Friendshoring the Lithium-Ion Battery Supply Chain

The Processing and Refining Stage

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Introduction

Lithium-ion batteries are among the most critical industrial items necessary to achieve the transition to lower carbon emissions worldwide. Essential to electric vehicles (EVs) and the effective delivery of solar and wind power throughout the electric grid, these batteries also charge a majority of consumer electronics products. While the supply chain for batteries is dispersed throughout the globe, the mining and processing of key minerals and materials is concentrated in just a few countries, with China dominating. As changing trade relationships, sanctions, and other geopolitical disruptions ripple through the global economy, the dispersion of supply chains and concentration of key inputs constitutes a significant vulnerability for maintaining and growing production in this key manufacturing sector.

The sourcing and processing challenges in the lithium-ion battery sector are formidable. As U.S industries strive to grow in this sector, they face complexities surrounding battery supply chains that have been generated by overlapping—and at times incompatible—government policies that aim to: (1) protect national security, (2) facilitate the green transition, and (3) improve U.S. economic competitiveness while re-shoring domestic industrial capabilities. Policies designed to address these serious and varied global challenges have at once offered generous market stimulating incentives while introducing non-market economic headwinds that may eventually threaten the survival of U.S. supply chains for lithium-ion batteries.

The Biden administration has embraced the vision of achieving an economy that emits less carbon by providing demand-inducing subsidies for EVs and lithium-ion batteries, which are the heart of these cars. Adding difficulty to achieving climate goals is the dominant role played by China in this
As changing trade relationships, sanctions, and other geopolitical disruptions ripple through the global economy, the dispersion of supply chains and concentration of key inputs constitutes a significant vulnerability for maintaining and growing production in this key manufacturing sector.

The business community, for its part, is engaged in extensive risk reassessment with respect to doing business in and with China to ensure greater resiliency in their supply chains. Depending on the current level of investment, the business model, and the structure of individual supply chains, risk reassessment can lead U.S. companies to take the decision to sever ties with China. More often, companies are identifying possible chokepoints for inputs and embarking on a quest for redundant sources of supply to backstop against future export restrictions and trade sanctions should economic relations with China further deteriorate.

A profound shift in trade, economic, climate, and national security policy is underway. The Biden administration has followed the European Union in articulating its goal as “de-risking” rather than decoupling from China, but as a practical matter, policies still under development have so far been disjointed and difficult for industry to follow. These policies, combined with tough rhetoric by various government officials and members of Congress who propose even more draconian measures to require local sourcing, have injected uncertainty into the commercial decisionmaking governing U.S. manufacturing capabilities. In the end, government measures to restrict commerce with China, in advance of alternative sources of supply of key inputs coming online, threaten to derail this range of overlapping policy objectives. In short, the United States is pursuing three conflicting goals: accelerating the green transition, reshoring production capabilities in critical sectors, and diversifying away from China in these key areas. Efforts to achieve the last two goals compromise the first.
The Biden administration and Congress have undertaken a full suite of industrial policy measures that are set to skyrocket demand for lithium-ion batteries, especially when it comes to EVs. The Infrastructure Investments and Jobs Act (IIJA) set up funding meant to create a “Made-in-America” EV network of 500,000 chargers. The law invests $7.5 billion in EV charging. The Inflation Reduction Act (IRA)’s tax incentives, which provide billions in tax benefits for manufacturers and consumers of EV batteries, is making lithium-ion technology more in demand than ever. Certain tax credit qualifications in the IRA include domestic content requirements for batteries and battery materials, including those used to support clean energy project deployment.

This is the first of three papers examining the lithium-ion battery supply chain and prospects for bringing more production on shore. This paper outlines the basic makeup of a lithium-ion battery and some of the complexities surrounding the purifying processes for several different scarce critical mineral inputs. In addition, it describes the role that the United States plays in the global sourcing of key minerals now and in the future by examining several trends expected to impact the market going forward. Lastly, this paper lays out what actions the Biden administration and Congress have undertaken to date to improve the security of critical mineral supply chains and proposes some recommendations to build upon that foundation.

Currently, the processing of battery materials is concentrated in a few nations outside of the United States, representing a daunting challenge for building resiliency in an environment of heightened geopolitical tension. According to the U.S. Department of the Interior, “The clean energy transition will
necessitate an overall 400–600 percent increase in global demand for key critical minerals like lithium, graphite, cobalt and nickel and for some minerals the increase will be many times higher.” U.S. reliance on Chinese extraction, refining, and processing of critical minerals creates a serious vulnerability.

Several stages of the lithium-ion battery supply chain need to be considered to understand how the United States can reach its goal of diversifying its supply of battery inputs while keeping the green transition moving. To reduce critical dependencies and build stronger global supply chains in this sector, the administration should consider balancing domestic production incentives with modernized trade relationships to best ensure that U.S. firms maintain an adequate supply of these key inputs.
The basic makeup of a lithium-ion battery consists of three main components: multiple lithium-ion cells, the wires connecting these cells, and a battery management system (BMS) to monitor the functioning and temperature of the battery. In turn, each lithium-ion cell is individually made up of four main components: the cathode, the anode, an electrolyte, and a separator. The anode and cathode components store the lithium. What creates electricity from a lithium-ion battery is the movement of the lithium between the anode to the cathode components, carried by the electrolyte via the separator, creating free electrons and thus a charge that flows through the device being powered. Each of these components are made of several constituent materials and chemicals that are critical to enhancing the performance of the lithium-ion battery, which will be discussed in more detail in subsequent papers.

Cathode

Batteries are composed of positive and negative electrodes to enable the creation of electrons to create electrical current. In a battery, the cathode is the positive electrode. Cathode active materials (CAMs), which define the output and application of the batteries, are generally composed of metal oxides. The most common metal oxides that make up CAMs are lithium cobalt oxide, lithium manganese oxide, lithium iron phosphate, and lithium nickel manganese cobalt oxide. Different cathode materials contain varying amounts of lithium: the higher the lithium content, the larger the battery capacity, as lithium storage has a direct impact on the battery’s ability to run.
**Anode**

While the cathode is the positive electrode enabling the flow of electrons, the anode is the negative electrode. Much like cathodes, anodes require active materials to function. Anode active materials (AAMs) are generally made from carbon-based materials such as graphite, silicon, or a combination of both. Graphite is the most commonly used because of its high electrical conductivity, lower cost, and stable structure, while silicon possesses higher energy density (the amount of energy stored in a given substance per unit volume) but presents challenges due to higher volume expansion and shorter life cycles.4

**Electrolyte**

A battery electrolyte is a solution inside batteries, the consistency and makeup of which varies based on the type of battery.15 However, electrolytes ultimately are used for the same purpose: they transport positively charged ions between the cathode and the anode—enabling the free flow of electrons and creating an electrical charge. The chemical in question allows the electrical charge to pass between the cathode and anode terminals and puts the chemicals required for a reaction in contact with the terminals, which converts stored energy into useful electrical energy. The most commonly used electrolyte in lithium-ion batteries is a lithium salt solution.16

**Separator**

Separators are placed in lithium-ion batteries between the anode and cathode to avoid a short circuit and facilitate a lithium-ion cell’s stability and safety. Because separators are not part of the reactions that produce the flow of electricity mentioned above, they have to be chemically stable relative to the electrolyte and electrode materials. Materials in a separator include nonwoven fabrics consisting of “a manufactured sheet, web, or mat of directionally or randomly oriented fibers.”17
Concentration and Purification of the Materials

Several critical minerals and raw materials are key to the lithium-ion battery supply chain. This paper highlights minerals that are currently used in batteries, but there may be new battery chemistries and types that could change what critical minerals and raw materials are required for renewable power generation. As stated by the Congressional Research Service, processes of obtaining permits, acquiring land and capital, and other necessary steps can vary considerably and may take years. The Government Accountability Office assessed that the amount of time needed simply to reach the approval stage “ranged from about 1 month to over 11 years and averaged approximately 2 years.”

Critical minerals key to lithium-ion battery manufacturing require rigorous, lengthy technical processes to avoid negative spillover effects on the environment and workers’ health. For instance, cobalt mining has come under scrutiny due to the issue of child labor as well as poor safety standards: a report from the Organization for Economic Cooperation and Development notes that a mine owned by the Kamoto Copper Company in the Democratic Republic of Congo collapsed, killing an estimated 36 workers. Setting up and operating these processes is therefore a difficult task, made all the more challenging by two features. First, demand for these minerals and materials is set to increase significantly. A report by the International Energy Agency found that, in order to meet the goals outlined in the Paris Agreement, demand for nickel, cobalt, and graphite is expected to grow by about 20 times, while lithium demand is expected to grow to 40 times its current level. Second, the movement to diversify away from China, which extracts a large amount of these minerals and materials and processes an even larger share, will require the significant retooling of current processing activities.
**Cathode**

**LITHIUM**
Lithium is generally extracted from brines and mines. For the former, lithium-rich brine comes to the Earth's surface and forms shallow ponds in which sunlight and wind evaporate the water and slowly concentrate the solution. It then undergoes thorough chemical treatments, such as precipitation and ion exchange, to reduce impurities and improve lithium-ion concentration. That concentrated solution is then turned into lithium carbonate or lithium hydroxide through precipitation and purification processes which convert it to battery-grade material. Lithium carbonate is a more commonly made compound used in lithium-ion battery production, while lithium hydroxide is becoming increasingly popular because of enhanced performance in cathode chemistries with high nickel content. Lithium extraction from brines is particularly significant because of the relative abundance of lithium in brine deposits.

When it comes to mines, the process is centered around sourcing minerals that carry lithium. The ore-containing lithium is first extracted and undergoes separation steps to get rid of any contaminants. The resulting lithium-rich concentrate is then used to extract lithium ions through a leaching process which mingles the concentrate with chemicals that are made for the purpose of leaching. There are other alternative sources of lithium aside from brines and mines; conventional mining operations can also source lithium from solid rock ore deposits.

Due to ongoing exploration, identified resources of lithium around the globe have increased significantly. According to the U.S. Geological Survey, identified lithium resources in the United States total 12 million tons and total 86 million tons in other countries. South America is particularly relevant when it comes to sourcing the mineral. Bolivia leads the world with 21 million tons, followed by Argentina’s 20 million tons and Chile’s 11 million tons. Other countries with sizable lithium reserves include Australia (8 million tons) and China (about 7 million tons).

**COBALT**
Cobalt deposits are found throughout different mineral formations, including igneous rocks and sedimentary rocks. Cobalt is generally retrieved as a byproduct from copper and nickel production, and its pricing therefore follows the demand of these primary metals. Cobalt has several applications, such as EV batteries, superalloys, cutting tools, and industrial catalysts, to name a few. Cobalt can be produced from three main types of ore deposits: copper deposits, for example, located in the central African copper belt comprising the Democratic Republic of the Congo and Zambia; magmatic nickel sulfide deposits, for example, found at Sudbury, Canada, and at Norilsk, Russia; and, lastly, nickel laterite deposits, located in tropical regions. Cobalt can also be found on the deep-sea floor, although such deposits are generally not being extracted. A majority of the world's cobalt mine production—about 70 percent—is located in the Democratic Republic of the Congo, followed by Russia (about 4 percent) and Australia (4 percent). According to the U.S. Geological Survey, around 70 percent of domestic production is from recycling.

Because cobalt is often a byproduct of copper and nickel production, and since the ores of these two metals are intertwined in sedimentary deposits, it is not possible to mine cobalt without mining...
these other metals. Therefore, the extraction process is essentially the same as mining and refining copper or nickel. Several processing methods can be used for cobalt. In short, crushed sulfite from mines is heaped up to extract a mineral soup leached from the rock by sulfuric acid. Copper, for instance, is extracted from the solution by electrolysis, which leaves behind a solution fairly rich in cobalt (along with other metals). Another set of chemical precipitation and second leaching removes these metals from the electrolyte, which slowly enriches the cobalt in the solution until it can be extracted out.

In other words, the purification of cobalt involves several steps to extract and separate the mineral from the ore. During the first step, the ore is crushed into small pieces and ground into a powder. That ground ore is mixed with water and chemicals and agitated in flotation cells, creating bubbles that attach to the valuable minerals and form a froth layer while the non-valuable minerals sink to the bottom. The froth containing the valuable minerals goes through a series of concentration steps, including more processing to remove impurities. The concentrated ore is then smelted—which involves heating the ore at very high temperatures to separate the individual metals. The separated component concentrates, copper and cobalt, are further processed to remove additional impurities.

**MANGANESE**
Manganese is a relatively abundant metal and is widely available throughout the Earth’s crust, including on the seafloor. Ores that contain over 35 percent manganese are considered commercially viable.

Impurities in manganese include oxides of other metals, and these are reduced during smelting. Nonmetallic impurities remain in the post-smelting slag. Smelting processes depend on the kind of manganese destined for final application: pure manganese, ferromanganese, or silicomanganese. For uses requiring pure manganese, the process of producing electrolytic manganese is preferred. In this method, manganese ores are roasted to obtain a calcine that is dissolved in sulfuric acid to make a manganous sulfate solution. The addition of ammonia and hydrogen sulfide then precipitates unwanted materials. Ferromanganese and silicomanganese are made through smelting ores in a furnace. South Africa leads the way in terms of manganese reserves at 640 million metric tons, followed by China (280 million metric tons), and Australia (270 million metric tons). Other large players include Ukraine (140 million metric tons) and Gabon (61 million metric tons).

**NICKEL**
Nickel, primarily used in stainless steel, is also used in alloys as well as chemicals and batteries due to its resistance to corrosion. According to the U.S. Geological Survey, nickel can be found primarily in two types of ore deposits: laterites and magmatic sulfides. Nickel deposits can generally be found in rocks rich in iron and magnesium. The extraction of nickel from ore is similar to the extraction of copper, and often the same equipment is used in both processes. Nickel, however, does require higher-temperature refractories and therefore enhanced cooling capabilities.

The purification processes depend on whether the ore-containing nickel is a sulfide or a laterite. For sulfides, the ores are ground to separate waste materials from the nickel mineral by selective flotation processes (in which the ore is mixed with reagents and agitated by devices to create
air bubbles; the sulfide clings to surfaces and then is collected as a concentrate. The resulting concentrate is then either leached or dried and smelted. That product is converted to an oxide and combines with a silica flux to form a slag drawn off to leave a matte with a high nickel content. The matte is then further treated using a variety of processes such as ammonia pressure leach, roasting, or electrorefining.

For laterite ores, because they are oxides and are not suitable for conventional concentration processes, large amounts must be smelted together. The moisture and water are chemically removed in furnaces. The oxide is then reduced to nickel metal using furnaces and then cooled. A large portion of laterite smelters make a crude ferronickel meant to be an alloying agent in steel production.

As of 2021, Indonesia and Australia had the largest global reserves of nickel with around 21 million metric tons each, followed by Brazil (16 million metric tons) and Russia (about 8 million metric tons). The United States itself possesses around 340,000 metric tons.

**LITHIUM IRON PHOSPHATE**

The basic production of lithium iron phosphate chiefly includes four elements: the production of iron phosphate precursor, wet ball milling, spray drying, and sintering. The synthesis of phosphate can come in two forms, solid or liquid. The solid-phase synthesis method is the most commonly used to prepare electrode materials because it is a relatively simple process that can be more quickly industrialized. Carbothermal reduction, which reduces substances using carbon as an agent, is likely the most common solid-phase method, as it involves using inexpensive ferric iron. Liquid-phase synthesis, on the other hand, adds a solvent such as water to obtain the calcination of lithium iron phosphate at high temperatures.

Australia has the largest reserves of iron content ore, with 27 billion metric tons, followed by Brazil’s 15 billion metric tons and Russia’s 14 billion metric tons. China possesses close to 7 billion metric tons, whereas the United States has around 1 billion metric tons of reserves.

**Anode**

**GRAPHITE**

Graphite is a pure form of carbon that comes in three main commercial forms: spherical graphite, coated spherical graphite, and synthetic graphite. The first is not involved in EV-battery applications as it is not processed enough to be suitable to be used in a vehicle. Graphite is a particularly attractive material for lithium-ion battery manufacturers, as it is widely available in a broad range of countries, such as Turkey, Brazil, China, Russia, and Sweden. In addition, the size and shape of graphite particles can be modified depending on the required application.

There are three main sources of graphite: natural graphite extracted directly from minerals, synthetic graphite, and bio-graphite. While natural graphite is an important source of graphite materials today, it can contain a large number of impurities, making its use difficult. Synthetic graphite is made out of calcined petroleum coke and coal tar pitch, and bio-graphite is obtained by pyrolysis of carbon-containing components. The carbon content of natural graphite is, in
general, fairly low when mined, requiring several enrichment processes. The first stage is the crushing process, in which the crushing methods (for instance, ball, hammer, air-jet, or rod mills) are determined by the type of graphite ore. The second stage is grinding and screening to graphite flakes, and the last stage is purification through a number of methods, such as flotation and high-temperature purification.50

Synthetic graphite, also known as artificial graphite, is produced through heating formless carbon materials. These chiefly include calcined petroleum coke and coal tar pitch. To produce synthetic graphite, the petroleum is first ground and sieved, and the coal tar pitch is used as a binder to form a paste. The actual shape of the graphite is formed and then heated to carbonize the pitch. A pitch is used to fill pores caused by that carbonization process, and the product is once again calcined to be carbonized and densified. Lastly, the temperature is raised to between 2700 and 3000 °C, where its shape transforms into graphitic crystallites that eventually become a stable graphitic structure. Synthetic graphite has no cost advantage to natural graphite, though it does present higher carbon content, better cyclability, and a more stable performance—as well as enhanced compatibility with electrolytes.51 There are several experimental ways to achieve the third type, bio-graphite, which refers to graphite produced from biomass. These methods have included, for instance, high-temperature heating.52

Given the different source and production methods of graphite mentioned above, the types of impurities they present also vary. A number of purification methods have been applied to natural graphite. Flotation, for instance, is the simplest type but obtains a lower amount of graphite purity. Acid-based methods can remove more impurities through their chemical reactions, as well as the high-temperature method, but they require large amounts of energy and create more environmental pollution. Because synthetic graphite is already graphitized at a very high temperature, its purification process is similar to its initial impurity removal method.53

Turkey leads the way globally when it comes to graphite reserves, with around 90 million metric tons, followed by Brazil (74 million metric tons) and China (52 million metric tons). Other large players include Madagascar (26 million metric tons), Mozambique (25 million metric tons), and Tanzania (18 million metric tons).54

**SILICON**

Graphite has been the technology of choice for lithium-ion batteries since its inception in the 1990s. However, as graphite hits energy-density limits, elements of the industry are championing silicon to play a larger role in battery anodes.55 Supporters of silicon argue that using the material could significantly increase the energy density of the anode and provide the battery longer runtimes. In theory, silicon anodes have tenfold the energy density of graphite anodes.56

Silicon is the most abundant mineral in the Earth’s crust. The production of pure silicon for batteries occurs in two stages, as each stage yields two different types of silicon based on varying levels of purity that are meant for different end uses. Silica occurs naturally in the form of quartz. It is purified by oxygen removal through a reaction with carbon in an electrode arc furnace, resulting in metallurgical-grade silicon that is 98 percent pure.57
Metallurgical-grade silicon is further refined by grinding it into a powder and reacting it with acid. The resulting chemical has a low boiling point and is distilled to remove further impurities. Lastly, it is reacted with hydrogen at a high temperature for 200 to 300 hours to produce a silicon of a very high purity level.\textsuperscript{58}

Excluding the United States, ferrosilicon accounted for almost 70 percent of world silicon production on a silicon-content basis in 2021. The leading countries for ferrosilicon production were, on a silicon-content basis, China (6 million metric tons), Russia (580,000 metric tons), and Norway (350,000 metric tons), highlighting China’s dominance of the mineral’s production. For silicon metal, the leading producers were China, Brazil, and Norway. China accounted for approximately 70 percent of total global estimated production of silicon materials in 2021.\textsuperscript{59}
Several nations, especially China, are ahead in the production, ownership, and control of refining, purification, and concentration of several critical minerals and raw materials key to the manufacturing of lithium-ion batteries. For instance, as of 2019, China was processing 65 percent of the world’s cobalt. Likewise, China refines more than 90 percent of global natural graphite. China also processes 58 percent of global lithium, 35 percent of the world’s nickel, and 87 percent of rare earths. Even critical minerals that are mined in the United States are often exported to China to be processed and then returned for domestic use. Whereas the United States has some reserves in a few critical minerals that are inputs in lithium-ion batteries, the country is not a significant player in processing capabilities.

In short, years of focused industrial policy in China—including trade protectionism, low environmental standards, and the use of state subsidies to enable operations to run at a loss—has paid off exceptionally. Nevertheless, while China is by far the leader in refining minerals, it is important to recognize that other countries have capabilities as well. Chile for example, processes 29 percent of the world’s lithium while Malaysia processes 12 percent of rare earths.

The Biden Administration’s Approach to Building More Resilient Supply Chains

After many months of research, the Biden administration identified several sectors whose supply chains are critical to U.S. economic security. In its 100-Day Reviews under Executive Order 14017, part of the report Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering
Broad-based Growth, the White House assessed supply chain vulnerabilities across four key sectors: semiconductor manufacturing and advanced packaging; large-capacity batteries, such as those for EVs; critical minerals and materials; and pharmaceuticals and advanced pharmaceutical ingredients. Critical minerals are recognized as the building blocks for modern technologies at the cornerstone of national security and economic prosperity, and in February 2022, the White House announced several investment packages to remedy the United States’ vulnerabilities in the critical minerals and raw materials sector. In addition, the Department of the Interior released a list of 50 critical minerals to inform these efforts. These investments aim to secure, among other essential technologies, the supply chains of lithium-ion batteries.

For instance, the Department of Defense’s Industrial Base Analysis and Sustainment program had awarded $35 million to separate and process heavy rare-earth elements in Mountain Pass, California. The Department of Energy is currently managing a $140 million demonstration project to recover rare-earth elements and critical minerals from coal ash and other mine waste as part of the IIJA. The Department of Energy likewise injects $3 billion in investments to refine battery materials and recycle them. Berkshire Hathaway Energy Renewables announced a new demonstration facility in Imperial County, California, to test a lithium extraction process from geothermal brine as part of a multibillion-dollar investment in lithium. Altogether, Sections 40207 of the IIJA requires the Department of Energy to fund more than $6 billion in grants related to the research, supply, processing, and recycling of materials and minerals critical for lithium-ion batteries.

The Department of Defense has also entered into agreements with mining companies to enhance domestic mining capabilities, such as the $90 million project signed with Albemarle to reopen the company’s Kings Mountain lithium mine in North Carolina. These agreements are entered into under the Defense Production Act (DPA) and utilize appropriated funds authorized in the IRA. A DPA determination issued in 2022 authorized the Department of Defense to conduct feasibility studies for mature mining and processing projects.

Legislation has also strived to enhance research in the critical minerals sector, particularly as it pertains to assessing and enhancing current U.S. capabilities. For instance, the Infrastructure Investment and Jobs Act establishes an Earth Mapping Resources Initiative within the U.S. Geological Survey, which aims to speed up efforts to acquire integrated topographic, geologic, geochemical, and geophysical mapping. The section prioritizes critical minerals.

The Biden administration’s “Securing a Made in America Supply Chain for Critical Minerals” announcement emphasizes that the administration is undertaking action across the federal government to secure critical minerals and raw materials supply chains. First, the Biden administration states that it aims to update outdated mining laws and regulations—chief among them the Mining Law of 1872, which “still governs mining of most critical minerals on federal public lands”—with the establishment of an interagency working group led by the Department of the Interior. The working group has produced several recommendations to enhance various features of mining operations. The announcement likewise directs the United States Geological Survey within the Department of the Interior to update the federal list of minerals essential to
economic or national security and vulnerable to disruption. Second, the White House announced a memorandum of understanding between the Departments of Energy, Defense, and State to coordinate stockpiling operations. National Defense Stockpile authority was given to the undersecretary of defense for acquisition and sustainment in an October 2021 executive order.

**Trade Tools and Tax Incentives**

The IRA is perhaps the most significant legislation to accelerate transportation electrification and clean energy project deployment in U.S. history and stands as the flagship policy to accelerate the transition to lower carbon emissions in the future. However, provisions in the IRA prohibiting reliance on China in the EV supply chain have come at the cost of added difficulty in the sourcing and processing of critical minerals that works at cross purposes with the goals of the green transition. The Biden administration’s current quest to diversify away from China is thus compromising efforts to spur a transition to renewable energy.

A layer of laws and regulations have put restrictions on how firms can source and produce critical minerals to remain eligible for subsidies. In March 2023, the Department of Commerce updated rules on how it applies the term Foreign Entity of Concern (FEOC), limiting the universe of suppliers (most notably China) that car manufacturers can use if they desire to have their vehicles remain eligible for the IRA EV tax credit. If any critical mineral used in the production of an EV was extracted, processed, or recycled in an FEOC, the end vehicle becomes ineligible for the $7,500 tax credit that consumers receive after purchase. Additionally, in December 2023, the Department of the Treasury released proposed guidance on clean vehicle provisions in the IRA where it set critical mineral sourcing requirements for the tax credit. Beginning at 40 percent in 2023 and increasing year over year, certain percentages of critical minerals must be extracted in the United States or a country that the United States has an FTA with (with an additional exception made for batteries recycled in North America). These policies, while having the laudable goal of diversifying dependence on China in EV supply chains, make sourcing and processing critical minerals for EVs more difficult and costly for manufacturers. Indeed, given market realities and scarcity of supply from countries other than China, IRA requirements for eligibility for tax credits appear impossible to meet in many cases.

Cognizant of the soaring demand for critical minerals related to the energy transition, the administration has lessened, through regulation, the sourcing and manufacturing requirements of the IRA with two novel interpretations of the statute. In December 2022, guidance from the Department of the Treasury permitted the “lease loophole,” in which EVs that are not assembled in North America, do not meet the origin requirements on battery content and critical minerals, and are above price caps are still eligible for the $7,500 tax credit if they are classified as “commercial vehicles.” This guidance has supported an increase in EV sales as more consumers have opted for leasing instead of outright purchasing an EV.

In the second workaround to a strict reading of the IRA, the U.S. Trade Representative (USTR) attempted to negotiate critical mineral agreements (CMAs) with supplying countries. These agreements could in turn ensure that partner countries would be considered as “FTA Countries.”
under the IRA an approach that seems to have floundered. The United States signed the first, and so far only, CMA in March 2023 with Japan. The objective of this novel trade and cooperation agreement is:

... to strengthen and diversify critical minerals supply chains and promote the adoption of electric vehicle battery technologies by formalizing the shared commitment of the Parties to facilitate trade, promote fair competition and market-oriented conditions for trade in critical minerals, ensure robust labor and environmental standards, and cooperate in efforts to ensure secure, sustainable, and equitable critical minerals supply chains.

While Japan is not a critical minerals source, the country possesses related capabilities, including mineral processing and EV battery production. This CMA sparked interest by other nations and blocs, notably Indonesia, the European Union, and the United Kingdom, which have expressed a desire to negotiate similar agreements. Indonesia and the United States have held preliminary talks on a deal involving Indonesian nickel, a critical mineral of which they hold the largest natural reserves globally. The United States and the United Kingdom’s trade representatives have touted “significant progress” in a bilateral CMA between the two trading blocs, although the agreement has yet to be concluded. Likewise, the European Union and the United States have discussed reaching a Japan-like CMA, although talks seem to have stumbled.

In a similar vein, U.S. policymakers have engaged allies Canada and Australia on critical minerals cooperation. The United States and Canada announced a previous Joint Action Plan on Critical Minerals collaboration, while the United States has established a Critical Minerals Working Group with Australia. In all, the United States is engaging its economic allies and partners to enhance the trade of critical minerals as they ramp up domestic capabilities. However, that engagement has so far been lackluster due to significant pushback domestically, including from lawmakers who either wish to be more engaged in negotiations or believe more agreements would undermine the reshoring objectives of current U.S. trade policy.

The Drive for CMAs Sputters

Efforts to strike additional CMA deals with allies and trading partners have met pushback domestically, including from the bipartisan leadership of the congressional committees with jurisdiction over trade, as well as from Senator Joe Manchin (D-WV), chairman of the Senate Committee on Energy and Natural Resources and an important author of the IRA. Senator Manchin has sharply criticized the workarounds, characterizing them as weakening the sourcing and manufacturing requirements in the IRA. Saying that the Biden administration is “distorting the plain text of U.S. law,” Representative Jason Smith (R-MO), chairman of the Ways and Means Committee, who generally objects to “corporate green welfare” contained in the IRA, has also decried the proposal to deem CMAs as FTAs under the IRA. Even strong proponents of the IRA, such as Senator Rony Wyden (D-OR), chairman of the Senate Committee on Finance, and Representative Richard Neal (D-MA), ranking member of the House Committee on Ways and Means, have risen up against the USTR’s current CMA strategy, citing workers’ rights and environmental concerns:
The critical minerals agreement announced today is unacceptable . . . the Administration does not have the authority to unilaterally enter into free trade agreements. Human rights, environmental rights, and economic opportunity are all closely interwoven, and had the Administration wanted to include meaningful labor or environmental protections in this agreement, they would’ve engaged Congress.\(^8\)

Another camp of opposition to administration policy and the IRA is led by Senator Mike Crapo (R-ID), ranking member on the Senate Committee on Finance, which argues: “Additionally, the Treasury Department has announced several sets of rules and planned rules that will enable Chinese minerals, materials and entities to qualify for IRA subsidies, while potentially also excluding domestic players who are connected to traditional energy source.”\(^9\) The rushed, disjointed policies at the heart of these provisions were unworkable from the outset. In October 2024, following diplomatic outreach by Vice President Kamala Harris and while the USTR engaged with Indonesia on CMA negotiations, more widespread opposition was expressed from another broad-based coalition of senators, including Kevin Cramer (R-ND), Tammy Baldwin (D-MN), Amy Klobuchar (D-WI), and Lisa Murkowski (R-AK), among others, who noted: “Given the extraordinary taxpayer resources at play we strongly believe that eligibility for the critical minerals credit must prioritize domestic producers and existing free trade agreement partners.”\(^10\)

**[U.S.] engagement has so far been lackluster due to significant pushback domestically, including from lawmakers who either wish to be more engaged in negotiations or believe more agreements would undermine the reshoring objectives of current U.S. trade policy.**

In a multilateral forum, the United States has engaged its partners and allies on critical minerals through the Department of State-led Minerals Security Partnership (MSP).\(^92\) This partnership, which includes 13 states and the European Union, seeks to develop sustainable critical mineral supply chains through public-private partnership, targeted financial support, and diplomatic work. In June, the MSP shortlisted a list of 15 projects that it intends to fund by the end of 2023.\(^93\) In September 2023, Norway, Italy, and–most importantly–India joined the MSP, signaling that the desire to diversify critical minerals supply away from China is strong throughout the international community.\(^94\)

Additionally, there are nascent talks mostly touted by Europe, where negotiations on a CMA are seemingly stalled, to create a “critical minerals club” or a “buyers club.”\(^95\) This club would benefit its members (in theory, Brussels and its allies) by setting more consistent prices for minerals purchasers, seeking to avoid unstable prices in a time of high demand and fluctuating supply.\(^96\) While meeting with the U.S. Treasury secretary in early 2023, a senior German official raised the possibility of a minerals club, but the idea has yet to gain much traction in Washington.\(^97\)
Policy Recommendations

Building U.S. and allied capacity to rebalance this dependency while achieving green transition goals will require a coherent, well-articulated industrial policy with U.S. leadership that expressly balances domestic production goals, objectives for the green energy transition, and domestic demand for imported inputs from allies and partners, as well as from China, when necessary.

The president should task an interagency team to draft an industrial policy plan for growing domestic production of lithium-ion batteries. Given its resources and the extensive work already done, the administration should prepare specific estimates and projections for future needs for key critical minerals, constituent minerals and chemistries that are necessary to reach its goals. This assessment could also include what CMAs and other enhanced trade relationships will be necessary to secure supply for projected needs. For example, a recent S&P report assessed that while lithium sourcing was fairly likely to meet the IRA’s requirements by 2035, it is very unlikely that enough cobalt and nickel supply will be able to keep up. Does the administration agree? How can trade relationships be improved to create access for U.S. manufacturers to a greater and more consistent supply of inputs critical to scaling up domestic production?

In terms of diversification, working effectively with other countries is essential. CSIS’s previous work on this subject concluded that an exclusive focus on domestic manufacturing was not the most productive path to resiliency and instead focused on “friendshoring”—encouraging the movement of supply chains to countries that do not pose a national security threat—and the development of “trusted trade partnerships” with them. The U.S. government should do more to ramp up
friendshoring efforts in the form of new agreements and should attempt to build up the United States’ own processing capabilities to ensure the future competitiveness of the U.S. lithium-ion battery sector. Additionally, the United States should also foster increased regulatory cooperation with other countries in key areas of the battery supply chain by building upon existing agreements.

Administration statements on supply chain policy regularly reference the importance of cooperation with friends and allies, but it is becoming clear that this administration may not be capable of actually concluding a viable set of international trade and cooperation agreements that would increase supply chain security in this sector, absent support of Congress and domestic stakeholders. Without this support, the administration’s campaign for additional CMAs has faltered, and business uncertainty continues to grow surrounding the viability of lithium-ion battery production in the United States. It is urgent that the administration engage with Congress to achieve a solid bipartisan consensus on how the United States should balance trade and industrial and climate policy objectives in this sector. Concluding several CMAs with key countries such as the United Kingdom, Europe, Indonesia, Argentina, and the Democratic Republic of the Congo will be important to shoring up supply chain resiliency.

The discriminatory aspects of the IRA, to be discussed in the next paper, have engendered sharp criticism and may result in retaliation from trading partners that could unnecessarily threaten a strategy built on trusted trade partners and the green transition. Again, a multilateral approach to friendshoring and reducing dependency on China cannot be achieved without more active involvement by Congress in shaping trade agreements and better calibration of the legislative requirements for domestic sourcing.

It is urgent that the administration engage with Congress to achieve a solid bipartisan consensus on how the United States should balance trade and industrial and climate policy objectives in this sector.

Taking the language in the IRA reflecting preference for FTA partners to heart, the administration should investigate options for increasing investment in FTA partners that possess significant reserves of key minerals (such as lithium deposits in FTA partner Chile or Canada’s cobalt, graphite, lithium, and nickel deposits). If the United States is to reach such agreements successfully, it will have to negotiate not only extraction opportunities but also responses to the other countries’ demands to establish more value-added refining operations in their countries. Additionally, the United States should push for regulatory reforms that could be made to incentivize domestic production of key constituent materials for the supply chain.
Conclusion

According to the bipartisan House Select Committee on the Strategic Competition between the United States and the Chinese Communist Party, China’s domestic industrial policy has over time “effectively monopolized numerous critical mineral supply chains, including mining, mineral processing, refining, metallurgy, and end-use manufacturing,” making the United States and much of the world dependent on China. An uncomfortable reality is that the United States is not currently a significant player in the global mineral extraction and processing markets. The United States depends on imports for renewable technologies, chief among them the lithium-ion battery, and the critical mineral inputs essential to accomplishing a green transition.

When it comes to processing the materials necessary for lithium-ion battery production, the Biden administration is making multifaceted efforts to incentivize more production in the United States. However, subsidies in the IRA are set to significantly increase the demand for lithium-ion batteries to a level that will far exceed the country’s current manufacturing capabilities and available supply of certain critical mineral inputs. Leveraging subsidy packages (chief among them IRA tax credits) and trade tools (such as CMAs) to incentivize production by U.S. partners and allies is therefore a critical piece of the puzzle.

Hindering U.S. producers from sourcing even small quantities of scarce inputs of critical materials for battery production from China and enforcing domestic content requirements that constrict the ability of U.S. businesses to turn to other nations to satisfy demand for manufacturing inputs will make it more difficult to achieve green transition goals. The three elements of current U.S. policy—incentivizing the green transition via ambitious policy packages such as the IRA,
reshoring capabilities in critical sectors, and diversifying away from China—reflects conflicting goals. Policies to diversify away from China and reshore production capabilities will hinder long-term environmental objectives. It is thus imperative that the United States adopt a friendshoring approach to the green transition and allow U.S. businesses further down the lithium-ion battery supply chain to access enough minerals and materials to scale up production. In two subsequent papers, the CSIS Scholl Chair will discuss views on pursuing a more coherent industrial policy that balances these competing objectives.
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Endnotes


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