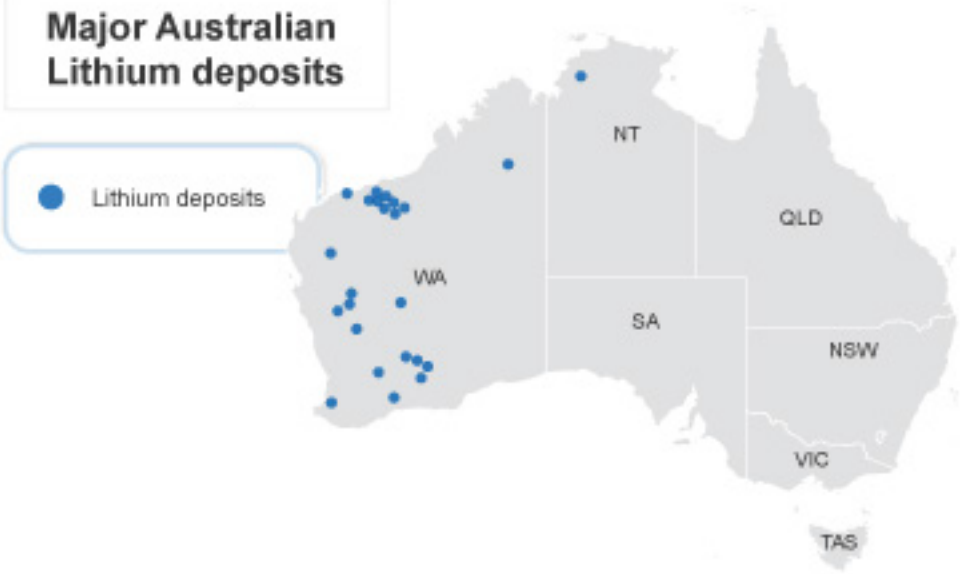
3 Li 6.94 Lithium

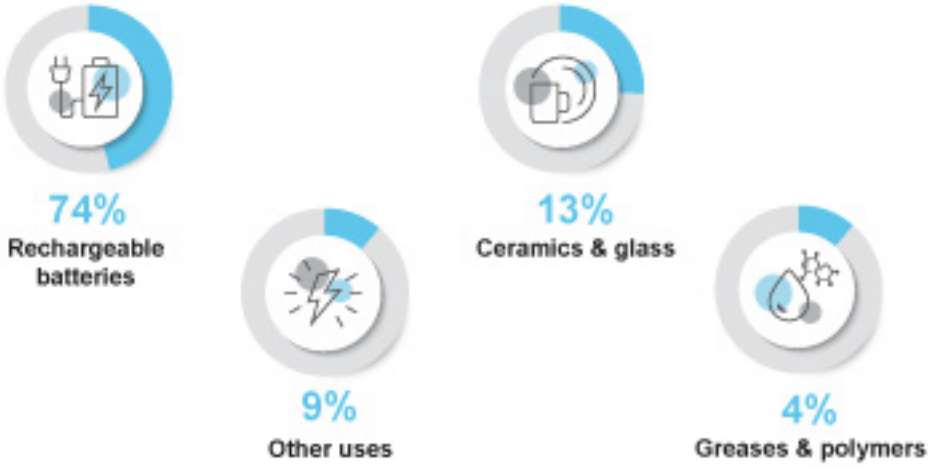
Major Australian Lithium deposits



Lithium facts

- Lithium metal is **so light it floats on water**
- **Electric vehicle sales** are expected to increase tenfold by 2030
- Australian lithium exports are tipped to **triple** by 2026–27
- In August 2021 Australia began **producing lithium hydroxide**

World consumption



Australia's lithium

- **Biggest exporter** in the world
- Produced 49% of the **world's lithium** in 2020
- **Production ramp up** planned for 2 refineries in 2022/23

15.1 Summary

- Spodumene prices are projected to rise from an average US$660 a tonne in 2021 to US$1,325 a tonne in 2022, before moderating to around US$800 a tonne in 2027 (in real terms). Lithium hydroxide prices are projected to rise from US$17,970 a tonne in 2021 to US$27,620 a tonne in 2022, before easing to around US$13,140 (in real terms) by 2027.
- Australia's lithium production is projected to more than triple over the outlook period, rising from 224,000 tonnes of lithium carbonate equivalent (LCE) in 2020–21 to 692,000 tonnes of LCE in 2026–27.
- Australia's lithium export earnings are projected to rise from $1.0 billion in 2020–21 to $6.7 billion in 2026–27 (in real terms), as lithium hydroxide production rises. A further 5 lithium hydroxide refining operations are projected to commence operations in Australia by 2026–27.

15.2 World demand

Surging lithium demand as electric vehicles gain market share

The demand for lithium continues to be driven by the trend toward battery usage for numerous portable electrical appliances and in electric vehicles (EV). Demand for lithium batteries accounted for almost 75% of all lithium use in 2021, and is expected to reach around 90% by the end of the outlook period as EVs gain market share in the world passenger car market.

EV uptake continues to be driven by a combination of falling EV prices, growing choice of models, and ongoing government measures, though government incentives are being wound back in some countries.

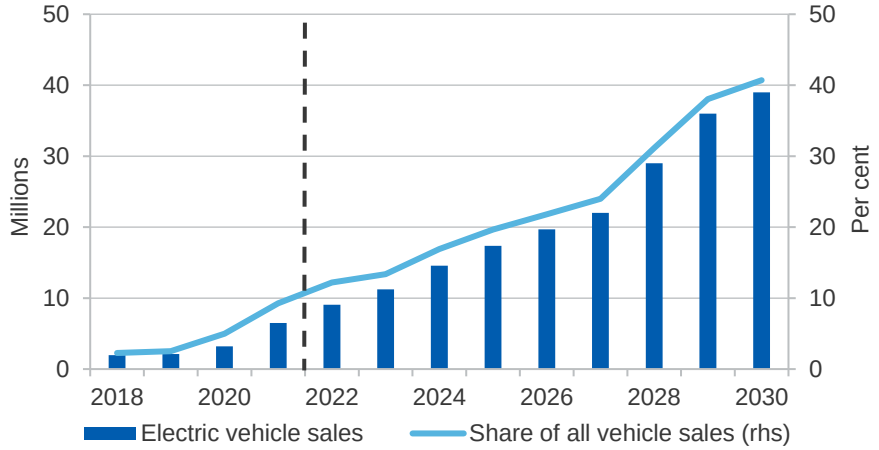
Despite EVs requiring around twice as many microchips as equivalent conventional vehicles carmakers have maintained rapid growth in production of EVs despite a chronic shortage of semi-conductor chips around the world over the past eighteen months. EVs use more modern, higher value chips than conventional vehicles and hence were prioritised by chip manufacturers. Some EV makers have been able to re-design their vehicles to cope with the shortage.

Key global automakers have accelerated targets to shift towards battery electric vehicles (BEV). In particular, Toyota lifted its 2030 BEV sales target from 2.0 million units to 3.5 million units. Toyota is expanding its battery capacity to 280GWh, up from 200GWh previously, with its Lexus brand expected to be fully electric by 2035.

Global sales of electric vehicles doubled in 2021

Global light electric vehicle (EV) sales surged in 2021, rising steadily in each quarter, with an estimated 2 million EVs sold in the December quarter 2021. Total EV sales for the year increased from 3.2 million in 2020 to an estimated 6.5 million vehicles in 2021 (Figure 15.1). Global EV sales are expected rise by a further 3 million units in 2022, pushing up total sales to over 9 million EVs. Global market share for EVs has tripled over the past two years, with EV sales now representing close to 9% of the global car market. Strong underlying demand and EV manufacturers' declarations of further increases in production imply that EV sales could reach around 40% of vehicle sales annually by 2030.

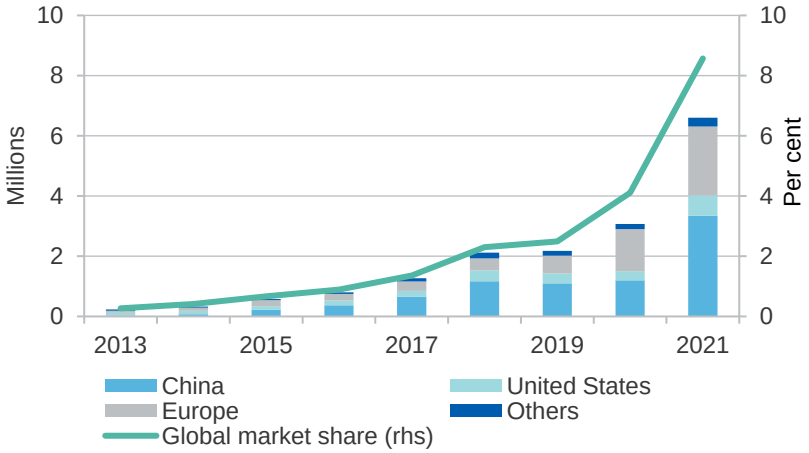
Figure 15.1: Long term electric vehicle sales projections



Source: Department of Industry, Science, Energy and Resources (2022); Wood Mackenzie (2022); BloombergNEF (2021).

However, EV uptake continues to vary greatly between countries, with growth driven largely by growth in China and Europe, where automakers are pushing to meet fuel economy regulations (Figure 15.2). China accounted for over half of global EV sales in 2021 and sales of EVs now represent around 15% of total light vehicle sales in China. European EV sales accounted for around 20% of passenger vehicle sales by the end of 2021. EV market penetration in the US lags that of Europe, with EVs accounting for around 5% of light vehicle sales in the September quarter 2021. However, US EV sales are growing rapidly, at around 30% last year.

Figure 15.2: Electric vehicle sales by country



Source: IEA (2022).

Surging global EV sales have implications for a range of critical minerals and metals. In addition to using about 9kg of lithium, the average light EV takes about 200kg of other key minerals and metals to produce — about 6 times the amount used in a car with an internal combustion engine (ICE).

World demand for lithium is estimated to increase from 526,000 tonnes of lithium carbonate equivalent (LCE) in 2021 to 636,000 tonnes in 2022 (Table 15.1). Demand is then forecast to more than double over the following 5 years, as global electric vehicle (EV) uptake continues to grow, with world demand forecast to reach 1.5 million tonnes by 2027.

Annual growth in lithium demand over the outlook period is forecast at almost 20%. Asia remains the major source of demand for lithium, despite the diversification of battery factories into Europe and the US.

A potential downside risk to EV forecast growth is the 30% cut to China's EV subsidy program for passenger vehicles in January 2022, with the program to be terminated by 2023. Another issue affecting the outlook is the increasingly challenging supply chain environment facing auto makers. A number of EV makers have pushed delivery timeframes for various models out to 2023. Tesla and Volkswagen have publicly announced that they are experiencing supply chain issues. Access to key non-lithium materials, including nickel, graphite and cobalt, will put pressure on overall battery costs. Benchmark Mineral Intelligence, for example, estimates that if lithium prices remain at the peaks seen in China in early 2022 (see price discussion below) that could boost the cost of a new EV by US$1,000.

15.3 World production

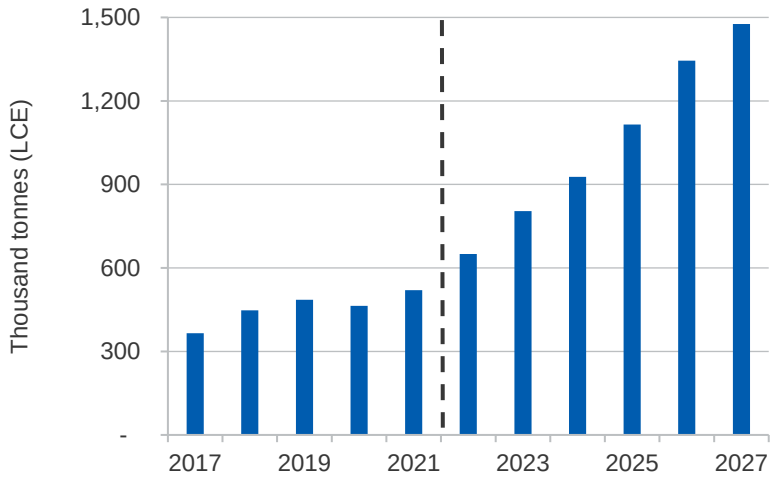
Concerns continue to grow around the security of supply

World output is estimated at 520,000 tonnes LCE in 2021, and is forecast to reach 650,000 tonnes in 2022 and 1,476,000 tonnes in 2027 (Figure 15.3). Growth is forecast to be met by increases in output among most producing nations. The primary source of ex-Australian growth over the next two years is expected to come from South America. Albemarle is commissioning an expansion at its Salar de Atacama project in Chile, while SQM has also signalled higher volumes at its Chilean operations. Strong growth in production is also expected in Argentina through new and expanded brine operations by Livent, Allkem and Minera Exar. Over the 5 year outlook, key sources of additional forecast supply include China, Brazil, Canada, DRC and Mali.

Total supply from mine and brine operations is currently unable to meet demand. While project development is underway, it will take time to close the supply gap. Stockpile size is difficult to determine, with some estimates of 4–8 weeks for spodumene. With such tight supply conditions, and given delays associated with shipping times and ongoing supply chain

challenges, it is unsurprising that some lithium processors and battery manufacturers are currently securing supplies at record high prices.

Figure 15.3: Global lithium production



Source: Department of Industry, Science, Energy and Resources (2022); Wood Mackenzie (2022).

Some greenfield projects accelerate while others face headwinds

In recent months, some highly publicised reversals of lithium projects have elevated concerns about the ability of lithium production to meet global demand in the next decade and beyond. In January 2022, Serbia revoked lithium exploration licences granted to Rio Tinto's $2.4 billion Jadar lithium project citing environmental concerns. The mine, due to start producing in 2027, was expected to produce 58,000 tonnes of battery-grade lithium carbonate a year, in what would have been Europe's largest lithium mine.

In January 2022, Chile — the world's largest lithium producer after Australia — experienced a setback in plans to bring about a significant new long term supply source. In 2021, the Chilean Government announced it was offering 400,000 tonnes of LCE for extraction via 5 80,000 tonne quotas through a national and international public tender process. Results of the first two quota auctions were announced in January 2022. BYD Chile, a subsidiary of Chinese auto maker BYD, was awarded one of the quotas, with the other awarded to local firm Servicios y Operaciones Mineras del Norte. However, in January 2022, a Chilean court ordered a suspension of the auction while the legal claim is resolved.

On the upside, a number of expansions and new projects have been announced in recent months. Chilean state-owned mining firm Codelco announced it will start lithium exploration in the Salar de Maricunga in March 2022, with drilling expected to be completed in early 2023.

In February 2022, Argentina's Ministry of Production announced that Chinese mining firm Zijin Mining Group Co Ltd will construct a lithium carbonate plant in Argentina via local subsidiary Liex. The plant, to be located in the northern province of Catamarca, will aim to produce 20,000 tons of lithium carbonate a year, with a goal of subsequently doubling production in the medium term. In addition, Livent has announced an additional expansion program to be completed by 2025. This will complement the previously announced capacity expansion to bring its Argentina operations to 60,000 tonnes of lithium carbonate, as well as 9,000 tonnes of lithium chloride.

Portugal, Europe's biggest lithium supplier, plans to launch a licensing auction for rights to mine lithium in 6 areas in April 2022. The auction was initially planned for 2018, but has been delayed due to environmental and social concerns. A feasibility study on James Bay in Canada was finished in December 2021 which indicated an expected 19 year mine life, with construction estimated to begin in the September quarter 2022, with commissioning due in the March quarter 2024. The project is estimated to have an annual output of 321,000 tonnes of spodumene concentrate.

China's Zijin Mining Group recently announced it is launching a lithium exploration project in a partnership with Democratic Republic of Congo's state-owned firm La Congolaise d'Exploitation Minière.

Interest in recycling continues to rise. However, recycling currently only accounts for around 1% of total supply, and will need to increase substantially to make an appreciable contribution to addressing the expected supply shortages over the outlook period. To date, recycling has yet to be established on a large scale. Glencore has announced it plans to build a new plant to recycle lithium-ion batteries in the UK in partnership with battery start-up Britishvolt. The plant will have the capacity to take in at least 10,000 tonnes of batteries a year. Neometals has also confirmed plans to partner with Mercedes-Benz to build a 25,000 tonne a year recycling plant in Germany. Stronger lithium prices, combined with increasing volumes of end-of-life electric vehicle batteries in coming years, should improve the economics of recycling projects.

15.4 Prices

Spot prices soar as a supply crunch hits battery producers

Strong demand is currently resulting in shortages of spodumene, lithium hydroxide and lithium carbonate, which is pushing spot prices for all three commodities to record levels.

Spot spodumene concentrate averaged around US$2,700 per tonne in February–March 2022, compared to US$1,900 in the December quarter and up more than six-fold from US$420 a tonne in January 2021. Surging demand and low inventories saw reports of spodumene trades above US$3,000 a tonne in early 2022.

Spot prices for lithium hydroxide (delivered to China) averaged US$57,000 a tonne in February 2022, with daily prices reaching over US$70,000 by mid-March, a more than eight-fold increase from the US$7,984 average in January 2021.

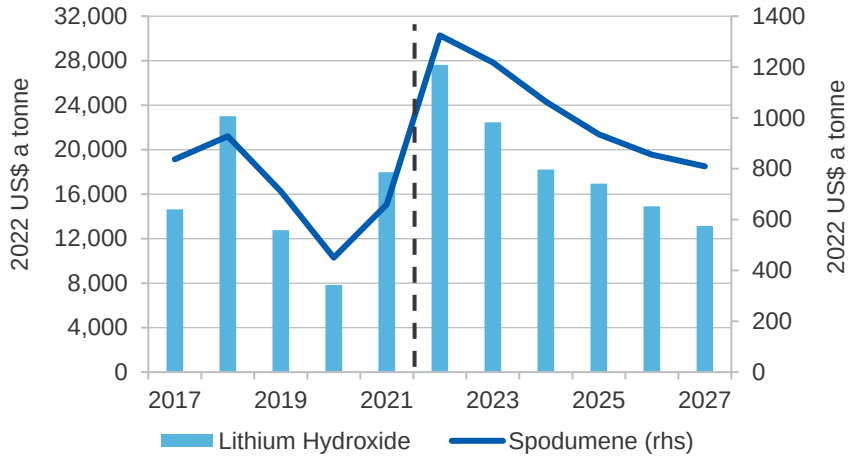
As most Australian producers have historically worked off long term contracts, prices received take time to adjust while changes in spot prices feed through into contract prices. While pricing mechanisms built into long-term contracts vary, they generally include a basket of measures such as trade data and price floor and price ceilings. This results in substantially reduced volatility in contract prices compared with spot prices.

Contract prices for spodumene are expected to increase strongly in 2022, driven by rising EV production and short term supply issues.

Spodumene prices are forecast to rise from an average of US$660 a tonne in 2021 to around US$1,300 a tonne in 2022, as spot and contract prices are renegotiated (Figure 15.4). The price is expected to moderate to around US$800 a tonne (in real terms) by 2027.

Lithium hydroxide prices are forecast to rise from US$17,970 a tonne in 2021 to over US$27,000 a tonne in 2022, before moderating over the outlook period to around US$13,000 in 2027 (in real terms) as global supply steadily rises.

Figure 15.4: Spodumene concentrate/lithium hydroxide prices



Notes: Lithium hydroxide price is for higher priced battery grade product.

Source: Wood Mackenzie (2022); Department of Industry, Science, Energy and Resources (2022).

Risks to the lithium price forecasts are weighted to the upside over the 5 year outlook. If shortages of spodumene and lithium hydroxide are larger and more protracted than expected spot prices will stay higher for longer.

The magnitude and the timing of pass-through of spot prices to contract prices would likely be affected, with the potential for higher realised prices lifting Australia's lithium export revenue over the outlook.

Lithium market could move into ongoing deficit

Despite an anticipated strong supply response, the global lithium shortfall may to be protracted, with shortages in supply expected for several years. The lithium outlook remains subject to considerable uncertainty given recent rapid price movements and the general immaturity of the market.

15.5 Australia

Export values forecast to grow strongly

Record spodumene prices are forecast to lift export revenue from $1.0 billion in 2020–21 to $2.8 billion in 2021–22, with production from lithium hydroxide refineries forecast to steadily add to earnings over the outlook period for a total annual lithium export revenue of $6.7 billion by 2026–27 (in real terms) (Figure 15.5).

Australian production to ramp up over the outlook period

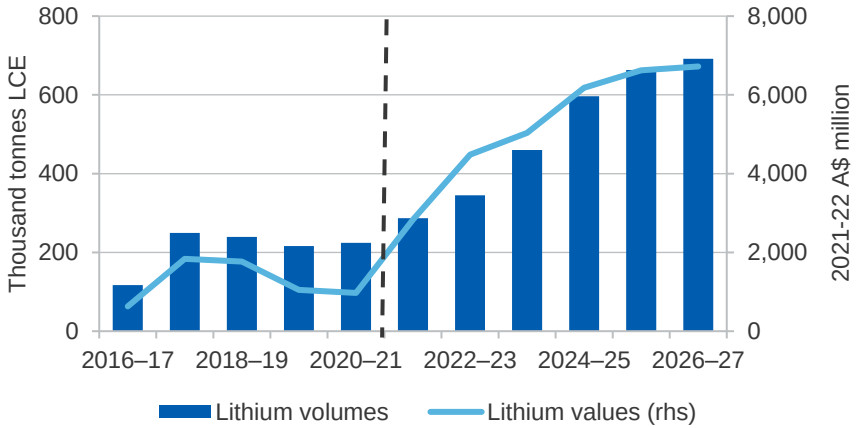
Australian production is now expected to grow strongly over the outlook. Expected annual growth of over 20% a year will see production rise from 224,000 tonnes of LCE in 2020–21 to 287,000 tonnes of LCE in 2021–22, growing to 692,000 tonnes in 2026–27 (Table 5.1, Figure 15.5). Correspondingly, export volumes of spodumene concentrate are forecast to increase from 1.6 million tonnes in 2020–21 to 4.7 million tonnes in 2026–27.

Strong price signals drive production increases

Australian spodumene concentrate output in the December quarter 2021 rose by 33% year-on-year, with further increases in production expected in 2022 as further capacity comes on stream.

Pilbara Minerals production increased by 49% in the six months to December 2021 — 170,228 dry metric tonnes (dmt) — compared to the six months to December 2020 (114,239 dmt). The average selling price achieved was US$1,250 per tonne, lifting revenue for the first half of the financial year to $292m, compared with $59m in the first half of 2020–21. According to the company, production rates were lower than expected due to a combination of plant down-time events (both scheduled and unplanned), a suboptimal ore feed blend due to mining constraints, the integration of a new plant at Ngungaju (which commenced operations in a staged restart) and widespread labour shortage issues and cost inflation in the WA resources sector.

Figure 15.5: Australia's exports of lithium



Notes: Export values include revenue from spodumene concentrate and lithium hydroxide. Lithium volumes include total exports of spodumene concentrate and lithium hydroxide converted to LCE.

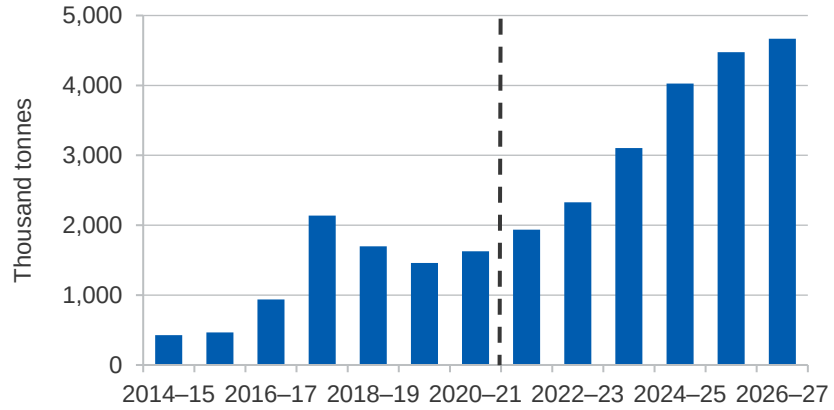
Source: Company reports; WoodMackenzie (2022); Department of Industry, Science, Energy and Resources (2022).

The construction phase of the Pilgan Plant Improvement Project has completed, with commissioning and ramp-up of the facilities now underway and a targeted 10–15% increase in annual production from 330,000 dmt to 360–380,000 dmt. When the Ngungaju Plant is restarted annual production is expected to be 540-580,000 dmt for the combined Pilgangoora operation. According to the company, a Financial Investment

Decision (FID) on the Phase 1 expansion of the Pilgan plant — for an incremental 100,000 tonnes a year of spodumene concentrate — is targeted for the June 2022 quarter. Further studies for subsequent incremental expansions to target 1 million tonnes a year of production will be undertaken, with a FID expected in the December quarter 2022.

Production from Mt Marion (owned 50% by Mineral Resources and 50% by Gangfeng Lithium Co. Limited) totalled 207,000 tonnes of spodumene concentrate in the six months to December 2021 with an average price of US$1,011 a tonne.

Figure 15.6: Spodumene production



Source: Wood Mackenzie (2022); Department of Industry, Science, Energy and Resources (2022).

The three operational plants at Greenbushes — operated by the Talison Joint Venture — produced a total of 526,300 tonnes of spodumene concentrate in the six months to December 2021. High spot prices are expected to lead to a significant increase in the contract price for chemical grade spodumene for the second half of 2021–22 to around US$1,770 a tonne (FOB) compared with US$592 a tonne in the first half of the financial year. Construction of the Tailings Retreatment Plant has continued, with first feed scheduled for the March 2022 quarter.

Lithium hydroxide production is rising in Australia, Korea and Japan

Trial production at the Kwinana lithium refinery (51% Tianqi and 49% ASX-listed Independence Group (IGO)) continued in the December quarter 2022, with the goal being a transition from a batch to continuous operation. IGO has stated it expects battery grade lithium hydroxide production from Train 1 by March 2022 and qualification of product with offtake customers to be completed by the second half of 2021–22. The company expects full recommencement of Train 2 construction in the second half of 2022. Each Train has a capacity of 24,000 tonnes a year.

Mechanical completion of Kemerton's Train 1 was achieved in November (60% US-based Albemarle and 40% ASX-listed Mineral Resources). Spodumene ore has now been introduced into the plant as part of the commissioning process, with commercial production expected mid-2022. Kemerton's Stage II — for an additional 25,000 tonnes a year — has been delayed due to COVID-19 restrictions, with completion and ramp up of both stages to name-plate capacity expected late in 2022–23.

ASX-listed Pilbara Minerals' joint venture with POSCO for the production of 43,000 tonnes a year of refined lithium hydroxide in South Korea is scheduled to commence major construction mid-2022. The joint venture plans to source 315,000 tonnes a year of spodumene concentrate from the Pilgangoora operations, based on existing production capacity.

Construction of the Kwinana lithium hydroxide refinery (50% ASX-listed Wesfarmers and 50% Chile-based SQM) is scheduled to continue to ramp up in the first half of 2022. The refinery will source spodumene from the Mt Holland deposit, with the project expected to begin operating in 2024. Mt Holland is initially expected to produce 400,000 tonnes a year of spodumene concentrate.

ASX-listed Orocobre (Allkem) has stated that pre-commissioning works continue at its Naraha plant in Japan within COVID-19 restrictions. The company plans to convert lithium carbonate into lithium hydroxide using feedstock from their operations in Argentina.

Greenbushes' chemical grade plant (CGP2) has been commissioned, with CGP3 committed. The Wodgina mine (60% Albemarle and 40% Mineral Resources) is to recommence production from one of its three spodumene 250,000 tonne production facilities. First production is expected in the September quarter 2022. The company has stated that it may decide to restart the other two processing trains subject to market demand.

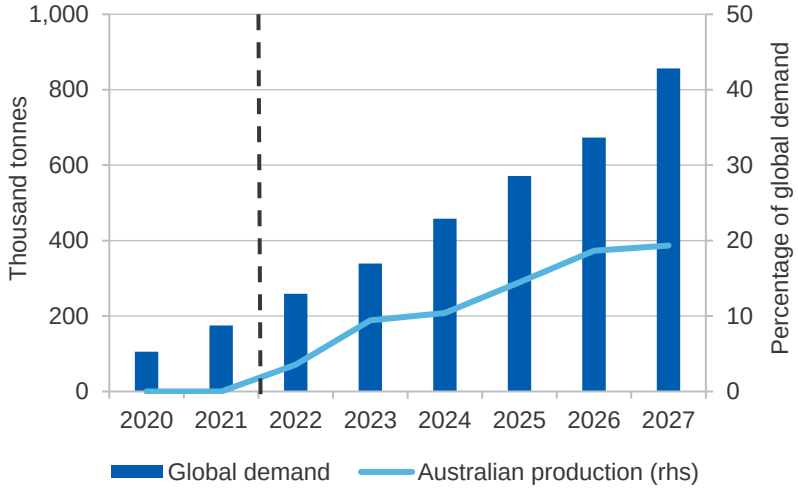
The definitive feasibility study for Liontown's Kathleen Valley deposit near Kalgoorlie was completed in the December quarter 2021. The study indicated a 23-year mine life with start up to deliver 500,000 tonnes a year of spodumene concentrate in the first year, increasing to around 700,000 tonnes a year by year 6. A final investment decision is targeted for the June quarter 2022. Production is expected to commence in the first half of 2024. In February the company signed an agreement with Tesla to supply 100,000 dry metric tonnes of spodumene concentrate, increasing to 150,000 per year in subsequent years.

Site construction and establishment works at Core Lithium's Finniss Project near Darwin commenced in the December quarter 2021. Commissioning of the plant and first production of lithium concentrate are scheduled for the December quarter 2022. Investigations are also underway exploring the long-term potential for additional downstream processing. Gangfeng and Yahua have offtake agreements for 80% of the first 4 years of production, amounting to 75,000 tonnes of spodumene concentrate a year supplied to each company. In February Core announced that recent exploration revealed significant extensions to spodumene bearing pegmatite to the south of the project, with further exploration and resource drilling to ramp-up in the June quarter 2022.

Australian businesses are expected to continue expanding their activities into higher value added activities over the outlook period. Potential avenues include growth up the battery value chain from mining and refining, into precursor chemicals for cathodes, battery anode plants, electrolyte production, battery cell research/production, and battery manufacturing (Figure 15.8).

By 2024, Australia may have around 10% of global lithium hydroxide refining capacity, rising to 19% of global lithium refining by 2027 (Figure 15.7).

Figure 15.7: World and Australian lithium hydroxide output



Source: BloombergNEF (2021); Department of Industry, Science, Energy and Resources (2022).

The robust forecast growth for Australian lithium production over the outlook is subject to a number of risks. Delays to approval and construction of new mine and processing plants, as well as difficulties achieving ramp up to full output, would see slower growth in spodumene production volumes and export values than forecast. Similarly, for Australia's nascent lithium hydroxide refining sector, unanticipated delays or technical challenges associated with achieving required product grade, purity and consistency could also push back forecast production and export growth over the outlook.

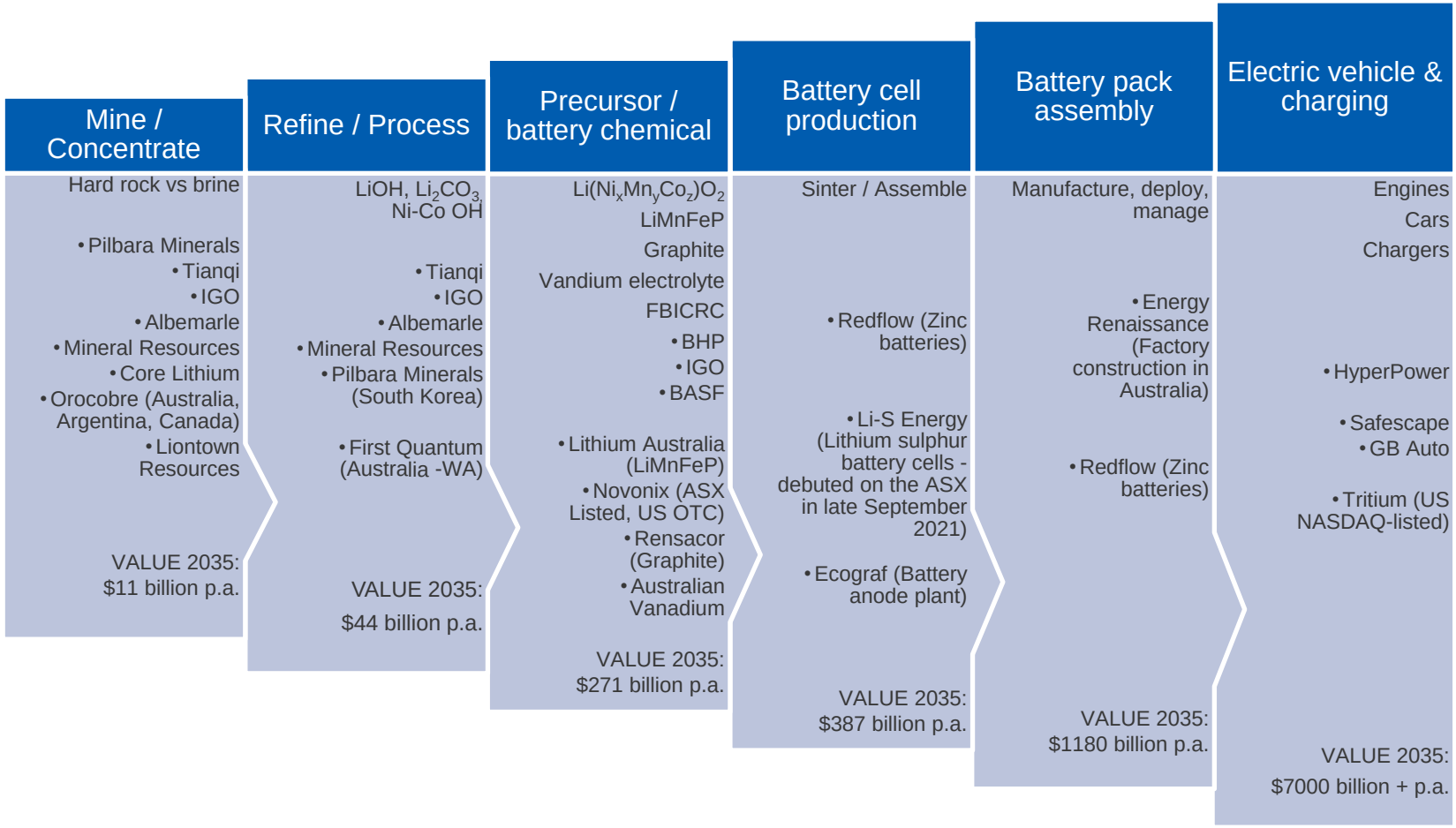
Revisions to the outlook

Forecast export revenue in 2021–22 has been revised down from $3.3 billion in the December 2021 Resources and Energy Quarterly to $2.8

billion, reflecting a downward revision to mine production due to a slower than expected ramp up in production in some operations. Export revenue for 2022–23 has been revised up from $4.2 billion to $4.5 billion (in nominal terms), reflecting the strong gains in the spodumene price rolling through into contract prices.

Compared to the March 2021 Resources and Energy Quarterly, exports in 2025–26 have been revised up from $6.0 billion to $7.4 billion (nominal) reflecting higher expected prices and production volumes.

Figure 15.8: Projected global value of lithium-ion battery value chain (+ zinc and vanadium batteries for large scale storage)



Notes: Redflow is ASX listed and is currently producing zinc batteries offshore. Zinc and vanadium batteries are suitable for large scale storage.

Source: BloombergNEF (2021), *Australasian Institute of Mining and Metallurgy: Thought leadership conference*, September 2021; Future Battery Industry Co-operative Research Centre (2021).

Table 15.1: Lithium Outlook

World	Unit	2021	2022[f]	2023[f]	2024[z]	2025[z]	2026[z]	2027[z]	CAGR[r]
Lithium production [a]	kt	520	650	804	927	1,115	1,345	1,476	19.0
Lithium demand [b]	kt	526	636	776	942	1,106	1,294	1,493	19.0
Spodumene price									
–nominal	US$/t	638	1,325	1,250	1,120	1,010	945	915	6.2
–real [c]	US$/t	660	1,325	1,218	1,064	936	855	809	3.5
Lithium hydroxide price									
–nominal	US$/t	17,369	27,620	23,050	19,180	18,300	16,460	14,855	-2.6
–real [c]	US$/t	17,970	27,620	22,451	18,209	16,950	14,898	13,138	-5.1
Australia	**Unit**	**2020–21**	**2021–22[f]**	**2022–23[f]**	**2023–24[z]**	**2024–25[z]**	**2025–26[z]**	**2026–27[z]**	**CAGR[r]**
Mine production [a]	kt	224	287	345	460	597	663	692	20.6
Spodumene export volume[d]	kt	1,628	1,936	2,328	3,104	4,026	4,476	4,668	19.2
Export value									
–nominal [g]	A$m	938	2,833	4,621	5,330	6,708	7,369	7,666	41.9
–real [h]	A$m	970	2,833	4,481	5,034	6,179	6,623	6,721	38.1

Notes: **a** Lithium Carbonate Equivalent — a measure of the quantity of refined product; **b** Demand is ahead of consumption by approximately 12 months due to the lead time required in battery manufacturing; **c** In 2022 US dollars; **d** Includes spodumene concentrates exported — mostly 6 per cent Li_2O concentrate — plus spodumene concentrate used to produce lithium hydroxide for export; **f** Forecast; **g** Revenue from spodumene concentrate as well as lithium hydroxide; **h** In 2021–22 Australian dollars; **r** Compound annual growth rate; **z** Projection.

Source: Company reports; Department of Industry, Science, Energy and Resources (2022); WoodMackenzie (2022); BloombergNEF (2022); Government of Western Australia Department of Mines, Industry Regulation and Safety (2021).