

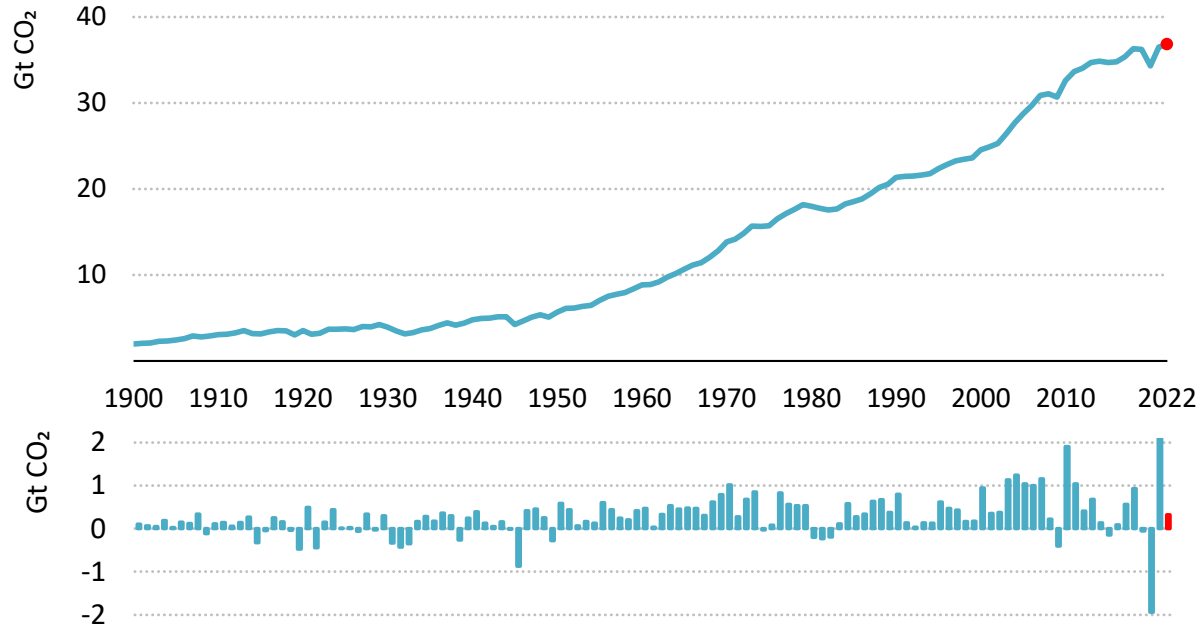


The Role of Critical Minerals in Clean Energy Transitions

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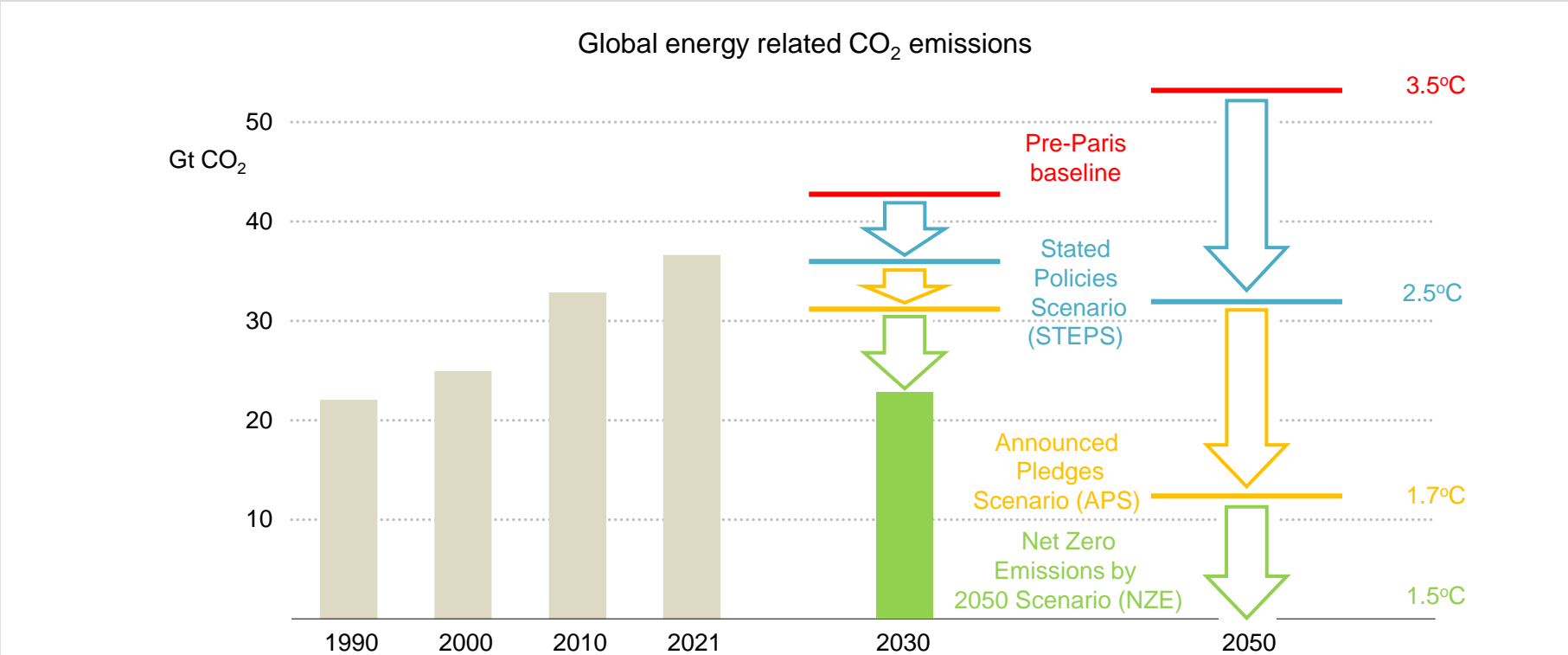
Global emissions grew in 2022, but less than feared

Global CO₂ emissions from energy combustion and industrial processes and their annual change, 1900-2022



Global energy-related CO₂ emissions grew by 0.9% or 321 Mt in 2022, reaching a new high of over 36.8 Gt

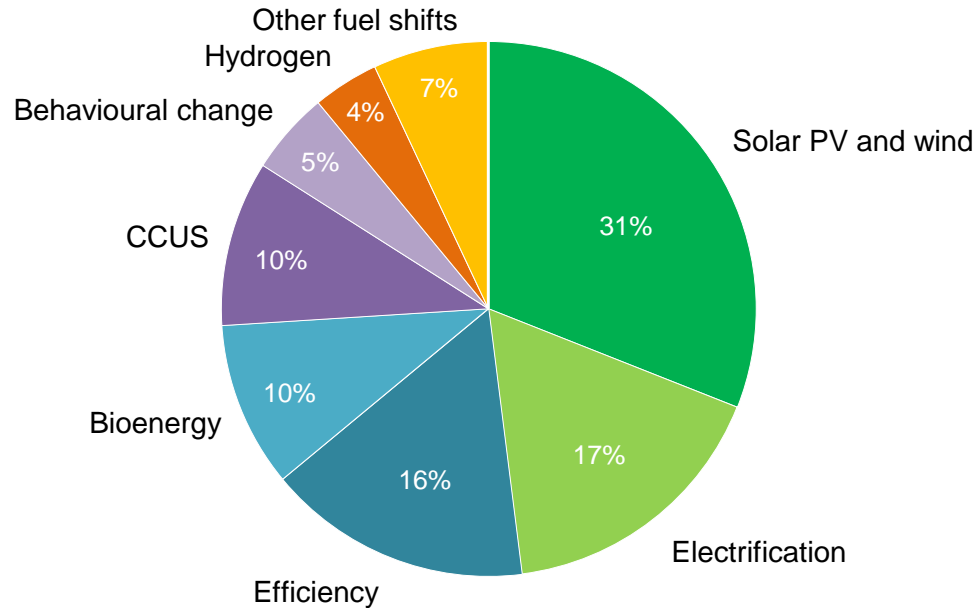
Keeping the door to 1.5 °C open



Policy and technology progress since 2015 has shaved 1 °C off projected warming, a step in the right direction; but much more needs to be done in order to avoid severe climate disruptions

What brings energy-sector emissions to net zero?

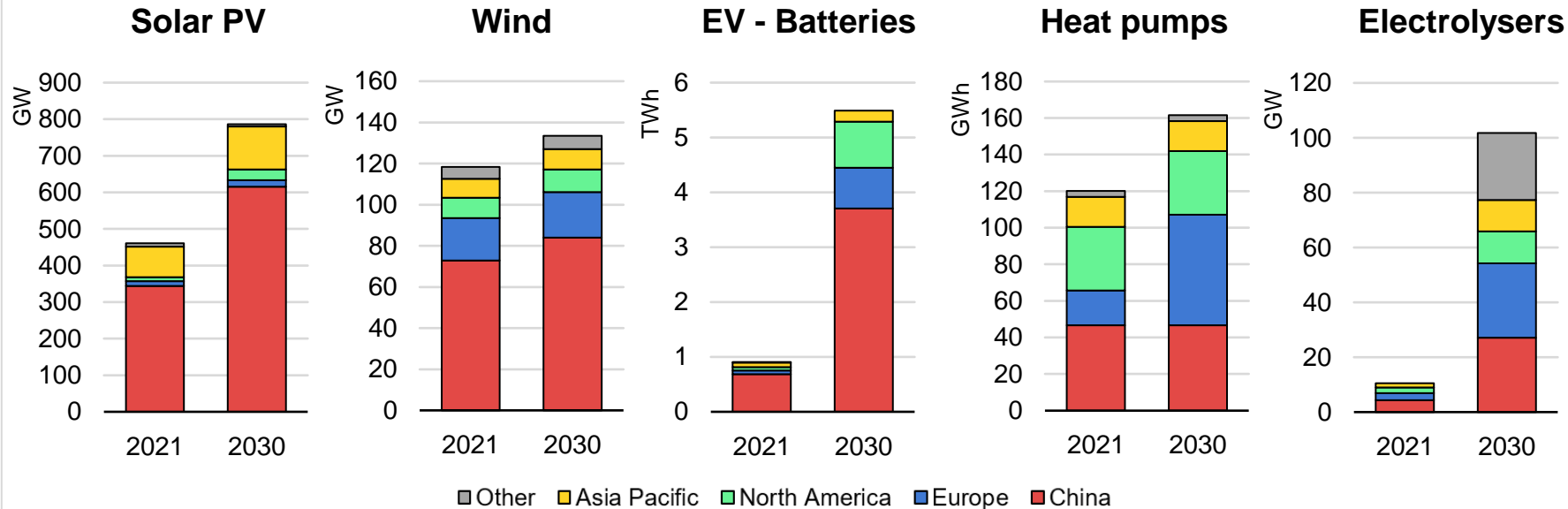
Global cumulative energy sector CO₂ emissions reductions by lever, 2021-2050



Renewables, electrification and energy efficiency play a major role in reducing emissions, but further technology innovation will be essential to aid the pursuit of a 1.5°C stabilisation

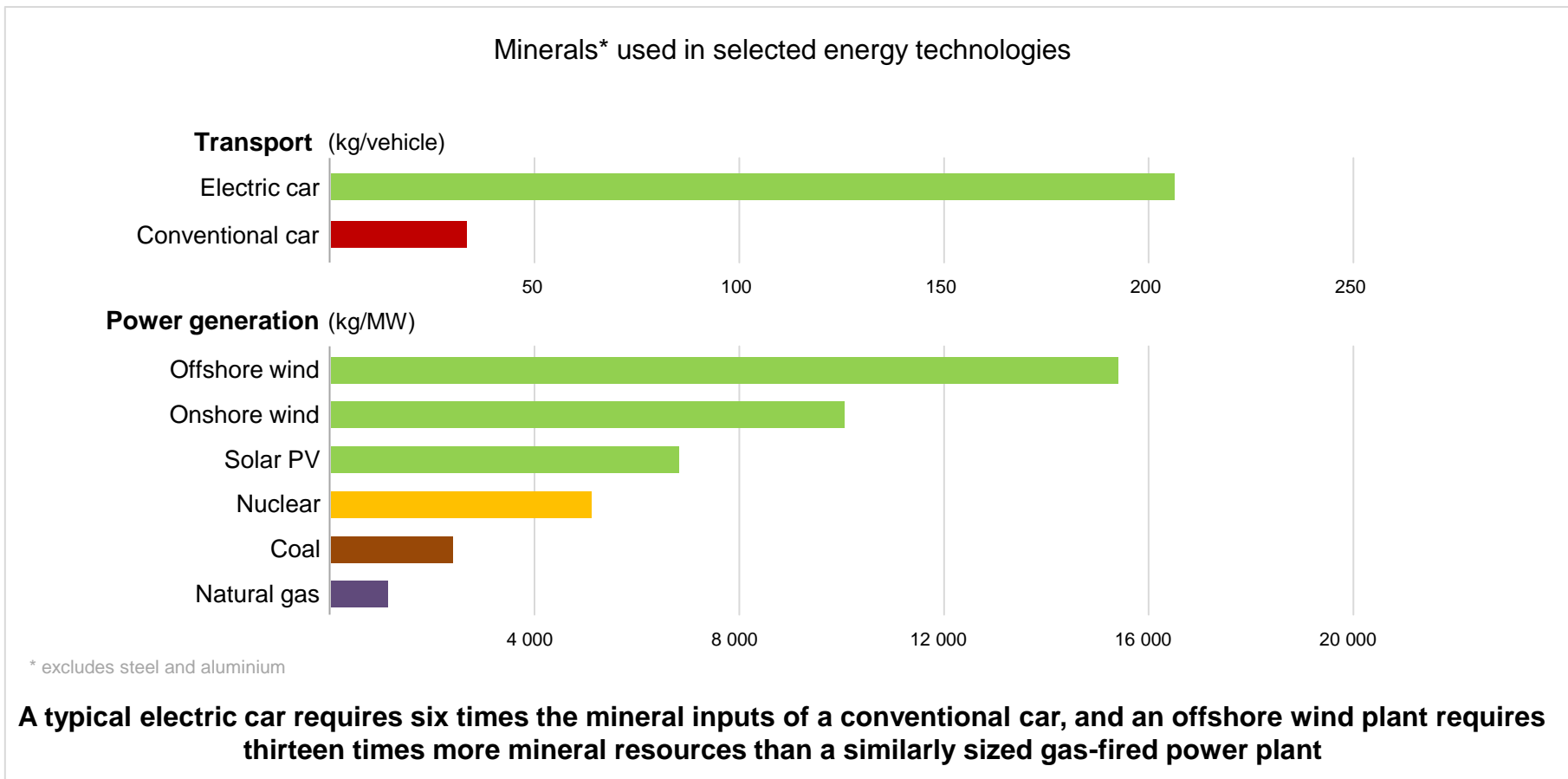
Clean energy manufacturers prepare the ground for faster transitions

Today's and announced future manufacturing capacity for selected clean energy technologies

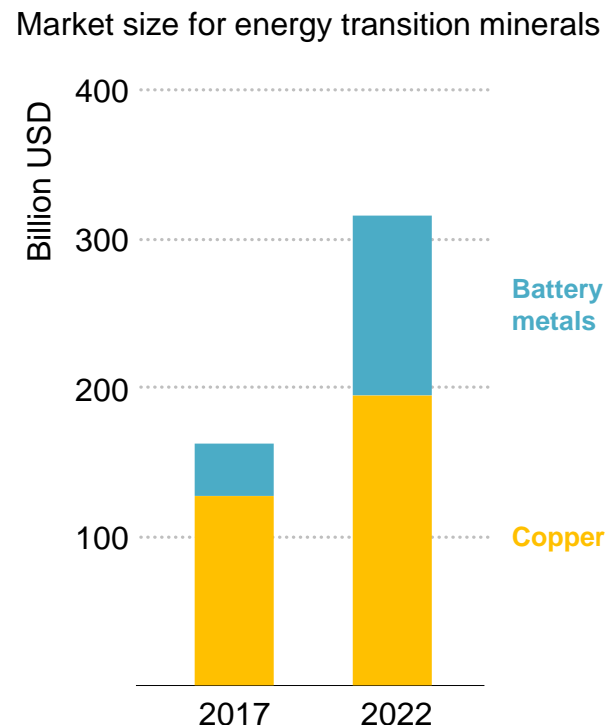
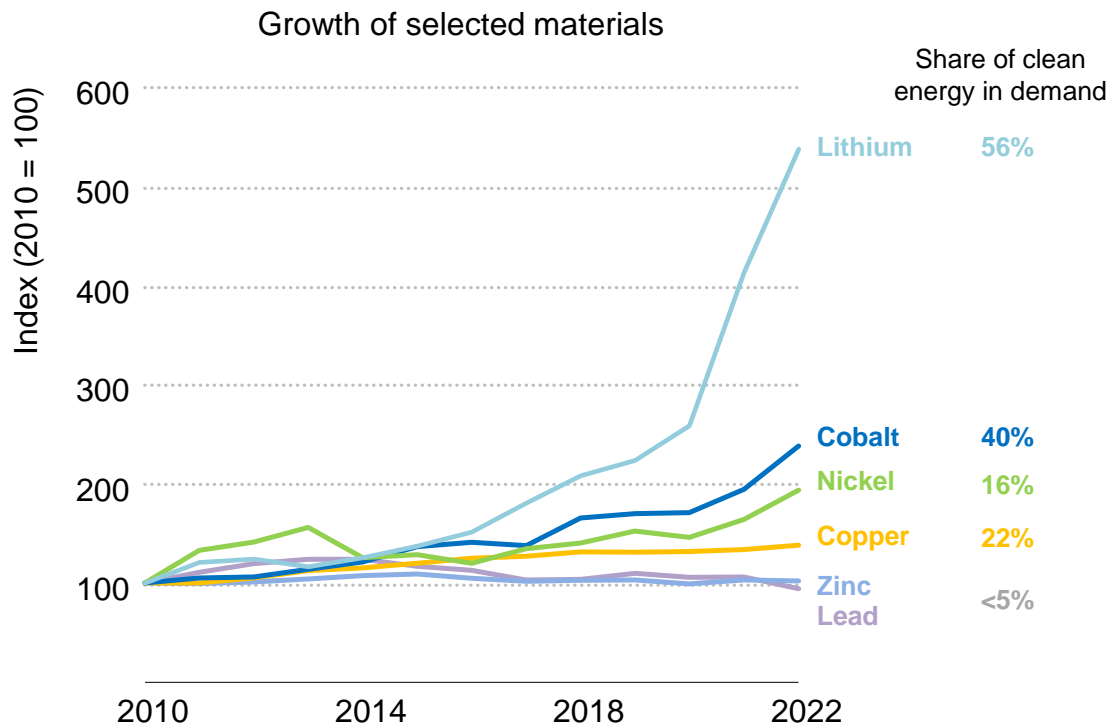


Clean technology manufacturing is increasing rapidly, owing in part to short project lead times

The shift to a more mineral-intensive energy system



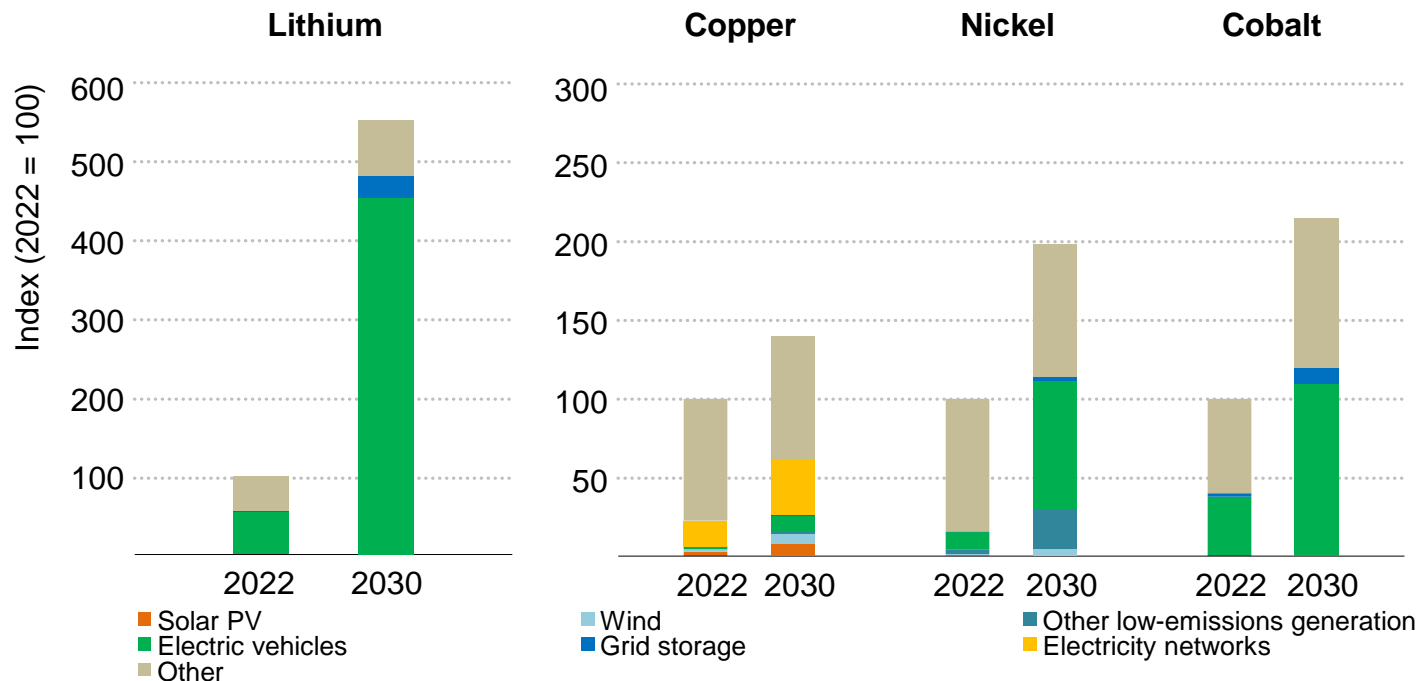
Clean energy is driving unprecedented growth for critical minerals



Rising deployment of EVs and renewables has underpinned major growth in mineral demand, leading to a doubling of market size for key energy transition minerals over the past five years

Meeting climate goals means further rapid growth this decade

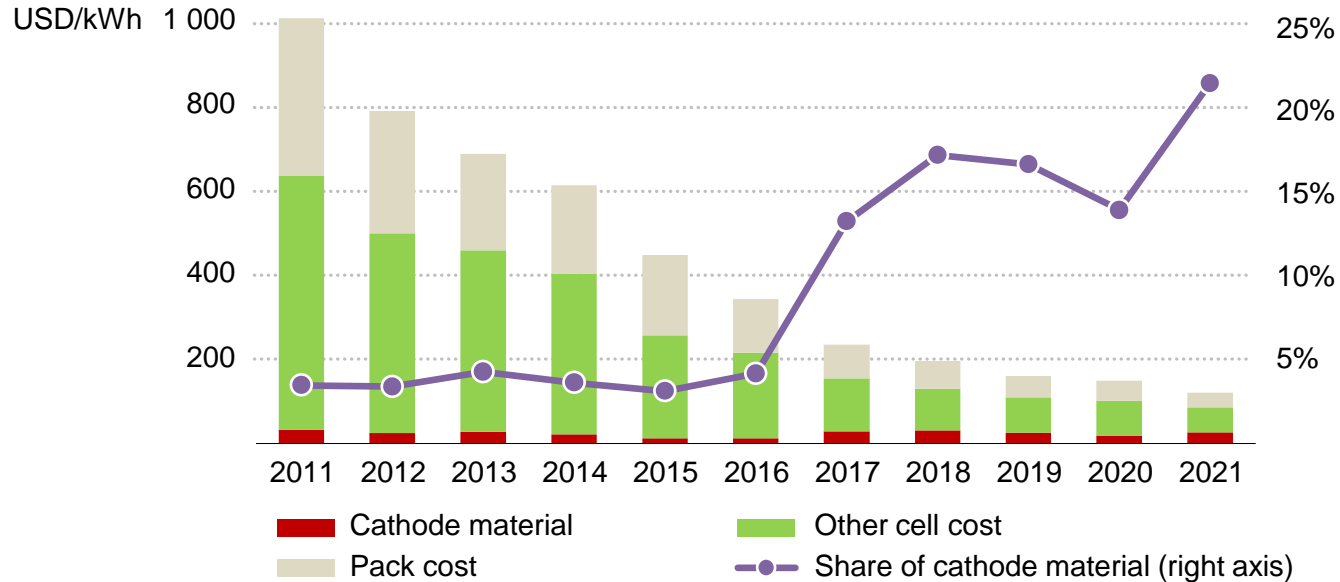
Total demand for key critical minerals in the Net Zero Emissions by 2050 (NZE) Scenario



Getting on track to limit global warming to 1.5°C would mean a further rise in mineral demand for clean energy by three and a half times to 2030

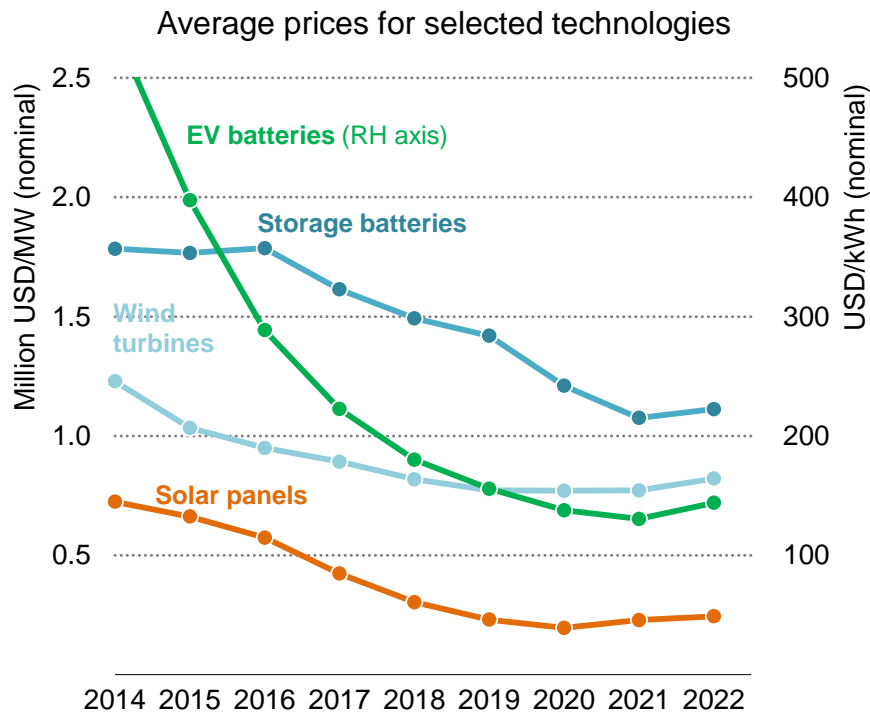
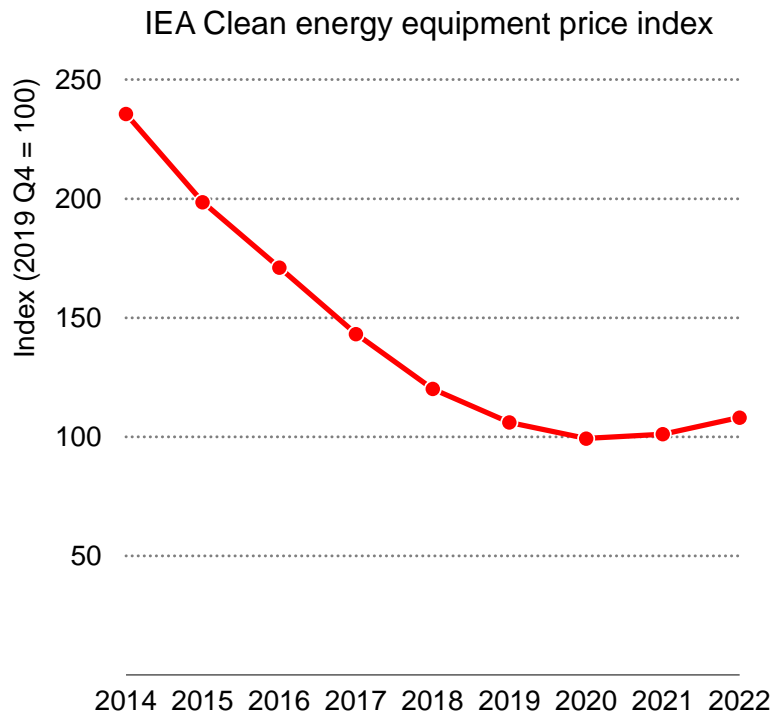
Growing impacts of commodity prices on clean technology cost

Average pack price of lithium-ion batteries and share of cathode material cost



As learning and economies of scale bring down other cost components, raw materials account for an increasingly large share of the total cost of batteries and other key clean energy technologies

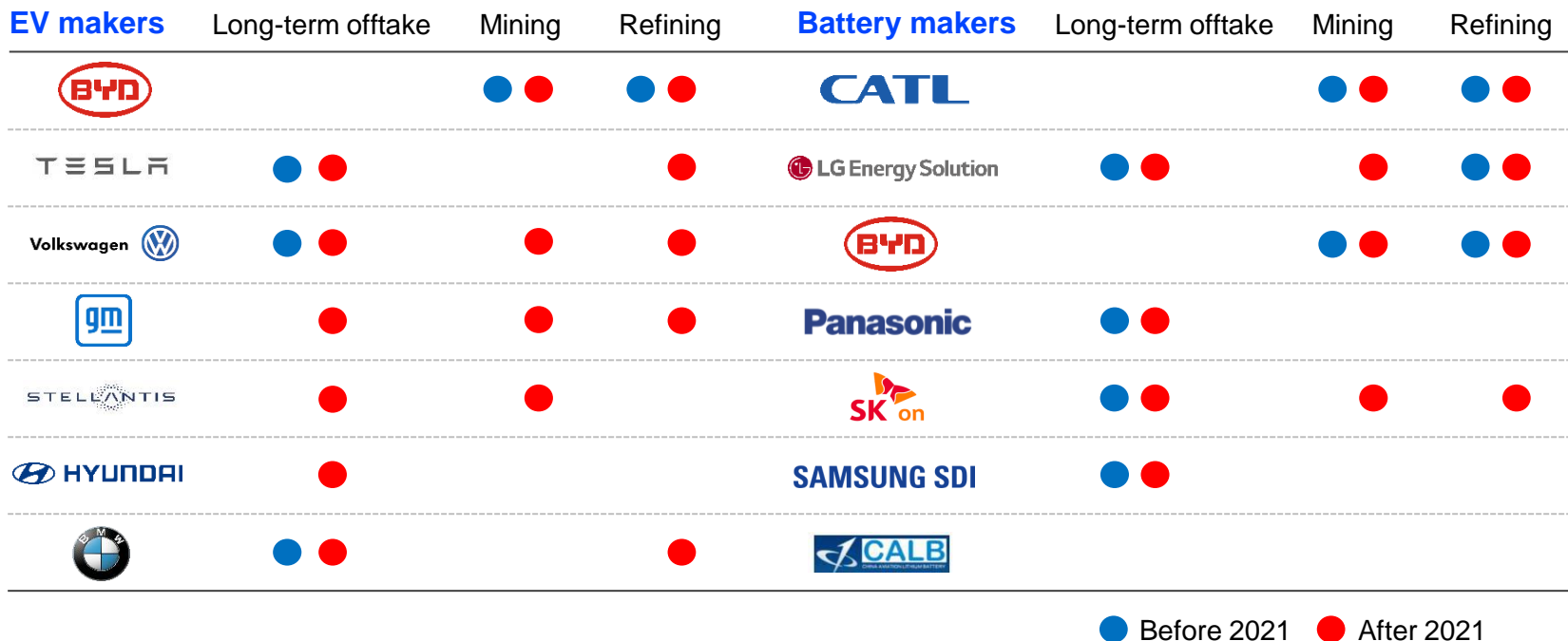
Uphill battle for continued cost reductions for clean energy



Clean energy technology prices continued to increase for the second year in a row although the recent price fall could provide some respite

Consumers are getting serious about mineral supplies

Top 7 EV and battery makers' involvement in the critical minerals supply chain

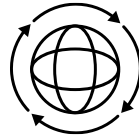


In a bid to secure mineral supplies, automakers, battery cell makers and equipment manufacturers are increasingly getting involved in the critical minerals value chain

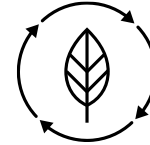
Three supply-side challenges



Can future supplies keep up with the rapid pace of demand growth in climate-driven scenarios?

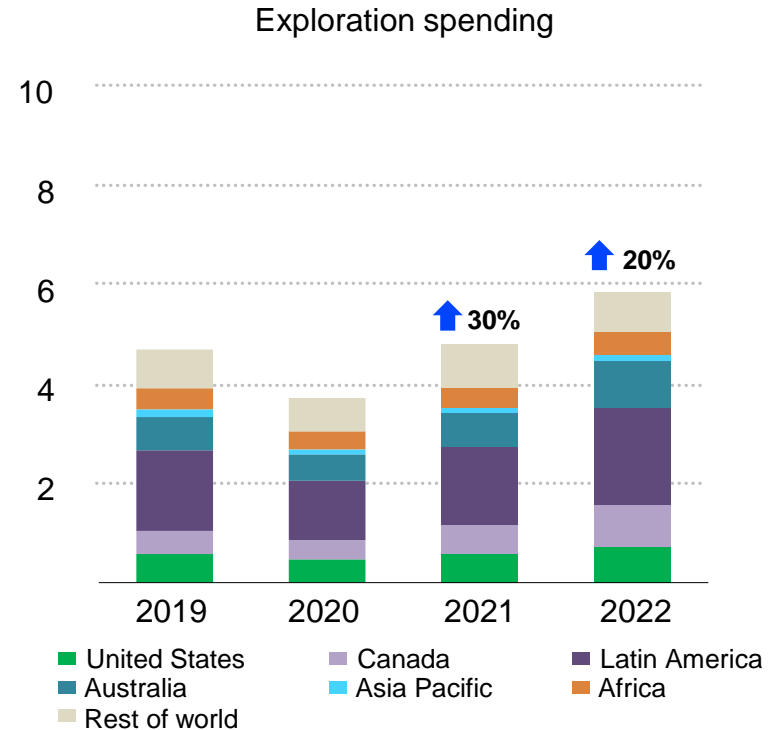
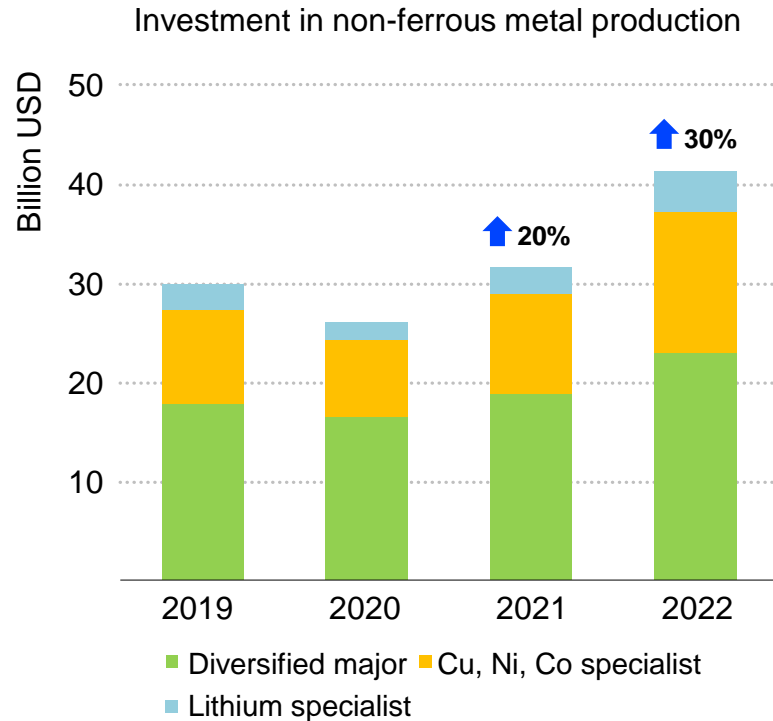


Can those supplies can come from diversified sources?



Can those volumes be supplied from clean and responsible sources?

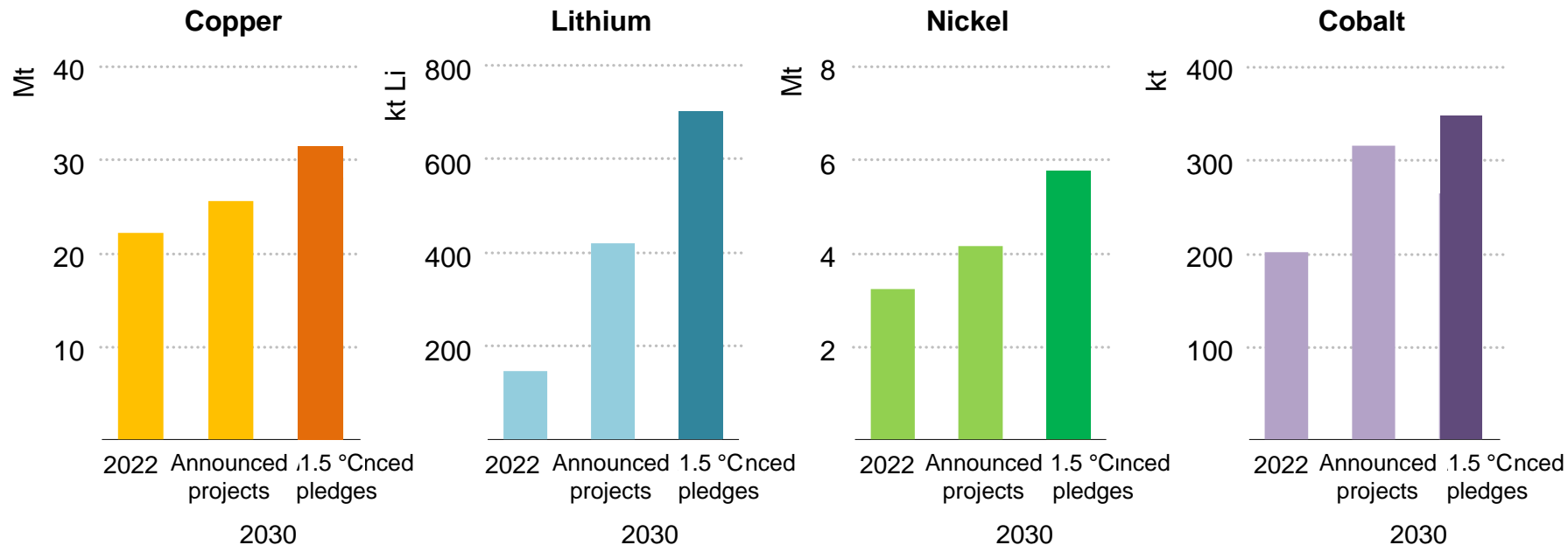
Investment in critical mineral supplies on the rise



Higher prices & strong expectations for demand have produced new strategies and investments from resource-rich countries – spending on critical minerals exploration and development is up sharply since 2020

Announced projects are matching announced climate ambitions

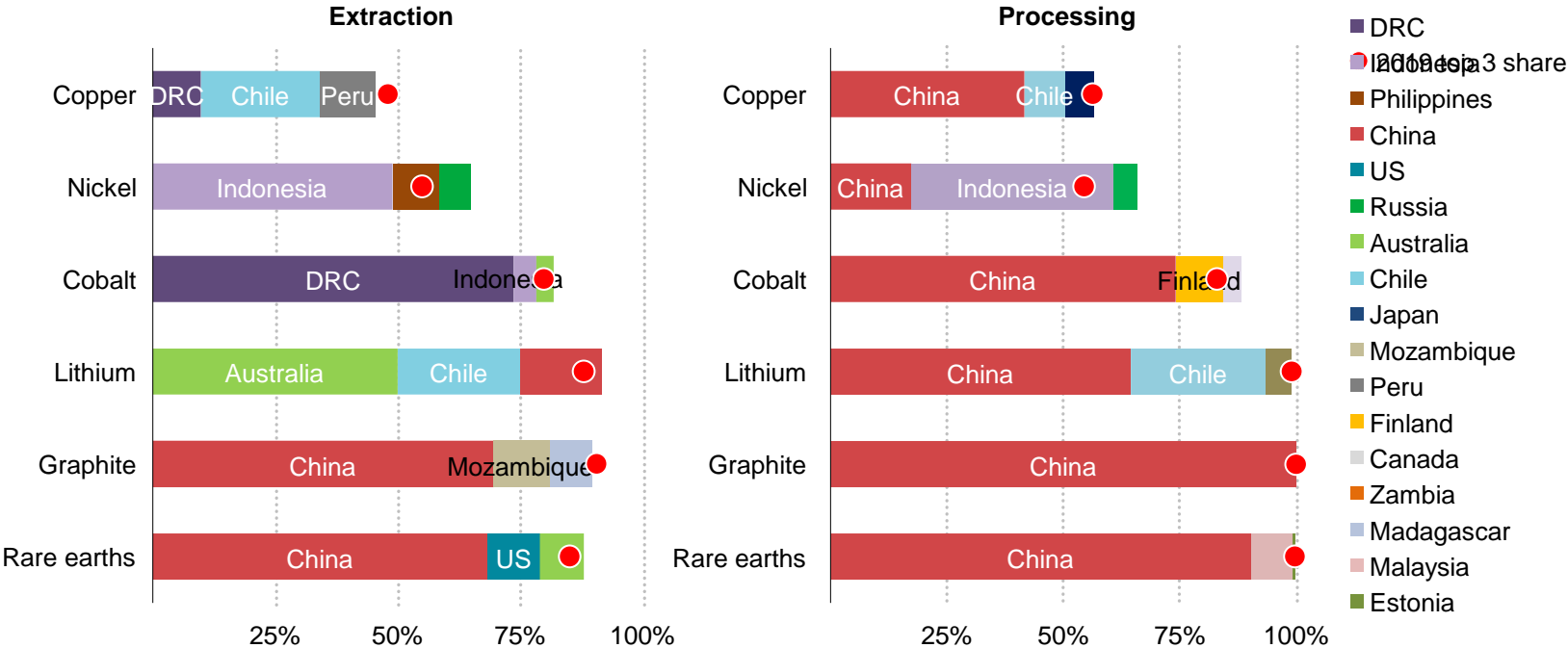
Anticipated supply from announced projects and primary supply requirements in different scenarios



A host of newly announced projects, if implemented as planned, would be sufficient to meet countries' clean energy ambitions for some minerals, but the adequacy of future supply is far from assured

But concentration of supply remains high

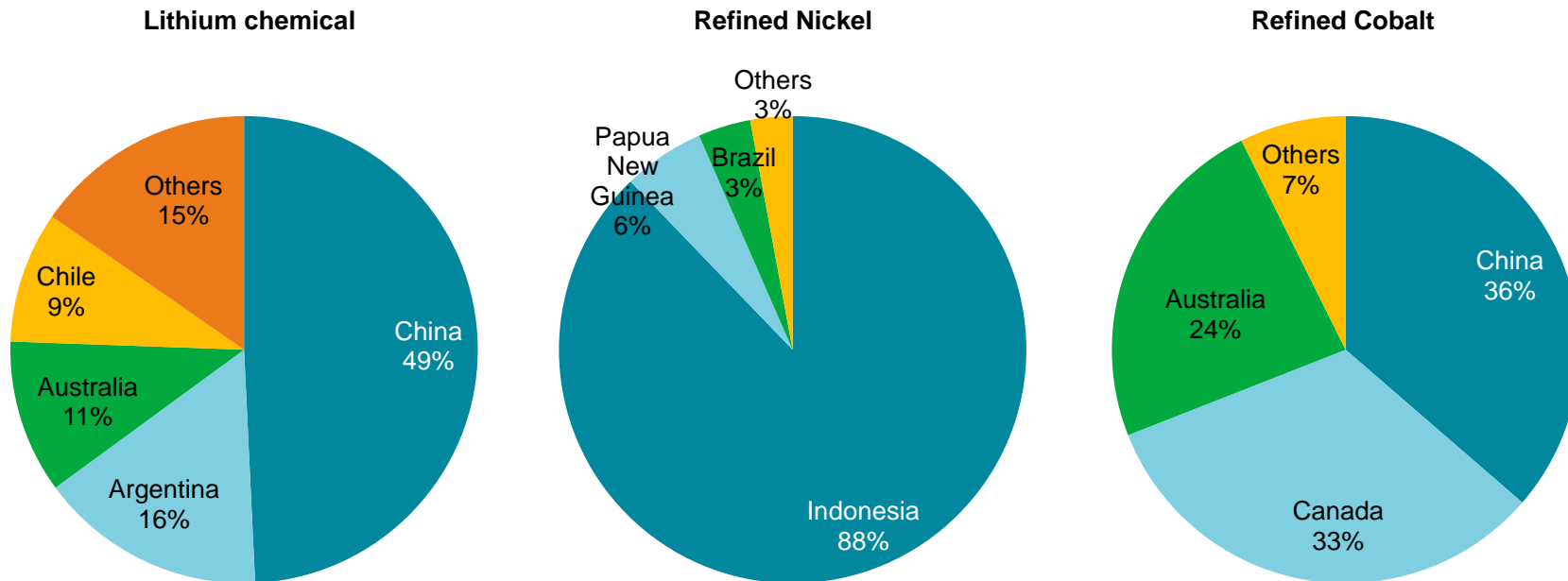
Share of top 3 producing countries in total production for selected resources and minerals, 2022



Limited progress has been made to diversify supply sources in recent years and, in some cases, the level of concentration has risen – announced projects would not change this picture dramatically

Today's refining project pipeline does not imply diversified supplies

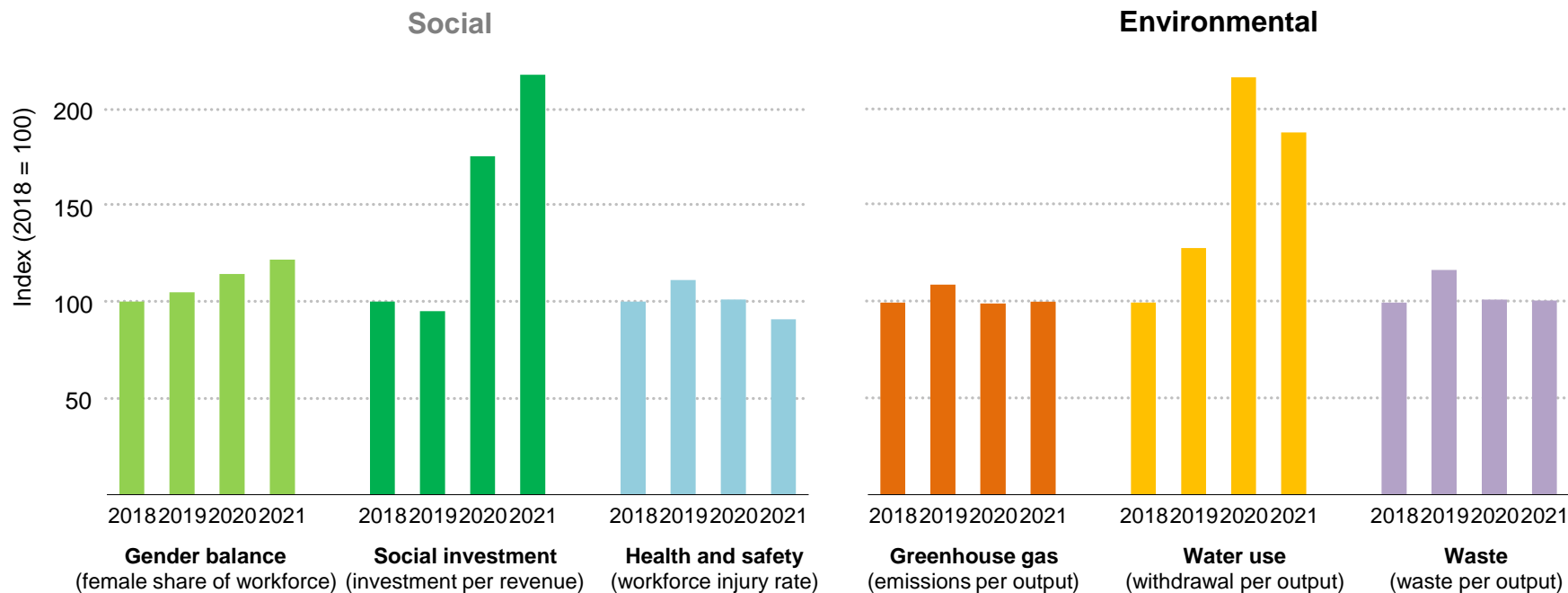
Geographical distribution of planned refining projects for key minerals



Analysis of project pipelines indicates that, in most cases, the geographical concentration of refining operations is likely to stay in the near term

Mixed progress towards sustainable and responsible mining

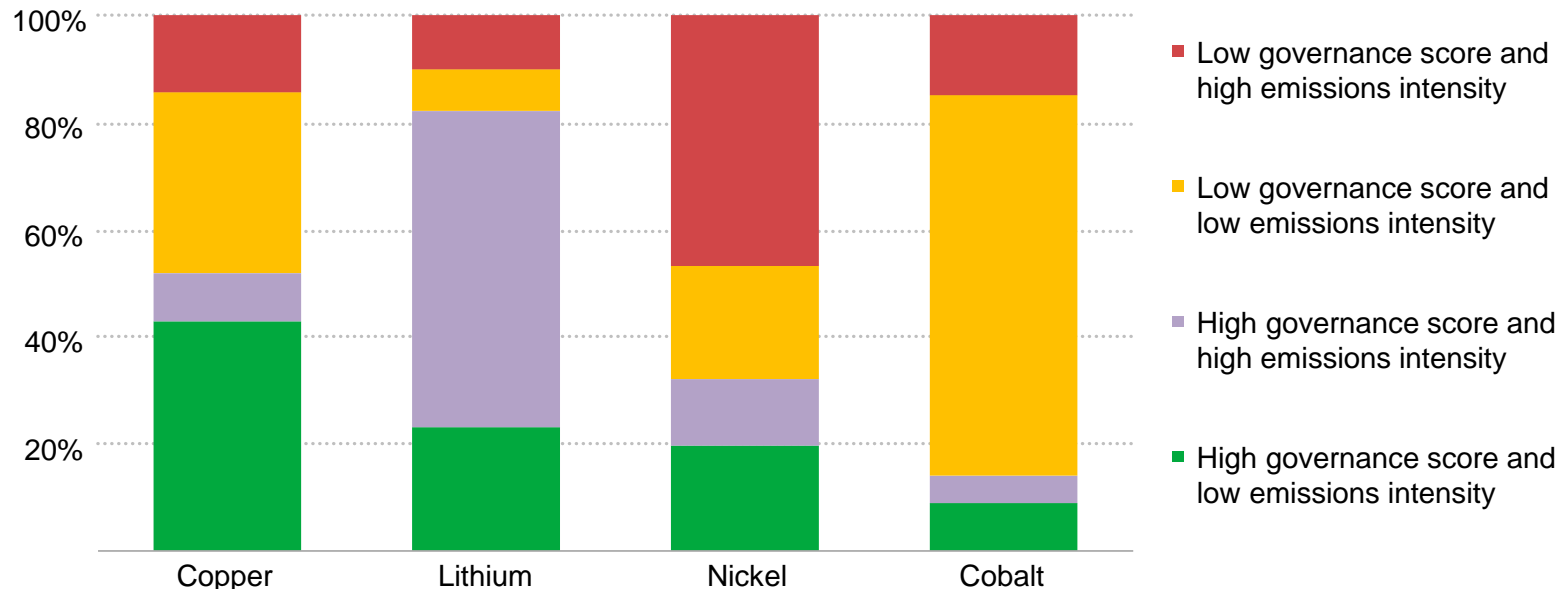
Aggregate social and environmental indicators for major mining companies



There are some signs that responsible social practices are taking hold across the mining industry, but industry-wide progress is still missing in key areas, especially on environmental sustainability

Strong linkage between ESG and supply security

Distribution of production of selected minerals by governance and emissions performance, 2019



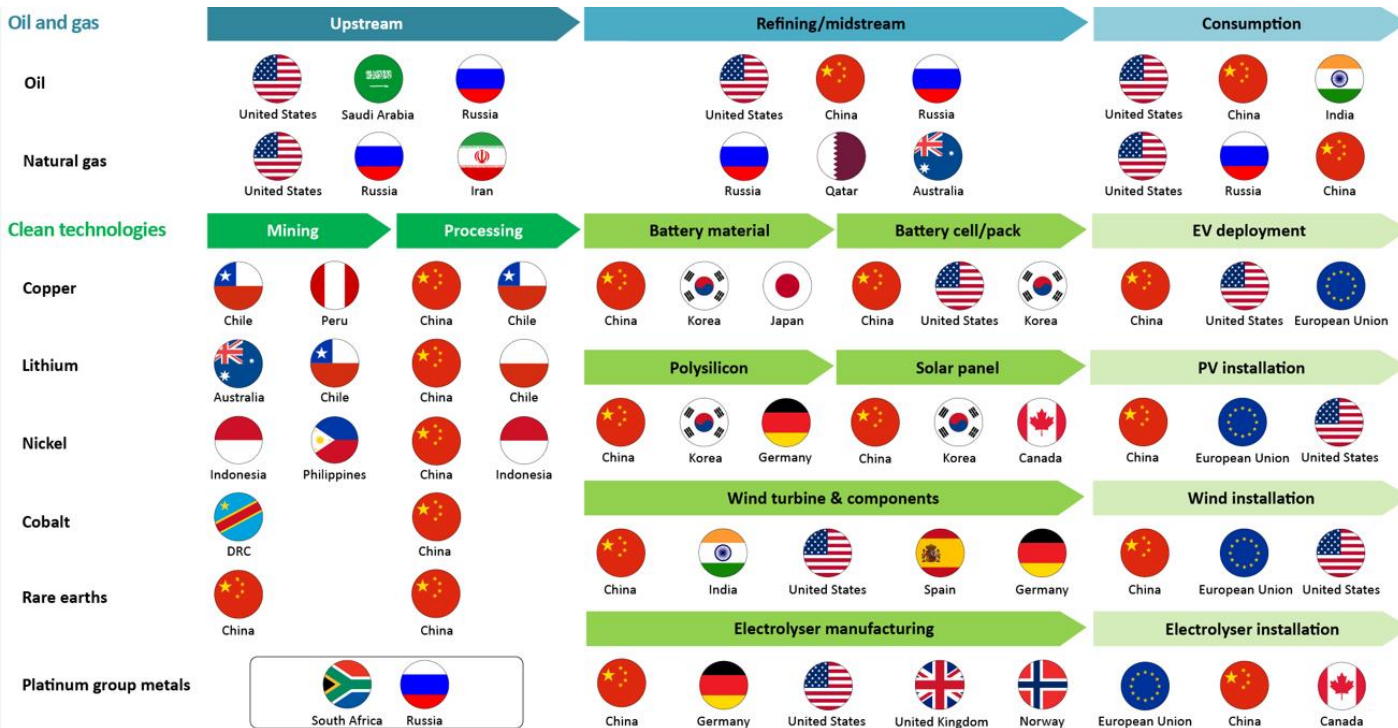
The majority of current production volumes come from regions with low governance scores or high emissions intensity

Building on the IEA's leadership role in energy security, these six key areas of action can ensure that critical minerals enable an accelerated transition to clean energy

- 1. Ensure adequate investment in diversified sources of supply**
- 2. Promote technology innovation at all points along the value chain**
- 3. Scale up recycling**
- 4. Enhance supply chain resilience and market transparency**
- 5. Mainstream higher environmental, social and governance standards**
- 6. Strengthen international collaboration between producers and consumers**

New energy trade patterns and geopolitical ramifications

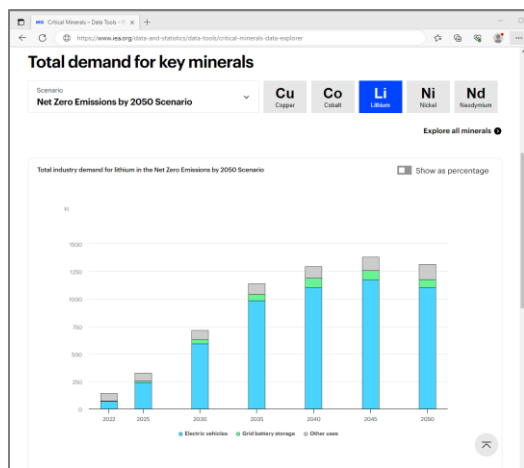
Indicative supply chains of oil and gas and selected clean energy technologies



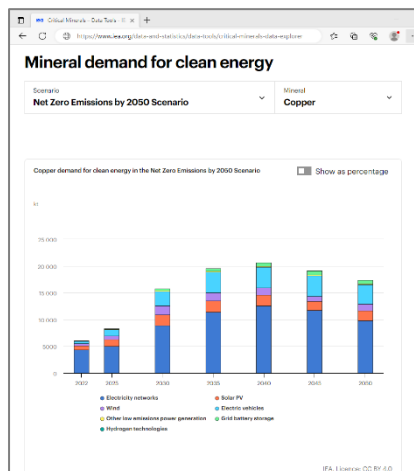
The transition brings new energy trade patterns, countries and geopolitical considerations into play

- Alongside today's new market report, the IEA is releasing an interactive online tool that allows users to easily access the IEA's scenario data for critical minerals
- This provides full access to the demand projections under various energy scenarios and technology evolution trends

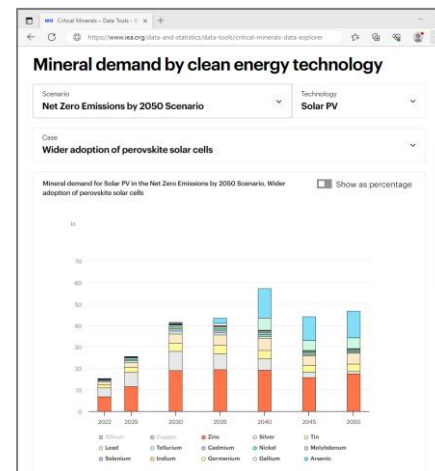
Total demand for focus minerals



Demand by mineral



Demand by technology



<https://www.iea.org/data-and-statistics/data-tools/critical-minerals-data-explorer>



<https://www.iea.org/topics/critical-minerals>