Resource Wars in a Renewable Future? Lithium, Cobalt, and Rare Earths

The Post-Petroleum Resource Race and What to Make of It

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Thanks to its very name — renewable energy — we can picture a time in the not-too-distant future when our need for non-renewable fuels like oil, natural gas, and coal will vanish. Indeed, the Biden administration has announced a breakthrough target of 2035 for fully eliminating U.S. reliance on those non-renewable fuels for the generation of electricity. That would be accomplished by "deploying carbon-pollution-free electricity-generating resources," primarily the everlasting power of the wind and sun.

With other nations moving in a similar direction, it's tempting to conclude that the days when competition over finite supplies of energy was a recurring source of conflict will soon draw to a close. Unfortunately, think again: while the sun and wind are indeed infinitely renewable, the materials needed to convert those resources into electricity — minerals like cobalt, copper, lithium, nickel, and the rare-earth elements, or REEs — are anything but. Some of them, in fact, are far scarcer than petroleum, suggesting that global strife over vital resources may not, in fact, disappear in the Age of Renewables.

To appreciate this unexpected paradox, it's necessary to explore how wind and solar power are converted into usable forms of electricity and propulsion. Solar power is largely collected by photovoltaic cells, often deployed in vast arrays, while the wind is harvested by giant turbines, typically deployed in extensive wind farms. To use electricity in transportation, cars and trucks must be equipped with advanced batteries capable of holding a charge over long distances. Each one of these devices uses substantial amounts of copper for electrical transmission, as well as a variety of other non-renewable minerals. Those wind turbines, for instance, require manganese, molybdenum, nickel, zinc, and rare-earth elements for their electrical generators, while electric vehicles (EVs) need cobalt, graphite, lithium, manganese, and rare earths for their engines and batteries.

At present, with wind and solar power accounting for only about 7% of global electricity generation and electric vehicles making up less than 1% of the cars on the road, the production of those minerals is roughly adequate to meet global demand. If, however, the U.S. and other countries really do move toward a green-energy future of the kind envisioned by President Biden, the demand for them will skyrocket and global output will fall far short of anticipated needs.

According to a recent study by the International Energy Agency (IEA), "The Role of Critical Minerals in Clean Energy Transitions," the demand for lithium in 2040 could be 50 times greater than today and for cobalt and graphite 30 times greater if the world moves swiftly to replace oil-driven vehicles with EVs. Such rising demand will, of course, incentivize industry to develop new supplies of such minerals, but potential sources of them are limited and the process of bringing them online will be costly and complicated. In other words, the world could face significant shortages of critical materials. ("As clean energy transitions accelerate globally," the IEA report noted ominously, "and solar panels, wind turbines, and electric cars are deployed on a growing scale, these rapidly growing markets for key minerals could be subject to price volatility, geopolitical influence, and even disruptions to supply.")

And here's a further complication: for a number of the most critical materials, including lithium, cobalt, and those rare-earth elements, production is highly concentrated in just a few countries, a reality that could lead to the sort of geopolitical struggles that accompanied the world's dependence on a few major sources of oil. According to the IEA, just one country, the Democratic Republic of the Congo (DRC), currently supplies more than 80% of the world's cobalt, and another — China — 70% of its rare-earth elements. Similarly, lithium production is largely in two countries, Argentina and Chile, which jointly account for nearly 80% of world supply, while four countries — Argentina, Chile, the DRC, and Peru — provide most of our copper. In other words, such future supplies are far more concentrated in far fewer lands than petroleum and natural gas, leading IEA analysts to worry about future struggles over the world's access to them.

From Oil to Lithium: the Geopolitical Implications of the Electric-Car Revolution

The role of petroleum in shaping global geopolitics is well understood. Ever since oil became essential to world transportation — and so to the effective functioning of the world's economy — it has been viewed for obvious reasons as a "strategic" resource. Because the largest concentrations of petroleum were located in the Middle East, an area historically far removed from the principal centers of industrial activity in Europe and North America and regularly subject to political convulsions, the major importing nations long sought to exercise some control over that region's oil production and export. This, of course, led to resource imperialism of a high order, beginning after World War I when Britain and the other European powers contended for colonial control of the oil-producing parts of the Persian Gulf region. It continued after World War II, when the United States entered that competition in a big way.

For the United States, ensuring access to Middle Eastern oil became a strategic priority after the "oil shocks" of 1973 and 1979 — the first caused by an Arab oil embargo that was a reprisal for Washington's support of Israel in that year's October War; the second by a disruption of supplies caused by the Islamic Revolution in Iran. In response to endless lines at American gas stations and the subsequent recessions, successive presidents pledged to protect oil imports by "any means necessary," including the use of armed force. And that very stance led President George H.W. Bush to wage the first Gulf War against Saddam Hussein's Iraq in 1991 and his son to invade that same country in 2003.

In 2021, the United States is no longer as dependent on Middle Eastern oil, given how extensively domestic deposits of petroleum-laden shale and other sedimentary rocks are being exploited by fracking technology. Still, the connection between oil use and geopolitical conflict has hardly disappeared. Most analysts believe that petroleum will continue to supply a major share of global energy for decades to come, and that's certain to generate political and military struggles over the remaining supplies. Already, for instance, conflict has broken out over disputed offshore supplies in the South and East China Seas, and some analysts predict a struggle for the control of untapped oil and mineral deposits in the Arctic region as well.

Here, then, is the question of the hour: Will an explosion in electric-car ownership change all this? EV market share is already growing rapidly and projected to reach 15% of worldwide sales by 2030. The major automakers are investing heavily in such vehicles, anticipating a surge in demand. There were around 370 EV models available for sale worldwide in 2020 — a 40% increase from 2019 — and major automakers have revealed plans to make an additional 450 models available by 2022. In addition, General Motors has announced its intention to completely phase out conventional gasoline and diesel vehicles by 2035, while Volvo's CEO has indicated that the company would only sell EVs by 2030.

It's reasonable to assume that this shift will only gain momentum, with profound consequences for the global trade in resources. According to the IEA, a typical electric car requires *six times* the mineral inputs of a conventional oil-powered vehicle. These include the copper for electrical wiring plus the cobalt, graphite, lithium, and nickel needed to ensure battery performance, longevity, and energy density (the energy output per unit of weight). In addition, rare-earth elements will be essential for the permanent magnets installed in EV motors.

Lithium, a primary component of lithium-ion batteries used in most EVs, is the lightest known metal. Although present both in clay deposits and ore composites, it's rarely found in easily mineable concentrations, though it can also be extracted from brine in areas like Bolivia's Salar de Uyuni, the world's largest salt flat. At present, approximately 58% of the world's lithium comes from Australia, another 20% from Chile, 11% from China, 6% from Argentina, and smaller percentages from elsewhere. A U.S. firm, Lithium Americas, is about to undertake the extraction of significant amounts of lithium from a clay deposit in northern Nevada, but is meeting resistance from local ranchers and Native Americans, who fear the contamination of their water supplies.

Cobalt is another key component of lithium-ion batteries. It's rarely found in unique deposits and most often acquired as a byproduct of copper and nickel mining. Today, it's almost entirely produced thanks to copper mining in the violent, chaotic Democratic Republic of the Congo, mostly in what's known as the copper belt of Katanga Province, a region which once sought to break away from the rest of the country and still harbors secessionist impulses.

Rare-earth elements encompass a group of 17 metallic substances scattered across the Earth's surface but rarely found in mineable concentrations. Among them, several are essential for future green-energy solutions, including dysprosium, lanthanum, neodymium, and terbium. When used as alloys with other minerals, they help perpetuate the magnetization of electrical motors under high-temperature conditions, a key requirement for electric vehicles and wind turbines. At present, approximately 70% of REEs come from China, perhaps 12% from Australia, and 8% from the U.S.

A mere glance at the location of such concentrations suggests that the green-energy transition envisioned by President Biden and other world leaders may encounter severe geopolitical problems, not unlike those generated in the past by reliance on oil. As a start, the most militarily powerful nation on the planet, the United States, can supply itself with only tiny percentages of REEs, as well as other critical minerals like nickel and zinc needed for advanced green technologies. While Australia, a close ally, will undoubtedly be an important supplier of some of them, China, already increasingly viewed as an adversary, is crucial when it comes to REEs, and the Congo, one of the most conflict-plagued nations on the planet, is the leading producer of cobalt. So don't for a second imagine that the transition to a renewable-energy future will either be easy or conflict-free.

The Crunch to Come

Faced with the prospect of inadequate or hard-to-access supplies of such critical materials, energy strategists are already calling for major efforts to develop new sources in as many locations as possible.

> "Today's supply and investment plans for many critical minerals fall well short of what is needed to support an accelerated deployment of solar panels, wind turbines and electric vehicles," said Fatih Birol, executive director of the International Energy Agency. "These hazards are real, but they are surmountable. The response from policymakers and companies will determine whether critical minerals remain a vital enabler for clean energy transitions or become a bottleneck in the process."

As Birol and his associates at the IEA have made all too clear, however, surmounting the obstacles to increased mineral production will be anything but easy. To begin with, launching new mining ventures can be extraordinarily expensive and entail numerous risks. Mining firms may be willing to invest billions of dollars in a country like Australia, where the legal framework is welcoming and where they can expect protection against future expropriation or war, but many promising ore sources lie in countries like the DRC, Myanmar, Peru, and Russia where such conditions hardly apply. For example, the current turmoil in Myanmar, a major producer of certain rare-earth elements, has already led to worries about their future availability and sparked a rise in prices.

Declining ore quality is also a concern. When it comes to mineral sites, this planet has been thoroughly scavenged for them, sometimes since the early Bronze Age, and many of the best deposits have long since been discovered and exploited. "In recent years, ore quality has continued to fall across a range of commodities," the IEA noted in its report on critical minerals and green technology. "For example, the average copper ore grade in Chile declined by 30% over the past 15 years. Extracting metal content from lower-grade ores requires more energy, exerting upward pressure on production costs, greenhouse gas emissions, and waste volumes."

In addition, extracting minerals from underground rock formations often entails the use of acids and other toxic substances and typically requires vast amounts of water, which are contaminated after use. This has become ever more of a problem since the enactment of environmental-protection legislation and the mobilization of local communities. In many parts of the world, as in Nevada when it comes to lithium, new mining and ore-processing efforts are going to encounter increasingly fierce local opposition. When, for example, the Lynas Corporation, an Australian firm, sought to evade Australia's environmental laws by shipping ores from its Mount Weld rare-earths mine to Malaysia for processing, local activists there mounted a protracted campaign to prevent it from doing so.

For Washington, perhaps no problem is more challenging, when it comes to the availability of critical materials for a green revolution, than this country's deteriorating relationship with Beijing. After all, China currently provides 70% of the world's rare-earth supplies and harbors significant deposits of other key minerals as well. No less significant, that country is responsible for the refining and processing of many key materials mined elsewhere. In fact, when it comes to mineral processing, the figures are astonishing. China may not produce significant amounts of cobalt or nickel, but it does account for approximately 65% of the world's processed cobalt and 35% of its processed nickel. And while China produces 11% of the world's lithium, it's responsible for nearly 60% of processed lithium. When it comes to rare-earth elements, however, China is dominant in a staggering way. Not only does it provide 60% of the world's raw materials, but nearly 90% of processed REEs.

To put the matter simply, there is no way the United States or other countries can undertake a massive transition from fossil fuels to a renewables-based economy without engaging economically with China. Undoubtedly, efforts will be made to reduce the degree of that reliance, but there's no realistic prospect of eliminating dependence on China for rare earths, lithium, and other key materials in the foreseeable future. If, in other words, the U.S. were to move from a modestly Cold-War-like stance toward Beijing to an even more hostile one, and if it were to engage in further Trumpian-style attempts to "decouple" its economy from that of the People's Republic, as advocated by many "China hawks" in Congress, there's no question about it: the Biden administration would have to abandon its plans for a green-energy future.

It's possible, of course, to imagine a future in which nations begin fighting over the world's supplies of critical minerals, just as they once fought over oil. At the same time, it's perfectly possible to conceive of a world in which countries like ours simply abandoned their plans for a green-energy future for lack of adequate raw materials and reverted to the oil wars of the past. On an already overheating planet, however, that would lead to a civilizational fate worse than death.

In truth, there's little choice but for Washington and Beijing to collaborate with each other and so many other countries in accelerating the green energy transition by establishing new mines and processing facilities for critical minerals, developing substitutes for materials in short supply, improving mining techniques to reduce environmental hazards, and dramatically increasing the recycling of vital minerals from discarded batteries and other products. Any alternative is guaranteed to prove a disaster of the first order — or beyond.

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