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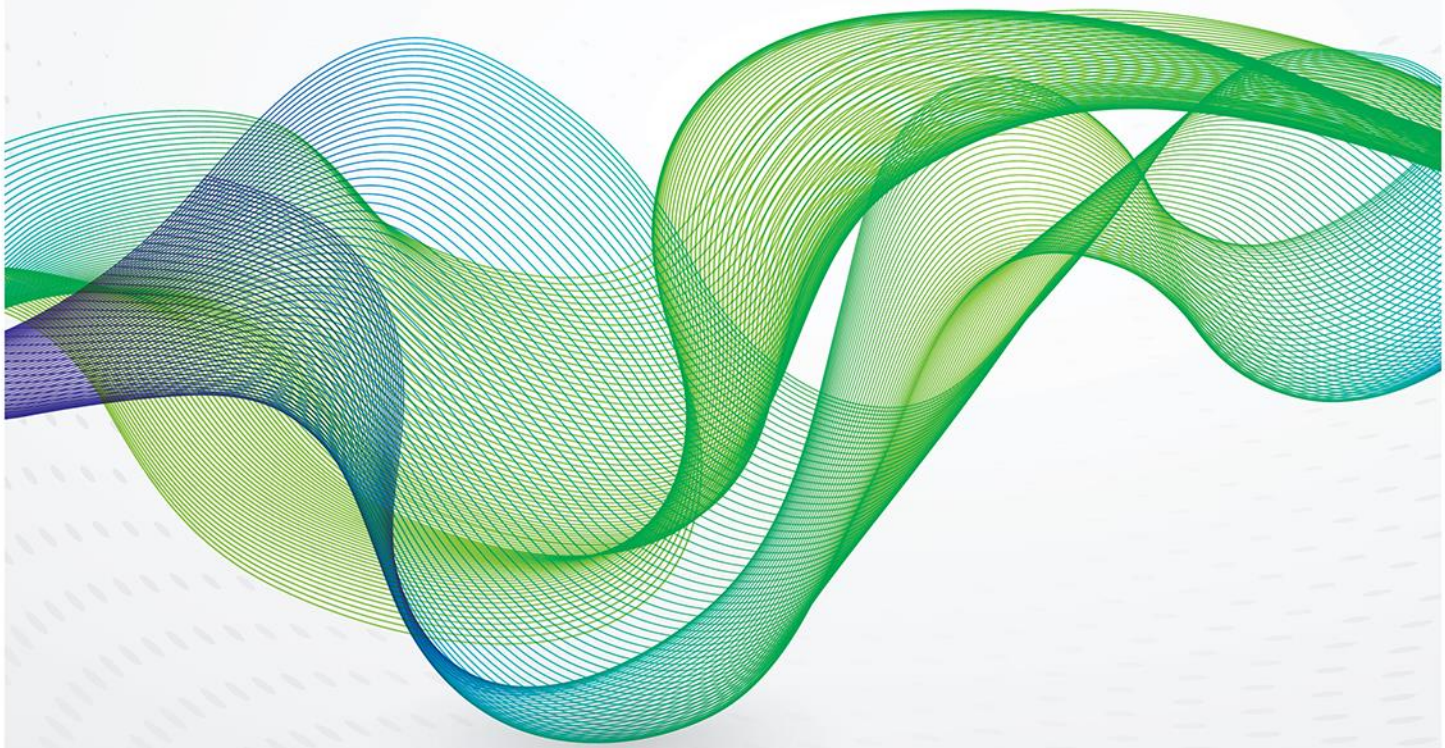
US efforts to decarbonize and de-risk the battery supply chains: Are they fundamentally incompatible?



OIES ENERGY COMMENT

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Introduction

The tenets of energy security have traditionally been to ensure access to affordable, reliable, and sustainable energy resources to power a modern economy. In the last century, when hydrocarbon commodities emerged as the dominant form of energy powering global markets, achieving energy security primarily depended on diversification of routes, suppliers, and fuels. Amidst an increasingly urgent imperative to decarbonize the global economy to address the climate crisis, there is a fundamental shift in these core tenets as hydrocarbon molecules are projected to give way to electrons produced with low-carbon technologies to reduce emissions. The crux of this shift is a reduction in the reliance on flows of molecules in favor of the deployment of stocks of industrial capacity required to rapidly expand access to carbon-free electricity. Such a historically unique transformation will result in radical changes to the energy system and to its vulnerabilities. Governments need to assess and then develop policies to promote energy security under this new global energy order. The motive to rethink historical energy security policy applications has been heightened not only by the urgency of the climate challenge (addressed below), but also by the geopolitical challenge posed by China, which has come to dominate manufacturing of new energy technologies.

China's economic model and the unprecedented pace and prowess of its industrialization have given it a powerful advantage in the manufacturing capabilities that will drive decarbonization. Coupled with strategic foresight to effectively prioritize and incentivize development of the primary technologies of decarbonization – solar, wind, and batteries – in its centralized economic planning, Beijing has achieved unprecedented market share across the supply chains of these technologies. Not only has China achieved extraordinary concentration for finished energy-generating and -storing technologies, but its stranglehold also extends to raw material processing, component manufacturing, and the capital equipment necessary to produce these technologies. In many segments of the supply chain, this market concentration poses potential risks to other post-industrial economies. This is because such concentration allows China to exert its leverage for geopolitical or coercive ends, but more importantly because disruptions in China create impacts on importing countries. Further, by falling behind on technological and industrial grounds in such a consequential economic sector, import-dependent countries will limit future pathways for economic development and potentially risk political support for the energy transition.

As international decarbonization momentum solidifies amidst increasingly dire evidence of climate change and its consequences, policymakers are confronted with a complex challenge. They must balance the imperative of emissions reduction with efforts to de-risk China's incumbent, dominant position in the supply chains of decarbonization technologies. Given the referenced paradigm shift, the traditional energy security policy toolkit will have limited applicability and relevance to realize an effective balance between emissions-reducing technology deployment and unsustainable industrial dependencies.

Tools of coercion and sanctions have frequently been the default approach for confronting adversaries and defending national or economic interests. That same thinking and policy foundation, however, is unlikely to achieve the balance of interests at stake in the geopolitics of decarbonization. China can be both an adversarial competitor and a foundational contributor to the advancement of cost-effective technologies and innovation to unlock the emission reductions desperately needed to tackle the climate crisis. Nonetheless, in recent years, governments are beginning to deploy new tools and policies intended to dilute Chinese industrial concentrations while incentivizing supply chain diversification and supercharging decarbonization technology deployment.

The United States updated its nationally determined contribution under the Paris Agreement in 2021, revising its ambition to target a 50–52 per cent reduction from 2005 levels economy-wide by 2030. Light-duty vehicles represent the largest contributor of greenhouse gases from the transport sector, which itself

comprises 29 per cent of overall U.S. emissions as of 2019.[1] To ultimately achieve the emission reduction levels necessary in the transport sector, the United States must achieve more rapid and broad-based consumer adoption of light-duty electric vehicles (EVs). For this, cost parity with incumbent internal combustion energy (ICE) vehicles is necessary. The Inflation Reduction Act (IRA) seeks to achieve this with consumer tax credits valued at $7500 per vehicle, which covers the majority of battery pack costs given recent pricing dynamics[2]. But the de-risking measures integrated into the tax credits are at odds with the current structure of the Li-ion battery supply chain, and present eligibility challenges that are insurmountable in the near term. This, in turn, will erode the impact of these tax credits, both by limiting the number of qualifying vehicles and by imposing costs to diversify production capacity where it is misaligned with the legislation's eligibility criteria. This paper outlines current electrification of transport policy goals, and examines the origins and design of 'foreign entity of concern' (FEOC) restrictions, which, as a de-risking tool growing in frequency and scope, will be vital in understanding future U.S. policy on supply chain resilience. The paper then identifies the artificial bottlenecks and unintended consequences that these measures entail, both for the Li-ion battery supply chain and for U.S. implementation.

1. Overview: The U.S. Inflation Reduction Act and the electrification of transport

The Biden administration has sought to balance de-risking tools and major energy and climate policies since entering office. In August 2021, the administration released Executive Order 14037 on Strengthening American Leadership in Clean Cars and Trucks,[3] which established the pledge for 50 per cent of all new passenger cars and light trucks sold in 2030 to be zero-emission vehicles. In addition to its statement on policy, this Executive Order instructs U.S. government agencies to devise new vehicle emission standards, expand key infrastructure, promote innovation, and invest in the domestic auto industry. The following year, the administration added further measures through the Inflation Reduction Act (IRA)[4] of 2022 to catalyze EV demand and reach its stated deployment goal.

Specifically, the IRA's section 30(d) provides a consumer tax credit for passenger vehicles of up to US$7,500 per vehicle subject to certain manufactured suggested retail pricing, consumer income, vehicle assembly, and component and material sourcing requirements. The credit is divided into two separate sets of supply chain eligibility requirements, evenly split in value, that specify (1) the proportion of the critical minerals composing the EV's battery that must be mined *or* processed in either the United States or in the jurisdiction of one of its free trade agreement (FTA) partners, and (2) the percentage of the battery's components that must be assembled or manufactured in North America. The required proportions of the materials and components increase over time, requiring that higher percentages be achieved to maintain eligibility as the tax credit matures. This long set of eligibility criteria seeks to comprehensively diversify the Li-ion battery supply chain, from the upstream mining segment to the battery pack assembly.

These criteria represent novel and repurposed policy tools that raise substantial questions on impact and efficacy. China's capture of market share in the Li-ion battery industry is a result of both its policy incentives and its sustained ability to achieve technology cost declines through manufacturing scale; battery science, research and development; and innovation in manufacturing and processing. As the United States seeks to diversify this market share through the IRA, there will inevitably be a cost associated with supply chain reconstruction, although how these costs are diffused throughout the chain remains to be seen.

[1] US Government (2022).
[2] BNEF (2023). The battery represents the largest single component cost in electric vehicles. BNEF reported lithium ion battery pack prices of $139/kWh at the end of 2023, which at a pack size of 75 kWh equates to around $9730 per vehicle.
[3] White House (2021a).
[4] White House (2023).

The 30(d) credit does, however, seek to establish a category of 'trusted suppliers,' defined by FTA countries and incorporating national security-based eligibility restrictions through the incorporation of FEOC statutory language. Utilizing FTA countries as a proxy for trusted suppliers and imposing FEOC restrictions in an attempt to diversify supply chains has raised widespread concerns from the auto industry that these requirements will create artificial sourcing bottlenecks in the near term. Whether these persist over the long term and fundamentally prevent the intended transport sector decarbonization targeted by the IRA is an open question.

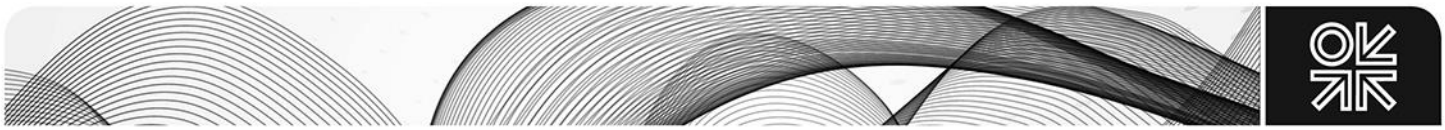
2. Foreign entity of concern: Origins, applicability, and interpretation

'Foreign entity of concern' (FEOC) is a recent legal construct with origins in the 2021 National Defense Authorization Act (NDAA), [5] but its growing legislative use and evolution in subsequent years demonstrates that Congress increasingly views it as a tool for managing technology and industrial risks in areas of national security. In the 2021 NDAA, Congress placed restrictions on the Department of Defense's procurement of 'sensitive materials,' namely rare earth magnets, from 'covered nations,' defined as North Korea, China, Russia, and Iran. The NDAA restrictions grew due to Congressional concerns over the United States' critical mineral dependencies in its defense industrial base, especially on rare earth extraction, processing, and magnet production. The NDAA language, alongside other legislative and executive incentives,[6] intended to revive U.S. and allied rare earth element mining and processing to insulate U.S. defense-related supply chains from complete dependency on China.

The existing concerns over rare earth processing quickly extended to the critical materials that serve as feedstock to energy transition technologies, leading Congress to repurpose the NDAA definition of covered nations under the legal term FEOC in the Infrastructure Investment and Jobs Act of 2021, more commonly referred to as the Bipartisan Infrastructure Law (BIL), to broaden its coverage to additional foreign entities.[7] The BIL definition placed additional restrictions on entities designated foreign terrorist organizations that appear on the Department of Treasury's Specially Designated National list, that have been convicted under various national security-related laws, or which the Secretary of Energy determines on a discretionary basis to have been engaged in 'unauthorized conduct that is detrimental to the national security or foreign policy of the United States.' Additionally and most consequentially, the expanded FEOC definition also includes restrictions on entities 'owned by, controlled by, or subject to the jurisdiction or direction of a government of a foreign country that is a covered nation' without providing further clarity on what constitutes such control.

The BIL provision in which FEOC appears governs a battery manufacturing and material processing grant funding award program allocated to the Department of Energy (DOE). It is intended to restrict the Department's ability to disburse funding to any awardee that could be considered a FEOC. The logic of such restrictions is to prevent intentional or unconscious awarding of U.S. government funding to companies developing innovative battery material processing technology or next-generation battery components that have ties to China. The DOE elected not to exercise its discretionary authority interpreting the BIL's statutory language in greater detail prior to the first round of awards under the battery material and component grant program. In that round of awards, Congressional scrutiny surrounding one of the

[5] LII (nd.a).
[6] See March 2022 Presidential Determination No. 2022-11 invoking Defense Production Act Title III for critical materials mining and processing and subsequent commercial grant awards for rare earth facilities; Bipartisan Infrastructure Law (BIL) Section 40205 funding a rare earth separation and processing demonstration facility, Sections 40207, 40208, and 40210 funding $6 billion in grants related to the supply, processing, and recycling of battery critical materials and minerals (including rare earths), and the BIL's expansion of Department of Energy (DOE) Title XVII loan guarantee program to include support for domestic critical material production.
[7] LII (nd.b).



conditional grants awarded to Microvast and the company's ties to China in the first round led to a cancelling of the award.[8]

Congress subsequently inserted FEOC language into both the Creating Helpful Incentives to Produce Semiconductors and Science Act of 2022 (CHIPS Act) and the IRA, in an effort to add legislative safeguards to prevent new, or sever existing, linkages to Chinese industrial capacity in transformative technology areas. The CHIPS Act language prohibits recipients of Department of Commerce funding from engaging in joint research or technology licensing with FEOCs,[9] while the IRA's consumer EV tax credit disqualifies companies that rely on FEOCs in their Li-ion battery supply chains.[10] The IRA language prohibits sourcing of battery components from FEOCs in 2024, and prohibits FEOC-derived critical mineral beginning in 2025. Put simply, the presence of a FEOC in an automaker's supply chain disqualifies it from the tax credit. This rapid succession of FEOC legislation suggests it is becoming the preferred mechanism in Congressional circles to de-risk technology supply chains, by reducing geographic concentration in China through new capacity domestically and in partner- and ally countries (e.g., friend- and reshoring), and to compel greater diligence surrounding the corporate structures of supply chain entities.

But the broad language used in the FEOC provision, particularly the 'owned by, controlled by, or subject to the jurisdiction […] of a foreign country that is a covered nation,' and the potential impact of different interpretation on the EV consumer tax credit, prompted auto and battery manufacturers to require further clarification. On December 1, the Departments of Treasury and Energy took the unusual step of simultaneously releasing coordinated notifications of proposed interpretive rulemaking for the FEOC clause[11,12] and released final guidance on May 3.[13],[14] The rule clarifies that the FEOC provision will require removal of any critical minerals, battery components, and battery materials that are directly produced within the boundary of a covered nation (e.g., China or Russia). However, the FEOC designation does not necessarily accompany a Chinese firm outside the physical borders of China: Chinese subsidiaries and joint ventures outside of China that can demonstrate that FEOC ownership of a particular entity's board seats, voting rights, and shares is below 25 per cent, and that the contractual or licensing arrangement avoids granting a FEOC 'effective control' over a specific mining, processing, manufacturing, or other supply chain asset, can qualify for the tax credit. Already, China is demonstrating an adaptability to these provisions, including through the offshoring of capacity in U.S. FTA jurisdictions such as Morocco, where Chinese firms including CNGR and Huayou Cobalt have announced plans to construct cathode material production.[15]

This gives companies seeking eligibility for the tax credit substantial flexibility provided they can substantiate that the Chinese Communist party does not exert direct material influence over individual facilities' operations. Of critical importance, the guidance states that in determining whether an entity *outside of the physical borders of China* is a FEOC under 30(d), industry should not 'factor in any voting share, equity interest, or board seats held by an entity that is a FEOC solely by virtue of being subject to the covered nation's jurisdiction.'

The nuanced guidance attempts one of the more intricate balancing acts by the U.S. government: It tries to avoid industrial dependencies that create national security concerns while preserving access to Chinese production capacity for Li-ion batteries and their precursor components and materials, given that these are

[8] Bikales and Tamborrino (2023).
[9] US Government (2023a).
[10] U.S. Congress (2021–2022).
[11] U.S. Government (2023b).
[12] U.S. Government (2023c).
[13] U.S. Government (2024a).
[14] U.S. Government (2024b).
[15] Hughes and Adham (2023).

often the most cost-effective sources. In its current form, and if preserved in the longer term, the guidance's effective control component will force the Chinese government to consider the risks of intervening in the commercial operations of its companies' activities outside of China's border to preserve Chinese dominance of these industries and market access in the United States.

3. Inflation Reduction Act: Politics and bureaucratic implications

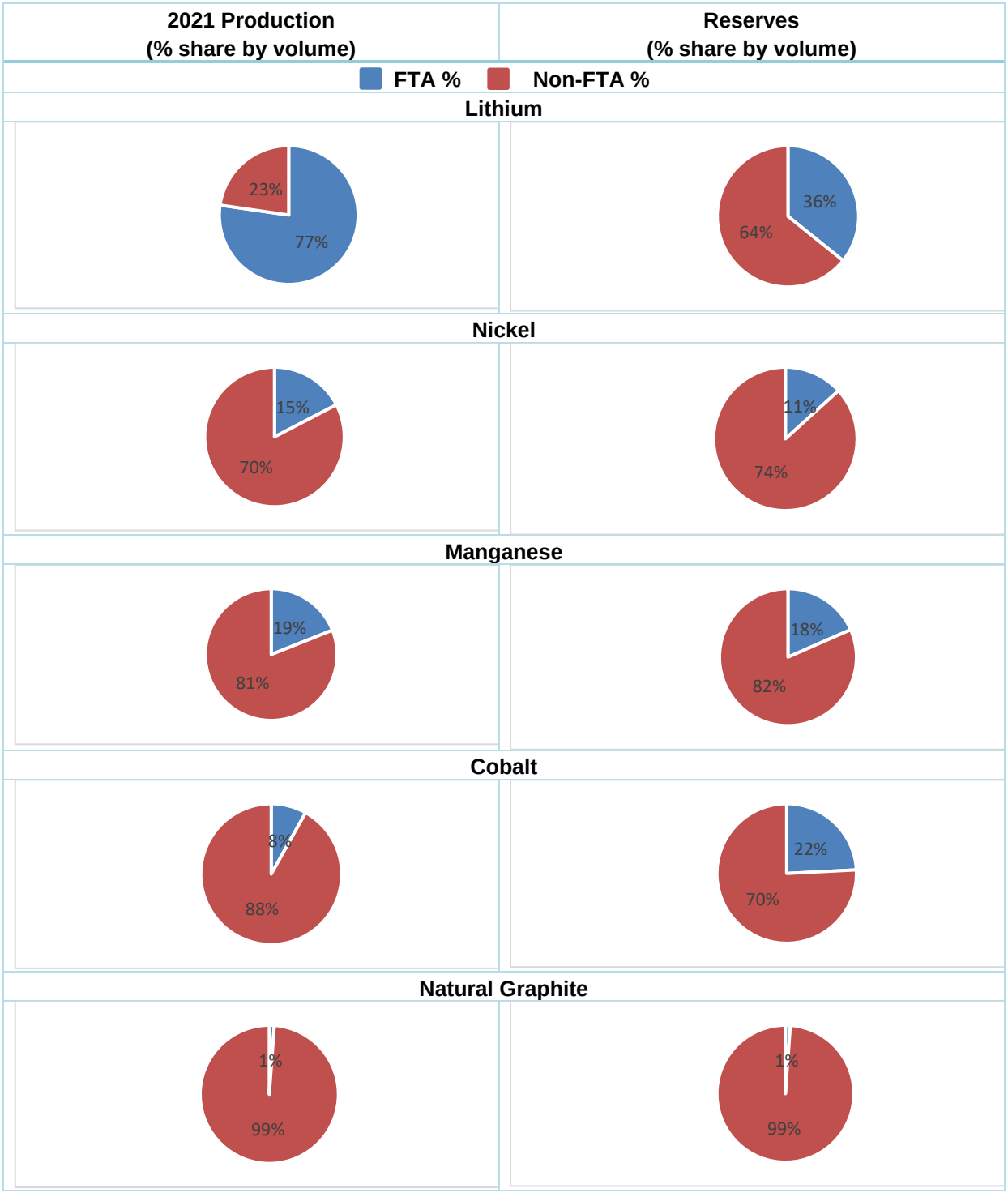
Given that FEOC provisions are used in multiple technologies and in various government agencies' funding programs, enforcement will require enhanced U.S. government interagency bureaucratic capacity and coordination. While the U.S. government has amassed substantial capacity and expertise to develop and implement economic sanction regimes, this bureaucratic capability is ill-suited for advancing technology supply chain resiliency. The sanctions capabilities within the U.S. government are precisely designed to disrupt, deter, or coerce adversaries from engaging in behaviors that undermine U.S. national security interests. But they place far more emphasis on the impact to the potential nefarious target than they do on evaluating collateral damage to U.S. economic and commercial interests. Promoting supply chain resilience must carefully consider the costs and potential for self-inflicted economic harm from overly ambitious or draconian mandates for diversification.[16]

Rather than map out a thoughtful and realistic pathway for achieving such resiliency in Li-ion battery supply chains, the FEOC tool, and the IRA 30(d) provision more broadly, represents a hastily considered, sanctions-like mechanism conceptually designed at its origin to insulate U.S. defense procurement and acquisition from sabotage and penetration by U.S. adversaries. Meeting decarbonization targets while achieving energy security, however, will require facilitation of a supply chain capable of advancing innovation, reducing costs, and achieving the necessary emission reductions from one of the largest global sources. The provision even extends authority to the DOE to designate as FEOCs entities that would not otherwise meet the statute's definition, restricting sourcing from those firms for the purposes of 30(d) qualification. This capability strongly resembles the Treasury's specially designated national authority, which is the central mechanism for cutting off access to the U.S. financial system in economic sanction regimes.

The sanction-like nature of 30(d) is notable, for instance, in its requirement for sourcing of mined and processed precursor materials from FTA countries. But there are limited U.S. FTA countries with geologic concentrations of the critical minerals required to achieve the administration's EV and emission reduction targets, based on existing commercial battery chemistries. Figure 1 demonstrates the disproportionate share of global reserves that non-FTA minerals occupy.

[16] For further discussion of economic security bureaucracy, supply chain resiliency, and institutional inadequacies see Farrell and Newman (2023).

Figure 1: U.S. Free trade agreement countries and geologic concentrations of Li-ion battery minerals



Source: USGS (2022).

Save for existing production of lithium in FTA partners Australia and Chile, coupled with the potential for U.S. domestic production, every significant Li-ion battery mineral is significantly concentrated in jurisdictions that are not U.S. FTA partners. Given the political opposition to new FTAs, auto manufacturers will struggle to meet the eligibility requirements based on the origin of the mined material. As a result, they will shift focus towards achieving compliance via the processing stage of the supply chain. The selection of FTA partners as the sole proxy for a 'trusted' supplier thus represents an unnecessarily narrow and arbitrary choice, particularly in a market in need of significant incentives to drive investment in new upstream capacity to meet projected demand growth for these minerals, as well as diversification from Chinese upstream producers. Although FTA partners tend to share strong economic and value-based ties with the United States, and would represent sources of supply less prone to being compromised by politically driven disruptions,[17] other categories could have been considered as a potential proxy. For example, utilizing a modestly refined version of the existing conditionality placed on U.S. foreign aid disbursements – that recipient countries must have held a democratic election within the past five years – could have widened the list of eligible critical mineral suppliers without compromising the law's objective. But such a change would require Congressional action to update the law – an unlikely prospect.

One way of circumventing the limitations of the FTA eligibility requirement is through fit-for-purpose critical mineral agreements (CMAs), which the Biden administration introduced and struck with Japan in March 2023.[18] While the Biden administration has made clear its intention to treat the CMA with Japan as an FTA for the purposes of 30(d), it represents a unique agreement. Firstly, the Japan CMA did not go through traditional procedures for legislative approval – the Japan CMA stipulates that it entered into effect immediately upon signature. Second, the agreement does not reduce tariffs or grant market access to Japan more broadly. The agreement instead grants Japan equal status to its Li-ion battery industrial and historical competitor South Korea, and opens the Japanese market to future Li-ion battery mineral processing conforming with 30(d)'s FTA criteria. There is ambiguity regarding executive branch-derived trade agreements made outside the bounds of a formal treaty process requiring Senate approval.[19] The danger of this ambiguity is that CMAs invoked by automakers to obtain the tax credit could be subjected to legal challenge. This, in turn, would put the underlying investments for new processing capacity in CMA jurisdictions at risk because the vehicle eligibility for the tax credit would be negated if those CMAs were invalidated. Regardless of the legal or Constitutional permissibility of CMAs, the members of relevant Congressional committees governing trade have expressed discontent over the potential commandeering of Congressional authority.[20] As Figure 1 indicates, additional agreements would expand eligibility avenues, but also risk antagonizing Congress further, or stimulating lawsuits against the administration that could stay the eligibility of Japan and potential future CMA partners for FTA treatment under 30(d).

4. Section 30(d) credits: Deployment/sourcing impact

A clear target for a CMA is Indonesia, which is a significant source of nickel production and nickel sulfate refining for production of cathode active material. Congressional scrutiny and a potentially fragile legal foundation present two of the many impediments facing one of the more artificial yet formidable supply chain bottlenecks that 30(d) creates for Indonesia's nickel output. Yet the prospects for a CMA between the United States and Indonesia are dim. In its April 2023 Notice of Proposed Rulemaking, the Treasury Department lays out criteria for establishing new CMAs, which include '[establishing] high-standard

[17] Academic study has applied statistical methodologies demonstrating the capacity of free trade agreements to reduce military conflict between states. Similar logic can be applied to the relative risk associated with prioritizing free trade agreement partners in supply chains critical to national security (see McDonald, 2004).
[18] U.S. Trade Representative (2023).
[19] See 'Congressional and Executive Authority Over Foreign Trade Agreements,' Congressional Research Service, Report R47679, September 1, 2023.
[20] Neal, Richard (2023).

disciplines in key areas affecting trade (such as core labor and environmental protections), and/or (D) [reducing] or [eliminating] restrictions on exports or [committing] the parties to refrain from imposing such restrictions on exports.'[21] Meeting these conditions would require substantial domestic reforms and actions by the Indonesian government, setting up a significant eligibility challenge for battery producers and automakers considering nickel market trajectories, as well as nickel's proportion of the battery metals' overall cost and its contribution to the battery's performance.

Commercially available Li-ion batteries for use in EVs typically are composed of several components, including the cathode, anode, electrolyte, current collector, and separator. There are two dominant forms of cathode chemistries in the market: lithium-iron phosphate (LFP) and nickel manganese cobalt (NMC). The specific proportions of the three minerals making up the NMC cathode can vary according to market dynamics, cathode formulation, technology provider, performance requirements, costs, and more. Generally speaking, material costs make up between 50 and 60 per cent of the overall battery pack costs. Of those material costs, cathode active material makes up the largest proportion, comprising nearly 50 per cent of material costs in the most nickel-heavy cathode chemistries.[22] Nickel-heavy cathodes tend to have superior energy density, allowing longer EV range and less frequent recharging requirements. These are sought after by automakers seeking to balance consumer preferences on cost, performance, and range. That said, LFP chemistries, comprised of more abundant and commercially available raw materials (iron and phosphorus) leading to lower costs, have made impressive strides in market penetration, improving performance and density to close the gap with NMC. In fact, nickel-free LFP cathodes have been steadily expanding market share in the past three years, growing from 3 per cent of the market in 2019 to 27 per cent in 2022,[23] and are forecast to reach 44 per cent of demand by 2030,[24] although those forecasts may be quickly eclipsed by market trends based on preliminary 2023 data indicating LFP already made up more than 40 per cent of the EV market.[25]

For NMC to achieve these performance traits, nickel ore streams must be refined into class 1 nickel of a very high purity (99.8 per cent) to yield nickel sulfate, the precursor material from nickel contributing to cathode active material. Nickel sulfide ores tend to have the highest nickel concentration and thus have been sought after as the most economical resource to meet growing Li-ion battery demand. This is depleting global reserves, and leading cathode active material and battery producers to seek precursor nickel products from alternative, lower-grade reserves such as nickel laterite.

Indonesia possesses the most globally significant nickel laterite reserves, and has surged production amidst declining global nickel sulfide reserves to meet accelerating Li-ion battery demand with nickel-heavy cathode chemistries. The U.S. DOE cited the decline in nickel sulfide supply as a significant risk in its 2021 report on the high-capacity battery supply chain: 'there are market indications that there could be a large shortage of Class 1 nickel in the next 3–7 years. If there are opportunities for the U.S. to target one part of the battery supply chain, this would likely be the most critical to provide short- and medium-term supply chain stability. In contrast to cobalt, nickel content per battery will increase in the coming years, as R&D focused on high-nickel in cathodes has shown significant and accelerated commercial adoption.'[26] In light of the nickel sulfide supply challenge and Indonesia's importance to it, Indonesia's non-FTA status and its reliance on Chinese investment in its nickel industry are problematic for IRA compliance.

[21] U.S. Government (2023d).
[22] NITI Aayog (2023).
[23] IEA (2023).
[24] Benchmark (2023a).
[25] Bullard (2024).
[26] White House (2021b).

Analysts are further forecasting that Indonesian nickel supply could represent as much as 60 per cent of globally produced volumes by 2025, compared to market share of 30 per cent in 2020.[27] For auto manufacturers that have yet to secure offtake agreements for future nickel-based Li-ion battery vehicles, Indonesia is therefore likely to be the source of new supply growth in the coming years. But this poses challenges for manufacturers intent on securing the IRA tax credit, and creates incentives for auto manufacturers to press the Biden administration to execute a CMA with Indonesia.

Alongside its recent period of extraordinary growth, the Indonesian nickel sector has been the target of growing scrutiny regarding its environmental, social, and governance (ESG) practices. Press reporting in the past two years has focused considerable attention on substandard labor practices leading to injuries and death, as well as the industry's damaging environmental footprint. Since 2022, nickel operations in Indonesia have led to worker deaths related to violent clashes between Chinese and Indonesian laborers, a smelter explosion, and a landslide of nickel waste tailings.[28] Further, the NGO China Labor Watch has alleged widespread labor rights violations through its communications with Chinese workers in Indonesia over the past two years, including passport confiscation, withholding wages, restriction of movement, pervasive workplace injuries, and poor occupational safety, among others.[29]

The expansion of Indonesia's nickel industry also poses waste management and carbon intensity challenges. The lower-grade ore in nickel laterite deposits requires substantially more energy and produces high volumes of waste to convert raw material into mixed hydroxide precipitate (MHP) or mixed sulfide precipitate precursor material for battery-grade nickel sulfate. *Benchmark Minerals Intelligence* has cited tailing waste production as high as 1.2 tons of waste per ton of ore consumed.[30] Indonesia's temporary solution to an expanding waste issue has been to mandate onshore dry stacking of tailings, which is prone to leakage and is not currently subjected to localized environmental regulatory oversight. The rise of industrial parks driven by Chinese firms such as Tsingshan has also led to rapid deployment of 'captive' coal-fired power plants to meet the energy needs of nickel smelters. The expansion of coal generation assets has already complicated U.S.–Indonesian energy cooperation under the Just Energy Transition Partnership, which set aspirational emission reduction targets in return for infrastructure financing, but failed to integrate new captive power plants in its baseline accounting.[31] As MHP emerges as the preferred feedstock for Chinese nickel sulfate producers, and alternative Indonesian supplies from nickel saprolite resources are depleted, Indonesia will increasingly rely on high-pressure acid leaching (HPAL) processing designed to handle the lower-grade laterite resources. Researchers at Transport and Environment (T&E) found HPAL facilities to generate 'almost twice as much emissions than the industry average and five to six times higher emissions than the lower scoring peer.'[32]

While a CMA could potentially help compel ESG-related improvements in Indonesia, its government also maintains nickel export controls. Initially established in 2014, and reimposed in 2020, Indonesian Law No. 3/2020 prohibits nickel ore exports and requires domestic processing. In a challenge to these policies brought by the European Commission, the World Trade Organization found in 2022 that Indonesia's law violated GATT Article XI prohibiting members from placing quantitative restrictions on exports.[33] Therefore on two of the four criteria for CMAs laid out by the U.S. Treasury Department, Indonesia would ostensibly not be eligible for an agreement without making transformative policy changes to its nickel sector; President-elect Prabowo Subianto has voiced strong support for continuity on outgoing President Joko Widodo's 'downstreaming' agenda.

[27] Desai, P. (2022).
[28] Aprilla (2023); Enmont (2023); Enmont and Ramzy (2023); Nangoy and Christina (2023).
[29] CLW (2023).
[30] Fisher and Grossi (2023).
[31] Suroyo and Nangoy (2023).
[32] T&E (2023).
[33] WTO (2022).

Even in an ambitious policy reform scenario, the United States would need a degree of confidence that MHP producers would not qualify as FEOCs under the proposed Treasury and Energy rules to justify the significant investment of resources and political capital that CMA negotiations would require. But the opacity of the corporate structures underpinning nickel industry joint ventures, and the lack of insights into 'effective control' wielded by the Chinese Communist Party on the assets, would make high-confidence FEOC judgments very difficult. Wood Mackenzie has reported Chinese industry capital intensity improvements for its Indonesian assets via HPAL flowsheet improvements yielding US$30,000–35,000 per annual ton of nickel, compared to an average US$100,000 per annual ton of nickel from Western competitors.[34] According to Indonesian nickel industry stakeholders, the cost declines that emergent MHP producers in Indonesia have claimed do not include enabling infrastructure investments or waste management and disposition costs. Exclusion of those project elements could suggest some modicum of Chinese government financial involvement to defray the associated costs, similar to industrial park subsidies provided to domestic manufacturers in China.

Thus, the unintended FTA and FEOC effect of IRA 30(d) could be the formation of a geopolitical accelerant to the growing momentum behind alternative, nickel-free cathodes in the Li-ion battery supply chain, although this field is also dominated by Chinese suppliers of LFP batteries. Given growing challenges for Indonesian nickel supplies to qualify for the EV tax credit, manufacturers may turn to alternative cathode chemistries, provided that the associated costs and market share incentives sufficiently outweigh the benefits of the tax credit on consumer demand.

With existing cost, thermal stability, and cycle-life advantages, the IRA's geopolitical intervention in the Li-ion battery supply chain could further bolster LFP's ability to compete with NMC chemistries, outweighing range anxiety in the U.S. consumer market. Furthermore, the LFP trendline underscores the extraordinary ability of Chinese firms to achieve breakthrough cost declines and technological improvements in extremely condensed periods of time. These then create substantial barriers for meaningful competition, and therefore supply chain diversification, to emerge. The growing emergence of LFP and its effect on market prices could mirror the manufacturing innovation and cost decline dynamics that led China to achieve total domination of the solar supply chain. The rapid gains that LFP is making on NMC's market share will ease dependencies on individual minerals in the energy transition, in this case nickel in the Li-ion battery supply chain, but could make IRA 30(d) compliance more difficult given the concentration of LFP production capacity within China by Chinese firms. Chinese firms reportedly represented more than 99 per cent of LFP production and ranked as the cheapest Li-ion battery packs in BloombergNEF's 2022 survey.[35]

To get around this, manufacturers could establish licensing agreements with Chinese companies for LFP production outside of China, along the conditions outlined in DOE's FEOC guidance. The guidance allows for FEOCs to enter into technology licensing agreements with non-FEOCs provided that those agreements do not confer the FEOC with 'effective control,' or the ability to control production of specific minerals, materials, or components, or restrict access to critical information or data necessary to achieve production at the intended scale and volume under the terms of the agreement. The FEOC restriction could drive such licensing agreements to standardize material sourcing as the responsibility of the licensee (i.e., the non-FEOC). Ford's BlueOval Battery Park in Michigan is an early example of this type of licensing arrangement in which Ford's wholly owned subsidiary will produce CATL-licensed LFP-based cells for its vehicle lines,[36] but also one that has attracted significant Congressional scrutiny for its reliance on Chinese technology.[37]

In its announcement, Ford underscores the benefits to customers seeking variety in battery performance characteristics. It also highlights that incorporating LFP into its product offerings enhances diversification.

[34] Wood Mackenize (2023).
[35] Lee and Coppola (2023).
[36] Ford (2023).
[37] Shepardson (2023).

If such licensing arrangements can be scaled, it could actually represent the most viable, secure near-term pathway to achieving the IRA's transportation decarbonization goals. It offers Chinese battery makers some of the financial benefit of a rapidly growing U.S. EV market, while potentially encouraging commercial and geographic diversification along other segments of the supply chain. Signaling that these agreements are a path for 30(d) compliance could also further incentivize Korean original equipment manufacturers (OEMs) to hasten expansion into LFP in the coming years, thereby growing options for licensing and joint venture partnerships in the burgeoning U.S. battery industry. This approach would also avoid the growing dynamic in Europe in which Chinese Li-ion battery industrial capacity is expanding its extraterritorial reach with limited security and diversification benefits (discussed further below).

Chemistry optionality will prove increasingly important for OEMs and auto manufacturers dependent on a single battery chemistry. Limited battery chemistry offerings implies those OEMs will face a potential competitive disadvantage by being a market taker on pricing for NMC minerals. If the nickel market falls intro structural deficit in the latter half of this decade, as many forecasts suggest,[38] OEMs with chemistry limitations will be at a disadvantage compared to those that can increase LFP production in response to market dynamics, drawing also on larger, more commodified markets for the underlying raw materials. Korean battery OEMs have signaled intent to diversify into LFP chemistries, but have been caught off-guard by LFP's performance improvements and market demand, stating they will not achieve commercial volumes of the chemistry before 2026 or 2027.[39]

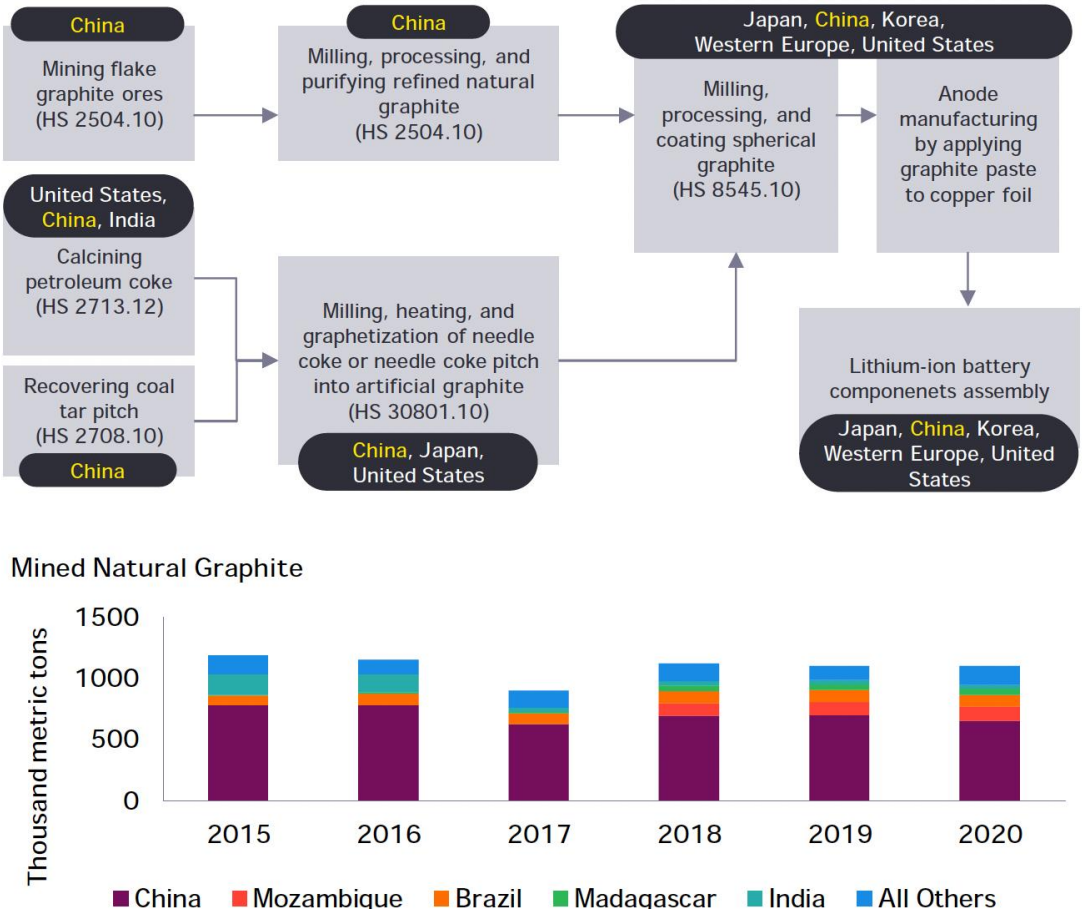
The near-term impact of this additional LFP momentum on Indonesia's nickel sector growth will likely be muted given broader global cathode demand growth, but it solidifies China's presence and control in a critical jurisdiction on the broader energy transition mineral chessboard at the expense of the United States, at a juncture when the Biden administration's economic agenda for the Indo-Pacific region has suffered significant setbacks. China is also making strides in localizing other key precursor material production facilities collocated with its expanding nickel refining operations, including BTR's decision to construct an anode production facility in the Indonesia Morowali Industrial Park in Sulawesi, delivering further on the Indonesian government's priority initiative to develop a battery manufacturing industrial hub.[40]

5. Anodes

Among Li-ion battery components, anode production is by far the most concentrated segment in terms of China's market share, which stands at 96 per cent of global anode supply. Recognizing the formidable challenge such extensive concentration creates for securing tax credit eligibility, the Department of Treasury adjusted course from the 30(d) draft guidance to the final guidance by exempting graphite from FEOC and sourcing related requirements until 2027. In the process, Treasury converted the "impossible to trace battery materials" to "impracticable to trace battery materials" to allow for the addition of graphite to the materials list. Graphite is the base mineral for anode production, with two primary forms providing feedstock to anode powder production: natural and synthetic graphite. Natural graphite is a globally mined ore found across a diverse range of geographies, while synthetic graphite is made from petroleum coke or coal tar pitch, processed byproducts from petroleum refining and coal coking. A process flow chart for graphite refining in the Li-ion battery supply chain from NITI Aayog can be seen in Figure 2.

[38] S&P Global (2023).
[39] Roy and Heekyong Yang (2024).
[40] Lambok Dominikus (2023).

Figure 2: Simplified process flow chart for graphite refining and mined graphite production



Source: NITI Aayog (2023), p. 49.

Anode producers differ in the composition of their proprietary active anode material (AAM), which can rely exclusively on natural or synthetic graphite, or a specific combination of the two. Synthetic graphite tends to have superior performance characteristics, such as battery and cycle life, producing a more stable and reliable product. As a result of the high temperature (3,000°C) graphitization process required to convert raw materials into battery grade inputs, synthetic also is a higher-cost, more carbon-intensive product. Globally, 14 per cent of AAM feedstock comes from natural graphite and 78 per cent is sourced from artificial graphite in a market of 1.67 million tons in 2022.[41]

In addition to China's dominant position in anode-producing countries, it is also dominant in commercial producers of anodes. In 2022, 84 per cent of the market was controlled by the six largest Chinese anode producers, as demonstrated in Table 1. For comparison, two of the most significant non-Chinese anode developers and producers, Mitsubishi Chemical and Posco, are included to underscore the minimal market share of non-Chinese firms, and the supply chain dynamics that have led those producers to move production capacity from their countries of origin to China for cost competitiveness.

[41] Rystad Energy (2022).

Table 1: Selected commercial anode producers, market share, and location of production

Anode producer	Market share* 2022 (%)	Country of production
BTR (PRC)	26	China Hungary (under construction) Indonesia (under construction)
Zhongke Xingcheng (PRC)	15	China (3 facilities)
Kaijin (PRC)	12	China (6 facilities)
Shangtai Technology (PRC)	12	China (4 facilities)
Shanghai Shanshan (PRC)	11	China (10 facilities) Finland (planned)
Jiangxi Zichen/Putailai (PRC)	8	China (5 facilities) Sweden (planned)
Mitsubishi Chemical (JPN)	0.05	China (1 facility)
POSCO Chemical (ROK)	0.04	Korea (1 facility)

Note: * Market share calculations are estimated based on reported sales volumes where available, and existing production capacity as of 2022. The figures should not be considered authoritative.

Sources: Data assembled from corporate websites, press releases, and various industry reporting outlets.

For the purposes of 30(d) eligibility, anodes sourced from any of the operating facilities listed in Table 1 save for POSCO's would be disqualifying material beginning in 2027, given all production is sourced from within China's borders. Cell manufacturers and automakers intent on qualifying for the tax credit will thus compete for the very small volume of production outside of China, or work with existing anode producers to develop new capacity outside of China before the graphite exemption is lifted. Regarding the latter, China has demonstrated a strong determination to defend its anode market share.

As EV sales have grown at a rapid pace, and Western governments have become more attentive to clean energy technology supply chain dependencies vis-à-vis China, battery component producers and OEMs have begun expanding capacity outside of China on a limited basis. In response to prospective competition, China has instituted a licensing regime for its exports of artificial and natural graphite, and enacted a phase down and eventual cessation of trade in anode-related materials with Sweden in 2020.[42] China's use of market share to harm competition often pairs commercial disputes with political undertone, and in this instance, its trade restrictions with Sweden coincided with Swedish battery OEM Northvolt's fundraising momentum and production of its first indigenous European Li-ion battery cell in 2021. As China imposed these restrictions, its anode producers began announcing significant investments to establish European industrial footholds to service the nascent European battery manufacturing sector. Chinese firms' investment in anode capacity in Europe also have the benefit of placating growing industrial policy inclinations and political appetite to demonstrate that the energy transition can be a catalyst for job growth and prosperity, all while preserving market share. China further escalated its oversight of the graphite market in October 2023, announcing export controls on high-purity synthetic graphite, natural flake graphite,

[42] Economist (2023).

and spherical graphite that require producers to secure permits to continue exporting.[43] Though China's announcement appeared to be in response to the U.S. government's expansion of existing technology export controls on China to artificial intelligence-related chips,[44] it had the dual purpose of heading off emerging battery manufacturer competition in the component where China enjoys its most extensive supply chain dominance.

While Chinese firms construct overseas anode production facilities, battery OEMs must confront challenges with integrating anodes of varying characteristics into battery cells that may have utilized Chinese anode inputs heavily reliant on synthetic graphite. For FEOC compliance, alternative, non-Chinese anode inputs will need to scale quickly to avoid a regression in qualifying vehicles when graphite's exemption expires in 2027. Natural graphite players ex-China have been largely nonexistent until the DOE Loan Program Office announced in July 2022 a $102.1 million loan to Syrah Resources to construct an AAM production facility in Vidalia, Louisiana, vertically integrated with its own upstream graphite production in Mozambique.[45] Integration of anodes with a new bill of materials into existing battery manufacturing processes, however, requires review on the impact of the battery design and performance, a process that can take anywhere between two and six years. The time investment for new anode sourcing performance reviews may lend momentum to those non-Chinese producers that can tap existing sources of synthetic graphite supplies. Posco's steelmaking segment provides it with access to needle coke supplies, which it is leveraging in its anode production, leading to a supply agreement with GM for its Ultium battery cells in 2022.[46]

Scaling up such offtake agreements and new capacity that are compatible with existing cell production feeding into the U.S. market in time to comply with FEOC's application to mined and processed materials in 2025 is a stark challenge. As the U.S. government wields incentives to expand EV market uptake, running cost and feasibility analysis for diversification to levels that provide greater resiliency during the peak growth period of EV sales, and that enable sustainable competition to emerge, will be necessary to inform future policy design. These efforts are aided by the market entry barriers, and the chilling effect that FEOC has had on Chinese firms' plans for U.S.-based capacity. Unlike the dynamic in Europe, where Chinese anode producers are actively constraining the supply of precursor material while developing their own nascent production footholds, the BIL and IRA provisions in the United States provide a near-term foundation for independent U.S. anode production to grow.

The United States' established petroleum refining sector also presents a potential source of petroleum coke, which could complement exploitation of U.S. domestic graphite reserves to establish artificial and natural graphite feedstock to aspiring anode producers, insulating a fledgling industry from Chinese tactics aimed at quashing competition. In recent years, the United States has been the largest exporter of petroleum coke globally, and with appropriate incentives and support could convert refining capacity for needle coke production to drive the formation of U.S.-based AAM supply.[47] The adjustment in the number of qualifying vehicles in January 2027 will be a telling marker of the availability of non-FEOC AAM supplies and the versatility of supply chains to adapt in short order to demanding policy signals. The magnitude of anode dependency clearly represents a security risk, and concentration at this level magnifies the potential impact of disruption, though Chinese anode producers are geographically diversified within China with access to key logistics nodes. Chinese authorities have already exhibited the view that its industry's anode market share endows the Chinese government with geopolitical leverage via its graphite product export controls.

[43] Benchmark (2023b).
[44] Sevastopulo (2023).
[45] DOE (2022).
[46] Posco (2022).
[47] Tsuji, K. (2022).

Conclusions

As EV sales continue to grow, future mass market adoption in the United States will be contingent on the availability of a high volume of consumer choices priced at or below $35,000, which would unlock access to around half of the U.S. new passenger car sales market. Establishing a $7,500 dollar tax credit alongside falling Li-ion battery prices, and increased competition amongst automakers and vehicle lines, all point to strong momentum in meeting the U.S. EV deployment goal and tackling surface transport emission reductions. The supply chain-related conditions placed on that tax credit, however, are likely to be too formidable in cost, complexity, and geopolitics to have the intended impact as the full set of qualifying criteria is finalized and enters into force. In 2023, EVs grew to 9.2 per cent of all passenger vehicle sales in the United States, which is the upper bound of what models from the Clean Investment Monitor[48] teams projected for IRA impact on sales, but occurred prior to the full scope of qualifications going into effect.[49] Further, the awkward marriage of a sanction-like function (the identification of and initiative to separate from existing markets supposed adversarial entities) with tax credits is a questionable vector to advance supply chain resiliency and energy security, given the shifting paradigms driven by energy transition and decarbonization.

Nonetheless, the DOE aimed to achieve a delicate balance of the risks of growing dependencies in China's Li-ion battery industrial capacity while identifying areas where market dependence becomes national security vulnerability. These are valuable, unmistakable signals for the United States to send to Beijing, drawing a distinction between a growing tendency in Washington to characterize Chinese economic activity as nefarious solely by virtue of it being undertaken by China, and China's ability to actually undermine U.S. interests through its supply chain concentration.

Original equipment manufacturers are increasingly caught in the middle of these geopolitical dynamics, and will be expected to make very substantial changes to sourcing and supply chain configurations along extremely limited timelines. However, as this paper finds, those changes will impose significant costs and technical challenges, and in some cases may not be feasible during the effective period of the tax credit. With limited avenues for qualifications, OEMs will have to evaluate the viability of licensing arrangements that maintain access to Chinese technology, but remove FEOCs from controlling relevant facilities and sourcing arrangements. Automakers face these same challenges and may elect to emphasize the consumer savings available through leasing agreements, which currently are exempted from the extensive qualifying criteria associated with section 30(d). Consumer appetite for leases in the near term, as automakers work with OEMs to expand the number of qualifying vehicles, will be significant variable in achieving the Biden administration's EV sales target and associated surface transportation emission reduction goals.

The outcome of the 2024 presidential election promises to complicate matters further. Given how extensive and prescriptive DOE and Treasury rulemaking guidelines for 30(d) have been, there is ample room to radically reinterpret and shift the implementation rules under a future Trump administration. Given the former President's negative comments regarding EVs and stated views on the deleterious effect of Biden administration climate policy on U.S. automakers, it is highly likely that revision of the rules would be an early priority under a new administration. In fact, rewriting the rules to increase stringency, limit qualification pathways, strengthen the FEOC provision to enact more comprehensive decoupling, and remove the leasing exemption would conform with the Trump campaign's rhetoric and its policy record, and would offer an administrative path more readily accessible than reforms to the IRA provisions themselves, which would require legislative action. While such measures will not themselves eliminate consumer demand for EVs, they would undoubtedly affect vehicle pricing and erode the future competitiveness potential of U.S. OEMs.

[48] The Clean Investment Monitor is a joint project of Rhodium Group and Massachusetts Institute of Technology's Center for Energy and Environmental Policy Research; see https://www.cleaninvestmentmonitor.org/about.
[49] Roberts and Houser (2024).

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