U.S. Senate Committee on Energy and Natural Resource

Hearing on "Critical Minerals"

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Mr. Chairman, Ranking Member and members of the Committee, it is an honor to address the United States Senate Committee on Energy and Natural Resources. I appreciate the invitation to participate in this important hearing. It is timely – and indeed urgent – to discuss critical minerals.

The move towards renewables and electric vehicles will motivate a fundamental shift in the energy foundations of the U.S. economy – from a fuel-based system towards a system increasingly weighted to minerals. This will be a very big change from hydrocarbons, which today provide 80% of U.S. energy, to minerals, which today are a small part of the overall energy system. "Big Oil" is a term long favored by headline writers, but this, in shorthand, is the shift from "Big Oil," to "Big Shovels." In other words, this implies a great deal more mining.[1]

This is hardly something that will happen with ease. The "energy transition" will not be linear. Rather, as S&P Global describes it in the new study *Shaping a Living Roadmap for the Energy Transition,* it will be "multidimensional," unfolding at different paces in different parts of the world, and indeed at different paces across the U.S. economy.[2]

One of the fundamental gating items will be the timely availability of sufficient minerals – the demand for which will grow enormously. But will those supplies be available? A host of governments and international organizations – the U.S. administration, Japan, the European Union, the United Kingdom, the World Bank, the International Monetary Fund, and the International Energy Agency – have all raised alarm about the sufficiency of mineral resources, their processing, and their sourcing. The IMF, for example, has warned that the pursuit of net-zero emissions by 2050 will "spur unprecedented demand for some of the most crucial metals," leading to "soaring costs" that could "derail or delay the energy transition itself."[3]

But how much will be needed? That is a critical question. It may seem abstract. But think of it this way: the state of California has in effect declared that

[1] Daniel Yergin, *The New Map: Energy, Climate and the Clash of Nations (*New York: Penguin, 2021)
[2] Shaping a Living Roadmap for the Energy Transition, https://www.ief.org/focus/ief-reports/gesi-shaping-a-living-roadmap-for-energy-transition
[3] https://www.imf.org/en/Blogs/Articles/2021/11/10/soaring-metal-prices-may-delay-energy-transition

all cars sold in the state from the mid-2030s onward should have two and a half times more copper than a combustion car. Of course, what the regulation actually says is that they must be electric vehicles, but each electric vehicle will, in fact, use two and a half times more copper. Similarly, offshore wind uses much more copper than on-land power generation. That is why it is so important to understand the scale of the requirements. In response, S&P Global, drawing upon its databases and analytic capabilities, has sought to calculate what the demand for these critical minerals will be.

S&P Global has done so in two studies, both of which are intended to contribute to an understanding of the mineral requirements and challenges: *The Future of Copper: Will the Looming Supply Gap Short-Circuit the Energy Transition?* and *Inflation Reduction Act: Impact on North American Metals and Minerals Market.*[4] These studies form much of the basis of my testimony today. They do not make policy recommendations. They are part of S&P's continuing work to understand the key issues for assuring the mineral supply required for the energy transition.

It is particularly important to understand what is ahead, for we are at the beginning of a global energy transition that will transform the global economy and drive a substantial strengthening in demand for minerals. An electrified future uses minerals such as cobalt, lithium, nickel, and copper much more intensively than today.

At S&P Global, we have classified and quantified this new consumption as "energy transition demand" – consumption coming from EVs, on- and offshore wind, solar panels, charging stations, battery storage, etc. This is different from traditional demand, such as, for instance, the wiring that goes into housing construction. The United States faces considerable obstacles ensuring enough supply to meet both energy transition demand and traditional demand.

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[4] *The Future of Copper: Will the Looming Supply Gap Short-Circuit the Energy Transition?*, https://www.spglobal.com/marketintelligence/en/mi/info/0722/futureofcopper.html; and *Inflation Reduction Act: Impact on North America Metals and Minerals Market*, https://cdn.ihsmarkit.com/www/prot/pdf/0823/Impact-IRA-Metals-Minerals-Report-FINAL-August2023.pdf

The Inflation Reduction Act will accelerate this energy transition demand for minerals even more. Our recent research demonstrates that there is no one way to bridge the impending gap between supply and demand – but rather that several facets will be necessary in a solution.

Our key findings from both studies are:

- Demand both globally and in the United States will grow substantially in the coming decades for minerals such as copper, lithium, cobalt, and nickel. Our research shows that energy transition demand for copper will double over the next 12 years on a global basis, while demand for the other three critical minerals is expected to grow 23 times over the same period in the United States.
- Securing enough supply of these minerals to meet demand will be increasingly challenging for the United States given current planned capacity increases, existing trade patterns, new sourcing requirements, geopolitical tensions, and the long and complicated lead times for permitting and developing new mines.

The United States is currently reliant on imports for much of its current cobalt, lithium, nickel, and copper demand. As demand for these minerals continues to grow on a global basis, securing supply will require a combination of an expanded international and domestic supply base and a realignment of trading patterns if a potential shortage of minerals that threatens to short-circuit the energy transition is to be avoided.

Increasing mineral demand

But what to expect in terms of demand? Starting with the 2050 goals proposed by the U.S. administration and the European Union and to understand their impact on the energy transition demand, our studies undertook a detailed bottom-up analysis by sub-technology to examine the mineral requirements to arrive at total energy transition demand.

Our research shows that energy transition-related U.S. demand for the critical minerals lithium, nickel, and cobalt, taken together, will be 23 times higher in 2035 than it was in 2021. For copper, total demand will be twice as high over the same period. In the pre-IRA analysis, this is equivalent to compound annual growth rates of 25% per year for the three critical minerals and 4% per year for copper. While the steep upward trend was established pre-IRA, it is even higher post-IRA – with a 26% increase per year for the three critical minerals and 5.2% increase for copper.

Compared with our outlook before the IRA, in 2035 the post-IRA analysis for the United States projects:

- Lithium demand: 15% higher
- Cobalt demand: 13% higher
- Nickel demand: 14% higher
- Copper demand: 12% higher

While copper is not currently classified by the U.S. Geological Survey (USGS) as a "critical mineral," it is the "metal of electrification" and it is indeed critical to the energy transition given central importance of electrification in decarbonization technologies. In addition, the United States Department of Energy added copper to its critical minerals list in early August.[5] Canada has also listed copper on its critical mineral list as a necessary input for priority supply chain.[6] Copper does not meet the European Union critical mineral thresholds but is included on the critical minerals list as strategic raw materials in line with the Critical Raw Materials Act.[7]

[5] U.S. Department of Energy Releases 2023 Critical Materials Assessment to Evaluate Supply Chain Security for Clean Energy Technologies | Department of Energy

[6] https://www.canada.ca/en/campaign/critical-minerals-in-canada/critical-minerals-an-opportunity-for-canada.html

[7] https://single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/critical-raw-materials_en

More than two-thirds of U.S. energy transition-related volumetric demand for the four metals is for copper. Post-IRA, U.S. demand for copper from energy transition related-infrastructure and EVs will increase to nearly 2.6 million metric tons in 2035. This is solely energy transition-related demand dominated by demand for copper in electric vehicles, renewable energy technologies, and electricity transmission and distribution. Lithium, cobalt, and nickel are critical in the energy transition space for battery manufacturing for EVs and energy storage systems. The 2.6 million metric tons of demand for copper that we project will be required in 2035 in the United States post-IRA compares to about 700,000 metric tons for nickel, 112,000 metric tons for lithium, and 53,000 metric tons for cobalt.

In our *Future of Copper* study, we found that global copper supply will need to double by 2035 to meet the United States and European Union's 2050 climate goals, while, over the same time frame, U.S. energy-transition copper demand alone is expected to more than double.

There are two obvious ways to modulate the pressures on mineral supply. One, of course, is through technological innovation, and strong incentives will continue to stimulate innovation. Breakthroughs and disruptive technologies can certainly change the balance. But the time frames envisioned for the shift to electrification are short, and innovation and deployment in materials generally takes longer than, for instance, in software. Second, domestic battery recycling will reduce the net demand for nickel, lithium, and cobalt, but only, it seems, in the longer term. The U.S. battery recycling industry is nascent, and recycling activity will only start scaling up when electric vehicles start reaching end of life. Recycling will have to address both the collection of dispersed materials and permitting of recycling facilities. There are already important initiatives aimed at applying innovation to recycling processes, including seeking to continue the progress in large-scale recycling at industrial levels.

It is important to recognize that other countries will be competing for the same supply at the same time as countries shift toward more renewable energy capacity, EVs, and electrification of their energy supply. This will further test the United States' ability to source additional volumes from outside the country.

These staggering projections underscore the challenge of increasing supply to the United States.

Securing supply

As demand for nickel, lithium, cobalt, and copper surges, the United States will be increasingly reliant on imports. However, these will be made more challenging to secure because of the IRA's sourcing requirements of production and/or extraction. Per IRA sourcing requirements, supply must originate from the United States or countries with a Free Trade Agreement with the United States (FTA countries). The U.S. administration is seeking to address this roadblock with the Minerals Security Partnership and with specific "critical minerals agreements" with allies and other countries. The requirements around "foreign entity of concern" will further complicate, given mainland China's dominant position in mining and processing minerals. Defining what that means operationally will have a major impact on the future availability and flow of minerals. Under the IRA, at least 50% of battery components of electric vehicles seeking tax credits in the United States must be finally assembled in North America, and this rises to 100% by 2029.

Of the four materials covered in our study analyzing the impact of the IRA on North America metals and mineral markets, only lithium is likely to be sufficiently supplied to the United States under the IRA's domestic content requirements, given already-planned capacity additions in the United States and other FTA countries such as Chile, Canada, and Australia.

Cobalt and nickel are both unlikely to be sourced at levels high enough to meet demand.

While there is enough cobalt produced in FTA countries to meet the IRA domestic sourcing requirement, the United States does not currently source most of its cobalt from those countries. Doing so would require a challenging reorientation of trading patterns across several countries given intense international competition for resources.

Nickel is the most challenging in terms of supply. There does not appear to be enough nickel supply in FTA countries to meet demand under the IRA requirements—even if all primary nickel production in FTA countries was exported to the United States.

While copper is not subject to sourcing requirements under the IRA, ensuring access to enough supply to meet U.S. demand post-IRA is also at risk. The United States will become more reliant on imports as growing demand for energy transition-related end markets outpace domestic supply.

For example, the United States relies on one country, Chile, for 60% of refined copper imports. However, for Chile, the United States accounts for only 20% of its refined copper exports, while China accounts for more than 40%. The United States could struggle to secure additional supplies from Chile if other markets that represent a larger share of Chilean exports also compete for that supply.

Concentration of minerals is a further concern. Three countries produce about 40% of the world's oil – the United States, Saudi Arabia, and Russia. By comparison, two countries produce about 40% of the world's copper – Peru, which has gone through seven presidents in the last few years, and Chile, where the government plans to take control of the country's lithium reserves, considered the world's largest. In general, as prices rise, governments of resource-holding countries will seek – in what has been called the "obsolescing bargain" – to redo agreements to increase their control and their share of revenues, which will tend to delay or inhibit new investment that would otherwise expand output.

The increasing reliance of the United States on imports as energy transition demand grows places new emphasis and urgency on challenges such as long lead times and permitting complexities that prolong development of domestic resources. S&P Global data on 127 mines across the world that began production between 2002 and 2023 shows that a major new resource discovery today would likely not become a productive mine until 2040 or later.

In addition to emerging and intensifying competition for sourcing minerals into the United States through trade, increasing supply globally to meet rising demand from the rest of the world will be challenging. In our *Future of Copper* study, we identified a chronic gap between worldwide projected copper supply and demand that will begin later in this decade and will have serious consequences in terms of actually achieving the goal of Net-Zero Emissions by 2050.

The shortfall will reach a high point in 2035, under what has become our base case – our Rocky Road Scenario. This case is structured around a continuation of current trends in capacity utilization of mines and recycling of recovered copper. This would mean a 20% shortfall from the supply level required for the Net-Zero Emissions by 2050 target. Substitution and recycling will not be enough to meet the demands of EVs, power infrastructure, and renewable generation. Unless massive new supply comes online in a timely way, the goal of Net-Zero Emissions by 2050 runs the high risk of being short-circuited and remaining out of reach.

Set against the backdrop of a potential shortfall on a global basis for minerals, competition for mineral exports will intensify further, underscoring the need to increase domestic supply in addition to securing strong trade relationships. While more mining is part of the equation, increasing mineral processing capacity is just as important – and possibly even more so given mainland China's enormous footprint in the processing of cobalt, lithium, nickel, and copper. Globally, about 70 percent of nickel and cobalt, 60 percent of lithium, and almost half of copper are refined in China.[8]

Yet, even though its untapped physical endowment is quite large, the United States currently imports a large percentage of minerals. For example, copper represents a particular opportunity in the United States. The country possesses what is estimated to be more than 70 million tons of an untapped

[8]https://www.brookings.edu/articles/chinas-role-in-supplying-critical-minerals-for-the-global-energy-transition-what-could-the-future-hold/

copper endowment, equivalent to more than 20 years of U.S. copper demand, even at the level of peak energy transition-related demand in 2035.

However, accessing future supplies underground depends on what happens above ground.

Above Ground

While policymakers in the United States have clearly recognized the strategic importance of critical minerals and mining more generally, the response is far from clear. Permitting and post-permit litigation risks, social license to operate, and political and environmental issues around mining – all these continue to be major above-ground challenges.

The complexity of permitting mines in the United States is reinforced by the long lead times also required elsewhere around the world. Multidimensional challenges make the development of mines a generational endeavor, spanning decades and requiring hundreds of billions of dollars. Projects under development today would likely not be sufficient to offset the projected shortfalls in copper supply, even if their permitting and construction were accelerated. A 1956 U.S. Bureau of Mines report stated that copper mines may take as long as "three to four years" to construct and deliver product – a process that would have included permitting along with everything else. Today, by contrast, the permitting process alone can take 7-10 years – or longer – to be followed by extended judicial processes. The result can extend total project time from discovery to production to 15 or 20 years or more, as delays get extended. That length of time is half or more of a professional's entire career. Controversy over environmental issues and issues involving local populations add further to the risk of delay – and greater cost – in both mature and emerging economies.

Conclusions

Policy efforts to stoke energy transition demand for minerals will be very effective, as our research shows. However, greater attention needs to be paid to securing enough supply to undergird these demand ambitions.

New technology and innovation could help increase supply directly. If such innovation addressed the environmental and social concerns of a growing portion of investors, then it would also attract more capital into the industry and increase supply indirectly.

While solidifying trade relationships with FTA countries will help, that alone will not be enough to secure supply for the United States. Sourcing mineral imports from friendly countries is one way to meet the sourcing requirements stipulated in the IRA, but rising demand from other countries means increased competition for minerals and that availability of imports should not be considered a given. Additional domestic capacity for both the mining and processing of minerals is required, as that is the only way to guarantee supply domestically.

However, policy solutions will be necessary to foster this, as permitting challenges have created both bottlenecks for bringing capacity online and disincentives against exploration and investment.