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Overdependent: A U.S. National Security Imperative to Diversify Battery and Solar Supply Chains?

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Memo for Workshop "Go Green Fast: Global Lessons for the Clean Energy Transition"

The clean energy transition is underway in the U.S. and around the world. Key to the transition and roll-out of clean energy technologies are the minerals within those technologies. The world today relies on only a handful of countries to extract the minerals and produce them for use in clean energy technologies with China leading the way. Rising geo-strategic competition between the U.S. and China has raised concerns that the U.S. and other Western states are overly dependent upon inputs from Chinese suppliers and that China's domination of clean energy technologies, including the metals and mineral supply chain, poses an unacceptable risk to U.S. national competitiveness and national security.[1] The risk assessment is increasing because some inputs are dual use, but also because clean energy technologies such as batteries are likely to be a major source of wealth generation this century.

Because of the unprecedented scope of energy globalization, even "energy independent" states such as the U.S. are not insulated from shocks to the market. Today, there is an emerging social science literature on the era of "weaponized interdependence," economic warfare, energy security, and the ways in which economic ties can be strategically used against trade partners.[2]

A study in *Science* by Davidson et al. surveyed various clean energy technologies and assessed the economic and national security risks of interdependent supply chains between the United States and China and the consequences of economic de-coupling. Relative to other sectors, they found limited national security risks overall, with the greatest risks economic in nature in solar photovoltaics and batteries given China's dominance of minerals extraction, refining, and manufacturing processes.[3] The study is an important contribution, though may understate the national security risks of dependence, suggesting a more robust U.S. industrial policy may be warranted. Namely, we argue:

(1) Source of national wealth to support military expenditures. Batteries and solar technologies will likely be major sources of wealth generation for countries this century which, in turn, will expand the national revenue base to support military expenditures. Allowing a potential rival to dominate these industries would deliver strategic economic advantages to a peer competitor and put the United States at a disadvantage.

(2) Anticipated systemic risks to critical infrastructure create contemporary incentives. Batteries and solar technologies at low levels of penetration do not pose risks to critical infrastructure but at higher levels of penetration, their expected ubiquity will create the sort of risks observed with semiconductor chips where supply chain disruptions create large systemic risks for the wider American economy.

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[1] Sanderson 2022; Bazilian and Brew 2023; Bazilian, Holland, and Busby 2023.

[2] Drezner, Farrell, and Newman 2021; Holland 2017; Balmaceda 2013.

[3] Davidson et al. 2022. Conversely, the research team found that technologies such as carbon capture and sequestration (CCS), green steel, and wind do not carry the same types of risks that batteries and solar currently have. Although these three new energy technologies will likely also be critical to meeting climate goals, their industries are either not mature enough yet or difficult to predict their impact (green steel and CCS), or will likely not have as large of a manufacturing market share in China to be considered Chinese dominant by 2050 (wind).

This short memo seeks to explore the national security risks of dependence in those two sectors in greater detail by surveying (1) the nature and extent of U.S. dependence on China in batteries and solar, (2) U.S. policies to date, (3) and whether this dependence constitutes a national security risk, drawing from examples of other energy and technological dependence, including oil, natural gas, and computer chips. The memo reflects on these observations and concludes with areas for future research.

Background: The Nature and Extent of U.S. Dependence on China in Batteries and Solar

While a true de-coupling from China is not likely, diversification in the supply chain to both domestic and more friendly countries is underway. Transitioning the U.S. transportation sector, the second largest source of emissions in the country away from internal combustion engine vehicles to electric vehicles (EVs) will be critical towards hitting U.S. decarbonization goals. With lithium-ion batteries currently the industry standard for EVs, there will be heightened demand for the minerals contained within the batteries, mainly cobalt, lithium and graphite.[4] Similarly, China and Chinese-owned solar panel companies operating internationally dominate the solar technology exports space, including finished modules but extend to the whole supply chain. The Biden administration's ambitious climate targets will require large-scale of renewables deployment in electricity, including solar.

For the minerals needed to produce lithium-ion batteries, China dominates the current market all along the supply chain. While these minerals are extracted in countries such as the Democratic Republic of the Congo (cobalt) and Australia (lithium), with each country holding more than 50% of the total world extraction of those minerals, China dominates the refining of cobalt (75%) and lithium (59%).[5] Additionally for graphite, China owns more than 60% of the refining market.[6] To meet the world's proposed energy storage demand needed by 2050 under a 2-degree warming scenario (2DS), both graphite and lithium production levels will need to grow by more than 500% compared to their 2018 levels.[7] Nickel production, another important mineral in batteries, is also expected to need to grow by over 6 times current levels to match 2030 battery demand.[8]

Both copper and aluminum will also play a substantial role in the build-out of the key clean energy technology. Aluminum demand is likely to increase rapidly to be the most utilized mineral for clean energy technologies in 2050 due to its use in a broad range of technologies.[9] The World Bank estimates that 88% of the total mineral demand that will be needed to meet a 2DS scenario will come from aluminum, an increase of 119% from 2018 levels. Copper production will need to double from today's levels to satisfy just the world's battery and solar demands. Although at market penetration levels lower than graphite, lithium, and cobalt, China is the world's largest producer of both copper (34%) and aluminum (48%) (see table 1).[10]

[4] Roberts 2022.
[5] IEA 2023.
[6] Denning 2023.
[7] World Bank 2020.
[8] Innovation News Network 2022.
[9] World Bank 2020.
[10] IEA 2023; Davidson et al. 2022.

Table 1: Key Minerals for Batteries and Solar

Key Minerals for Batteries & Solar	Global Chinese Extraction[11]	Global Chinese Refining	US Imports[12]	US Imports from China[13]
Lithium	13%	59%	50%	5%
Cobalt	1%	75%	76%	0%
Nickel	18%	69%	50%	0%
Graphite	64%	60%	100%	32%
Copper	9%	34%	45%	<5%

At the final production stage, China holds 70% share of the world's production capacity of lithium-ion batteries. The U.S., by comparison, currently only has a 10% global share of the subcomponents necessary for the batteries (see table 2). [14]

Table 2: Battery Manufacturing Production

Battery Manufacturing Production	Global Chinese Production[15]	Concentration of Production among Chinese Firms[16]	US Imports[17]	US Imports from China[18]
Cathode	78%	-	-	-
Anode	91%	-	-	-
Electrolyte Solution	65%	-	-	-
Separator	43%	-	-	-
EV Batteries	70%	59%	92%	80%

With regards to the subcomponents needed to create solar panels, China accounts for 66 percent of polysilicon, 97 percent of silicon wafers, 78 percent of solar cells, and 72 percent of global production of solar modules (see table 3).[19]

[11] The White House 2021b; Vinachem 2022; Benchmark Source 2022a.
[12] Department of Energy 2022.
[13] USGS 2023.
[14] Davidson et al. 2022.
[15] The White House 2021b.; Benchmark Source 2022a.
[16] Doll 2023. Finished EV Battery concentration among top five Chinese firms (percentage of global market share: CATL, 37.0%; BYD, 13.6%; CALB, 3.9%; Guoxuan, 2.7%, Sunwoda, 1.8%.
[17] Pike 2022.
[18] Crompton 2022.
[19] Davidson et al. 2022.

Table 3: Solar Manufacturing

Solar Manufacturing	Global Chinese Production	Concentration of Production among Chinese Firms[20]	US Imports[21]	US Imports from China[22]
Polysilicon	66%	-	-	*
Silicon Wafers	97%	-	-	*
Solar Cells	78%	-	-	*
Solar Modules	72%	52%	94%	*

U.S. Policies

The U.S. government has increasingly become concerned about these dependencies. The Energy Act of 2020 required the U.S. government to update a list of "critical minerals," defined as "as a non-fuel mineral or mineral material essential to the economic or national security of the U.S. and which has a supply chain vulnerable to disruption."[23] The United States Geological Service (USGS) has developed a sophisticated methodology to assess supply chain vulnerability based on (a) net import reliance (b) how concentrated production is outside the United States, and (c) the willingness and ability of importers to supply the United States.[24]

The most recent critical minerals list was released by the USGS in February 2022 and included 50 critical minerals, a number of which are important for batteries and solar technologies such as aluminum, cobalt, graphite, lithium, manganese, nickel, and tellurium.[25] Interestingly, minerals such as copper, which have been subject to recent supply chain disruptions in Peru, did not make the list.[26] That list is being used to inform efforts to refill the National Defense Stockpile whose assets were largely sold off at the end of the Cold War, with the 2023 National Defense Authorization Act authorizing $1bn to acquire additional strategic and critical materials.[27]

Beyond the list of critical minerals are other efforts to shore up the broader supply chain. In February 2021, the Biden administration issued Executive Order 14017 which asked for a review of U.S. supply chain vulnerabilities within one hundred days.[28] That review, released in June 2021, covered "strategic and critical minerals" encompassing both critical minerals and downstream products like batteries.[29]

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[20] 9 of the top 10 module production firms are Chinese. The top 10 firms accounted for 65.4% of total global manufacturing.
[21] Jamison 2021.
[22] Hering and Christian 2022. Many sources have found evidence that Chinese modules have been circumventing US tariffs by assembling finished product solar modules through four Southeast Asian countries (Cambodia, Malaysia, Thailand, and Vietnam) which make up for 82% of US solar module imports.
[23] U.S. Geological Survey 2022.
[24] Federal Register 2022.
[25] U.S. Geological Survey 2022.
[26] Hendrix 2023.
[27] Barna, Hastings, and Pearce 2023.
[28] The White House 2021a.
[29] The White House 2021b.

In February 2022, the Administration published its 1-year report card on its actions to address these vulnerabilities.[30] In April 2022, President Biden invoked the Defense Production Act Title III authorities which allows the DOD to conduct feasibility studies and modernization projects to support domestic manufacturing of critical materials for batteries.[31]

The Bipartisan Infrastructure Act and the Inflation Reduction Act (IRA) sought to address these vulnerabilities through a variety of investments and tax credits. The IRA appropriated $11.7bn for the Department of Energy's Loan Program, increasing its lending authority by $100bn to $140bn.[32] Already, the DOE Loan Program has announced a variety of large loans for battery recycling, battery manufacturing, and lithium processing.[33]

While the manufacturing that will arrive domestically from the IRA's passage won't be seen for a few years, many companies have already announced the construction of major clean energy manufacturing facilities since the legislation's passage. Estimates suggest existing and planned polysilicon refining capacity will reach over 900 GW annually in the U.S. by 2025, a number that the domestic solar industry took two decades to reach.[34] For the battery sector, 78 battery refining and manufacturing facilities have been announced since President Biden took office. With the majority of those facilities in the Midwest and South, some analysts are starting to call the region the "Battery Belt."[35]

While much of the emphasis of the IRA is on securing domestic supplies or sourcing from friendly countries of these materials, another strategy, also supported by the IRA, is recycling and upcycling, the re-use of a product through the repair and refurbishing of certain components. China currently dominates the market for battery recycling, holding roughly 70% of the global capacity. In the U.S., however, recent announcements by both private industry, including Tesla and Li-Cycle, and the Department of Energy, deploying $7 billion dollars for facilities, suggest the U.S. capacity for recycling will grow dramatically.[36]

Beyond these efforts, the Biden Administration created the Minerals Security Partnership (MSP) in June 2022, largely a body of wealthy countries in need of such materials to build multilateral processes for ethical sourcing of raw materials.[37] In early 2023, MSP also engaged with minerals-rich countries on standards for sourcing and processing raw materials.[38]

Supply Shocks and National Security

The climate crisis and the increased need for batteries and minerals exposes a tension between the rapid deployment of new clean energy technologies and the risks of interdependent supply chains. Already, through policies such as the Inflation Reduction Act, there are efforts to friend-shore or ally-shore the production of batteries for the new clean energy economy. The supply shocks resulting from the COVID-19 pandemic and the Russia-Ukraine war are leading to a realignment of trade relationships with security

[30] The White House 2022.
[31] Department of Defense 2022.
[32] Department of Energy's Loan Programs Office 2022.
[33] Korosec 2023.
[34] Liebreich 2022.
[35] Jones 2023.
[36] Hotter 2022.
[37] Department of State 2022.
[38] Department of State 2023.

alliances.[39] Some scholars have warned of the risks associated with wider de-coupling of U.S. and Chinese economies for the clean energy transition.[40] Still others have written approvingly of how U.S.-China competition could be a boon for climate protection.[41]

While securing the supply of these materials will be needed to transition from fossil fuels, shifting away from China for these key materials carries risks as does maintaining the status quo. Understanding the nature of these risks is important, as how they are understood can shape the policy response.

Risks of (Partial) Decoupling

First, there is a risk that the transition will be slowed if critical materials are in short supply or if shortages lead to price spikes that make low-carbon technologies more expensive. Even a threat of supply shortages could slow the pace of change for countries and manufacturers that are reluctant to rely on supply chains they perceive as risky.[42]

Second, sourcing raw or even processed materials for the clean energy transition from unstable countries could trade one form of resource dependence based on oil to another based on minerals. That could risk elevating the strategic importance of source countries such as the Democratic Republic of Congo, Australia, Indonesia, Chile, and Argentina, among others. The potential for large windfalls from mineral wealth could lead to a new resource curse for some source countries, undermining their governance and political stability. At the same time, these countries could get caught up in wider geo-strategic competition between the United States and China, as they jockey for access to supplies.[43]

Third, more extensive de-coupling of the U.S. and Chinese economies could remove a conflict buffer between them. Extensive trade relations between the U.S. and China create cross-pressures for cooperation since both countries materially benefit from the exchange of goods and services. While the Soviet Union and the United States avoided war despite low levels of economic integration, that may have been fortuitous. While economic interdependence is a source of friction between the U.S. and China, it also induces some caution among policymakers of the consequences of deeper decoupling and conflict.

Risks of the Status Quo

At the same time, import dependence on potential adversaries for raw materials and finished products also poses risks for the United States, particularly should China decide to withhold them in the lead up to or in the midst of a crisis over Taiwan. Scholars have begun writing about the emergent geopolitics of Chinese domination of lithium and other critical minerals,[44] though it is not clear that China has either the incentive to shut off supplies or if such a move would even be effective were it to try.

How should we characterize and evaluate these risks? Davidson et al. distinguish between economic and national security risks of technology integration with China. Under economic risks, they include domestic job losses, intellectual property losses, and supply chain disruptions. Under national security risks, they include critical infrastructure, dual use technologies, and energy security. For various clean energy technologies (solar, batteries, wind, green steel, and carbon capture and sequestration), they code risks from low to medium to high along the supply chain for different sub-attributes.

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[39] Foroohar, Rana 2022.
[40] Davidson et al. 2022.
[41] Colgan and Miller 2022.
[42] Helveston, He, and Davidson 2022.
[43] Ross 1997; Vandeveer 2013.
[44] Altiparmak 2022.

Distinguishing between economic risks and national security risks is potentially important. Problems that are labeled national security risks may be seen as the responsibility of the government whereas economic problems might primarily be seen as private sector responsibilities. The greater the national security risk, the stronger the motivation to more fully decouple supply chains. Russia's invasion of Ukraine, for example, prompted an effort by the Europeans to try to eliminate imports of Russian gas. By contrast, Davidson et al. argue that the U.S. should only pursue modest levels of supply chain diversification and domestic production away from China in batteries and solar. Going further would jeopardize the clean energy transition by imposing higher costs and inefficiencies.

Determining how serious the national security risks are, therefore, should help inform how far the United States should pursue de-coupling in favor of on-shoring and ally-shoring of supply chains.

Reviewing the Davidson et al. judgments is the first point of departure. They regard the most serious risks to be for battery and solar supply chains. However, they see these risks to be economic. They consider national security risks related to energy security, critical infrastructure, and dual use technologies. These are all coded as low for batteries and solar, save for batteries where dual use is coded as medium.

Critical Infrastructure. They regard infrastructure risks for batteries and solar as currently low. There could be isolated risks to individual facilities from cyber-security incidents, but they argue system-wide risks are limited. With solar comprising 2.3% of electricity generation, risks of Chinese dependence for critical infrastructure are currently minor but long-term could be more significant.

Dual Use. Battery technologies they note are increasingly important in military applications but less important for solar. They regard the risks of dual-use technologies in solar as low and batteries as medium, primarily based on supply chain risks in refining raw materials.

Energy Security. They dismiss energy security risks, noting that unlike fossil fuels which require constant supply, existing energy availability cannot be affected disruptions in low carbon energy technologies. Those risks only extend to the future, which are captured in their metric of supply chain disruptions.

Supply Chains. They regard supply chain risks as high for batteries and solar, given Chinese dominance along the supply chain. However, they rate these as economic not security risks.

For solar, they consider manufacturing (disaggregating polysilicon, wafers, cells, modules), sales, installation and development, and operation and maintenance. They code solar as high for supply chain risks for all components of manufacturing but low for other dimensions. For batteries, they consider raw materials (disaggregating mining and refining), components, and batteries (disaggregating cells and packs). Supply chain disruptions are categorized as high risk based on refining, components, and cells and medium risks in mining and packs.

These evaluations raise interesting questions about whether the categorization and judgments fully capture the national security risks of battery and solar supply chain interdependence and what the desired goals of diversification and on-shoring should be.

Russia's invasion of Ukraine, as well as its long-term strategy of using its gas and oil exports as a coercive tool of statecraft, demonstrated the vulnerabilities associated with tightly knit economies– particularly between adversaries and competitors. For European countries, excessive dependence could lead to supply shocks that might make it impossible to keep the lights or heating on during winter. That risk to the physical security of millions of Europeans as well as the economic risks to their economies led to unprecedented actions to reduce their exposure to Russian energy coercion through diversification of supplies, energy conservation, and strategic stockpiles.

With respect to batteries and minerals, somewhat unstated is a concern that China could potentially withhold such inputs for geopolitical leverage, or that the U.S. might be forced to sanction imports from China in the event of conflict, though analysts dispute whether this would have the same effect as an oil embargo given the nature of the minerals in question and the technologies.[45]

Could disruptions in the supply of minerals, batteries, or solar panels ever lead to shortages of materials that could have a meaningful short-run impact on energy access? Although current penetration levels of 3.4% for solar[46] for energy and 2% for EVs[47] for light-duty vehicles on the road, both of those numbers are projected to grow rapidly as the U.S. decarbonizes. For EVs, more than half of all U.S. car sales are projected to be electric by 2030 after the passage of the Inflation Reduction Act and the new extra incentive available to consumers via tax credits.[48] By 2050, the total number of EVs on the road globally is expected to explode from 0.7% today to 31%, or 672 million total cars, according to the EIA.[49] Solar will also continue to increase to 22% of the U.S.' energy mix by 2050, becoming the second most used form of energy behind only natural gas.[50]

Still, as Davidson et al. note, it is not clear that a disruption in these markets could on its own constitute a national security risk, since unlike liquid fuels, neither minerals nor batteries are immediate feedstocks used to power vehicles or heat homes. What makes Russian energy coercion particularly potent is the risk that as a consequence of a supply disruption, millions of Europeans could find themselves without adequate heating in the dead of winter. A supply disruption of minerals, panels, or batteries would likely require a longer period time for supply disruptions to have an appreciable impact on available energy resources, enough time to run down inventories, ramp up alternative suppliers, and identify substitutes.

Nevertheless, could a supply disruption in battery or solar technologies constitute a national security crisis because of worries of fears of a supply induced recession or broader fears of ceding key resources for economic growth to a competitor? Here, the example of semiconductor chips may be apt. Like batteries and solar technologies, a supply chain disruption for chips would not lead to immediate shortages of technologies dependent upon chips but nonetheless Chinese domination of these technologies is considered a national security risk. Should battery and solar technologies, recognizing their uses may become as widespread as chips, also be considered strategically important goods in the same way?

Here, further exploration of the chips case may be worthwhile. With chip production concentrated in Taiwan and potentially vulnerable to being seized by China via an invasion, popular media have begun to compare chips to oil,[51] with Iraq's invasion of Kuwait a rough metaphor for the threat of a single country controlling a key economic resource. Through the 2022 Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act, the U.S. federal government elected to spend $52 billion in subsidies to help new semiconductor plants get built in the U.S. to safeguard domestic supply.[52] Since the chips in U.S. military equipment have longer lifecycles and only 2% of the world's chips are currently

[45] Bordoff and O'Sullivan 2021.
[46] Feldman, Wu, and Margolis 2021.
[47] BloombergNEF 2022.
[48] Boudway 2022.
[49] Wiklund 2022.
[50] Energy Information Administration 2022.
[51] Blank 2020.
[52] Fitch and Ip 2023.

dual-use,[53] chips' overall importance to the U.S. economy may be as if not more relevant than dual use in national security considerations.

U.S. lawmakers agreed that securing advanced semiconductor supply was important enough that industrial policy was necessary. American industry leaders such as Ford and Apple warned of the dramatic economic consequences if the United States did not shore up its supply of chips.[54] Discussion in the chip space often focuses on Taiwan and the vulnerability of the Taiwan Semiconductor Manufacturing Company (TSMC), the world leader in the manufacturing of advanced semiconductors that accounts for a third of the world's new computing power in our multitude of devices each year.[55] Taiwan still accounts for over 70% of China's advanced semiconductor supply.[56] Modeled studies have shown that slight delays at fabs, or fabrication production facilities such as TSMC, would have dramatic effects further down the supply chain for chips. A Harvard Business Review study showed that just a 10-day disruption at a fab would lead to more than 12 months of delays down the supply chain.[57]

Were China to invade Taiwan and attempt to takeover TSMC the supply of a key component to U.S. cutting-edge military technologies and civilian uses would be in jeopardy.[58] TSMC would likely not withstand a Chinese invasion if China attempted to take over the plant, as either the U.S. or Taiwan would look to destroy the facility rather than let it sink into Chinese control. If the U.S. were to be knocked offline in Taiwan from TSMC's chip supply, scholars estimate that it would take anywhere from 3-5 years for the U.S. to get the necessary supply it needs from allies and its up-and-coming domestic chip industry, wiping trillions of dollars from its economy in the process.[59]

Indicative of the lengths to which the Biden Administration was prepared to go is the executive order from the Biden administration from October 2022 which forced U.S. citizens working for Chinese chip makers to stop working with the firms or lose their U.S. citizenship.[60] Additionally, the Biden administration in January of 2023 successfully lobbied the Netherlands, where ASML, the proprietary owner of the only lithography machines in the world that can help create advanced chips, is headquartered, and Japan, home to numerous chipmaking companies such as Tokyo Elektron, to restrict exports of chip technology to China and grant favor to the U.S. and its allies.[61]

The Biden administration sees advanced semiconductors as a critical piece towards maintaining a technological advantage over China. While advanced chips have direct uses in military technologies, they also help the country generate revenue for the U.S. economy which ultimately supports the country's capacity to invest in its military. In this sense, active industrial policy by the state to enhance its economic competitiveness itself is justified on national security grounds. By this logic, the long-run importance of chips, batteries, and solar technologies to the country's long-run economic fortunes warrant industrial policy to have a significant portion of production located in the United States.

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[53] Miller 2022a.
[54] Fitch and Ip 2023.
[55] Miller 2022b.
[56] Cronin 2022.
[57] Simchi-Levi, Zhu, and Loy 2022.
[58] Miller 2022a; Shivakumar and Wessner 2022. Military applications include artificial intelligence-based applications and a kind of integrated circuit field-programmable gate arrays. Advanced chips are also used in cell phones, graphics cards, 5G communications systems, and data center processors.
[59] Blank 2020; Miller 2022a.
[60] Cox 2022.
[61] Durbin and Madhani 2023.

Chinese dominance of batteries and solar technology is relatively recent, driven by state action. Moreover, the scale of those industries is only a small fraction of what those industries will ultimately become. Accepting that China will dominate production of these industries was considered antithetical to the future economic prosperity of the United States, elevating batteries (and to a lesser extent) solar panels to the "commanding heights" of the 21st century economy alongside chips. For example, the lithium-ion battery market was valued at $65.9 billion in 2021 with growth by one estimate expected to rise to nearly $274 billion in 2030.[62] Similarly, the global solar photovoltaics panel market was estimated to be nearly $158bn in 2021 and estimated to grow to almost $287 billion by 2030.[63] Ceding most of these markets to international actors, primarily China, would mean the United States would forego revenue from a major growth industry and mean that once these industries are pervasive as chips, the United States could face more systemic risks in the event of a disruption in supply chains. Those systemic risks would include the economic costs of key components for electricity, energy storage, and transportation but potentially cybersecurity risks.[64]

While advanced chip production is concentrated in a single vulnerable supplier in Taiwan, the United States is dependent upon Chinese-controlled supply chains in the batteries and solar space but largely without a single firm being a major supplier. On the other hand, unlike chips, China already controls the supply chain for batteries and solar. In the midst of a hot conflict with China, would China want or be able to continue to supply batteries or solar panels or other parts of the supply chain to the United States?

Anticipating that those supply chains may not be robust to conflict and will become increasingly important to the U.S. national economy and competitiveness likely underpins the U.S. diversification impetus (reinforced by the domestic political advantages of a revival in U.S. manufacturing as well as concerns about solar panels being produced by slave labor in China).

Concluding Thoughts and Questions for Further Research

The question that remains is how far those efforts should go or how much de-risking insurance should the U.S. pursue through domestic production or ally shoring. Supply chains in this space will likely inevitably be interdependent and excessive efforts to on-shore or re-shore production will impose unnecessary costs and inefficiencies.[65] For example, Benchmark Source estimates that North American cathode and anode production would only amount to 4% and 3% of domestic demand by 2030.[66] Some scholars argue that countries should instead focus on meeting climate targets and ensuring no single country dominates the entire supply chain of a product. Other analysts counsel policymakers that markets will eventually intervene if there are supply shortages and let the private sector respond.[67]

That ship may have sailed. The United States is trying to reduce its perceived vulnerabilities to Chinese market dominance in these sectors through domestic production and sourcing from friendly countries.[68] Through the Inflation Reduction Act, the U.S. government has already taken steps to ensure that domestic mineral mining and production capacity grows. The question going forward may be how to balance competing considerations.

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[62] Spherical Insights 2023.
[63] 3/25/23 2:51:00 PM
[64] Trabish 2022.
[65] Goldthau and Hughes 2020.
[66] Benchmark Source 2022b.
[67] Gholz 2014.
[68] Juul and Katulis 2022.

The IRA has roiled relations with U.S. allies in Europe and Asia. For certain aspects of the tax credits, depending on the year, only a portion will be available to firms and consumers if the contents of the clean energy product are not produced in the U.S. or sourced from countries that have a free trade agreement with the United States. A number of European clean energy firms have decided to invest in U.S. operations to take advantage of the large tax incentives available. U.S. allies such as the European Union (EU) and South Korea among others have stated that these policies violate international trade law as protectionist and potentially in violation of WTO trade rules.[69] In response, the EU is discussing the rollout of its own package of green subsidies to incentivize its clean energy industry. South Korea and its automakers Hyundai and Kia are worried that they won't be able to qualify for the tax credits with the domestic content requirement rules of the IRA.

Chinese companies have also sought to take advantage of the tax credits and loans by offering to invest in battery manufacturing in the United States. While head of the DOE loan office Jigar Shah suggested Chinese eligibility would be determined on a case-by-case basis depending on the reputation of the Chinese firm,[70] state-level politicians like Republican Governor Glenn Youngkin of Virginia have been more categorical in their opposition to Chinese investments in the clean energy space. He withdrew Virginia from consideration for the site of a joint venture between Ford and CATL, a leading Chinese battery manufacturer.[71] Other governors, like Governor Whitmer of Michigan, made a different determination and supported a Ford manufacturing plant that is licensing Chinese lithium iron phosphate battery technology from CATL, though it is unclear if Ford will be able to use this partnership to learn how to make these batteries without Chinese expertise.[72] This episode turns the question of Chinese export dominance into a more far-reaching concern about Chinese investment and influence, even if it takes place in the U.S. Those concerns emerged in other spaces like Huawei and TikTok, though it is not clear if there are data security or intellectual property equivalent considerations in the batteries and solar space. Subsequent research can serve to elucidate whether the fears from Youngkin and others are merely extensions of political grandstanding or are rooted in legitimate national security concerns.

Whether the mineral supply will be sufficient to provide the needed materials for solar and, especially, batteries over the coming decades requires further discussion and analysis. While recycling, upcycling, and the discovery of new mineral deposits worldwide will assist industries in gaining the needed materials for manufacturing, gaining access to those in countries around the world that are not named China may prove to be a tall task. Additionally, increasing U.S. involvement with unstable countries where critical minerals exist could present new challenges and unintended consequences for national security that policymakers should analyze to a greater degree.

As the debate continues, policies such as the Inflation Reduction Act have already started a decades-long process to create a domestic industry of the minerals needed for the clean energy transition. With multiple years of construction ahead before these new domestic projects are online, the U.S. and its allies will continue to rely on China for these ever-important minerals. Despite these significant challenges and opportunities, there is a fairly limited amount of robust analytical work looking into the scale and details of demand for these varied minerals and metals and how extraction and trade is governed going forward. Given the renewed policy focus on energy security in the light of the global energy crisis and Russia's invasion of Ukraine, understanding the benefits and challenges associated with securing metals and critical minerals is more critical than ever.

[69] Fleming, Hancock, and Espinoza 2023.
[70] LeVine 2022.
[71] Budryk 2023.
[72] Wayland 2023.

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