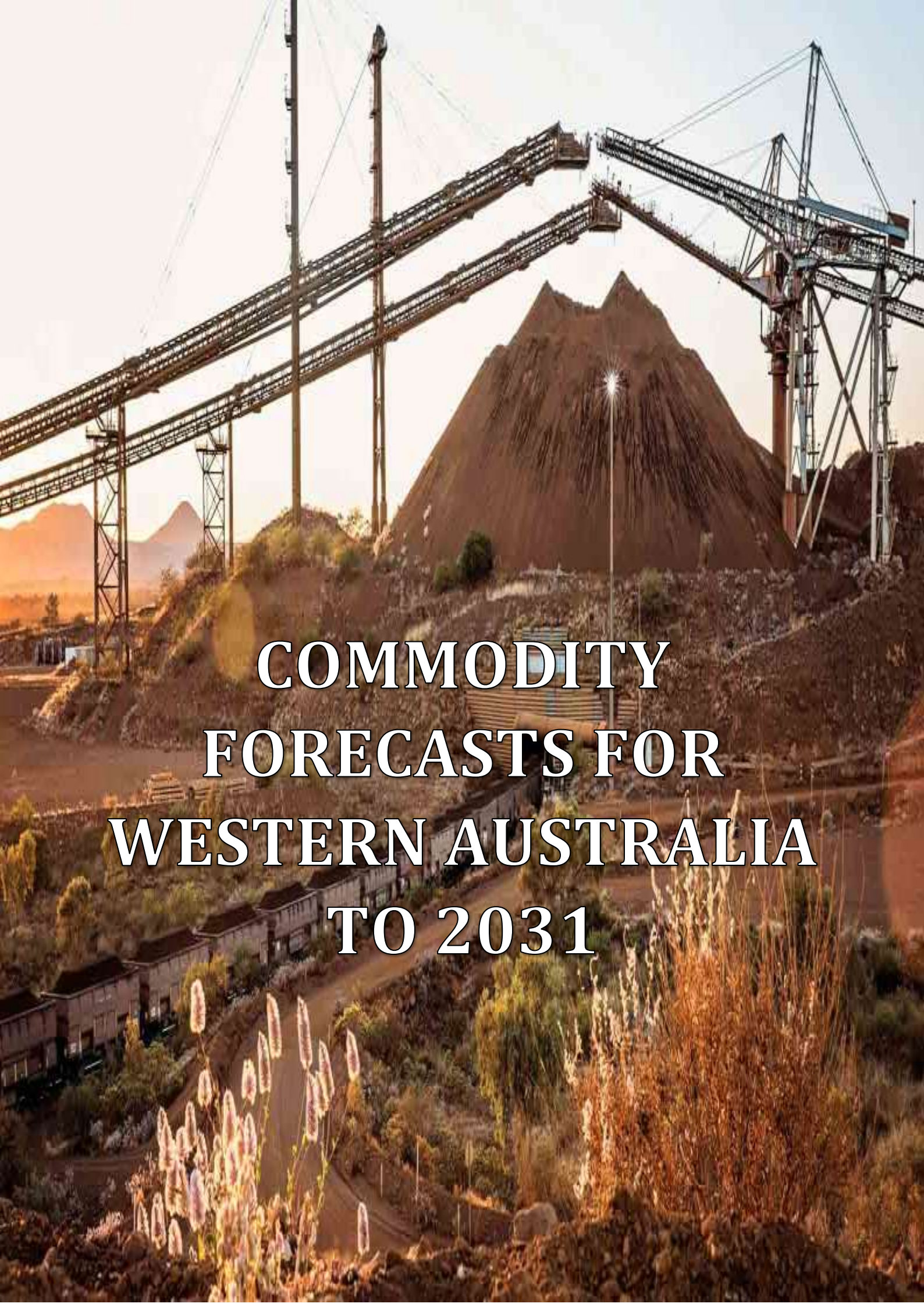


COMMODITY FORECASTS FOR WESTERN AUSTRALIA TO 2031

A report for
AUSTRALIAN ENERGY MARKET OPERATOR (AEMO)

July 2021

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.

Prepared by the
National Institute of Economic and Industry Research
ABN: 72 006 234 626
Lower Ground, Unit 1A, 663 Victoria Street, Abbotsford, Victoria, 3067
Telephone: (03) 9488 8444; Email: admin@nieir.com.au

TON907-Commodity forecasts-AEMO/AEMO/2021

Contents

List of tables

List of figures

List of figures (cont.)

1. Introduction and background

This report presents commodity forecasts for selected commodity groups or types extending out 10 years to 2031 on a calendar year basis. The forecasts were prepared for Western Australia and for base, high and low scenarios.

1.1 COVID-19 pandemic and mineral resource production

Global economic growth continued to recover over 2021 as the vaccine rollout continues. China and the United States appear to be recovering steadily. Infections across the world also appear to be falling.

Over 2020 and 2021, the COVID-19 pandemic has had significant impacts on world minerals markets. These include:

- significant commodity price falls over the first half of 2020;
- mine closures or suspended operations impacting on world production of copper, iron ore, coal and other mineral products; and
- energy commodities, such as oil, gas and LNG, were also impacted by reduced consumption and falling prices.

In Australia, the direct impacts of COVID-19 on mineral production have been less severe than in Latin America, Asia (including India) and Africa. Australian operations were suspended at some mines, however, this was not widespread given the limited outbreaks of COVID-19 in Australia.

In June 2021, the outbreak of COVID-19 led to the suspension of fly-in/fly-out mining workers to Western Australia meaning that they were blocked as interstate arrivals. Future outcomes remain uncertain with the Delta Strain of the virus spreading in New South Wales.

1.2 Commodity outlook scope of works

By 31 December each year, AEMO is required to publish a WA Gas Statement of Opportunities (GSOO). A significant proportion of Western Australian gas demand is driven by the outlook for commodity production for specific metals and minerals. AEMO therefore requires commodity production forecasts for its base, high and low gas demand forecasts.

Mining projects in Western Australia are usually located off the South West Interconnected System (SWIS), often in remote areas. Gas usage at these mines can include power generation for process use at the mine site and sometimes generation for the township of mine employees.

The commodity forecasts in this section are based on production for each commodity group or type. The commodity outlooks covered include the following:

- iron ore;
- alumina;
- gold;
- nickel;
- lithium;
- copper;
- zinc;
- lead;
- cobalt; and
- mineral sands.

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, including impacts of COVID-19 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 2031 are presented in Section 13 at the end of this report.

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

Western Australia mining commodity production by type is shown in Table 2.1 for 2014-15 to 2019-20. These are reported as values in Australian dollars. The table also shows the percentage change in the value of each commodity produced between 2014-15 and 2019-20.

The total value of mining commodities produced declined in 2014-15 and 2015-16, mainly reflecting a decline in commodity prices over this period. Rising actual production quantities for some commodities (such as iron ore) and improved prices led total Western Australian commodity production to reach A$173 billion in 2019-20.

Table 2.1 Nominal value of Western Australian mining commodities produced – 2014-15 to 2019-20

	Value by year						Average per cent change 2014-15 to 2019-20 (%)	Per cent share 2019-20 (%)
	2014-15 (A$m)	2015-16 (A$m)	2016-17 (A$m)	2017-18 (A$m)	2018-19 (A$m)	2019-20 (A$m)		
Iron ore	54376	48768	64319	62074	81782	104629	14.0	60.5
LNG	13817	10765	12728	18921	28800	27048	14.4	15.6
Gold	9107	10105	10860	11421	11959	15873	11.8	9.2
Alumina	5023	4937	5074	6597	8212	6350	4.8	3.7
Condensate	3529	2214	2230	3301	6163	5510	9.3	3.2
Nickel	3170	2203	2095	2636	2700	3164	0.0	1.8
Crude Oil	4568	3045	2128	2322	1840	2695	-10.0	1.6
Natural Gas	1820	1908	1835	1660	1607	1770	-0.6	1.0
Copper Metal	1283	1181	1241	1348	1322	1387	1.6	0.8
Spodumene	246	261	595	1698	1661	988	32.1	0.6
Mineral sands	493	572	583	550	703	793	10.0	0.5
Salt	375	336	292	303	304	375	0.0	0.2
COAL	307	336	338	332	319	327	1.3	0.2
Cobalt	211	175	240	510	332	295	7.0	0.2
Zinc Metal	197	195	204	324	263	225	2.7	0.1
Diamonds	342	354	268	250	219	225	-8.1	0.1
LPG - Butane and Propane	406	249	273	331	328	217	-11.7	0.1
Construction materials	163	80	63	72	95	127	-4.9	0.1
Silver	96	105	98	105	85	109	2.5	0.1
Lead Metal	137	15	10	23	13	7	-44.1	0.0
Other commodities	609	438	411	813	1083	875	7.5	0.5
Total	**100272**	**88241**	**105886**	**115591**	**149790**	**172989**	**11.5**	**100.0**

Source: Department of Mines, Industry Regulation and Safety, Western Australia (DMIRS (WA)), 2020, Major Commodities Resources Data.

Whilst Western Australia's overall mining commodity production is diverse, over 90 per cent of production values were concentrated in five groups in 2019-20. These were:

- iron ore (60.5 per cent);
- LNG (15.6 per cent);
- gold (9.2 per cent);
- alumina (3.7 per cent); and
- crude oil and condensate (4.8 per cent).

In terms of the value of production, the fastest growing commodity production groups in Western Australia between 2014-15 and 2019-20 in terms of average per cent change per annum were:

- LNG (14.4 per cent);
- gold (11.8 per cent);
- iron ore (14.0 per cent);
- condensate (9.3 per cent);
- spodumene (a Lithium ore mineral) (32.1 per cent);
- cobalt (7.0 per cent); and
- mineral sands (10.0 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, which, notwithstanding a fall in crude oil and condensate production, has increased significantly over recent years. In volume terms, crude oil and condensate production in Western Australia peaked in 2010, however has declined since then. The iron ore price peaked in 2011, but fell sharply until 2015. This had a significant impact on Western Australian production values for iron ore over this period.

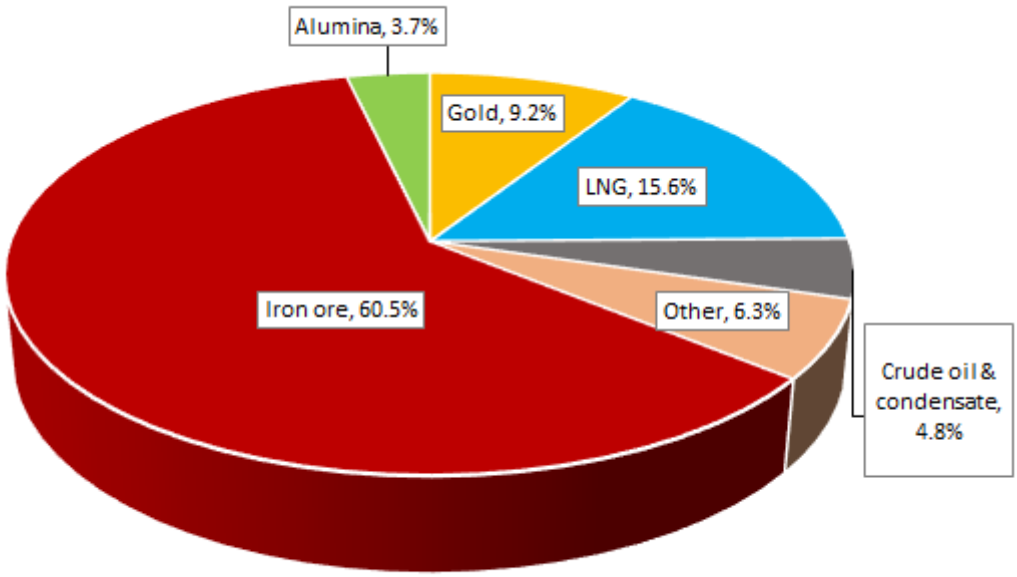
Table 2.2 shows quantities of mining commodities produced in Western Australia by type from 2010-11 to 2019-20. As indicated in Table 2.2, there have been some large production increases over the last nine years in Western Australia. These include the following commodities:

- iron ore (8.6 per cent per annum);
- gold (1.6 per cent per annum)
- LNG (11.8 per cent per annum)
- silica-sand (9.7 per cent per annum); and
- spodumene (17.1 per cent per annum).

Australian metals and other minerals private exploration expenditure over the last 10 years is shown in Table 2.3. During the previous mining boom, exploration expenditure reached nearly A$3 billion in 2011-12. There was a significant fall in expenditure on exploration in Australia between 2011-12 and 2016-17. In 2015-16 exploration expenditure was only $1.2 billion.

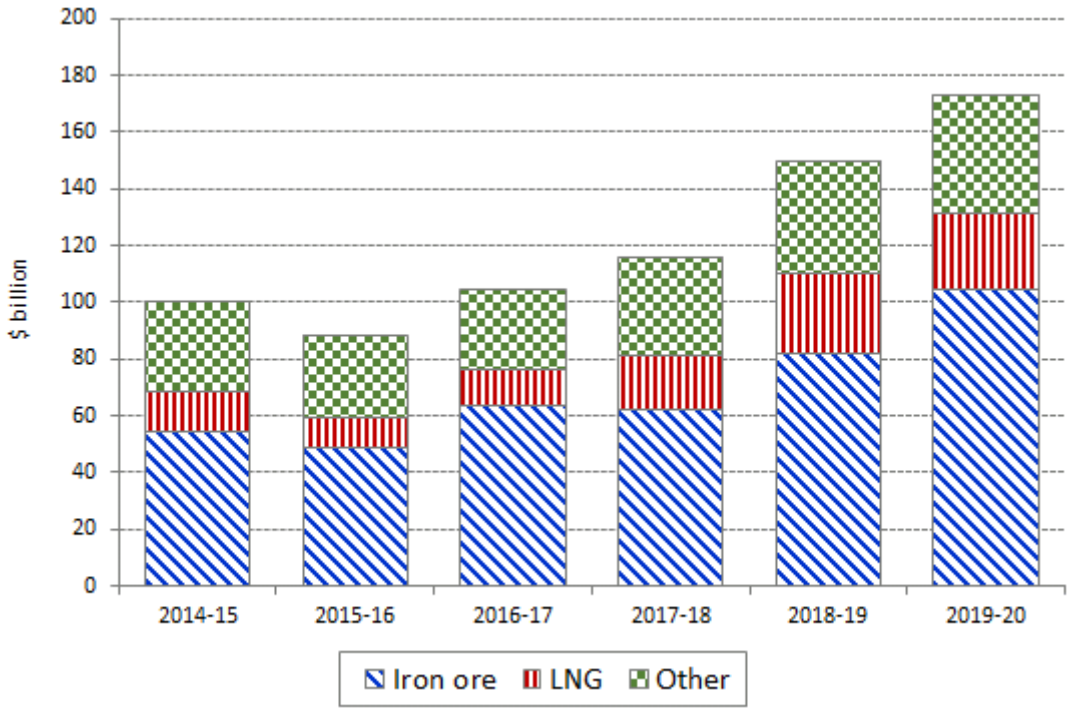
With the increase in base metals prices over 2018 and 2019, exploration expenditures have risen quite significantly in Australia. Compared to 2016-17, large increases in Australian exploration expenditure occurred for copper, gold, nickel, cobalt, lead, silver, zinc and for mineral sands. Iron ore exploration expenditure has remained relatively flat at around $300 million per year since 2015-16. Total exploration expenditure in Australia was $2.8 billion in 2020-21. Gold exploration over the last five years has accounted for 48 per cent of total Australian private metals and other mineral exploration expenditure.

Figure 2.1: Value of commodity production, Western Australia, 2019-20 – Main commodities



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

Figure 2.2: Value of Western Australian mining commodities produced 2014-15 to 2019-20 ($ billion)



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

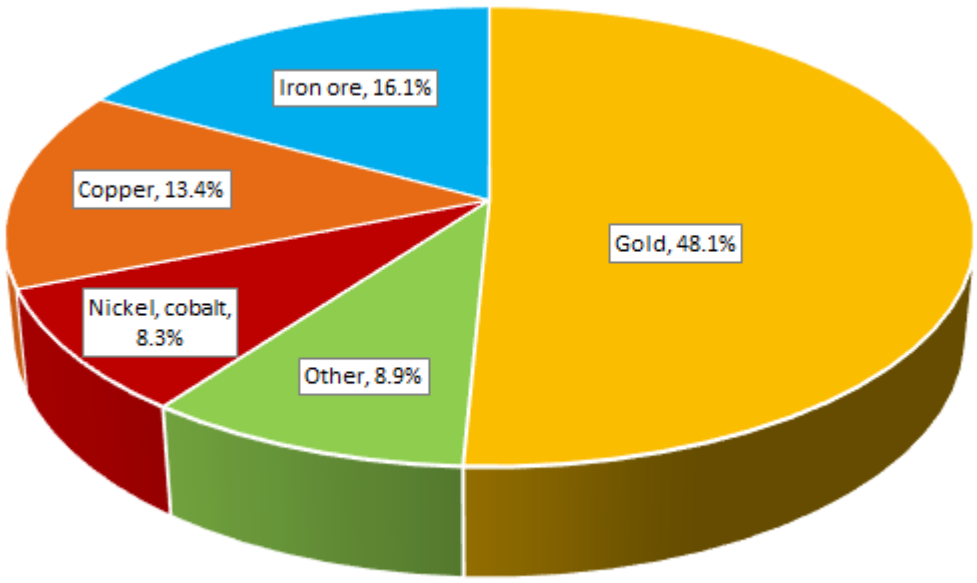
Table 2.2 Quantities of principal mining commodities produced in Western Australia – 2010-11 to 2019-20												
	Unit	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	Average % change 2010-11 to 2019-20
Alumina	kt	12281	12425	13531	13718	13771	13894	13855	13669	13643	14015	1.5
Copper metal	kt	150	159	209	211	184	190	171	174	162	171	1.5
Lead metal	kt	41	7	17	79	59	6	4	7	5	3	-25.8
Zinc metal	kt	71	64	56	54	78	83	83	93	71	72	0.2
Coal	kt	7234	6986	7494	6275	6553	6891	6806	6680	6275	6196	-1.7
Aggregate	kt	1935	3722	4391	2155	1964	1314	1053	1237	1608	3286	6.1
Gravel	kt	231	284	561	52	173	177	261	155	168	172	-3.2
Rock	kt	298	510	1110	403	1747	220	413	267	382	330	1.1
Sand	kt	4818	6287	5416	3797	5659	3435	2579	4120	2016	2459	-7.2
Diamonds	ct '000	10122	8690	9609	11611	10388	13870	12607	15281	11150	17490	6.3
Gem & semi-precious stones	kt	292	228	198	310	721	243	335	204	129	268	-1.0
Gold	kg '000	184	181	180	196	193	196	203	212	211	212	1.6
Gypsum	kt	587	334	1576	533	577	552	531	896	1004	623	0.7
Garnet	kt	227	302	317	357	299	251	566	380	388	324	4.0
Ilmenite	kt	394	332	271	79	100	175	179	120	225	269	-4.2
Leucoxene	kt	26	22	29	29	17	18	7	14	15	27	0.5
Rutile	kt	50	39	47	65	30	46	22	21	24	33	-4.5
Zircon	kt	299	180	216	212	183	192	185	73	134	175	-5.8
Iron ore	kt	397604	454385	511760	623507	718806	748100	792985	839424	794652	836758	8.6
Limesand-limestone-dolomite	kt	3721	4158	4092	3117	4903	4446	4178	3943	4305	4010	0.8
Manganese ore	Kt	873	846	650	712	801	425	237	379	573	554	-4.9
Cobalt	T	3767	4950	6200	6236	6036	5479	4759	5200	5228	5795	4.9
Nickel	Kt	194	209	227	233	183	176	158	163	154	153	-2.6
Palladium and platinum by-product	kg	440	626	658	1015	464	687	783	645	512	482	1.0
Condensate	Kt	6882	5889	6117	4399	6753	6775	6038	7113	11147	12739	7.1
Crude oil	kl '000	13925	11122	8609	6867	7952	7686	5404	4877	3097	5035	-10.7
LNG	kl '000	17290	15611	19805	19826	20448	20956	28685	37894	43635	47113	11.8
LPG – butane and propane	Kt	924	835	753	390	553	532	527	451	447	432	-8.1
Natural gas	million m3	8981	9081	8714	8218	9875	10224	9709	10175	10410	11138	2.4
Salt	Kt	12247	12807	12390	12992	11727	10975	10874	12964	11729	11266	-0.9
Silica – silica sand	Kt	430	453	498	450	484	582	729	974	992	991	9.7
Silver	kg '000	84	120	124	137	151	155	143	162	129	132	5.2
Spodumene	Kt	352	461	486	342	489	466	914	2138	1697	1460	17.1

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

Table 2.3	Australian metals and other minerals private exploration expenditure, Australia 2008-09 to 2020-21 ($ 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	166	1742
2010-11	323	1	652	665	6	271	76	224	2218
2011-12	443	3	768	1151	20	265	88	227	2965
2012-13	319	6	662	1011	38	165	80	161	2442
2013-14	177	8	434	711	21	99	46	170	1666
2014-15	144	5	396	448	27	83	52	131	1286
2015-16	130	4	548	291	20	51	50	115	1209
2016-17	136	2	689	291	20	81	55	150	1423
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 (est.)	343	3	1465	433	37	198	66	208	2752
5 year average	284	6	1019	340	31	177	74	189	2120
Per cent share	13.4	0.3	48.1	16.1	1.5	8.3	3.5	8.9	100.0

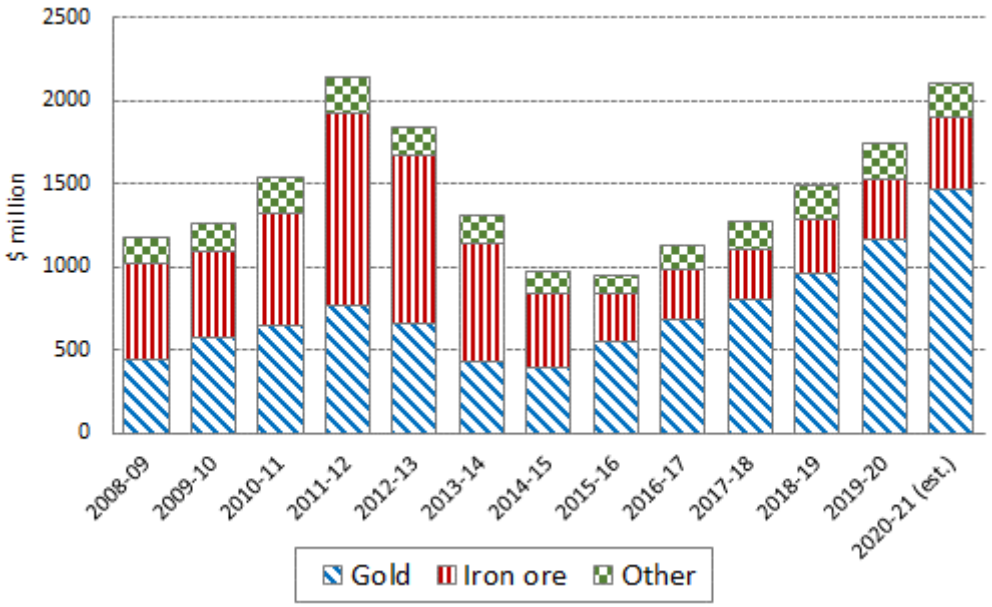
Note: Excludes petroleum exploration and uranium and coal exploration.
Source: Mineral and Petroleum Exploration, Australia, ABS, March 2021.

Figure 2.3: Australian metals and other minerals expenditure – percentage share by group, 2020-21 (%)



Note: Excludes petroleum exploration and uranium and coal exploration.
Source: Mineral and Petroleum Exploration, Australia, ABS, March 2021.

Figure 2.4: Western Australian private exploration expenditure – Selected metals and other minerals ($m)



Note: Excludes uranium and coal.
Source: Mineral and Petroleum Exploration, Australia, ABS, March 2021.

Figure 2.4 shows private mineral and metal exploration expenditure for Western Australia since 2008-09. Exploration expenditure in 2020-21 of $1.9 billion has almost returned to the peak of $2 billion in 2011-12. Western Australia accounted for over 70 per cent of total national mineral and metal exploration expenditure in 2020-21.

Table 2.4 shows Australia's world ranking of mineral resources in December 2019 in terms of share of world resources and share of world production.

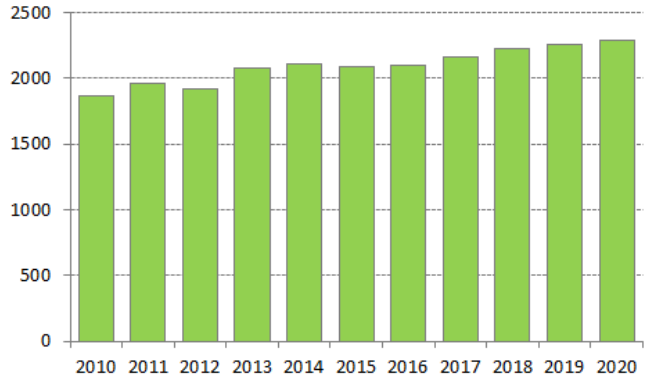
Table 2.4 Australia's ranking for selected minerals and metals in terms of reserves and share of production, 2019

Mineral	World ranking for resources	Resource as a share of world (%)	World ranking for production
Bauxite	2	18	1
Black coal	4	10	5
Cobalt	2	19	3
Copper	2	11	6
Gold	1	21	2
Iron ore	1	30	1
Lead	1	41	2
Lithium	2	29	1
Nickel	1	24	6
Rutile	1	65	1
Zinc	1	27	3
Zircon	1	72	2

Source: Australia's Identified Mineral Resources, 2020, Geoscience Australia, pp. 19.

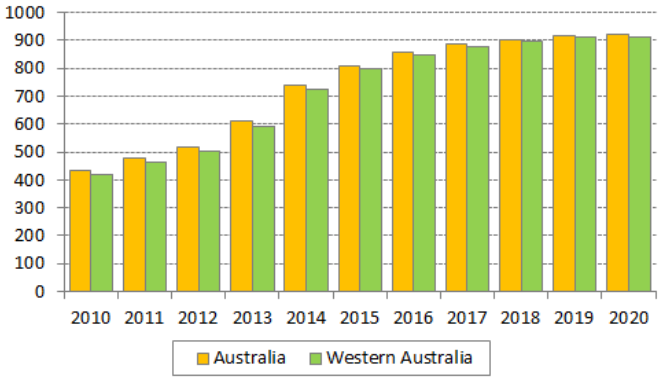
3. Iron ore

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 2021.

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 2021.

Global iron ore production in 2020 was 2,287 million tonnes, up slightly from world production in 2019 of 2,258 million tonnes. Australian production of iron ore in 2020 was 922 million tonnes, around 40 per cent of total global production. Other major producers of iron ore are Brazil (19 per cent) and China (14 per cent).

Global production of iron ore over 2020 and 2021 was impacted by a number of factors. These include:

- production falls in Brazil, reflecting mine closures associated with COVID-19 and the Brumadinho tailings dam collapse. Brazilian production is expected to recover over 2022;
- China looking to diversify supply away from Australia, however, many supply sources in China are high cost operations and potential supplies from Guinea may take some years to develop; and
- Chinese steel production reaching record levels over 2021, leading to surging iron ore prices. In May 2021, iron ore prices exceeded US$200 per tonne. Chinese authorities are attempting to curb steel production in China.

Australia has large reserves of iron ore located in the Pilbara region of Western Australia. Australia's Economic Demonstrated Resources (EDR) in 2019 were 50,593 million tonnes, or 30 per cent of world reserves.[1] Reserves in Brazil were 17 per cent of global resources in 2019.

Exploration expenditures for iron ore in Australia in 2020-21 was around $433 million.

Iron ore is principally used in steel production. World production of crude steel was 1,877.5 million tonnes in 2020.[2] Steel is used extensively in many applications, including:

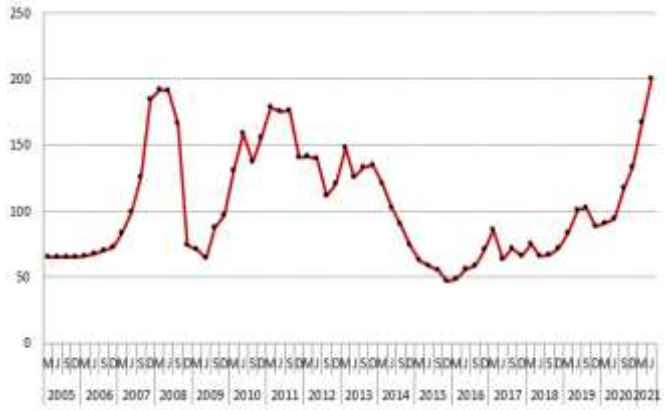
- building and engineering construction – non-residential building construction (e.g. shops, hotels) and engineering construction (e.g. railways, bridges, heavy industrial) and residential (e.g. apartments, house frames);
- mechanical equipment (e.g. motors, power tools) and automotive equipment (e.g. cars, trucks, construction machinery); and
- other transport, domestic and commercial appliances and other electrical equipment (including applications of stainless steel).

China's steel production in 2020 was 1,065 million tonnes, representing 57 per cent of total world crude steel production. Australian production of steel was 0.3 per cent of global production, reflecting the closure of steel making facilities in Australia.

[1] Australia's Identified Mineral Resources, 2020, Geoscience Australia, pp. 48.

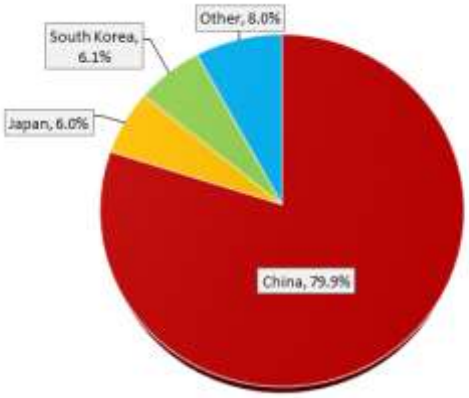
[2] World Steel in Figures, World Steel Association, 2021, www.worldsteel.org.

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



Source: World Bank, June 2021.

Figure 3.4: Percentage share of Australian iron ore exports by destination, 2020 (%)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021.

Australian production of iron ore in 2020 was 922 million tonnes, slightly higher than 2019 levels. Australian production of iron ore has increased substantially over the last 10 years. Production levels rose from 433 million tonnes in 2010 to 810 million tonnes by 2015, and to 922 million tonnes in 2020. The increase in production was fuelled by demand from Chinese steel mills, sourced from internal demands for steel in China, and manufactured steel products exports to other countries in the world.

In Australia, the major producers of iron ore are BHP Billiton, Rio Tinto Limited and the Fortescue Metal Group Ltd, all located in Western Australia. All of these iron ore producers have expanded their production capacity over recent years.

High iron ore prices over 2021 has encouraged some smaller producers to enter the market. Many of these projects have a capacity of only 2 to 4 million tonnes per annum. Some of these smaller producers include:

- Strike Resources Paulsen's East Project (Western Australia);
- Mount Gibson's Shine Project (Western Australia); and
- Roper Bar and Frances Creek mines in the Northern Territory.

World iron ore prices it record highs in mid-2021, reaching US$238 per tonne in May 2021. The surge in prices reflects the strong demand for steel, both within China but also from other countries, and the recovery in demand for Chinese consumer goods. With increased world production of iron ore, prices are expected to ease over 2022 and 2023.

The value of Australian iron ore exports was a record A$116.8 billion in 2020, up 21 per cent on the value of exports in 2019. Iron ore exports in volume terms in 2020 were 867.1 million tonnes, up by 3.8 per cent. China accounted for nearly 80 per cent of Australian iron ore exports in 2020, and Japan and South Korea with 6 per cent each represented the main other global markets.

Table 3.1 Major iron ore projects, Western Australia – committed

Company	Project	Resource (kt)	Timing
BHP	South Flank (replacement)	80,000	2021. First delivery from South Flank in May 2021.
Rio Tinto	Robe Valley (replacement)	25,000	2021
Rio Tinto	West Angelas (replacement)	30,000	2021
Rio Tinto	Koodaideri	40,000	2022
Fortescue Metals Group	Eliwana (Western Hub)	30,000	2023
Fortescue Metals Group	Iron Bridge	10,000	2022 (December)
Fortescue Metals Group	Nyidinghu (feasible)	10,000	2026

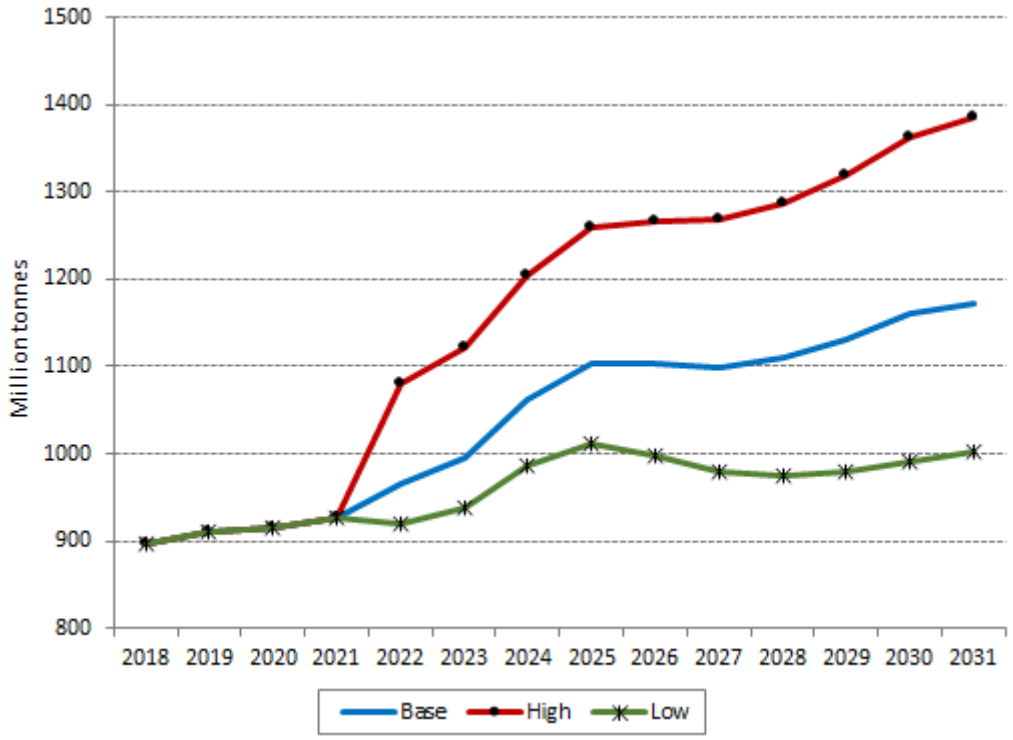
Source: ASX company announcements, reports, websites.

Australian iron ore production is expected to increase steadily over 2022 and 2023. Table 3.1 outlines the major developments by BHP, Rio Tinto and Fortescue Metals Group in Western Australia. There are other publically announced proposals or feasible projects, including:

- the Balmoral South resource (80,000 kt) owned by Australian Resources Limited and Mineralogy which may be developed by CITC;
- Atlas Iron's Sanjir Ridge operation, commissioned in mid-2021, is expected to produce around 4 million tonnes of iron ore lump and fines;
- West Pilbara Iron Ore Project owned by API Joint Venture (40,000 kt); and
- Pilbara Iron Ore Project (15,000 kt) owned by Todd Corporation/Flinders Mines.

Figure 3.5 shows the forecasts for iron ore production for Western Australia to 2031 by scenario.

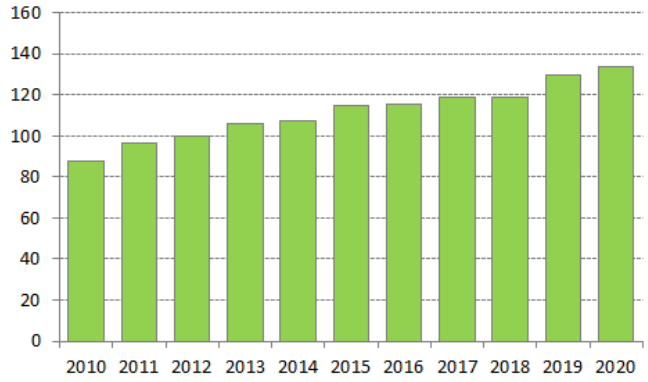
Figure 3.5: Western Australian iron ore production to 2031 by scenario (million tonnes)



Sources: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021 and NIEIR.

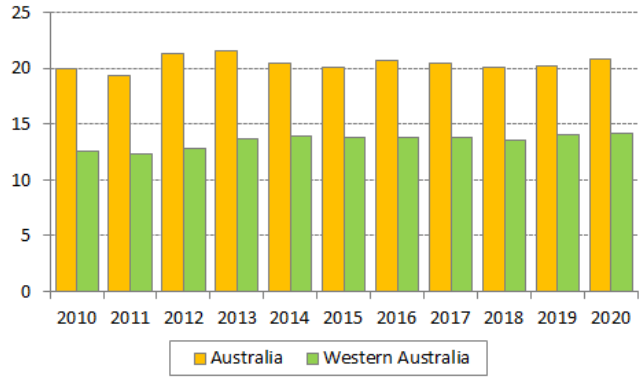
4. Alumina

Figure 4.1: Alumina production – World (million tonnes)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021.

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 2021.

In 2019, globally Australia was the second largest producer of alumina (15 per cent), behind China (54 per cent). Brazil produced 7 per cent of global alumina production in 2019.[3]

Australia is the largest producer of bauxite ore in the world, accounting for 30 per cent of world production in 2019. Other major producers of bauxite were Guinea (20 per cent), China (18 per cent) and Brazil (9 per cent). Australia is increasingly exporting bauxite rather than expanding alumina refining capacity. Australian exports of bauxite were 36 per cent of production in 2020, compared to only 12 per cent in 2010.

Production of alumina in Australia has been relatively flat over the last 10 years, as indicated in Figure 4.2. Alumina refinery plant expansions in Western Australia and Queensland have been offset by the closure of the Gove refinery in 2014 in the Northern Territory. The Gove bauxite mine is still operating, exporting all production.

Australian reserves of bauxite were 5,292 million tonnes in 2019, an increase of 3 per cent over 2018.[4] Australia has the second largest bauxite reserves (18 per cent) in the world, behind Guinea (25 per cent). There were 10 mines operating in Australia in 2019. The main mines in Western Australia are Huntly and Boddington, which supply alumina refineries of Pinjarra, Kwinana, Wagerup and Worsley.

Alumina is a manufactured product. It is produced from bauxite ore that is mined in Australia from topsoil in Western Australia, the Northern Territory and Queensland. The Bayer process extracts alumina from bauxite ore. Aside from the use of chemicals, such as Caustic soda, large quantities of heat are required by the process, usually natural gas. Alumina is refined into aluminium.

Global alumina production in 2020 was 134 million tonnes. As indicated in Figure 4.1, global production has expanded quite rapidly since 2010. World production was only 88 million tonnes in 2010. By 2020, world alumina production expanded by 50 per cent.

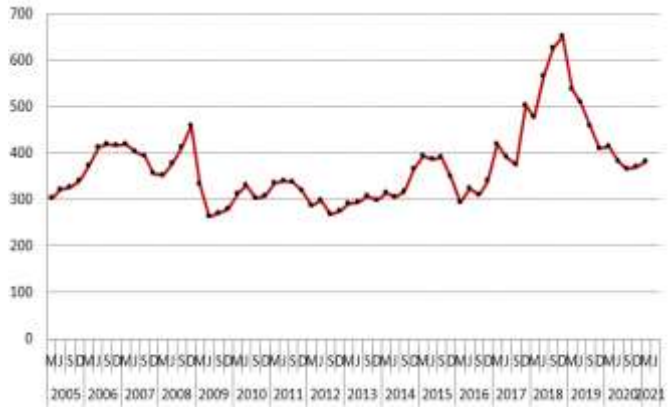
Alumina's correct name is aluminium oxide, a white powder. Alumina is generally used to produce aluminium metal. Alumina, however, does have some other direct industrial uses, such as production of spark plug insulators, metallic paint, and as a fuel component for solid rocket boosters. Aluminium is a light weight metal which has extensive applications in transport, construction and packaging applications. Aluminium is the main component used in aircraft construction, a key component in motor vehicle manufacturing and used extensively by the shipping and boating construction industries.

Australian exports of alumina in 2020 were valued at $6.9 billion, down significantly on the $8.5 billion in 2019. Australia's volume of alumina exports were 18.2 million tonnes in 2020, up from 17.8 million tonnes in 2018. The fall in Australian export values reflects a fall in average prices. Australian average alumina prices fell from A$479 per tonne in 2019 to A$383 in 2020, a fall of 20 per cent.

[3] Australia's Identified Mineral Resources, 2020, Geoscience Australia.

[4] Australia's Identified Mineral Resources, 2020, Geoscience Australia.

Figure 4.3: Alumina export value (A$/t)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021.

Figure 4.4: Shares of Australian bauxite production by State, 2020 (%)

Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021

Production of alumina in Australia is concentrated in Western Australia and Queensland. Queensland has major alumina refineries in Gladstone (Queensland Alumina Ltd) and Yarwun (Rio Tinto) located close to Gladstone. Total alumina refining capacity in Queensland is some 7.4 million tonnes. Western Australia, however, has four major alumina refineries located in the South West, namely:

- Kwinana (Alcoa, 2.2 million tonnes);
- Pinjarra (Alcoa, 5.0 million tonnes);
- Wagerup (Alcoa, 2.6 million tonnes); and
- Worsley (South 32, 4.7 million tonnes).

Total alumina refining capacity in Western Australia in 2021 is some 14.5 million tonnes per annum. Refinery production of alumina in 2019 was just over 14 million tonnes, so relatively close to nameplate capacity.

Alumina and aluminium prices over 2020 were adversely impacted by COVID-19 restrictions and their associated impact on manufacturing activity and the transport sector. Car sales fell globally and the aircraft fleet was significantly impacted. The alumina price was also affected by stockpiles from 2019. Some improvement in alumina prices is expected over 2021 and 2022.

Under the base scenario, Australia's production of alumina is expected to remain at just over 20 million tonnes per annum. Western Australia's production under the base scenario will remain at around 14.7 million tonnes per annum to 2031.

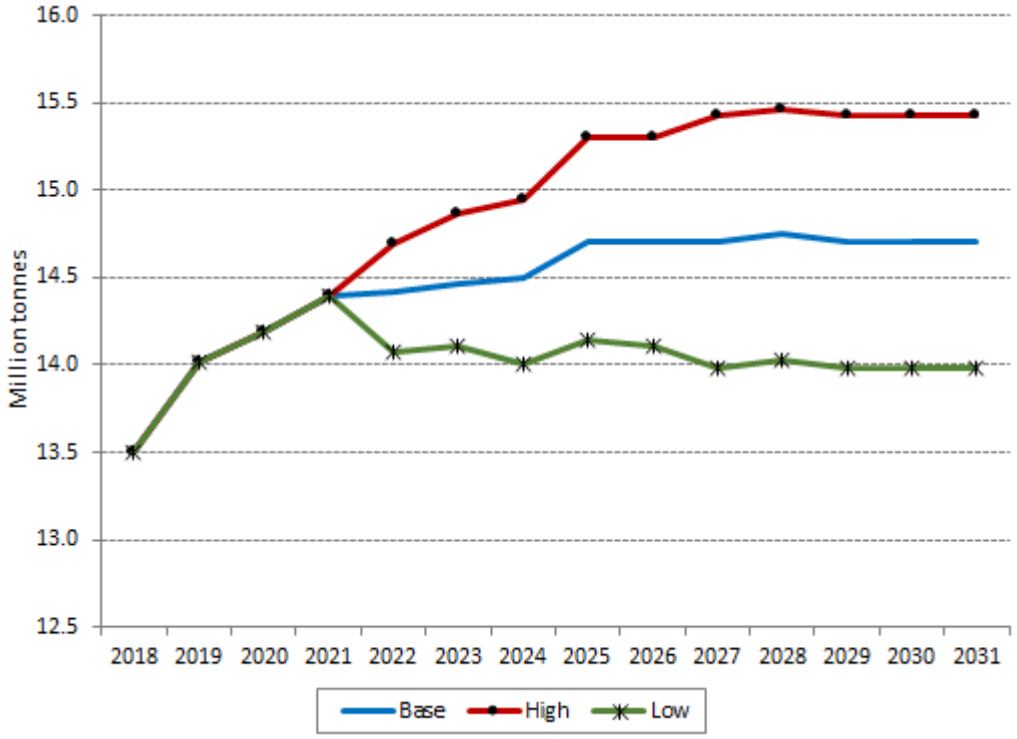
Alcoa Australia was reported to have deferred expansion plans for Pinjarra and Wagerup alumina refineries in April 2020. Applications with Western Australia's Environmental Protection Authority include:

- an expansion in Pinjarra from 5.0 to 5.25 million tonnes per annum; and
- an expansion of Wagerup to 3.3 million tonnes and then to a maximum capacity of 4.7 million tonnes per annum.

The expansion to 4.7 million tonnes at Wagerup refinery would require construction of a third production unit on the site. In May 2021, Alumina Limited, co-owner of Wagerup and Pinjarra refineries, announced it was reconsidering expansion plans given the improved outlook for alumina. The expansion at Wagerup is included in the high scenario, however, beyond 2024.

Figure 4.5 shows the forecasts for alumina production by calendar year for Western Australia to 2031 by scenario.

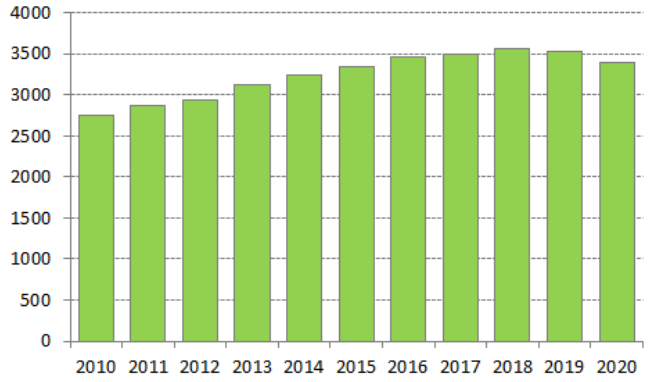
Figure 4.5: Western Australian alumina production to 2031 by scenario (million tonnes)



Sources: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021 and NIEIR.

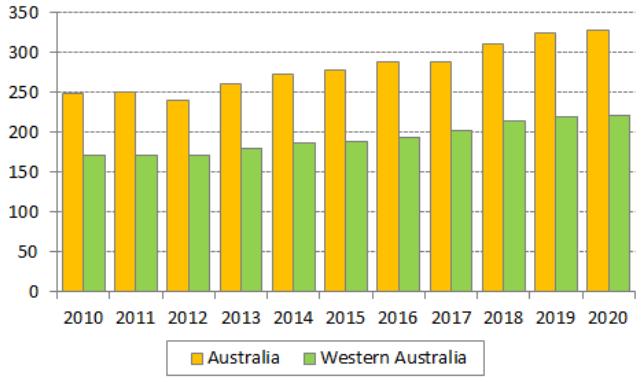
5. Gold

Figure 5.1: Gold production – World (tonnes)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021.

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 2021.

Global gold production in 2020 was 3,401 tonnes, slightly below production levels in 2019. Since 2010, world gold production has increased by 651 tonnes, or just under 25 per cent. Gold is mined across most countries in the world. The four largest gold producing countries in the world in 2019 were China (11 per cent), Australia (10 per cent), Russia (9 per cent) and the United States (6 per cent), together accounting for just over 36 per cent of total gold mine production.[5]

Australia's Economic Demonstrated Resource (EDR) in 2019 was 10,795 tonnes, or 21 per cent of world global resources of gold.[6] Australia's resource of gold is the largest in the world. In terms of the Australian States and Territories, the largest reserves are in Western Australia (45 per cent), South Australia (26 per cent) and New South Wales (16 per cent). Gold exploration represents nearly 50 per cent of Australian metals and other mineral exploration expenditure. Australian expenditure for gold exploration was nearly $1.5 billion in 2020-21.

Australian gold resources can fall into three different geological or metal association types. These are:

(i) lode-gold deposits (e.g. Kalgoorlie Super Pit);

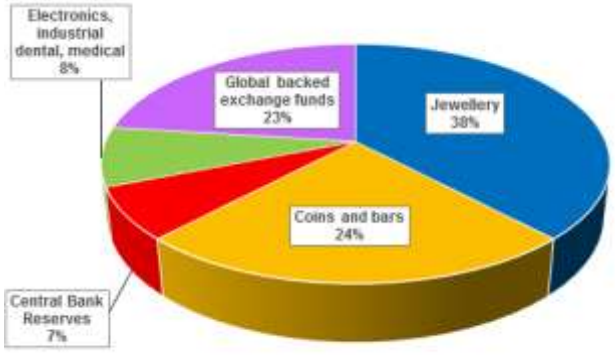
(ii) copper-gold deposits (Cadia); and

(iii) polymetallic and other gold deposits.

Depending on the type of gold ore extracted, the processing can involve different processes. Gold ore is generally extracted from the mine, then initially crushed, then finely ground. The extraction of gold involves leaching, using tanks with cyanide, lime, oxygen and lead nitrate. Further processing separates gold from other base metals. The Perth refinery produces gold at 99 per cent purity.

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. In current times, the main gold end-uses have changed slightly, but are still quite similar to 3,000 years ago. Global uses of gold are shown in Figure 5.3.

Figure 5.3: Global end-uses of gold metal



Sources: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021.

[5] World Mineral Production, 2015-2019, British Geological Survey, 2021.

[6] Australia's Identified Mineral Resources, 2020, Geoscience Australia, pp. 44.

As indicated in Figure 5.3, the main end-uses of global gold are in jewellery (38 per cent), coins and bars (24 per cent) and speculative trading (23 per cent).

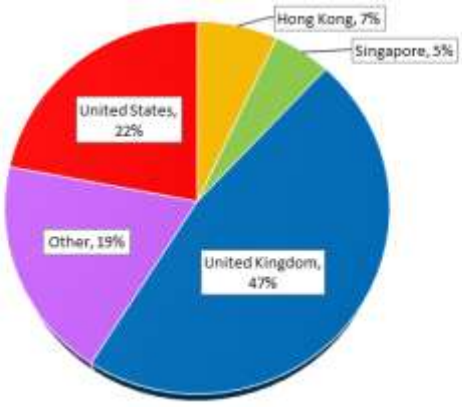
World gold prices rose sharply following the onset of the COVID-19 pandemic in 2020. The gold price reached a high of US$2,072 per ounce in August 2020, compared to US$1,479 per ounce in December 2019. The gold price eased to around US$1,900 per ounce by December 2020 and over the first six months of 2021 has averaged around US$1,800 per ounce. A key driver of the high gold price through the COVID-19 pandemic has been cuts to interest rates, lowering short-term and long-term bond yields.

Australian exports of refined gold in 2020 were $25.5 billion. Imports of refined and unrefined gold bullion were $9.1 billion, implying net exports of around $16.5 to $17.0 billion. The Perth Mint refinery can process up to 800 tonnes of gold per annum. Gold is sourced from Australian mines and from Asia.

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

Source: World Bank, June 2021.

Figure 5.5: Percentage share of Australian gold exports by destination, 2020 (%)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021.

Total Australian production of gold in 2020 was 328 tonnes, slightly up on 2019 production of 326 tonnes of gold. Australian gold production has increased by 77 tonnes or 30 per cent since 2010, most of this increase in Western Australia. In 2020, Western Australia produced 220 tonnes of gold, 67 per cent of total Australian production. New South Wales (12 per cent) and Victoria (8 per cent) also produced significant quantities of gold in 2020.

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 five mines operated by Northern Star, Newcrest, Tropicana and Newmont represented 33 per cent of total gold production in Western Australia in 2020.

Outside Western Australia, the Cadia mine in New South Wales near Orange is Australia's largest gold mine producing 822,478 ounces in 2020. BHP's Olympic Dam mine in South Australia produced 127,830 ounces in 2020.

Gold prices are expected to ease post-2021 as the world economy recovers from the COVID-19 pandemic. Gold production will expand over 2021-22 and 2022-23. A falling gold price by 2023-24 is expected to lead to production falls by 2023-24 and 2024-25.

A number of projects in Western Australia should help boost gold production in the short-term. These include:

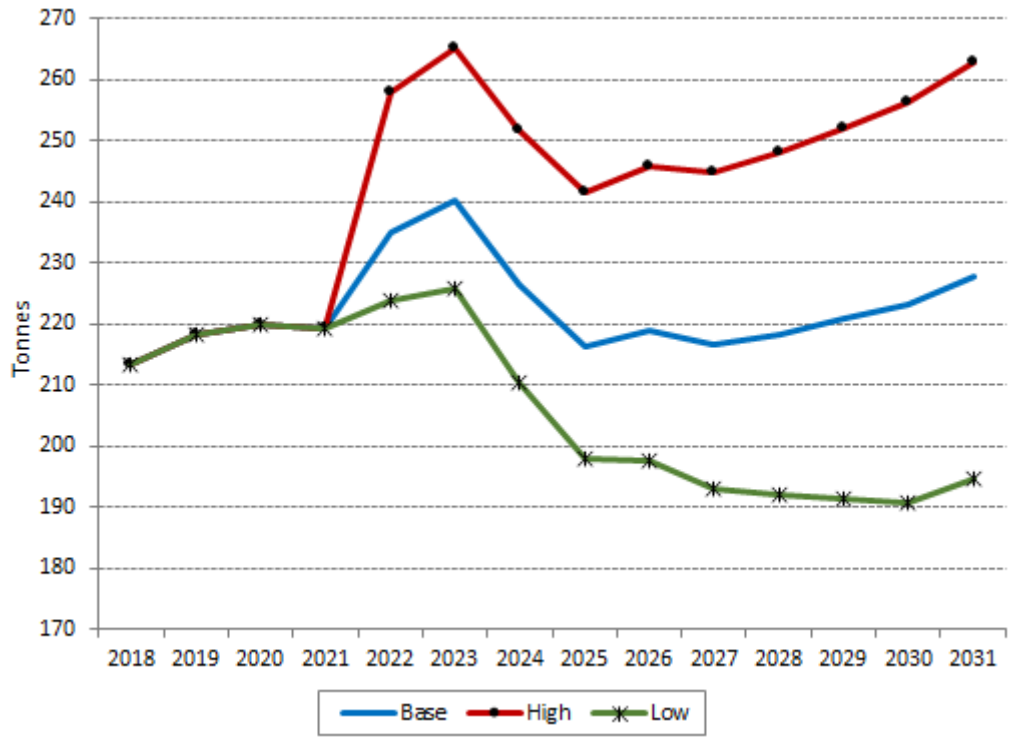
- St Barbara's Gwalia expansion (7.9 tonnes) in 2020;
- Tropicana's expansion of 15 tonnes per annum;
- Newmont's expansion at Boddington;
- KCGM's Golden Pike Cutback due to come online in 2021; and
- KCGM's Super Pit (Fimiston) South Open Pit Stage 1.

There are many other committed gold projects in Western Australia due to come online over the 2022 and 2023 period. The largest project outside Western Australia is Newcrest's Cadia expansions – Stage 1 and Stage 2.

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 2031 by scenario.

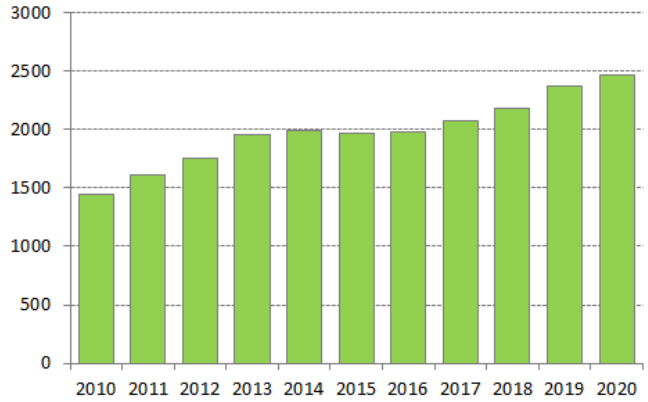
Figure 5.6: Western Australian gold production to 2031 by scenario (tonnes)



Sources: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021 and NIEIR.

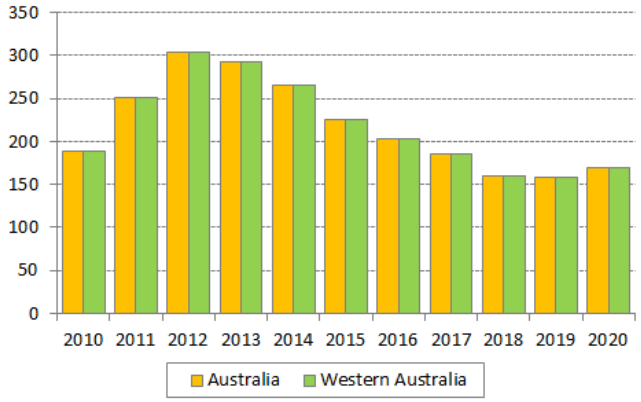
6. Nickel

Figure 6.1: Nickel production – World (kt)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021.

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 2021.

Global nickel production in 2020 was 2.47 million tonnes. World production levels have increased from under 1.5 million tonnes in 2010, to 2.0 million tonnes in 2015, and nearly 2.5 million tonnes in 2020.

In 2019, Australia was the sixth largest producer of nickel in the world, at 158.8 kt and representing 5.7 per cent of world production. Countries with larger nickel production in 2019 included Indonesia (37.5 per cent), Philippines (11.7 per cent), Russia (8.2 per cent), New Caledonia (7.6 per cent) and Canada (6.5 per cent).

In 2020, Australian nickel production was 169.4 kt. All Australian nickel is mined in Western Australia. Australia has 24 per cent of the world's economic resources of nickel. Australian reserves of nickel were 21.2 million tonnes in 2019, up 8.0 per cent from 197 million tonnes in 2018.[7] Nickel West, part of the BHP group, produced 91 kt of nickel in calendar 2020.

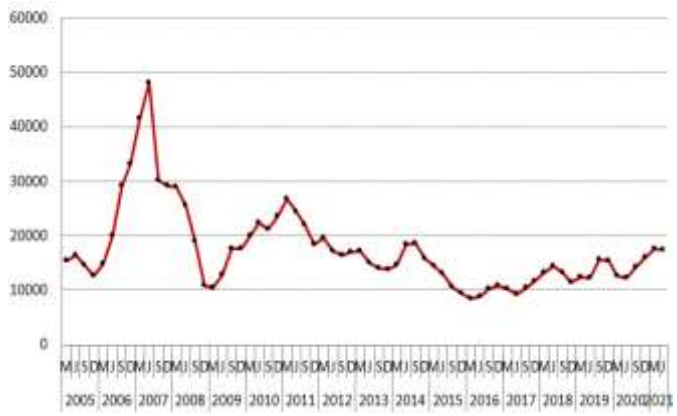
Australian nickel exports were $2.6 billion in 2020, a fall of 46 per cent over the value in 2019. Over 80 per cent of Australian exports were refined and intermediate nickel. The reduction in the value of exports from Australia (Western Australia) directly reflects a fall in the volume of exports in 2020.

Nickel is mainly used as an alloy to enhance toughness, strength and resistance to conversion. Around two-thirds of all nickel produced is used in the production of stainless steel. Nickel is widely used in the chemical industry, the construction industry and in consumer products, such as sinks, cooking utensils, white goods and cutlery and coinage. Nickel sulphate is also used in the production of batteries.

Nickel prices were impacted by expectations associated with the spread of COVID-19 across the world. Nickel prices in mid-2019 were US$15,650 per tonne, however, declined to only US$12,200 in June 2020. Nickel prices have since recovered strongly over the second half of 2020 and 2021, reaching US$17,980 in June 2021.

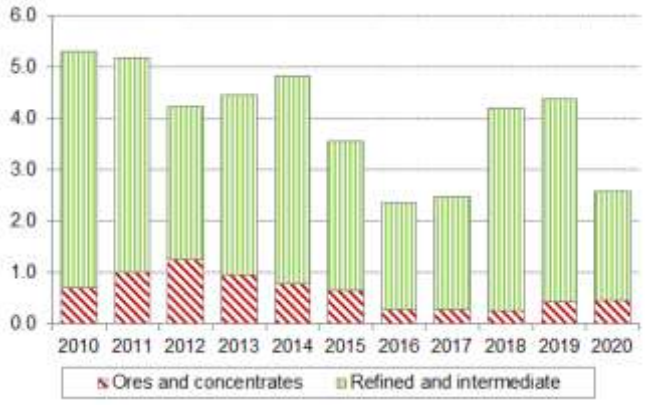
[7] Australia's Identified Mineral Resources, 2020, Geoscience Australia, pp. 65.

Figure 6.3: Nickel nominal price (US$/tonne)



Source: World Bank, June 2021.

Figure 6.4: Australian nickel exports by class (A$ billion)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021.

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

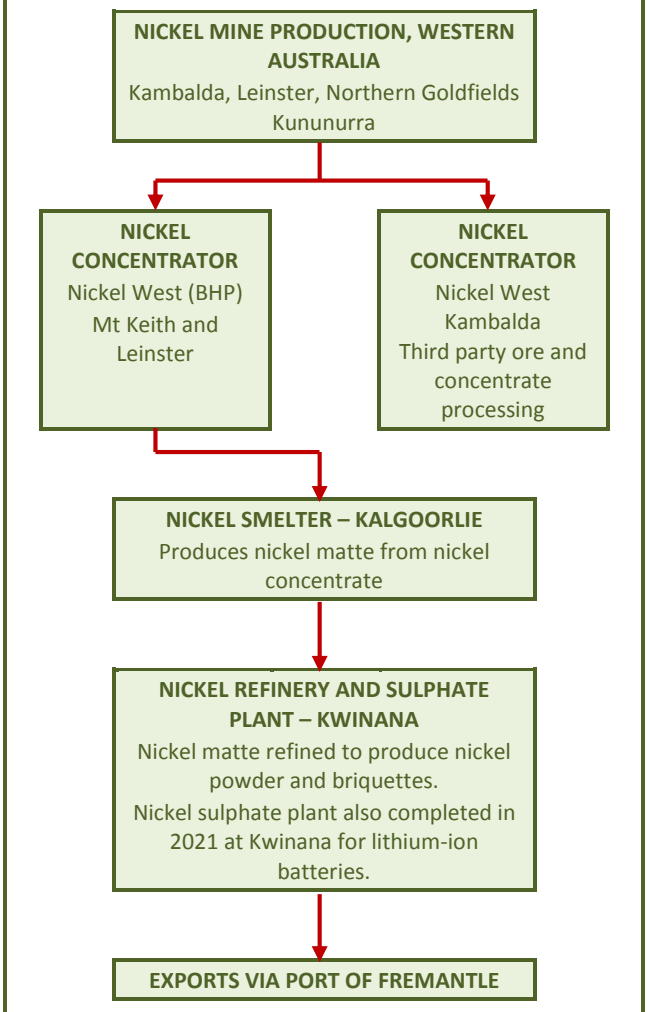
- ore mine at Mt Keith open cut and ore from the underground Cliffs and Leinster mines;
- a concentrator and dryer at Leinster and Mt Keith, as well as a concentrator at Kambalda, which processes ore from third parties;
- a smelter at Kalgoorlie which converts nickel concentrate to nickel matte; and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

Over 75 per cent of Nickel West's output is now sold to global battery material suppliers. BHP has completed building a 100 kt nickel sulphate plant in Kwinana which will be used in lithium-ion batteries that power electric vehicles (commissioned in 2021).

In the medium-term Australian nickel production is expected to increase, reflecting increasing demands from batteries and stronger underlying world consumption growth. There are a number of nickel mining projects committed in Western Australia, including:

- the Black Swan – Silver Swan Restart by Poseidon Nickel with an estimated capacity of 8 kt;
- the Kambalda mine restart by Mincor Resources near Kalgoorlie (16 kt);
- the Leinster B11 Black Cave expansion by BHP (10 kt); and
- the Odysseus Project by Western Areas Ltd with an estimated capacity of 13 kt.

Figure 6.5: The Nickel West (BHP) supply chain

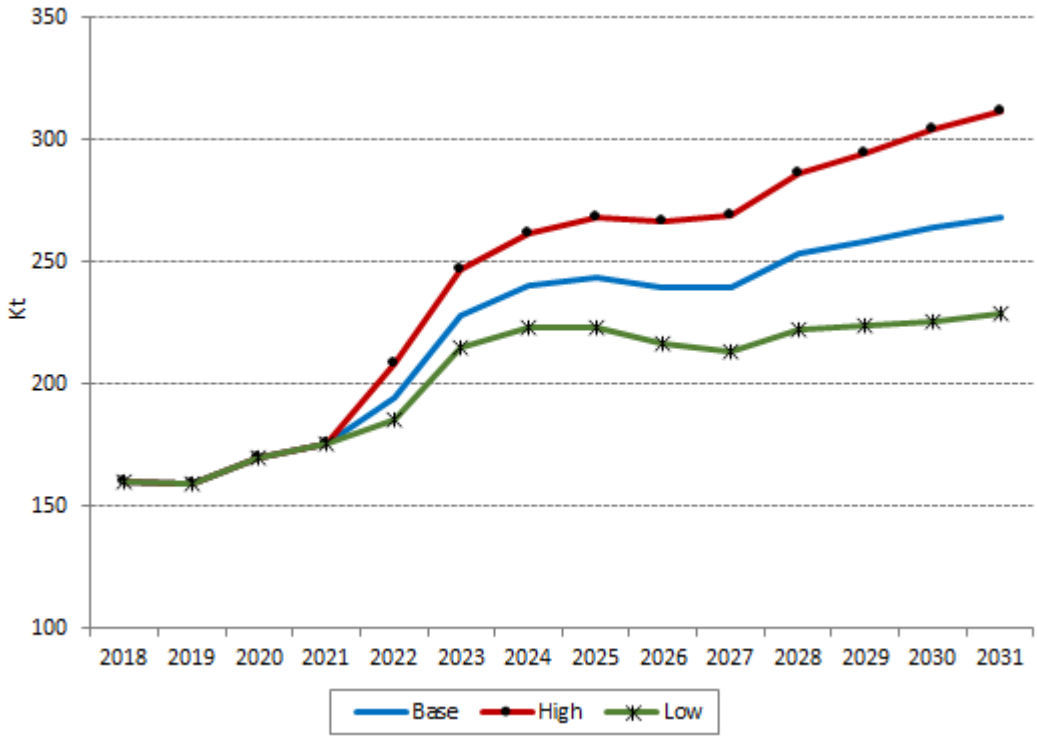


Source: BHP website.

In addition to these major nickel projects, there are a number of other development proposals that have been announced, which may proceed by the mid-2020s. These future developments, if they proceed, will account for an extra 80 kt of nickel mine production capacity.

Figure 6.5 shows the forecasts for nickel production on a calendar year basis for Western Australia to 2031 by scenario.

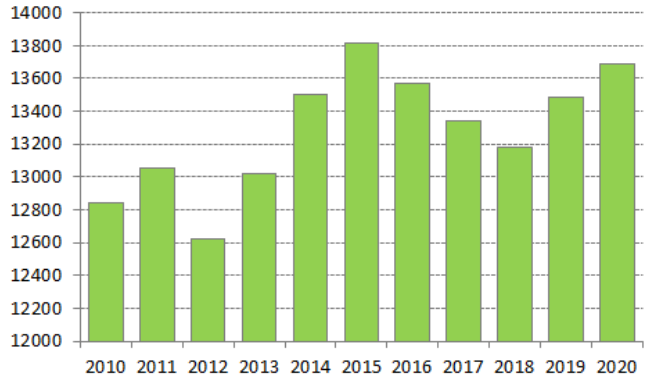
Figure 6.6: Western Australian nickel production to 2031 by scenario (kt)



Sources: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021 and NIEIR.

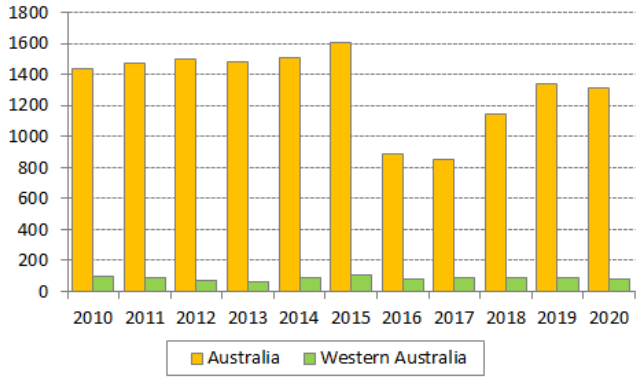
7. Zinc

Figure 7.1: Zinc production – World (kt)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021.

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 2021.

Global production of zinc in 2020 was 13.7 million tonnes, up from 13.5 million tonnes in 2019. Zinc is produced across many countries, however, the dominant producers of zinc metal in 2019 were China (30 per cent), Peru (11 per cent) and Australia (11 per cent). Around 30 per cent of zinc use in the Western World comes from recycled materials.[8]

Australian zinc metal production in 2020 was 1,312 kt, down slightly on 2019 production of 1,337 kt. These are significantly higher production rates when compared with production of only 852 kt in 2017. [9] A prolonged period of low prices forced zinc mine closures in Queensland at the Century and Mt Isa deposits and by Glencore (McArthur River) in the Northern Territory.

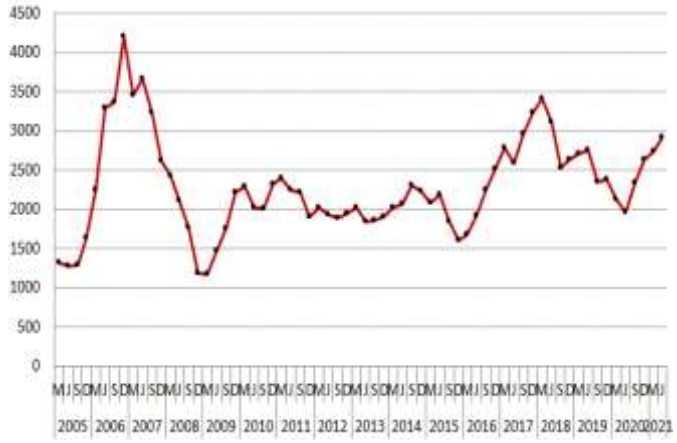
Australian zinc production is concentrated in Queensland and the Northern Territory. In 2020, Queensland accounted for 56 per cent of total Australian production of zinc. The Northern Territory accounted for 21 per cent of Australian production. Smaller amounts of zinc are produced in New South Wales and at Rosebery in Tasmania. Western Australia's share of Australian zinc production in 2020 was 6 per cent.

Australia's EDR of zinc were 68.9 million tonnes in 2019, up 3.0 per cent from 2018. Australia has the largest share of zinc resources of any country in the world. The largest reserves are located in Queensland and the Northern Territory, an area known as the Carpentaria Zinc Belt.

[8] World Mineral Production 2015-19, British Geological Survey, 2021, pp. 78.

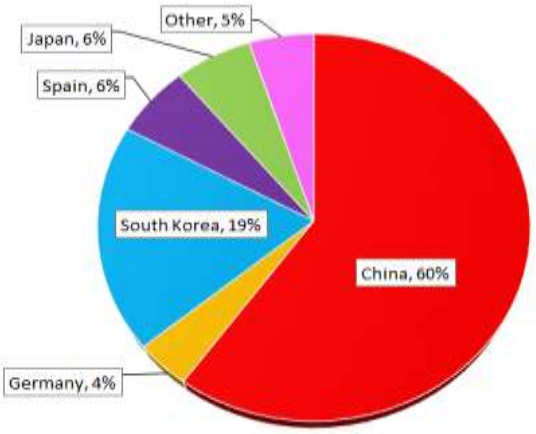
[9] Australia's Identified Mineral Resources, 2020, Geoscience Australia, pp. 51.

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



Source: World Bank, June 2021.

Figure 7.4: Percentage share of Australian zinc concentrate exports by destination, 2020 (%)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021.

The main uses for zinc are in galvanising steel, diecasting and making brass and bronze alloys. These alloys are used in automobiles, electrical components and household fixtures. Zinc oxide is also used in many other products such as paints, cosmetics, pharmaceuticals, rubber and soaps. Zinc is also used in batteries and on-going battery developments could lead to increased demands for zinc. Zinc is used in the zinc-carbon battery, zinc-bromide battery and the newer zinc-nickel power cell battery.

Zinc metal prices have risen strongly over the latter part of 2020 and 2021. Zinc prices fell to US$1,968 per tonne in June 2020 during the COVID-19 pandemic, however, has since increased to nearly US$2,900, or by nearly 50 per cent by June 2021. These price increases reflect supply shortages emerging as some zinc smelters are rebuilding stockpiles.

Australian exports of zinc in 2020 were $3.2 billion, down from $3.8 billion in 2019. Around 60 per cent of the value of Australian zinc exports are in the form of zinc concentrates, the remaining 40 per cent in refined zinc.

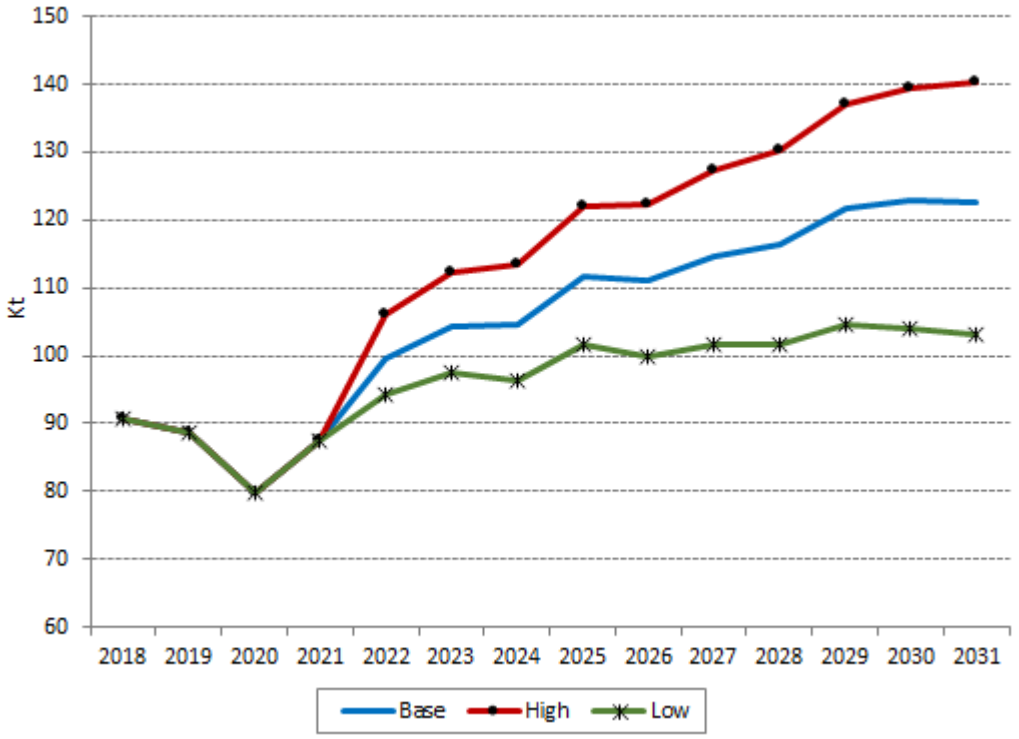
Australian zinc is refined at Sun Metals in Townsville (Queensland) and by Nyrstar at Risdon in Tasmania. The main overseas markets for zinc concentrate in 2020 were China (60 per cent), South Korea (19 per cent) and Spain and Japan (both 6 per cent). For refined zinc the major export markets in 2020 were China (29 per cent), Chinese Taipei (9 per cent) and the United States (8 per cent).

Zinc production in Australia is expected to expand over the medium term. Refined zinc production will increase with the expansion at Sun Metals in Townsville by 50 kt in 2021. The main driver will be expansions at major zinc concentrate mines in Queensland and the Northern Territory.

In Western Australia, EMR's Golden Grove mine produces zinc as a base and precious metals mine. The mine consists of two deposits, Gossan Hill and Scuddles. Round Oak Minerals Jaguar operation near Leonora also produces zinc from its copper-zinc operation.

Figure 7.5 shows the forecasts for zinc production for calendar years for Western Australia to 2031 by scenario.

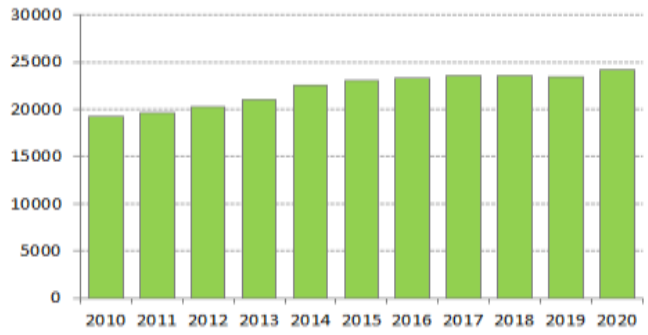
Figure 7.5: Western Australian zinc production to 2031 by scenario (kt)



Sources: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021 and NIEIR.

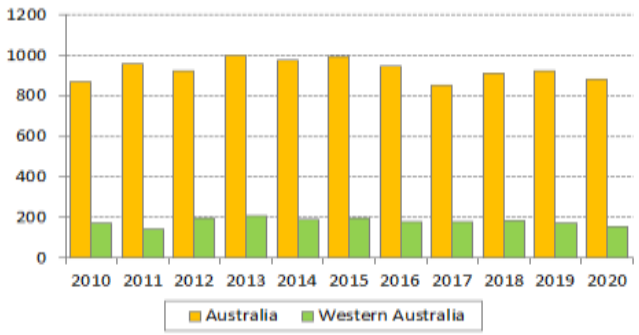
8. Copper

Figure 8.1: Copper production – World (kt)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021.

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 2021.

Global copper production in 2020 increased to 24.1 million tonnes from 23.5 million tonnes in 2019. Copper production experienced very strong growth between 2010 and 2017, however, world production levels have flattened out since 2017.

World production in 2020 was adversely affected by the COVID-19 pandemic with mine closures and reduced output in South American countries such as Chile and Peru. Chile (28 per cent) and Peru (12 per cent) are the world's largest producers of copper metal. Other major producing countries in 2019 were China (8 per cent), Democratic Republic of Congo (7 per cent) and Australia (5 per cent). In 2019, Australia was the fifth largest producer of copper globally.[10]

Australia's EDR of copper in 2019 were 93.4 million tonnes, an increase of 6 per cent over 2018 reserves.[11] The majority of Australia's reserves of copper are in South Australia (67 per cent), New South Wales (14 per cent), Queensland (11 per cent), Western Australia (6 per cent) and smaller reserves in Victoria, Tasmania and the Northern Territory. Copper use in Australia, like other base metals, is significantly impacted by materials recycling.

Australian production of copper fell to 885 kt in 2020, from 925 kt in 2019. Two mine closures in early 2020 contributed to this decline, the Hillgrave Resources' Kanmantoo mine (South Australia) and Panoramic Resources Savannah mine (Western Australia). Copper metal production fell in 2020 in both these States. The Savannah mine was subsequently re-started in July 2021.

Western Australia produced 152 kt of copper in 2020, or 17 per cent of Australia's total. Other Australian States producing copper in 2020 were South Australia (33 per cent), New South Wales (25 per cent) and Queensland (25 per cent). South Australian copper production is at Olympic Dam (BHP) and OZ Minerals' Prominent Hill and Carrapateena mines. The Olympic Dam mine has significant reserves and could expand further in the future. Copper mines in Queensland are predominately located in the Mt Isa region. In New South Wales major copper mines are North Parkes, Cobar, Cadia East and Marsden.

Copper processing operations in Australia can be done at the mine site (e.g. Olympic Dam, BHP) or have a supply chain. Glencore's processing operations extend from mines at Mt Isa and Ernest Henry to smelting at the Mt Isa smelter, to refining in Townsville. Copper product is exported through the Port of Townsville.

Copper is used extensively in electrical equipment, such as wiring and motors. Copper conducts heat and electricity well. In construction, copper is used in cabling and pipes. Copper is also used in jewellery and coinage and also used in industrial equipment, heating and cooling systems as well as telecommunications applications.

The shift to renewable energy in Australia and across the world will generate significant additional demands for copper. Copper is used extensively in power networks. In wind farms, copper is used in the coil windings and rotor portion of the generator, and in transformers and cables. In photovoltaics, copper is used in cabling, inverters and transformers.

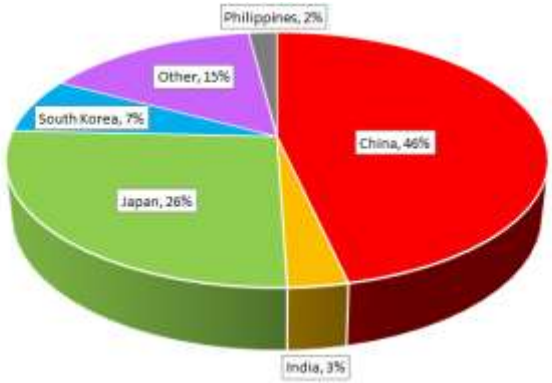
[10] World Mineral Production, 2015-2019, British Geological Survey, 2021, pp. 18.

[11] Australia's Identified Mineral Resources, 2020, Geoscience Australia.

Figure 8.3: Copper nominal price (US$/tonne)

Source: World Bank, June 2021.

Figure 8.4: Percentage share of Australian copper ore and concentrate exports by destination, 2020 (%)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021.

Copper prices have risen sharply since the June quarter 2020, the onset of the COVID-19 pandemic. In June quarter 2020, the copper price was US$5,350 per tonne. By June quarter 20201, the copper price had reached nearly US$9,750 per tonne, an increase of around US$4,400 per tonne or 80 per cent.

Copper is one of Australia's major mineral exports. Exports of copper ore and refined copper in 2020 were $10.4 billion. The major export market for copper ore and concentrates in 2020 were China (46 per cent) and Japan (26 per cent). For refined copper, Australia's major export markets were China (52 per cent), Malaysia (18 per cent) and Chinese Taipei (9 per cent).

Australian copper production is expected to increase over the medium-term with a number of prospective copper or copper-gold projects in South Australia, Western Australia and Queensland. Western Australia has a number of existing copper mines, including DeGrussan, Nifty, Telfer, Boddington and Golden Grove. Many of these are copper-gold mining operations.

The DeGrussa Operation, run by Sandfire Resources, includes two copper-gold mines, DeGrussa and Monty. The DeGrussa mine has a 1.5 mtpa concentrator on site. Copper ore and concentrate is then transported to Port Hedland and Geraldton for export.

The DeGrussa operation produced 73 kt of copper in calendar 2020, 46 per cent of Western Australian copper production. Newcrest produces a small amount of copper at its Telfer mine in Western Australia, however, much larger quantities are produced in New South Wales at its Cardia mine. The Nifty copper mine in the East Pilbara region of Western Australia, operated by Metals X, suspended operations in 2019. The mine is under care and maintenance.

The main prospects for increased copper production in Western Australia include:

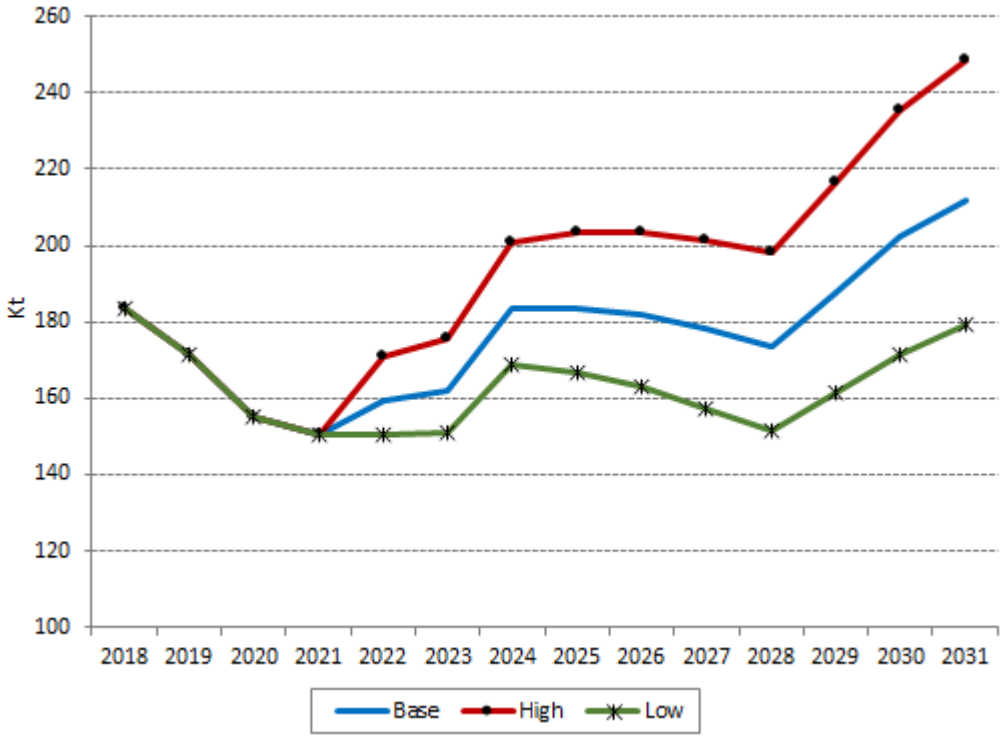
- recommissioning the Metals X Nifty mine which could produce up to 26 kt of copper concentrate per annum;[12]
- the Caravel Copper Project by Caravel Minerals which has an annual capacity of 45 kt per annum with future expansion possible;
- the OZ Minerals West Musgrave Copper-Nickel Project which has an estimated capacity of 28 kt per annum; and
- the Venturex Resources Sulphur Springs copper-zinc-silver mine south of Port Hedland.

Some of these prospective mines may not proceed until post-2025 as other resources are depleted.

Figure 8.5 shows the forecasts for copper production on a calendar year basis for Western Australia to 2031 by scenario.

[12] Metal X sold its copper assets (including Nifty) to Cyprium Metal on 30 March 2021. Cyprium Metal seems intent on commencing operations at Nifty even if production is scaled back (ASX, May 2021).

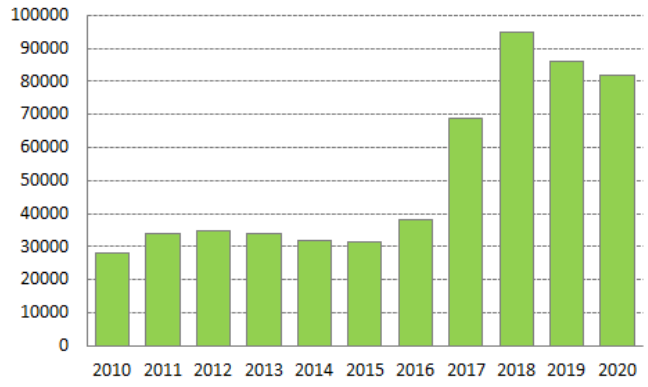
Figure 8.5: Western Australian copper production to 2031 by scenario (kt)



Sources: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021 and NIEIR.

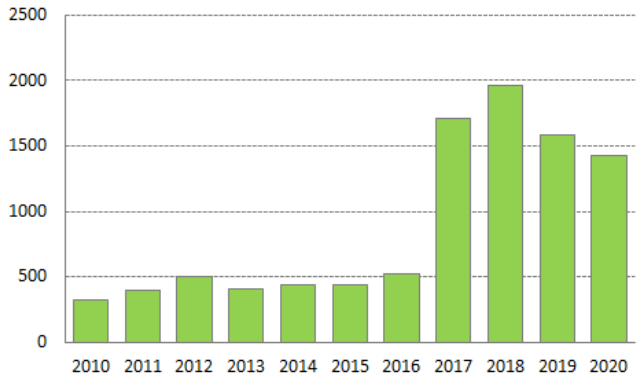
9. Lithium

Figure 9.1: Global lithium mine production (metric tonnes)



Source: Statista, February 2021.

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



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

World mine production of lithium in 2020 was 82,000 tonnes, similar to 2019 production levels but well down on 2018 mine production of 95,000 tonnes. There appears to be some inconsistencies in the reporting of lithium production by different countries. Australia reports spodumene concentrate, others report lepidolite, others by Li content and others carbonate.

By **Li** content, global lithium mineral production in 2019 was 97.5 kt in 2019, down from 111.6 kt in 2018 and 93.7 kt in 2017. Production by Li content globally was only 36.4 kt in 2015.[13] Clearly, the market for lithium has increased very significantly, however, global production well exceeded demand in 2018, but it seems to have stabilised over 2020.

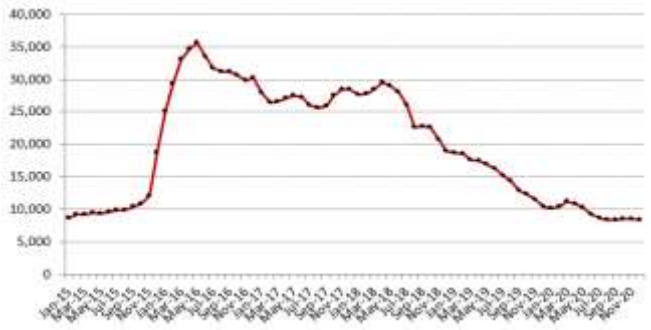
Lithium is typically hosted in hard rock spodumene deposits, mainly located in Western Australia. Lithium's main end-use is in battery production. Other end-uses include ceramics and glass, lubricating greases and polymer production. The growing market for lithium over recent years reflects the growing demand for rechargeable lithium batteries. These batteries are being used in portable electronic devices, electric tools, electric vehicles and electricity network grid storage applications. In South America lithium can be mined from brines, recovered from earlier drilled oil wells.

Australian reserves of lithium (Li) were 5,702 kt in 2019, up 5 per cent from 2018. Australia ranks second in the world for reserves of lithium (29 per cent), behind Chile (44 per cent).[14] Australia's lithium reserves are primarily located in Western Australia and the Northern Territory. Western Australia's lithium deposits are concentrated at Greenbushes, Wodgina, Pilgangoora and Earl Grey. Other resources are at Mount Marion, Mount Cattin and Bald Hill. In the Northern Territory the main deposit is known as the Grants Deposit (Finniss Project).

[13] World Mineral Production, 2015 to 2019, British Geological Survey, 2021, pp. 44.

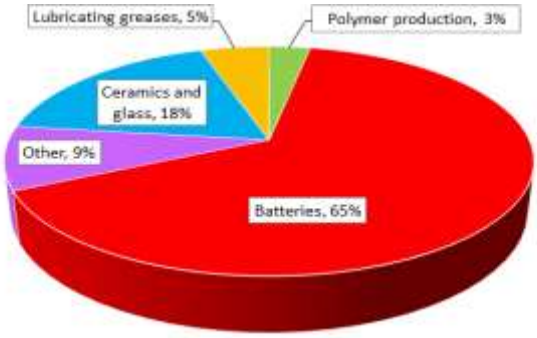
[14] Australia's Identified Mineral Resources, 2020, Geoscience Australia, pp. 56.

Figure 9.3: Lithium carbonate nominal price – (A$/tonne)



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

Figure 9.4: Main end-uses of lithium



Source: US Geological Survey, Mineral Commodity Summaries, Lithium, January 2021.

Lithium prices fell sharply over 2019 and continued to fall over 2020. Prices averaged A$27,000 per tonne in 2017, falling to A$15,150 in 2019 and A$9,406 in 2020. The fall in lithium prices largely reflected excess supply of lithium product and soft demand, due to the very slow uptake of electric vehicles due to their high capital costs. Spot prices for lithium hydroxide rose in 2021. Lithium is not currently traded on the LME, but may commence in 2021. Spot spodumene prices have also increased over 2021.

Australia's first lithium mine was the Greenbushes' mine in Western Australia, owned by Tianqi Lithium and Albemarle. It is the world's largest lithium mine and is operated by Talison Lithium. The mine contains the highest grade hard rock lithium in the world. The operators have announced a two-stage expansion at Greenbushes. First, an increase in annual production capacity from 650 to 1,350 tonnes per annum completed in 2019.

The Kemerton lithium hydroxide plant being developed by Albemarle will have a capacity of 100,000 tonnes per year. The Kwinana plant, being developed by Tianqi Lithium, has a capacity of 24,000 tonnes per annum (commissioned early 2019).

In an over-supplied market over 2019 and 2020 and falling prices there were significant changes in lithium mineral production in Western Australia. These included the following:

- The Bald Hill mine suspended operations in late 2019 (Alita Resources) and was placed into voluntary administration;
- MRA placed the Wodgina lithium mine under care and maintenance;
- The Mount Holland Lithium Project was deferred in January 2020;
- Galaxy Resources reduced its production guidance for its Mt Cattin mine by 50 per cent;
- the Pilbara Minerals' Pilgangoora Lithium-Tantalum Project was only operating at a 30 per cent capacity factor; and
- the Altura mine, commissioned in 2019, was only operating at an 80 per cent capacity factor. Altura Mining went into receivership in October 2020 and was subsequently purchased by Pilbara Minerals.

The short- to medium-term outlook for lithium has strengthened over 2021, partly due to production cuts over 2019 and 2020. The shift to EV penetration has strengthened in many countries across the world. More stringent emission standards for motor vehicles and government incentives will bolster EV demand in Europe. China has also set targets for EV penetration.

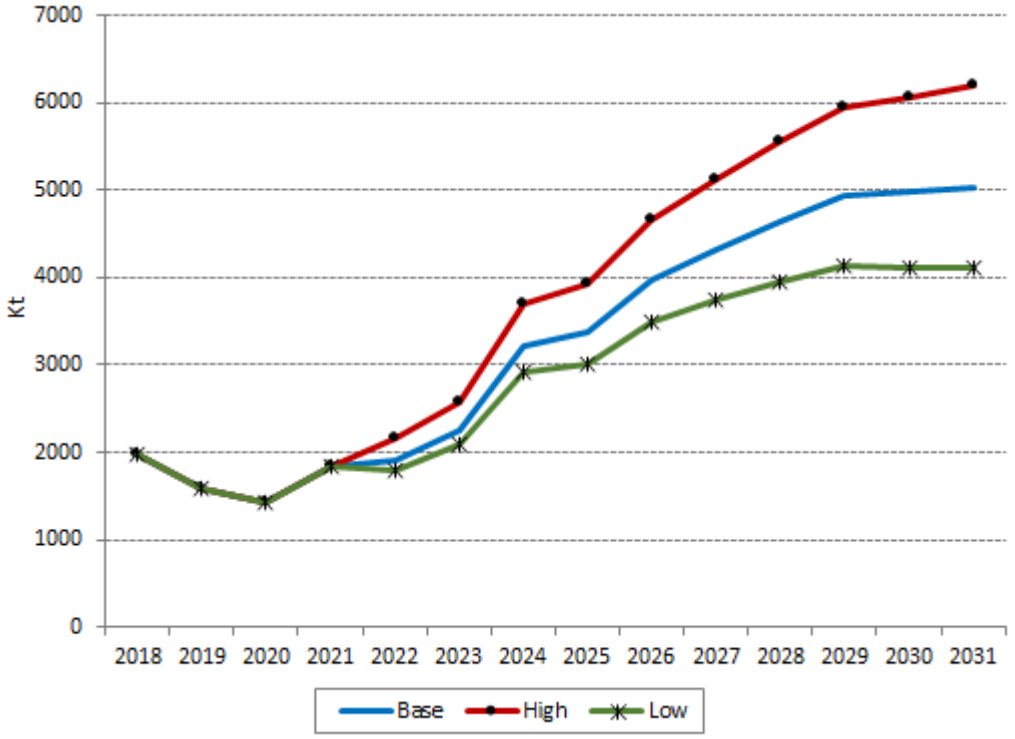
As a result of these trends, lithium projects across the world and in Australia are being re-assessed and possibly developed over the next two to three years. In Australia these include:

- Wesfarmer's and Sociedad Quimicay Minera (SQM) are proceeding with the development of the Mt Holland deposit, including producing lithium hydroxide (45,000 tpa) at Kwinana by 2024;
- MRA and Albemarle's Kemerton lithium refinery is due to come on-line in 2021-22 with production reaching 50,000 tonnes of lithium hydroxide;
- the recommissioning of Tiangi's Kwinana lithium refinery which could come on-line by 2022; and
- Pilbara Minerals announced restarting the Ngungaju operation (formerly Altura Lithium) in June 2021. Total capacity could reach 180,000 to 200,000 tonnes of lithium by mid-2022.

There are other potential projects in Western Australia over the next five years, some are expansions to existing operations while others are greenfield mine developments.

Figure 9.5 shows the forecasts for lithium production by calendar year for Western Australia to 2031 by scenario.

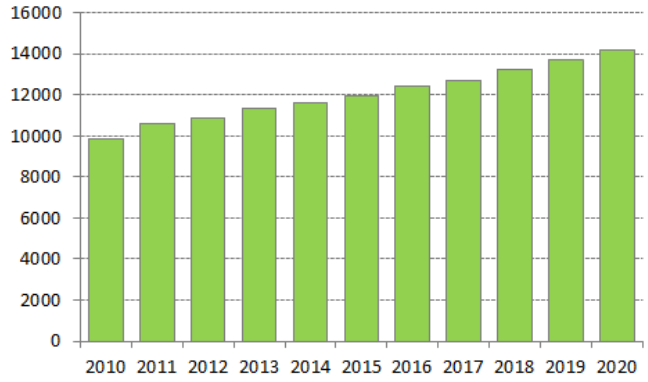
Figure 9.5: Western Australian lithium spodumene concentrate production to 2031 by scenario (kt)



Sources: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021 and NIEIR.

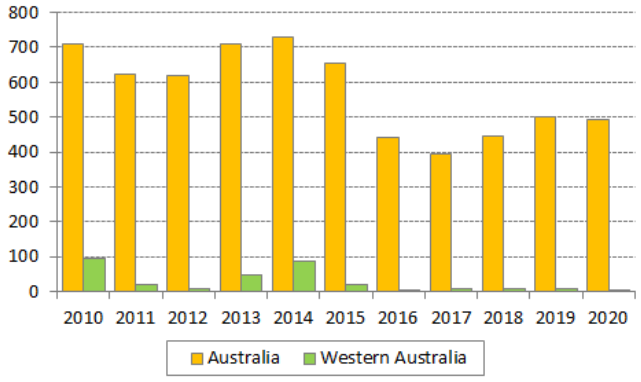
10. Lead

Figure 10.1: Lead production – World (kt)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021.

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 2021.

World production of lead in 2020 was 14.2 million tonnes (primary refined metal). Global production of lead has risen by over 40 per cent since 2010, or by 4 million tonnes.

China dominated world mine production of lead in 2019, producing 41.1 per cent of total global mine lead production. Australia was the second largest producer, accounting for 10.8 per cent of lead mined. Mexico, the United States and Peru all produced over 5 per cent of global lead mined in 2020.

Australian lead production in 2020 was 498.6 kt. Australia has 41 per cent of the world's economic resources of lead, with reserves of 35.78 million tonnes in 2019.[15] Lead is typically produced at zinc-lead-silver mines, predominately located in Queensland.

In 2020, Queensland produced 60 per cent of Australia's lead mine production, followed by New South Wales (19.6 per cent), the Northern Territory (10.7 per cent) and Tasmania (8.0 per cent). Production of lead in Western Australia in 2020 represented only 1.4 per cent of the Australian total lead mined.

Lead is a dull, silver grey metal and is easily worked. Lead has been used extensively since the Roman Empire. Lead is used in car batteries, pigments, ammunition, weights, diving bells, lead crystal glass (lead lights) and in some solders. Lead was used in petrol, hair dyes and insecticides but has since been banned. Lead-based paints are also becoming less common.

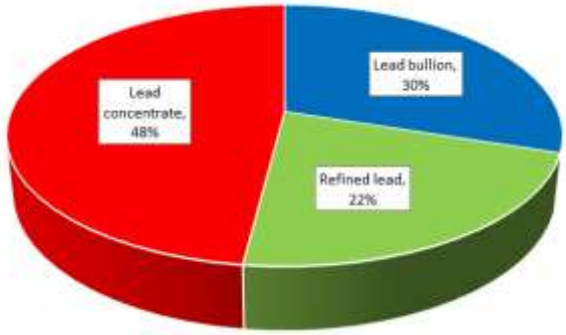
Lead recycling, and in particular car batteries, is a major source of lead production in many countries.

[15] Australia's Identified Mineral Resources, 2020, Geoscience Australia, pp. 51.

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

Source: World Bank, June 2021.

Figure 10.4: Percentage share of Australian lead exports by type, 2020 (%)



Source: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021.

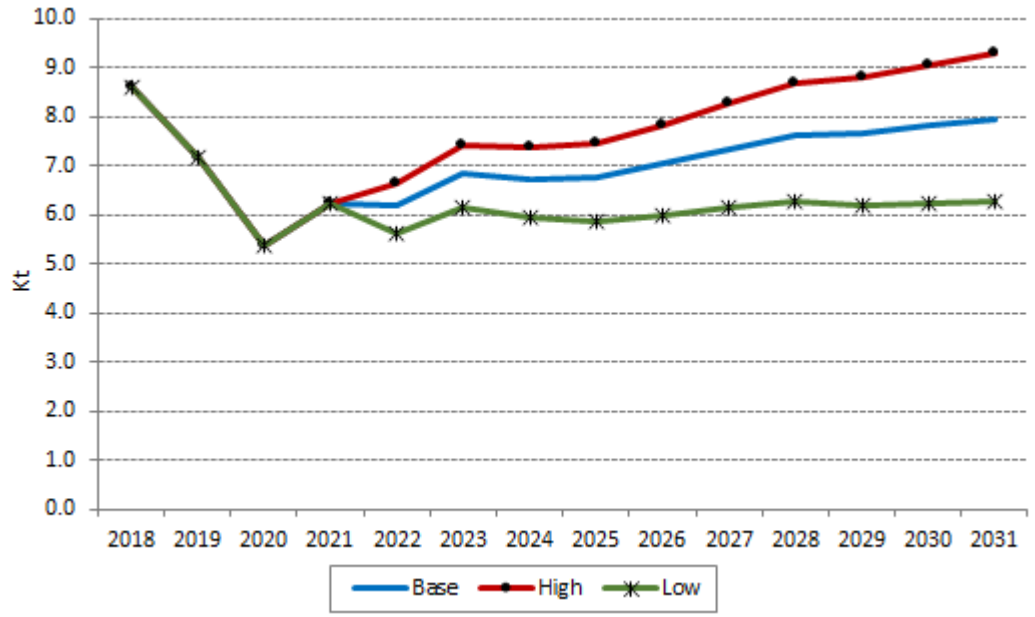
The value of Australian lead exports in 2020 was $1.7 billion, comprising lead concentrate, lead bullion and refined lead. Exports of lead concentrate were predominately to China (44 per cent) and South Korea (44 per cent) in 2020. Lead bullion exports were to the United Kingdom. Refined lead exports were to countries including Vietnam (26 per cent), India (15 per cent) and Thailand (14 per cent).

Like many base metal prices, the lead price fell with the outbreak of the COVID-19 pandemic in 2020, falling to US$1,676 per tonne. The lead price has slowly recovered over the remainder of 2020 and into 2021, reaching nearly US$2,100 per tonne in June 2021. The most recent peak in the lead price was in the March quarter 2018, at US$2,518 per tonne.

Western Australia currently has two prospective lead-silver mines that may proceed. The Abra Base Metals Project owned by Galena is located in the Gascoyne region of Western Australia. The lead resource has been estimated at 95 kt with a mine life of 16 years. The Sorby Hills Project by Pacifico is a smaller resource of 20 kt located near Kununurra.

Figure 10.5 shows the forecasts for lead production by calendar year for Western Australia to 2031 by scenario.

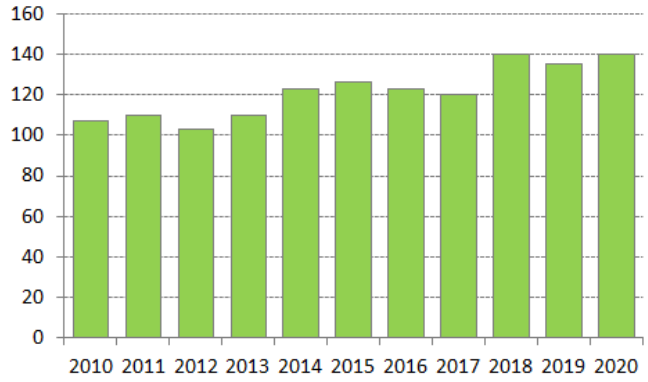
Figure 10.5: Western Australian lead production to 2031 by scenario (kt)



Sources: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021 and NIEIR.

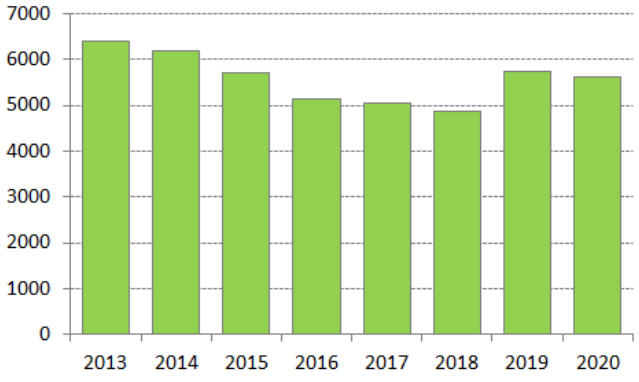
11. Cobalt

Figure 11.1: Cobalt production – World (metric tonnes '000)



Source: Statista, 2021.

Figure 11.2: Cobalt production – Western Australia (metric tonnes)



Source: DMIRS (WA), Major Commodities Resources Data, April 2021.

Global production of cobalt in 2020 was 140,000 metric tonnes. World production has risen over the last 10 years from around 110,000 metric tonnes in 2010 to just over 120,000 metric tonnes in 2015, and reaching 140,000 metric tonnes in both 2018 and 2020.

The Democratic Republic of Congo (DRC) is the world's largest producer of cobalt, accounting for 63.3 per cent of total cobalt mine production in 2019. Cobalt is mined at copper-cobalt mines in Africa and South America. Glencore is a major producer of copper and cobalt. Cobalt production by Glencore was adversely affected by the shutdown in operations at its Mutanda mine in 2020. Operations are expected to restart at Mutanda by early 2022.

Australia is the third largest producer of cobalt globally, producing around 5,000 metric tonnes in 2020. In Australia, cobalt is produced at nickel-cobalt mines mainly located in Western Australia. Australia's EDR were 1,399 kt in 2019, representing 19 per cent of global economic resources of cobalt.[16]

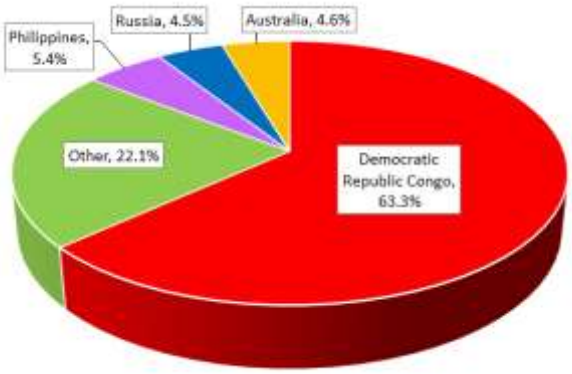
Around 70 per cent of cobalt reserves are in Western Australia, although there are also significant reserves in New South Wales (13 per cent) and Queensland (16 per cent). Glencore's Murrin Murrin mine in Western Australia (a nickel-cobalt mine) produced 2,900 metric tonnes of cobalt in 2020, down 15 per cent on 2019 production levels.

[16] Australia's Identified Mineral Resources, Geoscience Australia, 2020, pp. 39.

Figure 11.3: Cobalt nominal price (US$/mt)

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

Figure 11.4: Percentage share of cobalt production by major country, 2019 (%)



Source: World Mineral Production, 2015-2019, British Geological Survey, 2021.

Cobalt is used in many commercial, industrial and military applications. Cobalt is used in battery electrodes, as a superalloy in engines, in tools, paints, magnets and tyres. Cobalt's main end-use is in rechargeable batteries, which are used in:

- electric vehicles and other transport equipment;
- portable devices, such as mobile phones, laptops and tablets; and
- home energy storage and larger battery storage applications.

Most electric vehicle batteries use lithium-ions, with nickel, manganese and cobalt (NMC) in various proportions in the cathode, a key part of the battery. Some battery manufacturers have been looking at reducing the cobalt content in batteries.

There has been a large amount of speculation regarding cobalt over recent years. In 2017, unrealistic expectations regarding the uptake of electric vehicles led to the price of cobalt to rise from around US$25,000 per tonne to US$87,700 by June 2018. The cobalt price fell sharply over the next 12 months, hitting lows of US$30,000 to US$35,000 per tonne in mid-2019. In early 2021, the cobalt price surged again, reaching US$50,000 per tonne.[17]

In Australia, interest in cobalt surged in 2018 with high prices and a number of prospective projects announced for Western Australia, Queensland and New South Wales. In New South Wales two projects have been publically announced, including:

- Cobalt Blue's Broken Hill Cobalt Project with an expected capacity of 3,500 to 4,000 tonnes per annum; and
- Australian Mines' Flemington Project.

In Western Australia prospective developments include:

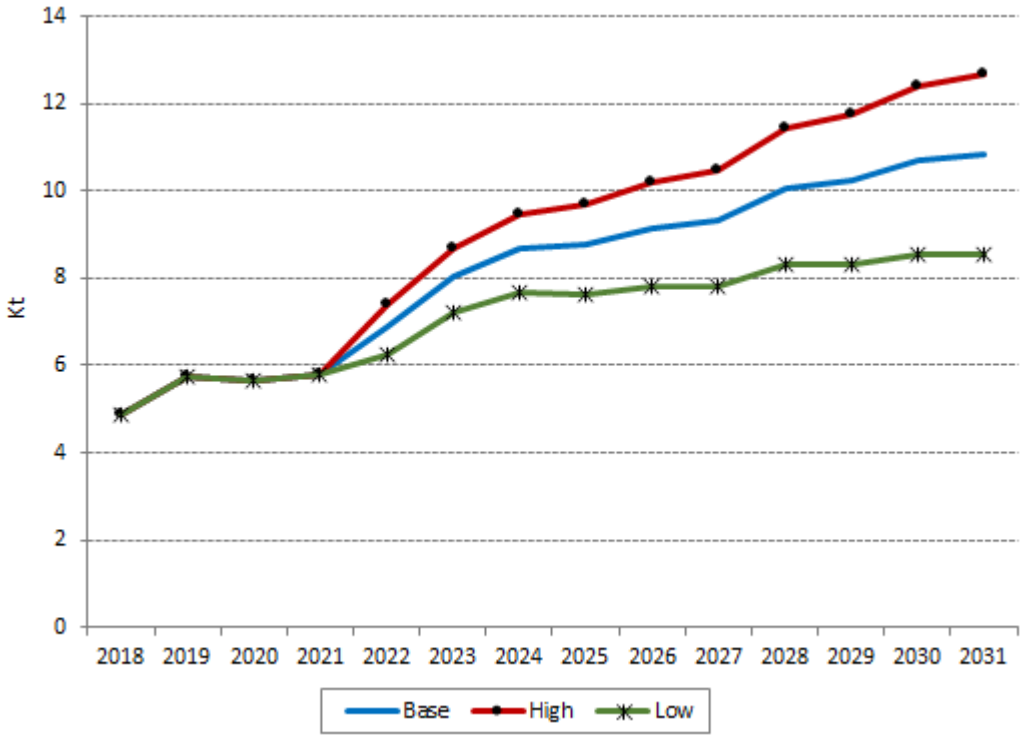
- a recommissioning of Kambalda (Mincor Resources), a nickel-copper-cobalt mine, by 2022;
- the Barra Resources' Mt Thirsty nickel-cobalt mine, with a cobalt resource of 19.1 kt; and
- the NiWest Nickel-Cobalt Project announced by GME Resources located near Leonora.

A number of publically announced projects are unlikely to proceed until post-2025. 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 11.5 shows the forecasts for cobalt production by calendar year in Western Australia to 2031 by scenario.

[17] Tradingeconomics.com/commodity/cobalt.

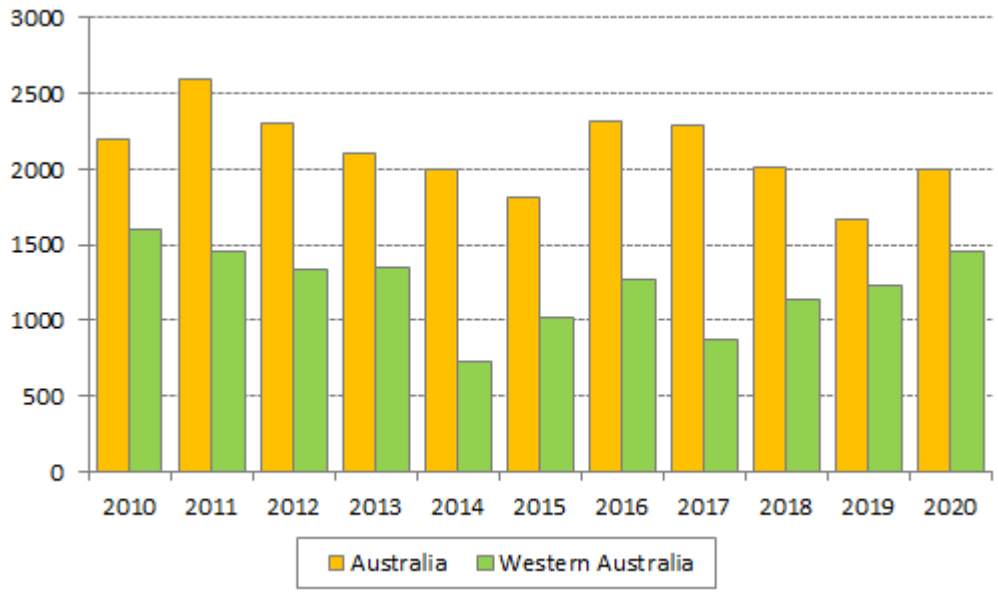
Figure 11.5: Western Australian cobalt production to 2031 by scenario (kt)



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

12. Mineral sands

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



Source: DMIRS (WA), 2020, Major Commodities Resources Data, April 2021 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 is primarily used as a white pigment in paints, plastics and paper. Titanium metal can also be manufactured from these minerals, which is used in medical equipment, engines and aircraft construction.

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 dioxide in 2018 was 7.4 million tonnes. Global production of zircon in 2018 was 1.2 million tonnes.[18]

Australia's mineral sands EDR in 2019 was 274.7 million tonnes of ilmenite, 35.4 million tonnes of rutile and 79.7 million tonnes of zircon.[19] In terms of Australia's share of global resources in 2019, Australia had:

- 24 per cent of global ilmenite resources, behind China (34 per cent) and India (12 per cent);
- 65 per cent of global rutile resources, followed by India (14 per cent) and South Africa (12 per cent); and
- 72 per cent of world zircon reserves, followed by South Africa (19 per cent).

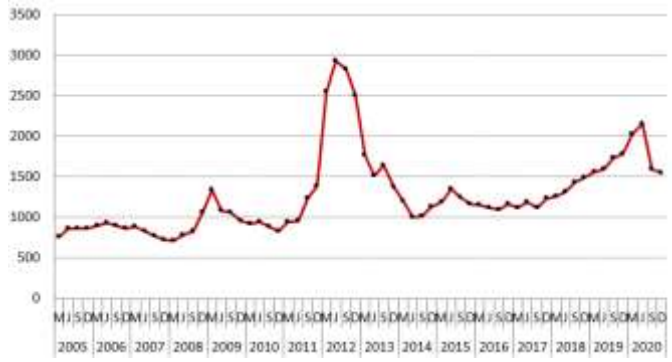
The majority of mineral sands reserves in Australia are located in Victoria and New South Wales in the Murray Basin, in the Eucla Basin in South Australia, and in various locations in Queensland and Western Australia. In Western Australia, resources are located in the Perth Basin, at Coburn, McLaren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

In 2019, 12 mines in Australia produced 1.0 million tonnes of ilmenite, 0.2 million tonnes of rutile and 0.5 million tonnes of zircon.

[18] Iluka, Mineral Sands Information, November, 2019.

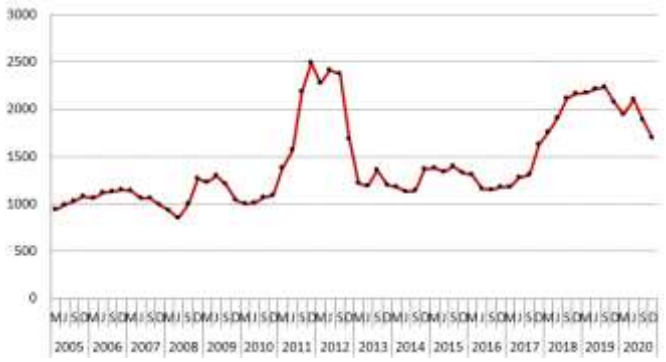
[19] Geoscience Australia, Australia's Identified Mineral Resources, 2020, p. 60.

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



Source: DMIRS (WA), 2020, Major Commodities Resources Data, April 2021.

Figure 12.3: Zircon nominal price (A$/t)



Source: DMIRS (WA), 2020, Major Commodities Resources Data, April 2021.

Mineral sands mining operations in Western Australia include the following:

- Doral Mineral Sands has two operating mines, Keysbrook and Yoongarillup, located near Brusselton. Doral also has downstream processing operations in East Rockingham and exports zircon, ilmenite and leucoxene;
- Tronox operates the Cooljarloo and Wonnerup mines and also has a titanium dioxide plant at Bunbury, the Chandala processing plant at Muchea and a pigment plant at Kwinana; and
- Image Resources operates the Boonanarring mine located in the North Perth Basin.

Iluka Resources has a number of mining and mineral sands processing facilities in Western Australia. These include:

- the Cataby mine, north of Perth;
- the Narngulu mineral separation plant near Geraldton which produces zircon and rutile products;
- the Capel operation which produces synthetic rutile; and
- the Eneabba operation which is basically a stockpile of high grade monazite and zircon concentrate.

Exports of mineral sands from Western Australia were $1.4 billion in 2020. The major markets for mineral sands in 2020 were China (46 per cent), the Netherlands (10 per cent), the United Kingdom (8 per cent) and Saudi Arabia and Spain (5 per cent each).

There are a number of committed and advanced new mineral sands projects in Western Australia:

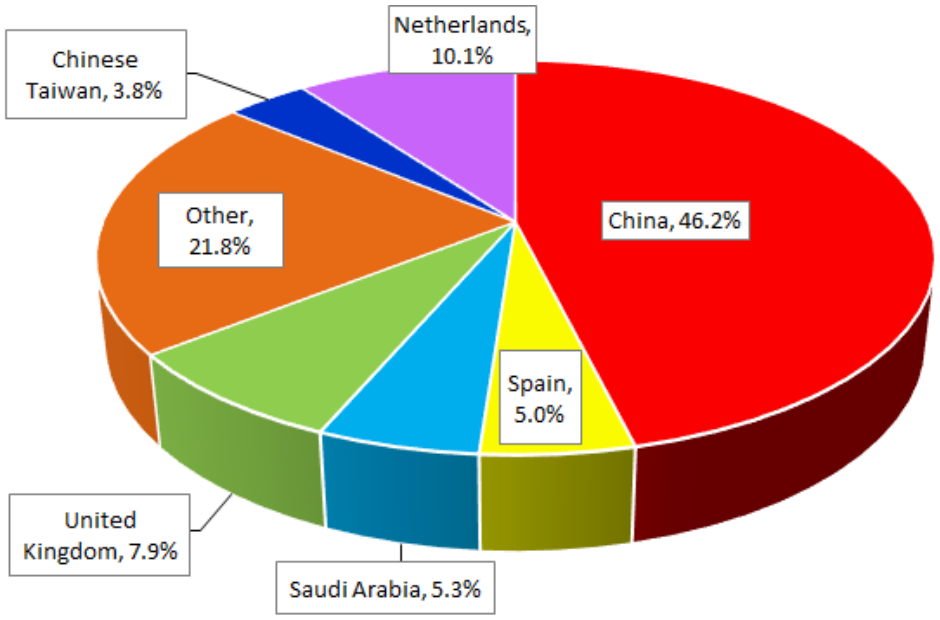
- the Coburn Mineral Sands Project operated by Strandline Resources Ltd is currently under construction with ore production due to commence in the 4th quarter 2022. The mine plans to produce 23.4 mtpa of ore with a mine life of 22.5 years;
- the Thunderbird Mineral Sands Project, a joint venture between Sheffield Resources (50 per cent) and Yansteel (50 per cent), is likely to proceed. A number of take-off agreements for zircon and ilmenite have been secured. The Stage 1 development will include 10.4 mtpa mined; and
- the Cyclone Zircon Project, located in the Eucla Basin near the South Australian border, is proposed by Diatreme Resources.

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.

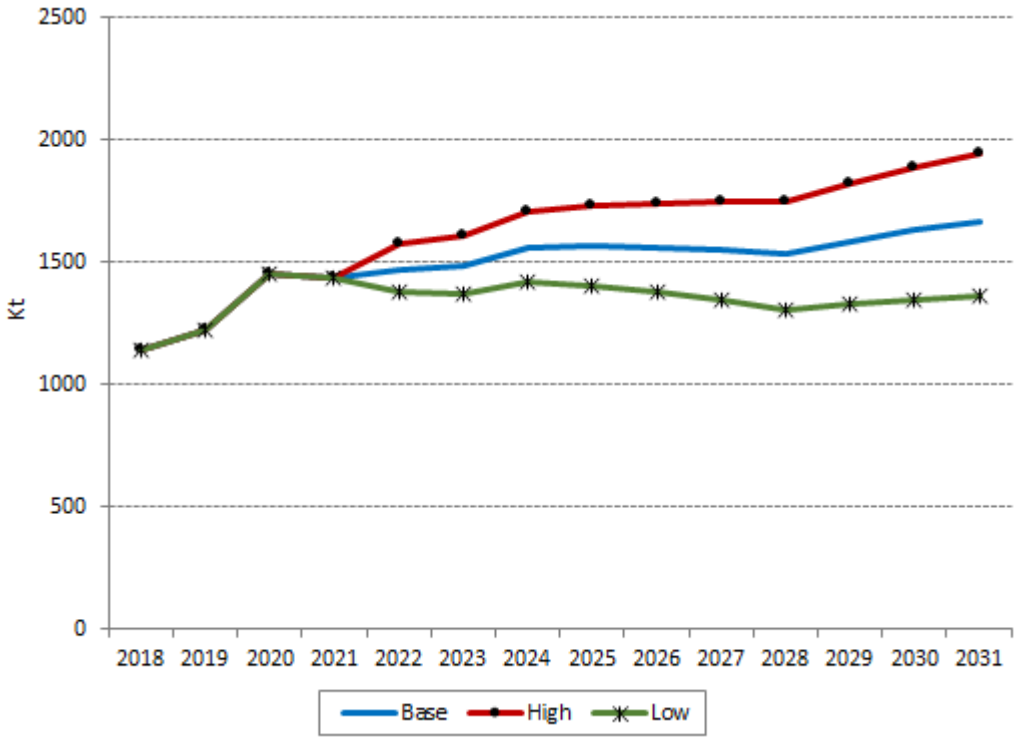
Figure 12.4 shows the forecasts for mineral sands production on a calendar year basis for Western Australia to 2031 by scenario.

Figure 12.4: Percentage share of Western Australian mineral sands exports, 2020 (%)



Source: DMIRS (WA), 2020, Major Commodities Resources Data, April 2021.

Figure 12.5: Western Australian mineral sands production to 2031 by scenario (kt)



Source: DMIRS (WA), 2020, Major Commodities Resources Data and NIEIR, April 2021.

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	1142.9
2019	14.0	171.2	218.3	909.8	158.8	88.7	1588.0	7.2	5.7	1225.4
2020	14.2	155.1	220.0	914.2	170.1	79.8	1427.4	5.4	5.6	1450.9
2021	14.4	150.2	219.3	927.5	175.4	87.3	1840.2	6.2	5.8	1438.3
2022	14.4	159.4	234.9	965.2	194.7	99.6	1907.2	6.2	6.9	1470.3
2023	14.5	161.8	240.1	996.1	228.3	104.4	2253.6	6.8	8.0	1484.1
2024	14.5	183.3	226.6	1062.7	240.1	104.6	3211.1	6.7	8.7	1560.2
2025	14.7	183.7	216.2	1103.4	243.7	111.7	3367.5	6.8	8.8	1563.4
2026	14.7	181.7	218.8	1103.2	239.6	111.2	3971.2	7.0	9.1	1559.0
2027	14.7	178.1	216.7	1098.8	239.7	114.8	4318.9	7.3	9.3	1547.9
2028	14.7	173.7	218.4	1109.0	253.1	116.5	4634.9	7.6	10.1	1533.9
2029	14.7	187.8	220.7	1129.7	258.1	121.7	4927.2	7.7	10.2	1583.9
2030	14.7	202.2	223.3	1161.0	264.1	122.8	4980.8	7.8	10.7	1631.1
2031	14.7	211.7	227.9	1173.1	268.1	122.5	5034.4	7.9	10.9	1662.5

Sources: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021 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	1142.9
2019	14.0	171.2	218.3	909.8	158.8	88.7	1588.0	7.2	5.7	1225.4
2020	14.2	155.1	220.0	914.2	170.1	79.8	1427.4	5.4	5.6	1450.9
2021	14.4	150.2	219.3	927.5	175.4	87.3	1840.2	6.2	5.8	1438.3
2022	14.7	171.1	258.0	1081.1	208.3	106.1	2159.6	6.6	7.4	1576.7
2023	14.9	175.5	265.2	1122.5	246.7	112.2	2576.1	7.4	8.7	1607.4
2024	15.0	201.0	251.7	1204.6	261.8	113.3	3705.3	7.4	9.5	1706.7
2025	15.3	203.5	241.4	1258.2	268.2	122.0	3922.0	7.5	9.7	1727.0
2026	15.3	203.3	245.8	1265.4	266.1	122.4	4667.9	7.8	10.2	1738.9
2027	15.4	201.3	244.7	1267.7	268.6	127.4	5123.1	8.3	10.5	1743.2
2028	15.5	198.3	247.9	1286.9	286.2	130.3	5548.0	8.7	11.4	1744.1
2029	15.4	216.5	252.0	1318.6	294.5	137.1	5950.9	8.8	11.8	1818.0
2030	15.4	235.3	256.3	1362.9	304.0	139.5	6069.3	9.1	12.4	1889.8
2031	15.4	248.8	262.9	1384.9	311.3	140.2	6188.9	9.3	12.7	1944.0

Sources: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021 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	1142.9
2019	14.0	171.2	218.3	909.8	158.8	88.7	1588.0	7.2	5.7	1225.4
2020	14.2	155.1	220.0	914.2	170.1	79.8	1427.4	5.4	5.6	1450.9
2021	14.4	150.2	219.3	927.5	175.4	87.3	1840.2	6.2	5.8	1438.3
2022	14.1	150.4	223.8	919.7	185.5	94.2	1792.0	5.6	6.3	1381.4
2023	14.1	150.8	225.8	936.9	214.7	97.6	2085.0	6.1	7.2	1372.5
2024	14.0	168.7	210.3	986.4	222.9	96.4	2924.1	5.9	7.7	1420.5
2025	14.1	166.8	198.0	1010.6	223.2	101.6	3018.2	5.9	7.6	1401.0
2026	14.1	162.8	197.7	996.8	216.5	99.7	3502.2	6.0	7.8	1374.6
2027	14.0	157.4	193.1	979.2	213.6	101.6	3747.0	6.2	7.8	1342.5
2028	14.0	151.5	191.9	974.6	222.4	101.7	3954.4	6.3	8.3	1308.3
2029	14.0	161.5	191.2	978.9	223.6	104.7	4132.8	6.2	8.3	1328.1
2030	14.0	171.4	190.7	991.6	225.5	104.1	4106.0	6.2	8.5	1344.2
2031	14.0	179.5	194.6	1001.9	229.0	103.1	4114.1	6.3	8.6	1358.6

Sources: Department of Industry, Science, Energy and Resources, Commonwealth of Australia, Resources and Energy Quarterly, June 2021 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 July 2021, 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 2023. These were prepared by NIEIR and the Office of the Chief Economist based on supply and demand characteristics of the forecast lithium market.

As indicated in Table 14.1, the short-term outlook for major commodities is mixed. Compared to 2020, gold, copper, nickel and zinc world prices are expected to rise. Base metals prices fall over the end of 2022 and 2023. Iron ore prices are expected to ease over the next two years, while alumina prices are expected to strengthen steadily.

Table 14.1 Survey of world commodity price forecasts, July 2021

	Iron ore (US$ per tonne)			Gold (US$ per ounce)			Copper (US$ per tonne)		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
2020	97	97	97	1770	1770	1770	6169	6169	6169
2021	135	145	152	1700	1779	1837	8372	8621	8836
2022	96	101	109	1600	1747	1850	7500	8372	8963
2023	80	89	98	1550	1600	1651	7000	7485	7970

	Nickel (US$ per tonne)			Zinc (US$ per tonne)			Alumina (US$ per tonne)		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
2020	13773	13773	13773	2265	2265	2265	0	270	0
2021	16500	17273	18706	2700	2762	2820	0	285	0
2022	15977	16887	18875	2400	2497	2639	0	299	0
2023	16146	17048	17950	2300	2362	2425	0	311	0

Note: Forecast prices from 2020 to calendar year 2023.
Sources: Office of the Chief Economist (June 2021), the World Bank (April 2021), National Australia Bank (August 2021), Scotia Bank (2021).

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

	2020	2021	2022	2023
Office of Chief Economist	9,892	12,088	13,960	14,288
NIEIR	9,892	12,088	14,150	13,800

Note: 2021 prices, fiscal years.
Source: Office of Chief Economist, June 2021.