October 2023

No Energy Transition without Green Metals

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> We believe the energy transition can only happen with green metals and minerals. Therefore, availability and security of supply are critical.

The energy transition offers potentially exciting and unprecedented investment opportunities that may be historic in terms of both the impact on the global economy and potential returns. However, we firmly believe that there will be ***no successful energy transition without successful development of green metals and minerals****. Investments across several green commodities and those companies engaged in exploring, developing, producing, processing and recycling them, are a necessity and could be compelling.*

We believe the "energy trilemma" that the world is facing - that is, delivering secure, clean and affordable energy – can only be successfully addressed by effectively developing secure, clean and affordable green metals and minerals.

Some of the most prominent among the metals and minerals we group as green are cobalt, copper, graphite, lithium, nickel, manganese and the rare earth elements.

Green metals and minerals are essential to a wide variety of clean energy technologies and supporting infrastructure, whether in solar panels, wind turbine nacelles, etc., or the copper wire connecting an electric vehicle ("EV") to its charging station.

Relative Importance of Various Minerals for Clean Energy Technologies

	Copper	Cobalt	Nickel	Lithium	REEs	Chromium	Zinc	PGMs	Aluminum
Solar PV	■	■	■	■	■	■	■	■	■
Wind	■	■	■	■	■	■	■	■	■
Hydro	■	■	■	■	■	■	■	■	■
CSP	■	■	■	■	■	■	■	■	■
Bioenergy	■	■	■	■	■	■	■	■	■
Geothermal	■	■	■	■	■	■	■	■	■
Nuclear	■	■	■	■	■	■	■	■	■
Electricity Networks	■	■	■	■	■	■	■	■	■
EVs & Battery Storage	■	■	■	■	■	■	■	■	■
Hydrogen	■	■	■	■	■	■	■	■	■

■ High ■ Medium ■ Low

Source: IEA, Data as of May 2021. Terminology: REEs=Rare Earth Elements; PGMs = Platinum Group Metals; CSP = Concentrating Solar Power

An Inflection Point

We believe that demand for the natural resources, especially green metals and minerals, that are essential to the energy transition, and that the transition itself, are at an inflection point. As both the breadth and depth of requirements become increasingly apparent, so does the challenge of meeting those needs—from where, in terms of supply/demand, we currently (and will) stand.

The International Renewable Energy Agency ("IRENA") estimates that a cumulative investment of $150 *trillion*[1] is needed to reach "Net Zero" by 2050. We see green metals (without which the Net Zero target will not be possible) as constituting one of our most exciting and compelling natural resources investment themes. As such, it would likely rival the mining super-cycle we had in the 2000s when Chinese demand for metals skyrocketed.

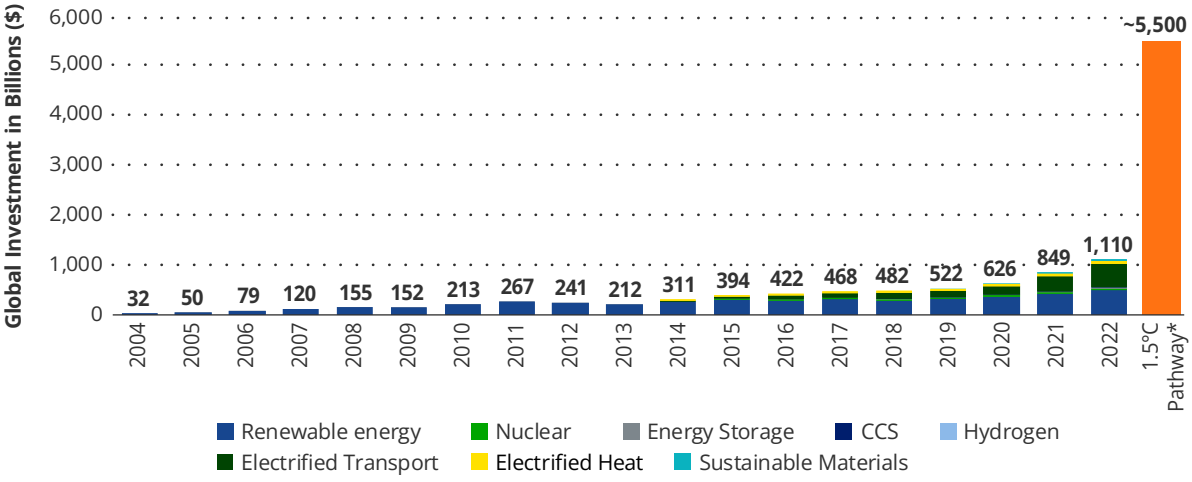
In addition to believing that demand is at an inflection point, thus, creating long-term investment opportunities (the precedent is there: metals have always been vital for industry, including green metals), we have noted three critical drivers:

- Clean energy technologies are *dependent* on the use of green metals and their concentration in those technologies is highly *intensive*. New technologies to produce clean energy require a quantum leap in terms of usage of these metals.
- *Supply* of these minerals and metals will struggle to keep up with burgeoning demand associated with the inevitable energy transition. Every aspect of green metal mining—from access to economics to social acceptance—suggests it will take longer and be more difficult and expensive to extract.
- *Security* of supply concerns are driving major geopolitical concerns. Control of many, if not most, green metals and minerals is concentrated in the hands of one country—China. This has led to unprecedented formulation of on-shoring/friend-shoring measures and policies creating opportunities across the extraction, processing and recycling industries.

IRENA's projected massive investment needed to reach "Net Zero" by 2050 suggests we are at the beginning of a multi-decade structural shift. To reach this figure of $150 trillion, investment on an annual basis needs to be at approximately $5.5 trillion, compared to the current $1.1 trillion estimate.[2]

It is important from an investment standpoint to recognize that opportunities lie not just in renewable energy, but much more broadly in industries such as smart grids, energy efficiency and, in particular, electrified transport and energy storage.

Global Investment in Resource Transition ($ Billion)



Source: BloombergNEF. Data as of January 2023.

Already Happening

While long-term demand looks positive, what about the near term? We believe that, in the near term, demand looks strong, particularly in clean energy.

In 2022, clean energy deployment achieved new records. Globally, approximately 340 Gigawatts ("GW") of capacity was installed. This was mainly driven by solar, which increased by 35% from 2021. While China led the way, adding approximately 100 GW, solar additions in the EU grew almost 50%, not least as the region responded to cuts in the supply of Russian gas. In 2023, global installations are expected to increase 30% over those of 2022, with China alone on track to add a further 150 GW.

Also in 2022, EV sales, registering a 60% increase over 2021, topped 10 million units for the first time. This meant that EV sales were 14% of all new car sales, up from less than 5% in 2020. China, once again, led the way with 60% of global EV sales, followed by the EU and the U.S.

2023 is setting up to be a very strong year. Global solar capacity is expected to increase by 30%, mainly from China, as it is on track to add another 150 GW. And for the first six months of 2023, electric vehicle sales were 40% higher than for the same period last year.

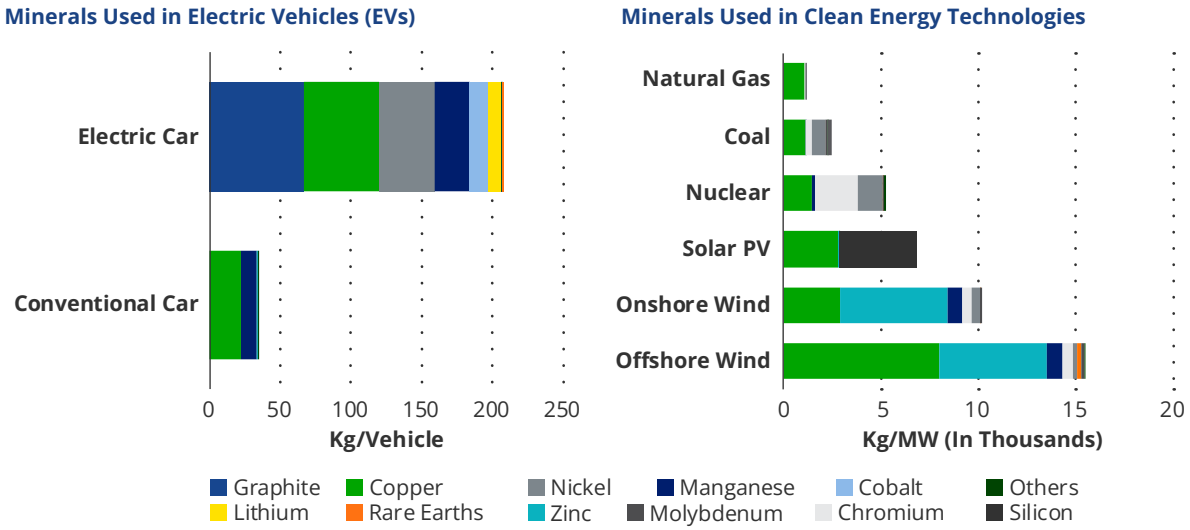
Within the U.S., EVs' market share of U.S. vehicle sales continues to increase. From 3.2% in 2021 to 5.7% in 2022 and to 7.0% in the first half of 2023. (In the second quarter of 2023 alone, there was a 48.8% rise in sales over the same period in 2022.)

Green Metals Dependency and Intensity

Clean energy is both green metals dependent and green metals intensive.

An average-sized electric car needs over 200kg of specialized metals and minerals, while a similar-sized conventional car needs approximately 30 kg. According to the International Energy Agency[3], EVs can require anywhere between six to eight times (6-8x) more such minerals than conventional gas-powered vehicles (see illustration below).

Equally important, though, is the range of minerals required. While among these the most commonly mentioned metals are cobalt, lithium and nickel, graphite (which is not a metal) is of comparable, if not greater, importance. By weight, graphite accounts for approximately 50% of a lithium-ion battery, while the figure for lithium is just some 8% - 10%. The opportunity set can often be wider than that enumerated by some market commentators.



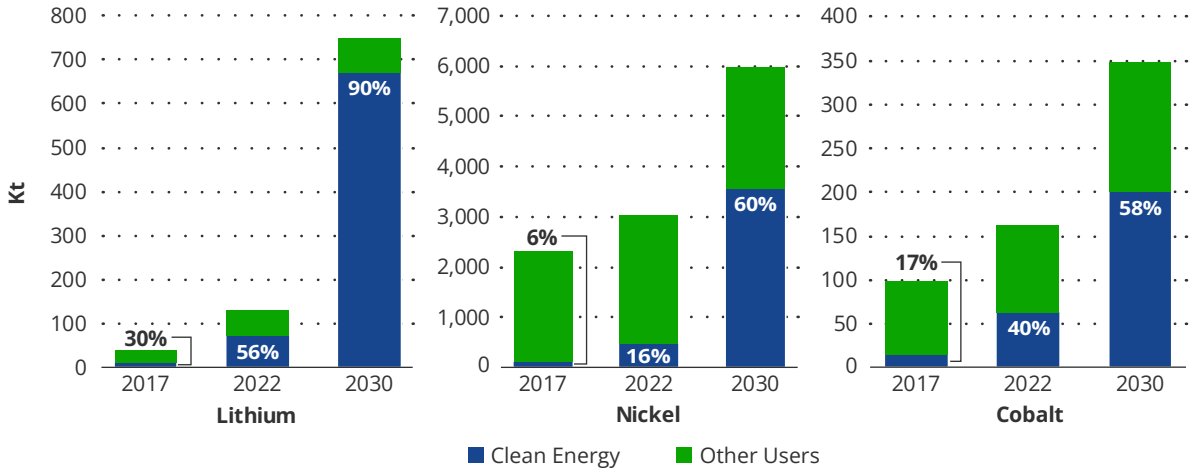
Source: IEA. Data as of May 2021

Mineral usage in clean energy technologies is also extremely intensive relative to conventional energy sources. For example, an offshore wind plant requires approximately thirteen times (13x) more minerals than a similarly-sized gas-fired power plant (see illustration above).

Supply Will Strain to Keep Up with Demand

The dependency and intensity of use of green metals by almost all renewable energy technologies imply that demand for these metals will skyrocket and supply will greatly struggle to keep up.

Clean Energy Expected to be a Major Force in Driving Demand



Source: IEA. Goldman Sachs, Data as of July 2023. Net-Zero (NZE) scenario in which coordinated efforts alingn us on a pathway well below Paris Agreement's Initial 2°C Target.

Since 2017, demand for lithium has tripled and that for nickel and cobalt has increased by 40% and 70%, respectively. Over the same period, clean energy demand as a percentage of total demand has jumped from 30% to 56% for lithium, for nickel, from 6% to 16% and, for cobalt, from 17% to 40%.

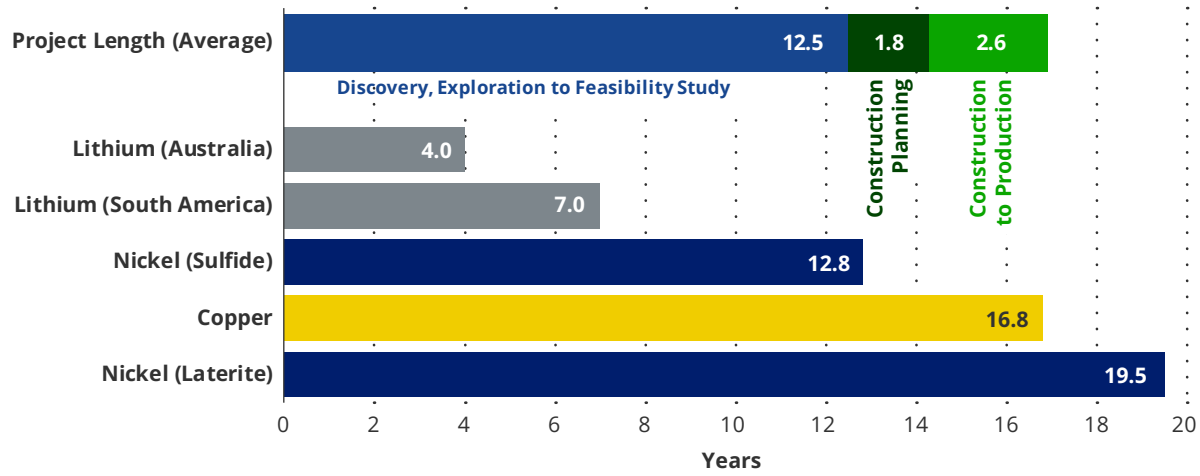
Looking forward to 2030, lithium demand is expected to surge, with approximately 90% of total demand forecast to come from clean energy technologies. The same is true for nickel and cobalt, where demand for clean energy is expected to be around 60% of total demand.

Sustaining current supply is also becoming a major concern: mines are aging, grade quality is diminishing and there has been persistent underinvestment in the industry. In addition to new discoveries becoming less frequent and of lower quality, assets are deeper. This can both add a new layer of complication to production and increase costs. Another issue is the availability of labor, with mining companies finding it **increasingly difficult to find the talent they need.**

Additionally, bringing on new supplies can take much longer than it used to, leading to insufficient supply volume to meet increasing demand.

Mining is complex and both capital- and equipment-intensive. Typically, mines are in remote and extreme locations. In addition, tighter requirements around ESG can be challenging. The result is that, for a new mine, the lead time, from discovery to exploration, financial investment decisions, construction and production, is very long. The average mining project development time is 16 years (see below). Even expanding existing operations can take years. The U.S. exemplifies the difficulty, time and capital required to develop a new mine. A stark example of this is the Resolution Copper Project in Arizona which remains stalled since 2008.

Average Mining Project Development Lead Times (From Discovery To Production)

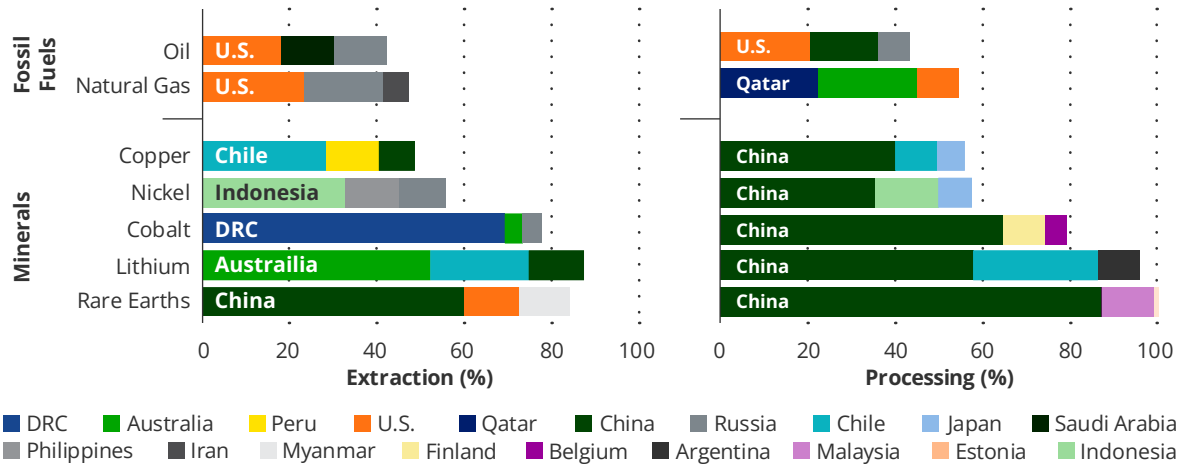


Source: IEA. Data as of May 2021

Security of Supply

While consumers and investors are placing a greater emphasis on responsible sourcing of minerals, there is heightened concern over the increasing geopolitical complexity of supply chains (see below). Global concerns continue to mount over the geographic concentration of minerals extraction/processing. This has led some governments to incentivize development of domestic onshore supply .

Top 3 Producing Countries of Selected Minerals and Fossil Fuels (2019)



Source: IEA. Data as of May 2021.

The U.S. may be the top country both extracting and processing oil (and currently the world's top producer of liquid natural gas ("LNG")), but when it comes to the processing of green metals, for cobalt, copper, lithium, nickel and the rare earth elements ("REEs"), China dominates.

Of these metals, China is also the world's largest miner of REEs. Just four other countries dominate production of the other metals: cobalt - the Democratic Republic of Congo ("DRC"); copper - Chile; lithium - Australia; and nickel - Indonesia.

With this in mind, it is hardly surprising that, in the U.S., the White House lists the security of supply as a significant threat. Using fossil fuels as an analog, despite the country being a significant producer of fossil fuels, we are all too well aware of what can happen when OPEC announces supply cuts.

We believe that herein lies an opportunity as more countries invest in the green metals industry to control their path to energy security and transition.

Conclusion

The energy transition can only happen with green metals and minerals and availability and security of supply are critical. New energy technologies require and are dependent on the intensive use of green metals.

Based on the Paris Accord, the IEA is projecting the following green metals demand growth. Lithium is expected to grow fastest, with demand growing over 40 times by 2040, while that for graphite, cobalt and nickel is expected to grow by over 20 times.

We need to put this into the context of global supply. In 2019, the mining industry produced around 2.6 billion tons of iron ore, of which most was consumed in the steel industry. At the same time, the mining industry produced only about 21 million tons of copper, with most being consumed in the construction industry.

However, this is where it all gets interesting. In the same year, the *whole* mining industry produced only 2.7 million tons of nickel, a little more than 1 million tons of graphite, 950,000 tons of manganese, 280,000 tons of rare earth, 200,000 tons of lithium and about 170,000 tons of cobalt. In terms of volume alone, contrast this with the output of just one of the big six diversified miners: 350 *million* tons of iron ore annually.

The green metals numbers are small. The industry is small. The mines even smaller. And yet, we have inordinately high expectations of the industry. Whether they can be met remains to be seen.

In conclusion, VanEck believes the "energy trilemma"— secure, clean, and affordable energy—is at an inflection point, creating interesting long-term investment opportunities across the green metals "spectrum." From not only a fundamental (supply/demand) standpoint but also from a security perspective, the drivers are already there. We just see them becoming even more powerful.

Recognizing the considerable potential of green metals, the portfolio of VanEck's **Global Resources Fund (ticker GHAAX)** reflects its investment team's confidence in both the metals' importance in the energy transition and, in particular, clean energy solutions. Additionally, it can provide investors with access to green metals exposure.

While large, diversified metals and mining companies are heavily involved in the extraction and processing of green metals, their revenues and expenses are often far more influenced by bulk metals such as iron ore. As a result, investors are left with few other options to gain direct exposure to this long-term narrative.

As passively managed funds, the **VanEck Green Metals ETF (GMET)** and **VanEck Rare Earth/Strategic Metals ETF (REMX)** offer exposure to those companies primarily involved in producing, refining and recycling of these metals. Though it can be difficult to pinpoint the exact exposure to any one metal, both ETFs provide meaningful access to the metals taking center stage in the aforementioned secular trend.

[1] IRENA: World Energy Transitions Outlook 2023 – VOLUME 1, https://www.irena.org/Digital-Report/World-Energy-Transitions-Outlook-2023.

[2] BloombergNEF: Global Low-Carbon Energy Technology Investment Surges Past $1 Trillion for the First Time, January 26, 2023, https://about.bnef.com/blog/global-low-carbon-energy-technology-investment-surges-past-1-trillion-for-the-first-time/.

[3] IEA: The Role of Critical Minerals in Clean Energy Transitions, May 2021, https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions.

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