CRITICAL MINERALS AND OTHER COMMODITY FORECASTS FOR WESTERN AUSTRALIA TO 2033

A report for

AUSTRALIAN ENERGY MARKET OPERATOR (AEMO)

Prepared by

NATIONAL INSTITUTE OF ECONOMIC AND INDUSTRY RESEARCH (NIEIR)

SEPTEMBER 2023

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September 2023

While the National Institute endeavours to provide reliable forecasts and believes the material is accurate it will not be liable for any claim by any party acting on such information.

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TON921-AEMO – Commodity forecasts for WA to 2033/AEMO/2023/Report

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1. Introduction

The National Institute of Economic and Industry Research (NIEIR) was engaged by the Australian Energy Market Operator (AEMO) to provide supporting forecasts for the Western Australian annual Gas Statement of Opportunities.

These forecasts include economic indicators for Western Australia and commodity production forecasts for key Western Australian minerals.

The commodity production outlooks were forecast by considering the following:

- a consensus of commodity price outlooks;
- future project expansions/closures;
- world market developments and conditions;
- historical production/price movements;
- the impact of emerging new technologies; and
- the world, national and state economic outlooks as captured in NIEIR's economic forecast models.

The short-term outlooks for each commodity were largely based on expected levels of activity at existing and new mining projects. For the medium-term to long-term, the commodity production outlooks were shaped more by the world and Australian economic outlooks and trends within each respective commodity market.

Following a brief review of recent commodity production trends in Western Australia, the remaining sections discuss the outlook for each commodity. Forecasts of commodity production for the base, high and low scenarios to 2033 are presented in Section 13 at the end of this report.

The scope of work is reproduced below.

1.1 Purpose

By 31 December each year, AEMO is required to publish a Gas Statement of Opportunities (GSOO) for Western Australia (WA) in accordance with the WA Gas Services Information (GSI) Rules. Under clause 104 of the GSI Rules, AEMO is required to develop annual gas supply forecasts for a 10-year outlook period and consider future commodity output forecasts, as well as other factors.

1.2 Description of Consultancy Services, Deliverables

The Consultancy Services are commodity output forecasts by calendar year (1 January to 31 December) for the period 2024 to 2033, for three scenarios: expected, high, and low. The forecast report will be published as part of the 2023 WA GSOO supporting materials. The forecasts will be used to determine the domestic gas demand for the WA gas market over the forecast period.

For the avoidance of doubt, the Consultancy Services includes the provision of the following Deliverables:

Deliverable	Description
Deliverable 1 – Commodities outlook report (Draft)	The Consultant must provide a written report (in Microsoft Word format and to remain confidential) and corresponding forecast data (in Microsoft Excel). As a minimum, for the expected, high and low scenarios, the report must: (a) Determine and deliver annual projections of mineral production output for WA for each calendar year over the period, 2024 to 2033 (inclusive) for the following minerals: ■ Iron ore; ■ Alumina; ■ Gold; ■ Nickel; ■ Lithium; ■ Copper; ■ Zinc; ■ Ammonia (manufactured product); ■ Mineral sands; ■ Lead; ■ Cobalt. (b) For each mineral listed above, discuss: ■ Any changes to global mineral production output which have occurred over the 12-month period, from 1 July 2022 to 30 June 2023; ■ Any relevant global or Western Australian trends which have contributed to changed production or are expected to influence the annual projections of mineral production output.

Deliverable	Description
	Relevant factors for discussion may include: - Commodity price; - International trade; - Commencement or closure of mines; - Policy or regulatory changes; - Australian Dollar to United States Dollar currency exchange rate.
Deliverable 2 – Commodities outlook report (Final)	The successful Consultant must develop a final written report (in Microsoft Word format and to remain confidential) and corresponding final forecasts (in Microsoft Excel) for Deliverable 1 above, incorporating any feedback provided by AEMO on the draft report and forecasts prior to delivery.

1.3 Acceptance criteria

All tasks must be completed to the reasonable satisfaction of the AEMO Contact and all work is subject to approval by the AEMO Contact, acting reasonably.

1.4 Timetable

Deliverable/Milestone	Due date
Deliverable 1 – Draft written report and commodities and economic forecasts for AEMO review	8 September 2023 or earlier
AEMO to provide comments on **Deliverable 1**	15 September 2023 or earlier
Deliverable 2 – Final written report to AEMO	29 September 2023 or earlier

2. Mining commodity production in Western Australia – value and quantities mined

This section provides an overall picture of mining commodity production in Western Australia. It considers the value of production, volumes and exploration expenditures.

Western Australia mining commodity production by type is shown in Table 2.1 from 2017 to 2022. These are reported as values in Australian dollars. The table also shows the percentage change in the value of each commodity produced between 2017 and 2022 on a calendar year basis.

Western Australia produces a diverse range of minerals and petroleum products. Many of these minerals are considered as 'critical minerals', that is, minerals required to transform the electricity sector to renewables, and shape the expansion in electric vehicles and stationary storage.

Some key battery resources include:

- lithium;
- cobalt;
- nickel;
- graphite; and
- manganese.

Other key commodities are copper, lead, zinc, and steel made from iron ore. Rising actual production quantities for some commodities (such as iron ore) and improved prices led total Western Australian commodity production to reach A$246 billion in 2022.

Whilst Western Australia's overall mining commodity production is diverse, over 89.5 per cent of production values were concentrated in five groups in 2022. These were:

- iron ore (51.4 per cent);
- LNG (20.6 per cent);
- gold (7.3 per cent);
- spodumene (6.6 per cent); and
- condensate (3.7 per cent).

In terms of the value of production, the fastest growing commodity production groups in Western Australia between 2017 and 2022 in terms of average per cent change per annum were:

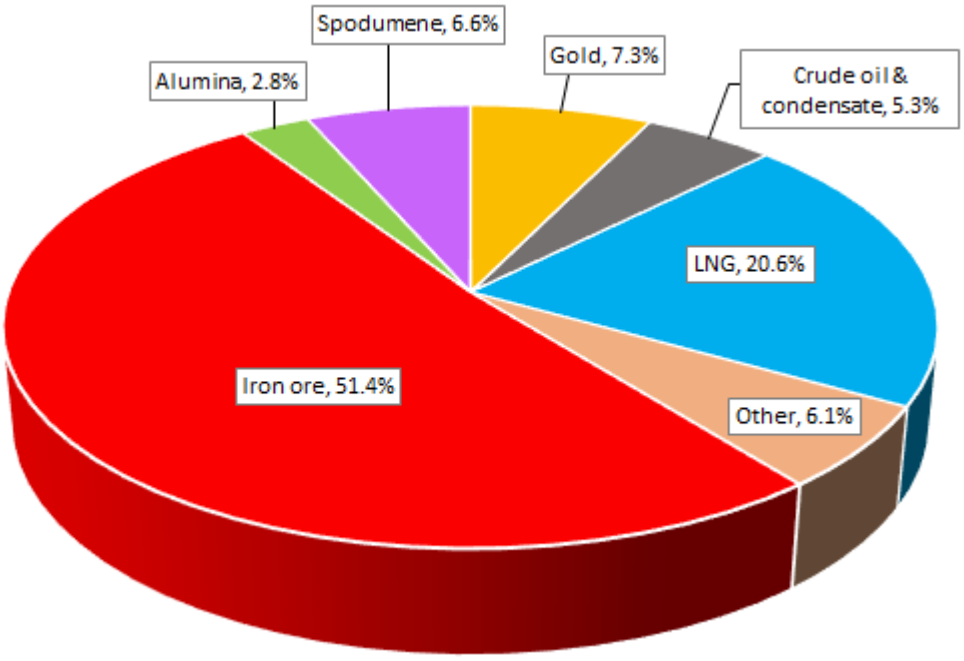
- spodumene (a Lithium ore mineral) (68.4 per cent);
- LNG (27.4 per cent);
- gold (9.9 per cent);
- iron ore (14.6 per cent);
- condensate (28.7 per cent);
- salt (17.9 per cent);
- zircon (48.5 per cent); and
- other mineral sands (33.4 per cent).

The Australian dollar value of Western Australian mining commodities produced is often significantly impacted by commodity prices and the US$ exchange rate. The data in Table 2.1 does not give an accurate picture of the volume of Western Australian commodity production. In volume terms, crude oil and condensate production in Western Australia peaked in 2010, however, has declined since then. The war in Ukraine has led to a sharp increase in world oil and gas prices in 2022. The value of petroleum products production in Western Australia rose from A$38.8 billion in 2021 to A$66.7 billion in 2022.

Table 2.2 shows quantities of mining commodities produced in Western Australia by type from 2017 to 2022. As indicated in Table 2.2, there have been some large production increases over the last nine years in Western Australia. These include the following commodities:

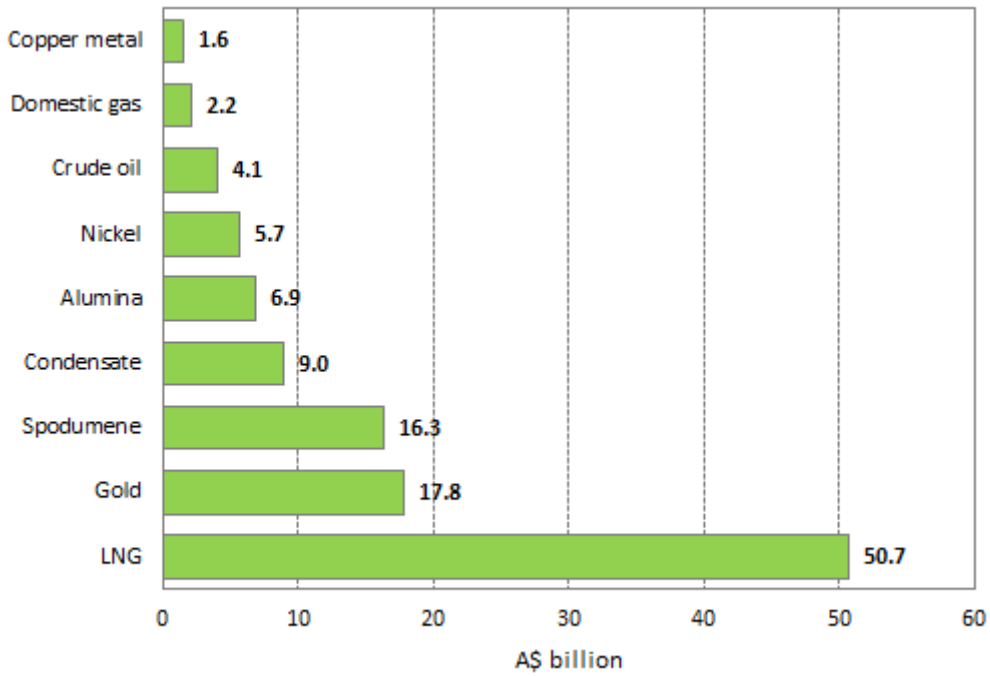
- iron ore (4.9 per cent per annum);
- gold (1.5 per cent per annum)
- LNG (10.5 per cent per annum)
- rare earths (25.3 per cent per annum); and
- spodumene (23.4 per cent per annum).

Figure 2.1: Value of commodity production, Western Australia, 2022 – Main commodities (per cent share)



Source: DMIRS (WA), 2023, Major Commodities Resources Data, 2022.

Figure 2.2: Value of Western Australian mining commodities produced 2022 over A$1 billion, excluding Iron ore (A$ billion)



Source: DMIRS (WA), 2023, Major Commodities Resources Data, 2022.

Table 2.1 Nominal value of Western Australian mining commodities produced – 2017 to 2022								
	Value by year						Average per cent change 2017 to 2022 (%)	Per cent share 2022 (%)
	2017 (A$m)	2018 (A$m)	2019 (A$m)	2020 (A$m)	2021 (A$m)	2022 (A$m)		
Iron ore	63829	65683	99694	118428	157894	126363	14.6	51.4
LNG	14989	27587	27580	19242	27052	50700	27.6	20.6
Gold	11130	11517	13808	17276	16006	17837	9.9	7.3
Spodumene	1199	1863	1317	823	2688	16251	68.4	6.6
Condensate	2555	4742	6779	3561	6776	9021	28.7	3.7
Alumina	5840	7869	7289	5788	5891	6857	3.3	2.8
Nickel	2259	2616	3082	3347	3807	5732	20.5	2.3
Crude oil	2195	2055	2601	1808	2506	4058	13.1	1.6
Domestic gas	1796	1543	1448	1472	1944	2166	3.8	0.9
Copper metal	1256	1350	1415	1311	1831	1638	5.5	0.7
Rare Earths (estimate)	344	362	448	270	334	797	18.3	0.3
LPG – Butane and Propane	288	349	337	219	528	762	21.4	0.3
Salt	274	304	325	431	600	625	17.9	0.3
Zircon	79	166	295	284	484	569	48.5	0.2
Cobalt	381	503	261	281	389	528	6.7	0.2
Other mineral sands	103	104	109	108	459	434	33.4	0.2
Zinc metal	292	257	263	220	286	326	2.2	0.1
Coal	339	327	323	309	318	314	-1.5	0.1
Silver	99	94	96	130	161	127	5.2	0.1
Construction materials	66	79	122	120	133	118	12.3	0.0
Rutile	18	30	34	38	76	115	44.6	0.0
Ilmenite	29	43	50	77	75	75	21.1	0.0
Other minerals	787	1218	1102	1095	786	595	-5.5	0.2
Total	**110146**	**130660**	**168781**	**176641**	**231024**	**246009**	**17.4**	**100.0**
Total petroleum	**21824**	**36275**	**38746**	**26303**	**38806**	**66707**	**25.0**	**27.1**
Total minerals	**88322**	**94385**	**130035**	**150337**	**192218**	**179302**	**15.2**	**72.9**

Note: Calendar year basis.
Source: Department of Mines, Industry Regulation and Safety, Western Australia (DMIRS (WA)), 2023, Major Commodities Resources Data, 2022.

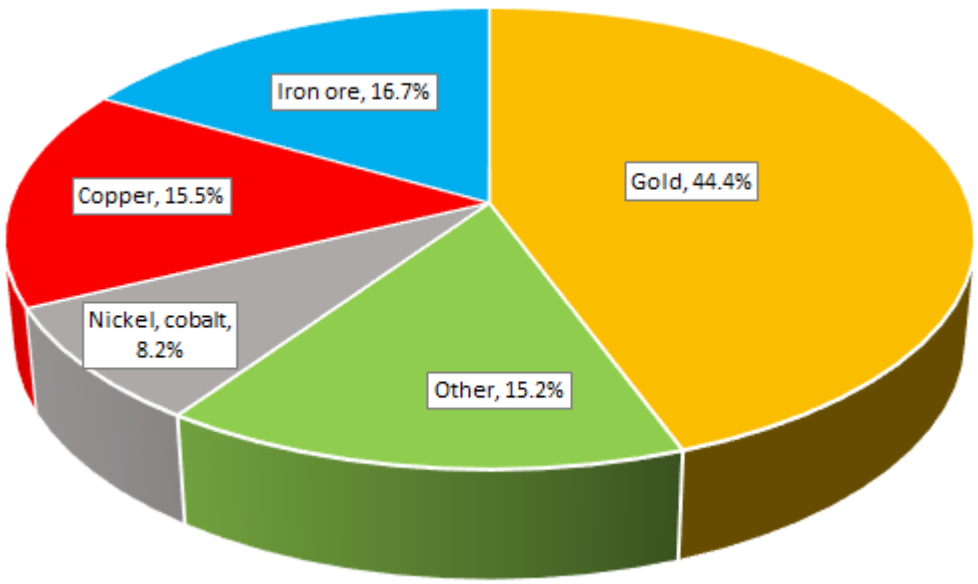
Table 2.2 Quantities of principal mining commodities produced in Western Australia – 2013 to 2022												
	Unit	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Average % change 2013 to 2022
Alumina	Kt	13626	13877	13778	13830	13847	13498	14014	14243	14194	13462	-0.1
Copper metal	Kt	216	197	189	182	166	169	172	148	149	142	-4.5
Lead metal	Kt	52	81	20	5	6	6	3	1	1	0	-100.0
Zinc metal	Kt	48	73	77	95	85	69	78	66	69	69	4.2
Coal	Kt	7087	6211	6946	6739	6815	6466	6239	5620	5273	4789	-4.3
Cobalt	Kt	6	6	6	5	5	5	6	6	5	6	-1.1
Construction materials												
Aggregate	Kt	5528	3151	1768	1026	1076	1450	2418	3403	2451	2232	-9.6
Gravel	Kt	395	172	113	197	287	134	171	106	203	310	-2.7
Rock	Kt	1223	1501	740	261	444	211	534	143	808	573	-8.1
Sand	Kt	6117	7136	4446	2513	2920	3600	2115	2538	3766	4056	-4.5
Gypsum	Kt	1636	612	581	487	679	855	747	504	1007	1426	-1.5
Diamonds	ct '000	10694	10629	12643	9996	15478	15977	15764	13911	46	0	-100.0
Gems and semi-precious stones	Kt	360	664	287	233	274	176	211	179	639	443	2.3
Gold	kg '000	187	195	194	197	211	212	214	210	208	214	1.5
Iron ore	Kt	554938	686234	742394	769278	814120	813578	807366	847132	838246	855073	4.9
Limesand – limestone-dolomite	Kt	4720	4857	4624	4427	4087	3956	4398	4338	4680	4986	0.6
Nickel	Kt	230	219	174	165	165	150	154	165	150	155	-4.3
Manganese	Kt	718	821	543	359	189	555	560	544	524	827	1.6
Mineral sands												
Garnet	Kt	396	275	283	575	364	360	353	296	321	388	-0.2
Ilmenite	Kt	200	14	188	168	129	183	256	333	269	201	0.1
Leucoxene	Kt	33	22	22	7	15	8	21	25	18	16	-8.0
Rutile	Kt	na	40	43	27	17	26	27	43	70	67	na
Zircon	Kt	232	204	215	203	62	97	178	190	275	258	1.2
Synthetic rutile	Kt	na	187	252	287	286	260	213	318	278	244	na
Petroleum products												
Condensate	Kt	5957	4916	6630	6457	6265	8782	12585	11368	12208	11121	7.2
Crude oil	Kl '000	6871	7608	8343	5814	5281	3638	4449	4579	4536	4425	-4.8
LNG	Kl '000	19220	20853	20386	23775	32730	44542	44631	44064	45659	47394	10.5
LPG – Butane and Propane	Kt	686	358	502	576	456	463	519	453	646	707	0.3
Domestic gas	million m3	9298	9590	10017	10044	10148	10223	10885	10774	9966	10427	1.3
Rare earths	Kt	3943	11027	16029	23274	28430	29932	25955	22985	28437	30075	25.3
Salt	Kt	12900	12998	11390	10410	11675	12894	11474	11542	12214	11681	-1.1
Silica – Silica sands	Kt	439	487	550	587	884	1006	998	940	770	1210	11.9
Silver	Kg '000	126	147	150	158	150	144	132	128	182	129	0.3
Spodumene	Kt	405	445	440	522	1707	1966	1588	1477	1967	2684	23.4

Note: Calendar year basis.
Source: DMIRS (WA), 2023, Major Commodities Resources Data, 2022.

Table 2.3	Australian metals and other minerals private exploration expenditure, Australia 2008-09 to 2022-23 ($ million)								
	Copper	Diamonds	Gold	Iron ore	Mineral sands	Nickel, cobalt	Silver, lead and zinc	Other	Total metals and other minerals
2008-09	179	10	438	589	31	260	81	154	1741
2009-10	202	4	575	524	16	204	52	147	1724
2010-11	323	1	652	665	6	271	76	196	2190
2011-12	443	3	768	1151	20	265	88	199	2937
2012-13	319	6	662	1011	38	165	80	161	2442
2013-14	177	8	434	711	21	99	46	156	1653
2014-15	144	5	396	448	27	83	52	129	1284
2015-16	130	4	548	291	20	51	50	113	1207
2016-17	136	2	689	291	20	81	55	145	1419
2017-18	193	8	810	292	27	200	103	176	1810
2018-19	329	9	967	324	36	203	89	194	2151
2019-20	420	5	1162	361	37	203	59	215	2461
2020-21	377	4	1530	473	37	210	65	222	2917
2021-22	585	5	1594	646	58	276	91	365	3620
2022-23 (est.)	600	3	1367	683	72	330	103	586	3744
5 year average	462	5	1324	497	48	244	81	317	2979
Per cent share	15.5	0.2	44.4	16.7	1.6	8.2	2.7	10.6	100.0

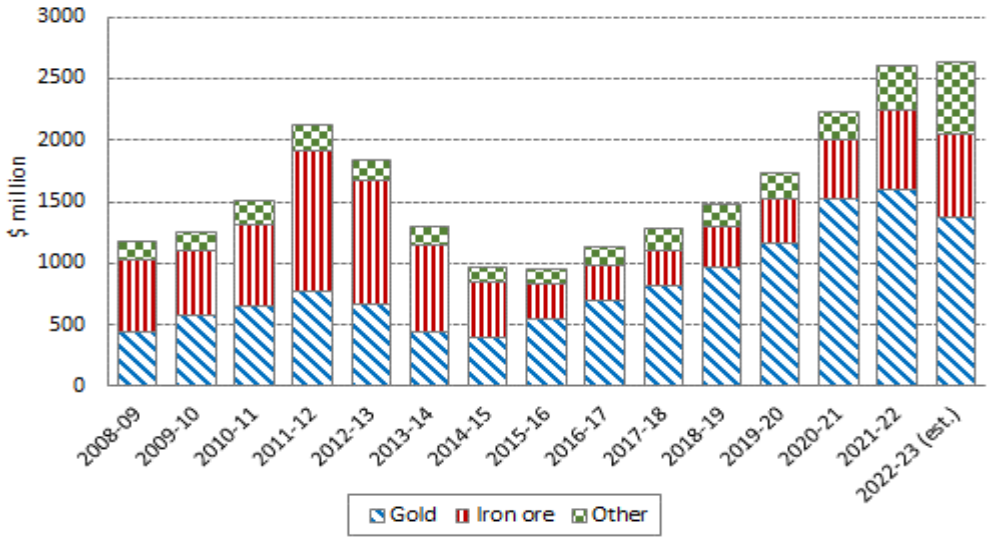
Note: Excludes petroleum exploration and uranium and coal exploration.
Source: Mineral and Petroleum Exploration, Australia, ABS, March 2023.

Figure 2.3: Australian metals and other minerals exploration expenditure – percentage share by mineral group, 2022-23 (%)



Note: Excludes petroleum exploration and uranium and coal exploration.
Source: Mineral and Petroleum Exploration, Australia, ABS, March 2023.

Figure 2.4: Western Australian private exploration expenditure – Selected metals and other minerals ($m) 2008-09 to 2022-23



Note: Excludes uranium and coal.
Source: Mineral and Petroleum Exploration, Australia, ABS, March 2023.

Australian metals and other minerals private exploration expenditure over the last 10 years is shown in Table 2.3.

In 2022-23, total mineral exploration expenditure in Australia reached A$3.7 billion. Total exploration expenditure over the last three years was A$10.3 billion.

The increase in metals prices since 2020-21 has seen exploration expenditures increase across all metals and other minerals. The high gold price led to exploration expenditure of A$1.6 billion in 2021-22. Copper, iron ore, nickel, silver and mineral sands exploration expenditures all rose in 2022-23.

In Western Australia, the largest exploration expenditures are in gold, iron ore and nickel.

Figure 2.4 shows private mineral and metal exploration expenditure for Western Australia since 2008-09. Exploration expenditure in 2022-23 was a record $2.5 billion. Western Australia accounted for nearly 67 per cent of total national mineral and metal exploration expenditure in 2022-23. Record exploration levels in Western Australia were recorded for gold, copper, lead, silver and other minerals.

Table 2.4 shows Australia's world ranking of mineral resources in December 2021 in terms of share of world resources and share of world production.

Net zero emissions

Most mineral production companies in Australia have adopted policies or pathways towards reducing their carbon footprint.

New initiatives in this area include the following:

- Sourcing the mine and concentrator power requirements from renewable energy sources such as solar (sometimes adjacent to the mine site);
- Examining new technologies in the refining processes (often with funding assistance from ARENA); and
- Powering downstream processing using renewable energy such as wind and solar.

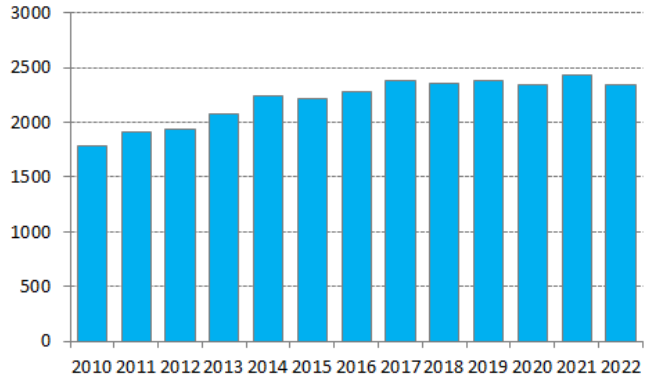
Table 2.4 Australia's world ranking for selected minerals and metals in terms of reserves and share of production, December 2021

Mineral	World ranking for resources	Resource as a share of world (%)	Share of world production (%)
Bauxite	3	12	27
Black coal	4	10	8
Cobalt	2	20	3
Copper	2	11	4
Gold	1	22	10
Iron ore	1	31	36
Lead	1	40	11
Lithium	2	29	53
Nickel	1	23	6
Rutile	1	63	26
Zinc	1	27	10
Zircon	1	72	30

Source: Australia's Identified Mineral Resources, 2022, Geoscience Australia, Table 5, Digital publication, 2023.

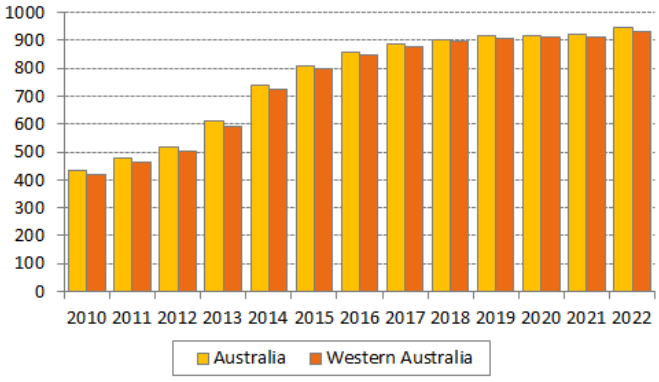
3. Iron ore

Figure 3.1: Iron ore production – World (million tonnes)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023.

Figure 3.2: Iron ore production – Australia and Western Australia (million tonnes)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023.

Global iron ore production was 2,339 million tonnes in 2022, down 90 million tonnes or 3.7 per cent. Global iron ore production, however, has risen solidly over the last 10 years, rising at just under 2 per cent per annum.

World production of iron ore in 2022 was impacted by a number of factors, including:

- reduced steel production in China, partly reflecting China's zero-COVID policy in 2022;
- continued weakness in China's residential property sector;
- reduced production by Brazil; and
- reduced European imports of Russian iron ore as a result of the war in Ukraine.

Production from Guinea's Simandou mine is set to ramp up from mid-2025. This mine and associated infrastructure is expected to produce between 150 and 200 million tonnes of iron ore.

Australian production of iron ore was 944 million tonnes in 2022, up 22 million tonnes on 2021 production. Western Australia accounted for 98.9 per cent of Australian iron ore production in 2022.

Iron ore is mined across many countries. In 2022 the largest producing countries were Australia (33.8 per cent), Brazil (15.8 per cent), China (14.6 per cent) and India (11.2 per cent).[1] Both Russia and Ukraine are significant producers of iron ore (around 3 per cent each).

Iron ore is principally used in the production of crude steel. Around 98 per cent is used in steel production and the remaining 2 per cent in paints, inks and dyes.

Production of crude steel world-wide in 2022 was 1,885 million tonnes. World crude steel production has been growing rapidly, increasing by 21 per cent over the last 10 years.[2] The key applications of steel are in infrastructure and equipment. These include:

- engineering infrastructure such as railways, bridges, roads and heavy engineering (manufacturing);
- non-residential building construction such as shopping centres, hotels, sports and entertainment facilities;
- residential building including apartments, houses and semi-detached dwellings;
- mechanical equipment (e.g. motors, power tools) and transport equipment (motor vehicles, trains, shipping); and
- other appliances and equipment.

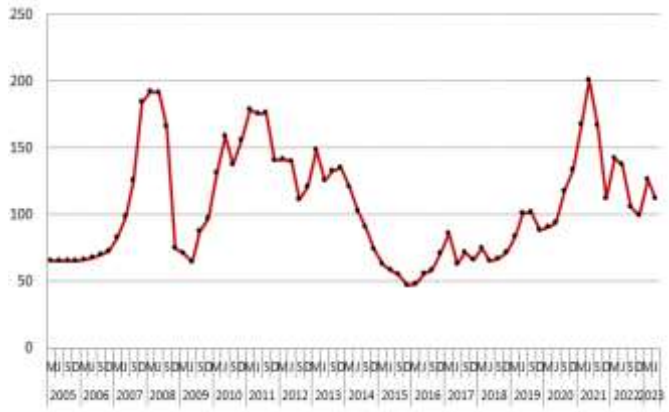
[1] Mineral Commodity Summaries 2023, Iron Ore, US Geological Survey, 2023.

[2] World Steel in Figures, World Steel Association, 2023, www.worldsteel.org.

Australia's Economic Demonstrated Resources (EDR) of iron ore in 2021 was 56,646 million tonnes.[3] Australian resources of iron ore are 31 per cent of world resources in 2021. Due to sustained exploration expenditures, Australian iron ore reserve estimates have been increasing.

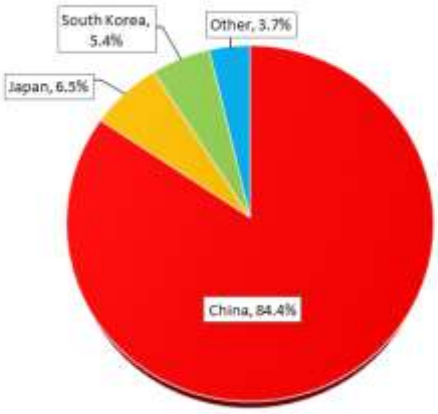
In 2021, 87 per cent of Australia's iron ore resources were located in Western Australia, with 11 per cent in South Australia. In 2021, there were 44 iron ore mines operating in Australia.

Figure 3.3: Iron ore nominal price (US$/dmtu)



Source: World Bank, August 2023.

Figure 3.4: Percentage share of Australian iron ore exports by destination, 2022 (%)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023.

China dominates world steel production, producing 1,018 million tonnes in 2022, representing 54 per cent of world crude steel production. Another 19.4 per cent of world crude steel production is located in India, Japan, the United States and Russia. Australian steel production was only 5.7 million tonnes in 2022, or 0.3 per cent of world production. Australian iron ore production has been directly fuelled by growing crude steel production in China.

Australian exports of iron ore in 2022 were 883.9 million tonnes, an increase of 1.5 per cent on 2021.[4] A fall in iron ore pieces led the value of iron ore exports to fall to A$124.1 billion in 2022, compared to A$154.7 billion in 2021. China remained the dominant destination for iron ore exports, accounting for 84 per cent of total Australian exports in volume terms. In 2022, Japan and South Korea accounted for 6.5 per cent and 5.4 per cent of exports respectively.

In 2021-22, the annual value of Australian iron ore exports accounted for 60.9 per cent of total mineral resource exports. The second largest was gold at 10.7 per cent.

After rising sharply following the pandemic in 2021, iron ore prices fell over 2022 with new production coming on-line and weaker demand from Chinese steel mills. In December quarter 2022 the iron ore price was US$99.25 per dmt. Iron ore prices recovered slightly over the first six months of 2023, averaging US$113.5 in June 2023.

With the expected recovery in China's economic growth over 2024 and 2025, along with the ramp up in production from new mines, iron ore prices could be expected to ease over 2024 and 2025.

Australian production of iron ore has risen substantially over the last decade. Production has nearly doubled over the last 10 years from 519 million tonnes in 2012 to 944 million tonnes in 2022. Nearly all of iron ore mined is exported from Australia.

The major producers of iron ore in Australia are BHP, Rio Tinto and Fortescue Metals Group. All these producers have large mining deposits in Western Australia. In 2022, production by these three companies accounted for over 85 per cent of Australia's total iron ore production of 944 million tonnes.

Australia's major producers of iron ore, BHP, Rio Tinto and Fortescue Metals, over the 2021 to 2023 period, all undertook major capacity expansions or replacing depleted resources.

[3] Australia's Identified Mineral Resources, 2022, Geoscience Australia, 2023.

[4] Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023.

Total new capacity increased by 207,000 tonnes in 2021, reflecting:

- BHP's South Flank project;
- Rio Tinto's West Angelas, Mesa Robe Valley, and Western Turner projects; and
- Fortescue Metals Group's (FMG) Eliwana Western Hub.

Over 2022 and 2023, additional capacity came on-line, including

- Rio Tinto's Gudai Darri (43,000 kt); and
- FMG's Iron Bridge magnetite project (22,000 kt).

A number of smaller magnetite and hematite projects have recently been commissioned in Western Australia.

Mineral Resources is currently developing the Onslow Iron Project. The project is forecast to ship around 35 million tonnes of iron ore and have a mine life of over 30 years. The first ore from this project is expected by mid-2024. Prospective Western Australian iron ore projects are shown in Table 3.1.

Australian production of iron ore is set to increase over the medium term, however, prices are expected to ease. Iron ore prices eased in the June quarter 2023 as global economic growth slowed.

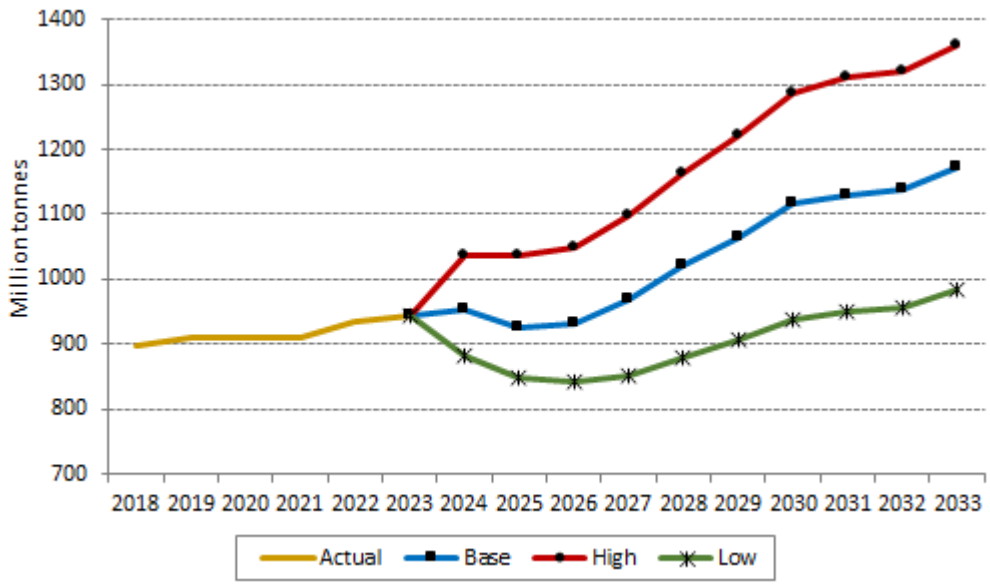
Figure 3.5 shows the forecasts for iron ore production for Western Australia to 2033 by scenario.

Table 3.1 Prospective major iron ore projects – Western Australia

Company	Project	Resource (kt)	Estimated timing
Atlas Iron/Hancock Prospecting	Hardey Project	10,000	2024+
Atlas Iron/Hancock Prospecting	Sanjiv Ridge (Stage 2)	10,000	2025+
FI JV Ltd	Yalgoo	12,500	2025+
Brockman Resources/Mineral Resources	Marillana and Opthalima – Pilbara	20,000	2027+
Fortescue Metals Group	Nyidinghu	40,000	2028+
Cashmere Iron	Cashmere Downs	20,000	2027+

Sources: Company websites, reports, ASX company announcements.

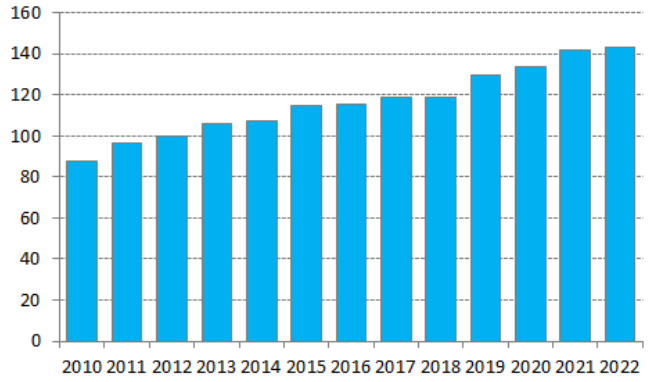
Figure 3.5: Western Australian iron ore production to 2033 by scenario (million tonnes)



Note: Actuals = 2018 to 2022; Estimate = 2023; Forecasts = 2024 to 2033.
Sources: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023 and NIEIR.

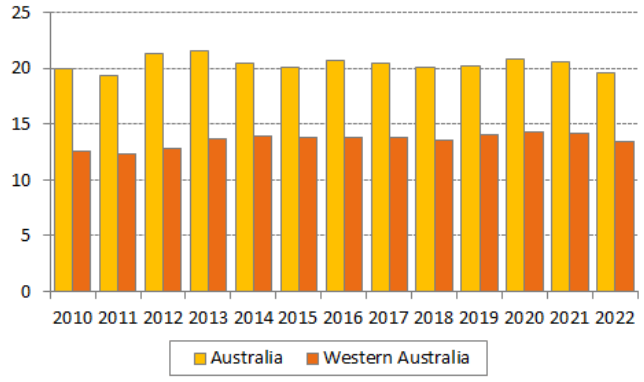
4. Alumina

Figure 4.1: Alumina production – World (million tonnes)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023.

Figure 4.2: Alumina production – Australia and Western Australia (million tonnes)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023.

World alumina production was 143.1 million tonnes in 2022. Over the last 10 years, world alumina production has grown by an average rate of 3.7 per cent per annum, supported by growing demands for aluminium from road, air and sea transport sectors, as well as consumer durables and consumables. World aluminium production has risen at an average rate of 3.4 per cent per annum over the last 10 years.

China dominates world production of alumina, accounting for 54.3 per cent of total production in 2022. In 2022, Australia (14.3 per cent) and Brazil (7.9 per cent) were the next largest producers by country.

Australian alumina production has remained flat over the last decade, at around 20 million tonnes per annum. Despite some capacity expansions at some Australian alumina refineries, Rio Tinto closed the Gove Alumina refinery in 2014 which had a nameplate capacity of 2 million tonnes.

Bauxite

Australia's EDR of bauxite was 3,565 million tonnes in December 2021.[5] This represents 12 per cent of world bauxite resources. Australia is ranked number one in terms of bauxite production, representing 21 per cent of world production in 2021. The majority of Australia's bauxite resources in 2021 were located in Queensland (59 per cent) and Western Australia (37 per cent).

World production of bauxite was 386.4 million tonnes in 2022. Bauxite production in Australia in 2022 was 102.3 million tonnes, 26.5 per cent of global production. The two other major bauxite producing countries in the world are China (23.4 per cent) and Guinea (22.4 per cent).

There are six major bauxite mines in Australia. These are:

- Bauxite Hills mine (Queensland);
- Weipa (Queensland);
- Gove (Northern Territory);
- Boddington (Western Australia);
- Huntly (Western Australia); and
- Willowdale (Western Australia).

There are three more smaller new mines operating at the exploration or approvals stage, bringing the total to nine mines.

Australian exports of bauxite in 2022 were 35.9 million tonnes, or 35.1 per cent of Australian production. The export share of bauxite in Australia has risen very rapidly over the last decade. The export share in 2012 was only 13.6 per cent.

[5] Australia's Identified Mineral Resources, 2022, Geoscience Australia, Digital publication, 2023.

Alumina

Alumina is a white powder, known as alumina oxide. Alumina is usually smelted into aluminium, although there are some direct primary uses of alumina in metallic paint, spark plug insulators and in rocket boosters. Aluminium is extensively used in transport, construction and packaging. Aluminium is a key component in aircraft construction, motor vehicles, boating and shipping. In construction, aluminium is used in doors, windows and fittings. Many consumer durables are cladded in aluminium and drinks are sold in aluminium cans.

Alumina is a manufactured product produced from bauxite mined in Western Australia, Queensland and the Northern Territory. Alumina refineries use the Bayer process to produce alumina from bauxite and caustic soda. Figure 4.3 provides an overview of the process from bauxite to aluminium.

Australian exports of alumina in 2022 were A$8.9 billion, up A$1.1 billion on 2021 exports. The volume of exports in 2022 from Australia was 17.2 million tonnes, down on 2021 exports of 18.4 million tonnes. Some of Western Australia's alumina production is shipped directly to the Portland Aluminium Smelter in Victoria.

Australian production of alumina is located at refineries in Western Australia and Queensland. Queensland has two large alumina refineries located in or near Gladstone, the Queensland Alumina Limited (QAL) and the Yarwun refinery (Rio Tinto) at Yarwun. Total alumina refining capacity is some 7.4 million tonnes per annum. Production of alumina in 2022 fell to 6.4 million tonnes by Rio Tinto, due to plant outages.

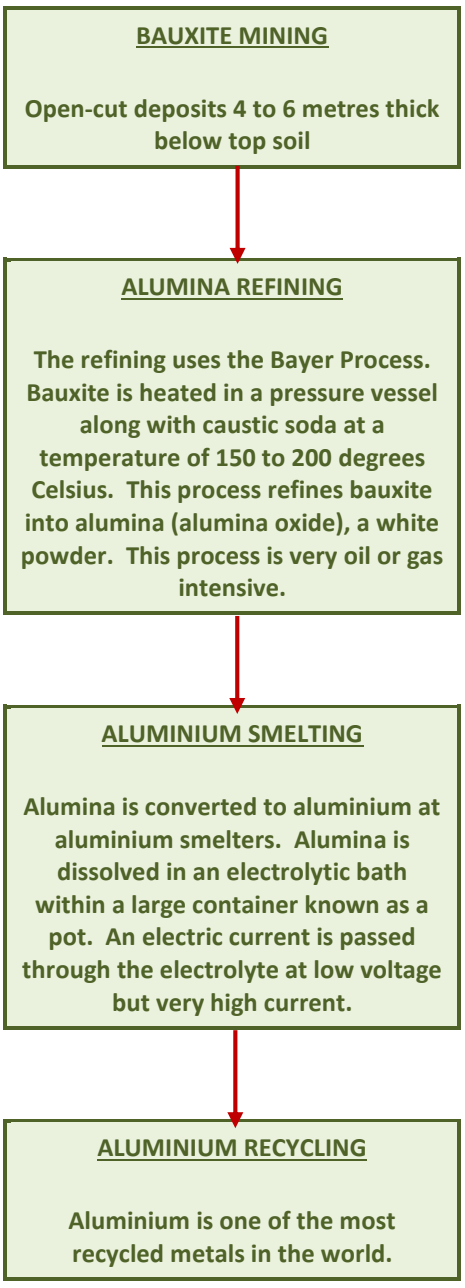
Total alumina refining capacity in Western Australia is some 14.5 million tonnes per annum. Table 4.1 shows the alumina refinery capacity for Western Australia and Queensland. In Western Australia, Alcoa owns three refineries totalling 9.8 million tonnes, while South32 holds a majority interest in Worsley Alumina. Western Australian production of alumina in 2022 was 13.5 million tonnes, down from 2021 production of 14.2 million tonnes.[6]

After initially falling with the pandemic, like many other metals prices, alumina prices rose sharply over 2021 and early 2022. The A$ alumina price peaked at A$611 per tonne in November 2021, some 64 per cent above the November 2020 price. The price peaked again in April 2022 at A$622 per tonne but has eased significantly over the remainder of 2022 and early 2023. The A$ alumina price in the March quarter 2023 was 355 per tonne.

In the short-term, an improvement in the operating performance at Australia's alumina refineries should bring Australian production back to 20 million tonnes per annum. Bauxite production will also expand with this, as well as an expansion of 3.5 million tonnes at Metro Mining's Bauxite Hills mine in Queensland.

Figure 4.6 shows the forecasts for alumina production by calendar year for Western Australia to 2033 by scenario.

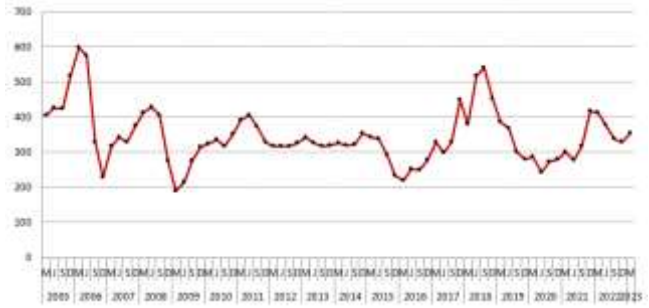
Figure 4.3: From bauxite to aluminium



Sources: Alumina Limited, Alcoa, company websites.

[6] DMIRS (WA) 2023 Major Commodities and Resources, 2022.

Figure 4.4: Alumina export value (A$/t)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023.

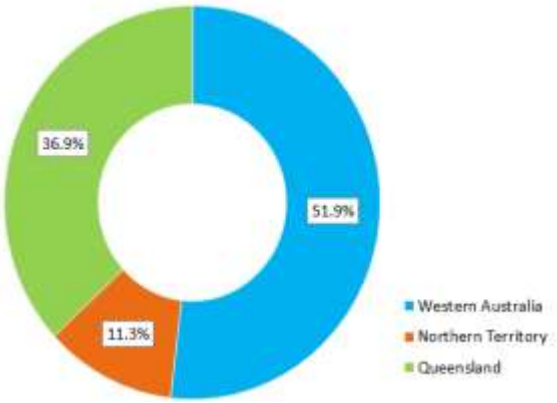
Australian production of alumina is expected to rise to just over 20 million tonnes under the Base scenario. Western Australian production of alumina will remain at between 14 and 15 million tonnes.

Planned expansions at Pinjarra and Wagerup were announced in 2020. Both expansions have been deferred. Alumina Limited also announced expansion plans in 2021, however, these again were deferred.

In 2022, Alcoa announced a proposal to expand mining and increase production at its Pinjarra Alumina refinery. Alcoa has applied to the EPA for approval, which may be assessed by March 2024. The proposal includes the following:

- an increase in alumina production by 5 per cent from 5.0 Mtpa to 5.25 Mtpa; and
- an increase in bauxite mining to supply up to 2.5 Mtpa for export.

Figure 4.5: Share of Australian bauxite production by State, 2022 (%)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023.

Non-zero emissions

Both Alcoa and Rio Tinto are committed to pathways to emission reductions in Alumina refining in Western Australia and Queensland.

Opportunities for reducing emissions include using renewable energy, either directly or by shifting production to low emissions electricity producing states.

Alcoa secured funding (from ARENA) to investigate the use of electric calciners powered by renewable energy to decarbonise the alumina refining process. ARENA has previously supported Alcoa Australia in trialling a Mechanical Vapour Recompression (MVR) to produce high pressure steam (using renewable energy) for use in the Bayer Process at Wagerup in Western Australia.

High Purity Alumina

Australian alumina production for supply to the aluminium smelting industry is usually supplied at purities of more than 99 per cent. It is generally known as metallurgical grade alumina.

Over recent years, the demand for High Purity Alumina (HPA) has increased.[7] HPA products could have purities of 99.99 per cent or greater. HPA products have applications in electronics, electric vehicles and the aeronautical sectors. The use of HPA would reduce the discharge rate in battery technologies.

The HPA production process unfortunately is very energy intensive. New processes are being investigated to develop low carbon HPA products. Given Australia's established Alumina-Aluminium industry, a number of HPA projects are under development. Australia's projects include the following.

- The Alpha project in Gladstone, Queensland which is due to be commissioned in the second half of 2023 with an output of 1,500 tonnes of HPA per annum. By 2025, the Alpha HPA will be capable of producing 10,000 tonnes of HPA per annum, all run on renewable energy.
- The FY1 Resources project which recently successfully tested a pilot HPA plant in Western Australia.
- A suitable high grade alumina mine has been identified at Lake Hope in Western Australia with an initial resource of 630,000 tonnes.

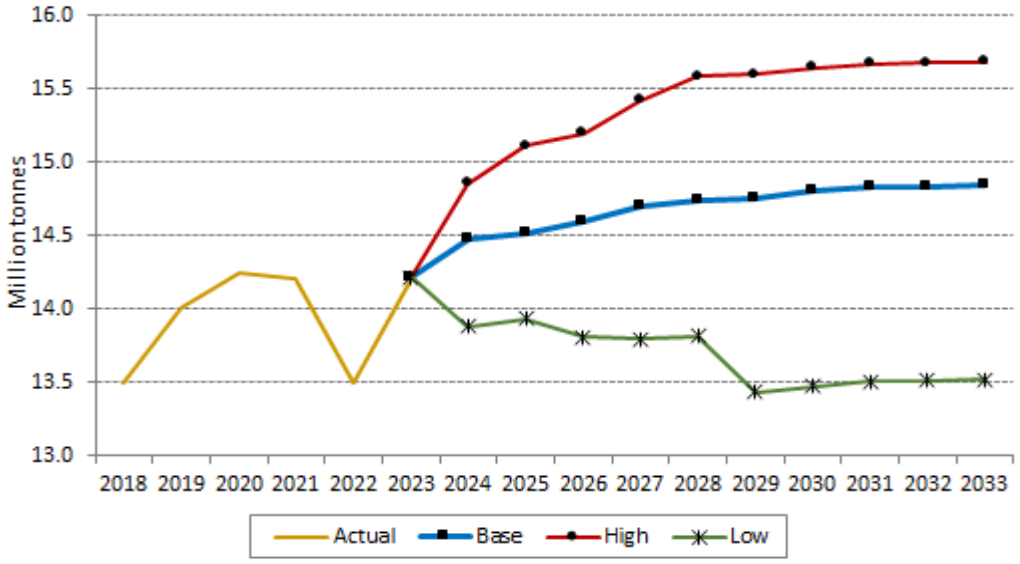
A small HPA plant is assumed to be commissioned by 2026 in Western Australia with production increasing to 100,000 tonnes by 2030.

[7] *Sources:* Australian Aluminium Council, Aluminium International Today, March/April 2022, Alpha HPA website.

Table 4.1 Australian alumina refining capacity by state and location				
State	**Refinery**	**Location**	**Owner/Operator**	**Capacity (Mt/pa)**
Queensland	Queensland Alumina Ltd (QAL)	Gladstone	Rio Tinto Alcan (80%), Rusal (20%)	3.95
Queensland	Yarwun Alumina	Yarwun (near Gladstone)	Rio Tinto Alcan	3.4
Western Australia	Kwinana Alumina Refinery	Kwinana	Alcoa	2.2
Western Australia	Pinjarra Alumina Refinery	Near Pinjarra Peel region	Alcoa	4.7
Western Australia	Wagerup Alumina Refinery	Wagerup	Alcoa	2.9
Western Australia	Worsley Alumina	Boddington	South32 (86%), Japan Alumina (10%), Sojitz Alumina (4%)	4.7

Sources: NIEIR and Alcoa, QAL, Rio Tinto, South32 websites.

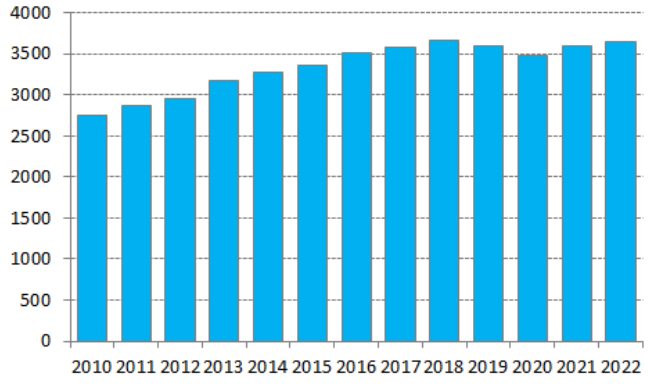
Figure 4.6: Western Australian alumina production to 2033 by scenario (million tonnes)



Note: Actuals = 2018 to 2022; Estimate = 2023; Forecasts = 2024 to 2033.
Sources: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023 and NIEIR.

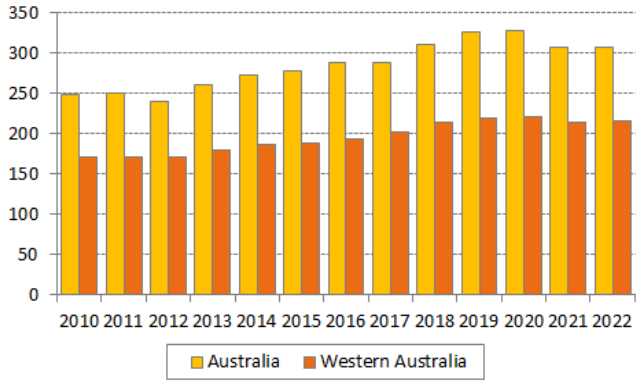
5. Gold

Figure 5.1: Gold production – World (tonnes)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023.

Figure 5.2: Gold production – Australia and Western Australia (tonnes)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023.

World production of gold in 2022 was 3,649 tonnes, up 60 tonnes or 1.7 per cent on 2021 production.[8] Global gold production over the last five years has been relatively stable, at between 3,500 and 3,650 tonnes. In 2022, the largest gold producing countries in the world were China (10.6 per cent), Australia (10.3 per cent), Russia (10.3 per cent) and Canada (7.1 per cent).[9]

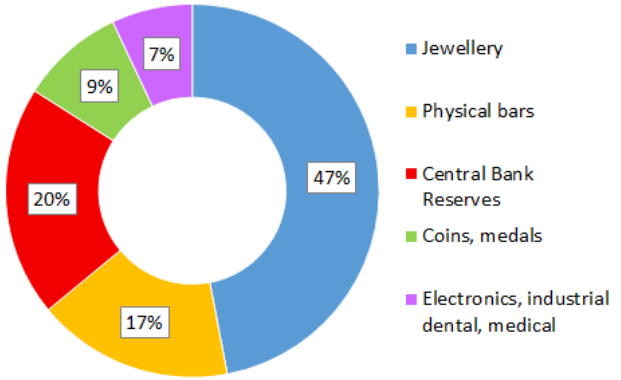
Australia's EDR of gold resources were 11,980 tonnes in December 2021. Australia's EDR of gold have increased by 62 per cent since 2010. In 2021, Australia's reserves of gold represented 22 per cent of total world reserves of 55,080 tonnes. Other countries with large gold reserves are Russia and South Africa. Australia's gold reserves in 2021 were located in Western Australia (47 per cent), South Australia (26 per cent) and New South Wales (14 per cent). Over the last five years gold exploration expenditure has represented 45 per cent of total Australian mineral exploration expenditure.[10]

Gold mined in Australia generally comes from open-cut and underground gold mines. The two main types of gold deposits are lode-gold deposits and copper-gold deposits. Lode-gold deposits are when the ore is embedded in a fissure. The Kalgoorlie Super Pit is an example of a lode-gold deposit. The Northern Star Resources mine at Junee is also a lode-gold deposit. Copper-gold deposits are at Telfer, Boddington in Western Australia, and the Cadia mine in New South Wales.

The supply chain process from mine to refined gold bullion may involve a number of different treatments. Mined ore is generally extracted, crushed and ground. Leaching gold with a cyanide solution is commonly used to extract gold from concentrates. Other base metals are also removed. Australia's only gold refiner is located at the Perth Mint in Western Australia. The Mint produces gold bullion from domestic and overseas sources.

Gold is a precious and very rare metal and has been used as a unit of currency since 700 BC. Gold was used well before this in ancient civilisations as jewellery. Global uses of gold are shown in Figure 5.3.

Figure 5.3: Global end-uses of gold metal



Sources: Mineral Commodity Summaries 2023, US Geological Survey.

[8] One tonne (1,000 kgs) = 32,150.7 troy ounces.

[9] US Geological Survey, Mineral Commodity Summaries, Gold, January 2023.

[10] Australia's Identified Mineral Resources, Geoscience Australia, 2023.

As indicated in Figure 5.3, the main end-uses of global gold are in jewellery (47 per cent), physical bars (17 per cent) and Central Bank Reserves (20 per cent).

After peaking at US$1,948 per troy ounce in March 2022, gold prices eased over the remainder of 2022 to average US$1,798 in December 2022. Over the first half of 2023, gold prices surged again, reaching an average US$2,000 per troy ounce in April 2023. Gold prices are expected to remain high for the next few years. However, gold prices could ease back to US$1,800 by 2025 due to pressure from high nominal interest rates, and a gradual easing in safe haven demand.

Australian exports of refined and unrefined gold bullion were 237.2 tonnes in 2022. Export volumes have fallen significantly over the last four years, by over 100 tonnes or 30 per cent. The value of Australian exports was A$23.5 billion in 2022. The value of gold imports in 2022 was A$6.9 billion, giving a net trade surplus in gold of A$16.5 billion. For gold exports the largest markets (in volume terms) are China (36.6 per cent), Hong Kong (23.6 per cent) and Singapore (12.3 per cent). Figure 5.5 shows export shares by main country.

Figure 5.4: Gold nominal price (US$/troy oz)

Source: World Bank, June 2023.

Figure 5.5: Percentage share of Australian gold exports by destination, 2022 (%)

Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023.

Gold production in Australia was 306 tonnes in 2022, down slightly from 2021. Western Australian production was 216 tonnes in 2021, or 71 per cent of the Australian total. The next largest gold mine producing states in 2022 were New South Wales (11.1 per cent) and Victoria (5.2 per cent). Gold production in Western Australia in 2022 is running nearly 50 tonnes higher than 10 years ago. This represents an increase of 27 per cent over 2012 production levels.

Gold mines in Western Australia are located around Kalgoorlie, in the Pilbara and also South of Perth. Major gold mining activities in Western Australia include:

- Kalgoorlie Consolidated Gold Mines (KCGM – Super Pit) and other Kalgoorlie Operations, operated by Northern Star;
- Newcrest's Telfer mine in the Pilbara;
- Tropicana gold mine located north-east of Kalgoorlie; and
- Newmont's Boddington mine, a copper-gold mine south of Perth.

These four mines operated by Northern Star, Newcrest, Tropicana and Newmont represented 37 per cent of total gold production in Western Australia in 2022.[11]

The KCGM operations is a world class asset located near Kalgoorlie in Western Australia. The KCGM includes the Fimiston Open Pit (Super Pit), Mt Charlotte Underground Mine and the Fimiston and Gidji processing plants. In 2022 Northern Star production at the KCGM and Junee (Yandal) was 40.8 tonnes, 19 per cent of total state production.

Outside Western Australia, the Cadia mine in New South Wales near Orange is Australia's largest gold mine producing 648,000 ounces in 2022, or 20.2 tonnes. BHP's Olympic Dam mine in South Australia produced 149,000 ounces of refined gold in 2021.

[11] Company websites and Quarterly Production Reports ASX.

The high gold prices over 2021 and into 2023 have stimulated a large number of new, committed and prospective projects. Table 5.1 shows recently completed and prospective projects in Western Australia. This list is not intended to be comprehensive, as it excludes many small to medium sized gold mining operations.

There are many other committed gold projects in Western Australia due to come online over the 2024 and 2026 period. The largest project outside Western Australia is the Newmont Tanami Expansion 2 in the Northern Territory of 580,000 ounces, due for commissioning in 2025.

Gold exploration has been expanding in the East Pilbara region of Western Australia. A number of discoveries have been made in the region. These include the De Grey mining discovery at Hemi, Rio Tinto's discovery of the Winu copper-gold deposit and Greatland Gold's discovery of the Havieron deposit. Newcrest has teamed up with Greatland Gold to develop Havieron, near the Telfer mine.

Figure 5.6 shows the forecasts for gold production on a calendar year basis for Western Australia to 2033 by scenario.

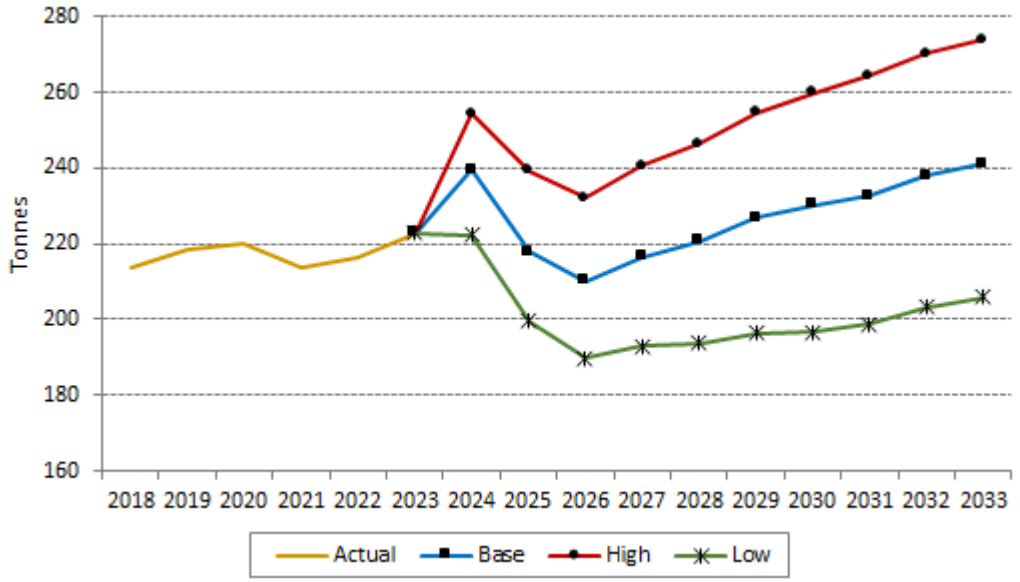
Table 5.1 Major gold projects – Western Australia

Company	Project	New capacity (oz)	Timing
Recently completed			
Wiluna Mining	Wiluna Gold Project (Stage 1)	120,000	2022-2023
Norseman and Pantoro	Norseman	108,000	2022
Anglo Gold, Ashanti and Regis Resources	Tropicana Marana (Stage 3)	450,000	2022
Newcrest	Telfer West Dome (Stage 5)	390,000	2022
Red 5 Ltd	King of the Hills	176,000	2022
Zijin Mining	Binduli North	225,000	2022
Calidus	Warrawoona	105,000	2022
Prospective and probable			
Gascoyne Resources	Glenburgh	73,000	2025
Kin Mining	Cardinia Gold Project	51,000	2025
Northern Star Resources	Thunderbox Mill Expansion	300,000	2023
Wiluna Mining	Wiluna Gold Project (Stage 2)	130,000	2024 – 2025
Ausgold	Katanning Gold Project	105,000	2025
St Barbara Ltd	Bardoc Gold Project	150,000	2024 – 2025
Northern Star Resources	Kalgoorlie Production Centre	675,000	2023 – 2027
De Grey	Mallina	540,000	2025 – 2027
Bellevue Gold Ltd	Bellevue Gold Project	200,000	2023 – 2024
Ramelius	Edna May (Stage 3)	90,000	2025 – 2026
Karora Resources	Higginsville Mill Expansion (Phase 2)	185,000	2024 – 2026
Westgold Resources	Great Fingal Mine	48,000	2025
Black Cat Syndicate	Paulsens Gold Operation (restart)	nya	2025 plus

Note: nya = Not yet announced.

Sources: Northern Star Resources, St Barbara, Bellevue Gold, De Grey Mining, Zijin Mining, Newcrest, Red 5 Ltd, Ramelius Resources and other company websites.

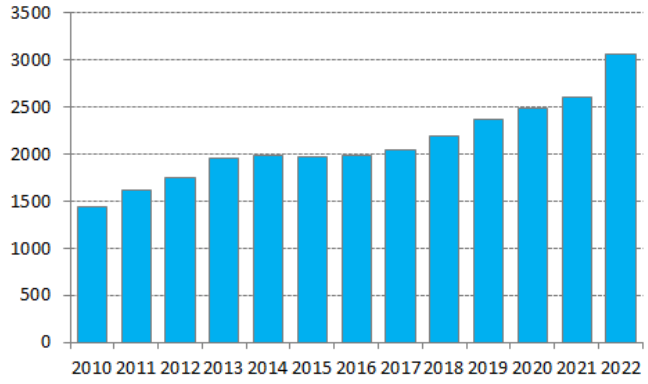
Figure 5.6: Western Australian gold production to 2033 by scenario (tonnes)



Note: Actuals = 2018 to 2022; Estimate = 2023; Forecasts = 2024 to 2033.
Sources: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023 and NIEIR.

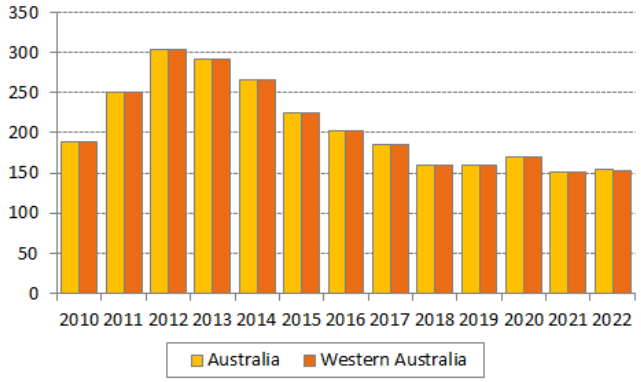
6. Nickel

Figure 6.1: Nickel production – World (kt)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023.

Figure 6.2: Nickel production – Australia and Western Australia (kt)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023.

World nickel production surged in 2022 to 3,059 kt. Total world production rose by 453 kt, or 17.3 per cent. The production increase partly reflects a large increase in the nickel price in the first half of 2022, amid fears of supply shortages following the war in Ukraine. The larger increase in production in 2022 mainly reflects production increases in Indonesia.

Nearly 50 per cent of world nickel production in 2022 was from Indonesia. The other major producing countries include the Philippines (10 per cent), Russia (7 per cent) and New Caledonia (6 per cent). Australian production of nickel in 2022 was just under 5 per cent of world production.

Australian production of nickel in 2022 was 154.4 kt. Over the last 10 years Australian production has nearly halved. Australian production in 2012 was 304 kt.

Nickel production in Australia has been dominated by Western Australia, accounting for 100 per cent of Australian production for nearly 15 years. In May 2022 it was announced that Tasmania's Avebury Nickel Mine was out of care and maintenance. The owner of the mine is Mallee Resources and production recommenced at this site in December 2022. Total annual production from this Tasmanian mine will be around 4.1 kt per annum.

Australia's EDR of nickel in 2021 was 21.7 million tonnes.[12] Australia was ranked number one in world nickel reserves, although reserves in Indonesia have been substantially upgraded. In 2021, 89 per cent of Australia's nickel reserves were in Western Australia. The remaining reserves were located in Queensland (6 per cent) and New South Wales (4 per cent).

Nickel West, owned by BHP, is a major producer of nickel in Western Australia. Upstream mines are located at Mt Keith and Leinster, north of Kalgoorlie. Production in calendar 2022 by Nickel West was 75.9 kt.[13] Another major producer is IGO Ltd, an Australian nickel and lithium miner. IGO owns and operates the following operations:

- Nova – nickel, copper, cobalt;
- Forrestania – nickel; and
- Cosmos – nickel (yet to reach commercial production and under review).

All these operations are located in Western Australia. Nickel concentrate production from Nova and Forrestania in calendar 2022 was 35.9 kt.[14]

Nickel is a silver-white metal that resists corrosion. Nickel is primarily used in making alloys such as stainless steel. Because nickel resists corrosion it is commonly used to plate other metals. It is commonly used in consumer durables such as toasters and electric ovens. Nickel is used in sinks, cooking utensils, cutlery and coinage. Nickel alloys are used in boat propeller shafts and turbine blades.

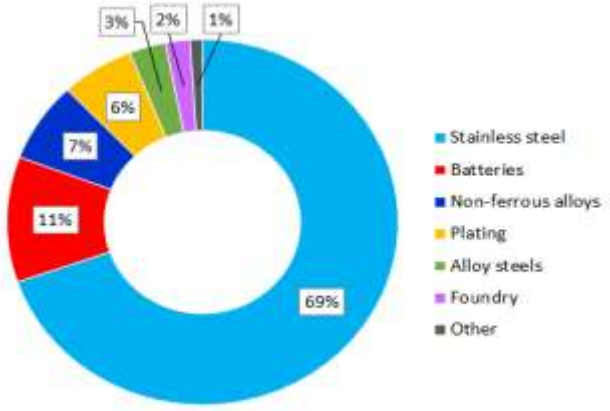
Nickel is used in batteries, including rechargeable nickel-cadmium batteries and nickel metal hydride batteries.

[12] Australia's Identified Mineral Resource, 2022, Geoscience Australia, Digital publication.

[13] Quarterly Activities Reports, BHP, December 2022.

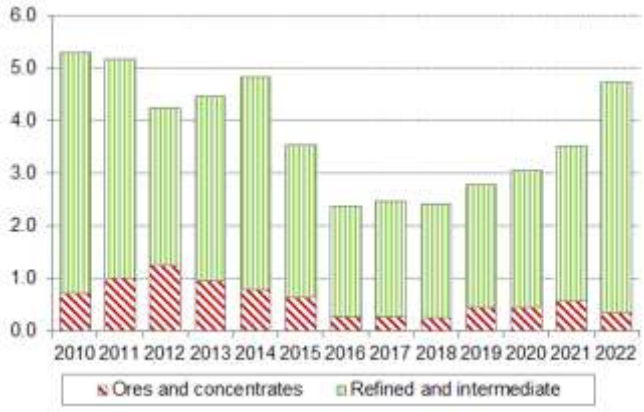
[14] Quarterly Reports, 2022, IGO Limited.

Figure 6.3: The main end-uses of nickel



Source: Nickel Institute, https://nickelinstitute.org.

Figure 6.5: Australian nickel exports by class (A$ billion)



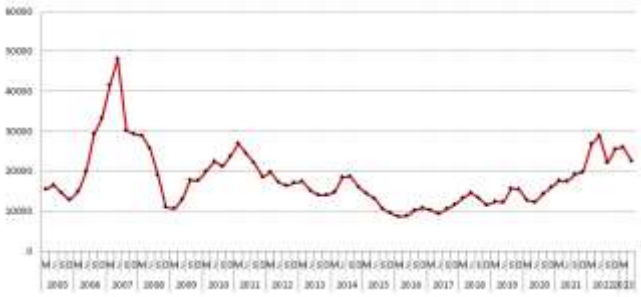
Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023.

World nickel prices rose sharply over the first half of 2022, reaching nearly US$34,925 in March 2022. World prices eased over the remainder of 2022 before rising again in early 2023. Russia's invasion initially drove nickel price movements in 2022, however, persistent low stocks and the anticipated demand from EV were also important drivers. In 2023 the nickel price has fallen since February, however, by June 2023 it still remained above US$21,000 per Mt.

The largest producer of nickel in Australia is BHP's Nickel West. Nickel West's operations in Western Australia encompasses the following:

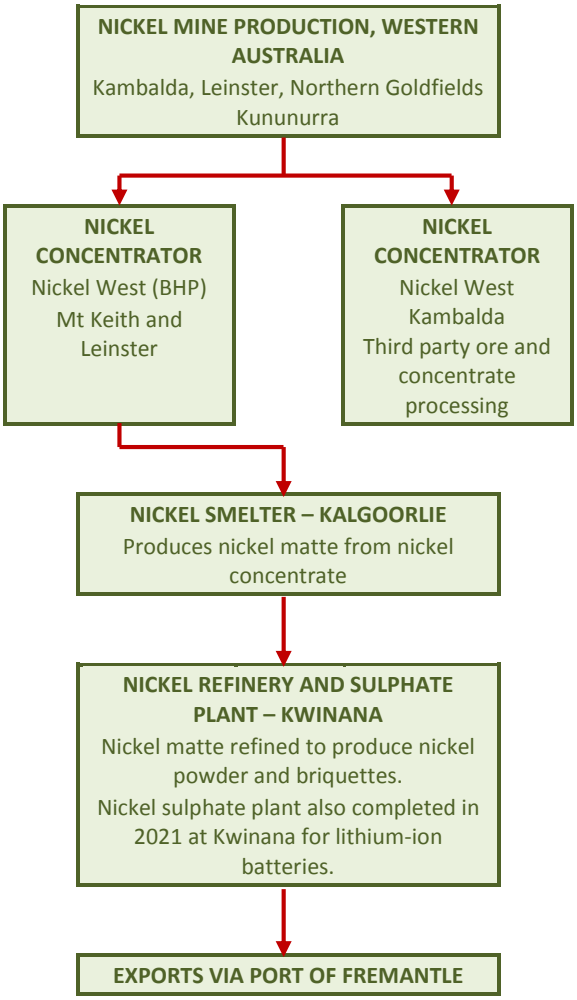
- ore mined at Mt Keith open cut and ore from the underground Cliffs and Leinster mines;
- a concentrator and dryer at Leinster and Mt Keith, as well as a concentrator at Kambalda, which processes ore from third parties;
- a smelter at Kalgoorlie which converts nickel concentrate to nickel matte; and
- a nickel refinery in Kwinana which converts nickel matte into premium grade nickel powder and briquettes.

Figure 6.4: Nickel nominal price (US$/tonne)



Source: World Bank, August 2023.

Figure 6.6: The Nickel West (BHP) supply chain



Source: BHP website.

Western Australian production of nickel is expected to increase, driven by the demand from electric vehicles, energy storage, and wind and solar projects. Key prospective nickel projects are outlined in Table 6.1.

The Ardea Resources Kalgoorlie Nickel Project is a large nickel-cobalt project. The ore reserve has been revised up to 194.1 Mt at 0.70 nickel and 0.005 cobalt. Assuming a mine life of 40 years, this would imply annual production of 30 kt of nickel and 2 kt of cobalt.[15]

Cannon Resources Fisher East Nickel Project is located in the North-Eastern Goldfields region. The total indicated and inferred nickel metal resource is 134.1 kt. Cannon Resources also has another nickel project known as the Collurabbie project, which has not yet progressed.[16]

The Odysseus underground mine under development by IGO is expected to deliver 20 kt per annum over a mine life of 10 years. It will more than replace the nickel produced by IGO's Forrestania operation, which may close by 2026.[17]

Chalice Mining made significant discoveries at Gonneville in 2020 (70 kilometres north-east of Perth). The Gonneville resources is one of the world's largest nickel sulphide deposits. It also has copper, cobalt, palladium and platinum resources. A pre-feasibility study commenced in 2023.[18]

Figure 6.7 shows the forecasts for nickel production on a calendar year basis for Western Australia to 2032 by scenario.

Table 6.1 Western Australian nickel projects

Company	Project	Nickel kt (annual)	Timing
Recently commissioned			
Mincor Resources	Kambalda Restart	16.0	2022
BHP	Leinster B11 Block Cave	10.0	2023
Prospective projects			
Cannon Resources	Fisher East	7.3	2025 plus
Ardea Resources Ltd	Goongarrie Nickel Project	30.0	2025 plus
Greenstone Resources (formerly Barra Resources)	Mt Thirsty	2.1	2025 plus
IGO Ltd (formerly Western Areas)	Odysseus Underground Mine (Cosmos)	13.0	Under construction and review 2026
Chalice Mining	Gonneville Base Metals Project	Mineral resource = 860 kt nickel 520 kt copper 83 kt cobalt	2026-27

Sources: Mincor Resources, Western Area, BHP, Ardea Resources, Cannon Resources, Greenstone Resources, IGO and Chalice Mining websites.

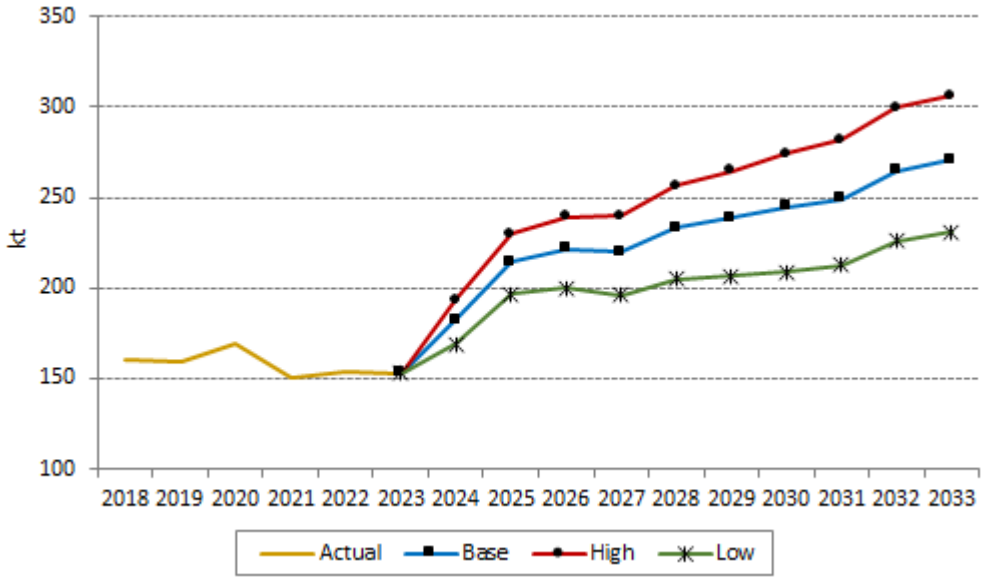
[15] Ardea Resources website, www.ardearesources.com.au, ASX Media Release, 5 July 2023.

[16] Cannon Resources, www.cannon.com.au/projects.

[17] IGO Limited, www.igo.com.au.

[18] Chalice Mining, www.chalicemining.com/gonneville.

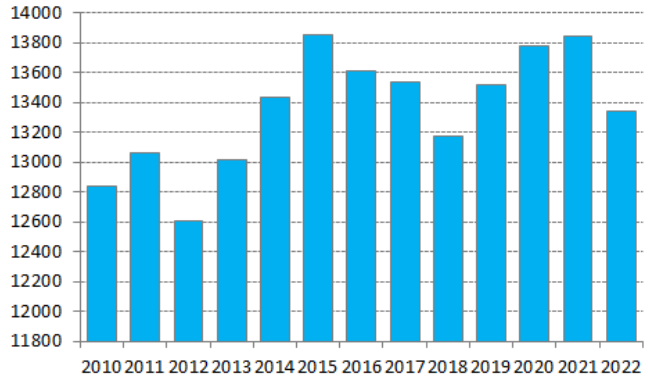
Figure 8.7: Western Australian nickel production to 2033 by scenario (kt)



Note: Actuals = 2018 to 2022; Estimate = 2023; Forecasts = 2024 to 2033.
Sources: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023 and NIEIR.

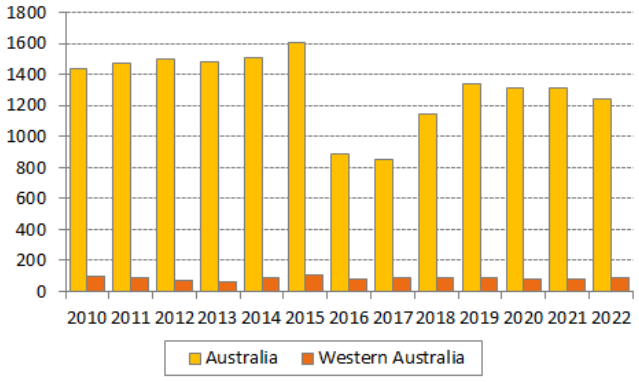
7. Zinc

Figure 7.1: Zinc production – World (kt)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023.

Figure 7.2: Zinc production – Australia and Western Australia (kt)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023.

In 2022, world zinc production fell to 13.3 million tonnes, down from 13.8 million tonnes in both 2020 and 2021. Major producers of zinc in 2022 were China (32 per cent), Peru (11 per cent) and Australia (10 per cent). In terms of world resources, Australia is ranked first, accounting for 27 per cent of world resources of zinc.

Australia's zinc metal production in 2022 was 1,244 kt, down around 5 per cent on production levels in 2020 and 2021. The largest producers of zinc in 2022 were Queensland (57 per cent) and the Northern Territory (22 per cent). Western Australia produced 90 kt of zinc in 2022, 7 per cent of the national total.

Australia's EDR of zinc metal in 2021 was 66.25 million tonnes. Western Australia has around 6 per cent of total reserves, located at Admiral Bay and also at Abra and Golden Gove. The Admiral Bay deposit is very deep underground (150 metres) and has a resource of 140 mt of zinc-lead. It is one of the largest undeveloped zinc deposits in Australia. Queensland had 56 per cent of reserves in 2021 and the Northern Territory 25 per cent.[19] Reserves in Queensland are located near Mt Isa in North-West Queensland and at McArthur River in the Northern Territory. Glencore reported production of 564 kt of zinc concentrate in 2022, 45 per cent of the Australian total. [20]

It should be acknowledged that zinc, lead and silver are often found together in mineral deposits. Mining activity at these sites may often involve extracting two or three of these ores from the same mine.

Zinc is a bluish-white element that can be refined into a metal. The main end-uses for zinc are in galvanising steel, diecasting and making brass and bronze alloys. Zinc is also used in many other applications. In the manufacturing sector, zinc can be used for coatings, plating and also in chemical and mining applications. Zinc metal is also used in various battery applications.

Around 40 per cent of zinc comes from reclaimed zinc sources. The most common recycling of zinc is from galvanised steel using Electric Arc Furnaces. Given zinc ore deposits are not renewable, recycling must become a growing viable source of this metal.

Table 7.1 Zinc usage by sector

End-use	Sector/Commodity	Per cent
Galvanising	Automobiles and construction	50
Diecasting	Door hardware, motor housings, toys	17
Brass and bronze	Plumbing fittings – taps, pipes	17
Rolled zinc	Roofing, guttering, coffins, batteries	6
Chemicals	Tyres, cosmetics (zinc cream)	6
Miscellaneous		4

Source: International Lead and Zinc Study Group, ilzsg.org/statistics/enduses.

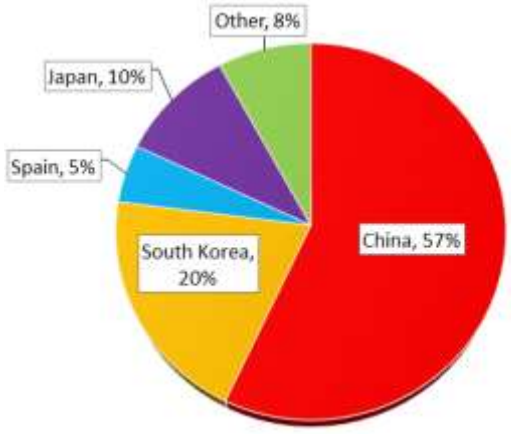
[19] Australia Identified Mineral Resources, 2022, Geoscience Australia, Digital Publication.

[20] Glencore Full Year 2022 Production Report.

Figure 7.3: Zinc nominal price (US$/tonne)

Source: World Bank, August 2023.

Figure 7.4: Percentage share of Australian zinc concentrate exports by destination, 2022 (%)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023.

World zinc metal prices are primarily driven by Chinese demand and supply, global stocks, US demand and import prices. Wold zinc prices rose sharply through the COVID-19 pandemic, averaging US$3,003 per Mt in calendar 2021. Cuts to refining capacity led to a surge in zinc metal prices over 2022. The zinc commodity price reached US$3,914 per Mt in the June quarter 2022. Prices retreated significantly over the remainder of 2022. In the June quarter 2023, there was a sharp 20 per cent fall in world zinc metal prices.

Australian exports of zinc (both concentrates and refined zinc) were $4.7 billion in 2022. The principal export markets for zinc concentrates in 2022 were China (57 per cent), South Korea (20 per cent) and Japan (10 per cent). For refined zinc, the principal markets were the United States (29 per cent), Chinese Taipei (16 per cent) and Indonesia (10 per cent).

In Australia, refined zinc is produced at Sun Metals in Townsville, Queensland and by Nyrstar at Risdon in Hobart, Tasmania. The processing of zinc requires roasting, leaching and electrolysis plant. The refining process is electrically intensive.

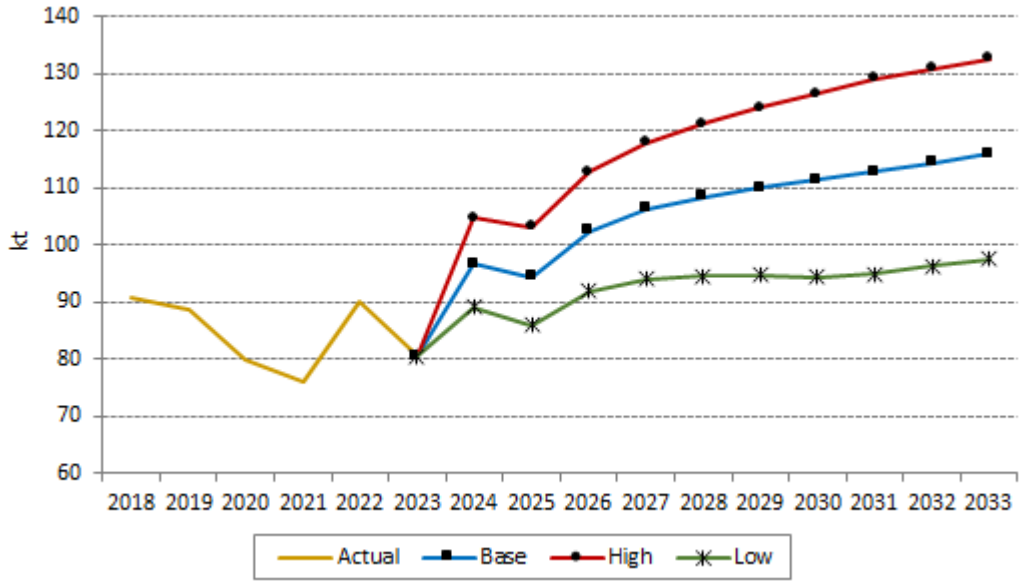
There is a reasonably positive outlook for zinc production in Australia over 2024 and 2025. Production increases will be driven by the Century mine in Queensland and production increases at existing mines (which have been impacted by labour shortages following COVID-19). Exploration expenditures for base metals, such as zinc, have also increased significantly.

The Golden Grove mine, operated by 29 Metals, is a base metals mine located east of Geraldton. It produces significant quantities of zinc, as well as gold, copper, silver and lead. It produced 57.4 kt of zinc in 2022, or 64 per cent of the state total.

Aeris Resources owns the Jaguar operations which is an underground zinc, copper, gold and silver mining operation in the Eastern Goldfields region. Full year guidance for zinc was around 24 to 29 kt in 2022. Mining operations were suspended following seismic activity and a weaker zinc price.

Figure 7.5 shows the forecasts for zinc production for calendar years for Western Australia to 2033 by scenario.

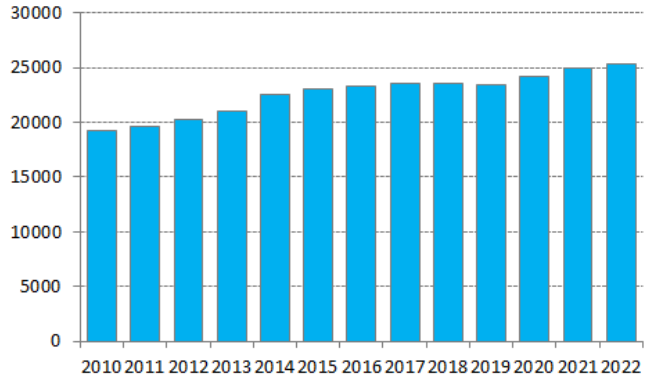
Figure 7.5: Western Australian zinc production to 2033 by scenario (kt)



Note: Actuals = 2018 to 2022; Estimate = 2023; Forecasts = 2024 to 2033.
Sources: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023 and NIEIR.

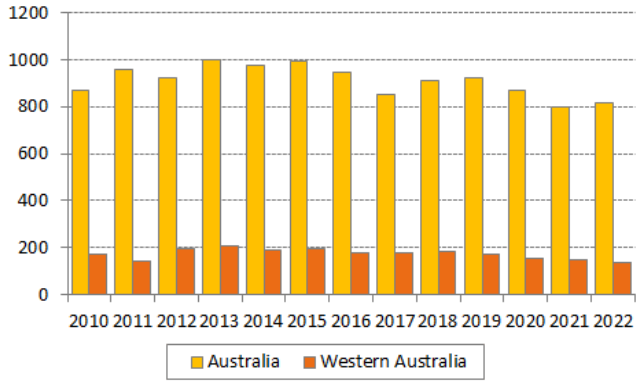
8. Copper

Figure 8.1: Copper production – World (kt)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023.

Figure 8.2: Copper production – Australia and Western Australia (kt)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023.

World copper production was 25.3 million tonnes in 2022. World copper production is 25 per cent higher in 2022 compared to production in 2012. This translates into an annual growth rate of 2.3 per cent.

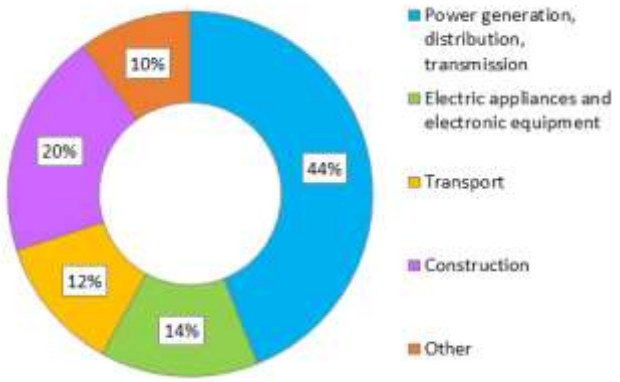
World copper production is dominated by four countries – Chile (23.6 per cent), Peru (10 per cent), Congo (10 per cent) and China (8.6 per cent).[21] Australia was ranked the 8th largest producer of copper in the world in 2022. Australian reserves of copper were 11 per cent of world copper reserves.

Geoscience Australia identified Australia's EDR of copper in 2021 were 100.1 million tonnes.[22] Australian reserves in 2010 were identified as 80.4 million tonnes, implying a 12.5 per cent increase in reserves. In Australia in 2021 there were 33 operating mines, producing 0.82 million tonnes of copper. Australia's copper reserves are primarily located in South Australia (69 per cent). There are also significant copper reserves in New South Wales (12 per cent), Queensland (9 per cent) and Western Australia (8 per cent).

South Australian copper reserves are located at Olympic Dam, Prominent Hill, Carrapateena and Woodlawn. BHP acquired OZ Minerals in 2023, thereby obtaining a direct interest in the Prominent Hill mine and the Carrapateena copper mine (under development). The largest reserves in Western Australia are located at Caravel north of Perth, and Winu located in the Pilbara region near Telfer.

Due to the high electrical conductivity of copper, its main end-use is in electricity generation (e.g. solar and wind farms), transmission and distribution. As indicated in Figure 8.3, copper is used extensively in electrical appliances and equipment (14 per cent). The construction sector uses copper in electrical wiring, plumbing, cooling, roofing and cladding. The transport sector uses copper in wiring and motors, providing power to multiple electronic applications in all types of vehicles. Copper is used in EVs and also by the telecommunications sector. Other end-uses of copper include coinage, sculptures, musical instruments, cookware and other consumer goods.

Figure 8.3: End-uses of copper



Source: Copper Alliance, www.copperalliance.org/resource/copper-recycling.

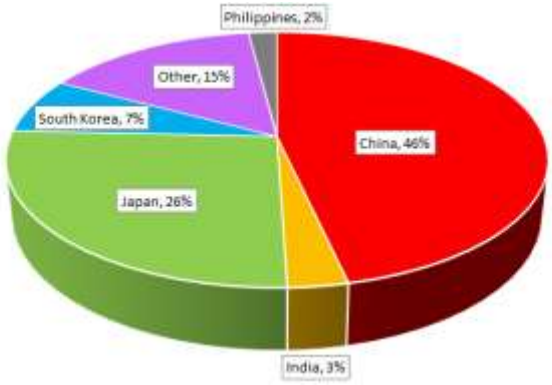
[21] US geological Survey, Major Commodity Summaries, Copper, January 2023.

[22] Australia's Identified Mineral Resources 2022, Geoscience Australia, 2023.

Figure 8.4: Copper nominal price (US$/tonne)

Source: World Bank, August 2023.

Figure 8.5: Percentage share of Australian copper ore and concentrate exports by destination, 2020 (%)



Note: Country export shares of copper are no longer published.
Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021.

Copper is extensively recycled, both globally and in Australia. Around 32 per cent of world copper usage is sourced from recycled scrap.[23]

In 2022, Australian production of copper was 819 kt, up by 2.9 per cent on 2021 production. Planned maintenance at BHP's Olympic Dam mine contributed to the slow growth in copper production. Heavy rainfall and flooding also constrained production. Australian copper production is expected to expand over the medium term as supply disruptions ease and new capacity comes on-line. In August 2023, BHP awarded a significant exploration contract for its Carrapateena copper mine.

In 2022, Australian production of copper was spread across four states:

- South Australia (38.6 per cent);
- New South Wales (23.2 per cent);
- Queensland (21.3 per cent); and
- Western Australia (16.8 per cent).

South Australia's Olympic Dam mine has significant reserves and could expand further in the future. Production at Olympic Dam in 2022 of 199 kt was 63 per cent of South Australian copper production. New South Wales copper resources are mainly located at Cadia East and Northparkes. Queensland copper resources are centred around Mt Isa.

Refined copper in Australia is produced at two locations, Townsville and Olympic Dam in South Australia. Olympic Dam is a fully integrated metals processing complex and incorporates mining, a copper smelter, a copper refinery and a recovery circuit for precious metals. Glencore's copper refinery in Townsville, Queensland, has a capacity of 300 kt producing pure copper cathode. Glencore's operations involve mines at Mt Isa and Ernest Henry, to smelting at Mt Isa, then transport and refining in Townsville. Estimated smelter and refinery production in Australia in 2022 was 775 kt.

After a strong rebound in world copper prices over the first six months of calendar 2022, weaker Chinese manufacturing has led prices to ease by the end of 2022. World copper prices fell from US$10,231 per mt in March 2022 to US$8,375 by December 2022. By June 2023 copper prices were around US$8,400 per mt. Despite expected increases in world production and stronger demand from China, world copper prices could improve over the remainder of 2023 and 2024.

Exports of copper from Australia in 2022 were valued at A$12.4 billion, comprising of copper ores and concentrates (A$7.5 billion) and refined copper (A$4.8 billion). The principal markets for copper ore and concentrates are China and Japan. For refined copper the largest export destinations from Australia are China, Malaysia and Taiwan.

Copper mines in Western Australia are typically copper-gold mines. Major mines in Western Australia are Telfer, De Grussa, Boddington and Nifty (under care and maintenance). The Golden Grove mine operated by 29 Metals produces multiple minerals, including copper, gold, lead and zinc.

Sandfire Resources De Grussa mine and Monty Mine's in Western Australia have produced significant quantities of copper. In 2021, copper production was nearly 70 kt and in 2022 54.7 kt. Underground mining at De Grussa was suspended in December 2022 and copper production is now limited to processing transitional stockpiles and

[23] Copper Alliance, www.copperalliance.org/resource/copper-recycling.

mineralised waste stockpiles. Operations at the mine are now under review.

Newcrest produced 12.7 kt of copper at its Telfer mine in 2022. The Golden Grove mine in Western Australia produced 16.9 kt in 2022, a similar quantity to 2021 production.[24]

There are a number of prospective copper mining projects in Western Australia. These are summarised in Table 8.1.

Copper production in Western Australia will ease in 2023 and 2024 with the closure of the De Grussa operations in 2022. By 2025 the commissioning of the West Musgrave project should see copper production recover in Western Australia.

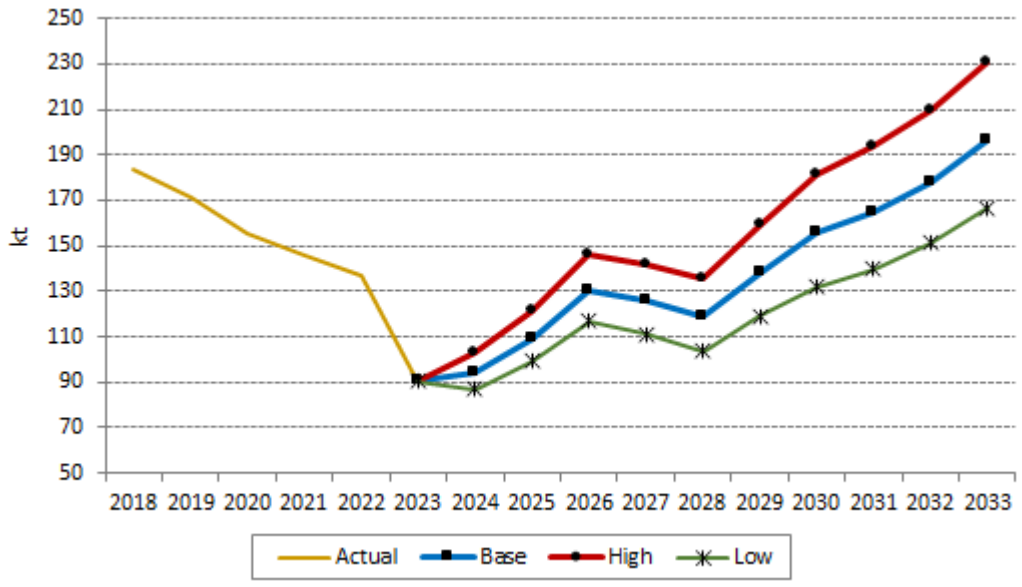
Figure 8.6 shows the forecasts for copper production on a calendar year basis for Western Australia to 2033 by scenario.

Table 8.1 Major copper projects – Western Australia – prospective

Company	Project	Production (kt/a)	Timing
Cyprium Metals Ltd	Nifty (re-commissioning)	25	2024 – 2025
BHP[1]	West Musgrave (copper, nickel)	41	2025 – 2026
Caravel Minerals Ltd	Caravel (Stage 1)	60	2026 – 2028
Rio Tinto	Winu (copper, gold)	150-250	2025 – 2027
Develop Global Ltd	Sulphur Springs (copper, zinc, silver)	15	2026 – 2028
Anax Metals	Whim Creek (re-commissioning)	11	2024 plus

Note: 1. Formerly OZ Minerals.
Source: Caravel Minerals, Cyprium Metals, OZ Minerals, Rio Tinto, and DEVELOP websites.

Figure 8.6: Western Australian copper production to 2033 by scenario (kt)

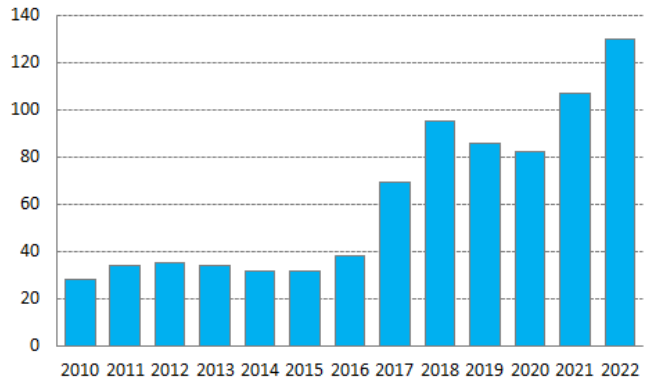


Note: Actuals = 2018 to 2022; Estimate = 2023; Forecasts = 2024 to 2033.
Sources: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023 and NIEIR.

[24] Company websites, Quarterly Production Reports.

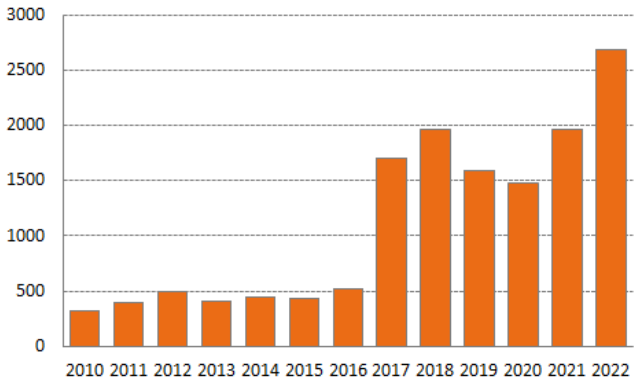
9. Lithium

Figure 9.1: Global lithium mine production ('000 tonnes)



Source: US Geological Survey, Mineral Summaries, Lithium, January 2023.

Figure 9.2: Lithium spodumene concentrate production – Western Australia (kt)



Source: DMIRS (WA), 2022, Major Commodities Resources Data, calendar years.

World production of lithium rose sharply in 2022 to 130,000 tonnes in response to strong demand from the battery market and increased lithium prices. Global production was only 107,000 tonnes in 2021. The US Geological Survey estimated global consumption of lithium in 2022 was 134,000 tonnes, up 41 per cent from 95,000 tonnes in 2021.

In 2022, the world's largest producers of lithium were Australia (50 per cent), Chile (30 per cent) and China (15 per cent). In Australia there are six operating mines producing lithium spodumene, two brine operations in Chile, and three mines and two brine operations in China. [25]

The market for lithium has increased enormously over the last five years, however, global production exceeded demand in 2018 and may possibly again post-2023. Australia is the largest producer of lithium in the world, accounting for over 50 per cent of world production.

Lithium is a light metal, which is silvery-white, and has a low melting point. The main lithium compound is lithium hydroxide, although processing technologies can produce lithium carbonate, lithium fluoride, lithium chloride and other lithium compounds.

Australia's EDR of lithium were 6,700 kt in 2021. [26] This represents 29 per cent of total world reserves. Larger reserves of lithium are located in Chile. There are significant uncertainties regarding lithium reserves across the world as exploration activities continue and new resources may be found.

In Australia, lithium reserves are primarily located in Western Australia, the Northern Territory and New South Wales. The largest lithium resources in Western Australia are located at Greenbushes and Pilgangoora. Significant resources of lithium are also located at Wodgina, Kathleen Valley and Mt Holland. Smaller reserves are at Mount Marion, Mount Catlin and Bald Hill. In the Northern Territory, lithium reserves are located at Finniss, south of Darwin.

In Australia, lithium occurs in hard rock spodumene deposits. In Chile and Argentina, lithium comes from salt deserts, known as salars. The most important end-use for lithium is in rechargeable batteries for mobile phones, laptops, digital cameras and electric vehicles. Lithium is also used in ceramics, glass and primary aluminium production. Other major end-uses include the manufacture of lubricants and greases, pharmaceuticals and synthetic rubber.

Lithium prices have been volatile over recent years. Lithium prices peaked in 2016 and 2017, however, excess supply led prices to fall over the 2018 to 2020 period. In Australia mine production was cut and mines closed.

Lithium prices surged from January 2021 right through to the end of calendar 2022. The price of spodumene concentrate rose from A$541 per tonne to A$9,240 per tonne in November 2022. There has been a sharp

[25] US Geological Survey, Mineral Summaries, Lithium, January 2023.

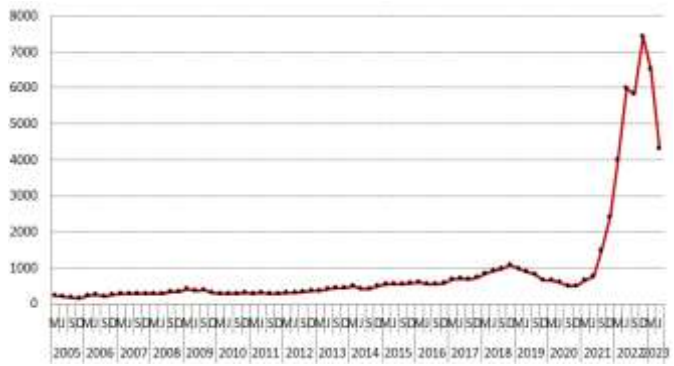
[26] Australia's Identified Mineral Resources, 2022, Geoscience Australia, 2023, Digital publication.

downward adjustment in 2023 with prices falling by around 33 per cent.

While the lithium market is still developing, future price fluctuations could still be significant. This is expected to stabilise in the future as the uptake of EVs improves over the coming years.

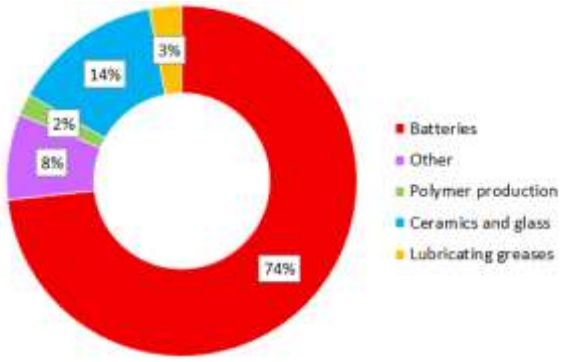
The value of spodumene concentrate production in Western Australia rose to a record $16.3 billion in 2022 calendar year. An increase of $13.6 billion over 2021. There was a 37 per cent increase in production, however, the remainder reflects the surge in lithium prices.

Figure 9.3: Spodumene concentrate nominal price – (A$/tonne)



Source: DMIRS (WA), 2023, Major Commodities Resources Data, 2022 and estimates for March and June quarters 2023.

Figure 9.4: Main end-uses of lithium



Source: US Geological Survey, Mineral Commodity Summaries, Lithium, January 2022.

If predictions regarding the world-wide take-up of electric vehicles are correct, then the lithium mining and processing industries may need to grow tenfold. For this to happen a period of sustained high prices may be necessary.

In 2022, Western Australian spodumene concentrate production was 2,684 kt, up from 1,967 kt in 2021.[27] Western Australian production up to 2022 represents 100 per cent of Australian production. Shipments from the Finniss mine in the Northern Territory did not commence until 2023.

Production of spodumene concentrate was up 717 kt, or 36.5 per cent on 2021 levels. Significant expansions at major mines in Western Australia are expected over the 2024 to 2028 period.

The total value of spodumene concentrate exports from Australia were A$16.3 billion in 2022, up from just A$2.7 billion in 2021. The majority of exports were to China in 2022 (98 per cent).

Core Lithium owns 100 per cent of the Finniss Lithium Project located in the Northern Territory. The Finniss Project, when completely on-line, will produce 160 kt of battery grade lithium concentrate. First shipments from Finniss were made in April 2023. Core Lithium is seeking to expand lithium production further with the development of the BP33 Project, a second mine at the Finniss Lithium Project.

In 2023, Western Australia had five operating hard rock lithium mines.

- The Greenbushes lithium mine is the world's largest hard rock lithium mine. It is operated by Tianqi Lithium Corporation (51 per cent) and IGO Limited (49 per cent) – the joint venture. The JV has a 51 per cent stake in the Greenbushes' lithium mine and 100 per cent ownership of the Kwinana Lithium Hydroxide Refinery. The mine is located 250 kilometres south of Perth.

  The Greenbushes resource contains the highest ore reserve grade of any lithium mine in the world. In 2023, the Greenbushes' operation consists of the following:

  - Technical Grade Plant (150 kt per annum);
  - Chemical Grade Plant (600 kt per annum);
  - Chemical Grade Plant (520 kt per annum); and
  - Tailings Retreatment Project (280 kt per annum).

  This brings total capacity to around 1.5 million tonnes per annum, or half of Western Australia's current lithium production. Due to be commissioned over 2026-2027 is the CGP3 expansion of 520 kt per annum. The additional CGP4 expansion of 520 kt per annum is subject to a

[27] DMIRS, 2023 Major Commodities Resources data, 2022.

Final Investment Decision (FID). It may be commissioned by 2028.

- Mineral Resources owns and operates two lithium mines in Western Australia – Mt Marion in the Goldfields region and Wodgina in the Pilbara region. The Mt Marion operation is jointly owned by Mineral Resources (50 per cent) and Jiangxi Ganfeng Lithium Co. Ltd (50 per cent).

  In 2023, the Mt Marion plant expanded from 450,000 tpa to 600,000 tpa of spodumene concentrate. Spodumene is shipped through the Port of Esperance. The Wodgina Lithium Project features a 750,000 tpa concentrate plant consisting of three 250,000 tpa trains. The Wodgina Project is a Joint Venture between Mineral Resources and Albemarle Corporation.

  The Joint Venture between Mineral Resources and Albemarle Corporation has also completed the Kemerton Lithium Hydroxide Plant, which was commissioned in 2021 (Train 1) and 2023 (Train 2). Total plant capacity is 50,000 tonnes per annum.

  - Pilbara Minerals operates the Pilgangoora Lithium Project in the Pilbara. It is one of the largest hard rock deposits in the world. Pilbara Minerals has two processing plants:
  - the Pilgan Plant which produces spodumene concentrate and tantalite concentrate; and
  - the Ngungaja Plant which produces spodumene concentrate.

  The Pilgan Plant currently produces between 360,000 and 380,000 tpa of spodumene concentrate. The P680 expansion project will increase production by 100,000 tpa. The Ngungaja Plant produces 180,000 to 200,000 tpa. Therefore, with the completion of the P680 expansion project, total production at Pilgangoora will be between 640,000 and 680,000 tpa.

  A further planned expansion at the Pilgan Plant, known as P1000, would increase capacity by 320,000 tpa. This project received FID in March 2023.

- Covalent Lithium operates the Mt Holland mining and concentrator operations. The mine is located 500 kilometres east of Perth. At full operation, total production will be around 380,000 tonnes of spodumene concentrate per annum.

  Covalent Lithium are also refining within the industrial area of Kwinana and will be able to produce 50,000 tonnes of battery-quality lithium hydroxide per annum. Covalent Lithium is the Joint Venture Manager of this Sociedad Quimica y Minera de Chile S.A. (SQM) and Wesfarmers project. In May 2023, the Joint Venture partners announced they were considering expanding the concentrator to 760,000 tpa and the refinery to 100,000 tonnes.

- Liontown Resources is an emerging battery minerals producer in Western Australia. It is developing the spodumene resource at Kathleen Valley, near Leinster. It aims to produce 500 kt of spodumene concentrate per annum with production starting in 2024. Liontown is also looking at downstream processing of lithium concentrate.

- More prospective lithium projects in Western Australia include:

  - Global Lithium Resources Manna Lithium project which, in July 2023, upgraded the resource to 406 kt of lithium oxide; and
  - Future Battery Minerals also have made a lithium discovery at Kangaroo Hill, near the existing Nepean nickel sulphide mine.

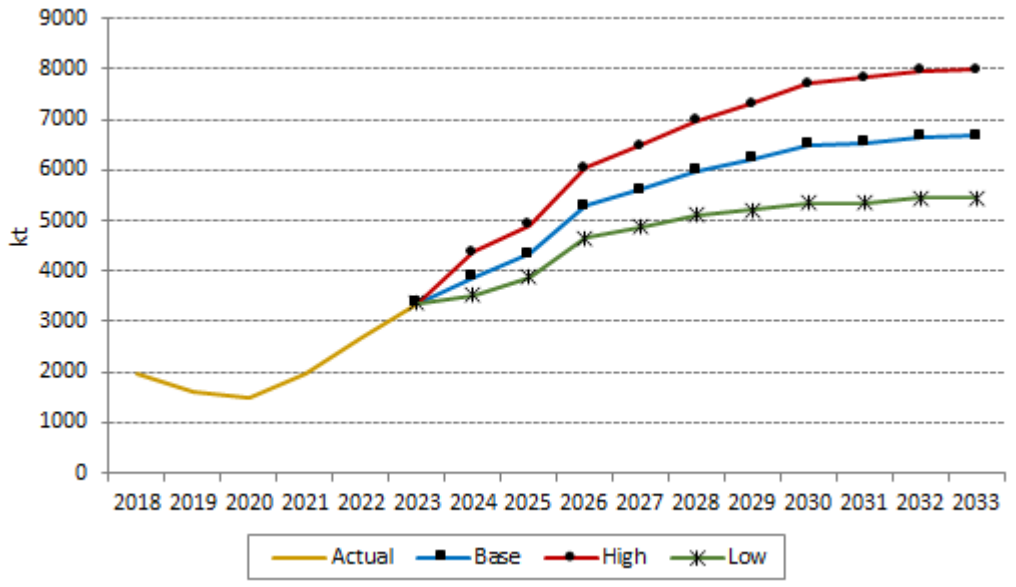
  There are two lithium hydroxide plants under construction at Kwinana, Western Australia. These include Tianqi Lithium's train 1 and train 2, and Covalent Lithium's plant for processing ore from Mt Holland. As indicated in Table 9.1, Liontown Resources also has refinery proposals in Western Australia.

Figure 9.5 shows the forecasts for lithium production by calendar year for Western Australia to 2033 by scenario.

Table 9.1 Western Australian spodumene and lithium projects			
Company	**Operation**	**Annual capacity (kt)**	**Timing**
Recently completed (under construction)			
Spodumene concentrate			
Talison Lithium	Greenbushes Expansion (CGP3)	520	2025 – 2026
Pilbara Minerals	Pilgangorra Expansion (P680)	100	2023
Mineral Resources	Mt Marion Expansion	150	2023
Liontown Resources	Kathleen Valley	500	2024
Lithium Hydroxide			
Tianqi Lithium	Kwinana Lithium Hydroxide Plant – Train 1	24 tpa	2022
Covalent Lithium (Wesfarmers and SQM)	Kwinana Lithium Hydroxide Plant	50	2024
Mineral Resources	Kemerton Lithium Hydroxide Plant (Stages 1-2)	50	2023
Pilbara Minerals and Calix	Mid-stream Demonstration Plant (Lithium Phosphate)	3	2023 – 2025
Prospective new projects			
Spodumene concentrate			
Pilbara Minerals	Pilgangoora Expansion (P1000)	320	2025 – 2028
Talison Lithium	Greenbushes Expansion (CGP4)	520	2027 – 2028
Liontown Resources	Kathleen Valley Expansion Year 6	200	2030
Global Lithium	Exploration – Manna and Marble Bar Lithium Projects	n.a.	2030 plus
Covalent Lithium (SQM and Wesfarmers)	Mt Holland Expansion (under consideration)	360	2028 plus
Lithium hydroxide			
Tianqi Lithium	Kwinana Lithium Hydroxide Plant Train 2	24	2025 – 2026
Albemarle/Mineral Resources	Kemerton Lithium Plant (Stages 3-4)	50	2025 – 2028
Liontown Resources	Kathleen Valley Refinery	86	2028 – 2030
Covalent Lithium (SQM and Wesfarmers)	Kwinana Lithium Hydroxide Plant (Stage 2) (under consideration)	50	2029 plus

Sources: Company websites.

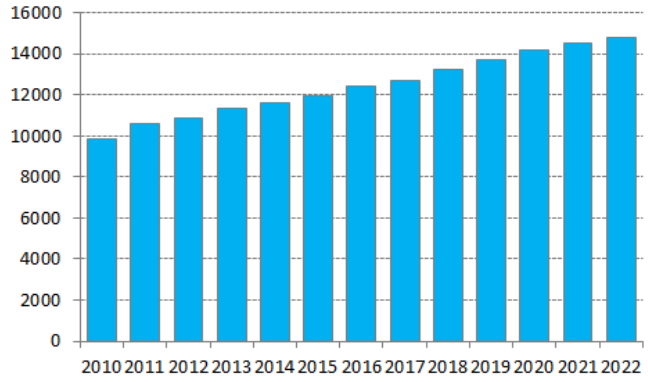
Figure 9.5: Western Australian lithium spodumene concentrate production to 2033 by scenario (kt)



Note: Actuals = 2018 to 2022; Estimate = 2023; Forecasts = 2024 to 2033.
Sources: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023 and NIEIR.

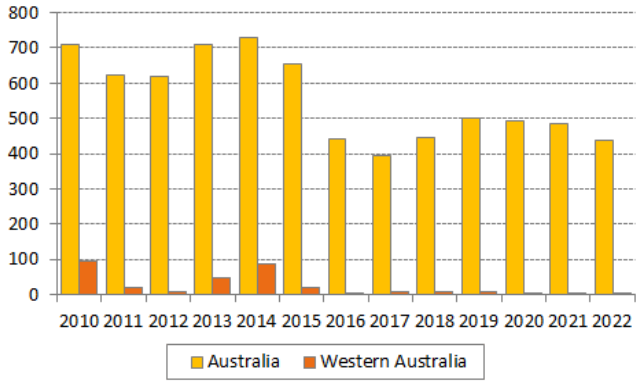
10. Lead

Figure 10.1: Lead production – World (kt)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023.

Figure 10.2: Lead production – Australia and Western Australia (kt)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023.

World lead production rose to 14.8 million tonnes in 2022. Over the last 10 years lead production has increased at an average rate of 3.2 per cent per annum. Over this 10 year period production has increased by nearly 4 million tonnes. The largest producer of lead in the world in 2021 was China (47 per cent), followed by Australia (11 per cent).

Australian production of lead fell to 437.8 kt in 2022. Australian production peaked at 728 kt in 2014. Queensland lead production in 2022 was 269 kt, representing 61.3 per cent of the Australian total. Glencore's operations in Queensland and the Northern Territory produced 165.9 kt in 2022, or 38 per cent of total Australian production.[28] The other states which are significant producers of lead are New South Wales (18.1 per cent) and the Northern Territory (12.7 per cent). Lead production in Western Australia in 2022 was 2.6 kt, or less than 1 per cent of total Australian production.

Australia's EDR of lead was 35.95 million tonnes in 2021.[29] Australia has 40 per cent of world reserves of lead. In 2021, there were 16 operating mines in Australia. These would normally be lead-silver mines or lead-silver-zinc mines. In 2021, Australia's EDR of lead was spread across the states as follows:

- Queensland (52 per cent);
- Northern Territory (21 per cent);
- New South Wales (13 per cent);
- Western Australia (12 per cent); and
- Tasmania (2 per cent).

Lead is a dull grey metal and is easily worked to alternative applications. Lead's main end-uses is in lead-acid batteries for motor vehicles, including heavy machinery and trucks. Lead is also used in construction, pigments, ammunition, weights, diving bells, glass and some solders. Lead has been banned from use in petrol, hair dyes and insecticides.

Lead is one of the most recycled materials in the world. This partly reflects the fact that nearly 100 per cent of lead is recovered from lead batteries. Lead can be re-melted and recycled indefinitely without losing its quality. Around half of Australia's lead consumed in Australia comes from recycling.

Table 10.1 Principal end-uses for lead

End-use	Industry/Sector	Per cent
Batteries	Lead-acid batteries for vehicles, industrial batteries	80
Cable	Cable sheathing	1
Pigments and compounds	Glass and plastics industries	5
Rolled and extruded products	Construction, manufacturing	6
Alloys	Manufacturing	2
Shot	Ammunition, military, policing	3
Other	Various	3

Source: International Lead and Zinc Study Group, ilzsg.org/statistics/enduses.

[28] Glencore Full Year 2022 Production Report.

[29] Australia's Identified Mineral Resources, Geoscience Australia, 2022, Digital publication, 2023.

The shift to electric vehicles will not displace the requirement for lead-acid batteries. The vehicles' electronics, mechanical operations (windows, windscreen wipers, etc.) will still require a reliable 12V battery system.

Lead metal exports from Australia in 2022 were 1.8 billion. Of this total, lead concentrate represented 44 per cent, lead bullion 31 per cent and refined lead 25 per cent. Concentrates from various lead mines are smelted and refined at Port Pirie in South Australia. Mt Isa mines smelt their lead concentrate into lead bullion and then ships it to the United Kingdom for refining. The principal markets for lead concentrate produced in Australia are China and South Korea.

World lead prices eased over 2022, to average US$2,151 per million tonnes. This follows a sharp increase of 20.5 per cent in calendar 2021. Lead metal prices over 2023 have been relatively flat so far, averaging US$2,128 per mt. These prices remain some 15 per cent below the March quarter 2018 peak of US$2,518 mt.

Western Australia's existing lead production has predominantly come from 29Metals Golden Grove mine.[30] The ore yields relatively low levels of lead, compared to copper and zinc (as well as gold and silver). The Golden Grove mine is located at the Gossan Hill deposit, located 280 kilometres east of Geraldton.

Another lead mine in Western Australia is the Paroo Station lead mine, a lead carbonate mine located near Wiluna in the Mid-West region.[31] Rosslyn Hill Mining owns the Paroo Station mine which is currently under care and maintenance.

The Abra lead-silver mine is located in the Gascoyne region of Western Australia.[32] The mine is 60 per cent owned by Galena Mining and 40 per cent by Toho Zinc Co. Ltd. The mine has a 16 year life, producing 95 kt of lead concentrate and 805 koz of silver per year. Full ore production will not be achieved until 2024.

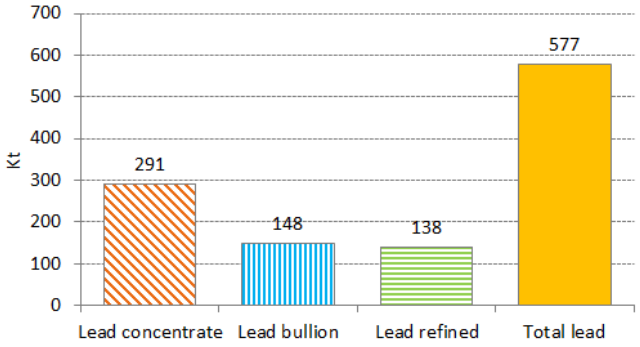
Another prospective lead-silver mine is the Sorby Hills project being developed by Boab Metals.[33] The Sorby Hills project is located North-East of Kununurra in the East Kimberley region of Western Australia. The project may achieve FID over 2023-24, once off-take agreements are in place. Annual production is expected to be 50 kt per annum.

Figure 10.5 shows the forecasts for lead production by calendar year for Western Australia to 2033 by scenario.

Figure 10.3: Lead nominal price (US$/mt)

Source: World Bank, August 2023.

Figure 10.4: Australian lead exports by type, 2022 (kt)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023.

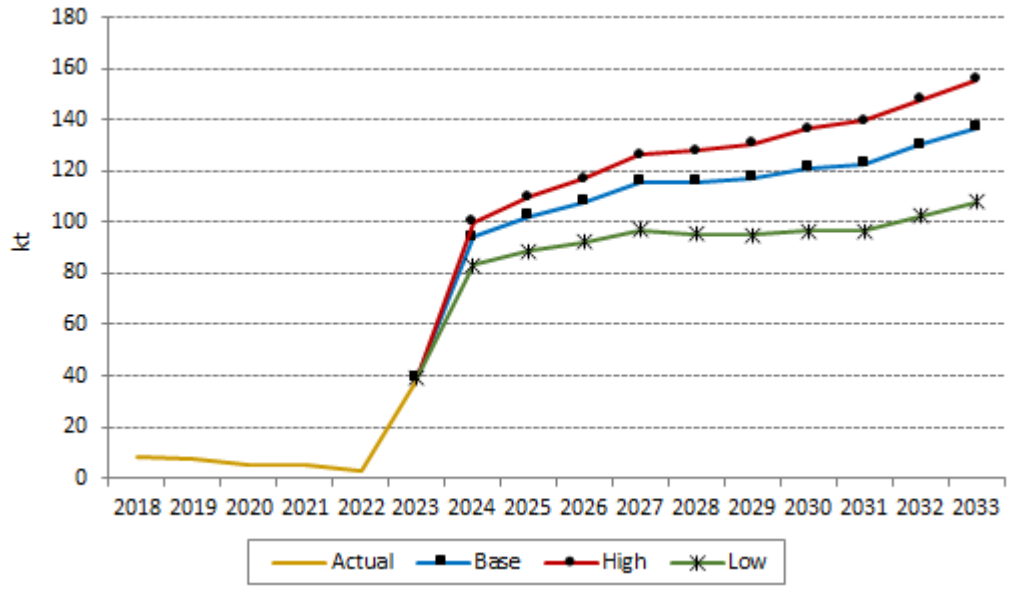
[30] 29Metals, www.29metals.com.

[31] Rosslyn Hill Mining, www.rosslynhillmining.com.au.

[32] Galena Mining, www.galenamining.com.au.

[33] Boab Metals Ltd, www.boabmetals.com.

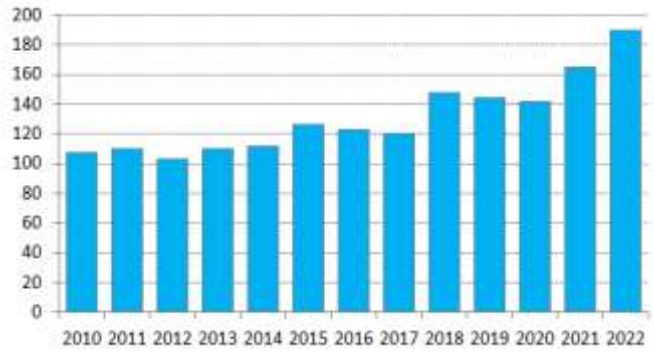
Figure 10.5: Western Australian lead production to 2033 by scenario (kt)



Note: Actuals = 2018 to 2022; Estimate = 2023; Forecasts = 2024 to 2033.
Sources: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023 and NIEIR.

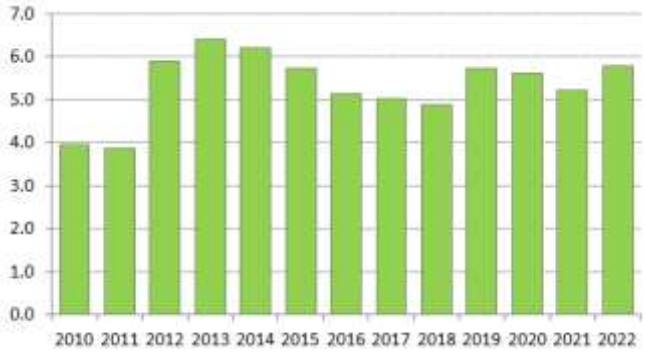
11. Cobalt

Figure 11.1: Cobalt production – World (kt)



Source: U.S. Geological Survey, Mineral Commodity Summaries, Cobalt, 2023.

Figure 11.2: Cobalt production – Western Australia (kt)



Source: DMIRS (WA), Major Commodities Resources Data, April 2022.

World production of cobalt has accelerated steadily since 2017 and then much more rapidly since 2020. World production was 142 kt in 2020, 165 kt in 2021 and 190 kt in 2022. Production levels in 2022 were 34 per cent above 2020 levels and reflects the acceleration in the take-up of battery technologies in transport, household equipment and electronics.

World production of cobalt is dominated by the Democratic Republic of Congo (DRC), who produced 130 kt in 2022, 68 per cent of world production. Indonesia, Russia and Australia account for an additional 13 per cent of world production in 2022. In terms of companies, Glencore is the largest producer of cobalt, producing 40.2 kt in 2022. The other major producers are two Chinese companies, China Molybdenum and Zhejiang Huayou Cobalt, Gecamines, a state controlled company in the DRC, and the Eurasian Resources Group.

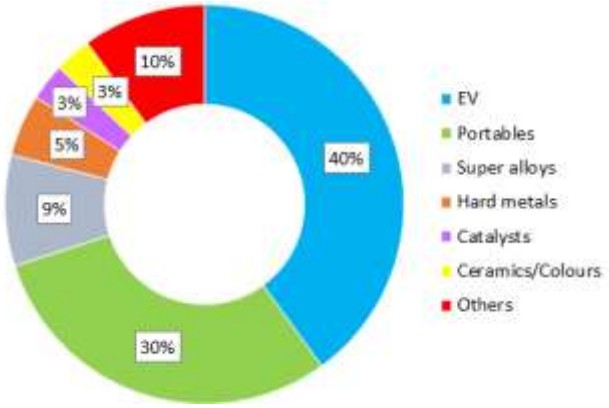
Australian production of cobalt in 2022 was 5,900 metric tonnes, nearly all of it sourced from Western Australia. As indicated in Figure 11.2, Western Australian cobalt production has been relatively stable at between 5,000 and 6,000 metric tonnes over the last eight years. The value of Western Australian cobalt mine production in 2022 was A$528 million.[34]

Australia has EDR of 20 per cent of world resources of cobalt and is ranked second in terms of its world share of resources. Total Australian cobalt EDR reserves were 1,582 kt in 2021.[35] Cobalt EDR have been increasing over recent years.

Western Australia has 67 per cent of Australia's cobalt reserves. Queensland has 16 per cent of cobalt reserves while New South Wales has 15 per cent.[36]

Australia's largest cobalt mine is the Murrin Murrin nickel-cobalt mine operated by Glencore. The mine is located in the North-Eastern Goldfields near Leonora. In 2022, production of cobalt at Murrin Murrin was 3.6 kt, or over 60 per cent, of total Western Australian production.

Figure 11.3: Consumption of cobalt by end-use, 2022



Note: 'Others' includes hard facing, 4,295t; magnets, 3,431t, and other applications including energy storage, tyres, soaps and paint driers.

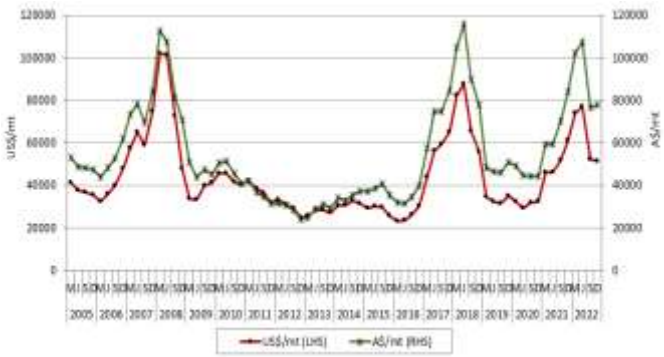
Source: www.cobaltinstitute.org, Cobalt Institute Market Report, 2022.

[34] DMIRS (WA), 2023 Major Commodities and Resources, 2022.

[35] Australia's Identified Mineral Resources, 2022, Digital publication, 2023.

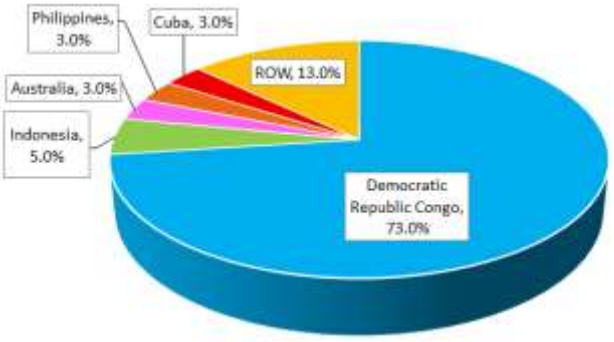
[36] Australia's Identified Mineral Resources, 2022, pp. 11.

Figure 11.4: Cobalt nominal price (US$/mt and A$/mt)



Source: DMIRS (WA), 2020, Major Commodities Resources Data.

Figure 11.5: Percentage share of cobalt production by major country, 2022 (%)



Note: 'ROW' includes (in descending order) Russia, Madagascar, Canada, Papua New Guinea, Turkey, New Caledonia, Morocco, Zambia, Finland, China, USA, Mexico and South Africa.
Source: Cobalt Institute, Cobalt Market Report 2022, pp. 22.

Cobalt's main end-use is in rechargeable batteries which are used in:

- electric vehicles and other transport equipment (e.g. forklifts, farm machinery);
- portable electronic devices (phones, laptops, tablets); and
- home battery storage and distribution storage solutions.

Cobalt has many other uses, such as a superalloy in engines, in tools, paints, magnets and tyres. In electric vehicles the batteries use lithium-ions, with nickel, manganese and cobalt in the cathode, a key part of the battery. Some cathodes can contain up to 0–15 kg of cobalt, 0–40 kg of nickel and 30–50 kg of lithium. Some electric car manufacturers are transitioning away from cobalt in batteries.

According to the Cobalt Institute (2022), battery applications now account for 72 per cent of cobalt demand, compared to 55 per cent in 2018. The energy storage sector has also been an important source of growth for cobalt, although from a low base.

The world price for cobalt has been relatively volatile over the last six years. This partly reflects supply disruptions (shipping delays around COVID-19) and uncertainties regarding the rate of take-up of EVs. The US$ price peaked in the June 2018 quarter, but then fell sharply through to June 2020. By the end of 2020 the price began to rise sharply again (see Figure 11.4), peaking in the June quarter 2022. By December 2022, the world price had fallen 35 per cent.

A number of potential cobalt projects have emerged in New South Wales and Queensland. The two main projects are Cobalt Blue Broken Hill project, which has an expected capacity of 3.6 kt per annum, and the Sconi Project in Queensland, by Australian Mines Ltd, with a capacity of 7 kt per annum of cobalt sulphate.

Western Australia has a number of prospective cobalt mine developments which are shown in Table 11.1. The GME Resources and the Ardea Resources projects are primarily nickel mines. All three proposals are still at the feasibility stage and may not proceed for a number of years.

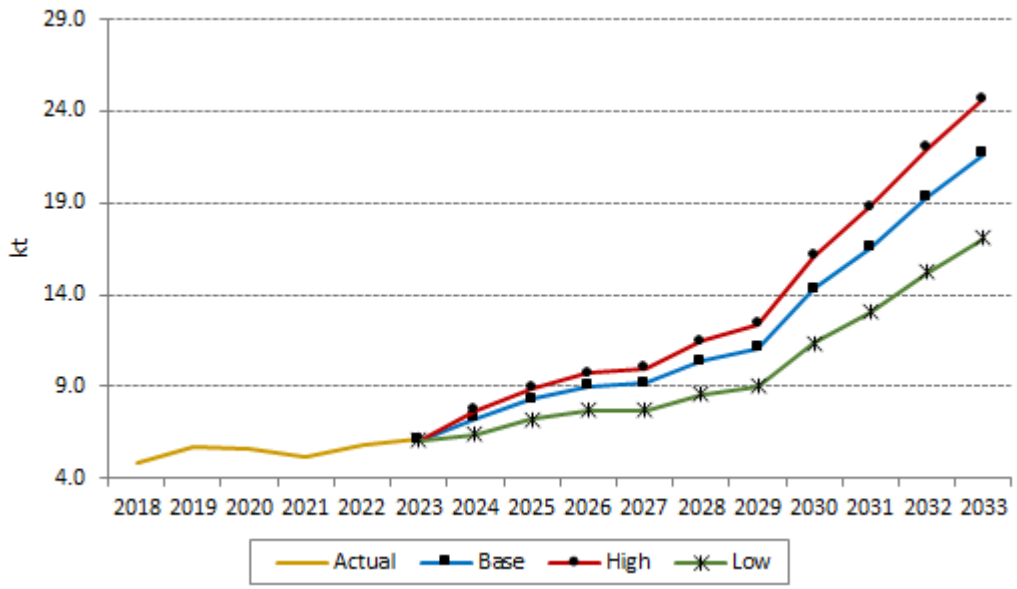
The rate of development of prospective new mines and new resources from exploration activities partly depends on the uptake of electric vehicles. A more rapid take-up of electric vehicles and battery storage by the household sector should lead to a more positive outlook for cobalt post-2025. Battery storage costs need to fall significantly in order for a mass market take-up to proceed.

Figure 11.6 shows the forecasts for cobalt production by calendar year in Western Australia to 2033 by scenario.

Table 11.1 Prospective cobalt projects – Western Australia			
Company	**Operation**	**Annual capacity (kt)**	**Timing**
Greenstone Resources (formerly Barra Resources)	Mt Thirsty cobalt-nickel	1.6	Post 2026
GME Resources	N. West nickel-cobalt project	1.4	Post 2026
Ardea Resources	Goongarrie nickel-cobalt	2.0	Post 2026

Sources: Company websites, ASX releases.

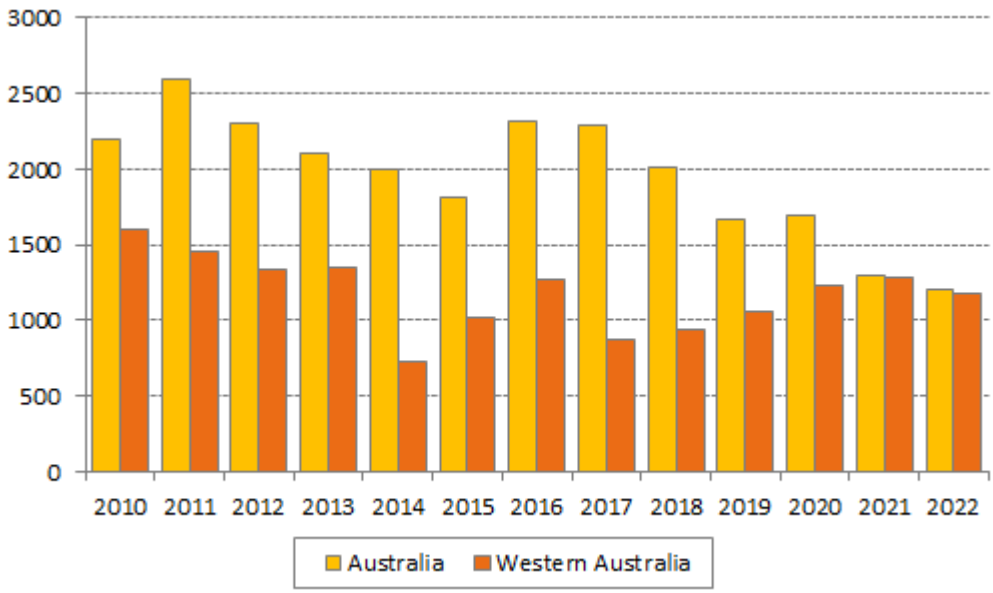
Figure 11.6: Western Australian cobalt production to 2033 by scenario (kt)



Note: Actuals = 2018 to 2022; Estimate = 2023; Forecasts = 2024 to 2033.
Source: DMIRS (WA), 2023, Major Commodities Resources Data, 2022, and NIEIR.

12. Mineral sands

Figure 12.1: Mineral sands production – Australia and Western Australia (kt)



Source: DMIRS (WA), 2022, Major Commodities Resources Data, April 2023 and NIEIR estimates.

The mineral sands industry involves the mining of zircon and titanium dioxide products, ilmenite, rutile and other upgraded titanium dioxide products.

The product zircon is an opaque, hard-wearing material that is mainly used in the ceramic tile industry. Zircon is also used in high tolerance casting/foundry applications. Lower quality zircon can also be used in digital printing, lower quality ceramics, zirconium chemicals and air and water purification systems.

The product titanium dioxide is mined as ilmenite or rutile. Both of these mineral sands are dark coloured, although turn white after processing. Titanium dioxide pigment is primarily used on paints, plastics, paper and other applications. These other applications include, for example, catalysts, ceramics, coated fabrics, floor coverings and printing ink. Titanium metal is used in aerospace applications, armour, marine equipment, chemicals, medical implants, consumer and power generation.

In the majority of mineral sands deposits zircon is produced in smaller quantities than titanium dioxide. The ratio of zircon to titanium dioxide is typically 1:4. World production of titanium concentrates in 2022 was 9.5 million tonnes. Global production of zircon in 2022 was 0.6 million tonnes.

World production of ilmenite was 8.9 million tonnes in 2022. The largest produces were China (3.4 mt), Mozambique (1.2 mt) and South Africa (0.9 mt).[37] World rutile production in 2022 was 0.59 million tonnes with the largest producers being Australia (0.19 mt) and Sierra Leone (0.13 mt).

The majority of mineral sands reserves in Australia are located in Victoria and New South Wales in the Murray Basin, in the Eucla Basin in South Australia, and in various locations in Queensland and Western Australia. In Western Australia, resources are located in the Perth Basin, at Coburn, McLaren West and Mindarra Springs.

Geoscience Australia in 2023 reported Australia's EDR reserves of mineral sands in December 2021 as follows:[38]

- 273.8 million tonnes of ilmenite;
- 33.8 million tonnes of rutile; and
- 78.6 million tonnes of zircon.

[37] Mineral Commodity Summaries, 2023, US Geological Survey, Titanium and Titanium Dioxide and Titanium mineral concentrates.

[38] Australia's Identified Mineral Resources, 2022, Geoscience Australia, 2023.

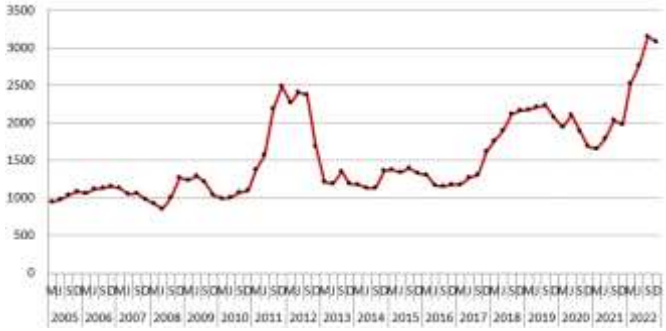
Australia has huge resources of mineral sands. In 2021 Australia had 23 per cent of world ilmenite, 63 per cent of the world's rutile resources and 72 per cent of the world's zircon resources. Geoscience Australia also ranked Australia in terms of world production in 2021. Australia was ranked 1st for rutile (26 per cent) and zircon (30 per cent) and 8th for ilmenite (4 per cent).

In 2022, Australian mineral sands production was 1,199 kt, a weaker production level compared to 2021. Australian production of mineral sands has fallen by nearly 50 per cent over the last 10 years.

Western Australian production of mineral sands was 1,175 kt in 2022.[39] This represented around 98 per cent of total Australian mineral sands production in 2022. Many of the reserves in eastern states of Australia remain undeveloped.

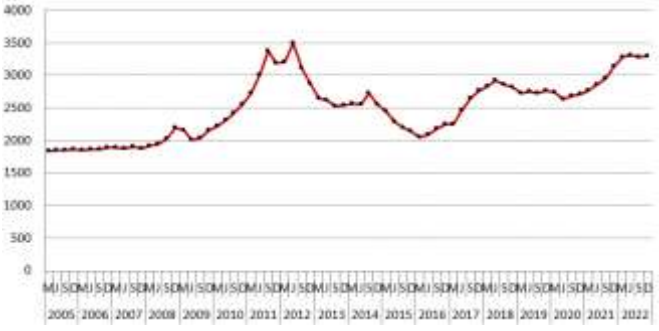
Australian production of ilmenite in 2021 was 660 kt from 11 mines, 45 per cent lower than in 2020. Production of rutile was 200 kt from 8 mines and zircon 500 kt from 10 mines.[40]

Figure 12.2: Zircon nominal price (A$/t)



Source: DMIRS (WA), 2022, Major Commodities Resources Data, April 2023.

Figure 12.3: Titanium dioxide pigment nominal price (US$/t)



Source: DMIRS (WA), 2022, Major Commodities Resources Data, April 2023.

In Western Australia the following mineral sands mines and downstream processing operations are in place.[41]

- Iluka Resources is a global critical minerals company specialising in exploration, mining and processing zircon and high grade titanium products. Iluka Resources has four establishments operating, the Cataby mine, the Narngulu mineral separation plant, Capel Operation and Eneabba.
  - The Cataby mine, north of Perth, is a large ilmenite deposit and has associated zircon and rutile. The Cataby mine has a mine life of 9 years, with a possible 4 year extension. The Cataby mine produces two main streams:
    - an ilmenite rich concentrate for cleaning and upgrading to rutile at Capel; and
    - a zircon/rutile rich concentrate for separation at Narngulu.
  - The Narngulu mineral separation plant is near Geraldton. The plant produces zircon, rutile and ilmenite products for export.
  - The Capel Operation has two synthetic rutile kilns. One has been operational and the other restarted at the end of 2022. The two kilns (SR1 and SR2) have a combined annual production capacity of around 335,000 tonnes. The synthetic rutile process upgrades ilmenite to a synthetic rutile product with a titanium dioxide content of 89-94 per cent.
  - The Eneabba is a large stockpile of high grade monazite. Iluka Resources is looking to commission a rare earths refinery at this site with a capacity of 17.5 kt per annum by 2025.

[39] DMIRS, 2023, Major Commodities Resource Data 2022.

[40] Australia's Identified Mineral Reserves, 2022, Digital publication, 2023.

[41] Company websites, ASX company releases.

- Tronox is a global heavy minerals mining and processing company. Tronox's main business activities in Western Australia include the following:
  - the Cooljarlo mine at Cataby;
  - the Chandala processing plant at Muchea;
  - the Bunburry Pigment Plant at Kemerton Industrial Park;
  - the Wonnerup/Northshare mines (Wonnerup North under development); and
  - the Kwinana Pigment Plant, located at Kwinana Beach.

  Tronox also has operations in other states of Australia. Tronox produces HMC from its heavy minerals mines and also titanium dioxide and pigment products as well as other titanium chemicals.
- Doral Mineral Sands (owned by the Iwatani Corporation, Japan) operates the Keysbrook Mineral Sand Mine, south of Perth. This operation produces 90 kt of heavy mineral concentrate per annum. The ore is transported to a minerals separation plant at Picton and then exported. Mines at Yoongavillup and Dardanup previously operated by Doral are being rehabitated.

  Doral also operates the Yalyalup mineral sands project. The Yalyalup mine will produce 100,000 tonnes per annum of HMC, comprising of ilmenite, Iuecoxene, rutile and zircon. The mine life is only five years.
- Image Resources NL operates a high grade zircon rich resource known as the Boonanarring Project. In calendar 2022, the Boonanarring Mineral Sands project produced 177.2 kt of HMC.

  Image Resources is looking at developing the Atlas project, 90 kilometres north of Boonanarring. The Atlas project has a resource of 18.1 mt at 6 per cent heavy mineral with a mineral content of 9.3 per cent zircon, 46 per cent ilmenite and 6.5 per cent rutile.
- Strandline Resources is a new producer of heavy mineral sands with assets located in Western Australia and Tanzania. Strandline operates the Coburn Mineral Sands project located 240 kilometres north of Geraldton. The project reached operational status in December 2022 with first production and shipment of heavy mineral concentrate (HMC). The Coburn project at full production would produce $160,000 tonnes of HMC. A scopy study is underway to double production to 320,000 tonnes of HMC. In 2023 Standline is commissioning a mineral separation plant to assist in producing premium rutile and zircon.

Western Australian exports of mineral sands in 2022 were A$2.2 billion in 2022. The major markets for mineral sands were China (38 per cent), Malaysia (10 per cent) and Spain (8.1 per cent).

Table 12.1 shows prospective mineral sands developments for Western Australia.

In the eastern states of Australia a number of other large mineral sands developments have been proposed. These include:

- the Balranald Project in New South Wales by Iluka Resources;
- the Donald Mineral Sands Project in Victoria (Astron Ltd);
- the Fingerboards Project in Victoria (Kalbar Operations); and
- the Wimmera Project in Victoria by Iluka Resources.

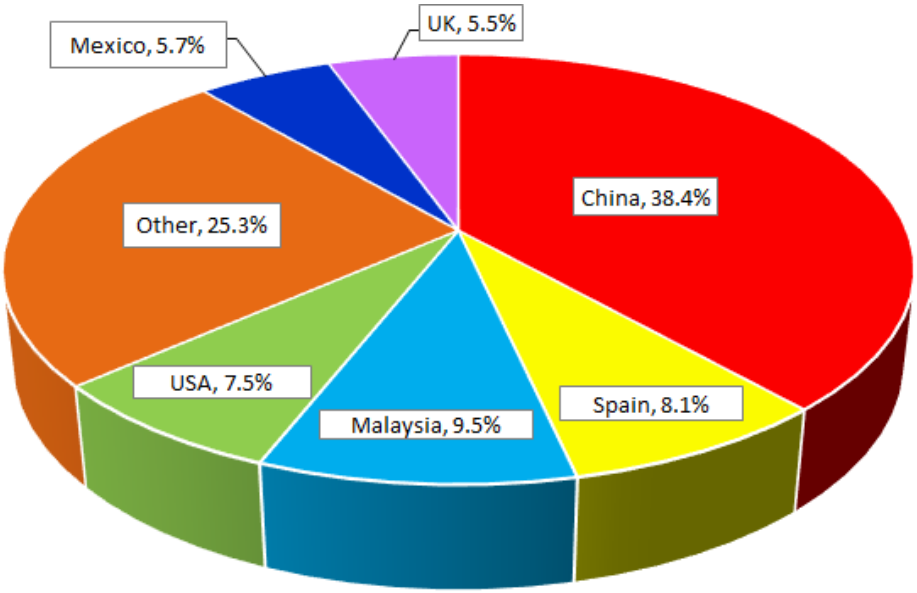
Figure 12.4 shows the forecasts for mineral sands production on a calendar year basis for Western Australia to 2033 by scenario.

Table 12.1 Prospective mineral sands projects – Western Australia

Company	Project	Capacity (kt)	Timing
Tronox	Dongara Expansion	nya	2026 – 2030
Diatreme Resources	Cyclone Zircon Project	59 Zircon	2026 – 2030
King River Resources	Speewah	Titanium Oxide	2025 – 2027
Standline Resources	Coburn Expansion Project (Feasibility)	109 Ilmenite 49 Zircon	2026 – 2030
Sheffield Resources	Thunderbird Project (Dampier)	114 Zircon 439 Ilmenite	2024 – 2025
Image Resources	Atlas Project	nya	2025 plus

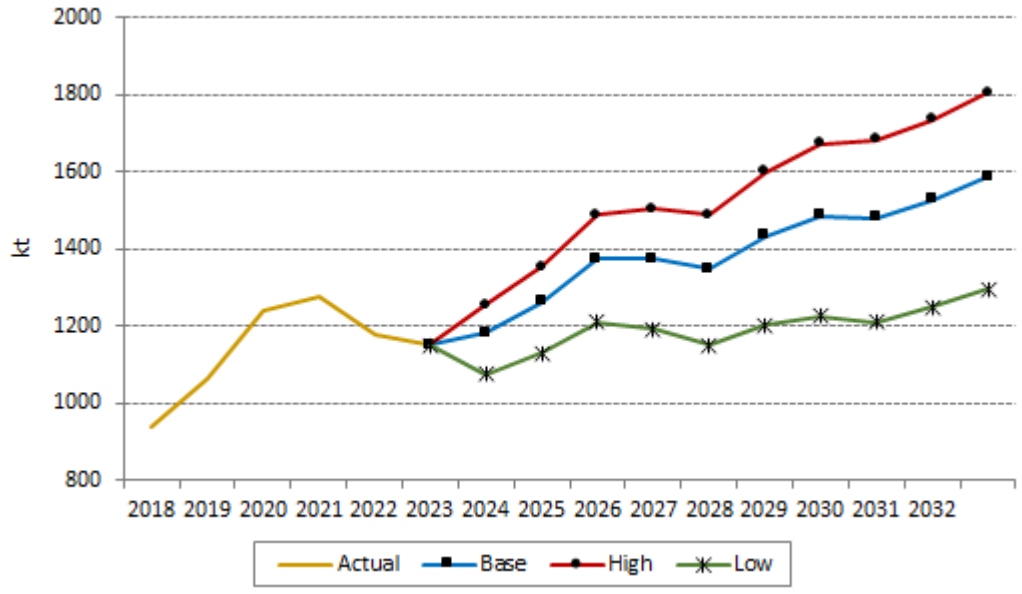
Note: nya = Not yet announced.
Sources: Company websites, ASX announcements.

Figure 12.4: Percentage share of the value of Western Australian mineral sands exports, 2022 (%)



Source: DMIRS (WA), 2023, Major Commodities Resources Data, 2022.

Figure 12.5: Western Australian mineral sands production to 2033 by scenario (kt)



Note: Actuals = 2018 to 2022; Estimate = 2023; Forecasts = 2024 to 2033.
Source: DMIRS (WA), 2022, Major Commodities Resources Data and NIEIR, April 2023.

13. Commodity production forecasts

Tables 13.1 to 13.3 summarise the production outlooks for the Base, High and Low scenarios, respectively, for Western Australia on a calendar year basis. The key drivers of the high and low growth scenarios for commodity production are different assumptions regarding world and Australian economic growth. This would also be reflected in different commodity price outlooks for the high and low growth scenarios. Australian production of mineral resources is primarily driven by the demands from overseas countries for these commodities, as well as commodity prices and movements in the exchange rate.

Table 13.1 Western Australian commodity production forecasts for the Base scenario

Calendar	Alumina (Mt)	Copper (kt)	Gold (t)	Iron ore (Mt)	Nickel (kt)	Zinc (kt)	Lithium (kt)	Lead (kt)	Cobalt (kt)	Mineral sands (kt)
2018	13.5	183.6	213.5	896.5	160.0	90.8	1965.9	8.6	4.9	936.6
2019	14.0	171.2	218.3	909.0	158.8	88.7	1616.8	7.2	5.7	1063.3
2020	14.2	155.1	220.0	909.8	169.3	79.8	1477.2	5.4	5.6	1237.1
2021	14.2	146.0	213.6	911.1	150.9	76.1	1966.7	4.9	5.2	1278.2
2022	13.5	137.2	216.3	933.5	153.4	90.2	2683.8	2.6	5.8	1175.5
2023	14.2	90.4	223.0	945.2	153.1	80.4	3363.6	39.2	6.1	1148.9
2024	14.5	94.2	239.4	951.8	182.3	96.6	3874.4	94.2	7.3	1179.9
2025	14.5	109.4	217.8	924.8	214.5	94.4	4337.2	102.5	8.3	1260.6
2026	14.6	130.3	210.1	932.1	221.3	102.4	5281.0	108.0	9.0	1372.9
2027	14.7	125.5	216.5	967.6	219.8	106.2	5613.5	115.6	9.2	1373.7
2028	14.7	119.0	220.6	1020.2	232.9	108.4	5988.5	115.9	10.4	1347.0
2029	14.8	138.6	226.8	1064.8	238.5	110.0	6213.5	117.3	11.1	1433.3
2030	14.8	155.7	230.1	1116.0	244.5	111.3	6493.5	121.2	14.3	1485.2
2031	14.8	164.7	232.7	1130.1	249.3	112.8	6533.5	122.7	16.5	1479.1
2032	14.8	178.3	237.9	1138.9	264.8	114.3	6658.5	130.1	19.3	1526.4
2033	14.8	196.3	241.2	1172.6	270.7	115.9	6673.5	136.8	21.7	1586.7

Note: Actuals = 2018 to 2022; Estimate = 2023; Forecasts = 2024 to 2033.
Sources: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023 and NIEIR.

Table 13.2 Western Australian commodity production forecasts for the High scenario

Calendar	Alumina (Mt)	Copper (kt)	Gold (t)	Iron ore (Mt)	Nickel (kt)	Zinc (kt)	Lithium (kt)	Lead (kt)	Cobalt (kt)	Mineral sands (kt)
2018	13.5	183.6	213.5	896.5	160.0	90.8	1965.9	8.6	4.9	936.6
2019	14.0	171.2	218.3	909.0	158.8	88.7	1616.8	7.2	5.7	1063.3
2020	14.2	155.1	220.0	909.8	169.3	79.8	1477.2	5.4	5.6	1237.1
2021	14.2	146.0	213.6	911.1	150.9	76.1	1966.7	4.9	5.2	1278.2
2022	13.5	137.2	216.3	933.5	153.4	90.2	2683.8	2.6	5.8	1175.5
2023	14.2	90.4	223.0	945.2	153.1	80.4	3363.6	39.2	6.1	1148.9
2024	14.9	103.3	254.4	1035.6	193.3	104.7	4373.7	100.0	7.7	1252.5
2025	15.1	121.2	239.3	1035.9	229.6	103.1	4911.1	109.9	8.9	1351.8
2026	15.2	145.8	232.1	1050.3	239.1	112.7	6036.8	117.0	9.7	1487.0
2027	15.4	141.8	240.5	1096.8	239.7	117.9	6477.4	126.5	10.0	1502.7
2028	15.6	135.8	246.4	1163.3	256.4	121.2	6974.6	128.0	11.5	1488.0
2029	15.6	159.8	254.7	1221.4	264.9	124.0	7303.6	130.8	12.4	1598.7
2030	15.6	181.2	259.9	1287.6	274.1	126.5	7702.7	136.4	16.1	1672.6
2031	15.7	193.6	264.2	1311.3	282.0	129.1	7820.6	139.5	18.8	1681.7
2032	15.7	209.5	270.1	1321.7	299.5	130.8	7970.2	147.9	22.0	1735.6
2033	15.7	230.6	273.8	1360.7	306.2	132.7	7988.2	155.5	24.7	1804.1

Note: Actuals = 2018 to 2022; Estimate = 2023; Forecasts = 2024 to 2033.
Sources: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023 and NIEIR.

Table 13.3 Western Australian commodity production forecasts for the Low scenario										
Calendar	Alumina (Mt)	Copper (kt)	Gold (t)	Iron ore (Mt)	Nickel (kt)	Zinc (kt)	Lithium (kt)	Lead (kt)	Cobalt (kt)	Mineral sands (kt)
2018	13.5	183.6	213.5	896.5	160.0	90.8	1965.9	8.6	4.9	936.6
2019	14.0	171.2	218.3	909.0	158.8	88.7	1616.8	7.2	5.7	1063.3
2020	14.2	155.1	220.0	909.8	169.3	79.8	1477.2	5.4	5.6	1237.1
2021	14.2	146.0	213.6	911.1	150.9	76.1	1966.7	4.9	5.2	1278.2
2022	13.5	137.2	216.3	933.5	153.4	90.2	2683.8	2.6	5.8	1175.5
2023	14.2	90.4	223.0	945.2	153.1	80.4	3363.6	39.2	6.1	1148.9
2024	13.9	86.7	222.2	883.5	169.2	89.1	3527.2	83.1	6.4	1074.5
2025	13.9	99.3	199.5	846.9	196.4	85.9	3887.4	88.9	7.2	1129.7
2026	13.8	116.8	189.8	842.2	199.9	91.9	4656.1	92.1	7.7	1210.7
2027	13.8	110.9	193.0	850.2	195.9	94.0	4870.3	97.0	7.7	1191.7
2028	13.8	103.8	193.9	880.5	204.7	94.6	5108.3	95.5	8.6	1149.0
2029	13.4	119.2	196.5	906.6	206.7	94.7	5211.9	95.0	9.0	1201.9
2030	13.5	132.0	196.5	937.2	208.8	94.4	5353.0	96.4	11.4	1224.1
2031	13.5	139.7	198.8	949.2	212.9	94.9	5339.2	96.7	13.0	1208.7
2032	13.5	151.2	203.2	956.8	226.2	96.2	5441.3	102.5	15.2	1247.4
2033	13.5	166.4	206.0	985.5	231.2	97.5	5453.6	107.8	17.1	1296.7

Note: Actuals = 2018 to 2022; Estimate = 2023; Forecasts = 2024 to 2033.
Sources: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2023 and NIEIR.

14. Commodity price forecasts

NIEIR conducted a survey of public world commodity price forecasts from major economic institutions. The survey presented in Table 14.1 was completed in August 2023, and was used to inform the commodity production outlook. The price forecasts are influenced by the timing, in terms of when they were prepared.

Table 14.2 also contains price forecasts for lithium hydroxide out to 2025. These were prepared by NIEIR and the Office of the Chief Economist based on supply and demand characteristics of the forecast lithium market.

Commodity price expectations to 2025 are shown in Table 14.1. For all commodities except gold, prices are expected to fall over calendar 2023 and 2024. The gold price is expected to rise over 2023 and then only fall back slightly in 2024. Gold prices ease further in 2025, although are only 5 per cent below 2023 levels.

In 2025, prices are expected to improve for some metals compared to 2024, including copper, nickel and zinc. Alumina prices remain flat. Iron ore prices are expected to fall further in 2025. The average iron ore price falls by 25 per cent between 2023 and 2025.

Table 14.1 Survey of world commodity price forecasts, August 2023

	Iron ore (US$ per tonne)			Gold (US$ per ounce)			Copper (US$ per tonne)		
	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum
2022	114	114	114	1801	1801	1801	8815	8815	8815
2023	93	101	112	1898	1923	1969	8500	8637	8828
2024	70	81	89	1750	1886	2019	8000	8526	8815
2025	66	76	86	1790	1818	1847	8463	9257	10052

	Nickel (US$ per tonne)			Zinc (US$ per tonne)			Alumina (Fob Australia) (US$ per tonne)		
	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum
2022	25826	25826	25826	3485	3485	3485	361	361	361
2023	22000	22487	23011	2513	2669	2800	345	346	344
2024	20000	20756	21375	2385	2657	2806	347	350	343
2025	20000	21657	23314	2601	2727	2853	349	349	349

Note: Forecast prices are from 2023 to calendar year 2025.
Sources: Office of the Chief Economist (June 2023), the World Bank (April 2023), Westpac (August 2023), NAB (August 2023), Scotia Bank (July 2023) and WA Treasury Budget Paper No. 3, 2023-24.

Table 14.2 World Lithium price forecast (US$ per tonne) – Lithium hydroxide LME

	2022	2023	2024	2025
Office of Chief Economist	72,505	46,746	34,614	29,057
NIEIR	72,505	49,310	40,130	34,650

Note: 2022 prices, fiscal years.
Source: Office of Chief Economist, June 2022..