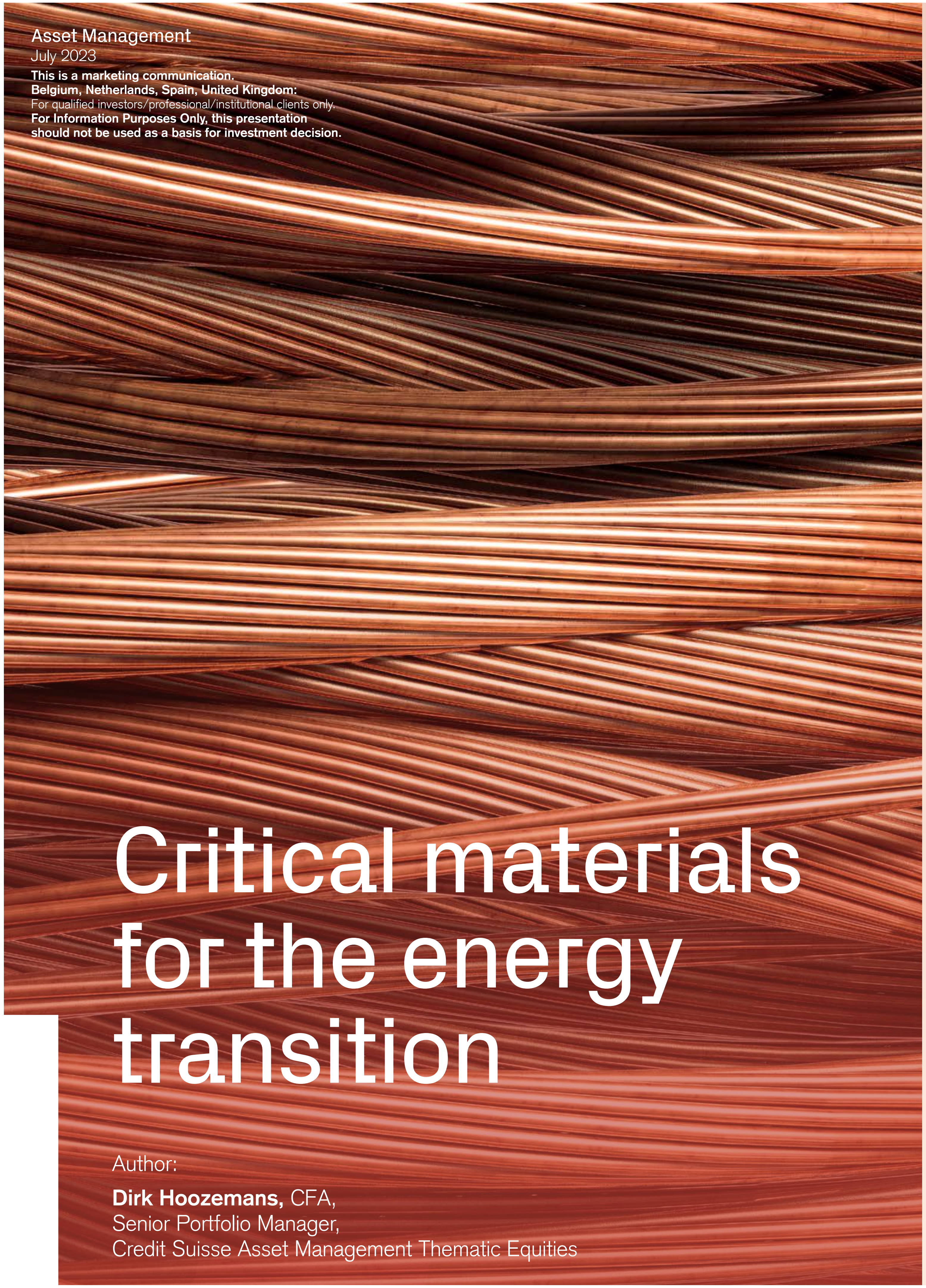

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Critical materials for the energy transition

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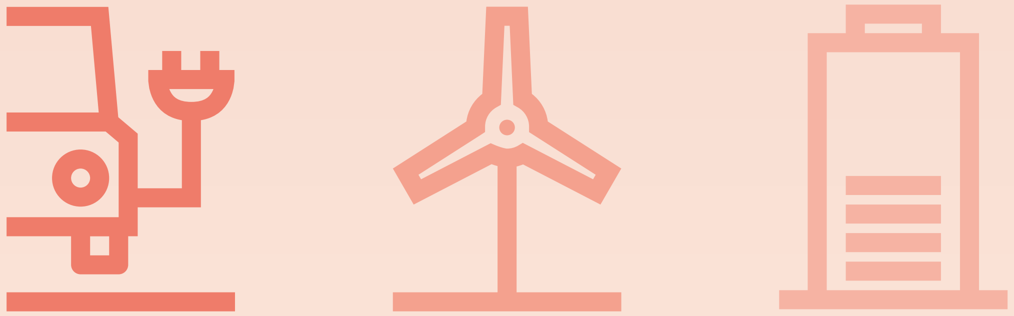
The global energy transition currently underway is a physical one that will need to be *built*. But what are the building blocks, and where do these critical materials for the energy transition come from? In this piece, we will focus on some of the demand growth and supply chain bottlenecks of these future-facing materials, while also seeing how these dynamics support a long-term investment thesis when it comes to these key transition materials.



Building blocks for the energy transition have different roles to play

Firstly, let's take a step back and look at the three main investment growth drivers of the energy transition:

1

Decarbonizing energy consumption via electrification: For example, switching from gasoline-powered cars to electric vehicles (EVs), switching from natural gas to electricity to generate heat for domestic or industrial purposes, etc. Massive investments in renewable and low-carbon electricity generation will be required here.

2

Decentralizing the grid: In order to accommodate this electrification, investments in smart grids, new connections, and grid storage will be required (homeowners will become power generators as they install rooftop solar systems, requiring a two-way grid; new offshore wind capacity must be able to transport electricity to shore via high-voltage submarine cables; intermittency in solar and wind power generation patterns means that batteries will have to store electricity for use when there is not enough sunlight or wind, etc.)

3

The abovementioned electrification of energy and renovating of the grid cannot happen without investment in critical materials: The energy transition requires key ingredients. In this report, we will focus on a handful of these ingredients:

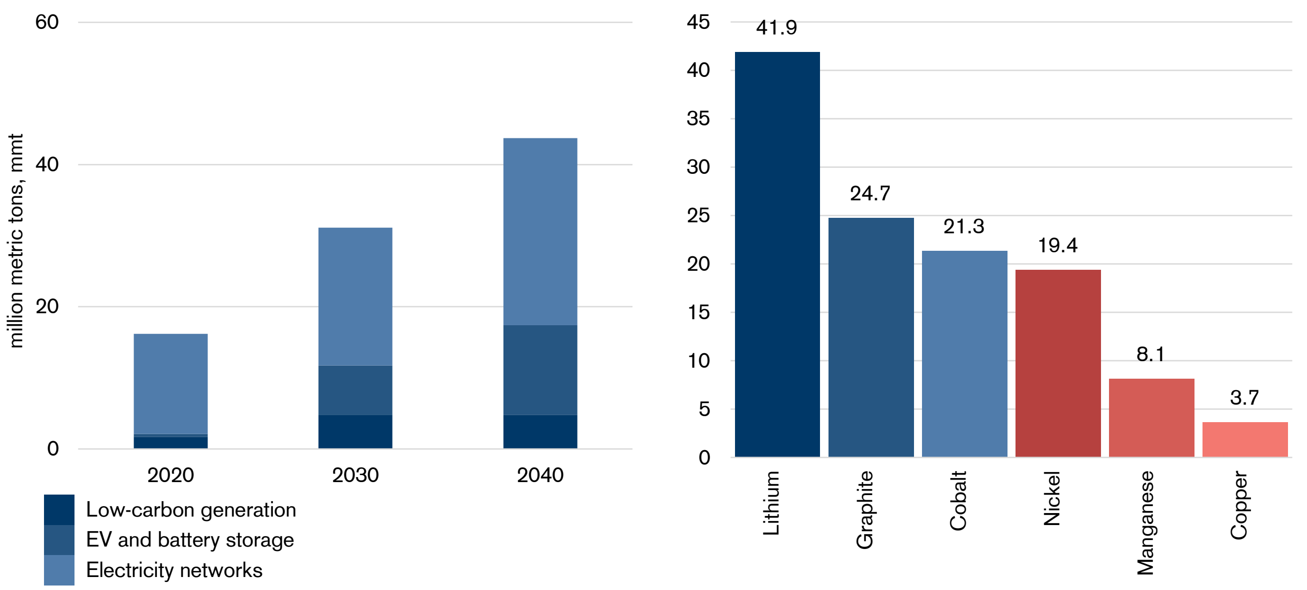
- Aluminum: used for lightweighting appliances and EVs, as well as for electricity transmission
- Copper: used for electricity transmission, application wiring, as a battery current collector, in solar inverters and in wind turbines
- Lithium, cobalt, nickel, and manganese: used as the active cathode material in lithium-ion batteries,[1] as well as in hydrogen electrolyzers and geothermal power (nickel)
- Graphite: used as active anode material in batteries
- Rare earth minerals: used as permanent magnets in EV motors and wind turbines

[1] In a lithium-ion battery, positively charged ions flow from anode to cathode when discharging, and vice versa when charging. The need for each critical mineral in a lithium-ion battery varies considerably depending on the cathode and anode chemistries. For example, nickel manganese cobalt oxide (NMC) batteries typically require more nickel, manganese, and cobalt than lithium iron phosphate (LFP) batteries, which do not contain these minerals, but in turn need a lot more copper.

Demand for critical materials is set to rise sharply in the coming decades

The IEA (International Energy Agency) estimates that there will be a minimum four-fold rise in overall mineral demand for clean energy technologies so that global climate ambitions can be met. It also forecasts particularly high growth for EV-related minerals such as lithium, which will see demand rise nearly 42-fold, graphite (nearly 25-fold), cobalt (over 21-fold), and nickel (almost 20-fold).[2]

Figure1: Growth in demand for selected minerals in the IEA Sustainable Development Scenario (SDS), 2040 relative to 2020.



Source IEA.
LHS absolute (Mt), RHS indexed to 2020 = 1; mmt = million metric tons.

Note that the IEA has not included aluminum demand in its Transition Metals outlook. According to Bloomberg New Energy Finance (BNEF),[3] demand for aluminum is set to more than double by 2050 under the Economic Transition Scenario (ETS) and Net Zero Scenario (NZS) in its BNEF New Energy Outlook 2022.

[2] The Role of Critical World Energy Outlook Special Report Minerals in Clean Energy Transitions, IEA (2022 version).
[3] BNEF Transition Metals Outlook, January 2023.

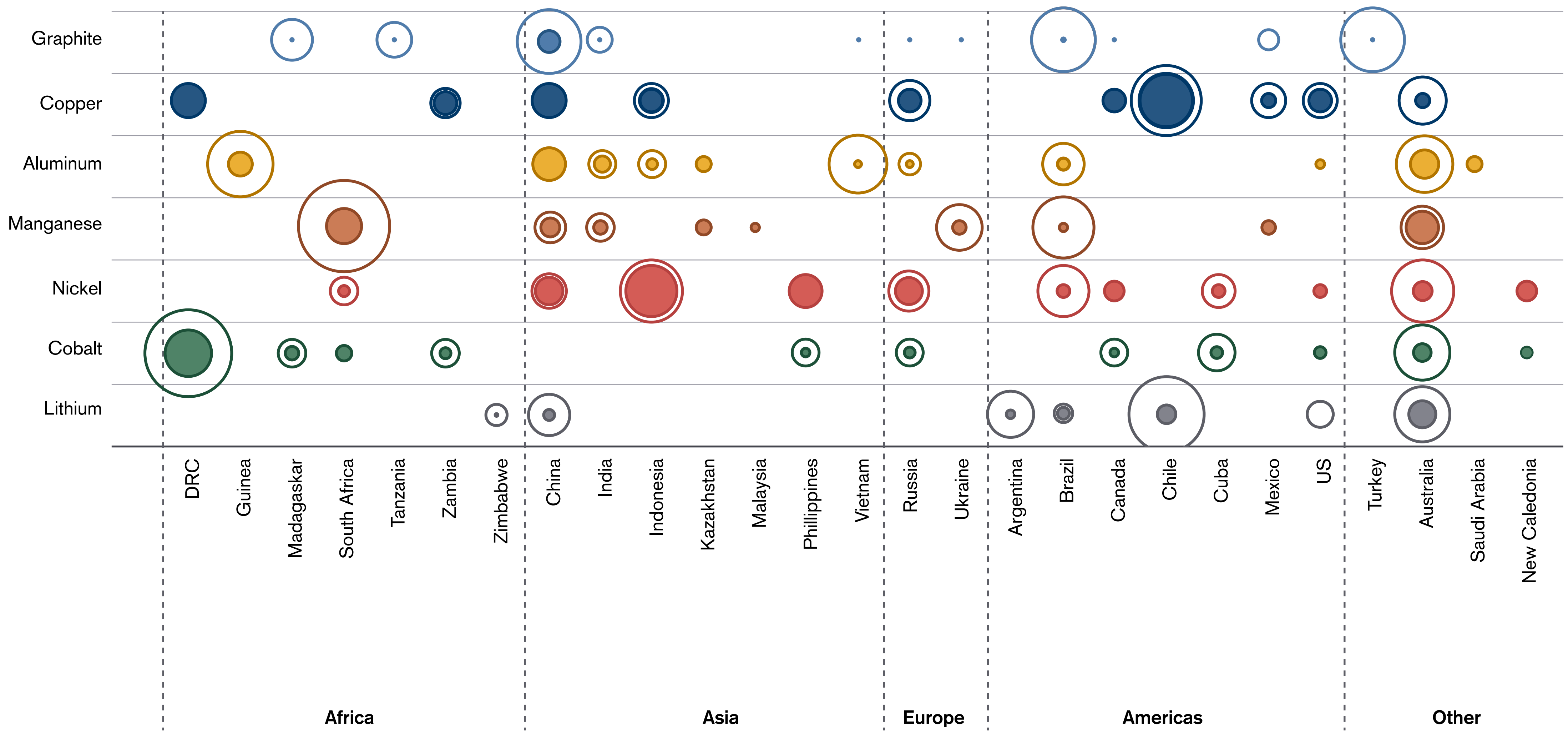
Supply of critical minerals is concentrated in a few regions, but not without risk

The energy transition brings a tremendous opportunity for investments in critical materials as supply growth will have to rise significantly in the coming decades. However, this opportunity does not come without risks: many of the critical materials needed for the energy transition are in a handful of countries,[4] bringing considerable political and geopolitical risks (such as trade wars,[5] resource nationalization,[6] and tax and royalty risks[7]).

Furthermore, over and above traditional resource-related and project development risks, bringing new mineral resources onstream takes time, and tight supply-demand balances or supply deficits can easily arise when lead times for new projects, from discovery to production, increase. Stricter permit-related standards, tougher environmental licensing (water stress, biodiversity impacts, energy intensity of smelting operations, greenhouse gas emissions), greater emphasis on safety and sustainability standards (governance, human rights and labor laws), and tight mining equipment supply chains are all putting upward pressure on the delivery timeframes of new resource-related developments.

With government initiatives such as the US Inflation Reduction Act (IRA) and the EU Critical Raw Materials Act (CRMA), however, Western economies are rapidly pushing ahead with the development of domestic resources and increasing local capacity to source and refine critical raw materials for the energy transition. This also means reducing dependence on key players such as China, which dominates the EV battery supply chain with two-thirds of global battery cell production as well as around 80% of the production of cathode and over 90% of anode material.[8]

Figure 2: Mineral reserves and mining production, 2021.



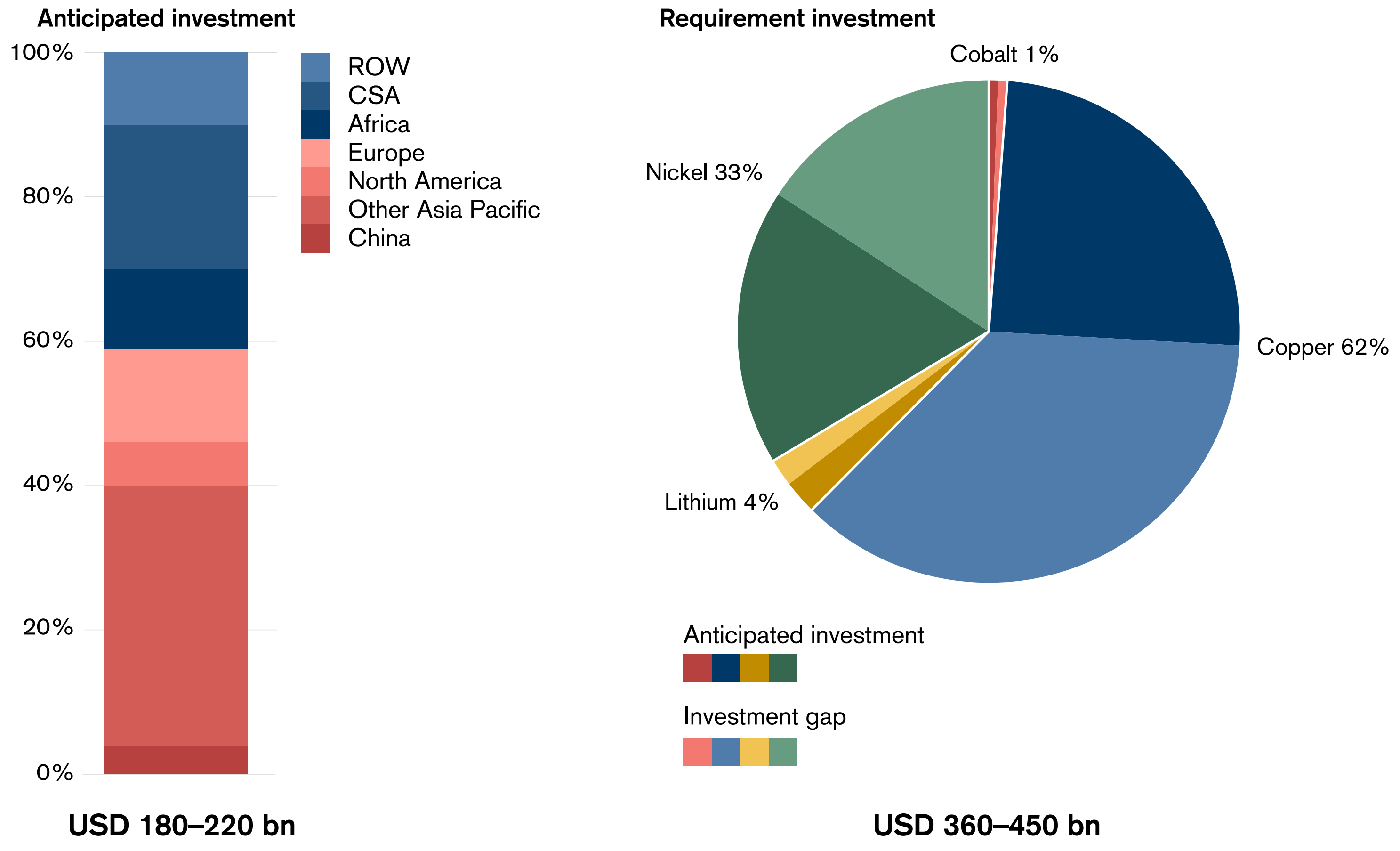
Source US Geological Survey 2021, BloombergNEF.
Note: Solid spheres represent production, the outer circle represents the total reserves. Sphere and circle sizes denote the proportionality of the resource between countries.

[4] USGS, Mineral Commodity Summaries 2021, https://pubs.er.usgs.gov/publication/mcs2021
[5] https://www.businessinsider.com/china-crushing-us-america-battle-energy-evs-batteries-tech-war-2023-5?r=US&IR=T
[6] https://www.reuters.com/markets/commodities/chiles-boric-announces-plan-nationalize-lithium-industry-2023-04-21/
[7] https://www.reuters.com/world/americas/chilean-lawmakers-give-final-approval-mining-royalty-reform-2023-05-17/
[8] IEA, Energy Technology Perspectives, 2023 (p. 96 to 97).

Massive investment is still needed to avoid bottlenecks

As strong demand is set to be met by limited supply, we expect production gaps and supply deficits to trigger higher prices, incentivizing investment in new developments. According to IEA, a total cumulative investment of USD 360 to 450 bn in mining and critical material production is required to bring the necessary capacity online in just four key transition materials by 2030, compared to just USD 180 to 220 bn of anticipated investment, implying an investment shortfall of USD 180 to 230 bn.[9]

Figure 3: Anticipated and required investment in mining critical minerals by region/country. Based on investments required to meet mineral demand between 2022 and 2030 in the IEA Net Zero Energy Scenario.



Sources IEA analysis based on company feasibility studies; Bartholomeusz (2022); S&P Capital (2022); USGS (2022); S&P Global (2022c); S&P Global (2022d); S&P Global (2022e); European Commission (2020); Eurometaux (2022); Jervois (2020).
Notes: CSA = Central and South America; ROW = rest of the world. Other Asia Pacific excludes China. Anticipated investments cover four critical minerals (lithium, nickel, copper, and cobalt) (see Note 3). Neodymium not included due to a lack of data. Cobalt production being mainly a co-product of copper and nickel, the additional capital investment needed to open a copper-cobalt mine compared with a pure copper mine is considered. A range is quoted for anticipated and required investments, considering the range of available cost estimates for diverse feasibility studies of mining projects.

[9] IEA, Energy Technology Perspectives, 2023 (p. 165 et seq.).

No energy transition without critical materials
As we mentioned at the start of this document, the global energy transition is a physical one; one that must actually be *built*. Whereas massive investment in clean technology manufacturing and clean energy supply chains and networks will be required, no energy transition is possible without investment in the critical material building blocks needed to move towards a cleaner economy and society. Under the EU Sustainable Finance Disclosure Regulation (SFDR),[10] so-called Article 9 funds – funds that invest with an environmental, social, or governance objective – are typically not allowed to invest in minerals, metals, and mining companies due to their ecological footprint, but rather may instead invest in clean technology stocks and renewable stocks. On the other hand, Article 8 funds – investing while taking ESG[11] considerations into account – *can* invest in mineral extraction companies. We believe that investments in critical materials companies should be part of a full-value-chain energy transition strategy.

Credit Suisse Asset Management has designed several highly focused strategies to provide clients with "pure-play"[12] exposure to a number of compelling long-term secular growth themes, such as Robotics & Automation, Security & Safety, Infrastructure, Digital Health, Edutainment, Environmental Impact and Energy Evolution.

[10] https://finance.ec.europa.eu/regulation-and-supervision/financial-services-legislation/implementing-and-delegated-acts/sustainable-finance-disclosures-regulation_en
[11] ESG stands for environmental, social, and governance factors.
[12] By "pure-play" exposure, we mean investment in companies that derive at least 50% of revenues from activities directly attributable to the corresponding theme.

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