

The Global Energy Transition and Critical Minerals

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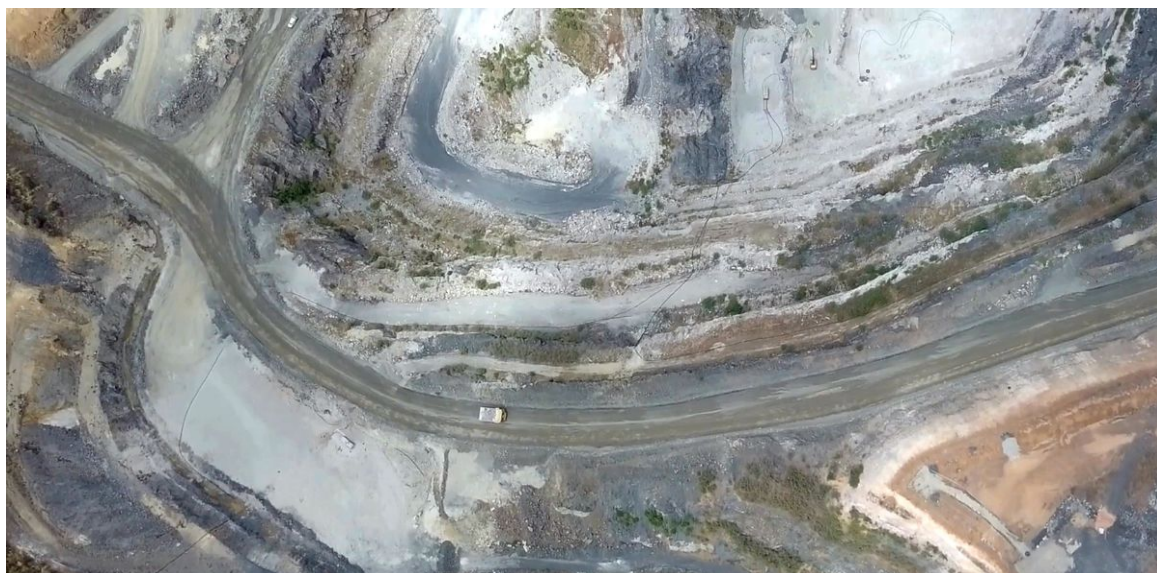


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Abstract

Australia is a key producer of some of the critical minerals that are likely to play an important role in the energy transition away from fossil fuels. Global demand for these minerals could grow significantly over the long term if the transition towards lower emissions progresses. This would support growth in the Australian production of these minerals, potentially increasing their relative importance to the domestic economy. However, this outlook is uncertain and depends on a range of factors such as the speed of the global energy transition, the relative take-up of different technologies and potential development of new technologies, global prices and the competitiveness of domestic production. In the near term, based on projects currently underway and announced, growth in production is likely to remain subdued, though new policy announcements may provide support for investment.

Introduction

A global, multisector transition to lower greenhouse gas emissions is underway. Adoption of renewable energy over the past decade has been generally faster than expected, alongside a larger-than-expected decline in the relative costs of production, in part driven by policy support in China and elsewhere. While annual global emissions have not yet peaked, these developments are contributing to a gradual shift in demand away from commodities like coal and oil and towards commodities that are used extensively in clean energy technologies.

‘Critical’ minerals are broadly defined as those that are important for the functioning of modern technologies or economies, or for national security, and are vulnerable to supply chain disruptions. The Australian Government maintains a list of critical minerals, which currently includes 31 minerals, and updates the list from time to time in response to changes in demand and supply conditions and technology (DISR 2024).¹

Our article focuses on the critical minerals that are used extensively in clean energy technology because these minerals have the greatest potential to become important for the Australian economy should global demand grow strongly as projected by the International Energy Agency (IEA).² This subset (referred to as critical minerals in this article) includes lithium, nickel, cobalt, graphite, rare earths, and copper (Table 1).³ While copper is not on Australia’s list of critical minerals, we include it here because it is a major component in most clean

energy technologies and it is widely recognised as a critical mineral by other major economies, including China, the European Union and the United States.⁴

Critical minerals are vulnerable to supply shortages due to a combination of factors. While it is possible that demand for critical minerals could grow rapidly, supply is largely fixed in the short run because it takes a long time to develop mines. It can take critical mineral projects more than 10 years to go from the exploration to the production stage, though this time period can vary by mineral and price incentives (Australian Government 2023). Critical mineral deposits and refining capacities also tend to be much more concentrated geographically than other minerals, and so they are particularly vulnerable to geopolitical and supply chain disruptions. For example, rare earths deposits are almost fully concentrated in three countries, and most of the world’s critical minerals refining capacity is located in China (Americo, Johal and Upper 2023).

Developments in the critical minerals sector, both in Australia and globally, will be an important determinant of how Australia’s role as a resource exporter may change as part of the global energy transition. Increased economic activity in Australia’s critical minerals sector – for example, due to more investment and exports – could at least partially offset the expected decline in activity from lower global demand for fossil fuel exports (Kemp, McCowage and Wang 2021).

Table 1: Select Critical Minerals and their Clean Energy Applications

Mineral	Applications		
	Batteries used in electric vehicles and energy storage systems	Wind turbines	Solar panels
Lithium	✓		
Rare earths	✓	✓	
Graphite	✓		
Nickel	✓	✓	
Cobalt	✓	✓	
Copper	✓	✓	✓

Sources: Department of Industry, Science and Resources; Geoscience Australia; International Energy Agency.

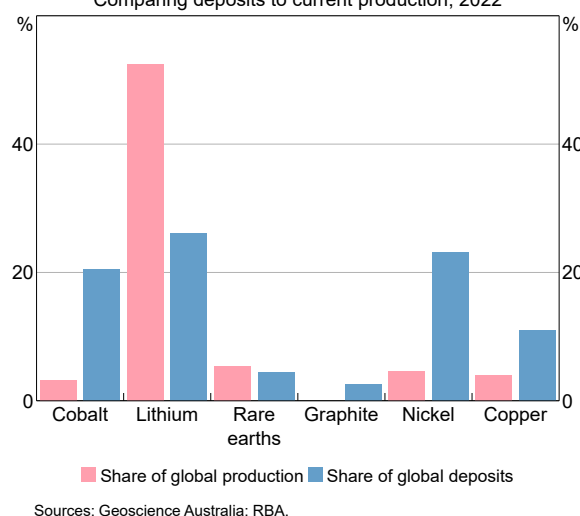
In this article, we provide some background on Australia's critical minerals sector, before then exploring how the demand for critical minerals could evolve in the medium-to-long term and how this might affect the size of Australia's critical minerals sector. We refer to two widely used benchmark global energy transition scenarios and focus specifically on the potential impact on export volumes, rather than export values or Australia's terms of trade. Export values can grow strongly and boost national income even if volumes are little changed. However, by anchoring our assessment of the long-term outlook around global mineral demand growth projections, we implicitly assume an increase in the average relative price of minerals that is consistent with these benchmark scenarios and that Australia's cost of production relative to the global average is unchanged over time. Scenario analysis is a useful tool because there is substantial uncertainty around how future technology and climate policy developments will affect the speed and manner in which the global energy transition proceeds and hence the supply and demand for critical minerals. That said, the scenarios that we explore are two of many possible future states and embed very particular assumptions about how climate policies and the relative price of different energy technologies will evolve in the future.

Australia's critical mineral sector

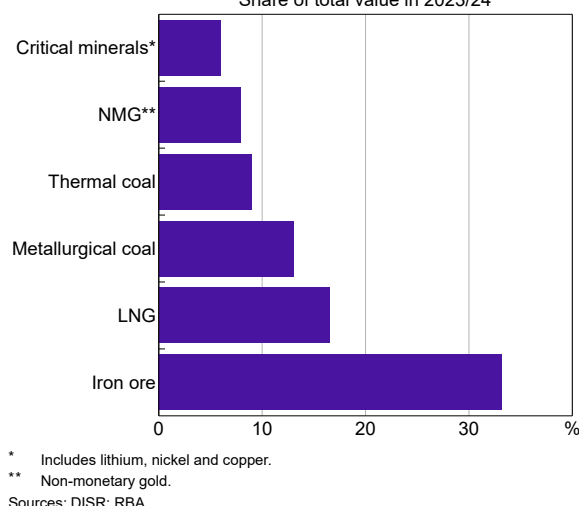
Australia has large endowments and is an important global producer and exporter of some critical minerals. It is the world's largest producer of lithium and one of the top five producers and exporters of cobalt and rare earths (Graph 1). Most of Australia's critical mineral deposits and mines are in Western Australia, with a large share of the mined minerals processed offshore in key export markets, including China, the United States, Japan and Malaysia.⁵ While Australia is a key exporter of these minerals, critical mineral exports currently comprise a small share of Australia's resource exports (Graph 2).

A number of critical mineral projects are currently underway in Australia that aim to boost Australia's production and processing capabilities, though most of these are still being assessed for viability, and so they are unlikely to increase Australia's production in the near term due to long lead times. Australia's processing and refinery capabilities are also expected to grow modestly in the near term based on the current pipeline of projects.

Graph 1
Australia's Clean Energy Critical Minerals
Comparing deposits to current production, 2022

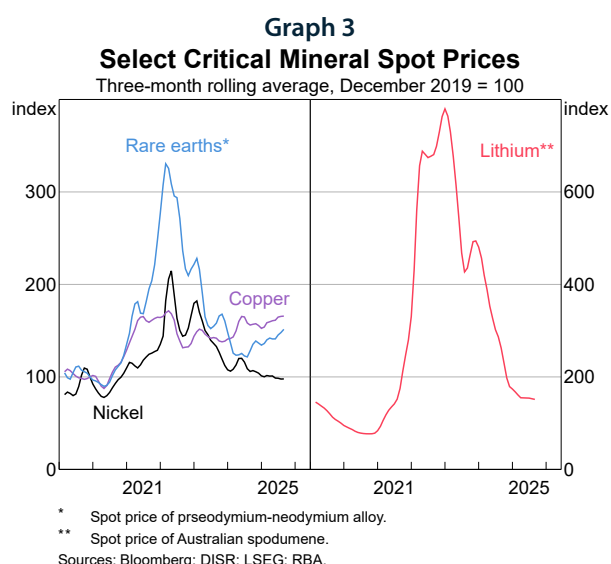


Graph 2
Australia's Resource Exports
Share of total value in 2023/24



In recent years, government policy has sought to encourage private investment in critical minerals projects. The Australian Government's Critical Minerals Strategy 2023–2030 sets out a framework for growing Australia's critical mineral sector and includes domestic funding facilities designed to support critical mineral exploration and production, as well as international partnerships (Australian Government 2023). The Future Made in Australia plan also includes policies aimed at growing the sector, including budgeted spending and production-linked tax incentives (Australian Government 2024). As this article was being finalised, the United States and Australia have agreed to a framework to support the supply of raw and processed critical minerals and rare earths crucial to the commercial and defence industries of the United States and Australia.

Global critical mineral prices play a significant role in incentivising Australian investment and production. In 2021, accelerated growth in the adoption of electric vehicles (EV) globally and expectations for strong future demand growth contributed to a sharp increase in the prices of many critical minerals (Graph 3). In response to the elevated prices, investment in and supply of lithium and nickel at the time were scaled up more quickly than anticipated.⁶ With supply increasing in more recent years, prices have declined substantially (DISR 2025a), and this has affected Australian investment and production of critical minerals. The RBA's liaison program suggests that some late-stage lithium projects were delayed in 2024, and some operating mines delayed investment, waiting for a sustained pick-up in prices. Production at several mines was also paused during 2024 due to concerns about profitability.⁷



Assessing the outlook for critical minerals demand

As global developments are important in shaping trends in the Australian critical minerals sector, we first consider the global outlook for critical minerals demand before then assessing the relevant implications for Australia. We use the IEA's global mineral supply and demand volumes projections, which cover the entire mineral and metal value chain from mining to refining. The scenarios we consider are just two of many possible future states, and there is a large degree of uncertainty about the global transition to lower emissions. Importantly, the IEA scenarios are not presented as forecasts nor as assessments of desired energy transition paths for the world. We use them here as benchmarks that have been directly translated into mineral demand projections.

Climate policy scenarios

A key source of uncertainty relates to climate policy and whether policy measures will be sufficient to achieve emissions reduction goals. To consider the policy outlook, we use two of the IEA's climate policy-based reference scenarios:

- Stated Policies Scenario (STEPS)
- Announced Pledges Scenario (APS).

STEPS assumes that climate policies that are either currently implemented or under development as at the end of August 2024 are preserved throughout the scenario horizon. Commitments and targets that have been announced are not assumed to be met in this scenario unless current policies are sufficient to meet them. The policies include ones that are part of large national decarbonisation reforms, such as the *Inflation Reduction Act of 2022* (IRA) in the United States and the Fit-for-55 package in the European Union, though some policies embedded in STEPS are now outdated (e.g. recent US policy changes have accelerated the termination of EV and clean electricity investment tax credits in the IRA).

APS is a more ambitious policy scenario that assumes that all climate targets that have been announced by countries, including commitments made under the Paris Agreement, are met in full and on time regardless of whether a country's climate policy is sufficient to achieve those targets. APS also assumes that all OECD countries

apply the same economy-wide carbon prices (or their policy equivalents) as each other, as do emerging and developing countries with net zero pledges. In practice, policies are more likely to continue to evolve in an uncoordinated manner.⁸

Uncertainty around technology developments

Another source of uncertainty is the development of technology, as new and more efficient or alternative technologies could affect relative demand for minerals directly, as well as indirectly through implications for climate policies. We use mineral projections from the IEA's Global Energy and Climate Model, which is conditioned on a set of assumptions about the pace of decline in production costs of clean technologies, ranging from EVs to innovative technologies like iron-based steel production with carbon capture (IEA 2024a).

In practice, different technological assumptions can drive major qualitative and quantitative differences. For example, different models used by the Network for Greening the Financial System (NGFS) in their scenarios can project a difference of around US\$95 billion in global energy storage investment over the next five years.⁹ Policies can help shape these technological development paths (e.g. China's long-running policy support for EV uptake and solar photovoltaic (PV) production has driven cost reduction in, and widespread deployment of, these technologies), but the climate targets and investments that countries commit to still depend on expectations around future technology developments.

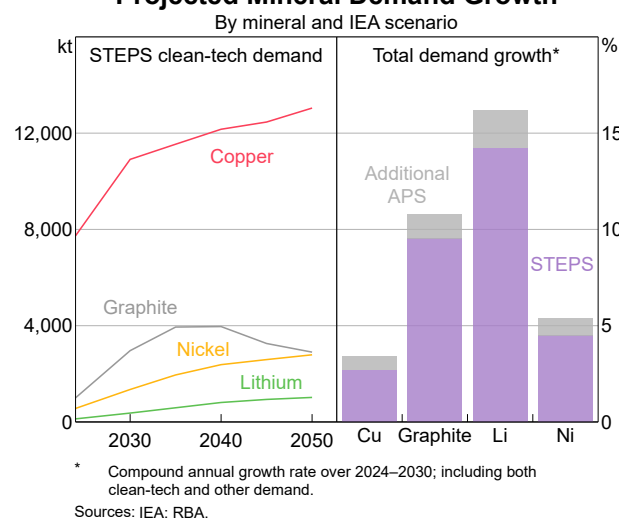
Global outlook for critical minerals

Demand

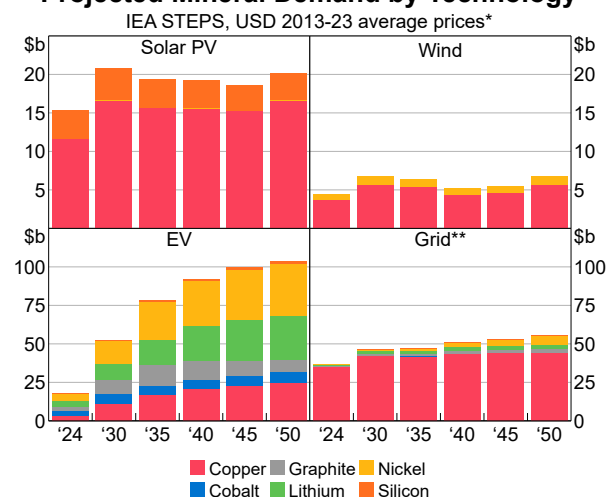
IEA projections indicate that the energy transition will drive the sharpest growth in demand for lithium, as well as a significant increase in demand for copper, graphite and nickel (Graph 4). Demand for batteries in the EV sector is the main driver of this projected growth (Graph 5).¹⁰ To put the scale of potential growth in perspective, even in STEPS, which does not assume any increase in climate policy ambition over time, the aggregate market value of key critical minerals is expected to grow to roughly 45 per cent of the 2023 global iron ore market by 2030.¹¹ Much of this

growth is concentrated in the short-to-medium term and is supported by current policy settings. Lithium demand is expected to grow at an average compound annual rate of around 14 per cent to 2030, with the more ambitious policy in APS increasing this by around two percentage points each year (Graph 4). This partly reflects the similar assumed rates of technological change across the two scenarios and may not be a feature of all possible scenarios.

Graph 4
Projected Mineral Demand Growth



Graph 5
Projected Mineral Demand by Technology



* All values computed using IEA projected volumes and average mineral prices over 2013-23, except lithium which uses the average 6% Li spodumene price over 2018-23, scaled to the 100% Li content of the IEA's demand projections.

** Includes demand for grid battery storage and electricity networks.

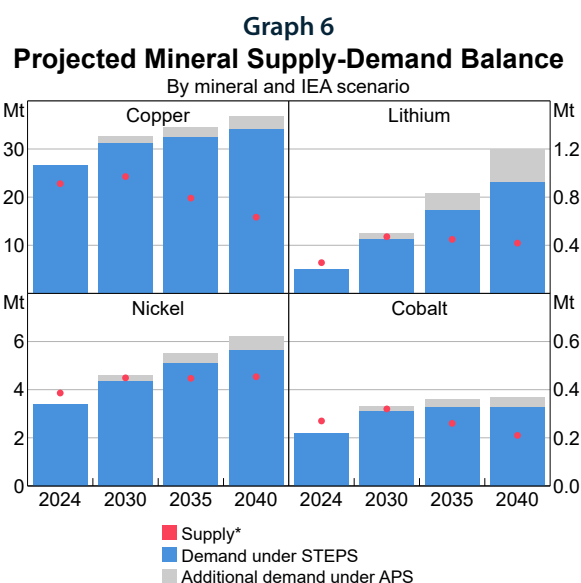
Sources: Bloomberg; IEA; LSEG; RBA.

IEA scenarios like APS highlight that more ambitious policies translate to larger mineral demand estimates. However, policy uncertainty could also present downside risks to the medium-term demand outlook that is implied by these scenarios. Recent policy developments – including greater restrictions on and accelerated phaseout of certain clean energy tax credits under the IRA in the United States, increased export bans on critical minerals and bilateral tariffs – have increased uncertainty around prices and the pace of clean technology deployment in some regions. Although these policy changes will likely slow the pace of adoption rather than reverse it (Economist 2025), demand estimates could be weaker than projected if current policies embedded in IEA scenarios are substantially unwound.

Uncertainties around technological developments not captured by the scenarios are more likely to affect long-term projections. The IEA expect EV battery demand to grow robustly despite uncertainties due to how much prices have declined and ongoing policy support in most countries (IEA 2024b; IEA 2025), though innovations in the chemistry mix of batteries could change the relative demand for minerals over time.¹² How the scale and relative cost of energy storage technologies develop will directly affect demand projections for battery minerals. They will also heavily influence the extent to which intermittent solar and wind energy can replace coal in the energy mix and how gas will be used to provide reliable power for electricity grids in the long term, in turn affecting demand for other clean technologies used in renewable energy generation and electricity grids.

Supply

To compare against the demand projections, we use the IEA's estimates of mined mineral output based on existing and announced mining projects as a conservative estimate of supply. Together, the estimates suggest that there may be insufficient supply of critical minerals by 2035 to meet the required demand under STEPS, particularly for copper and lithium (Graph 6). However, these projected 'shortfalls' in the medium and long term are likely to be overstated, as the estimates do not account for how endogenous price changes could encourage supply to expand. If company investment decisions have been based on more conservative assumptions of demand than what STEPS implies is required, there could be upside risks to mineral prices and supply in response. As we have less information about projects that will influence supply out to 2040, unannounced projects could also commence within that timeframe. Alternatively, the projected 'shortfall' could imply that STEPS is currently unrealistic, and future realisation of weaker actual demand could drive average prices lower than the level needed to achieve the STEPS demand projections. Nevertheless, the risk of price volatility remains elevated in the short-to-medium term due to these demand uncertainties and the long development timelines of some minerals, and this will weigh on investment and production incentives in Australia.



* Projected supply is based on mined output expected from existing and announced projects. Does not account for recycled volumes that may contribute as secondary supply.

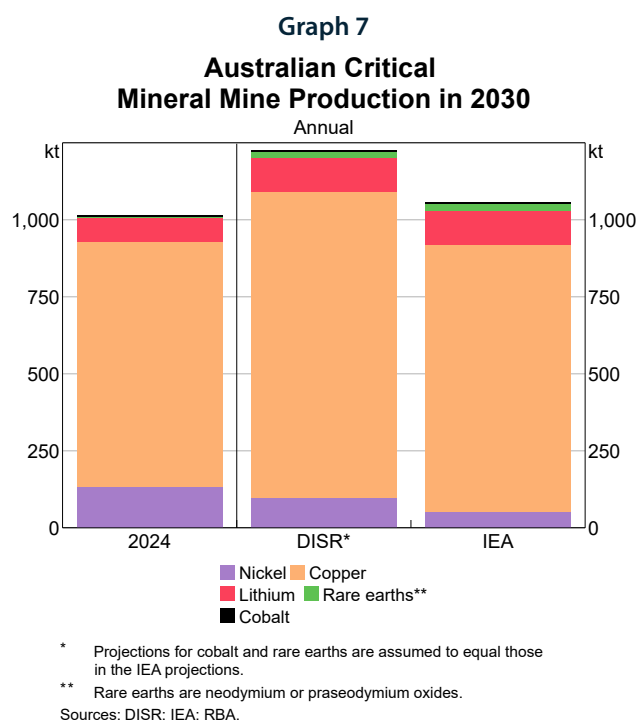
Source: IEA.

Australian outlook for critical minerals

In this section, we explore the outlook for Australian critical minerals production until 2050. We use Australian supply projections from the IEA and the Department of Industry, Science and Resources (DISR) to 2030 (based on current and announced mining projects in Australia) and extend this to 2050 by assuming that Australian supply grows at the same rate as global demand in the IEA STEPS and APS scenarios.¹³ However, this long-term outlook for Australia's critical mineral production is extremely uncertain. Whether Australian production will grow in line with global demand will depend on a range of domestic and global factors, including government policy, technological developments, developments in global prices relative to Australian producers' marginal costs and other factors that determine the viability of Australian projects such as exploration success and mine approvals.

Medium term

The IEA and DISR supply projections suggest that Australia's production of lithium, rare earths, and copper will increase strongly over the next five years, but this will be somewhat offset by a material decline in the production of nickel (Graph 7). The projected increase reflects new projects, as well as the expansion of existing mines (e.g. Greenbushes and Mount Holland in Western Australia), while the projected decline in nickel production reflects lower prices, resulting in projects being cancelled and the scaling back of production at existing operations. There is some uncertainty, however, around the magnitude of this decline. DISR projects that the decline in nickel production will be around half the size of the estimates in the IEA projections.¹⁴ Export value projections from DISR suggest that exports of lithium, copper and nickel will account for around 10 per cent of Australia's resource exports in 2030 (DISR 2025b), compared with the modest share of around 6 per cent today.

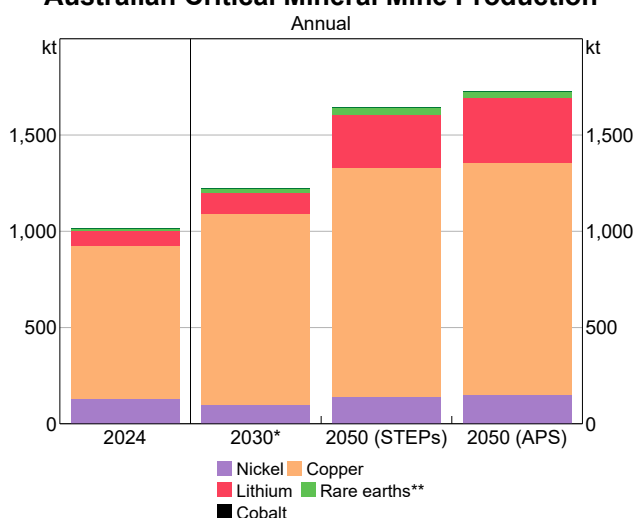


Developments in global demand for critical minerals, which will drive mineral prices, are a key uncertainty in this medium-term outlook. Low prices for critical minerals have halted production and delayed investment plans at some Australian mines in recent years. If global demand does not pick-up as projected and prices remain low, there is a risk that production increases by less than assumed in these supply projections, with projects being delayed or cancelled and operating mines remaining closed. Alternatively, if global demand grows more quickly than projected, and critical mineral prices increase substantially relative to the price of Australia's other resource exports, the critical minerals share of resource exports could be materially higher than projected and the critical mineral sector could become more important for the Australian economy.

Long term

In the long term, growth in Australian production will depend on the international competitiveness of Australian critical mineral producers. By assuming that Australian supply grows in line with global demand in STEPS, we implicitly assume that Australia's marginal cost of production changes in line with global marginal costs over time. Under this assumption, Australian production grows strongly between 2030 and 2050, with growth driven by lithium as global lithium demand is expected to be around 2.5 times higher in 2050 than in 2030 (Graph 8). In the ambitious APS projections, Australia's annual critical mineral production could be around 1.5 times higher in 2050 than in 2030. Although, in a scenario in which the energy transition and growth in global demand are slower, critical mineral production would increase by less than in the STEPS and APS projections.

Graph 8
Australian Critical Mineral Mine Production



* Projections based on supply projections from DISR and IEA derived from current and announced mining projects in Australia.

** Rare earths are neodymium or praseodymium oxides.

Sources: DISR; IEA; RBA.

In the long run, the size of the critical minerals sector in Australia will also depend on productivity in Australia and how much value-adding activity is captured onshore. As discussed above, Australian Government policy aims to develop Australian producers' involvement in downstream activities. IEA projections for refined production, which are based on current projects, suggest that Australia's processing and refinery capabilities will grow modestly until 2040, and most of the refinery of lithium, rare earths, and cobalt is expected to continue to take place in China, Indonesia and

Malaysia. Contacts in the RBA's liaison program note that Australia's relatively high input costs make it less internationally competitive in developing this capacity. Firms have also reported that some downstream processing operations require specialised skillsets that are currently difficult to find in the Australian labour market.

Conclusion

In Australia, recent global price declines have halted the production of some minerals and delayed investment plans, such that growth in production is likely to remain subdued. Recent policy announcements may provide support for investment. Medium-term supply projections suggest that Australia's production of lithium and copper could increase strongly over the next five years, though aggregate critical mineral production growth is buffered somewhat by expected declines in the production of nickel. In the long term, investment and production of critical minerals could increase strongly in Australia, noting that some climate policy scenarios suggest global demand will grow strongly.

However, the magnitude of both long-term global demand projections and Australian production remains subject to considerable uncertainty. The path of policy and technological developments will be key determinants of relative mineral demand and the overall pace of global mineral demand growth. Whether Australian production grows in line with global trends will depend on future government policy, developments in global prices, exploration success, whether Australian producers can maintain or improve international competitiveness, and how much value-adding activity is captured onshore.

Endnotes

- * Harry Stinson is from Economic Analysis Department and Irene Cam is from Economic Research Department. Thanks to Anna Park, Jeremy Lawson, John Boulter, Mick Plumb, Joanne Embry and Ellen Waterman for their comments and contributions to this analysis. This article was largely finalised prior to the signing of the Critical Minerals Framework between the United States and Australia on 20 October 2025.
- 1 Australia's list differs from those in other countries (e.g. the United Kingdom and the United States) because, in practice, countries have different frameworks for determining whether a given material is important for the functioning of modern technology and vulnerable to supply shortages.
 - 2 There are also significant data gaps that make it difficult to conduct analysis on other minerals on the Australian Government list.
 - 3 Rare earths are a group of metals that are generally not found in concentrations sufficient to make them viable for commercial mining.
 - 4 Copper is recognised as a critical mineral by the US Department of Energy and will likely be added to the US Geological Survey's updated list later in 2025. Copper is also classified as a critical mineral at the state level in South Australia.
 - 5 Copper is an exception as copper mines are located across Australia, but are concentrated in South Australia, Queensland and New South Wales.
 - 6 For example, this is faster than forecasted by McKinsey & Company (2024) and the IEA (2024c).
 - 7 For example, BHP's Nickel West operation and Mineral Resources' Bald Hill lithium mine.
 - 8 This non-uniformity may be better captured in reference scenarios like the Fragmented World Scenario from the NGFS, which assumes that current policy settings in countries are maintained until 2030 before policies are ramped up substantially (but divergently) to progress climate goals. NGFS scenarios calculate carbon prices endogenously in their models, so these cross-country differences may have larger feedback effects than in the IEA model where the carbon price assumptions are set exogenously. However, we do not consider the NGFS scenario here as it is not consistently mapped to mineral demand projections like the IEA scenarios.
 - 9 Estimates are from a comparison of world energy storage investment projections under current policy settings between the NGFS' 2024 REMIND-MAGPIE and MESSAGEix-GLOBIOM models.
 - 10 Non-clean technology uses of lithium are also expected to generate lithium demand growth comparable to growth from clean-technology use. These include use in batteries for digital appliances and producing ceramics and glass.
 - 11 The aggregate market value of key critical minerals is estimated using current long-run average prices as in Graph 5.
 - 12 Sodium-ion batteries are an alternative to lithium-based batteries that would reduce global lithium demand if deployed on a wider scale, but the technology is still under-developed and development incentives are currently weak due to low lithium prices.
 - 13 This implicitly assumes that Australia's marginal cost of producing these minerals will move in line with global marginal cost shifts, such that Australia's relative position on the global cost curve is unchanged. Australia's lithium producers appeared to sit around the middle of the global cost curve in 2022, while cobalt and nickel producers were at the higher end.
 - 14 DISR (2025b) assumes that higher nickel prices will result in improvements in domestic production closer to 2030.

References

- Americo A, J Johal and C Upper (2023), 'The Energy Transition and Its Macroeconomic Effects', BIS Paper No 135.
- Australian Government (2023), 'Critical Minerals Strategy 2023–2030', June.
- Australian Government (2024), 'Future Made in Australia', Plan.
- DISR (Department of Industry, Science and Resources) (2024), 'Australia's Critical Minerals List and Strategic Materials List'.
- DISR (2025a), 'Resources and Energy Quarterly: June 2025', Report.
- DISR (2025b), 'Resources and Energy Quarterly: March 2025', Report.
- Economist (2025), 'What Happens If the Inflation Reduction Act Goes Away?', *The Economist*, 21 May.
- IEA (International Energy Agency) (2024a), 'Global Energy and Climate Model: Documentation – 2024', Report, October.
- IEA (2024b), 'World Energy Outlook 2024', Report, October.
- IEA (2024c), 'Global Critical Minerals Outlook 2024', Report, May.
- IEA (2025), 'Global EV Outlook 2025: Expanding Sales in Diverse Markets', Report, May.
- Kemp J, M McCowage and F Wang (2021), 'Towards Net Zero: Implications for Australia of Energy Policies in East Asia', *RBA Bulletin*, September.
- McKinsey & Company (2024), 'Global Materials Perspective 2024', Report, September.