³Li Lithium



15.1 Summary

- Spodumene prices are forecast to rise from an average US\$675 a tonne in 2021 to US\$2,235 a tonne in 2022, before easing to about US\$1800 a tonne in 2024. Lithium hydroxide prices are forecast to rise from US\$17,370 a tonne in 2021 to US\$35,570 a tonne in 2022, before easing to about US\$28,810 by 2024.
- Australia's lithium production is forecast to rise by more than half over the outlook period, rising from 278,000 tonnes of lithium carbonate equivalent (LCE) in 2021–22 to 438,000 tonnes of LCE in 2023–24.
- Australia's lithium export earnings are projected to more than double over the outlook period, from \$4.1 billion in 2021–22 to \$9.4 billion in 2023-24 (see Australia section).

15.2 World demand

Electric vehicles continue to increase global market share

In the March quarter 2022, global light electric vehicle (EV) sales fell slightly (down 1%) from record sales in the December quarter 2021, but were up 44% from the March quarter 2021. Global EV production and sales were also down in April; there were lower sales in China, Europe and the US, resulting from a combination of macroeconomic challenges, vehicle delivery delays and production cutbacks in China (due to COVID lockdowns and restrictions). However, EV sales in China rebounded strongly in May, with major producers, including BVM and Tesla, reporting strong growth as supply chains recovered and demand improved.

Despite these setbacks, global passenger EV sales are expected to continue to grow strongly, albeit at slower rates than the record growth in 2021 — when passenger EV sales more than doubled to an estimated 6.6 million vehicles. EV sales are expected to reach 10.7 million in 2022 and 13.2 million in 2023 (Figure 15.1).

The global market share for passenger EVs has quadrupled since 2019, with EV sales representing about 9% of the car market in 2021 (Figure 15.2). Strong underlying demand and EV manufacturers' declarations of

further increases in production, imply that EV sales could reach up to 40% of vehicle sales annually by 2030.

In addition to a growing choice of models, EV uptake is also being driven by falling EV prices and ongoing government measures — though government incentives are being wound back in some nations. Over the past year, many global automakers announced plans to accelerate the transition to electric vehicles by developing new product lines and converting existing manufacturing capacity. For example, in April Honda announced an investment of US\$40 billion over the next decade to deliver 30 EV models worldwide, with a goal of 100% electric sales by 2040.

Figure 15.1: Long term electric vehicle sales projections



Note: Projections reflect an assumed long run EV demand profile based on the IEA Announced Pledges Scenario with adjustments to take into account expected higher EV uptake rates associated with increased demand and the 2050 net-zero trajectory. Source: Department of Industry, Science and Resources (2022); Wood Mackenzie (2022); BloombergNEF (2022); IEA (2022).

World demand for lithium is estimated to increase from 555,000 tonnes of lithium carbonate equivalent (LCE) in 2021 to 677,000 tonnes in 2022 (Table 15.1). Over the following two years, demand is forecast to rise by over 40%, reaching 947,000 tonnes by 2024. Asia remains the major source of demand for lithium, despite the spread of new battery manufacturing capacity into Europe and the US.





Source: IEA (2022).

Cuts to China's EV subsidy program for passenger vehicles earlier this year present a potential downside risk to EV forecast growth. The program was originally scheduled to expire in 2022, however it has been reported that the Government is now considering extending the incentives to next year.

Another issue affecting the outlook is the challenging supply chain environment facing auto makers. A number of EV makers have publicly announced they are experiencing supply chain issues, with reports that delivery timeframes for key models, such as Tesla's Model Y Long Range, have been pushed well into 2023. Higher prices for lithium as well as other key battery materials (such as nickel, graphite and cobalt) are putting pressure on battery costs.

15.3 World production

Security of supply concerns continue to plague processors

World output is estimated at 520,000 tonnes LCE in 2021, and is forecast to reach 655,000 tonnes in 2022 and 944,000 tonnes in 2024 (Figure 15.3). This rapid growth — of around 80% in three years — is forecast to be met by gains in output by Australia (see section below), Chile (via expansions to Albemarle and SQM operations) and Argentina (via new and expanded brine operations by Livent, Allkem and Minera Exar).

Total supply from mine and brine operations is currently insufficient to meet demand. While project development is underway, it will take time to close the supply gap. Stockpile size is hard to ascertain, with some estimates of 4-8 weeks for spodumene. Ongoing tight supply conditions and ongoing concerns about supply chain bottlenecks are forcing lithium processors and battery makers to pay record prices to secure supply.

Figure 15.3: Global lithium production



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

Project development is underway, but supply gap will take time to close

The stronger and more mature demand outlook for lithium chemicals is attracting large capital allocations to build global supply. Estimates by Benchmark Mineral Intelligence indicate that as much as US\$42 billion in investment will be needed by 2030 to meet demand for lithium.

A number of expansions and new projects have been announced in recent months. Europe and North America are looking to reduce their dependency on Chinese imports and develop their own lithium production. The US Government is providing more than US\$3 billion in grants to help process critical minerals — including lithium — to accelerate production of key battery metals. Canada has also earmarked up to C\$3.8 billion to build a domestic critical metals supply chain.

Argentina, the world's 4th biggest lithium exporter, has over 20 lithium projects at various stages of development, and is expecting to receive US\$4.2 billion in investment over the next 5 years. Among these, Chinese mining firm Zijin Mining Group has announced it will construct a 20,000 tonne capacity lithium carbonate plant, with a goal of subsequently doubling production in the medium term. Albemarle has announced plans to restart exploration in the Salar de Antofalla, while Posco Holdings is investing US\$830 million in a lithium hydroxide plant. In March, Rio Tinto completed the acquisition of the Rincon lithium project in Salta, which holds reserves of almost 2 million tonnes of LCE.

Chilean state-owned mining firm Codelco has commenced exploration in the Salar de Maricunga, and drilling is expected to be completed in early 2023. The Democratic Republic of Congo's state-owned firm La Congolaise d'Exploitation Minière has announced it is launching a lithium exploration project in partnership with Zijin Mining Group.

Interest in recycling continues to rise, with recycling projects announced in many countries across Europe and other parts of the world. However, large scale operations will take time to be established. Stronger lithium prices, combined with increasing volumes of end-of-life electric vehicle batteries, should improve the economics of recycling projects.

15.4 Prices

Hydroxide prices soften, while spodumene prices set new records

Shortages of spodumene, lithium hydroxide and lithium carbonate continue to push spot prices to new records. Surging demand and low inventories saw spot spodumene trade as high as US\$7,000 a tonne in June 2022. Spot spodumene concentrate averaged about US\$3,950 per tonne in May 2022. This was up from US\$3,107 in April, representing a nine-fold increase from the US\$418 a tonne recorded in January 2021.

Spot prices for lithium hydroxide (delivered to China) averaged US\$68,900 a tonne in May 2022, down slightly from the April average of US\$74,688, but still more than eight times the US\$7,984 average of January 2021.

As most Australian producers have historically utilised long term contracts, prices received take time to adjust to shifts in spot prices. High average realised prices reported by Australian producers indicate spot prices are now flowing more rapidly into contract prices. Anecdotes suggest that contract prices for spodumene have increased strongly so far in 2022, as processors seek to ensure supply is sufficient to meet expected demand.

Spodumene prices are forecast to rise from an average of US\$675 a tonne in 2021 to about US\$2,235 a tonne in 2022, as spot and contract prices are renegotiated (Figure 15.4). Prices are expected to moderate to about US\$1,800 a tonne by 2024.

Lithium hydroxide prices are forecast to rise from US\$17,370 a tonne in 2021 to US\$35,570 a tonne in 2022. As global supply steadily rises over the outlook period, prices should moderate to around US\$28,810 in 2024.

Considerable uncertainty exists, given recent rapid price movements and the general immaturity of the market. Risks to the lithium price forecasts are balanced over the outlook period. While expansions to production are already underway in Australia and overseas, long lead times for lithium mine and brine operations, and the potential for delays in bringing such large volumes of lithium into production, mean risks remain of supply shortages persisting over the next few years. However, one of the drivers of recent high spot prices is a push by refiners and battery producers to build up stocks, due to concerns about global supply chains. If these concerns ease, prices could moderate more rapidly over the next couple of years. A slowdown in global economic growth would adversely affect demand and ease the pressure on prices.



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 and Resources (2022).

15.5 Australia

Export values forecast to grow strongly as production ramps up

Record spodumene prices are estimated to have lifted export revenue from \$1.1 billion in 2020–21 to \$4.1 billion in 2021–22. Production from lithium hydroxide refineries is forecast to steadily add to earnings over the outlook period, lifting total annual lithium export revenue to \$9.4 billion by 2023–24 (Figure 15.5).

Australian production is now expected to grow strongly over the outlook. Expected annual growth of over 20% a year will see production rise from 218,000 tonnes of LCE in 2020–21 to 278,000 tonnes of LCE in 2021–22,

growing to 438,000 tonnes in 2023–24 (Figure 15.5). Accordingly, export volumes of spodumene concentrate are forecast to increase from 1.7 million tonnes in 2020–21 to around 3 million tonnes in 2023–24.

Strong price signals drive production increases

Pilbara Minerals' spodumene concentrate output in the March quarter 2022 was 81,431 dry metric tonnes (dmt), down 2.5% compared with the December quarter 2021 (83,476). March quarter 2022 production was affected by resourcing shortfalls, due to COVID-19 impacts and the tight labour market. With the Pilgan Plant Improvement Project now successfully commissioned, installed production capacity has been rerated from 330 kilotonnes per annum (ktpa) to 360-380 ktpa. The staged restart of the Ngungaju Plant is underway, with load commissioning of the fines flotation circuit commencing in April. Once the Ngungaju Plant is fully operational, annual production is expected to be 540,000-580,000 dmt for the combined Pilgangoora operation. FID for an incremental 100ktpa capacity increase for the Pilgan plant remains targeted for the June 2022 quarter.

Pilbara Minerals stated that the average spodumene sales price achieved in the March quarter 2022 was US\$2,650 per tonne, more than double the US\$1,250 average price achieved for the second half of 2021. However, prices of US\$6,250 and US\$7,017 were achieved in April and June respectively for cargos sold under auction at the Battery Metal Exchange (BMX). The company expects a significant step up in the spodumene offtake price achieved in the June quarter. Auctions will be held more regularly, as Ngungaju output ramps up and more uncommitted tonnes become available.

Finally, Pilbara Minerals has partnered with Calix to develop a demonstration-scale chemicals facility to process fine, lower-grade spodumene concentrate from the Pilgangoora project to create a lowcarbon, concentrated lithium salt using renewable energy. The project is being supported through an Australian Government grant under the Modern Manufacturing Initiative.



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

Output from Mt Marion (owned 50% by Mineral Resources and 50% by Jiangxi Ganfeng Lithium Co. Limited) totalled 104,000 dmt of spodumene concentrate in the March quarter 2022, with an average realised price of US\$1,952 a tonne (up about 70% on the December quarter). In April 2022, the joint venture announced a decision to lift spodumene production at Mt Marion from 450,000 to 600,000 tonnes per annum of mixed-grade concentrate, targeting an annual plant capacity of 900,000 tonnes by end 2022 (equal to 600,000 tonnes of 6% spodumene concentrate).

Mineral Resources and Albemarle have announced an acceleration to the restart of the Wodgina mine. Wodgina Train 1 achieved production of first new spodumene concentrate in the June quarter 2022, following two years in care and maintenance. An accelerated resumption of operations at Train 2 is expected to see first production in July 2022.

The three operational plants at Greenbushes operated by the Talison Joint Venture produced a combined total of 270,000 tonnes of spodumene

concentrate in the March quarter 2022, a 5% rise on the December quarter 2021. Construction of the Tailings Retreatment Plant was also completed, and commissioning is underway. In addition, construction of a chemical grade plant (CGP2) has been commissioned, with CGP3 committed. Independence Group expects construction to be completed by early 2025.

High spot prices have seen the contract price for chemical grade spodumene reset to US\$1,770 a tonne from January 2022, an increase of almost 300% on the US\$592 a tonne average price in H2 2021. IGO believes the price of US\$1,770 applied in the June quarter 2022.



Figure 15.6: Spodumene exports

Australia's hydroxide refineries on verge of commercial production

Trial production at the Kwinana lithium refinery (51% Tianqi and 49% IGO) continued in the June quarter 2022. In May, the company announced the first consistent production of battery grade lithium hydroxide. The qualification process with offtake customers is expected to commence following the completion of independent verification. Construction of Train 2 has been partially completed, with the decision for the full recommencement of construction to be made in H2 2022. Each Train has a capacity of 24,000 tonnes a year.

Spodumene ore has now been introduced into the Kemerton hydroxide plant, and production expected to commence in the June quarter 2022. Mechanical completion and commencement of production at Kemerton's Stage 2 — which will produce an additional 25,000 tonnes a year — is targeted for the December quarter 2022.

Pilbara Minerals' joint venture with POSCO for the production of lithium hydroxide in South Korea was completed in April, with major construction scheduled for the June quarter 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 progressed in H1 2022. The refinery will source spodumene from Mt Holland, and is forecast to start in 2024 — making 50,000 tonnes of lithium hydroxide a year.

Liontown's Kathleen Valley deposit near Kalgoorlie is scheduled for FID in the June quarter 2022. The project is expected to deliver 500,000 tonnes a year of spodumene concentrate in the first year, rising to about 700,000 tonnes a year by year 6. Production is expected to commence in the first half of 2024. Offtakes are in place with tier-1 customers, including Tesla, for more than 50% of production over the first five years.

Site construction continues at Core Lithium's Finniss Project near Darwin, and environmental approval for the BP33 underground mine was granted in May. Commissioning of the plant and first production of lithium concentrate are scheduled for the end of 2022. Investigations are also underway exploring the long-term potential for additional downstream processing. Offtake agreements have been made with Ganfeng and Yahua for 80% of the first 4 years of production, amounting to 75,000 tonnes of spodumene concentrate a year supplied to each company.

Australian businesses are expected to continue their expansion 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, electrolyte production battery anode plants, battery cell research/production, and battery manufacturing (Figure 15.8).



Figure 15.7: World and Australian lithium hydroxide output

Source: BloombergNEF (2022); Dept of Industry, Science and Resources (2022)

By 2024, Australia may have about 10% of global lithium hydroxide refining capacity (Figure 15.7), rising to about 20% of global lithium refining by 2027. The robust forecast growth for Australian lithium production and revenue 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 output volumes and export values. Similarly, for Australia's nascent lithium hydroxide refining sector, more unanticipated delays or technical challenges associated with achieving required product grade, purity and consistency, could delay forecast output and exports.

Revisions to the outlook

Forecast export revenue over the outlook has been revised up substantially. This reflects a combination of sustained record spodumene prices, faster than expected pass-through of spot prices to contract prices and new production and trade data. Estimated export revenue in 2021–22 has been revised up, from \$2.8 billion in the March 2022 *Resources and Energy Quarterly* to \$4.1 billion. Further out, 2022–23 has been lifted from \$4.6 billion to \$7.8 billion, and 2023–24 from \$5.3 billion to \$9.4 billion.

Mine / Concentrate	Refine / Process	Precursor / battery chemical	Battery cell production	Battery pack assembly	Electric vehicle & charging			
Hard rock vs brine • Pilbara Minerals • Tianqi • IGO • Albemarle • Mineral Resources • Core Lithium • Orocobre (Australia, Argentina, Canada) • Liontown Resources VALUE 2035: \$11 billion p.a.	LiOH, Li ₂ CO ₃ Ni-Co OH • Tianqi • IGO • Albemarle • Mineral Resources • Pilbara Minerals (South Korea) • First Quantum (Australia -WA) VALUE 2035: \$44 billion p.a.	Li(Ni _x Mn _y Co _z)O ₂ LiMnFeP Graphite Vandium electrolyte FBICRC • BHP • IGO • BASF • Lithium Australia (LiMnFeP) • Novonix (ASX Listed, US OTC) • Rensacor (Graphite) • Australian Vanadium VALUE 2035: \$271 billion p.a.	• Redflow (Zinc batteries) • Li-S Energy (Lithium sulphur battery cells - debuted on the ASX in late September 2021) • Ecograf (Battery anode plant)	Manufacture, deploy, manage • Energy Renaissance (Factory construction in Australia) • Redflow (Zinc batteries)	Engines Cars Chargers • HyperPower • Safescape • GB Auto • Tritium (US NASDAQ-listed)			
			\$387 billion p.a.	\$1180 billion p.a.	VALUE 2035: \$7000 billion + p.a.			

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

						Annual percentage change		
World	Unit	2021	2022 ^s	2023 ^f	2024 ^f	2022 ^s	2023 ^f	2024 ^f
Lithium production ^a	kt	520	655	808	944	26.2	23.4	17.0
Lithium demand	kt	555	677	817	947	21.8	20.7	16.0
Spodumene price								
– nominal	US\$/t	675	2,235	2,290	1,810	230.9	2.5	-21.0
– real ^b	US\$/t	728	2,235	2,226	1,721	207.1	-0.4	-22.7
Lithium hydroxide price								
– nominal	US\$/t	17,370	35,570	40,100	28,810	104.8	12.7	-28.2
– real ^b	US\$/t	18,717	35,570	38,987	27,389	90.1	9.6	-29.7
Australia	Unit	2020–21	2021–22 ^s	2022–23 ^f	2023–24 ^f	2021–22 ^s	2022–23 ^f	2023–24 ^f
Mine production ^a	kt	218	278	339	438	27.5	21.8	29.1
Spodumene export volume ^c	kt	1,711	1,878	2,287	2,952	9.8	21.8	29.1
Export value								
 nominal value ^d 	A\$m	1,055	4,082	7,759	9,413	287.0	90.1	21.3
- real value ^e	A\$m	1,100	4,082	7,412	8,705	270.9	81.6	17.4

Notes: a Lithium Carbonate Equivalent (LCE) — a measure of the quantity of refined product; b In 2022 US dollars; c Includes spodumene concentrates exported — mostly 6 per cent Li₂O concentrate — plus spodumene concentrate used to produce lithium hydroxide for export; f Forecast; d Revenue from spodumene concentrate as well as lithium hydroxide; e In 2021–22 Australian dollars; s Estimate.

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