

CRITICAL MINERALS & ENERGY TRANSITION

A LOOK AT AFRICA & WESTERN & CENTRAL ASIA



Toward A New Era of Minerals
Be Part of it

Introduction

As energy systems evolve on a global scale, the shift to a clean energy economy will depend on fulfilling critical mineral supply needs. Demand for raw materials such as Lithium, Nickel, Cobalt, Copper, Graphite, Silicon, Platinum Group Metals, and Rare Earth Elements are expected to increase fivefold over the next two decades.¹ New estimates report more than 3 billion tons of critical minerals will be needed to create infrastructure and accomplish the 2050 net-zero goals set forth in the Paris Agreement.² To meet this level of demand required to build a renewable energy future, the world looks to mineral-rich countries for reliable sourcing of inputs along the value chain.³ In the short to medium term, economies across Africa and Western and Central Asia can aim to play an important role in critical minerals supply chains. This region possesses the mineral endowment required for a global low-carbon society and the right geography to become a hub for the minerals value chain.

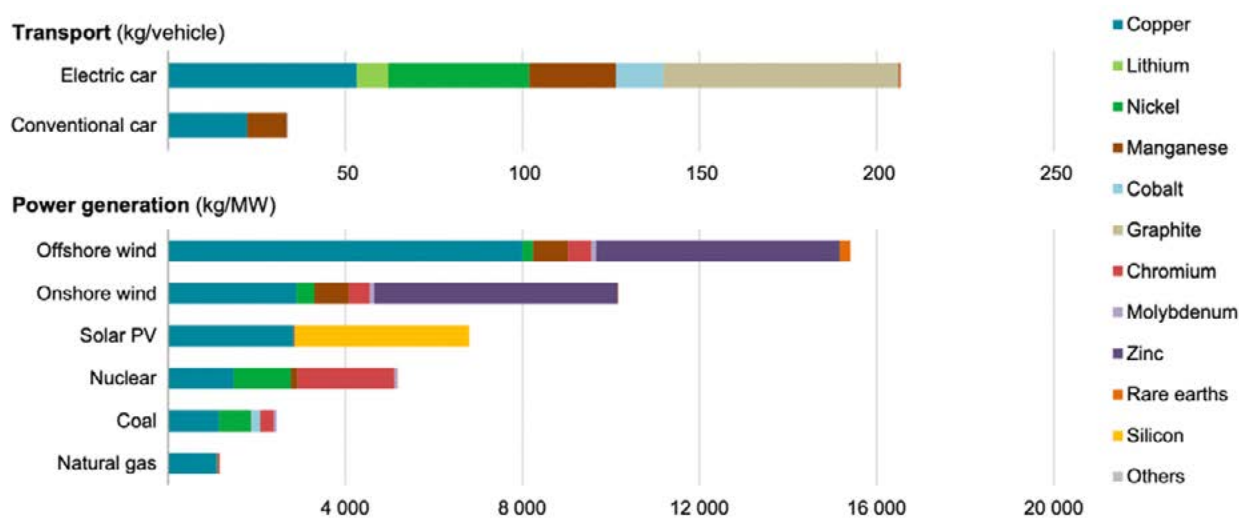


Figure 1 below displays critical minerals used in major energy technologies in 2021.

Note: kg = kilogramme; MW = megawatt. Steel and aluminum are not included in this figure.
Source: International Energy Association (IEA), World Energy Investment Report, 2022

An economic transition from hydrocarbon resources to critical minerals for clean energy technologies is not straightforward and will take decades (fossil fuels still account for 84 percent of global energy consumption).⁴ However, with renewable energy being the fastest growing energy source in 2022, this area of the world has a historic opportunity to ensure sustainable supply and use of these raw materials.⁵

1 World Bank Group, <https://pubdocs.worldbank.org/en/961711588875536384/pdf/Minerals-for-Climates-Action-The-Mineral-Intensity-of-the-Clean-Energy-Transition.pdf>. Accessed 2022/23/11

2 World Bank Group, <https://pubdocs.worldbank.org/en/961711588875536384/pdf/Minerals-for-Climates-Action-The-Mineral-Intensity-of-the-Clean-Energy-Transition.pdf>. Accessed 2022/02/12

3 The World Bank, <https://www.worldbank.org/en/news/feature/06/06/2022/mineral-rich-developing-countries-can-drive-a-net-zero-future>. Accessed 2022/06/12

4 "How Circular Economy Approaches can Increase Supply Security for Critical Raw Materials", https://www.systemiq.earth/wp-content/uploads/11/2022/Systemiq2022--Circular-Economy-CRM-Resilience-Summary-Presentation_final.pdf. Accessed 2022/30/10

5 EIA (2022) Annual Energy Outlook 2022 Report, EIA, U.S. Department of Energy

The supply chains of the many critical minerals are not homogenous. To ensure this region of the world will contribute in a significant way to achieving climate targets and furthering local economic development, the following actions will be important:

- It is essential to work together with partners in order to reduce bottlenecks in critical mineral supply chains, build stable markets, and ensure to spread the margins from the value chain. Improving transparency and governance will be a clear focus.
- Critical mineral supply chains must be widened at every step, from mines to downstream processing and recycling.⁶ Reshaping current supply chains will create new opportunities for value added via processing and manufacturing.

- Ramped up investment, along with associated permitting and community engagement, in critical mineral exploration, innovation, and processing will be a key component of alleviating capacity constraints. Along with increased investments must also come revised permitting, planning, and engagement with communities.

The remainder of this brief is as follows: Section 2 provides a brief assessment of global investments in critical minerals. In this section there are two regional focuses centered on critical mineral investment updates from the Middle East and Africa. Section 3 reviews factors impacting critical mineral markets, Section 4 presents the Payne Institute for Public Policy's Mineral Systems Model as a tool for projecting demand, and Section 5 concludes.

Section II. Critical Mineral Investment Trends and Supply Chains

Against the backdrop of the global energy crisis, there remains robust expectations for raw materials linked to energy investment in mineral-rich countries, with projections estimating an uptick of 8 percent globally this year alone (IEA, 2022).⁷ To supply enough critical minerals needed to support the level demanded for solar and wind energy, and battery metals, an estimated \$1.7 trillion in global mining investments will be required.⁸ This level of spending can provide opportunistic advances for regions of the world rich in critical minerals, such as Western and Central Asia and Africa.

Following the IEA's sustainable development scenario, by 2040 global demand is forecasted to rise 19x relative to 2020 for Nickel, 21x over the same period for Cobalt, and 42x relative to 2020 for lithium (2021).⁹ Largely as a result of rapid adoption of electric vehicles and clean energy technologies, Copper demand is also expected to dramatically increase over the next few years. Forecasts project production will climb from 6 million metric tons (MT) per year to between 11 million and 16 million MT by 2030, leading to an expected production deficit of about 9 million metric tons at this time (S&P Global, 2022).

⁶ How to Avoid a New Cold War Over Critical Minerals", Foreign Policy, <https://foreignpolicy.com/2022/11/22/critical-minerals-resources-us-china-competition-cold-war-supply-chains/>. Accessed 12/06/2022

⁷ It should be noted that nearly half of this increase in spending is associated with higher costs in the market.

⁸ Low carbon world needs \$1.7 trillion in mining investment", Reuters, 2022. <https://www.reuters.com/business/energy/low-carbon-world-needs-17-trillion-mining-investment-2021-05-10/>. Accessed on 12/06/2022

⁹ This scenario assumes that concerted policy efforts speed up innovation timelines for new energy technologies so that innovation happens at a quick rate globally.

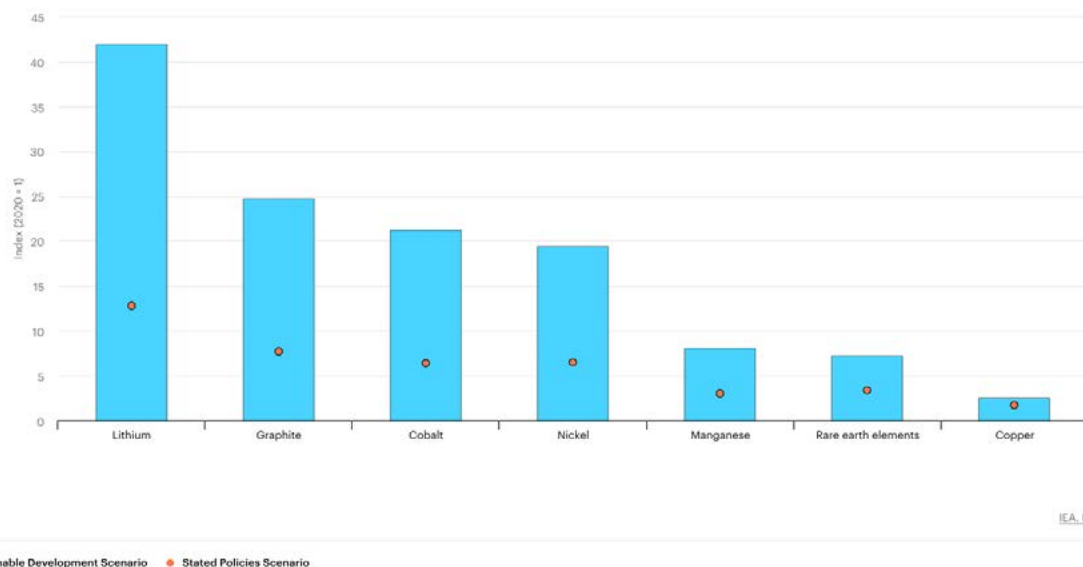


Figure 2 displays projected demand growth by IEA scenario.

Note: Demand from other sectors was assessed using historical consumption, relevant activity drivers and the derived material intensity. Neodymium demand is used as indicative for rare earth elements.

Source: International Energy Association (IEA), *The Role of Critical Minerals in Energy Transitions, 2021*

Looking forward, sustainable financing allocated towards critical mineral production in Africa and Western and Central Asia will be a driving force to retract global output slowdown seen in 2021, mitigate market failures and optimize market conditions (International Monetary Fund (IMF), 2022). Consequently, national governments should consider establishing transparent regulatory frameworks that protect communities and the environment, with mandates that incorporate some corporate social responsibility.



Spending Strategies in the Middle East towards Critical Mineral Markets vs Traditional Energy Sectors

The types of investments in 2022 linked to energy supply chains in the Middle East vary substantially across short- and long-term scenarios, and current trends are caught between two contrasting visions for the future.

The outlook for Saudi Arabia's role as a global leader in building out efficient critical mineral supply chains is promising, in part, due to a welcoming investment climate. By providing incentives for investment and being transparent/open to investors, the Kingdom has started to attract a lot of interest in investment partnerships, with the CEO of Eurasian Resources Group, recently stating that Saudi Arabia has all the "ingredients to be successful."¹⁰

The Kingdom plans to attract \$32 billion of investment towards creating integrated value chains, with goals to become a major player in global mining production.¹¹ Target investments are projected to create roughly 14,000 new jobs in clean energy within the region.¹² Currently, the Kingdom is processing 145 exploration license applications sent in by foreign companies.¹³ At the same time, Middle Eastern National Oil Companies (NOCs) have announced significant investment hikes for fossil fuels in 2022. Spending has risen above pre-pandemic levels in 2022 for the Middle Eastern NOCs - with a net increase of \$5 billion USD in 2021 allocated towards traditional oil and gas operations (IEA, 2022).



10 S&P Global, <https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/011222-saudi-arabia-could-play-important-role-critical-mineral-supply-chains-conference-panel>. Accessed 12/06/2022.

11 Ministry of Industry and Mineral Resources, https://www.my.gov.sa/wps/portal/snp/agencies/agencyDetails/AC423!ut/p/z0/04_Sj9CPykssy0xPLMnMz0vMAfIjo8zivQIsTAwdDQz9LQwNzQwCnS0tXPwMvYwNDz0gIPz9L30o_ArAppiVOTr7JuuHIWQWJKhm5mXlq8f4ehsYmSsX5DtHg4AsZzAvg!!. Accessed 12/04/2022.

12 Saudi Arabia to boost mining and logistics capabilities to attract \$32 billion in investment", Fast Company, <https://fastcompany.com/news/saudi-arabia-to-boost-mining-and-logistics-capabilities-to-attract-32-billion-of-investment/>. Accessed 12/06/2022.

13 Saudi Arabia to boost mining and logistics capabilities to attract \$32 billion in investment", Fast Company, <https://fastcompany.com/news/saudi-arabia-to-boost-mining-and-logistics-capabilities-to-attract-32-billion-of-investment/>. Accessed 12/06/2022.

Figure 3 displays data from the IEA (2022), showcasing diversification in energy investment decisions by international groups linked to large oil and gas producing companies in 2019 relative to 2022.

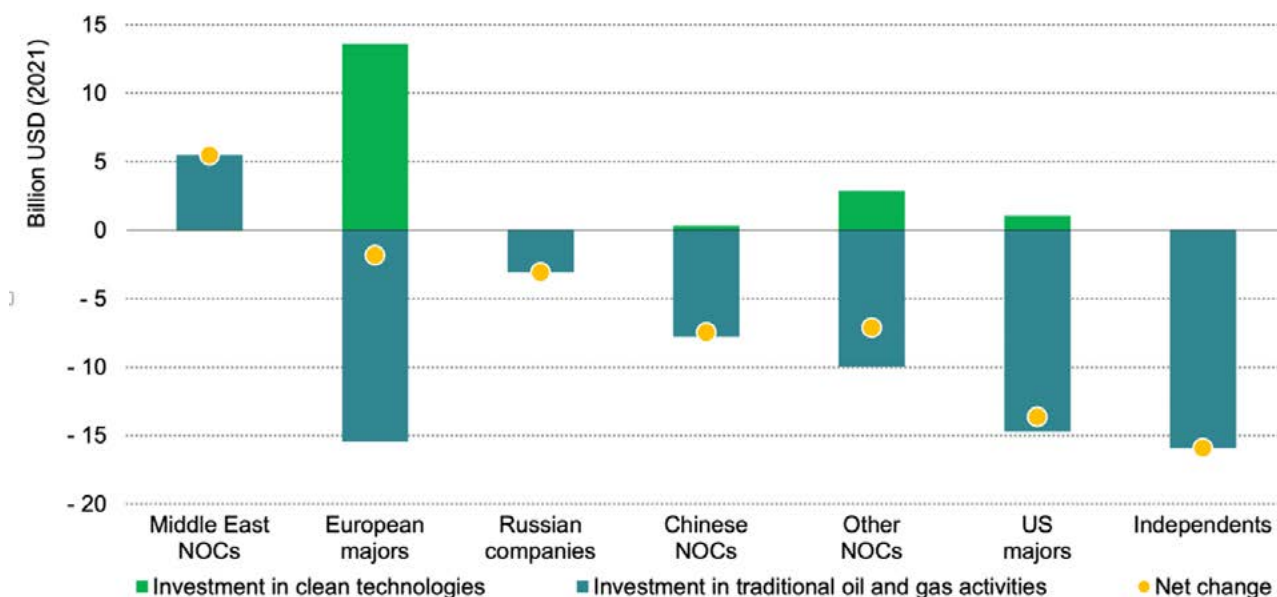


Figure 3: Range of Investment Strategies Across Different Parts of the Oil and Gas Industry

Note: Chart displays changes in investment by different groupings of oil and gas companies, 2022E vs 2019.

Source: International Energy Association (IEA), World Energy Investment Report, 2022

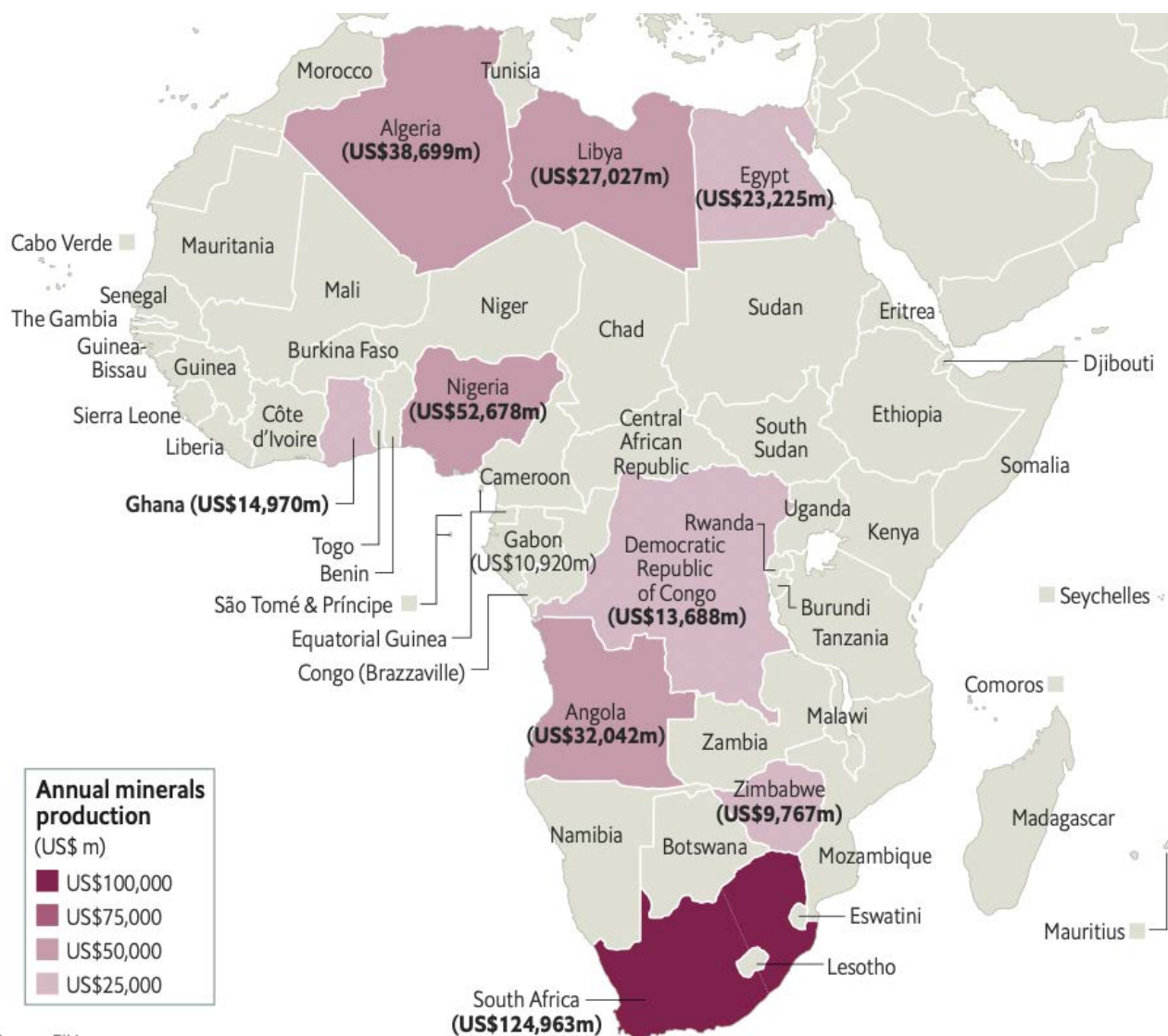
The IEA’s 2022 estimates suggest aggregate fossil fuel investment is largely aligned with the near-term needs but will require governments to ease capital spending cutbacks and bolster the ability of markets to weather volatility. How this capital allocation “makes room” for other sectors, like critical minerals, remains unclear.

Africa’s Critical Mineral Investment Opportunities

Africa is resource rich. The continent is endowed with significant hydrocarbon reserves as well as critical minerals (Freeman, 2022). As political and environmental developments around the world seek to decarbonize supply chains, pivoting investments over time from traditional energy production towards building out critical mineral supply chains can help to bridge gaps linked to economic development in this region.

Africa's land is host to many critical mineral reserves. Nearly 50 percent of the countries in the region contain substantial amounts of one or more critical minerals required for the energy transition, with South Africa, Nigeria, Algeria, Angola and Libya producing more than two-thirds of Africa's mineral wealth.¹⁴

Data from the Economist Intelligence Unit (EIU) (2022), presented in Figure 4, reports the top mineral producing countries in Africa and their associated annual production worth.



Source: EIU.

Figure 4: Africa's Top Mineral Producers

Figure 4 includes some top producers, such as Algeria, Egypt and Libya that largely export natural gas and petroleum. To view the *critical* minerals extracted in Africa by country, see Table 1.

¹⁴ S&P Global (2022). "Critical minerals: Illuminating the path to an electric future", <https://www.spglobal.com/marketintelligence/en/mi/research-analysis/critical-minerals-illuminating-the-path-to-an-electric-future.html>. Accessed 12/01/2022.

Top Green Mineral Country	Main Critical Mineral(s) Extracted
Democratic Republic of Congo	Lithium, Cobalt, Copper
Botswana	Copper, Nickel
Gabon	Manganese
Ghana	Bauxite, Manganese, Lithium
Guinea	Bauxite
Madagascar	Nickel
Mali	Lithium
Morocco	Cobalt
Namibia	Lithium
Nigeria	Lithium, Cobalt
South Africa	Copper, Nickel, Manganese
Zambia	Cobalt, Copper
Zimbabwe	Lithium

Table 1: Critical Minerals by Country in Africa

Sources: Mining Digital Magazine, Supply Chain Operations (2022); Statistica, Mineral Production in Africa (2022)

While Africa has an abundance of critical mineral supply, industrialization has been limited due to lack of investment in technology innovation and infrastructure in place. The continent is competitive in terms of attracting exploration and mining of critical minerals, but largely lacks the capacity for processing/refining operations, manufacturing, and industrialization. As a result, minerals mined are exported in unprocessed form or, at best, concentrates for value addition elsewhere beyond the continent.

Manganese, for example (used in the steel industry and for battery chemistries), is a rare mineral resource largely sourced in Africa and processed in China.¹⁵ Exporting raw materials to other countries creates vulnerabilities

and lowers security within critical mineral supply chains, often exacerbating concerns linked to time constraints and bottlenecks. Creating more efficient supply chains from exploration to a mineral's end-use would lower costs of end-products, ensure faster market response time, create jobs, and foster Africa's economic and social development for the long-run.

As part of a wider product industrial development strategy, the Democratic Republic of Congo (DRC) - the world's largest producer of cobalt (about 70 percent) - and Zambia (part of the mineral-rich Copper Belt region) have begun efforts to restrict the export of some critical minerals in raw form (USGS, 2021). This directly impacts the need for companies to set up local

15 The Wilson Center, (2021). "The Mosaic Approach: a multidimensional strategy for strengthening America's critical minerals supply chain", https://www.wilsoncenter.org/sites/default/files/media/uploads/documents/critical_minerals_supply_report.pdf. Accessed 11/29/2022.

processing plants within these countries. Governments in both areas are now pushing investors to consider the efficiency and additional value added to raw materials by producing critical minerals in-country. Operations currently export 95 percent of extracted minerals in raw form, blocking significant revenues to these economies.¹⁶

Trade tensions with China and Russia's ongoing war in the Ukraine have triggered many Western countries to turn to Africa for investment opportunities in critical mineral supply during 2022. In the third quarter of this year, Minerals Security Partnership countries (including the U.S., Australia, Canada, Finland, France, Germany, Japan, South Korea, Sweden, the U.K. and the European Commission) began conversations around the benefits of clean energy investments in areas that already possess the skills and experience to process rare earths domestically. This led to partnership discussions involving African regions.

International investors expect partnerships to diversify and bolster critical mineral supply chains while lowering trade reliance with China and Russia. For Africa, this would provide development opportunities through higher profits from all stages of the value chain as well as energy security in a traditionally consumed less energy (World Bank, 2021). Five African countries came to September's UN General Assembly conference to initiate these conversations, including: the DRC, Mozambique, Namibia, Tanzania and Zambia.¹⁷

With the continent set to remain one of the major suppliers of critical minerals for clean energy, the scale and pace of investment inflows will largely hinge on the restructuring of domestic governance and policy changes. If done correctly, investments could have a positive impact on economic development—but there are not many good examples of this to date.



¹⁶ The Africa Report (2022). <https://www.theafricareport.com/243847/us-looks-to-africa-to-diversify-supply-chain-for-critical-minerals/>. Accessed 11/19/2022.

¹⁷ The Africa Report (2022). <https://www.theafricareport.com/243847/us-looks-to-africa-to-diversify-supply-chain-for-critical-minerals/>. Accessed 11/19/2022.

Section III. Factors Impacting Critical Mineral Markets

The shift away from fossil fuels is expected to significantly boost requirements for critical minerals utilized to power clean energy. To meet goals outlined in the 2016 Paris Agreement, over the next two decades, demand for critical minerals is estimated to increase by more than 40 percent for Copper and Rare Earth Elements (REE), 60-70 percent for Nickel and Cobalt, and almost 90 percent for Lithium (IEA, 2022).

Innovation and market expansion in mineral rich regions of the world, including Africa and Western and Central Asia, come with the promise of new job creation across the cleaner energy landscape (Bazilian et al., 2022). Prioritizing supply chain efficiencies and industry dynamics that retain high environmental and labor standards are appropriate and important.

Markets for critical minerals are diverse and, and while new policies intended to accelerate domestic supply in some parts of the world have been put in place, the markets will not be changed overnight. Geographical heterogeneity linked to extraction and processing of minerals implies a complex market picture. Some examples include:

- Australia and Chile - produce 70 percent of the global Lithium supply;
- The Democratic Republic of Congo (DRC) - contributes about 70 percent of global Cobalt;
- Indonesia – provides close to 30 percent of the global supply of Nickel;
- Chile and Peru – together produce 40 percent of the world’s Copper; and
- China – large producer of strategic metals and dominates midstream refining and downstream advanced Rare Earth Elements (REE) extraction and processing (Roskill, 2019; SMM, 2021; Williams, 2021; Brew and Bazilian, 2022).¹⁸

¹⁹ 20 21

These geographic concentrations increase supply chain exposure to changing tariff rates, concerns over labor standards, conflict financing, and export restrictions from industrial policy and environmental concerns (Global Times, 2021; Roskill, 2020; Sovacool et al., 2020).

¹⁸ USGS, “Mineral Commodity Summaries Tables”, <https://d9-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/atoms/files/myb1-2019-lithi-adv.xlsx>. Accessed 11/30/2022

¹⁹ “Profiling the world’s eight largest cobalt-producing countries”, NS Energy, 02/22/2021.

²⁰ Global Data, <https://www.globaldata.com/data-insights/mining/the-top-five-nickel-producing-countries-thousand-tonnes-2021/>. Accessed 11/30/2022.

²¹ Global Data, <https://www.globaldata.com/data-insights/mining/the-top-five-copper-producing-countries-thousand-tonnes-2021/#:~:text=The%20major%20producing%20countries%20are,tonnes%2C%20down%201.7%25%20YoY>. Accessed 11/30/2022.

Critical Mineral Supply and Price

Critical mineral prices are bringing new challenges to clean energy and areas of the world that supply them. On the other hand, the rate of deployment of clean energy technologies will be a key determinant in the demand for minerals moving forward (IEA, 2022). Technological innovations will expand access to raw materials and drive production costs down, however, the application of technology takes time. How quickly the world can invest, innovate, and implement into the value chain cause uncertainty around the energy transition's timeline.

Prices associated with the critical minerals responsible for driving the energy transition have been on an upward trend since early 2021, spurring global investment levels thanks to boosts in profits and cash flows of mining companies (S&P Global, 2022). Major projects linked to critical minerals (such as the announced plan by the Saudi Arabian Ministry of Industry and Mineral Resources seeking \$32 billion in investments towards the mining and mineral sector) will be an important factor in determining prices in upcoming years, as they have potential to bring new supplies into the market (IEA, 2022).

Figure 5 showcases price patterns over time for lithium, cobalt, nickel, and aluminum

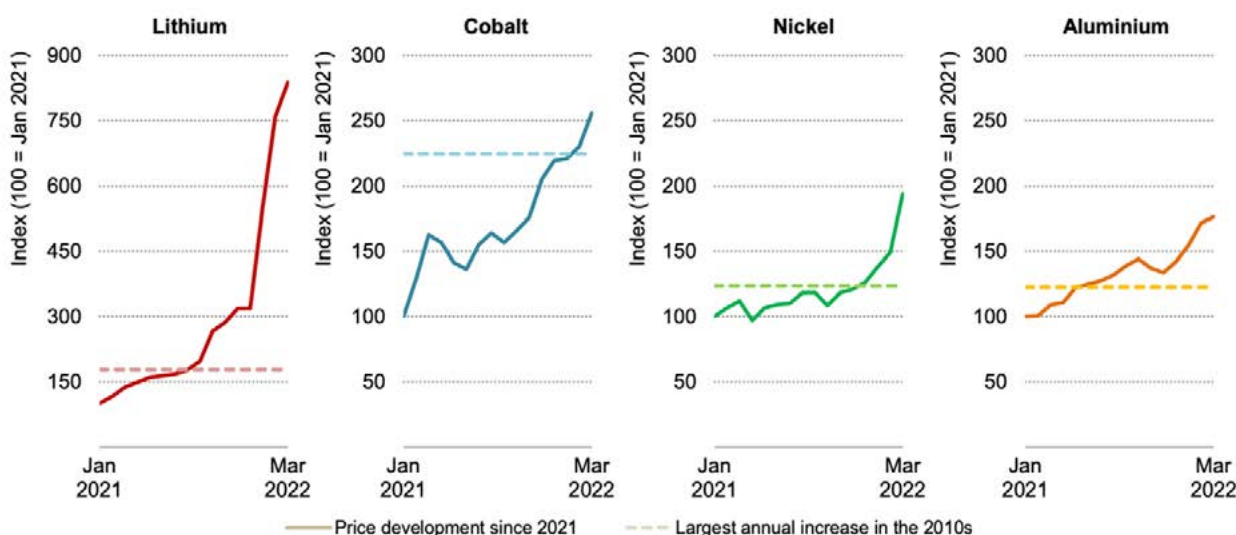


Figure 5: Price Development for Selected Energy Transition Minerals and Metals (2021-2022)

Note: Assessment based on Lithium Carbonate Global Average, LME Cobalt Cash, LME Nickel Cash and LME Aluminium 99.7 percent Cash prices.

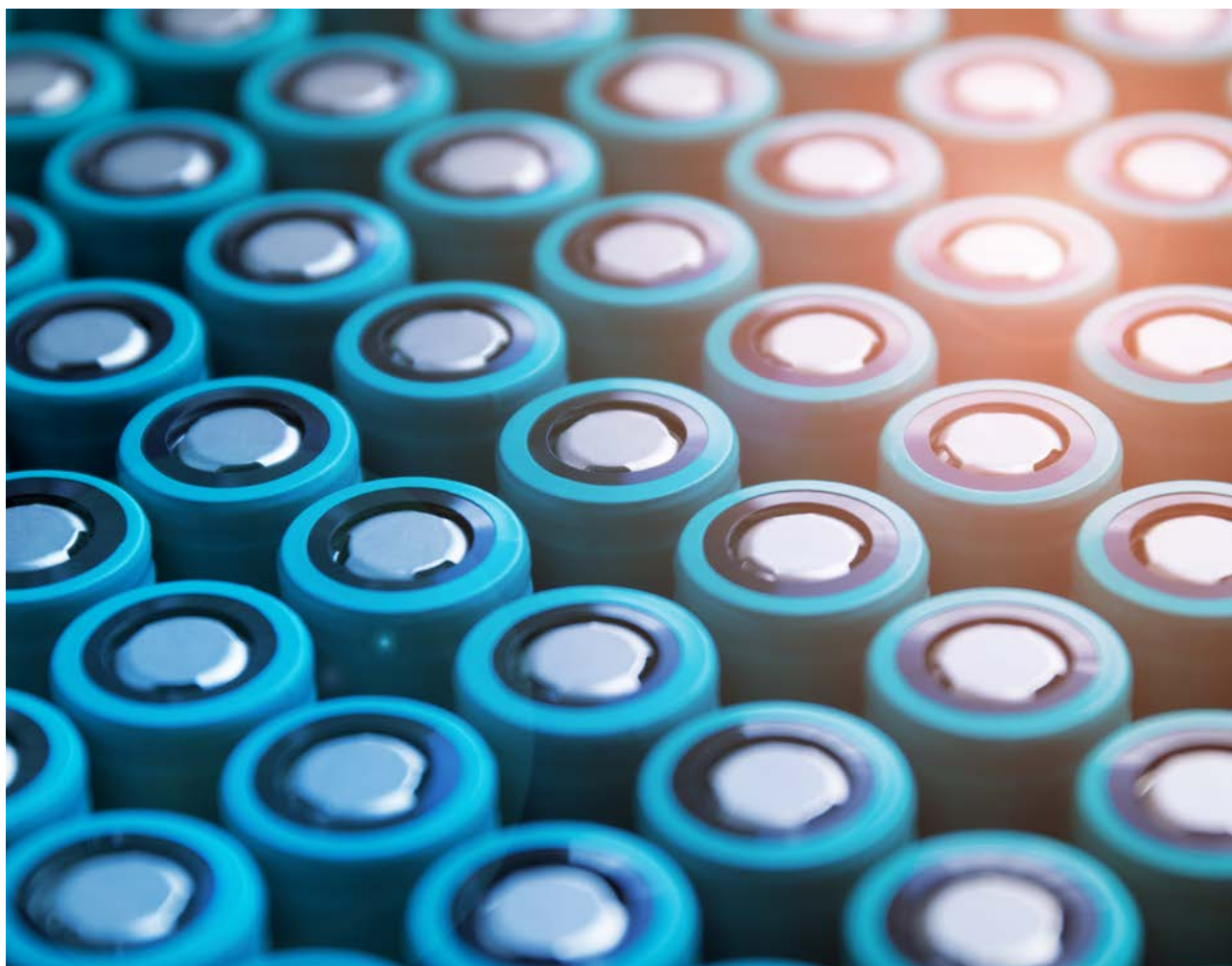
Source: S&P Global, 2022

Price upticks in critical materials surged upwards in 2021 due to a mix of robust demand, ruptures in supply chains and concerns over a tightening supply. Increases in prices of critical minerals pose a threat to a decades-long trend of falling costs for clean energy technologies (BNEF, 2022). Prices are expected to remain elevated in 2022 and the beginning of 2023 largely due to supply chain disruptions and continued inflationary pressure.

Rising raw material prices impact the magnitude and pace of energy innovations and end up reflected in final

commodity prices. By way of illustration, the cost share of cathode materials in lithium-ion battery packs has grown by more than 20 percent in the last decade, just as some 300 gigafactories were at different planning and construction stages around the world.²² The upward pressure from rising costs of cathode materials reflected a direct increase of lithium-batteries, rising in price by 15 percent in year-over-year changes relative to 2021 (IEA, 2022).

It is important to note, high critical mineral costs do not serve to lower investment in clean energy innovations in the long-term.



22 Benchmark Mineral Intelligence, <https://www.benchmarkminerals.com/gigafactories/>. Accessed 12/01/22

Section IV. Modeling Critical Mineral Demand

Previous testimony provides confidence in continued large-scale growth for clean energy technological innovations that rely heavily on significant levels of certain mineral commodities (Bazilian, 2019). The Payne Institute for Public Policy has developed a Mineral Systems Model (MSM) as a collaborative platform and tool for looking at future mineral demand. The model considers the outer bounds and possible equilibria associated with mineral demand and provides a “first approximation” qualitative approach.

The approach translates energy generation capacity into mineral demands, following the empirical methods laid out by Watari et. al (2019). The central model offers simplicity and transparency by projecting mineral market growth through multiple energy transition scenarios. The outcomes generated consider inflow and outflow impacts including recycling rates.

Initial findings suggest three distinct magnitudes of market growth associated with critical mineral demand in the energy transition.

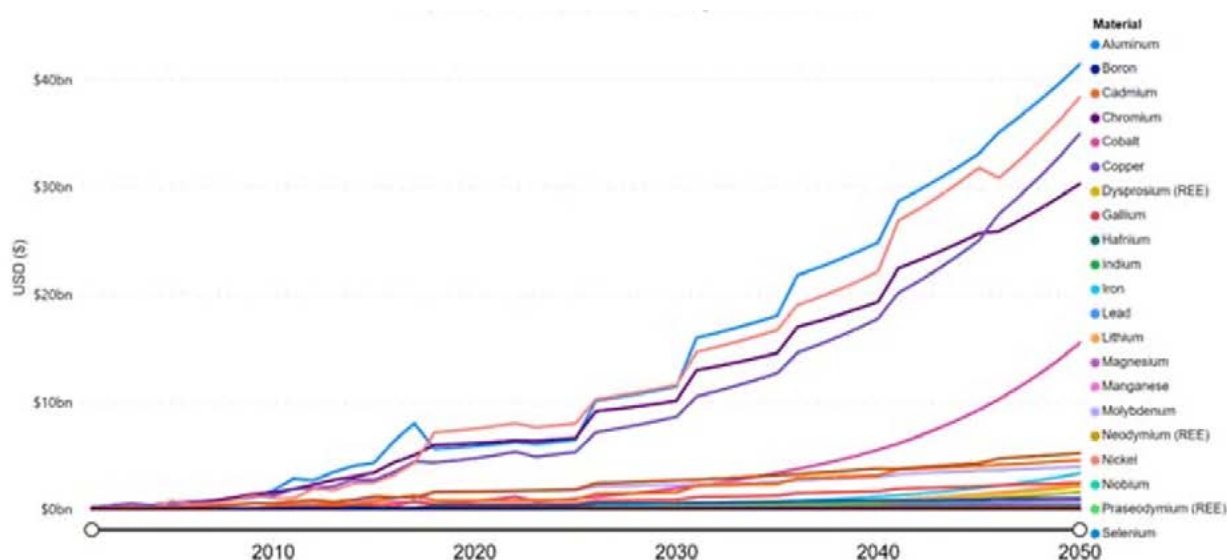


Figure 6: Global Market Size per Year, per Material (2010-2050)

Source: Payne Institute for Public Policy, Colorado School of Mines, 2022

Iron, lithium, neodymium and silver are expected to achieve between \$1 and \$6 billion in worth, and a third (less vital) group is shown to achieve less than a \$1 billion market size value during the same period. Similarly, we find three distinct magnitudes of relative growth, with terbium, lead, dysprosium, neodymium, cobalt, and lithium increasing by more than 300 percent by 2050. A second group in-

cluding tellurium, gallium, indium, nickel, praseodymium, vanadium, molybdenum, tin, selenium, silver, and zirconium sees medium relative growth (between 30 percent and 300 percent). A third group with the lowest relative growth (1 percent to 30 percent) includes minerals with large absolute growth but in already large markets such as steel, aluminum, copper and silver.

Figure 7 illustrates mineral demand for China.

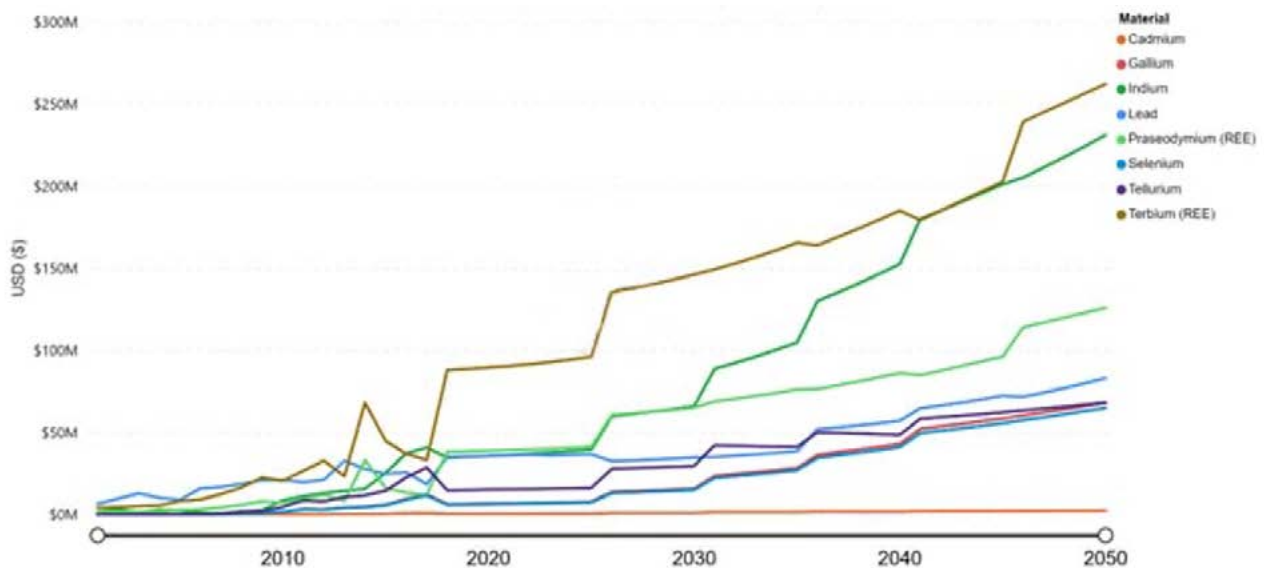


Figure 7: China's Mineral Market Size per Year, per Material (2010-2050)

Source: Payne Institute for Public Policy, Colorado School of Mines, 2022

Section V. Conclusion

It is an exciting time for critical minerals and areas of the world with endowments capable to supply a clean energy future. The mineral-rich region spanning from Africa and Western and Central Asia has potential to play vital roles in the global energy transition channeled by critical mineral supply chains.

To make the most of this opportunity, governments, companies, and communities will have to work together towards a set of sustainable, secure, resilient, transparent, and well governed supply chains and markets. In doing so, current supply chains will be reshaped, and others will be strategically implemented, creating new opportunities for value added to production processes and bolstered economic growth.

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