

Lithium

Major Australian Lithium deposits

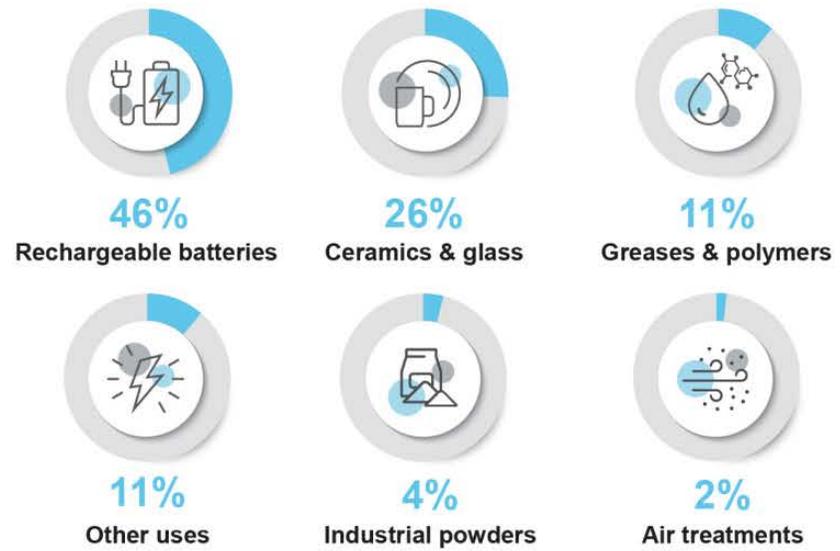


Lithium facts



- Electric vehicle sales** are expected to increase from **3m to 30m** by 2030
- Lithium exports** contributed **A\$1.1b** to economy in 2020-21
- Australian lithium exports are tipped to increase to **3.9m tonnes** in 2025-26
- In August 2021 Australia began **producing lithium hydroxide**

World consumption



Australia's lithium



15.1 Summary

- Spodumene prices are forecast to rise to an average US\$1,185 a tonne in 2022 from an estimated US\$720 a tonne in 2021, but fall back to US\$990 a tonne in 2023.
- Lithium hydroxide prices are forecast to rise from US\$7,300 a tonne in 2020 to US\$18,940 a tonne in 2023.
- Australia's lithium production is forecast to rise from 217,000 tonnes of lithium carbonate equivalent (LCE) in 2020–21 to 373,000 tonnes of LCE in 2022–23 (see [Australia section](#)).
- Australia's lithium export earnings are forecast to rise from \$1.1 billion in 2020–21 to \$4.2 billion in 2022–23 as lithium hydroxide production rises. First lithium hydroxide output occurred in August 2021.

15.2 World consumption

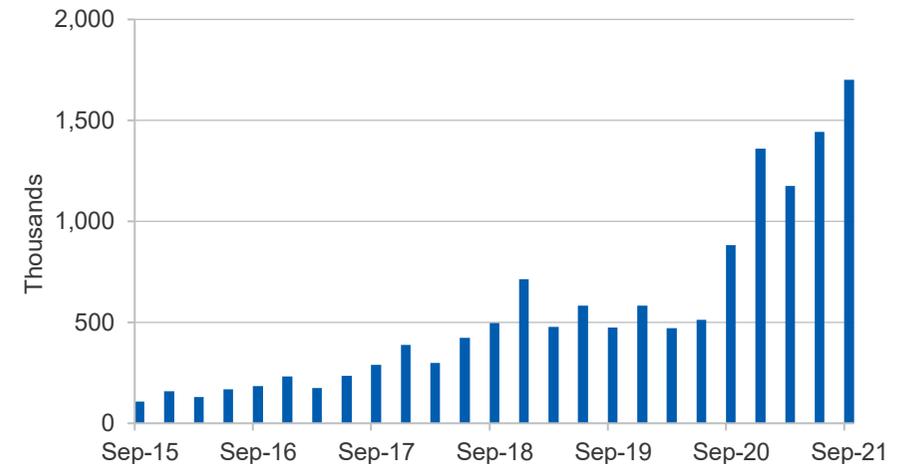
Increase in September quarter 2021 electric vehicle sales

Global electric vehicle (EV) sales rose by 18% quarter-on-quarter in the September quarter 2021 to be 93% higher than a year before (Figure 15.1). Global EV sales in 2021 are likely to exceed 5 million units. Sales were dominated by China and Europe.

The forecast for lithium demand is subject to greater than usual uncertainty, due to a semi-conductor shortage affecting the auto industry — which has led to a number of EV makers pushing delivery timeframes for various models out to 2023. Tesla and Volkswagen have publicly announced that they are experiencing supply chain issues. Market commentators such as Bloomberg New Energy Finance have internal combustion engine vehicles been projected to reach cost parity with EVs in 2023 in large markets, but supply chain issues may strain this timeline.

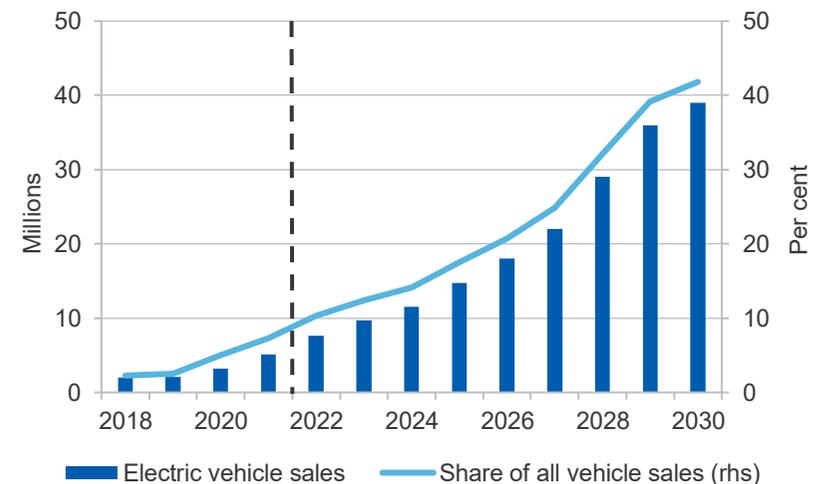
Bloomberg New Energy Finance and the International Energy Agency have EV demand projected to rise to about 30% of vehicle sales annually by 2030, given manufacturers' declarations of capacity hikes and recent strong sales trends (Figure 15.2).

Figure 15.1: World quarterly electric vehicle sales



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

Figure 15.2: Long term sales projections



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

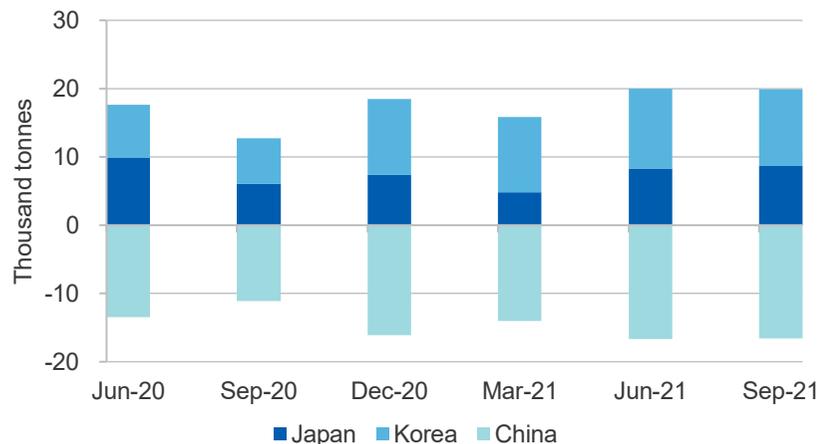
Lithium trade decreased due to a supply shortage

Over the September quarter 2021, China's lithium hydroxide exports decreased by 0.5% quarter-on-quarter, while its imports increased by 26% quarter-on-quarter as it struggled to maintain sufficient supply.

China's net imports of lithium carbonate fell by 34% from the June quarter, as supply became difficult to source. South Korean lithium hydroxide imports fell by 4.6% in the September quarter 2021, while imports of lithium carbonate fell by 23% quarter-on-quarter, as supply was difficult to obtain. Japan's lithium hydroxide imports rose by 5.2% quarter-on-quarter in the September quarter 2021, while carbonate imports rose by 9.9% quarter-on-quarter, with Japan able to obtain supply. Trade in lithium hydroxide between these nations tends to mirror Chinese refining patterns.

Lithium carbonate imports decreased overall (Figures 15.3 and 15.4), but Australia's growing exports of spodumene made up for some of the shortfall (Figure 15.5). Australian spodumene is processed into lithium hydroxide in China, but some domestic capacity for this is being built up.

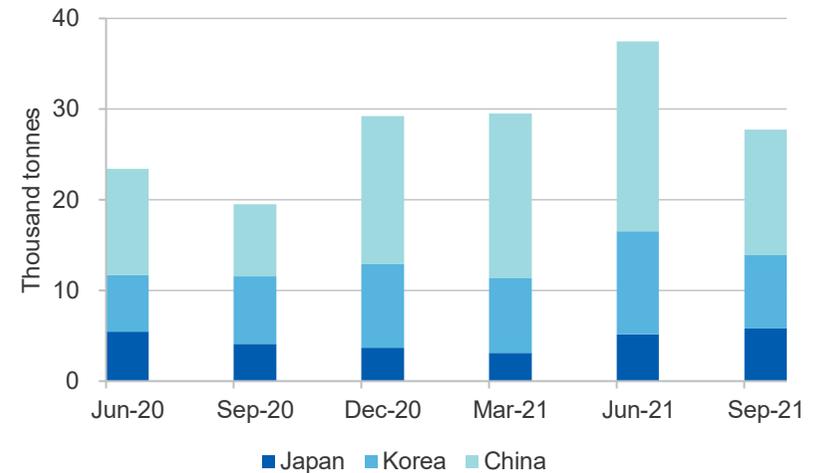
Figure 15.3: Lithium hydroxide imports and exports



Notes: Positive numbers = imports, negative numbers = exports.

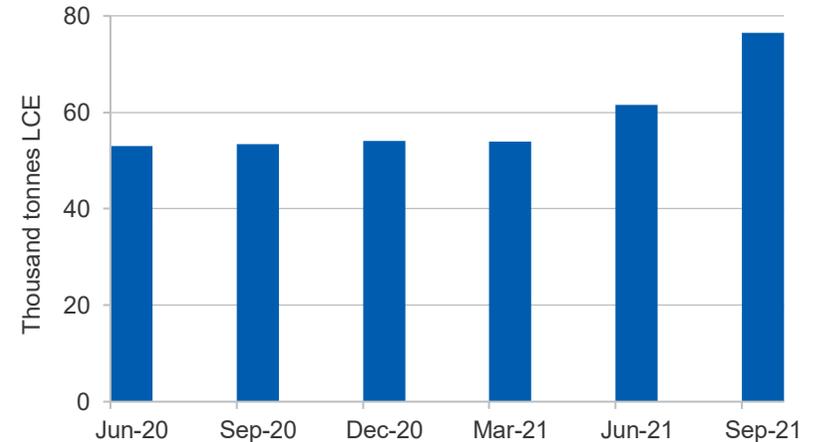
Source: BloombergNEF (2021); Department of Industry, Science, Energy and Resources (2021).

Figure 15.4: Lithium carbonate imports



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

Figure 15.5: Australian spodumene sales



Notes: ABS started collecting spodumene data as of 1 July 2021. Units in terms of lithium carbonate equivalent (LCE).

Source: Company reports; Department of Industry, Science, Energy and Resources (2021).

Lithium demand increasing strongly

World demand for lithium is estimated to increase to 486,000 tonnes of lithium carbonate equivalent (LCE) in 2021, from 305,000 tonnes in 2020 (Table 15.3). Demand is then forecast to reach 724,000 tonnes by 2023, as global EV uptake rises.

Increasing EV uptake is being driven by government measures, lower vehicle prices, and increasing model choice. Currently, there is a shortage of spodumene and lithium carbonate. Project development is underway — as well as increasing interest in recycling — that will aid in meeting the supply shortfall. The shortfall may continue beyond the outlook period.

Asia is still dominating lithium product demand, despite battery factories diversifying into Europe and the United States (Figures 15.3 and 15.4).

15.3 World production

Security of supply a priority as world demand lifts

Output is estimated at 485,000 tonnes LCE in 2021, and is forecast to increase to 615,000 tonnes in 2022 and 821,000 tonnes in 2023. At this stage, supply from mine and brine operations is falling short of matching demand growth. Project development is underway, but will take time to fill the supply gap.

The Americas

Chile is offering 400,000 tonnes of LCE for extraction, with five quotas of 80,000 tonnes each, with development over 7 years and production of 20 years. This is potentially a large increase in supply, but is one which will take significant time to come online. Bids for the quotas close in December 2021. Chile's Sociedad Quimica y Minera de Chile (SQM) and Albemarle are currently the only licenced lithium carbonate producers in Chile.

Chile's SQM is continuing its development path towards 180,000 tonnes a year of lithium carbonate, as well as 30,000 tonnes a year of lithium hydroxide. These levels are expected to be reached by end of 2022.

Albemarle's La Negra III and IV expansion projects in Chile are due to complete their ramp up by the end of 2022, with the operation set to be capable of producing 40,000 tonnes a year of lithium carbonate.

Galaxy Resources and Orocobre have finalised merger arrangements, with the new entity to be known as Orocobre. Its key development sites are for lithium carbonate production in Argentina. Orocobre's Sal de Vida project in Argentina is planned for possible production in 2022. The company expects final approvals by year end.

Production from the Olaroz operation in Argentina was 2,800 tonnes of lithium carbonate in the September quarter 2021 — down from 3,300 tonnes in the June quarter 2021. Expansion plans are underway to enable the production of 22,000 tonnes in 2022. Feasibility studies on James Bay in Canada are nearing completion for production of a spodumene concentrate.

Livent's expansion activities in Argentina remain on track to meet target dates for production increases — from 20,000 to 40,000 tonnes LCE — by the end of 2024. Additionally, the company is aiming to increase annual lithium hydroxide production in the US from 25,000 tonnes to 30,000 tonnes by late 2022.

Africa

AVZ Minerals announced an increase in lithium oxide reserves of the Manono deposit in the Democratic Republic of Congo, from 1.47 million tonnes to 2.14 million tonnes. Capital raising has been undertaken and financing discussions are advancing. A mining licence application has been lodged.

Asia

Orocobre is nearing the completion of construction for its Naraha plant in Japan to convert lithium carbonate into lithium hydroxide, based on feedstock of 10,000 tonnes a year of lithium carbonate from Argentina. Pre-commissioning work is underway, according to Orocobre.

15.4 Prices

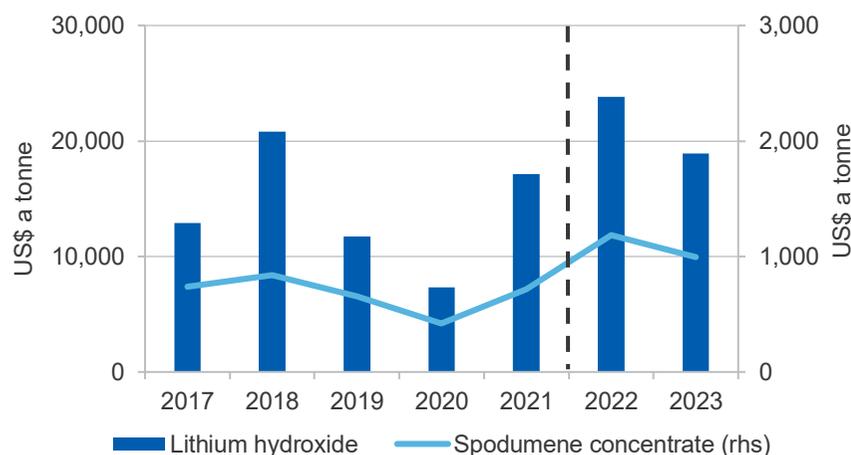
Lithium market: spot prices soar and contracts are negotiated

In the ten months to end October 2021, the spot lithium hydroxide price (delivered to China) averaged US\$14,917 a tonne — double what was achieved in the full year 2020.

However, in early November 2021, LME cash-settled lithium hydroxide futures closed at US\$29.00 a kilogram (or US\$29,000 a tonne) via price assessment from Fast Markets. This is 61% higher than the price for the September quarter 2021, which averaged US\$18,008 a tonne. The futures market lacks depth at present. As the market matures, lithium hydroxide futures contracts will assist in liquidity and transparency.

Lithium hydroxide prices are forecast to rise from US\$7,300 a tonne in 2020 to US\$18,940 a tonne in 2023. The drive upward in prices reflects forecast increased demand for the chemical from EV makers for cars with a longer driving range. High prices are also due to an inability to bring on more hydroxide refining capacity in a timely and cost effective manner.

Figure 15.6: Spodumene concentrate/lithium hydroxide prices



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

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

Spot spodumene prices (delivered to China) rose to US\$2,240 a tonne in September 2021, up over five-fold since the start of the year. Spodumene prices are forecast to rise from an average of US\$420 a tonne in 2020 to US\$1,185 a tonne in 2022 and US\$992 a tonne in 2023, with spot and contract pricing under negotiation.

Some Australian spodumene suppliers have historically worked off long term contracts. Pilbara Minerals' Battery Metals Exchange trading platform — intended to be used for uncontracted spodumene concentrate — commenced in July, with the initial parcel clearing at US\$1,250 a tonne. However, at their late-October auction, they achieved US\$2,350 a tonne on small volumes. Contract prices for spodumene are expected to increase strongly in 2022, driven both by rising EV production as well as short term supply issues (Figure 15.7).

15.5 Australia

Export values forecast to increase

A strong rise in the spodumene price is forecast to see export revenue increase from \$1.1 billion in 2020–21 to \$3.3 billion in 2021–22, with production from lithium hydroxide refineries forecast to add to earnings for a total export revenue of \$4.2 billion by 2022–23 (Figure 15.7).

Australian production forecast to rise over the outlook period

Australian production is now expected to rise over the outlook period, from 217,000 tonnes of LCE in 2020–21 to 328,000 tonnes of LCE in 2021–22 and 373,000 tonnes of LCE in 2022–23. Correspondingly, spodumene concentrate exports are forecast to increase from 1.7 million tonnes in 2020–21 to 2.5 million tonnes in 2022–23 (Figure 15.7).

Price appreciation induced production increases

Australian spodumene concentrate output in the September quarter 2021 rose by 35% quarter-on-quarter (39% year-on-year) to 79,000 tonnes of LCE. Output is rising in response to surging spot prices.

Contract prices can be expected to rise in the wake of the spot prices, which should boost production at operations using long-term contracts.

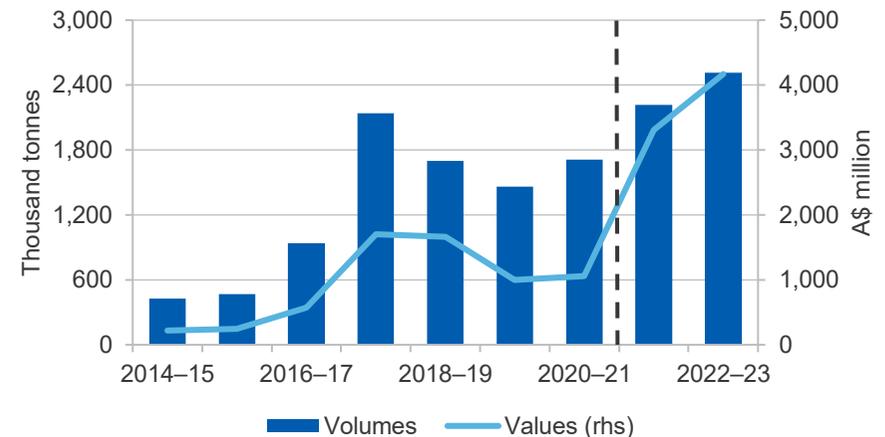
Pilbara Minerals production increased by 11% in the September quarter 2021 to 85,800 tonnes of spodumene concentrate. The Ngungaji plant (the old Altura plant) has now restarted, while the Pilgan plant has undergone modifications designed to debottleneck and enhance production. According to the company, 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 — may take place in early 2022.

A date has not yet been foreshadowed for the Phase 2 expansion, which would boost production by 320,000 tonnes a year. Production at the combined site is due to ramp up from around 380,000 tonnes a year to around 580,000 tonnes a year by mid-2022, before the Phase 1 and 2 expansions. The incremental production, to be processed through the Ngungaji plant, is not yet committed in contract. Pilbara Minerals stated that ore reserves on Pilgangoora increased by 54%, due to the discovery of new pegmatite domains as well as the tonnages acquired as a part of the Altura transaction.

Production from Mt Marion (owned 50% by Mineral Resources and 50% by Gangfeng Lithium Co. Limited) totalled 100,000 tonnes of spodumene concentrate in the September quarter 2021. Production at Orocobre's Mt Cattlin mine increased by 7.3% quarter-on-quarter to 68,000 tonnes of spodumene concentrate. The price achieved was US\$779 a tonne, with contract pricing for next year under negotiation.

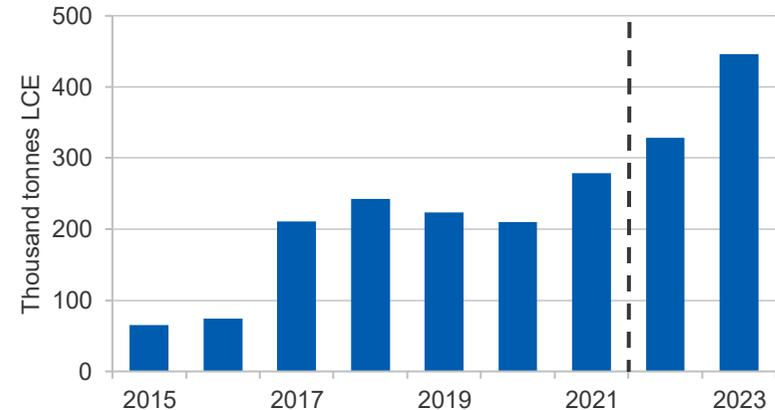
The Greenbushes mine — operated by the Talison Joint Venture — had estimated production of 40,000 tonnes of LCE in the September quarter 2021. Greenbushes commissioned their second chemical plant (CGP2) to produce 160,000 tonnes a year of LCE in total (i.e. approximately 1 million tonnes a year of spodumene concentrate) with the contract for design and engineering the third chemical grade plant (CGP3) awarded to Lycopodium.

Figure 15.7: Australia's exports of spodumene concentrate



Notes: Income figures include lithium hydroxide and spodumene volumes contain hydroxide.
Source: Company reports; Roskill (2021); Department of Industry, Science, Energy and Resources (2021).

Figure 15.8: Australia's spodumene concentrate production



Notes: Lithium hydroxide is not included.
Source: Company reports; Roskill (2021); Department of Industry, Science, Energy and Resources (2021).

The sell-down by Tianqi to ASX-listed Independence Group included a 49% interest in the Kwinana lithium refinery. The Kwinana refinery processed its first lithium hydroxide in October, and is ramping up production to capacity of circa 24,000 tonnes a year.

Lithium hydroxide produced in Australia, Korea and Japan

Production commenced at Train I of Tianqi’s Kwinana lithium hydroxide refinery (51% Tianqi and 49% ASX-listed Independence Group). Battery grade product is expected in the March quarter 2022, with ramp up to 24,000 tonnes a year by the end of 2022. Train 2 — 24,000 tonnes a year as well — is currently due to start production in 2024.

Finalisation of construction is underway at Kemerton’s Stage I for 25,000 tonnes a year of lithium hydroxide (60% US-based Albemarle and 40% ASX-listed Mineral Resources). 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. Albemarle plans for Kemerton to initially source spodumene concentrate from Greenbushes. By 2023, Australia may have around 9% of global lithium hydroxide refining capacity and potentially reach 19% of global lithium refining by 2026 (Figure 15.9).

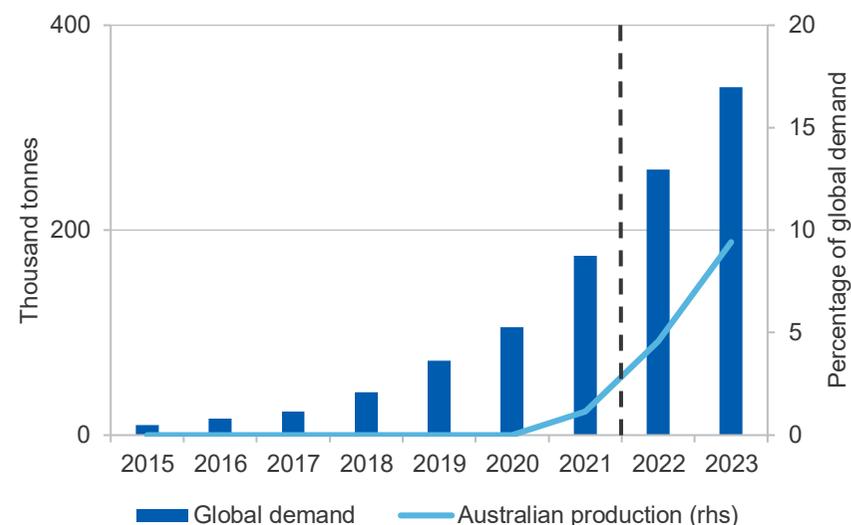
ASX-listed Pilbara Minerals have finalised their joint venture agreement with POSCO for the production of 43,000 tonnes a year of refined lithium hydroxide to be produced in South Korea. The joint venture plans to source 315,000 tonnes a year of spodumene concentrate from the Pilgangoora operations, based on existing production capacity.

Construction of the Kwinana lithium hydroxide refinery (50% ASX-listed Wesfarmers and 50% Chile-based SQM) continues. The refinery will source spodumene from the Mt Holland deposit. According to the joint venture partners, the refinery is expected to begin operating in 2024. Mt Holland is initially expected to produce 400,000 tonnes a year of spodumene concentrate.

ASX-listed Orocobre is in the process of completing construction of their Naraha plant in Japan. The company plans to convert lithium carbonate into lithium hydroxide using feedstock from their operations in Argentina. Pre-commissioning works are underway, according to the company.

The branching out of Australian companies into Japan and Korea for the production of lithium hydroxide, as well as production in Australia, shows Australian companies are eager to grasp the available opportunities from the current shift in the market towards low emissions technologies.

Figure 15.9: World and Australian lithium hydroxide output



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

Project development in Australia

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 production facilities, at 250,000 tonnes a year of spodumene concentrate.

A detailed feasibility study on Liontown's Kathleen Valley deposit near Kalgoorlie is due for completion in late 2021, with the company suggesting production in 2024 at 50,000 tonnes a year (LCE). The company is working on compressing its development timetable. The deposit is similar to that of Mt Holland.

Core Lithium have made an FID on the development of its Finiss deposit near Darwin. A scoping study is underway on extending the mine life, as well as creating a fine grained lithium product from the tailings, in order to maximise revenue from the project. The company has stated that it plans to start production in 2022. Recent equity raising and offtake agreements have the project fully funded to commence construction. Production could commence from late 2022 to early 2023. Investigations are also underway on the potential for an associated lithium hydroxide refinery. Gangfeng and Yahua have offtake agreements for 80% of the first 4 years of production.

Value-adding in Australia

Australian companies are branching out along 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. There is also production of electric trucks for underground mine use. The supply chain is not fully integrated as yet, but clearly demonstrates Australian companies' willingness to engage in the opportunities at hand (Tables 15.1 and 15.2, Figure 15.10).

Revisions to the outlook

Forecast exports in 2021–22 have been revised slightly — from \$3.4 billion to \$3.3 billion — allowing for the timing of contract roll-over with higher prices. Export earnings in 2022–23 have been revised up from \$3.8 billion to \$4.2 billion (up 8.8%), again reflecting the very strong gains in the spodumene price to roll through on the contract pricing front.

Box 15.1: Lithium value-adding in Australia - Li-S Energy ASX Debut

Li-S Energy made its debut on the ASX in late September 2021. The company is developing lithium sulphur batteries. These type of batteries have an energy density around five times higher than normal lithium-ion batteries. These batteries have suffered from 'degradation' in the past, which has made them impractical for commercial applications. However, Li-S Energy appears to have solved the degradation issues using boron nitrate nanotubes. According to the company, their battery technology allows for around 1,000 cycles of discharge/recharge — similar to commercial lithium-ion batteries — but has higher energy density, which may lead to a longer driving distance.

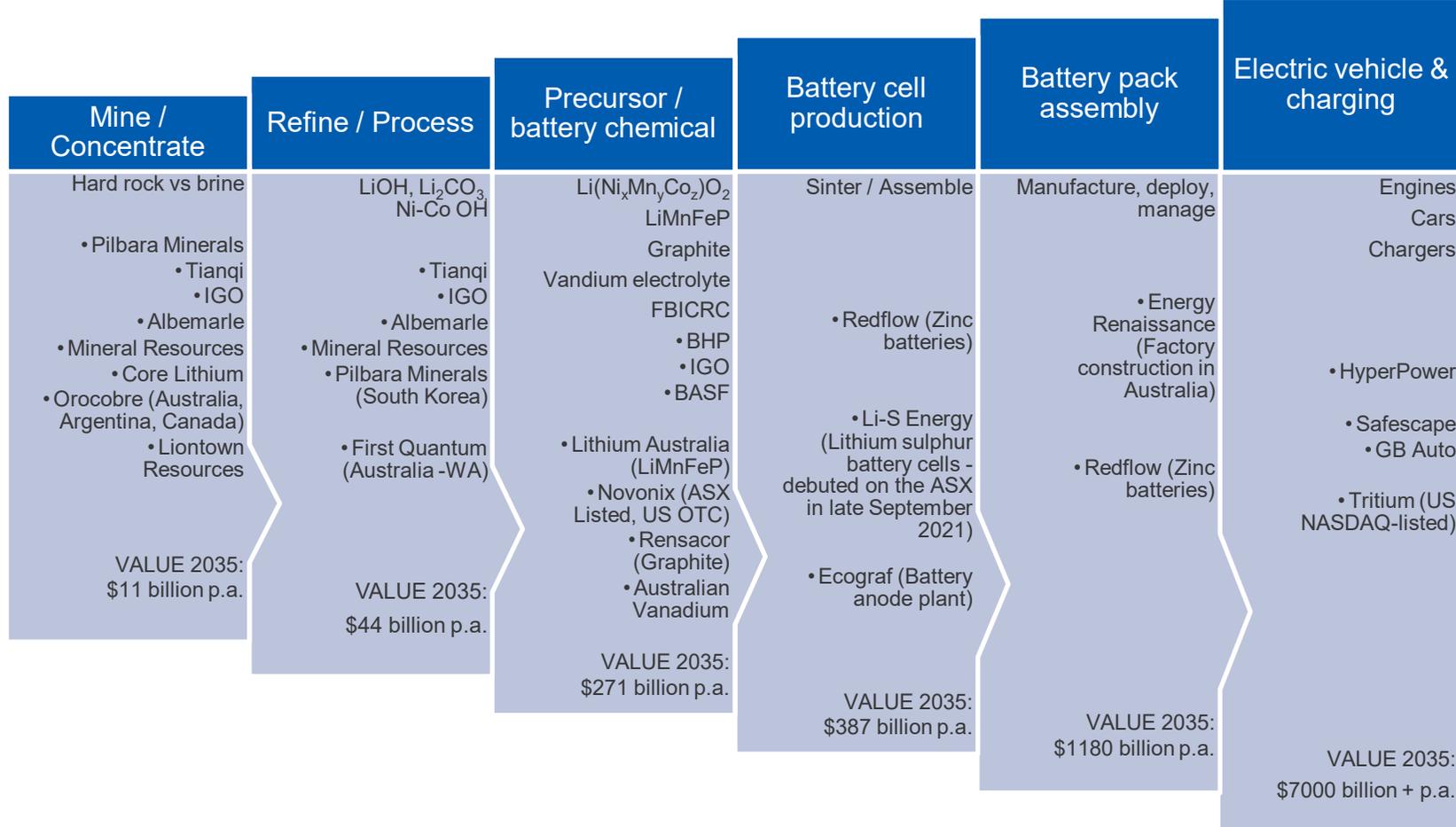
The company has been conducting its research in conjunction with Deakin University in Geelong and is being assisted towards commercialisation by PPK Group Limited — a Queensland based company — which specialises in battery and mining technology.

They have also developed a nano-mesh to fix the 'dendrite' problem in batteries — a problem which affects numerous battery types, leading to fires when the dendrites pierce the cell membranes. Single layer cells have been tested, and multilayer cell testing is underway, with a pilot plant in the planning stage.

Li-S Energy has entered into a collaborative agreement with Janus Electric (Janus). Janus have developed a proprietary system for converting diesel prime movers to battery powered via battery change over, multiparty battery ownership, charging network and custom software. Subject to further agreement Janus may acquire almost 500,000 battery cells by 2023.

Source: Company reports (2021); <https://www.aumanufacturing.com.au/li-s-energy-to-supply-novel-batteries-for-janus-electric-trucks> (2021); <https://www.abc.net.au/radio/brisbane/programs/drive/energy-asx/13561938> (2021)

Figure 15.10: 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: Australian companies: value-adding lithium (chemical refining and batteries)

Company Name	Main Exchange	Country of development opportunity	Commentary
Chemical refining and new 'brands' of lithium			
Mineral Resources	ASX	Australia	Albemarle is in the process of commissioning/completing construction of the Kemerton lithium refinery. Mineral Resources Limited has a 40% share in the operation. Construction is due for completion in 2022 / 2023.
Independence Group	ASX	Australia	Independence Group has purchased a 24.99% share in Greenbushes and a 49% share in its associated Kwinana lithium refinery. The Kwinana lithium refinery started producing lithium hydroxide in August 2021.
Wesfarmers	ASX	Australia	Mt Holland and its associated Kwinana–Covalent lithium refinery for lithium hydroxide production in Australia in conjunction with partner, SQM. Production may commence in 2024.
Pilbara Metals	ASX	Korea	Pilbara Minerals has entered a joint venture with POSCO to refine 43,000 tonnes a year of lithium hydroxide, to be produced in South Korea.
Lake Resources	ASX	Argentina	Feasibility studies are ongoing for the Kachi deposit, and finance is well advanced for development.
Battery components & battery manufacture			
Novonix	ASX	United States	Novonix is developing its anode graphite technology in the US. Phillips 66 (A spin-off of Conoco Phillips) has taken a strategic stake in the company.
Energy Renaissance	Private	Australia	Construction has commenced on a lithium battery production facility just outside of Newcastle – due for completion in 2021. The factory is designed to produce lithium batteries for hot Australian conditions.
Li-S Energy	ASX	Australia	Li-S Energy debuted on the ASX in late September 2021. It focuses on the commercialisation of lithium sulphur batteries with very high energy densities via boron nitrate nano-tubes, as well as solving battery issues such as fire caused by dendrites penetrating cell membranes using nano-mesh. It is currently planning a pilot plant to further test these developments. It has a collaborative agreement with Janus Electric, who specialise in converting prime movers from diesel to battery power.

Source: Company reports (2021).

Table 15.2: Australian companies: value-adding lithium (recycling, research and manufacturing)

Company Name	Main Exchange	Country of development opportunity	Commentary
Lithium batteries and recycling			
Lithium Australia	ASX	Global	The company is developing lithium recycling and examining lithium iron phosphate (LFP) battery manufacturing with the addition of manganese to improve battery performance. A patent application for the manufacture of LFP cathode powder has been accepted. An application has been lodged for a grant under the Modern Manufacturing Initiative.
Neometals	ASX	Germany and India	A shredding demonstration plant has been successfully commissioned. A demonstration hydrometallurgy plant is in the process of commissioning. Scale up options are being examined due to high demand.
Electric vehicles, charging infrastructure			
Tritium	Private	Global	Tritium became the first company in the world to implement ISO15118, allowing electric cars and charging equipment to communicate and transact seamlessly via the charging cable. Tritium is now NASDAQ-listed.
GB Auto	Private	Australia	Conversion kits for mine trucks are to become electric, including Toyota Land Cruisers and Toyota Hilux trucks.
HyperPower	Private	Global	The company is working on production of motors for electric transport, via vehicle or rail, capable of speeds of over 600 kilometres per hour. It is scaling up production and iterative engineering to evaluate industrial and commercial end-uses. They are also assessing mining applications.
Safescape	Private	Australia	The company is developing mine-specification heavy duty 4WDs through its Bortana EV range. Independence Group has successfully trialled the vehicles in its underground Nova nickel operation.
Battery industries research and development			
Future Batteries Industry CRC	Government	Global	The Future Batteries Industry CRC is Australia's largest battery industry R&D collaboration, which aims to help leverage Australia's traditional competitive advantages downstream in the global battery value chain and support the development of new battery storage systems. The German company, BASF, is now part of the sponsorship of the cathode precursor pilot plant. Trials are scheduled out to 2024 with continuous manufacture, similar in style to that being undertaken by BASF in Europe.

Source: Company reports and websites (2021).

Table 15.3: Lithium Outlook

World	Unit	2020	2021 ^s	2022 ^f	2023 ^f	Annual percentage change		
						2021 ^s	2022 ^f	2023 ^f
Lithium production ^a	kt	464	485	615	821	4.7	27	33
Demand ^b	kt	305	486	573	724	60	17.8	26
Stocks ^c	kt	122	114	124	175	-	6.3	41
– weeks of consumption		20.7	12.2	11.3	12.6	-	41	- 7.2 11.2
Spodumene price								
– nominal	US\$/t	420	719	1,185	992	71	65	- 16.2
– real ^d	US\$/t	435	719	1,145	934	65	59	- 18.4
Lithium hydroxide price								
– nominal	US\$/t	7,303	17,137	23,804	18,943	135	39	- 20
– real ^d	US\$/t	7,571	17,137	23,009	17,835	126	34	- 22
Australia	Unit	2019–20	2020–21	2021–22 ^f	2022–23 ^f	2020–21	2021–22 ^f	2022–23 ^f
Mine production ^a	kt	216	217	328	373	0.4	51	13.5
Spodumene export volume ^e	kt	1,460	1,714	2,215	2,515	17.4	29	13.5
Export value								
– nominal value ^g	A\$m	999	1,054	3,308	4,170	5.6	213	26
– real value ^h	A\$m	1,039	1,080	3,308	4,082	3.9	206	23

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** Stockpile estimates — difficult to estimate, calculated after losses from refining, and allowing for lead time in battery manufacturing; **d** In 2021 US dollars; **e** Spodumene concentrates — mostly 6 per cent Li₂O concentrate. Stockpiles run down in 2019–20; **f** Forecast; **g** Revenue from spodumene concentrate as well as lithium hydroxide; **h** In 2021–22 Australian dollars; **s** Estimate.

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