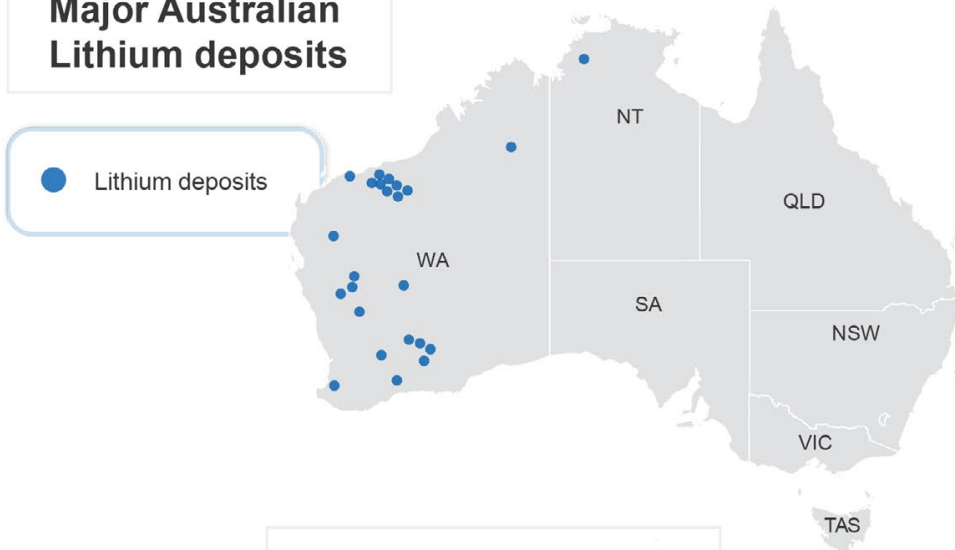


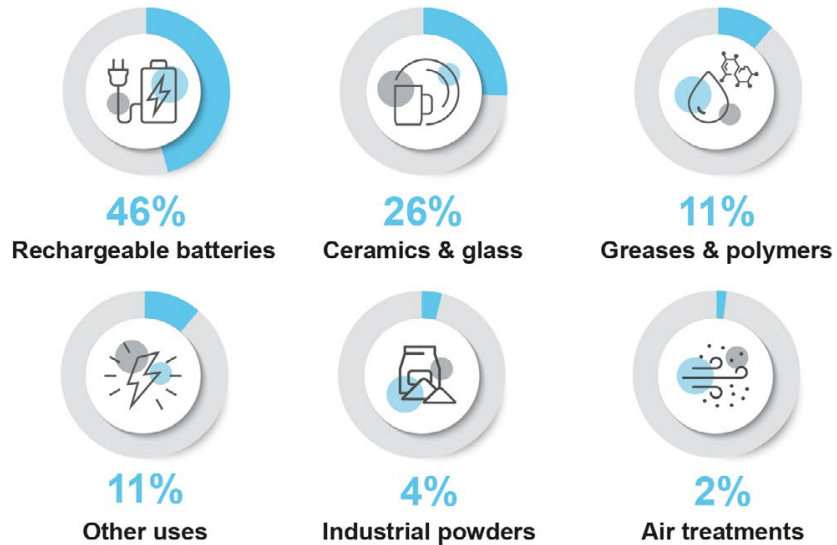


Lithium

Major Australian Lithium deposits



World consumption



Lithium facts



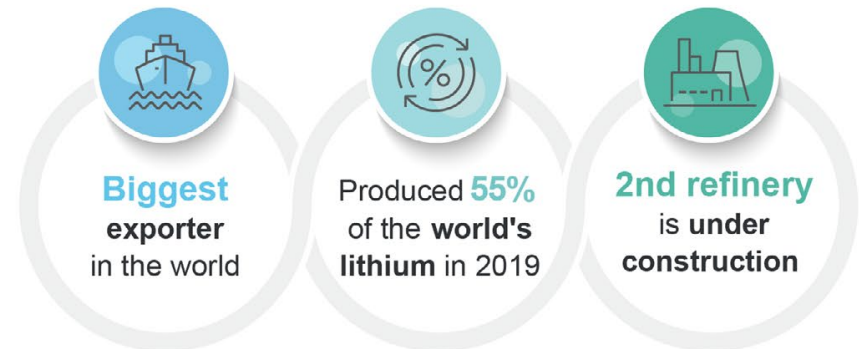
Electric vehicle sales are expected to increase from 2m to 26m by 2030

Lithium exports were A\$1.1b in 2019-20

Australian lithium exports are tipped to rise to 1.6m tonnes in 2021-22

Australia's production of lithium is recovering from a downturn

Australia's lithium



15.1 Summary

- The spot spodumene price (delivered to China) increased by 0.2 per cent to US\$392 a tonne between September and November 2020. Prices are forecast to rise to US\$510 a tonne by 2022, based on rising electric vehicle uptake and ‘green’ government stimulus packages in response to the COVID-19 pandemic.
- Australian lithium production is expected to rise from 233,000 tonnes (lithium carbonate equivalent) in 2019–20 to 277,000 tonnes in 2021–22, based on production tied to offtake agreements (see [Australia section](#)).
- After falling from \$1.1 billion in 2019–20 to \$1.0 billion in 2020–21, Australian lithium export earnings are forecast to increase to \$1.3 billion by 2021–22.

15.2 Prices

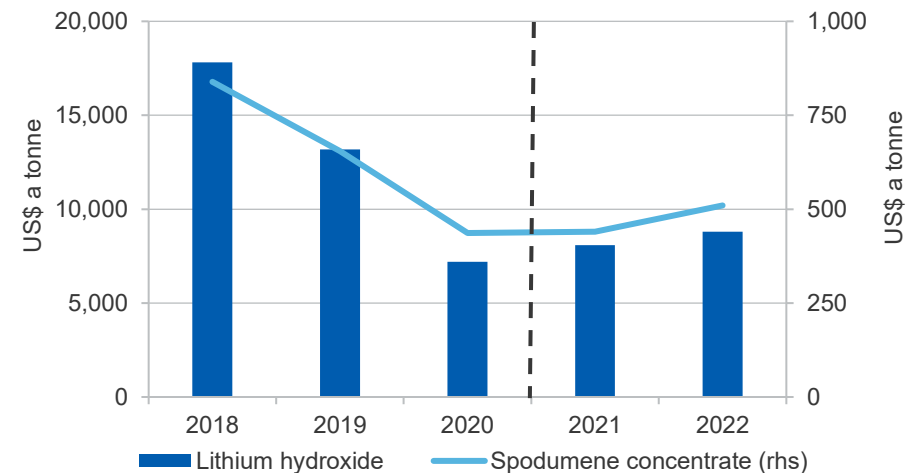
Lithium prices stabilised in the three months to November 2020

The lithium carbonate price (delivered to China) was US\$6,400 a tonne at the end of November — up 1.6 per cent over three months, but down 27 per cent year-on-year. This compares with price falls — off a higher base — in Europe of 7.7 per cent for the same period and 41 per cent year-on-year (delivered to Europe). Although European prices ended at around US\$6,000 a tonne; lower than China.

Lithium hydroxide prices (delivered to China) declined by 0.5 per cent to US\$6,992 a tonne between September and November, and fell by 14 per cent year-on-year. This compared with a price decline of 3.9 per cent into Europe for the same period and 30 per cent year-on-year (to US\$8,050 a tonne, delivered). Lithium carbonate prices improved before lithium hydroxide, suggesting lithium iron phosphate (LFP) batteries have preference in production due to cost and flammability advantages.

Spodumene prices (delivered to China) increased by 0.5 per cent to US\$392 a tonne from September to November, but declined 25 per cent year-on-year. Spodumene prices are expected to increase in 2021 and 2022, with ‘green’ government stimulus packages and electric vehicle manufacturers continuing to expand production (Figure 15.1).

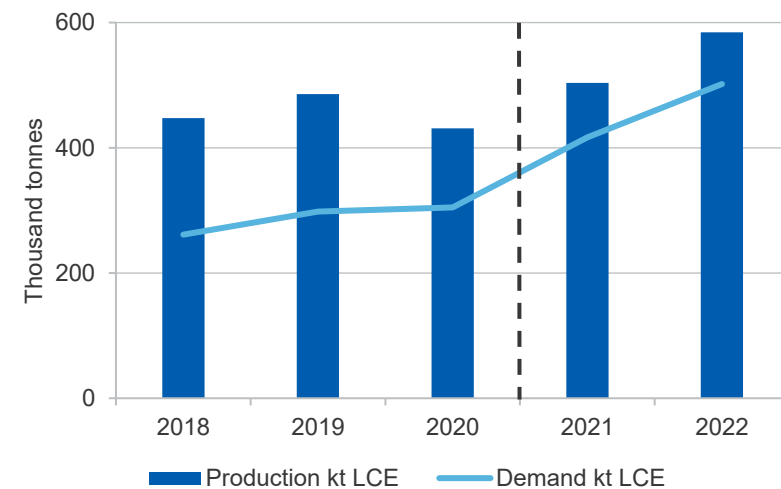
Figure 15.1: Prices of spodumene concentrate and lithium hydroxide



Notes: Lithium hydroxide price is for lower priced technical grade

Source: Roskill (2020); Brokers (2020); Department of Industry, Science, Energy and Resources (2020)

Figure 15.2: World lithium production and demand



Source: Roskill (2020); BloombergNEF (2020); Department of Industry, Science, Energy and Resources (2020)

15.3 World demand

Demand increasing for lithium carbonate as LFP batteries increase in use

World demand for lithium is estimated to have increased to 305,000 tonnes lithium carbonate equivalent (LCE) in 2020, up from 298,000 tonnes in 2019 (Table 15.1). Demand is forecast at 417,000 tonnes in 2021, increasing 20 per cent to 502,000 tonnes by 2022 (Figure 15.2). The increase in 2021 demand is based on 'green' stimulus packages to raise economic growth following the COVID-19 pandemic. It is worth noting that demand is usually ahead of consumption by approximately 12 months, due to the lead times required in battery manufacturing. This lead time may get shorter in the future, as production is streamlined.

The largest market for lithium carbonate is China. Lithium carbonate imports were up 54 per cent month-on-month and 73 per cent year-on-year in the nine months to September 2020. Higher imports led to a firming in the market for lithium carbonate — decreasing the need for lithium hydroxide — as LFP batteries became the preferred option for lower driving range models in China. This was due to their low cost and lower flammability. At this stage, LFP batteries can only be made in China, with patents due to start expiring in 2022. This has implications for demand for Australia's spodumene, which is primarily geared towards the lithium hydroxide market — with South America geared primarily towards the lithium carbonate market.

Despite changing market dynamics, lithium hydroxide exports from China were up 35 per cent month-on-month and up 14 per cent in the year to September. Exports were driven by strong demand for longer range electric vehicles. The changing demand pattern is eroding the premium that lithium hydroxide traditionally holds over lithium carbonate — of around US\$1500 a tonne — due to the cost of converting carbonate to hydroxide. The price difference between lithium carbonate and lithium hydroxide in Europe is currently around US\$2000 a tonne, but is now only around US\$700 a tonne in China.

South Korea is a very important market for lithium hydroxide, due to its refineries and its battery makers. Imports of lithium carbonate for conversion into lithium hydroxide or for use in LFP batteries were back to previous levels with no net change for the September 2020 quarter compared to the September 2019 quarter. The return to 'normal' trading is despite a 36 per cent reduction in the nine months to September, reflecting disruption due to the COVID-19 pandemic. Japan showed more strength in the lithium hydroxide market — reflecting its concentration on the higher end markets for batteries — with imports up 94 per cent month-on-month in September 2020, after imports were down 13 per cent for the nine months to September 2020, compared to the previous corresponding period.

Lithium hydroxide: battery grade purity and volume – expertise required

Lithium hydroxide battery grade purity product is increasingly being supplied from China instead of Chile. Value-adding countries — such as Chile — are not gaining the same momentum as China, due to product purity and availability issues. Expertise in China includes Albemarle's Chinese operations. However, outside of China, expertise in the production of lithium hydroxide has yet to fully mature. This includes Albemarle's Chilean operations, as well as its proposed Australian operation at Kemerton. Australia could reach 4 per cent of world production in lithium hydroxide in 2022, if the ramp up of operations proceeds steadily.

Strong market appetites for electric vehicles

Price points for electric vehicles are becoming more competitive relative to the internal combustion engine (ICE). China's adoption of LFP batteries for short commutes is playing into this dynamic. Additionally, flexible battery choice is being offered by Nio (based in China). This allows for low driving range batteries to be swapped out by the owner to higher performance units — potentially offering a better value proposition to customers who are unsure of which electric vehicle to purchase. Nio has established battery swapping stations in China, and the process is understood to take 'minutes' compared with longer charging times. Additionally, they have

also given customers the option of lower priced electric vehicles, with batteries as a subscription service instead of the upfront cost. Chinese electric vehicle manufacturers have also been experiencing significant share price appreciation as China's economy grows in 2020 (see *macroeconomic outlook* chapter).

Volkswagen released 8,000 ID4 electric 4WDs for sale in the US during the September quarter, priced at US\$32,500 after federal tax credits. The vehicles sold out in eight hours. The ID4 is the electric equivalent of the Tiguan 4WD. This comes on the back of California banning the sale of ICE's by 2035. Meanwhile the UK has brought forward its ban on ICE sales from 2040 to 2030. Hybrid vehicles with no emissions will still be allowed until 2035. In Australia, the ACT introduced zero interest loans of \$15,000 for private and not-for-profit electric vehicles as well as two years of free registration.

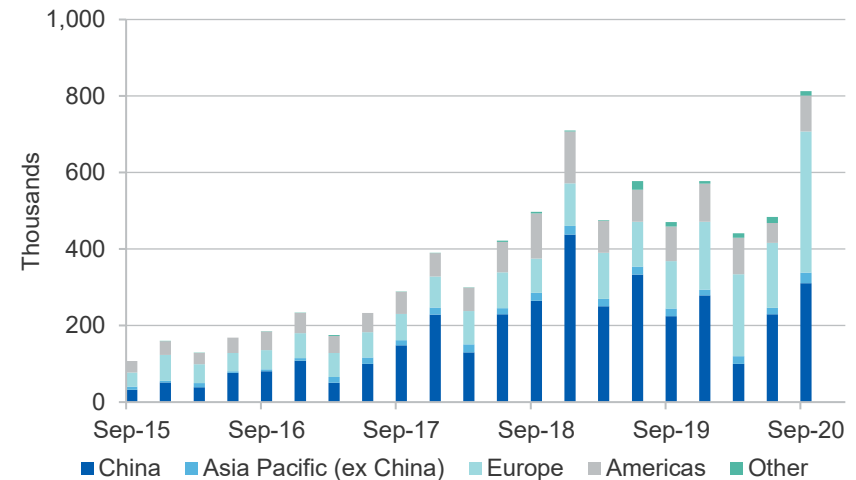
Start up 'Australian Clean Energy' is offering electric vans and utility trucks. Units are planned to be in available in late 2021 with online reservation available now. The price point of \$26,000 before on road costs makes them a potentially attractive entry point for Australian motorists. However, there are still a number of safety and regulatory hurdles to overcome before models are released.

Electric vehicle sales for September quarter 2020

World electric vehicle sales for the September quarter increased 68 per cent quarter-on-quarter, with China increasing 35 per cent (Figure 15.3). Sales in Europe increased by 117 per cent quarter-on-quarter. The European increase is largely driven by impending tighter emissions standards at the start of 2021. Sales were also strong elsewhere in Asia increasing beyond pre-COVID-19 levels, whilst sales in the US returned to pre-COVID-19 levels.

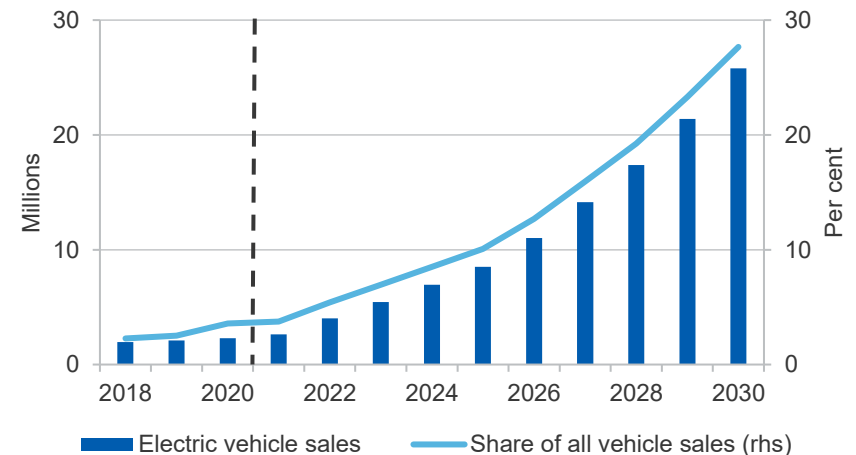
The overall strength of electric vehicle sales in 2020 (estimated at 2.3 million, up 17 per cent on the September quarter estimate) supports the expectation of increasing electric vehicle uptake over the long term — and therefore increasing lithium demand (Figure 15.4).

Figure 15.3: World electric vehicle sales



Source: BloombergNEF (2020)

Figure 15.4: Long-term electric vehicle sales projection



Source: Department of Industry, Science, Energy and Resources (2020); International Energy Agency (2020); BloombergNEF (2020)

Technological developments

Two key developments in battery technology are currently playing out: low technology with incremental improvements (i.e. lithium iron phosphate batteries with cell to pack technology to increase the driving range) versus new battery technology (i.e. Tesla's new 4680 battery, using nickel powders for longer driving range, backed up by continuous manufacturing instead of stepwise batch production) (see the *nickel* chapter).

Tesla's new battery technology was revealed on 'Battery Day' in October. While market responses were initially muted, battery partners Panasonic and LG now appear to be getting on board, with a potential scaling up of the new manufacturing processes. The benefits of the new battery technology include potentially lower costs, and significantly increased driving range. Claims for both parameters are currently at greater than 50 per cent improvement on each front. If it can perform on both fronts, it may be a significant rebuttal to the LFP argument for quick and cheap development at the expense of driving range. It is worth noting that Mercedes Benz have entry level electric vehicles that use LFP batteries, whilst those above entry level use the nickel-based lithium batteries.

In Indonesia, Contemporary Amperex Technology Limited (CATL), LG and Tesla are also considering setting up lithium battery supply chain projects. This might then connect with nickel and cobalt developments, via high pressure acid leach projects in Indonesia (due to start in 2021) — creating opportunities and challenges for Australia. Indonesia may capture the full value chain in electric car manufacture, from some mining inputs (nickel and cobalt) to batteries and then electric vehicles. India is also pursuing the full value chain for electric vehicles. Therefore, both India and Indonesia represent potential markets for Australia's lithium products.

European majors, Solvay and Veolia, have entered into partnership that examines the life cycle for electric car batteries. From 2025, recycling may be a key supply component. It is worth noting that LFP batteries also have simpler recycling pathways for lithium — in contrast to batteries containing nickel and cobalt, with these more valuable metals recovered at the expense of the cheaper lithium.

15.4 World production

Security of supply being sought as world production lifts

World production in 2020 has been stronger than anticipated, driven by increasing electric vehicle demand. In 2020, output is estimated at 431,000 tonnes LCE, down from 486,000 tonnes in 2019. Production is forecast at 503,000 tonnes in 2021, and at 585,000 tonnes by 2022. Production has been less affected than anticipated by the COVID-19 pandemic, as major producing countries have been able to maintain healthy work sites. Disruptions were experienced at some smaller operations in Argentina in the early stages of the pandemic — due to safety concerns — but most operations have resumed. Most disruption has taken place in the active development or expansion stage of the projects, due to logistical constraints imposed by the COVID-19 pandemic.

'Green' stimulus packages and tightening emissions standards in Europe, coupled with supply chain disruption due to the COVID-19 pandemic, is changing the nature of a previously oversupplied market. Consequently the gap between supply and demand is narrowing. Stockpiles still exist but they are difficult to determine at this time and offtake agreements continue to be signed, suggesting an eagerness to gain secure access to production. Additional offtake agreements in the September 2020 quarter include production from Australian spodumene producer Galaxy Resources, after multiple agreements were signed in the June 2020 quarter with a number of Australian producers.

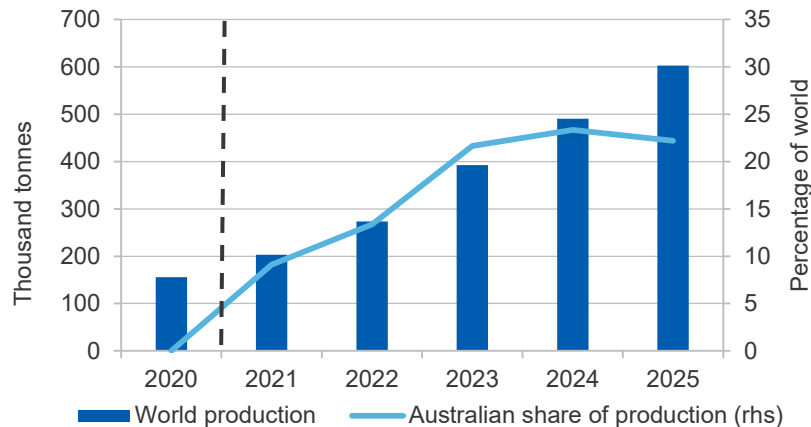
Outlook positive if battery grade lithium products produced

The outlook for the demand for battery grade lithium carbonate and lithium hydroxide remains positive. Production is increasing on both fronts, but challenges in obtaining reliable quality and quantities of battery grade lithium hydroxide are driving some countries to reprocess lithium carbonate into battery grade lithium hydroxide. The market for battery grade chemicals is strongly affected by battery technology trends. LFP batteries and nickel manganese cobalt (NMC) batteries often use lithium carbonate for their production. High end, high purity nickel-based lithium batteries tend to use lithium hydroxide. This represents an opportunity for

Australia — as it begins to ramp up its lithium hydroxide refineries — as well as an opportunity for its nickel (see the *nickel* chapter).

In Australia, the value-adding of spodumene into lithium hydroxide might come at an opportune time — with respect to possible world supply changes — if sufficient quality production can be established (Figure 15.5).

Figure 15.5: World lithium hydroxide production



Source: BNEF (2020); Department of Industry, Science, Energy and Resources (2020)

Project development

As market conditions improve, expansion plans of Chilean lithium carbonate producer, Sociedad Química y Minera de Chile (SQM) are moving forward. SQM plans to spend US\$1.3 billion expanding lithium carbonate production to 180,000 tonnes per annum and lithium hydroxide production to 30,000 tonnes per annum by 2023. Albemarle-led expansions at La Negra III and IV in Chile could also occur in 2021–22. This could place pressure on Australian miners, as they seek to respond to changing market conditions. Production from Livent and Orocobre in Argentina is likely declined in 2020, due COVID-19 pandemic disruptions.

In Chile, state-owned Corporación Nacional del Cobre de Chile (CODELCO) has started going down the lithium development path, although CODELCO has yet to be granted a quota for lithium extraction.

The entry of CODELCO highlights the importance of lithium production, despite the environmental challenges in the Atacama region. These challenges are being addressed on a number of fronts, with water efficiency measures and potential new processing techniques. SQM is to cut water use by 50 per cent by 2030. The Chilean government is also in dispute with Albemarle over royalties, which have declined as a result of falls in the price of lithium products. Production of lithium elsewhere in Chile is currently limited by the state to production by SQM and Albemarle.

In Argentina, development is more market based with less direct control limiting the number of companies. Development by ASX listed Galaxy Resources of the Sal da Vida deposit in Argentina continues with FEED and pilot plant work, targeting production in late 2022. Production by ASX listed Orocobre, at their Argentinian Olaroz lithium facility, was down 6 per cent due to planned shutdown but operations in country are still being hampered by the COVID-19 pandemic. A stage 2 expansion is underway.

Water efficient direct lithium extraction (DLE) by US based Lilac Solutions is being further trialled by ASX listed Lake Resources in Argentina, in order to advance its Kachi project. Samples produced thus far are of battery grade quality lithium carbonate. Gangfeng lithium has increased its stake in the Sonora project in Mexico to 50 per cent, with production scheduled to commence in 2023. Gangfeng has agreements to supply lithium to Tesla. ASX listed Vulcan Resources obtained additional EU funding after its successful capital raising in Australia. It is now advancing the prefeasibility studies on its zero carbon lithium project in Germany.

Despite challenging conditions in the spodumene market, the mothballed Whabouchi project in Quebec is being refinanced by creditors in conjunction with Pallinhurst Group. Elsewhere in North America, ASX listed Piedmont Lithium concluded a spodumene supply agreement with Tesla for product from their North Carolina deposit. They are currently completing bench-scale test work on conversion of the spodumene into lithium hydroxide. A feasibility study was also completed on the Goulamina deposit in Mali, with planned production of over 400,000 tonnes per annum of spodumene, further adding to potential supply in the medium term.

15.5 Australia

Exports forecast to recover

Exports of lithium were around \$1.1 billion in 2019–20. Subdued spodumene prices may see revenue fall to \$1.0 billion in 2020–21, despite possible production from lithium hydroxide refineries. However, increased production — due to new offtake agreements and firming prices — is forecast to raise lithium export earnings to \$1.3 billion by 2021–22.

Production has started to increase

Weak prices have continued to weigh on producers, with Altura Mining going into receivership. A number of other producers are lining up to take over its operations. Australia's short to medium term production profile will largely depend on whether the acquisition of Altura's Pilgangoora operation is used as a substitute for a more capital-intensive expansion. If it is used as a substitute, the net result will be a reduction in the short to medium term production of spodumene in Australia. The transaction may crystallise in the March quarter 2021.

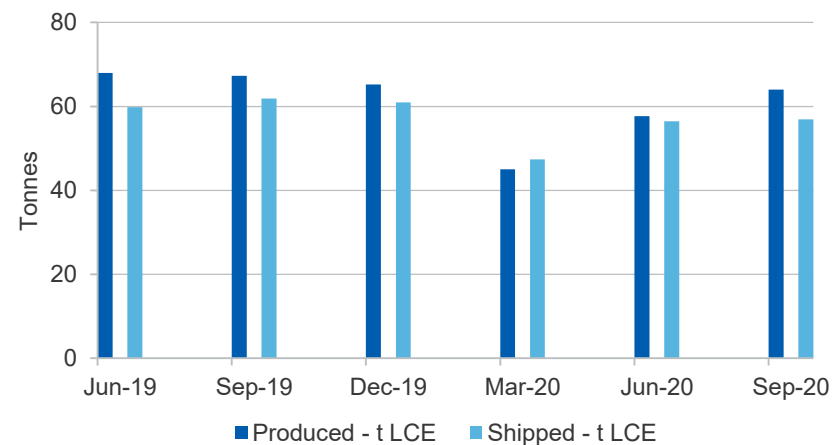
In the September quarter 2020, spodumene output continued to rise, up an estimated 11 per cent quarter-on-quarter. An estimated 64,000 tonnes LCE was produced, with strong performance by a number of miners. Shipments rose by 0.7 per cent quarter-on-quarter, after the previous record quarter to 57,000 tonnes LCE — when inventory was drawn down significantly (Figure 15.6). Inventory levels of concentrate are difficult to forecast at this time, given potential operational changes — as a result of corporate activity regarding the potential sale of Altura.

Pilbara Minerals exceeded its September quarter guidance of 40,000 tonnes, producing 62,000 tonnes of spodumene from its Pilgangoora mine in WA. Sales were 44,000 tonnes of spodumene. Meanwhile, production from the Mt Marion mine in WA grew from 116,000 tonnes to 133,000 tonnes. Elsewhere in WA, production at Mt Cattlin and Pilgangoora (Altura) was steady. However, a new offtake agreement between Galaxy and Chengxin — for 60,000 tonnes per annum of spodumene concentrate over the next three years — could see

production at Mt Cattlin expand significantly if full entitlements are purchased.

Quotation of costs has been sparse, with some producers at over US\$400 a tonne of spodumene. Pilbara Minerals achieved a production cost of US\$355 a tonne (CIF China), similar to its June 2020 quarter. The company is still targeting US\$320-350 a tonnes when fully operational. Capacity utilisation by Pilbara Minerals was 70-75 per cent in the September quarter.

Figure 15.6: Australian spodumene concentrate - quarterly production and exports



Source: Company reports; Roskill (2020); Department of Industry, Science, Energy and Resources (2020)

Australian production forecast to rise over the outlook period

Australian production is now expected to rise over the outlook period. Output is forecast at 277,000 tonnes LCE in 2021–22, driven by anticipated price appreciation (due to rising electric vehicle demand). Spodumene exports are forecast to increase from 1.5 million tonnes in 2019–20 to 1.9 million tonnes in 2021–22 (Figure 15.7).

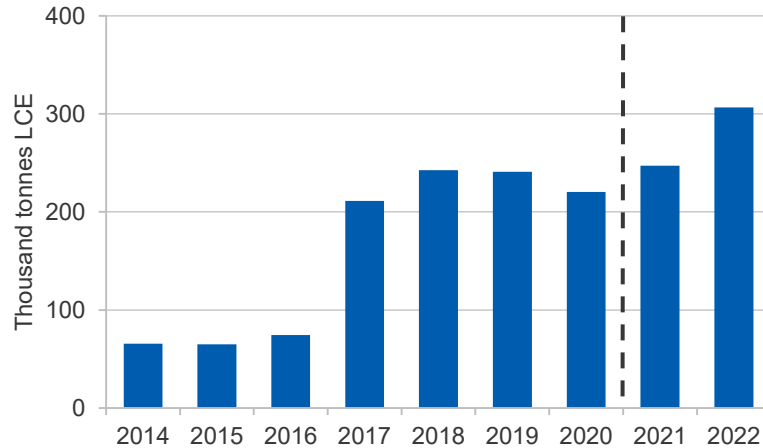
Lithium hydroxide production is still mooted in 2021–22 for both Kwinana and Kemerton. A financial investment decision is also possible on Mt Holland (owned by SQM and Wesfarmers) with its associated lithium hydroxide plant, also at Kwinana. However, a cautious approach is likely, given the difficulties in ramping up.

Revisions to the forecast

No changes in forecast export revenue from lithium have been recorded for the December quarter 2020. Upside risk, due to ‘green’ stimulus packages is noted, but is tempered by the changing nature of demand from lithium hydroxide to lithium carbonate — as a result of rising demand for LFP batteries (Figure 15.8).

World production in 2020 has been stronger than anticipated, with an estimated 431,000 tonnes LCE in 2020, compared with the previous forecasts of 373,000 tonnes.

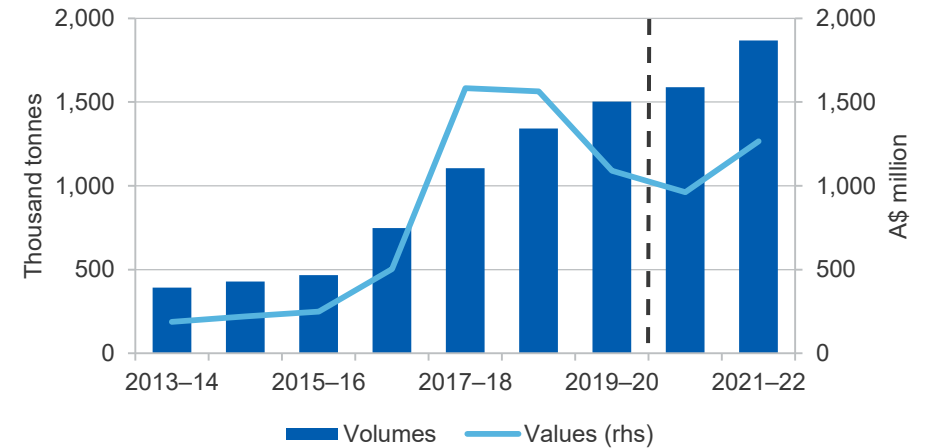
Figure 15.7: Australian spodumene concentrate production



Notes: Lithium hydroxide is not included.

Source: Company reports; Roskill (2020); Department of Industry, Science, Energy and Resources (2020)

Figure 15.8: Australian spodumene concentrate exports



Notes: Income figures include lithium hydroxide and spodumene volumes contain hydroxide.

Source: Company reports; Roskill (2020); Department of Industry, Science, Energy and Resources (2020)

Table 15.1: Lithium Outlook

World	Unit	2019	2020 ^s	2021 ^f	2022 ^f	Annual percentage change		
						2020 ^s	2021 ^f	2022 ^f
Lithium production ^a	kt	486	431	503	585	-11.2	16.7	16.1
Demand ^b	kt	298	305	417	502	2.3	36.6	20.5
Stocks ^c	kt	100	120	143	170	19.7	19.2	18.7
– weeks of consumption		17.5	20.5	17.9	17.6	17.0	-12.7	-1.5
Spodumene price								
– nominal	US\$/t	655	437	440	510	-33.4	0.8	15.9
– real ^d	US\$/t	663	437	431	490	-34.2	-1.2	13.5
Lithium hydroxide price								
– nominal	US\$/t	13,184	7,200	8,080	8,800	-45.4	12.2	8.9
– real ^d	US\$/t	13,353	7,200	7,922	8,450	-46.1	10.0	6.7
Australia	Unit	2018–19	2019–20 ^s	2020–21 ^f	2021–22 ^f	2019–20 ^s	2020–21 ^f	2021–22 ^f
Mine production ^a	kt	246	233	233	277	-5.3	-0.2	19.0
Spodumene export volume ^e	kt	1,343	1,503	1,589	1,868	12.0	5.7	17.6
– nominal value	A\$m	1,563	1,091	962	1,265	-30.2	-11.8	31.6
– real value ^g	A\$m	1,598	1,100	962	1,244	-31.2	-12.6	29.4

Notes: **a** Lithium Carbonate Equivalent: This is 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 possibly inaccurate due to increasing product purity specifications. Calculated from residual after losses from refining and allowing for lead time in battery manufacturing; **d** In 2020 US dollars; **e** Spodumene concentrates: 2018–19 products include direct ship ore, 4 per cent Li₂O concentrate and 6 per cent concentrate, thereafter mostly 6 per cent Li₂O concentrate, stockpiles run down in 2019–20; **f** Forecast; **g** In 2020–21 Australian dollars; **s** Estimate.

Source: ABS (2020) International Trade in Goods and Services, Australia, Cat. No. 5368.0; Company reports; Department of Industry, Science, Energy and Resources (2020); Roskill (2020); Government of Western Australia Department of Mines, Industry Regulation and Safety (2020)