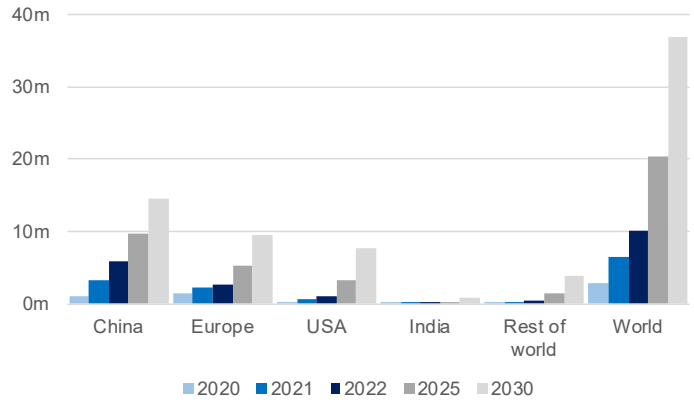
WESTERN AUSTRALIA BATTERY AND CRITICAL MINERALS PROFILE – September 2023

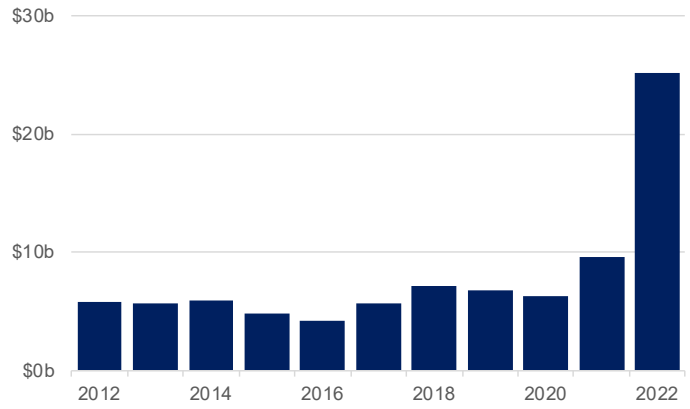
Electric car sales outlook[1]



m = Million. [1] Sales of battery electric cars and plug-in hybrid cars under the Stated Policies Scenario, which includes existing policies and measures and policy ambitions and targets that have been legislated by governments to support the deployment of electric vehicles.
Source: International Energy Agency, Global EV Outlook 2023 (Annual).

- In 2022, global electric car sales rose 57% to 10.2 million, despite total car sales falling 3% globally. The growth in electric car sales led to the number of electric cars on the road globally increasing to 26 million in 2022.
- Higher demand for electric vehicles is increasing the demand for battery and critical minerals. Automotive lithium-ion battery demand increased by 65% in 2022.
- Electric vehicle batteries now account for a much larger share of global demand for lithium (up from 15% in 2017 to 60% in 2022), cobalt (up from 10% to 30%) and nickel (up from 2% to 10%).
- Under the International Energy Agency's (IEA) Stated Policy Scenario, global electric car sales are projected to rise to 37 million in 2030, by which time there will be 226 million electric cars on the road globally.

Battery and critical minerals[1] sales from Western Australia



Kt = Thousand tonnes. [1] Lithium (spodumene concentrate), nickel, cobalt, manganese, copper and rare earths.
Source: WA Department of Mines, Industry Regulation and Safety, Resource Data Files (Bi-Annual); and WA Department of Jobs, Tourism, Science and Innovation.

- Western Australia has significant resources of battery and critical minerals and already produces many of these minerals for export.
- Western Australia's battery and critical minerals are mainly exported to China and other Asian markets (Japan, South Korea, Philippines, Taiwan), Europe (Netherlands, Germany, Finland, Belgium, Norway, Spain), the United States and Canada.
- The value of Western Australia's battery and critical minerals sales rose from $9.6 billion in 2021 to $25.2 billion in 2022.
- Western Australia's battery and critical minerals industry contributed $729 million in royalties in 2022, an increase from $275 million in 2021.
- Direct full-time equivalent employment in Western Australia's battery and critical minerals industry rose 19% to 14,293 in 2021-22.
- The estimated value of exploration expenditure for battery and critical minerals in Western Australia rose 19% to $774 million in 2022-23.

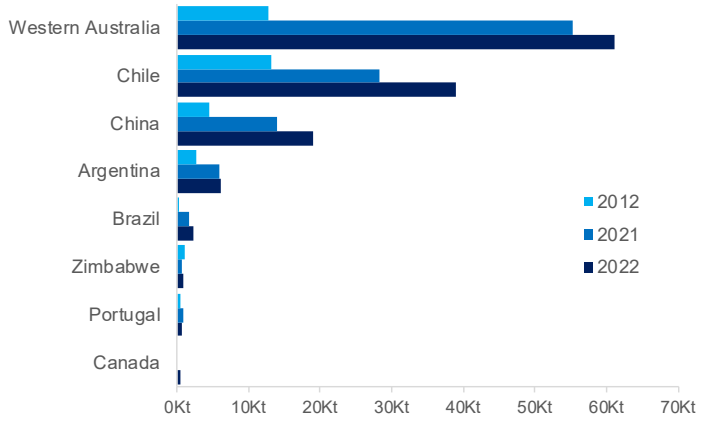
Western Australia's battery and critical minerals industry

- Lithium
- Nickel
- Cobalt
- Manganese
- Copper
- Rare earths

- Western Australia's lithium, cobalt and nickel exports are mostly used in battery manufacturing, although some exports are used for other purposes.
- New investment in battery and critical minerals processing is expected to result in Western Australia moving further down the value chain and exporting more minerals specifically for battery manufacturing. For example, Western Australia currently exports lithium mainly as spodumene concentrate, but will export more lithium hydroxide in coming years.
- This report provides information on the battery and critical minerals industry, including:
  - global reserves and production
  - global demand and prices
  - Western Australia's reserves, production, sales, royalties and employment.

Lithium

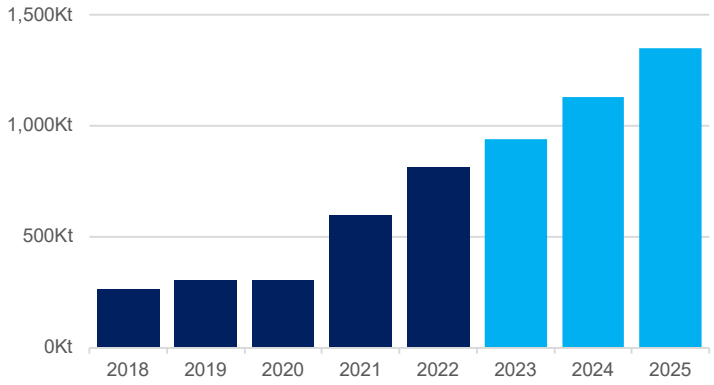
Lithium supply[1]



Kt = Thousand tonnes. [1] Lithium content from mine production.
Source: US Geological Survey, Mineral Commodity Summaries (Annual).

- Western Australia is the largest lithium supplier in the world, accounting for 47% of global supply in 2022, followed by Chile (30%).
- Western Australia accounted for 100% of Australia's lithium production in 2022.
- Global lithium supply almost quadrupled to 130,000 tonnes between 2012 and 2022, with supply from Western Australia contributing 51% of the increase.
- In 2022, lithium supply from:
  - Western Australia rose 10% to 61,000 tonnes
  - Chile rose 38% to 39,000 tonnes
  - China rose 36% to 19,000 tonnes
  - Argentina rose 4% to 6,000 tonnes.

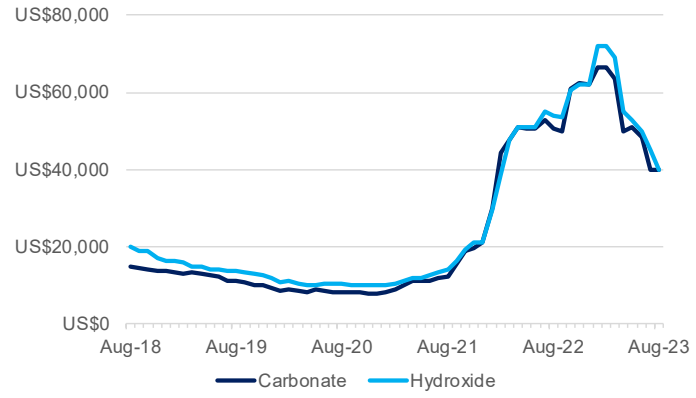
Lithium demand[1]



Kt = Thousand tonnes. [1] Demand is ahead of consumption by around 12 months due to time taken to manufacture batteries.
Source: Office of the Chief Economist, Resources and Energy Quarterly (Quarter).

- Lithium is mainly used in rechargeable batteries for mobile phones, laptops, digital cameras and electric vehicles. Rechargeable batteries account for 80% of the world's consumption of lithium.
- World lithium demand rose 38% to 814,000 tonnes in 2022.
- The Australian Government's Office of the Chief Economist forecasts annual world lithium demand will rise to 1.35 million tonnes in 2025.

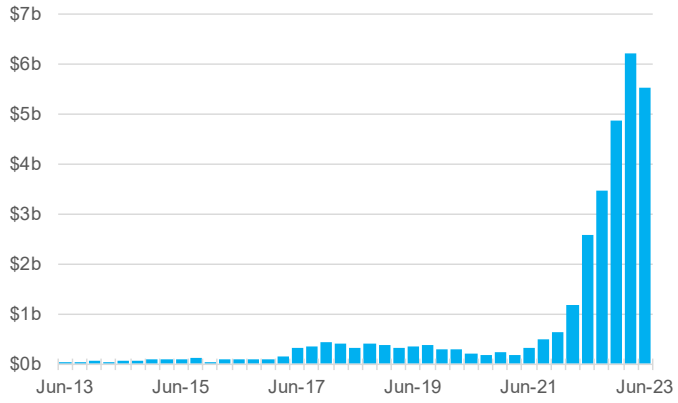
Lithium prices[1]



[1] US dollars a tonne. Asia, Cost, insurance and freight (CIF). [2] Unit price of Western Australia's spodumene exports (free on board) converted to US dollars using the monthly average exchange rate.
Source: S&P Global Market Intelligence/Benchmark Minerals (Month).

- Lithium prices increased sharply from mid-2021 to early 2023 as China implemented subsidies for electric vehicles, but have declined in recent months as those subsidies were removed, leading to lower demand for lithium from battery manufacturers in China.
- For lithium carbonate, the monthly average price remained at US$40,000 a tonne in August 2023. The annual average price rose 83% to US$57,083 a tonne in 2022-23.
- For lithium hydroxide, the monthly average price fell 11% to US$40,000 a tonne in August 2023. The annual average price rose 92% to US$59,833 a tonne in 2022-23.
- For lithium spodumene[2], the monthly average price fell 12% to US$3,377 a tonne in July 2023. The annual average price rose from US$1,579 a tonne in 2021-22 to US$4,138 a tonne in 2022-23.
- The Office of the Chief Economist forecasts the annual average price of:
  - lithium spodumene will be US$2,740 a tonne in 2024 and US$2,149 a tonne in 2025
  - lithium hydroxide will be US$35,416 a tonne in 2024 and US$30,357 a tonne in 2025.

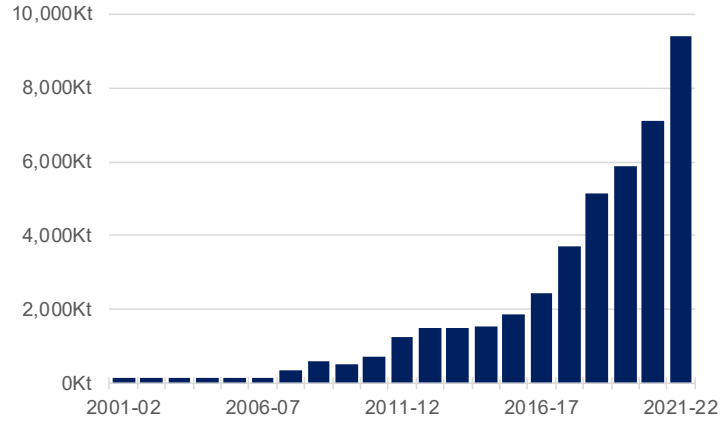
Lithium[1] exports from Western Australia



[1] Spodumene concentrate. Includes some other crude minerals.
Source: Based on data from ABS 5368.0 International Trade in Goods and Services, Australia (Monthly).

- Western Australia exports lithium mainly as spodumene concentrate for further processing.
- China is Western Australia's largest market for lithium, accounting for 99% of the State's lithium exports in 2022-23. Other lithium export markets in 2022-23 included Belgium, South Korea, United States, Japan and Taiwan.
- Western Australia exported $5.5 billion of lithium in the June quarter 2023, 11% less than in the previous quarter.
- The value of Western Australia's lithium exports rose from $4.9 billion in 2021-22 to $20.1 billion in 2022-23.
- Western Australia has started producing lithium hydroxide and will export it in greater volumes in coming years. The newly built Kwinana and Kemerton processing plants each have a capacity to produce around 25,000 tonnes of lithium hydroxide a year, supplied by lithium concentrate from the Greenbushes and Mt Marion mines. Additional trains are also being built at these plants that will double their production capacities.

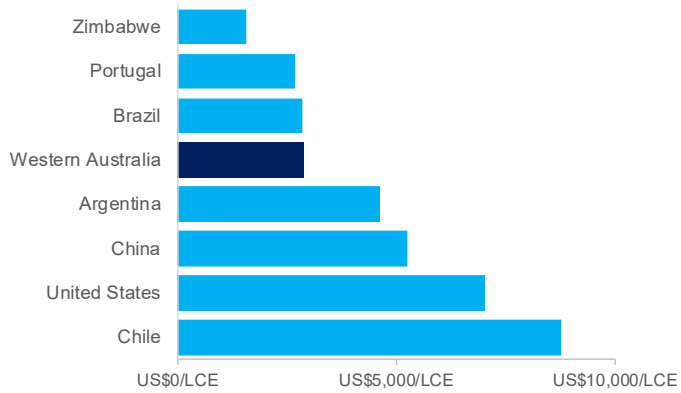
Lithium resources in Western Australia[1]



Kt = Thousand tonnes. [1] Estimated based on 99% of Australia's identified lithium resources.
Source: Based on data from ABS 5204.0 Australian System of National Accounts (Annual), Geoscience Australia, Australia's Identified Mineral Resources (Annual); and WA Department of Jobs, Tourism, Science and Innovation.

- Western Australia has large lithium reserves, accounting for 24% of the world's lithium reserves in 2022.
- Chile has the largest lithium reserves, accounting for 36% of the world's lithium reserves in 2022.
- Western Australia's estimated economic demonstrated lithium resource has increased rapidly over the past 5 years due to increased expenditure on lithium exploration.
- In 2021-22, Western Australia's estimated economic demonstrated lithium resource rose 32% to 9.4 million tonnes. This resource could sustain the State's lithium production for 28 years at 2021-22 production rates.

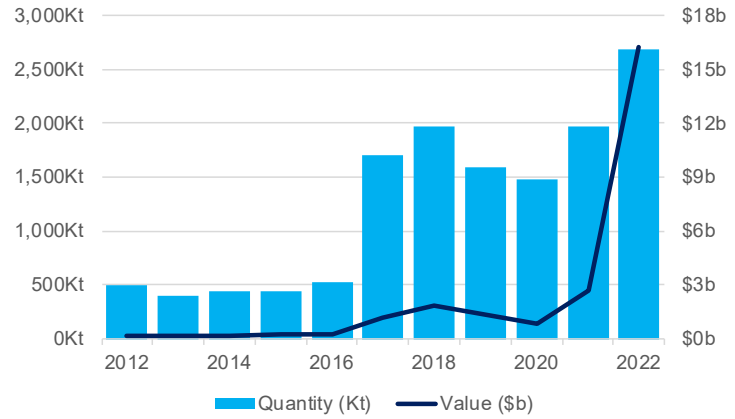
Lithium production costs per unit[1]: 2022



[1] Total cash costs per tonne of lithium carbonate equivalent (LCE) in US dollars. LCE is a benchmark product for the different lithium products of concentrate, carbonate, hydroxide, chloride and direct shipping ore.
Source: S&P Global Market Intelligence (Annual).

- Western Australia's lithium producers are among the world's lowest-cost producers and produce lithium at a much lower cost than the world's other major producers in Chile, China and Argentina. The cost competitiveness of Western Australia's lithium producers is due to relatively low costs for chemicals, royalties, energy and onsite services.
- The average total cash cost of Western Australia's lithium production was US$2,892 a lithium carbonate equivalent in 2022, below the world average of US$4,848 a lithium carbonate equivalent.
- Western Australia produces lithium at a much lower cost than its major competitor in Chile.
- In 2022, Western Australia's average total cash cost of lithium production was 67% lower than Chile's average total cash cost of US$8,769 a lithium carbonate equivalent.

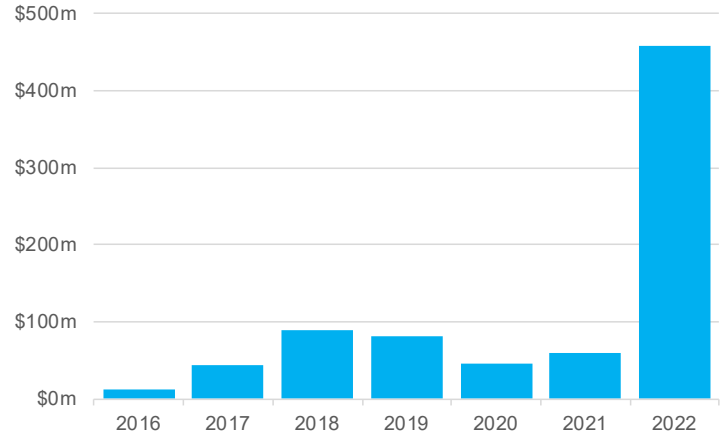
Lithium[1] sales from Western Australia



Kt = Thousand tonnes. [1] Spodumene concentrate.
Source: WA Department of Mines, Industry Regulation and Safety, Resource Data Files (Bi-Annual).

- Greenbushes is Western Australia's largest lithium mine, accounting for 51% of the State's lithium production in 2022. Other major lithium mines included Mt Marion (15%), Pilgangoora (14%), Wodgina (14%) and Mt Cattlin (6%).
- The quantity of Western Australia's lithium sales rose 36% to 2.7 million tonnes in 2022.
- The value of Western Australia's lithium sales increased by more than six times to $16.3 billion in 2022.
- Western Australia's third lithium hydroxide plant is under construction at Kwinana as part of the Mt Holland project, due for completion in 2025. The plant will have the capacity to produce 50,000 tonnes a year of lithium hydroxide.
- Trains 1 and 2 at the Wodgina lithium mine restarted in 2022 after the mine went into care and maintenance in November 2019. Train 3 is planned to restart in 2024 and a fourth train is being considered.
- The Kathleen Valley lithium project was sanctioned for development in August 2022 and is targeting first spodumene production in mid-2024.
- The P1000 expansion of the Pilgangoora lithium operation was sanctioned in March 2023. The expansion will increase the project's production by 47% to 1 million tonnes of spodumene concentrate a year.

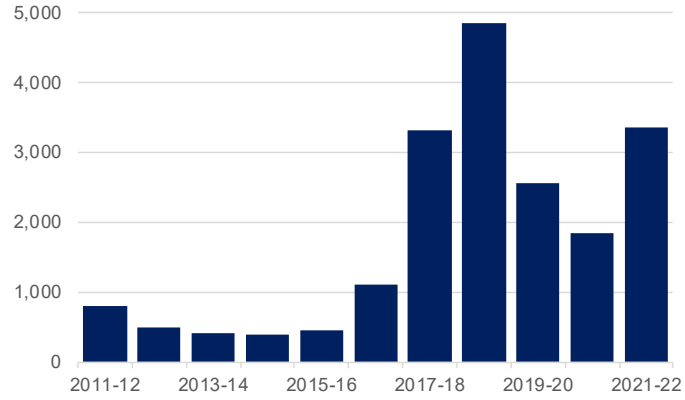
Lithium royalty revenue in Western Australia



Source: WA Department of Mines, Industry Regulation and Safety, Resource Data Files (Bi-Annual).

- Western Australia has a 5% royalty rate on the value of lithium concentrate (spodumene) feedstock.
- Lithium accounted for 4% of Western Australia's royalty revenue (including North West Shelf grants) in 2022.
- Lithium royalties in Western Australia rose from $60 million in 2021 to $457 million in 2022.

Lithium employment in Western Australia[1]

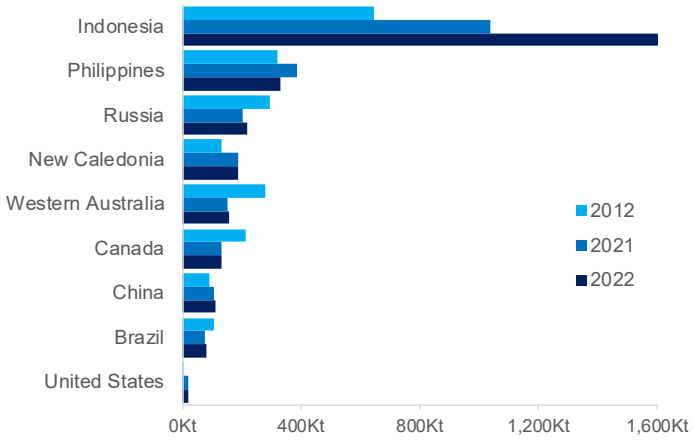


[1] Direct employment. Full-time equivalent (average on site).
Source: WA Department of Mines, Industry Regulation and Safety, Resource Data Files (Bi-Annual).

- Direct full-time equivalent employment in Western Australia's lithium industry rose 82% to 3,361 in 2021-22.
- Western Australia's largest employing lithium mine sites in 2021-22 were:
  - Pilgangoora (794)
  - Greenbushes (665)
  - Mt Marion (552)
  - Yilgarn (452)
  - Mt Cattlin (289).

Nickel

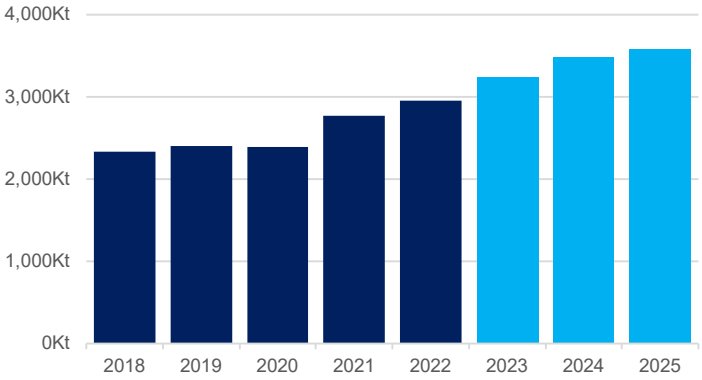
Nickel supply[1]



Kt = Thousand tonnes. [1] Nickel content from mine production.
Source: US Geological Survey, Mineral Commodity Summaries (Annual).

- Western Australia is the 5th largest nickel supplier in the world, accounting for 5% of global supply in 2022.
- Indonesia is the largest nickel supplier in the world, accounting for 49% of global supply in 2022.
- Western Australia accounted for 100% of Australia's nickel production in 2022.
- Global nickel supply rose 36% to 3.3 million tonnes between 2012 and 2022, mainly driven by increased supply from Indonesia.
- In 2022, nickel supply from:
  - Indonesia rose 54% to 1.6 million tonnes
  - Philippines fell 15% to 330,000 tonnes
  - Russia rose 7% to 220,000 tonnes
  - New Caledonia rose 2% to 190,000 tonnes
  - Western Australia rose 6% to 160,000 tonnes.

Nickel consumption



Kt = Thousand tonnes.
Source: Office of the Chief Economist, Resources and Energy Quarterly (Quarter).

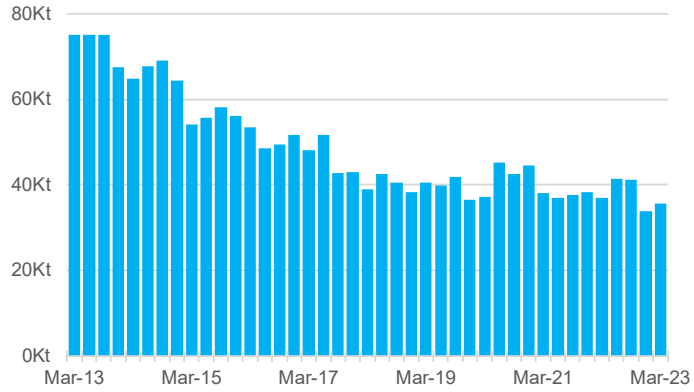
- Nickel is mainly used to make stainless steel, which accounts for 65% of global nickel consumption. The use of nickel for electric vehicle batteries is growing. Around 15% of the world's nickel is consumed in batteries, including rechargeable batteries for electronics, power tools, transport and emergency power supply.
- World nickel consumption rose 5% to 2.9 million tonnes in 2022.
- The Office of the Chief Economist forecasts world nickel consumption will rise 21% to 3.6 million tonnes between 2022 and 2025.

Nickel prices[1]

[1] US dollars a tonne. London Metal Exchange (LME) Cash.
Source: S&P Global Market Intelligence/Thomson Reuters (Month).

- Nickel prices declined sharply in the first half of 2023 as the demand for nickel from China's passenger plug-in electric vehicle market weakened.
- The monthly average nickel price fell 9% to US$20,087 a tonne in August 2023.
- The annual average nickel price rose 3% to US$23,982 a tonne in 2022-23.
- The Office of the Chief Economist forecasts the annual average nickel price will be US$20,625 a tonne in 2024 and US$20,000 a tonne in 2025.

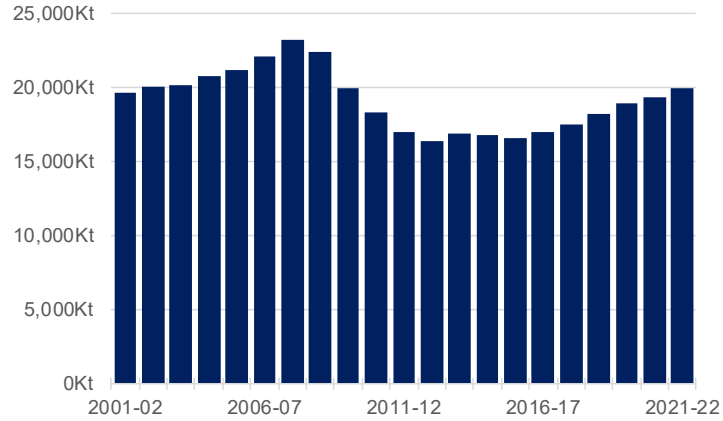
Nickel production[1] from Western Australia



Kt = Thousand tonnes. [1] Nickel content from mine production.
Source: Office of the Chief Economist, Resources and Energy Quarterly (Quarter).

- Nickel West is Western Australia's largest nickel operation and includes the Mt Keith and Leinster mines, the Kambalda Concentrator, Kalgoorlie Smelter (matte) and Kwinana Refinery (powder and briquettes). Many other miners sell nickel ore to Nickel West for processing.
- The Mt Keith and Leinster mines accounted for a combined 37% of Western Australia's paid nickel mine production in 2022.
- Murrin Murrin is Western Australia's largest nickel mine, accounting for 19% of the State's paid nickel mine production in 2022. Other major nickel mines included Ravensthorpe (13%), Nova-Bollinger (13%), Forrestania (8%), South Kambalda (7%) and Savannah (3%).
- Western Australia produced 36,000 tonnes of nickel in the March quarter 2023, 5% more than in the previous quarter.

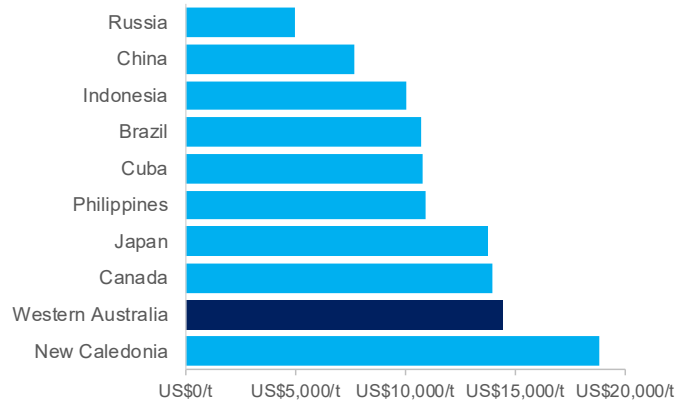
Nickel resources in Western Australia[1]



Kt = Thousand tonnes. [1] Estimated based on 89% of Australia's identified nickel resources.
Source: Based on data from ABS 5204.0 Australian System of National Accounts (Annual), Geoscience Australia, Australia's Identified Mineral Resources (Annual); and WA Department of Jobs, Tourism, Science and Innovation.

- Western Australia has large nickel reserves, accounting for 18% of the world's nickel reserves in 2022.
- Indonesia has the largest nickel reserves, accounting for 21% of the world's nickel reserves in 2022.
- Western Australia's estimated economic demonstrated nickel resource has increased steadily over the past 5 years.
- In 2021-22, Western Australia's estimated economic demonstrated nickel resource rose 3% to 19.9 million tonnes. This resource could sustain the State's nickel production for 100 years at 2021-22 production rates.
- The value of Western Australia's nickel and cobalt exploration expenditure rose 19% to $287 million in 2022-23.

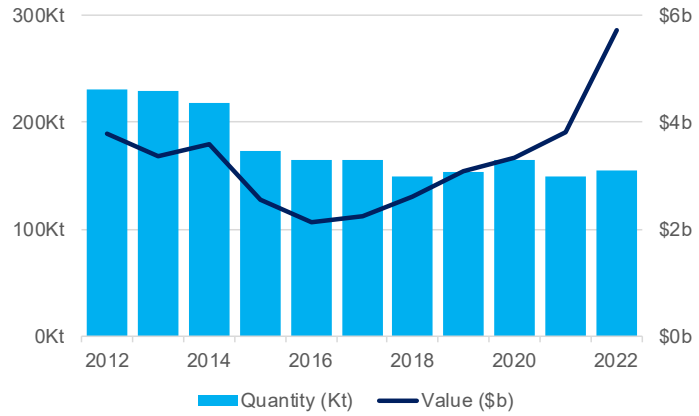
Nickel production costs per unit[1]: 2022



Note – Includes the top 10 global producers only.
[1] Total cash costs per tonne of paid nickel production in US dollars on a co-product or shared cost basis.
Source: S&P Global Market Intelligence (Annual).

- Western Australia's nickel producers are among the world's highest-cost producers, mainly due to relatively high costs for labour, energy and royalties.
- The average total cash cost of Western Australia's nickel production was US$14,416 a tonne in 2022, above the world average of US$10,992 a tonne.
- Despite high production costs, Western Australia's nickel production is competitive because of low impurities.
- Less than half of the world's current nickel production is suitable for battery manufacturing. Battery manufacturing requires nickel that is at least 99.8% pure. High-grade nickel is mainly found in nickel sulphide deposits, which are in abundance in Western Australia.

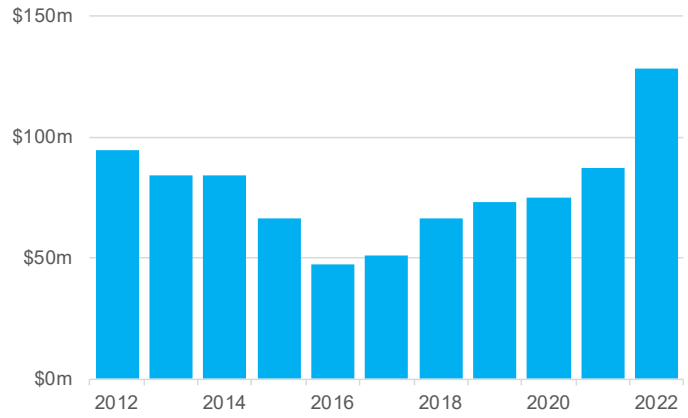
Nickel sales from Western Australia



Kt = Thousand tonnes.
Source: WA Department of Mines, Industry Regulation and Safety, Resource Data Files (Bi-Annual).

- Nickel produced in Western Australia is mainly used in battery manufacturing. For example, over 85% of Nickel West's nickel production is sold to battery material suppliers.
- The quantity of Western Australia's nickel sales rose 3% to 155,000 tonnes in 2022.
- The value of Western Australia's nickel sales rose 51% to $5.7 billion in 2022.
- In September 2021, nickel sulphate production for lithium-ion batteries started from a newly built plant on the site of the existing Kwinana nickel refinery. The facility's current production capacity is 100,000 tonnes a year and there are plans to double this capacity in the coming years.
- China is Western Australia's largest market for nickel exports, accounting for 59% of the State's nickel exports in 2022. Other major nickel export markets in 2022 included Japan (16%) and South Korea (9%).

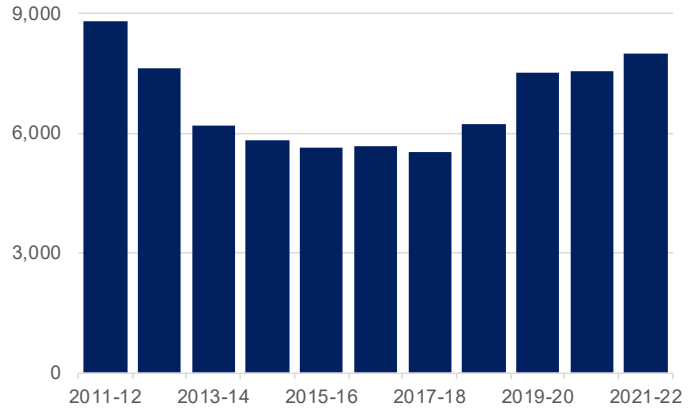
Nickel royalty revenue in Western Australia



Source: WA Department of Mines, Industry Regulation and Safety, Resource Data Files (Bi-Annual).

- Western Australia has a 2.5% royalty rate on the value of nickel sold.
- Nickel accounted for 1.1% of Western Australia's royalty revenue (including North West Shelf grants) in 2022.
- Nickel royalties in Western Australia rose 47% to $128 million in 2022.

Nickel employment in Western Australia[1]

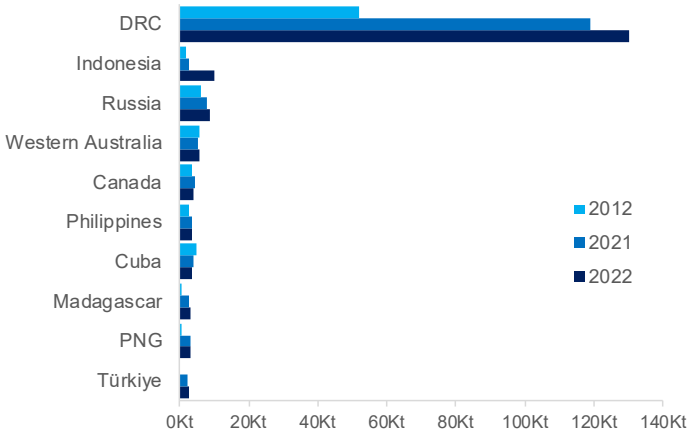


[1] Direct employment. Full-time equivalent (average on site).
Source: WA Department of Mines, Industry Regulation and Safety, Resource Data Files (Bi-Annual).

- Direct full-time equivalent employment in Western Australia's nickel industry rose 6% to 7,992 in 2021-22.
- Western Australia's largest employing nickel mines and processing sites in 2021-22 were:
  - Murrin Murrin (1,616)
  - Ravensthorpe (858)
  - Leinster (748)
  - Mt Keith (621)
  - Kwinana (543).

Cobalt

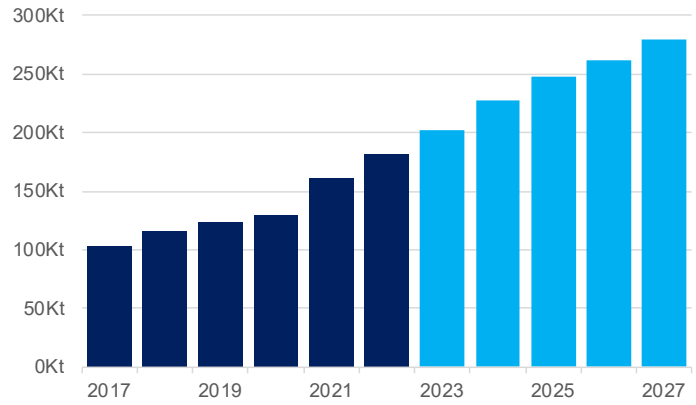
Cobalt supply[1]



Kt = Thousand tonnes. [1] Cobalt content from mine production.
Source: US Geological Survey, Mineral Commodity Summaries (Annual).

- Western Australia is the 4th largest cobalt supplier in the world, although accounted for only 3% of global supply in 2022.
- The Democratic Republic of Congo (DRC) is by far the largest cobalt supplier in the world, accounting for 70% of global supply in 2022.
- Western Australia accounted for 100% of Australia's cobalt production in 2022.
- Global cobalt supply rose 96% to 190,000 tonnes between 2012 and 2022, mainly driven by increased supply from the DRC.
- In 2022, cobalt supply from:
  - the DRC rose 9% to 130,000 tonnes
  - Indonesia rose from 3,000 tonnes to 10,000 tonnes
  - Russia rose 11% to 9,000 tonnes
  - Western Australia rose 11% to 6,000 tonnes.

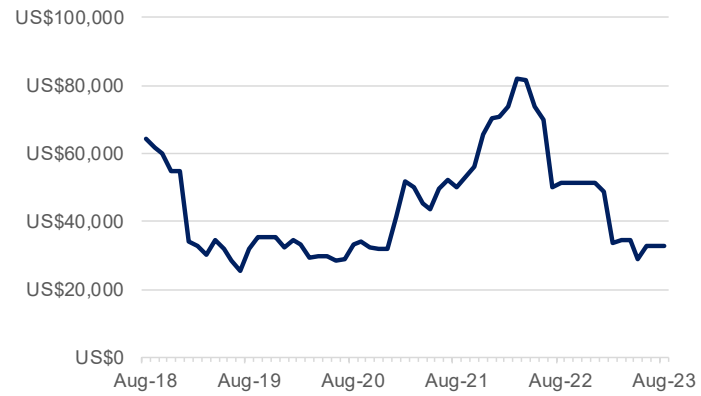
Cobalt consumption



Source: S&P Global Market Intelligence – Battery Materials Summary (Quarter).

- Cobalt is mainly used in rechargeable battery electrodes, as well as superalloys to make gas turbine blades and aircraft engines. Over 80% of the world's consumption of cobalt is for manufacturing rechargeable batteries.
- World cobalt consumption rose 13% to 182,000 tonnes in 2022.
- S&P Global Market Intelligence forecasts world cobalt consumption will rise 54% to 280,000 tonnes between 2022 and 2027.

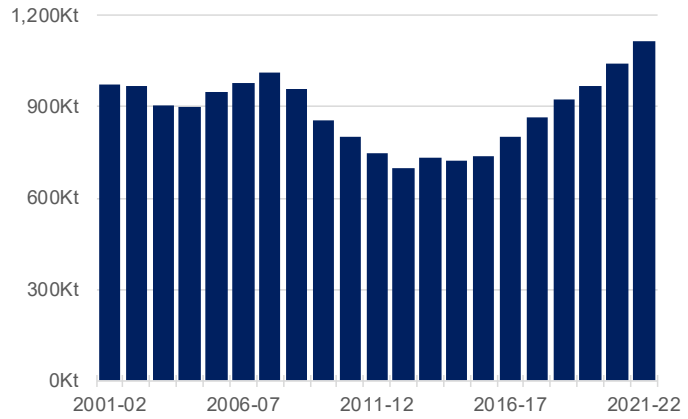
Cobalt prices[1]



[1] US dollars a tonne. London Metal Exchange (LME) Cash.
Source: S&P Global Market Intelligence/Thomson Reuters (Month).

- Cobalt prices declined sharply in the first half of 2023 as the demand for cobalt from China's passenger plug-in electric vehicle market weakened. However, cobalt prices have stabilised in recent months due to improved demand for cobalt-contained batteries.
- The monthly average cobalt price rose 0.05% to US$32,991 a tonne in August 2023.
- The annual average cobalt price fell 35% to US$43,416 a tonne in 2022-23.
- S&P Global Market Intelligence forecasts the annual average price of cobalt will be US$49,546 a tonne in 2024 and US$51,266 a tonne in 2025.

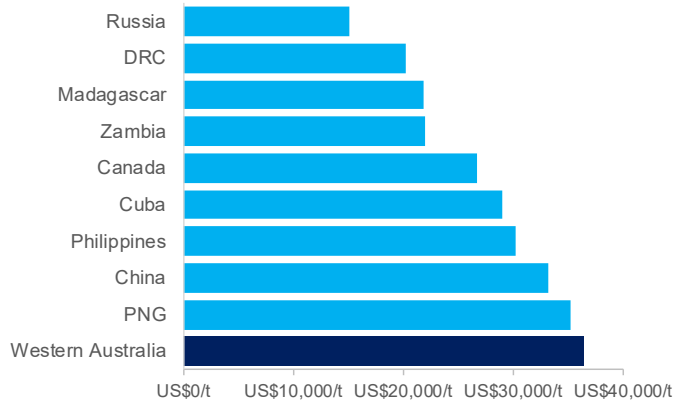
Cobalt resources in Western Australia[1]



Kt = Thousand tonnes. [1] Estimated based on 67% of Australia's identified cobalt resources.
Source: Based on data from ABS 5204.0 Australian System of National Accounts (Annual), Geoscience Australia, Australia's Identified Mineral Resources (Annual); and WA Department of Jobs, Tourism, Science and Innovation.

- Western Australia has large cobalt reserves, accounting for 12% of the world's cobalt reserves in 2022.
- The DRC has the largest cobalt reserves, accounting for 48% of the world's cobalt reserves in 2022.
- Western Australia's estimated economic demonstrated cobalt resource has increased steadily over the past 5 years.
- In 2021-22, Western Australia's estimated economic demonstrated cobalt resource rose 7% to 1.1 million tonnes. This resource could sustain the State's cobalt production for 210 years at 2021-22 production rates.

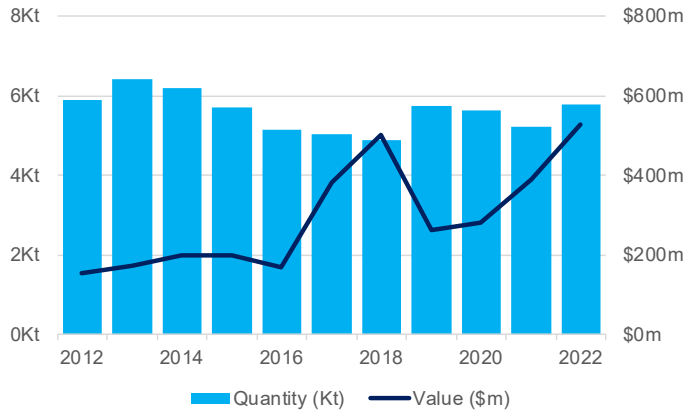
Cobalt production costs per unit[1]: 2022



Note – Includes the top 10 global producers only.
[1] Total cash costs per tonne of paid cobalt production in US dollars on a co-product or shared cost basis.
Source: S&P Global Market Intelligence (Annual).

- Western Australia's cobalt producers are among the world's highest-cost producers, mainly due to relatively high costs for labour, chemicals and onsite services.
- The average total cash cost of Western Australia's cobalt production was US$36,405 a tonne in 2022, above the world average of US$22,495 a tonne.
- Western Australia's close proximity to major cobalt markets in Asia reduces shipping costs relative to some of its competitors. The average cost of seaborne shipment for Western Australian cobalt producers was 27% lower than the world average.

Cobalt sales from Western Australia

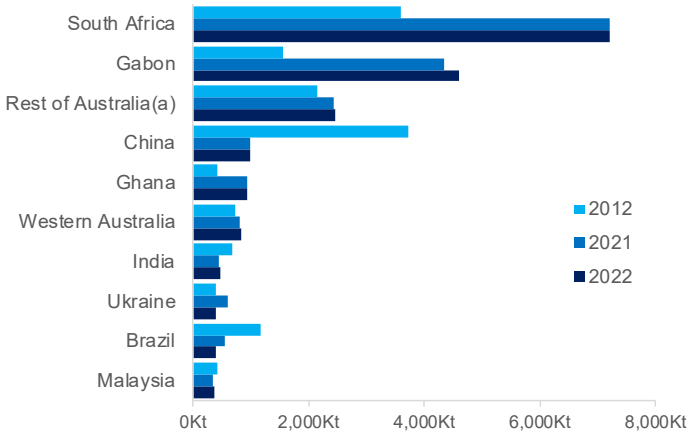


Kt = Thousand tonnes.
Source: WA Department of Mines, Industry Regulation and Safety, Resource Data Files (Bi-Annual).

- Western Australia's cobalt production mainly comes from the State's major nickel mines.
- In 2022, Murrin Murrin accounted for 63% of Western Australia's paid cobalt mine production, followed by Ravensthorpe (13%) and Nova-Bollinger (11%).
- The quantity of Western Australia's cobalt sales rose 11% to 6,000 tonnes in 2022.
- The value of Western Australia's cobalt sales rose 36% to $528 million in 2022.
- Mt Thirsty is a major cobalt deposit proposed for development in Western Australia, which could produce 19,000 tonnes of cobalt a year and 25,000 tonnes of nickel a year if developed.

Manganese

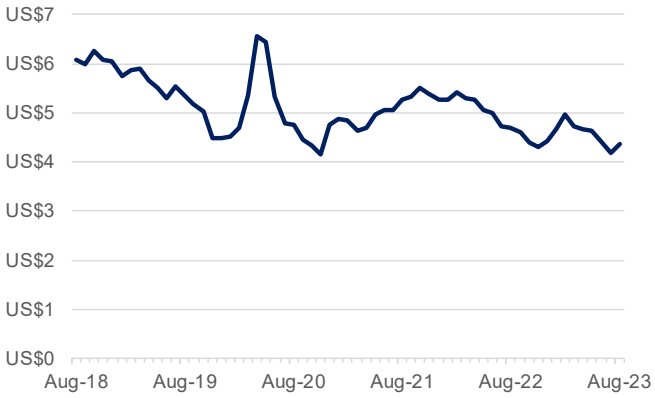
Manganese supply[1]



Kt = Thousand tonnes. [1] Manganese content from mine production. (a) Northern Territory.
Source: US Geological Survey, Mineral Commodity Summaries (Annual).

- Western Australia is the 6th largest manganese supplier in the world, accounting for 4% of global supply in 2022.
- South Africa is the largest manganese supplier in the world, accounting for 36% of global supply in 2022.
- Western Australia accounted for 25% of Australia's manganese production in 2022.
- Global manganese supply rose 23% to 20 million tonnes between 2012 and 2022, mainly driven by increased supply from South Africa and Gabon.
- In 2022, manganese supply from:
  - South Africa was steady at 7.2 million tonnes
  - Gabon rose 6% to 4.6 million tonnes
  - Northern Territory rose 1% to 2.5 million tonnes
  - Western Australia rose 1% to 828,000 tonnes.

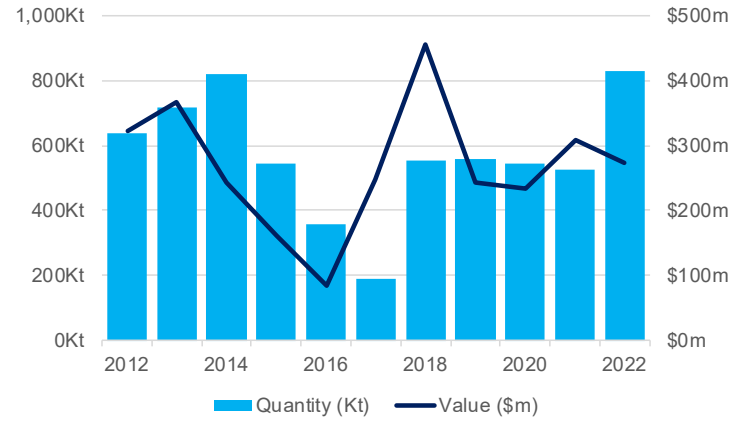
Manganese prices[1]



[1] US dollars a dry tonne. Minimum 32% manganese and 20% iron content, Tianjin (China)-South Africa.
Source: S&P Global Market Intelligence/Thomson Reuters (Month).

- Manganese is mostly used in steel production. There is increasing demand for manganese from the battery manufacturing industry as electrolytic manganese dioxide and electrolytic manganese metal are used in the production of rechargeable electric vehicle batteries.
- Manganese prices rose in August 2023 following five consecutive months of price decline.
- The monthly average manganese price rose 4% to US$4.4 a tonne in August 2023.
- The annual average manganese price fell 13% to US$4.6 a tonne in 2022-23.

Manganese sales from Western Australia

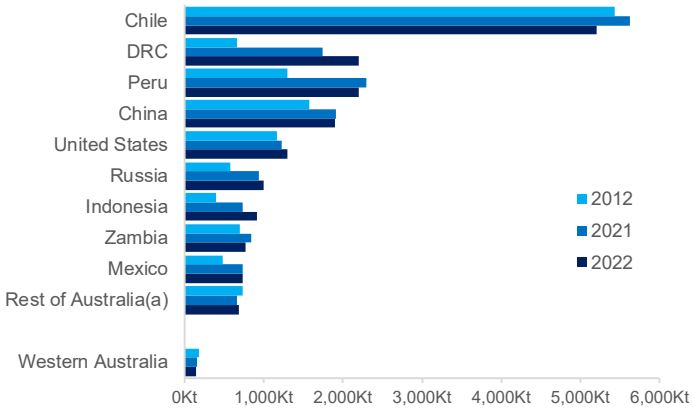


Kt = Thousand tonnes. Note – Values in some years are estimated using average unit prices.
Source: WA Department of Mines, Industry Regulation and Safety, Resource Data Files (Bi-Annual) and WA Department of Jobs, Tourism, Science and Innovation.

- Western Australia's manganese production comes from the Woodie Woodie and Butcherbird mines.
- Woodie Woodie returned to full-scale production in October 2017, after being put on care and maintenance in February 2016.
- Butcherbird started operating in 2021 at a capacity of 365,000 tonnes a year. Production capacity was expanded to 1 million tonnes a year in 2022.
- In 2022, the quantity of Western Australia's manganese sales rose 58% to 827,000 tonnes.
- The value of Western Australia's manganese sales fell 11% to $273 million in 2022.
- Direct full-time equivalent employment in Western Australia's manganese industry rose 5% to 571 in 2021-22, with 517 workers employed at the Woodie Woodie mine and 54 workers employed at the Butcherbird mine.

Copper

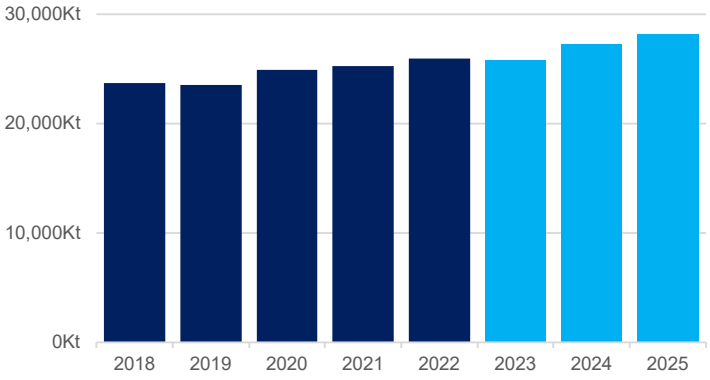
Copper supply[1]



Kt = Thousand tonnes. [1] Copper content from mine production. (a) Mainly South Australia, New South Wales and Queensland.
Source: US Geological Survey, Mineral Commodity Summaries (Annual).

- Western Australia is not a major global copper supplier, ranking as the 14th largest global supplier in 2022.
- Chile is the largest copper supplier in the world, accounting for 24% of global supply in 2022.
- Western Australia accounted for 17% of Australia's copper production in 2022.
- Global copper supply rose 32% to 22 million tonnes between 2012 and 2022, mainly driven by increased supply from the DRC.
- In 2022, copper supply from:
  - Chile fell 7% to 5.2 million tonnes
  - DRC rose 26% to 2.2 million tonnes
  - Peru fell 4% to 2.2 million tonnes
  - China fell 1% to 1.9 million tonnes
  - Western Australia fell 6% to 143,000 tonnes.

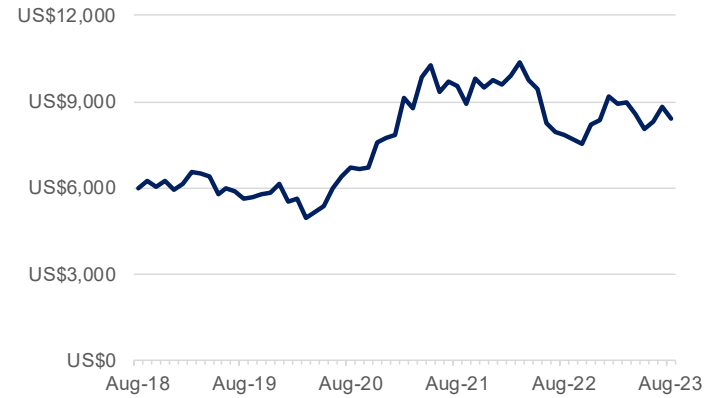
Copper consumption



Kt = Thousand tonnes.
Source: Office of the Chief Economist, Resources and Energy Quarterly (Quarter).

- Copper is used in building construction, power generation and transmission, electronic product manufacturing and in the production of industrial machinery and transport vehicles. Building and infrastructure construction accounts for 45% of the world's consumption of copper, with 31% of copper consumed in equipment manufacturing, 12% in transport vehicles and 12% used for industrial uses.
- Electric vehicle motors, batteries and charging infrastructure require significant amounts of copper. Electric vehicles require five times more copper than vehicles with internal combustion engines.
- World copper consumption rose 3% to 26.0 million tonnes in 2022.
- The Office of the Chief Economist forecasts world copper consumption will rise 8% to 28.2 million tonnes between 2022 and 2025.

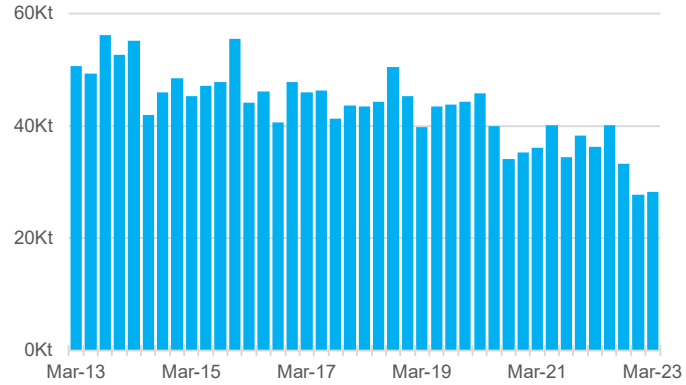
Copper prices[1]



[1] US dollars a tonne. London Metal Exchange (LME) Grade A Cash.
Source: S&P Global Market Intelligence/Thomson Reuters (Month).

- Copper prices fell in August 2023 due to weaker copper demand in China's property sector and a stronger US dollar.
- The monthly average copper price fell 4% to US$8,405 a tonne in August 2023.
- The annual average copper price fell 13% to US$8,308 a tonne in 2022-23.
- The Office of the Chief Economist forecasts the annual average price of copper will be US$8,502 a tonne in 2024 and US$8,463 a tonne in 2025.

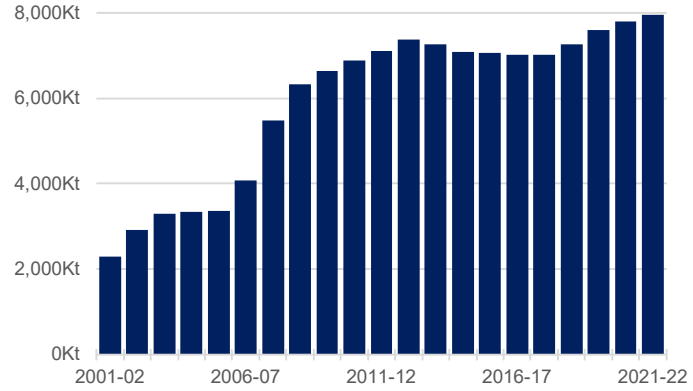
Copper production[1] from Western Australia



Kt = Thousand tonnes. [1] Copper content from mine production.
Source: Office of the Chief Economist, Resources and Energy Quarterly (Quarter).

- Western Australia's copper production mainly comes from mines that also produce gold or nickel.
- The DeGrussa copper-gold mine is Western Australia's largest copper mine, accounting for 35% of the State's paid copper mine production in 2022. However, copper production ended at the DeGrussa mine in the September quarter 2022 due to resource depletion.
- Boddington, Western Australia's largest gold mine, is also the State's second largest copper mine, accounting for 33% of the State's paid copper mine production in 2022.
- Other major copper mines in Western Australia are the Golden Grove copper-gold mine (11%), Telfer gold-copper mine (10%) and Nova-Bollinger nickel-copper mine (7%).
- Western Australia produced 28,000 tonnes of copper in the March quarter 2023, 2% more than in the previous quarter.

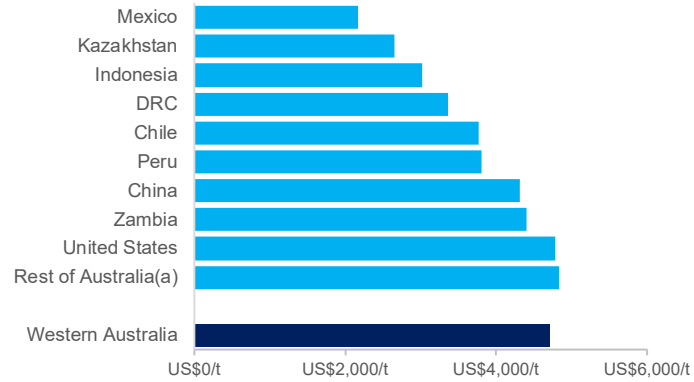
Copper resources in Western Australia[1]



Kt = Thousand tonnes. [1] Estimated based on 8% of Australia's identified copper resources.
Source: Based on data from ABS 5204.0 Australian System of National Accounts (Annual), Geoscience Australia, Australia's Identified Mineral Resources (Annual); and WA Department of Jobs, Tourism, Science and Innovation.

- Western Australia's copper reserves accounted for 1% of the world's copper reserves in 2022.
- Chile has the largest copper reserves, accounting for 21% of the world's copper reserves in 2022.
- Western Australia's estimated economic demonstrated copper resource has increased steadily over the past 4 years.
- In 2021-22, Western Australia's estimated economic demonstrated copper resource rose 2% to 8.0 million tonnes. This resource could sustain the State's copper production for 58 years at 2021-22 production rates.
- The value of Western Australia's copper exploration expenditure fell 26% to $188 million in 2022-23.

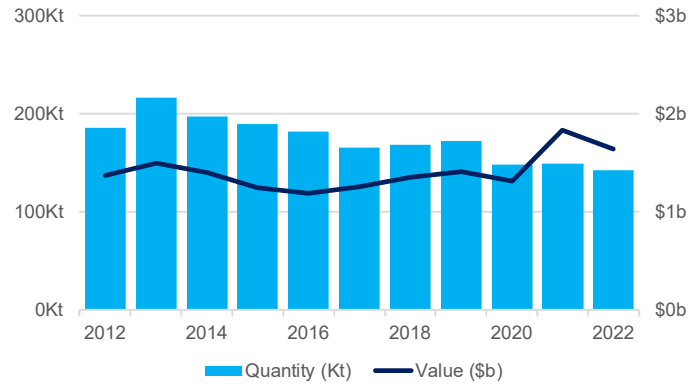
Copper production costs per unit[1]: 2022



Note – Includes the top 10 global producers and Western Australia only.
[1] Total cash costs per tonne of paid copper production in US dollars on a co-product or shared cost basis.
Source: S&P Global Market Intelligence (Annual).

- Western Australia's copper producers are reasonably cost-competitive against other global producers. Western Australia's copper production has relatively low costs for chemicals, energy and royalties, but relatively high costs for labour, onsite services and seaborne shipment.
- The average total cash cost of Western Australia's copper production was US$4,709 a tonne in 2022, above the world average of US$3,902 a tonne.

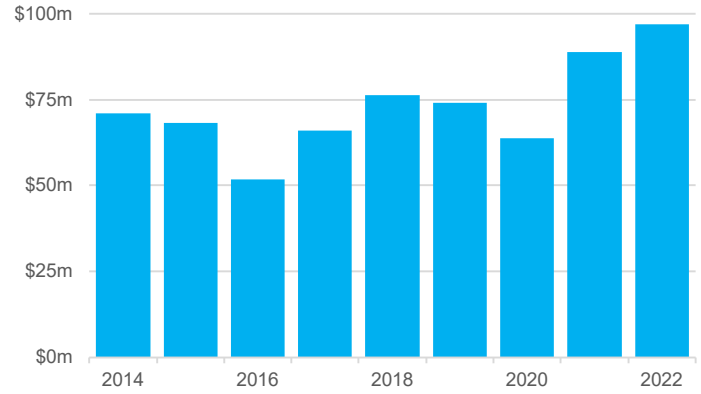
Copper sales from Western Australia



Kt = Thousand tonnes.
Source: WA Department of Mines, Industry Regulation and Safety, Resource Data Files (Bi-Annual).

- Copper produced in Western Australia is exported mainly as concentrates for further refining in overseas facilities.
- South Korea is Western Australia's largest market for copper, accounting for 28% of the State's copper exports in 2022. Other major copper export markets in 2022 were the Philippines (20%), Japan (16%) and Germany (13%). China was the State's largest market for copper prior to imposing restrictions on Australian copper imports in 2020.
- The quantity of Western Australia's copper sales fell 5% to 142,000 tonnes in 2022.
- The value of Western Australia's copper sales fell 11% to $1.6 billion in 2022.
- The West Musgrave copper project was sanctioned for development in September 2022. The project will produce 32,000 tonnes of copper concentrate a year, starting in the second half of 2025.
- Western Australia has a number of proposed copper projects that if developed would add around 60,000 tonnes of annual copper production from 2026. Proposed projects include Caravel, Winu and Sulphur Springs.

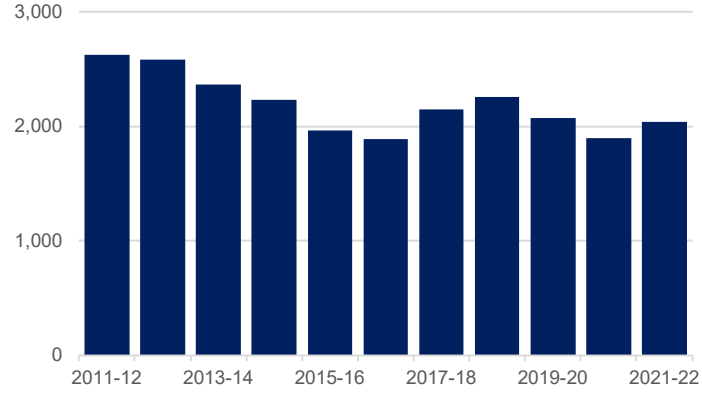
Copper[1] royalty revenue in Western Australia



[1] Includes lead and zinc.
Source: WA Department of Mines, Industry Regulation and Safety, Resource Data Files (Bi-Annual).

- Western Australia has a 5% royalty rate on the value of copper sold as concentrate.
- Copper accounted for 0.8% of Western Australia's royalty revenue (including North West Shelf grants) in 2022.
- Copper royalties in Western Australia rose 9% to $97 million in 2022.

Copper employment in Western Australia[1]

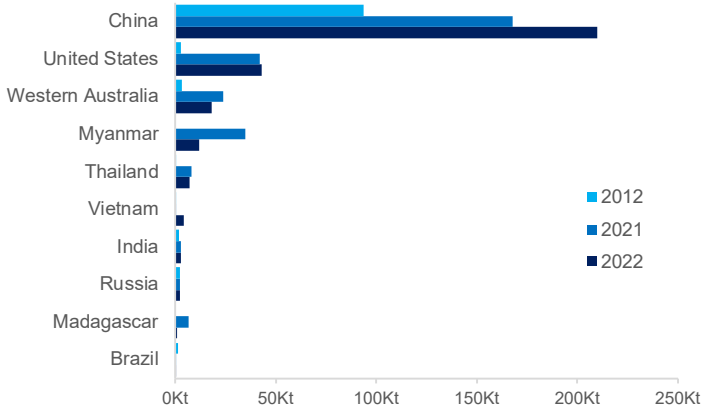


[1] Direct employment. Full-time equivalent (average on site).
Source: WA Department of Mines, Industry Regulation and Safety, Resource Data Files (Bi-Annual).

- Direct full-time equivalent employment in Western Australia's copper industry rose 8% to 2,037 in 2021-22.
- Western Australia's largest employing copper mine sites in 2021-22 were:
  - Golden Grove (879)
  - DeGrussa (477)
  - Jaguar (271).

Rare earths

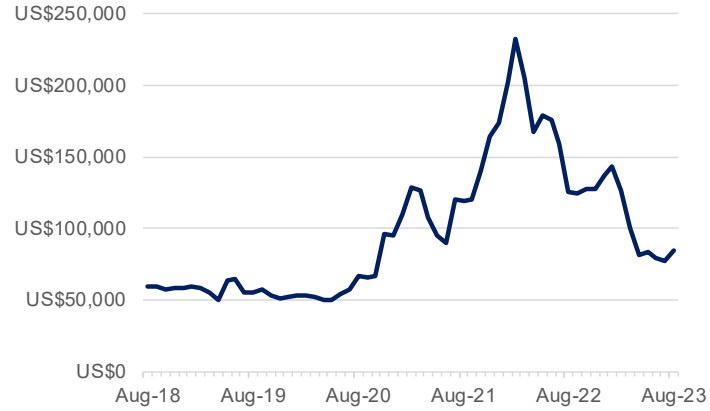
Rare earths supply[1]



Kt = Thousand tonnes. [1] Rare earth oxide equivalent content from mine production.
Source: US Geological Survey, Mineral Commodity Summaries (Annual).

- Western Australia is the 3rd largest rare earths supplier in the world, accounting for 6% of global supply in 2022.
- China is by far the largest rare earths supplier in the world, accounting for 70% of global supply in 2022.
- Western Australia accounted for 100% of Australia's rare earths production in 2022.
- Global rare earths supply almost tripled to 300,000 tonnes between 2012 and 2022, mainly driven by increased supply from China.
- In 2022, rare earths supply from:
  - China rose 25% to 210,000 tonnes
  - United States rose 2% to 43,000 tonnes
  - Western Australia fell 25% to 18,000 tonnes.

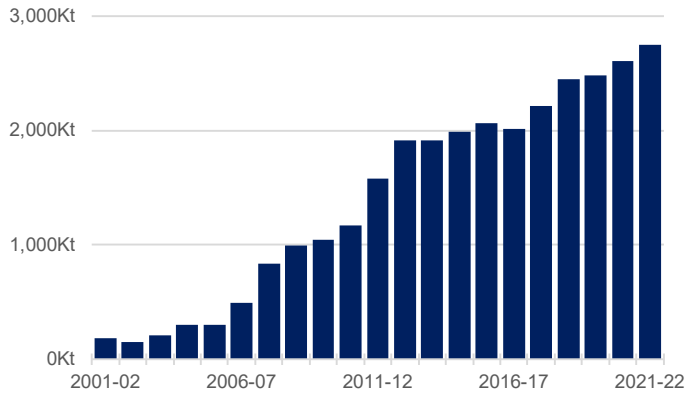
Neodymium prices[1]



[1] US dollars a tonne.
Source: WA Department of Jobs, Tourism, Science and Innovation based on data from Trading Economics.

- Rare earths are used in high-tech consumer products and defence applications.
  - Neodymium is used in electric vehicle motor magnets and wind turbines.
  - Praseodymium is used in aircraft engines.
  - Cerium is used in catalytic converters for cars.
  - Lanthanum is used in lenses for cameras and telescopes.
- Neodymium prices rose in August 2023 due to neodymium supply constraints.
- The monthly average neodymium price rose 9% to US$84,378 a tonne in August 2023.
- The annual average neodymium price fell 29% to US$118,122 a tonne in 2022-23.

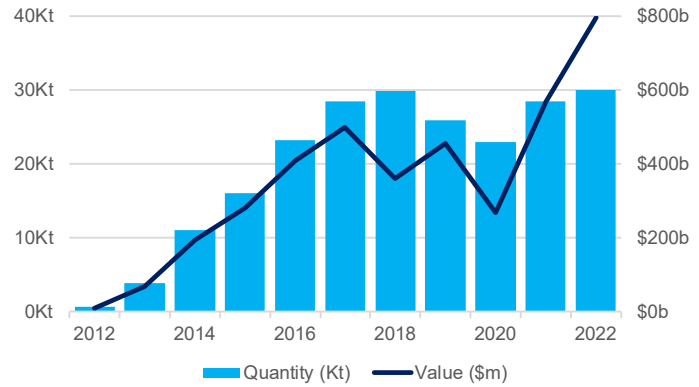
Rare earths resources in Western Australia[1]



Kt = Thousand tonnes. [1] Estimated based on 60% of Australia's identified rare earths resources.
Source: Based on data from ABS 5204.0 Australian System of National Accounts (Annual), Geoscience Australia, Australia's Identified Mineral Resources (Annual); and WA Department of Jobs, Tourism, Science and Innovation.

- Western Australia's rare earths reserves accounted for 2% of the world's rare earths reserves in 2022.
- China has the largest rare earths reserves, accounting for 35% of the world's rare earths reserves in 2022.
- Western Australia's estimated economic demonstrated rare earths resource has increased significantly over the past 5 years.
- In 2021-22, Western Australia's estimated economic demonstrated rare earths resource rose 5% to 2.7 million tonnes. This resource could sustain the State's rare earths production for 110 years at 2021-22 production rates.

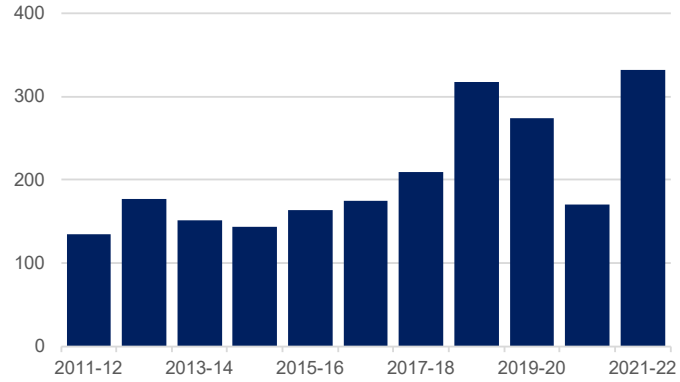
Rare earths sales from Western Australia



Kt = Thousand tonnes. Note – Values in some years are estimated using average unit prices.
Source: WA Department of Mines, Industry Regulation and Safety, Resource Data Files (Bi-Annual) and WA Department of Jobs, Tourism, Science and Innovation.

- Western Australia is one of the world's largest rare earths producers outside of China, with production mainly coming from the Mt Weld mine.
- In 2022, the quantity of Western Australia's rare earths sales rose 6% to 30,000 tonnes.
- The value of Western Australia's rare earths sales rose 40% to $797 million in 2022.
- The production capacity of the Mt Weld mine is being expanded by 12,000 tonnes of neodymium praseodymium equivalent a year by 2025.
- A rare earths processing plant is being constructed in Kalgoorlie to process rare earths concentrate from the Mt Weld mine. The plant will produce 38,000 tonnes of rare earths carbonate a year by 2025.
- In April 2022, the Eneabba rare earths refinery was sanctioned for development, after receiving a $1.25 billion loan from the Australian Government. Construction of the 20,000 tonnes a year facility started in 2022 with first production expected in 2025.
- Early construction works started on the Yangibana rare earths project in 2022. The project is targeting first production in late 2024 (15,000 tonnes a year).
- The Browns Range Stage 2 project is another proposed rare earths development in Western Australia (3,000 tonnes a year). The Browns Range pilot plant operated between 2018 and 2021.

Rare earths employment in Western Australia[1]



[1] Direct employment. Full-time equivalent (average on site).
Source: WA Department of Mines, Industry Regulation and Safety, Resource Data Files (Bi-Annual).

- Direct full-time equivalent employment in Western Australia's rare earths industry rose 95% to 332 in 2021-22.
- Western Australia's largest employing rare earths mine and processing sites in 2021-22 were:
  - Mt Weld (196).
  - Kalgoorlie Processing Plant (100).
  - Browns Range (36).