in NCA anodes, aluminum represents 18.9 percent of the weighted average of battery compositions in the 2020 market (see Table 3).[45]

Finally, academics across the world are looking to leverage aluminum's versatile benefits in new batteries. Researchers out of the Massachusetts Institute of Technology (MIT) promise a cheaper and less flammable aluminum-sulfur battery best applied for energy storage.[46] The graphene aluminum-ion battery cell, out of the University of Queensland, allegedly charges "60 times faster than the best lithium-ion cells," in addition to holding "three times the energy of the best aluminum-based cells."[47] Despite these gains, neither technology is commercially viable to the point where U.S. aluminum producers could benefit from these grants.

With the current state of aluminum use in batteries, the first $2.8 billion tranche of these grants thereby focused on building up lithium, graphite, nickel, and silicon production in the United States.[48] Graphite and lithium have an even smaller processing footprint in the United States and globally, compared to aluminum. Meanwhile, the demand for those two minerals is so high, the World Bank finds production would have to "ramp up nearly 500 percent by 2050" to meet climate commitments.[49] Outsized government support needed to process these minerals for the clean energy transition overshadows aluminum's use in the battery space.

Beyond the inter-material competition, the money available is limited. One Charge released a recent white paper which found that to catch up with China's battery production, the United States needs to invest $175 billion in the next three years.[50] The $3 billion pool for a variety of needed materials is a drop in the bucket. It costs at least $1 billion to build a greenfield aluminum smelter and the IIJA battery materials grants for new facilities are capped at $100 million. Together with the other hurdles mentioned, it is therefore unlikely these grants will be used for any U.S. aluminum production.[51]

That aside, the battery grants in the IIJA laid the foundation for the "foreign entities of concern" portion of the 30D clean vehicle tax credits in the IRA. The IIJA limits the scope of the grants to outside these countries to ensure a secure supply chain.[52] This precedent setting is critical for the future of the domestic aluminum industry. As the United States reshores manufacturing and sees demand for material inputs rise, overdependence on unreliable or unstable sources could hamper the efficiency and security of a clean energy transition.

Demand Side Policies

Electrical Transmission and Distribution

The IIJA contains $73 billion in electric infrastructure funding.[53] This investment enables the clean energies the IRA incentivizes to connect to the grid. As the "most widely used material in modern electricity transmission and distribution systems," aluminum is key to the build out of electric networks.[54] It is employed in cabling for high-power transmission, as well as controls, like electronic components and heat sinks.[55]

To accommodate the Biden-Harris 2050 net zero goal, transmission infrastructure must at least double or maybe triple.[56] The IIJA establishes a $2.5 billion revolving loan fund to increase transmission capacity, efficiency, resiliency, and reliability. On top of that, another $500 million is allocated for state energy programs, with a transmission and distribution planning requirement.[57]

Coupled with the IRA clean electricity incentives and modest transmission funding, IIJA-funded transmission and distribution development is more feasible. However, perennial siting and permitting issues delay grid build out. While the IIJA bolsters the federal government's backstop authority in permitting grid infrastructure, more is needed to overcome these challenges and ultimately construct millions of miles of overhead transmission lines with aluminum conductors and wiring. Already, the World Bank estimates 4.7 tons of aluminum are used per mile of transmission and distribution lines today. By 2030, grid lines will increase 80 percent globally.[58]

Table 3 How Battery Chemistries Differ, by Mineral Content (60KWH Lithium Ion Battery)

Mineral	Cell Part	Amount Contained in the Avg. 2020 Battery (kg)	% of Total
Graphite	Anode	52kg	28.1%
Aluminum	Cathode, Casing, Current collectors	35kg	18.9%
Nickel	Cathode	29kg	15.7%
Copper	Current collectors	20kg	10.8%
Steel	Casing	20kg	10.8%
Manganese	Cathode	10kg	5.4%
Cobalt	Cathode	8kg	4.3%
Lithium	Cathode	6kg	3.2%
Iron	Cathode	5kg	2.7%
Total	**N/A**	**185kg**	**100%**

Source: Visual Capitalist, 2023

43 Michael Wayland, "Tesla will change the type of battery cells it uses in all its standard-range cars," CNBC, October 20, 2021.

44 EMP Tech Co., Ltd, "The Lightweight of Aluminum Die-Casting Battery Housing," 2022.

45 Govind Bhutada, "The Key Minerals in an EV Battery," Visual Capitalist, May 2. 2022.

46 David L. Chandler, "A New Concept for Low-cost Batteries," MIT News, August 24, 2022.

47 Michael Taylor, "Developer of Aluminum-Ion Battery Claims it Charges 60 Times Faster than Lithium-Ion, Offering EV Range Breakthrough," Forbes, May 13, 2021.

48 Green Car Congress, "DOE Awarding $2.8B to 21 Projects to Boost Minerals Output for Batteries," October 20, 2022.

49 Kirsten Hund et al., Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition, World Bank Group, 2020.

50 OneCharge, "U.S. Role in Global Lithium Battery Manufacturing," January 7, 2022.

51 Office of Energy Efficiency & Renewable Energy, "Notice of Intent to Issue Funding Opportunity Announcement No. DE-FOA-0002678," 2022.

52 Lance T. Brasher et al., "Part II / Infrastructure Investment and Jobs Act: A Guide to Key Energy and Infrastructure Programs and Funding," Skadden, September 6, 2022.

53 Kroll Institute, "Bipartisan Infrastructure Investment and Jobs Act Guide," 2021.

54 The Aluminum Association, "Aluminum Association Encouraged by Bipartisan Infrastructure Package Framework," June 24, 2021.

55 Deanne Toto, "Aluminum to Benefit from Infrastructure Bill," Recycling Today, November 12, 2021.

56 Eric Larson et al., "Net Zero America: Potential Pathways, Infrastructure, and Impacts," Princeton University, October 29, 2021.

57 Rachel Smith, "The Grid Wins Big in the IIJA," Bipartisan Policy Center, September 23, 2021.

58 International Energy Agency, "The Role of Critical Minerals in Clean Energy Transitions," March, 2022.

EVs, Batteries, and Charging

The IIJA is lauded for its significant funding to electrify the transportation industry, with:

- $5 billion for a nationwide network of 500,000 EV charging stations
- $10.9 billion for low- and zero-emission buses & ferries
- $3 billion battery manufacturing and recycling grants[59]

These funding pathways directly and indirectly enable more EVs of all sizes to hit the roads. More charging access, increasingly affordable U.S.-made batteries, and programs for electric school and transit buses all make U.S. electrification possible.

The IIJA electrification programs also accelerate a megatrend in the auto industry: lightweighting. Lightweighting removes weight from a component or assembly of a vehicle.[60] As heavy batteries weigh down EVs, more lightweight metals will be needed to ensure efficiency.

"In lightweighting, inclusive of the support of the infrastructure bill, pretty much anything that moves is going to be needing more aluminum"

— Mike Stier, Norsk Hydro

On top of battery casings and automotive parts, the rise of electric transportation creates an emerging area for aluminum in the EVs wire and cabling. "Wire and cable in traditional ICEs formed just 1 percent of the total aluminum content, but for EVs, this increases to 7 percent."[61] With all these sources of demand, CRU International forecasts passenger EVs will require 5.5 Megatons of aluminum in 2030 alone, which is over 6 percent of 2030's forecasted global demand.[62] That demand equates to United States, Australian, and Canadian 2021 production, combined.[63] Aluminum still faces competition here; steel and copper present similarly valuable attributes to EVs, in terms of battery casing and cabling respectively.[64]

Defense Production Act Title III

In 2022, the Biden-Harris administration has invoked Section 303 of Title III of the Defense Production Act of 1950 (DPA Title III) on two occasions to accelerate U.S. manufacturing of clean energy technologies. Under the law, the President can offer incentives for domestic private industry to produce and supply critical goods necessary for national defense, which can go beyond military requirements. But before DPA Title III can be invoked, the President must determine there is a "domestic industrial base shortfall."[65]

Use of DPA Title III has long been on the drawing board for the administration. President Biden's Executive Order on Supply Chains (EO 14017) kicked off the process of identifying cracks in the energy and defense industrial bases only a few weeks after he entered office. One year later, the U.S. Departments of Defense and Energy recommended the use of DPA Title III to supply metals for EVs and renewables.

DPA Title III carries an important history. Amid global conflict, President Truman signed the 1950 law to ensure adequate domestic capacity of materials as a follow on from World War II and forthcoming challenges from the Cold War and Korean War. The Eisenhower-Nixon administration then used DPA to raise production of metals for the National Stockpile. Even though aluminum was a major focus of President Eisenhower's invocation, aluminum has not been a focal point of recent DPA Title III efforts.

Demand-Side Policies: Critical Minerals for Large-Scale Batteries

Framing it as a response to Ukraine-Russia war and its consequential impacts on American energy prices, the administration issued a presidential determination permitting the use of DPA Title III authorities to secure domestic critical mineral supply for batteries.[66] The DPA is historically used for economic and national security purposes to prop up domestic industry in war time or crises. Even with the Secretary of Defense declaring climate change a threat to national security and ongoing war as justifications for this action, the Biden-Harris administration's use of the law here also reflects a growing trend to reshore critical industries. Specifically, it will support the domestic production and processing of strategic and critical materials used in large-capacity batteries, such as lithium, nickel, cobalt, graphite, and manganese.[67]

The use of the DPA Title III comes with appropriated flexible funding to support its execution through grants, loans, and investments. Cumulative funding for DPA Title III for a project to address a specific industrial shortfall is limited to $50 million and the total DPA Title III fund is capped at $750 million, without further action from Congress. However, language in the FY2022 Emergency Supplemental Funding for Ukraine eliminated the $50 million limitation and removed the funding cap. The IRA then included $500 million in additional funding for implementation of existing Presidential determinations.[68]

The President's Determination directs the Secretary of Defense to support the following activities:

- feasibility studies for "mature mining, beneficiation, and value-added processing projects;"
- byproduct and co-product production at existing mining and other industrial facilities; and
- improvements to increase productivity, workforce safety, and sustainability in critical minerals mining, beneficiation, and processing.[69]

Similar to the funding opportunities for batteries in the IRA and the IIJA, the focus here is not on aluminum. The list of eligible minerals does not preclude aluminum, but it does not specifically mention it either. Further, the first two directed activities of DPA Title III focus more on the upstream of processes for mineral refining, which, for aluminum, predominately do not take place in the United States.

Aluminum smelters could theoretically leverage the third directive to increase sustainability in critical mineral processing, like ELYSIS. However, aluminum produced at those smelters would likely have to be linked to large-capacity battery end uses.

Despite limits of direct use of DPA Title III funding for aluminum, the electrification of military equipment will increase needs for aluminum; Aluminum remains a key input for EVs, batteries, and defense vessels.

Demand- and Supply-Side Policies: Clean Energy Technologies

President Biden also issued presidential determinations to authorize the utilization of DPA Title III in five clean energy technologies:

- Solar
- Transformers and Electrical Grid Components
- Heat Pumps
- Insulation
- Electrolyzers, fuel cells, and platinum group metals [70]

In these determinations, aluminum is only implicitly affected. As the IIJA and IRA sections of this report underscored, both solar and grid investments drive aluminum demand. For solar, there is a strong focus on increasing domestic production of solar PV to increase energy independence and fight climate change. This follows the U.S. Department of Energy's Solar Future's Study, which aims for solar energy to provide 40 percent of U.S. electricity supply by 2030.[71] DPA Title III's application for transformers and grid components links to the administration's goal of a 60 percent increase in transmission infrastructure by 2030, as well as modernizing and securing the grid.[72]

While these invocations are more recent and no awards have been granted to date, the U.S. Department of Energy expressed interest on how "DPA Title III tools could be used across the full supply chain, including raw materials, processed materials, subcomponents, final products, end-of-life materials recovery and recycling, and deployment."[73] This request for information opens the door to applying DPA Title III authorities directly to aluminum production and recycling.

This policy may yield supply-side assistance for U.S. aluminum production, but much remains to be seen on funding levels and how it will be allocated along the production value chains. Moreover, these invocations cover a variety of technologies and aluminum is only a major component part of two of them.

59 Lance T. Brasher et al., "Part II / Infrastructure Investment and Jobs Act: A Guide to Key Energy and Infrastructure Programs and Funding," Skadden, September 6, 2022.

60 Boyd Corporation, "What is Lightweighting and Why is it Important?" May 9, 2022.

61 CRU Group, "Opportunities for Aluminium in a Post-Covid Economy," 2022..

62 Ibid.

63 USGS, Minerals Commodities Summaries 2022 - Aluminum, January 31, 2022.

64 Ibid.

65 Congressional Research Service, "2022 Invocation of the Defense Production Act for Large-Capacity Batteries: In Brief," May 27, 2022.

66 Michelle Lewis, "Biden Invokes Defense Production Act to Boost EV, Storage Battery Minerals," Electrek, May 31, 2022.

67 Congressional Research Service, "2022 Invocation of the Defense Production Act for Large-Capacity Batteries: In Brief," May 27, 2022.

68 The White House, "FY2022 Emergency Supplemental Assistance to Ukraine," April 28, 2022.

69 See, e.g., Kirsten Hund et al., Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition, World Bank Group, 2020.

70 DOE, "President Biden Invokes Defense Production Act to Accelerate Domestic Manufacturing of Clean Energy," June 6, 2022.

71 Solar Energy Technologies Office, "Solar Futures Study," 2021.

72 See, e.g., Kroll Institute, "Bipartisan Infrastructure Investment and Jobs Act Guide," 2021.

73 Office of Manufacturing and Energy Supply Chains, "Defense Production Act: Request for Information," 2022.

Supply-Side Policies: Aluminum

Though aluminum is not the direct target of the 2022 invocations of DPA Title III, it has benefited from this act in the past and Congress has considered leveraging it again. In 1955, DPA Title III expenditures covered 16 percent of the nation's aluminum production.[74] Several new factories across the country were built in the first half of the decade, ultimately "doubling the tonnage of aluminum available" between 1955-1950.[75]

Another important consideration is under DPA Title III, Canada counts as a domestic source. This relationship is often associated with U.S. investments in Canadian smelters during World War II to support the allied effort. Today, the United States imports 50 percent of its aluminum from its northern neighbor and enjoys the benefits of a cross-border value chain for this industry.[76]

In the last two years, Congress considered and enacted legislation related to DPA Title III and aluminum. Section 852 of the FY2021 NDAA required the Secretary of Defense to submit a report to Congress on how to utilize DPA to increase domestic aluminum refining, processing, and manufacturing. A redacted version of this report found multiple shortfalls for high-purity aluminum, essential to national defense, under multiple national emergency scenarios.[77] Further, the report pointed to energy costs and disruptions as a main reason domestic "industry cannot reasonability provided capability in a timely manner."[78] As such, the report seemingly concluded without DPA Title III for high purity aluminum, national defense may be undermined. More stress tests and future reports are anticipated.

74 Douglas I. Bell, ""A Little-known Bill of Great National Significance": The Uses and Evolution of the Defense Production Act, 1950-2020," U.S. Army Heritage and Education Center, 2020.

75 Ibid.

76 USGS, Minerals Commodities Summaries 2022 - Aluminum, January 31, 2022.

Anodes in Aluminum Smelting

When alumina goes through the smelting process, electricity runs through the mixture of alumina and an anode. Historically, these anodes have been carbon-based. The electricity induces a chemical reaction, splitting the raw aluminum from the oxygen, which then combines with the carbon anode and is released off as carbon dioxide. 1.5 tons CO_2 per ton of aluminum on average are emitted from electrolysis. Companies are developing new forms of anodes or deploying specific types of carbon capture technologies to eliminate these emissions.

Source: C-SIM, 2023

CHIPS Act

The White House attributes a 1 percent loss of GDP and 25 percent of inflation to the semiconductor shortage that beset the U.S. economy in 2021.[79] It exposed vulnerabilities in U.S. supply chains and how a weak spot can send waves rapidly throughout the country. The CHIPS Act was signed into law to institute guardrails to prevent this type of situation from occurring in the future. The law sets aside $39 billion in direct federal financial assistance and provides a 25 percent tax credit to entice the private sector to produce semiconductors in the United States.[80] It also creates a stronger foundation for these investments to thrive, with $13.7 billion in R&D and workforce development.[81] The Biden-Harris administration already attributes $150 billion in private sector investment announcements to these provisions.[82]

Supply-Side Policies

Broadly, the CHIPS Act is hailed as a climate bill, and, because aluminum enables decarbonization, aluminum policy is climate policy. RMI analysis finds $67 billion of the funding in the CHIPS Act could be spent on zero-carbon industries and climate research.[83] One of the research focus areas of the Directorate for Technology, which the law establishes, is "advanced energy and industrial efficiency technologies."[84] Additional research and funding to commercialize inert anodes for smelters is a boon for the aluminum industry.

77 DOD, "Report to Congress on Aluminum Refining, Processing, and Manufacturing," 2022.

78 Ibid.

79 Jordan Fabian, "Biden Aide Deese Says Semiconductor Shortage Cost 1 percent of U.S. GDP," Bloomberg, April 6, 2022.

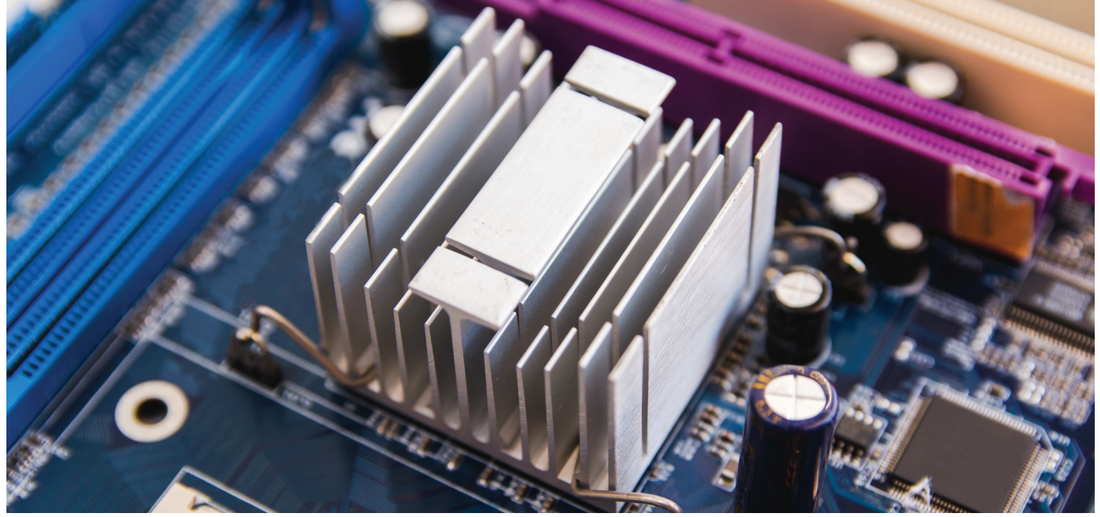
80 Elizabeth Zane, "Chips Act: What Companies Need to Know," Orrick, August 29, 2022.

81 Ibid.

82 The White House, "FACT SHEET: CHIPS and Science Act Will Lower Costs, Create Jobs, Strengthen Supply Chains, and Counter China," August 9, 2022.

83 Robinson Meyer, "Congress Just Passed a Big Climate Bill. No, Not That One." The Atlantic, August 10, 2022.

84 Ibid.



Semiconductors have the largest and fastest growing demand share of high purity aluminum discs.

Demand-Side Policies

More concretely, aluminum, and particularly high-purity aluminum, plays a key role in the conductivity of certain types of semiconductors. In fact, semiconductors have the largest and fastest growing demand share of high purity aluminum discs.[85] It is the preferred coating for circuits in semiconductors for its conductivity and low-cost, compared to other highly conductive metals.[86] With $80 billion in public corporate investments to date, policy makers and industry are now beginning to wake up to the materials needs, including for high-purity aluminum, accompanying this great reshoring movement.[87]

The CHIPS Act is a landmark response to a supply chain hitch, but implementation will expose even more challenges further up the chain. C-SIM's report, *Aluminum's Energy Problem and Energy Solution*, revealed a clear risk in the aluminum supply chain. Just like semiconductors, aluminum has concentration of supply in China and low viability of substitutes for the automotive sector.[88] Pre-existing and new demand drivers within the IRA, IIJA, and CHIPS push the nation closer to a point of concern.

Furthermore, as that point approaches, the United States will fill the gap with increased imports from its top import countries after Canada, whose production is stagnant. Growing imports from Russia, the Middle East, and China leave the United States exposed to nefarious action, putting a vital industry at risk. By getting to the crux of the semiconductor challenge, the CHIPS Act is an example of how deliberate industrial policy can ensure economic stability and national security. But its cascading effect increasing needs for other critical materials with vulnerable supply chains, like aluminum, proves this is only the beginning.

85 Digital Journal, "Demand Growth of Semiconductors likely to Boost Growth of High Purity Aluminium Disc—Fact.MR Study," April 13, 2022.

86 AlumiPlate, "High purity AlumiPlate Aluminum for Semiconducting Materials and as a Superconductor."

87 The White House, "FACT SHEET: Biden-Harris Administration Bringing Semiconductor Manufacturing Back to America," January 21, 2022.

88 Laura Juliano et al, "Gauging the Risks of Raw-Material Volatility," Boston Consulting Group, October 14. 2022.

Conclusion

It is clear the Biden-Harris administration recognizes an all-of-the-above approach is needed to fight the climate crisis, strengthen supply chains, and modernize the nation's infrastructure. As an all-of-the-above metal, aluminum is impacted by their new policies. Unfortunately, the impacts are heavily weighted on the demand side rather than the much-needed supply side (see Figure 3).

The sweeping legislative packages on transportation, clean energy, and defense accelerate demand for aluminum. Across the board, these policies share the same goal: green the U.S. economy with technologies made at home. But how can there be more American-made solar panels on houses, EVs on roads, transmission lines overhead, and semiconductors enabling it all, without a secure and abundant source of the metal that transcends those sectors?

At the same time, the IRA, IIJA, DPA Title III uses, and CHIPS Act take an important step towards recognizing the security implications of supply vulnerabilities. There are attempts to loosen the grip of "foreign entities of concern" in upstream and midstream extraction and processing of minerals across all four laws. But in every case, aluminum is either not directly implicated or is at the bottom of the list in terms of focus—despite the Department of Defense confirming without DPA Title III intervention, domestic industry is unlikely to sustain capacity of high-purity aluminum.

In terms of direct supply-side relief, there are some opportunities for aluminum producers. Decarbonizing programs and incentives in the IRA and IIJA, as well as R&D for high-emitting sectors in CHIPS, can help modernize an aging fleet of smelters. However, in the face of current industry challenges and stark competition from other eligible industries, it's unclear whether domestic aluminum producers will be able to fully capitalize on these programs.

Perhaps most importantly, the only supply-side provisions for aluminum bypass the biggest issue the industry is facing; they focus on decarbonizing the smelting process, rather than the energy fueling it. From a cost and an environmental perspective, aluminum smelters are hurting far more from their dependence on fossil fuels than on carbon anodes.

Meanwhile, these bills take the biggest strides in advancing U.S. clean energy production and use in the nation's history—clean energy production that relies heavily on aluminum. This disconnect persists at the cost of U.S. global competitiveness and national security.

Additional interventions to connect U.S. aluminum production to these new energy sources are needed. Reliable, affordable, and abundant sources of clean energy will release domestic smelting from the energy trap, ensuring more stability in primary aluminum supply. C-SIM's follow-on reports will examine the role of trade policy, as well as global best practices, to build this energy bridge between aluminum supply and demand.

SAFE

SAFE is a non-partisan, non-profit policy thought leadership organization dedicated to accelerating the real-world deployment of secure, resilient, and sustainable transportation and energy solutions of the United States and its partners and allies by shaping policies, perceptions, and practices that create opportunity for all. SAFE unites prominent military and business leaders to develop and advocate for policies that improve America's energy security by significantly curtailing our dependence on oil and promoting responsible use of our domestic energy resources. SAFE relies on the knowledge and experience of four-star retired military officers, Fortune 500 CEOs, and its expert staff to produce high-quality, fact-based analysis and policy recommendations for lawmakers, regulatory agencies, and the public.

ENERGY SECURITY LEADERSHIP COUNCIL

The Energy Security Leadership Council (ESLC), a group of business and former military leaders committed to reducing U.S. oil dependence. The ESLC is chaired by Adam Goldstein, Former Vice Chairman, Royal Caribbean Cruise Lines, and General James T. Conway, the 34th Commandant of the U.S. Marine Corps, and retains its strategic mix of business and four-star former military leaders.

CENTER FOR
Strategic Industrial Materials

C-SIM is a policy initiative dedicated to advancing more secure, reliable, and sustainable supply chains for aluminum and other industrial materials critical to America's national and economic security. The Center is exploring new federal government purchasing regulations that prioritize domestic aluminum and developing policy recommendations designed to reduce carbon emissions to net zero by 2035.

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