The transition to low-carbon energy will be a tremendous challenge. Not only do we need to ramp up clean-energy supply to replace fossil fuels, we also need to meet growing energy demand for a rising population, and set up infrastructure to accommodate new energy sources. But what people sometimes do not fully grasp is the huge quantity of raw materials that will be needed to produce and deploy clean-energy technologies, such as wind turbines, solar panels and electric vehicles (EVs). These face potential supply chain and geopolitical headwinds, which, if not properly addressed, could result in an energy transition that's more turbulent than many expect.

Clean-energy technologies rely heavily on a group of **raw materials**, dubbed critical minerals. This includes lithium, nickel, cobalt, graphite and rare earth elements that are essential to the energy transition and more broadly, economic and national security.

An electric passenger car requires six times more minerals than a conventional gasoline car. Similarly, wind turbines, solar panels and expanded electricity grids that are needed to transport power, require a whole lot more minerals than their fossil fuel counterparts. This could result in an almost 40-fold growth in demand for some minerals required for battery storage from today's level to 2050, and triple the demand for minerals used in low-carbon electricity generation. As the International Energy Agency (IEA) puts it, the future will be a transition from a fuel-intensive energy system to a mineral-intensive one.

Automakers are already becoming anxious about the shortage of minerals. And the recent focus on countries' industrial policy to onshore parts of supply chains has led policymakers to re-evaluate their country's supply chain security.

Critical Differences

Critical minerals differ from other commodities, such as oil, in three ways. First, critical minerals are not a single commodity. There is a mix of different minerals and this differs to a certain extent from country to country. Each has a different list of minerals they deem "critical." For instance, the US has identified 50 critical minerals, compared with 26 that made the list in Australia. Copper is also not considered a "critical" mineral in the US at the moment, but is considered to be critical in the European Union. The fact that there is a group of different minerals means that pricing and characteristics differ from mineral to mineral. If countries were to consider a strategic reserve of minerals, for instance, they would have to come up with different mechanisms for different minerals.

Secondly, minerals and even most of the refined minerals, don't interact directly with end consumers as some refined oil products do. Minerals are regarded as a crucial input for technologies, such as batteries and semiconductors, rather than as an end product. Therefore, if a shortage of minerals were to arise, it would have a big ripple effect, eventually affecting consumers, but not have a direct impact on them. Many may recall (or have heard of) queuing in front of gas stations during the 1973 oil crisis. When Opec imposed an oil embargo against the US, this directly affected end consumers. In case of minerals, on the other hand, we may see a delay in new cars or laptops being delivered to consumers, but cars already on the road or laptops at home would still be able to run. Thirdly, unlike oil that disappears when combusted (emitting carbon emissions), minerals can be reused and recycled continuously as long as the right infrastructures and technologies exist. This would give governments an incentive to keep minerals within countries as long as possible, keeping them in circulation.

Geographical Concentrations

But critical minerals are similar in a way to oil and gas resources when we look at geographical concentration of production and processing capacities. For instance, the three largest lithium producing countries — **Australia, Chile and China** — account for nearly 90% of the global market, while 70% of global cobalt production comes from the Democratic Republic of Congo. The situation is worse when we look at the processing capacity of the minerals. A single country, China, dominates here, with 60% of lithium processing, 70% of cobalt processing, and as high as 90% for rare earth elements processing. Considering that the top three oil- and gas-producing countries together account for less than 45% of global production, there is a big risk that this geographical concentration of minerals may be used as geopolitical leverage, and create chokepoints in the global supply chain.

And unfortunately, it is not unheard of for a country to use critical minerals as leverage: in 2010, amid a dispute in the East China Sea, **China** embargoed the export of critical minerals to Japan. As Russia’s weaponization of natural gas in Europe today demonstrates, there is a need to diversify supply and address the strategic vulnerability arising from China’s domination of the minerals market.

The Inflation Reduction Act (IRA) in the US shows that increasing reliance of the domestic minerals supply chain is high on Washington’s agenda. EV tax credits outlined in the IRA are a case in point. The tax credits are only eligible for vehicles that source their battery and minerals domestically or from “friendly” countries. Now Washington needs to think about implementation and how to meet this requirement, while striving to meet the increased demand for EVs and other clean-energy technologies that require more minerals. This will require not only a diplomatic effort from the government, but also finding the right balance to expedite the permitting process for domestic mining projects. Currently, mining projects around the world take about 17 years from discovery to production. Streamlining permitting procedures to shorten lead times and providing financing support to de-risk long-term mining projects will be crucial moving forward.

More Urgency Needed

Why is securing critical minerals supply such an urgent issue? Based on today's production and production plans, critical mineral demand will start outpacing supply already by 2030. For copper, the gap will emerge by the middle of this decade, while for lithium and cobalt, a supply shortfall is likely to begin toward the end of the decade. If mining capacity under construction does not deliver as expected, some minerals could face shortages as early as next year. As the long duration of mining projects shows, we are only one investment cycle away from 2050, the year targeted by many countries and companies to reach net-zero emissions. This means that the decisions we make today will have impacts until 2050, including whether we reach significant emissions reduction by then or not.

The message this gap gives us is clear: we need to take the supply and demand of critical minerals seriously and brace ourselves for a supply chain disruption. The combination of rising demand and tight supply in the short term can affect prices and reverse some of the technology cost reductions that have happened over the past decade. If this happens, it could significantly slow down the energy transition.

The phrase **"net-zero future"** has a good ring to it — and we cannot delay any further. However, it will never become a reality if the world does not start taking action today to enhance critical minerals security.

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