The Clean Energy Transition Motivates Innovation and Recycling in Critical Mineral Supply Chains

The rapid buildout of the clean energy economy is fueling a significant increase in demand for responsibly sourced critical minerals. Minerals like lithium, cobalt, and nickel are "critical" to modern computer chips, consumer electronics, electric vehicle (EV) batteries, and to our national security. Recent federal investments like the Inflation Reduction Act are the first steps towards ensuring that the United States has a stable supply of critical minerals that can meet rising demand and address supply chain risks. Congress and the Biden administration can support the U.S. and global supply chains through increased investments in innovation and recycling, domestic mining law reform, and international cooperation.

The U.S. needs a sustainable and responsible critical mineral supply chain to meet our climate, security, and competitiveness goals.

The demand for minerals such as lithium, cobalt, and nickel has grown substantially in recent years, driven by the clean energy transition, upgrades to military technologies, and the uptake of digital services. Overall mineral demand is expected to double by 2040 under current climate policy commitments and could quadruple if the global deployment of EVs and renewable energy technologies ramps up in line with international commitments. Electric vehicles and battery storage alone are projected to account for half of global mineral demand in coming decades.

Projections of heightened demand for critical minerals have sparked concerns about the adequacy of global supplies. Reserves, production, and processing of critical minerals are unevenly concentrated across the globe—with some countries having a near-monopoly over the production or processing of certain minerals. The United States is reliant on one or a handful of foreign suppliers for a number of critical minerals, raising the risk of costly disruptions to supply in the context of increasing geopolitical competition. For example, in 2022 it was estimated that a 30% disruption in the supply of gallium could cost the economy about $600 billion in lost output, or roughly 2% of GDP. However, even if it wanted to, the United States could not meet its critical mineral needs through domestic production alone. A wide-ranging approach to diversifying and securing U.S. mineral supply chains is thus essential to mitigating economic and security risks, as well as the environmental and social impacts of mining.

Recycling and innovation have important roles to play in bolstering the U.S. critical mineral supply chain and our economy.

To meet this increasing demand for critical minerals, the United States has already started directing resources towards all parts of the critical minerals supply chain and is investing in both domestic and international avenues to expand capacity. Additional emphasis on innovation and recycling of critical minerals is essential.

Investment and coordination across the federal government have already begun.

Building on the Energy Act of 2020, the Bipartisan Infrastructure Law (BIL), the CHIPS and Science Act, and the Inflation Reduction Act (IRA), investments and coordination on critical minerals across the federal government have already begun. Across these laws, more than $8.5 billion was authorized or funded for critical minerals activities at the Department of the Interior (DOI) and Department of Energy. The BIL appropriated funding for the United States Geological Survey (USGS) to map critical minerals in the United States. The Defense Advanced Research Projects Agency has partnered with USGS to explore the potential to use artificial intelligence to enhance these domestic critical mineral assessments. A domestic workforce for mining and mineral processing is integral to a robust U.S. supply chain, and the BIL, CHIPS and Science Act, and Energy Act of 2020 support several programs for training, education, and research. The IRA tax credits for the clean energy industry are also revitalizing the lithium industry in states like North Carolina, which used to be a hub for the mineral, but where investment dropped off due to global competition.

Securing critical mineral supply chains was also a key focus for both Democrats and Republicans in drafting the 2024 National Defense Authorization Act (NDAA). The final negotiated Act includes provisions directing the federal government to develop a strategy to end its dependence on critical minerals from covered nations (Iran, North Korea, Russia, and China), authorizing the Pentagon to replenish domestic stockpiles with minerals processed domestically, and investing in research on critical mineral access and commercialization.

The U.S. can build on these initial investments through broader coordination across the federal government and innovation led by science agencies and national labs, in addition to continued appropriations. For example, researchers at Lawrence Berkeley National Laboratory just reported that there may be 18 million metric tons of lithium available in the Salton Sea in California. **This is enough to build approximately 382 million EV batteries.** This new estimate highlights the importance of continued state and federal investment in this region and clean technology broadly.

A robust recycling supply chain for critical minerals will support U.S. supply chains and reduce dependence on raw materials.

A robust critical mineral recycling supply chain or a "reverse supply chain" can reduce American dependence on raw materials both domestically and internationally while minimizing environmental pollution. At the core of a reverse supply chain, or a circular economy, is recovering still viable critical minerals from existing products and reintegrating them into commerce.

Currently only 5% of lithium-ion batteries, which are commonly used in EVs, are recycled in the United States. By comparison, the EPA estimates that 99% of the lead-acid batteries used in internal combustion vehicles are recycled, which provides a useful business case for how to incentivize a recycling supply chain at scale. EV batteries also have good potential to be reused

as batteries for other purposes, whether as back-up energy for buildings or to support the broader energy grid.

Many critical mineral recycling companies are already working with automakers and are locating their facilities close to large battery manufacturers – with some reporting recovery of over 95% of critical minerals from recycled batteries. The BIL provides over $3 billion in funding to prioritize EV battery recycling, which will help expand private sector recycling programs. Other innovations in sourcing minerals from recycled material include extracting critical minerals from coal production waste, a novel process that the BIL invested in via $32 million overseen by the Department of Energy.

The IRA requirement for the Clean Vehicle Tax Credit that the EV battery be recycled in North America and/or source critical minerals domestically or from a free trade partner may also encourage domestic or near-shore recycling efforts. The bipartisan Secure E-Waste Export and Recycling Act introduced in the 117th Congress would help grow the domestic recycling economy, prohibit the export or reexport of electronic waste, and reduce unsafe disposal of e-waste abroad.

Innovations in battery technology can also shift critical mineral needs in ways that complement U.S. goals.

Innovation in battery design can also complement efforts to increase the domestic supply of critical minerals by reducing the need for the hardest-to-source critical minerals. While nearly all modern EV batteries use lithium, the quantity of lithium and other critical minerals varies across batteries—with advantages and disadvantages in terms of cost, performance, and ethical sourcing. For example, lithium iron phosphate (LFP) batteries are gaining in popularity because they require no cobalt, a critical mineral that is primarily sourced by the Democratic Republic of the Congo, where miners often violate child labor laws.

These LFP batteries are cheaper to produce and good for acceleration power, but are currently less common in the U.S. market because current versions provide limited range. However, some U.S.-based companies are now marketing LFP batteries with ranges that better align with what domestic car-buyers expect. As these battery technologies become more widespread, it would reduce the need for some critical minerals in ways to support key U.S. domestic and foreign policy goals.

Updating U.S. mining laws would also enhance the critical mineral supply chain and support the broader economy while protecting the environment.

Unlike other environmental laws, U.S. mining law has not been updated since 1872 when it was first passed – over 150 years ago. The Mining Law of 1872 governs all hardrock mining on public lands in Western states, and covers critical mineral mining in this region. The land covered under this law makes up more than 15% of all land in the United States and two thirds of the lands that the federal government holds in trust for the American people. An update to this

mining law is long overdue that can enable the clean energy transition, address environmental justice concerns, and ensure economic benefits to the American people.

Recent bills introduced in both the House and Senate, such as the Clean Energy Minerals Reform Act led by JEC Chairman Martin Heinrich, have proposed bringing mine operators in line with other public lands users and modernizing permitting. Currently, companies that hardrock mine on public lands pay nothing in royalties and are not charged rental fees for public lands used for mining operations. The Clean Energy Minerals Reform Act proposes annual royalty payments that would allow the U.S. public to benefit from their natural resources while ensuring a fair return for publicly owned mineral resources.

Revenues would be deposited into a reclamation fund for abandoned mine cleanup – a significant source of pollution, which has already contaminated 40% of western watershed headwaters. Estimates put the cost to taxpayers of this pollution remediation at $20 – 50 billion. These negative externalities hit Indigenous communities particularly hard because the vast majority of critical minerals are found within 35 miles of Tribal lands. The bipartisan Good Samaritan Remediation of Abandoned Hardrock Mines Act also aims to enable easier mine clean up by organizations that had no role in causing the pollution.

A recent DOI report found that modernizing and streamlining U.S. mining law, such as with the Clean Energy Minerals Reform Act, could shave months off a process that currently results in U.S. mining projects taking roughly 16 years from exploration to commercialization. More broadly, the outdated mining law allows speculators to stake claims that they can hold indefinitely with very little cost. This encourages secret, early development, which can often create mistrust and conflict with the public, especially Native American communities. An updated permitting and review process with public engagement up front would allow for communities to express input in a less contentious and litigious way. Updating U.S. mining laws would allow communities to exempt certain areas from new mining claims, which would protect sacred lands and areas important for outdoor recreation or wildlife habitats, while speeding up mine plan approvals in other areas.

International cooperation can help further bolster supply chains and the clean energy transition.

While the United States invests in domestic innovation and recycling of critical minerals, it also needs to support international cooperation that bolsters the global supply chains of these materials. The federal government could investigate diplomatic and other ways to support U.S. mining interests abroad. The Minerals Security Partnership aims to bolster critical mineral supply chains, in part by supporting companies of partner countries. One important step is for the U.S. to identify opportunities to increase both mining and processing with free trade agreement partners with significant supplies, which include Australia, Canada, Chile, and Peru.

Mechanisms to promote knowledge transfer and resource pooling among the United States and its allies can also help prevent supply chain disruptions. The Supply Chain Early Warning System (EWS) pilot program recently announced by Biden Administration in coordination with

Korea and Japan is one such example. Broadening these efforts and establishing shared buffer stocks of key commodities with allied countries could help prevent destabilizing price shocks and ensure adequate development of critical minerals.

Often countries still export the minerals they produce to China for processing, which highlights the importance of broadening out the number of friendly countries who can meet growing processing and recycling needs. Because processing plants have more manageable environmental risks, speeding up processing facility development is essential to supply chain continuity. The U.S. could also take steps to support mining education and training efforts, including learning exchanges in Latin America (which is geographically close by and has large lithium and manganese supplies) and elsewhere to broaden the mining workforce and enhance international development efforts. These can provide the basis for partnerships that support sustainable development both in the U.S and abroad.

Conclusion

U.S. demand for critical minerals is surging in response to American clean energy goals. Domestic and international efforts are ongoing to shore up access to these key materials, and recent federal government investments are helping to catalyze a more robust and innovative supply chain for critical minerals. As the United States expands its own capacity and updates its approach to recycling and mining, it has a prime opportunity to make sure that its approach minimizes human and environmental harms while bolstering its economic security.