australian venture CONSULTANTS PTY LTD

A case for building resilience into Western Australia's lithium industry

Chamber of Minerals and Energy and Association of Mining and Exploration Companies

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Executive Summary

A faltering Western Australian lithium industry?

The operational footprint of Western Australia's spodumene production and emerging lithium hydroxide manufacturing sectors spans the Perth metropolitan area, South West, Goldfields-Esperance and Pilbara Regions. Regarded by many as *fait accompli* and the basis for an inevitable domestic battery manufacturing industry only 18 months ago, millions of tonnes of spodumene concentrate capacity that has come on-stream only in the past several years and the State's yet to be commercialised lithium hydroxide manufacturing sector, despite an encouraging medium-term outlook, is now at a critical cross-roads facing some significant short-term challenges.

The absence of domestic upstream chemical manufacturing capacity would nullify any aspirations the State may have with respect to developing downstream lithium-ion battery manufacturing sectors.

The price of lithium (measured as Lithium Carbonate Equivalent) is currently four times below its 2017-18 peak and has been the subject of downward pressure for the past two years, with most forecasts expecting depressed conditions to continue for the next few years. These circumstances have arisen despite strong demand for lithium, which increased by 30 percent between 2018 and 2019.

Indeed, the medium-term outlook for the demand profile presents favourably for Western Australia's upstream industry. Demand for lithium-ion batteries across portable devices, energy storage systems (ESS) and particularly electric vehicles (EV) will continue to grow from 50 percent of lithium demand currently to over 80 percent in the next several years. Importantly for Western Australia, EVs will be the largest driver of demand in the battery sector, growing from just over 60 percent of battery derived demand for lithium currently to just under 90 percent in the next few years. Most importantly for Western Australia, the nickel-rich cathode chemistries should see demand for lithium hydroxide substantially outstrip demand for lithium carbonate. While ESS is also a growing source of derived demand, the fact that most applications do not require the same performance characteristics of EV batteries and there are competing technologies, it is a less certain source of derived demand.

These forecasts bear well for Western Australia's upstream industry, theoretically supporting demand that should underpin the development of an economically sustainable lithium hydroxide manufacturing industry and demand for spodumene concentrate as the preferred feedstock for manufacturing battery grade lithium hydroxide that is used in high performance batteries. Given Western Australia's global dominance as a supplier of spodumene concentrate, an analyst could be forgiven for attributing the current market circumstance as being a quintessential and predictable medium-term outcome in resources industries – when demand outstrips supply prices increase, leading to investment in new capital, but as a result of the lag in deploying capital, the market is inevitably over supplied with new capital continuing to come on stream, resulting in downward pressure on price.

However, in the case of the lithium industry, circumstances are more complex and relatively new to Western Australia's resources industry – demand is derived through a long and complex value chain, with significant, fickle and opaque foreign government policy intervention in the

market for the final product and at key stages of that value chain making predicting short-to-medium term demand for various lithium products difficult.

Status and Trends in final demand

As key components of the decarbonisation policies of foreign governments, EV markets globally are the subject of significant and unpredictable distortions that are the result of extensive, complex and fickle 'carrot-and-stick' policy intervention. Furthermore, government incentives and disincentives are the key factor in influencing consumer purchase decisions in the EV market, a paradigm that is likely to remain at least until electric vehicles reach price parity with internal combustion engine vehicles.

This is evident in the World's three largest EV markets – Peoples Republic of China (PRC), United States and European Union. Recent decreases and in some case removal of EV adoption subsidies across various layers of government in the PRC and decreases and threats of decreases in incentives in the United States have led to dramatic and immediate decreases in final product demand in these two key electric vehicle markets. On the other hand, continuing aggressive policy frameworks designed to drive adoption of EVs in the EU have resulted in significant growth of EV sales.

Combined with other factors discussed in subsequent sections of this report, the reduced demand from the world's two largest markets for EVs – PRC and United States – that is only partly offset by growing demand in the EU, is resulting in excess supply of lithium chemicals and the mineral and brine feedstock used in their manufacture.

Status and trends in supply of lithium mineral and brine concentrates

A majority of the World's lithium reserves remain concentrated in the brine-resources of the 'Lithium Triangle' on the borders of Bolivia, Argentina and Chile. There are significant resources of lithium carbonate that can be bought on stream from this region, but the full activation of these resources has for a long time been constrained by investment market perceptions of sovereign risk, particularly with respect to Bolivia and Argentina, but also more recently Chile, as well as notoriously protracted project development.

However, while constraining full development, these circumstances have far from halted investment in Latin American resources, with major global players such as SQM, Albemarle, Galaxy Resources Orocobre and Ganfeng Lithium continuing to invest in brine-based production in the Region, despite a more nationalised policy environment. Increased supply relating to these investments will likely enter the market from 2022 to 2025 onwards.

Despite a Presidential Order designed to, in part, encourage the development of domestic lithium resources, development of several brine projects in Nevada have made limited progress. Prospective developments in Canada have been rendered sub-economic in the current market and developments in Mexico have slowed, largely in response to current market conditions and COVID-19 restrictions.

While Western Australian spodumene production still accounts for the majority of raw material supply on a Lithium Carbonate Equivalent (LCE) basis, primarily as a result of curtailed domestic production, its global market share has declined from earlier peaks in 2017-18. The market share of Western Australian spodumene concentrate is the result of the rapid development and expansion of nine separate mining operations.

However, as a result of the current market conditions and the lack of predictability, Western Australian spodumene producers have been forced to take a range of drastic and immediate actions to preserve viability, that vary according to the technical, economic and offtake circumstances pertaining to the specific project. Across the nine Western Australian spodumene concentrate operations this has included renegotiating offtake agreements, refinancing, altering project development pathways and timeframes, delaying planned expansions, investing in process productivity optimisation, placing production into care-and-maintenance, and even continued escalation of production to drive down per unit costs and stockpile lower cost product.

Despite the immediate and in some cases drastic measures taken by Western Australian spodumene producers, the viability of the sector remains at significant risk in the short term. While medium-term price recovery will likely see a return to an expansionary phase, actions taken now will significantly impact how competitive the sector is with respect to new production capacity elsewhere when markets recover.

Status and trends in lithium chemical manufacturing

There has been a significant expansion in global lithium chemical manufacturing capacity, mostly in the PRC whose capacity has doubled since 2015 to 350,000 tonnes LCE, with some estimates suggesting even greater current capacity. While most of the chemical output is consumed by the PRC's extensive domestic battery manufacturing supply chain, the PRC has also recently become an exporter of both lithium carbonate and hydroxide.

As the result of both aggressive investment in the sector and delayed commissioning that is a function of current excess supply, there is also significant latent PRC lithium chemical manufacturing capacity in the pipeline, with some new capacity also expected to come on stream in the Republic of Korea (ROK) and Japan.

Of note, around three-quarters of new PRC capacity is focused on lithium hydroxide. This pivot toward lithium hydroxide production is in response to demand for nickel-rich cathode chemistries derived from electrical vehicle final demand and is the main driver of the extensive PRC conversion plant offtake footprint on Western Australian spodumene concentrate production. However, the dramatic decline in the lithium price over particularly the past 12 months has significantly decreased the portion of the cost of manufacturing lithium hydroxide that is attributable to the feedstock, potentially rendering the more costly process of producing lithium hydroxide from brine-sourced lithium carbonate a viable option.

The current global excess of lithium chemical manufacturing capacity has had a significant impact on Western Australia's emerging lithium hydroxide manufacturing sector. Widely touted as a certainty only 18 months ago, the commissioning of Stage 1 of Tianqi's Kwinana Plant has been delayed and investment in Stage 2 suspended, and the Albemarle-Mineral Resources Kemerton Plant has been reduced in scale with its development slowed. Other proposals for lithium hydroxide plants in Western Australia have not progressed to Final Investment Decision.

While there may be an argument to support hydroxide manufacture outside of PRC to avoid sovereign risk, Western Australian production is competing with other non-PRC locations that have competitive cost structures and are in closer proximity to established battery manufacturing supply chains. Furthermore, the industrial ecosystems in many of these jurisdictions further benefit from direct government support.

Regardless of any second-order elements of a case, it is difficult to see circumstances in the short-term that would support further investment in lithium hydroxide manufacturing capacity in Western Australia. The extent to which this occurs and indeed the competitiveness of existing committed investment will be to a large part dependent on actions taken by industry and government now.

Impact of COVID-19

The COVID-19 pandemic and government responses to it represent a disruption to global markets and industry that will be at least equivalent to the Global Financial Crisis and perhaps equal the Great Depression in severity.

While the full current and potential impact on the lithium-ion battery supply chain is as yet fully understood, there are three highly probable short-to-medium term impacts. Firstly, lower incomes and greater uncertainty will result in lower levels of consumer and business discretionary spending. This will reduce demand for EV's in the short-term, particularly higher performing EVs that are dependent on nickel rich battery chemistries, the mains source of derived demand for Western Australia's upstream lithium industry.

Secondly, while manufacturers along the supply chain will respond to lower levels of demand by reducing output, their productivity and ability to manufacture will be further hampered by a labour market that is constrained as a result of government 'lock-downs', as well as a need to lay-off and then re-hire staff. This will affect manufactures that are direct participants in the lithium-ion battery supply chain, as well as their suppliers and service providers around the globe. Importantly, the world's major battery and automotive manufacturing economies – PRC, United States EU are among those that have been most severely impacted by COVID-19 and had the most aggressive government lock-down responses.

Both reduced demand and constrained manufacturing capacity in the EV, particularly higher performing EV battery value chain will almost certainly contribute to lower levels of demand for Western Australian spodumene concentrate and lithium hydroxide in the short-to-medium term in market circumstances that are already characterised by excess capacity.

The third eventuality is less certain. As a function of simple economics, the decrease in demand for electricity that is the result of industry shutdown during COVID-19 is resulting in renewable energy taking a greater share of generation capacity than would otherwise be the case. As major economies restart we could see a continuation of this trend as industries and governments observe the capacity of existing grid infrastructure to support renewable generation and we could see pressure for utilities to store more energy in battery systems to avert future energy crisis. Either of these outcomes would see increased demand along the lithium-ion battery value chain. However, in an attempt to optimally activate large economies quickly, we could see government policy turn to supporting immediate reactivation and expansion of large-scale fossil fuel generation, particularly in economies that also host large fossil fuel industries and particularly for so long as hydrocarbon prices remain depressed. This will very much be determined by the policies of national governments of the day, and the most likely outcome is a mix of responses across the global economy.

Implications for Western Australia's upstream lithium industry

The medium-term outlook for Western Australia's upstream lithium industry remains strong – demand for EVs will continue, nickel-rich battery chemistries will increasingly become the dominant cathode technology for EV batteries and this will drive derived demand for lithium

hydroxide and spodumene concentrate. In this regard Western Australia has a clear opportunity to entrench its spodumene production sector as the predominant supplier of spodumene concentrate to lithium ion-battery supply chains, particularly those in the PRC and other parts of Asia and to establish a non-PRC source of lithium hydroxide and potentially a small niche cathode precursor material manufacturing sector, albeit the latter is significantly more challenging.

However, Western Australia still faces significant challenges:

- Complex, opaque and fickle foreign government policy remains the main driver of the final demand from which demand for Western Australian upstream lithium products is derived
- If low prices persist, processing pathways from brine sourced carbonate may become competitive with spodumene concentrate as feedstock for lithium hydroxide manufacture
- Significant excess capacity in the PRC chemical manufacturing sector is likely to remain for the medium term
- COVID-19 related decline in spending and manufacturing exacerbates the issue in the short-term

Current policy settings

Compared to other jurisdictions globally, the Western Australia and Australian governments have done little policy-wise to support the upstream Western Australian lithium sector. While this *laissez faire* approach is consistent with most Australian economic policy and in some instances necessary given Australia's obligations under various bilateral and multi-lateral trade agreements, the reality is that the Western Australian upstream industry is competing in an environment where international governments are a significant influencer of commercial outcomes through policy, regulation and direct investment on both the demand and supply-side.

In 2018, Western Australian industry made recommendations to the Western Australian Government as to a set of initiatives it could put in place that would optimise the competitiveness of Western Australia's upstream lithium industry within the boundaries of Australian *laissez faire* economic policy principles. While the Western Australian Government has paid attention to some of these recommendations, none have been implemented in full. Furthermore, increasingly dynamic policy in competing and customer nations, combined with the uncertainty created by COVID-19 result in an environment where a more proactive policy framework is justified to support the industry in the short-to-medium term.

The case for policy intervention

This study asserts that given the strong medium-term prospects for the upstream Western Australian lithium industry and its current short-to-medium term precarious position, there are factors which justify policy intervention to support the industry:

- The current circumstance is not a typical resources industry price cycle. The recent rapid expansion of Western Australian production capacity is in response to a major disruption to a globally significant industry. While the Western Australian resources industry has navigated major expansions previously, none have been (a) from such a very limited existing domestic production base; (b) caused by such a significant global industry disruption; and (c) resulted in such a dramatic expansion of capacity in such a short time.

- The demand for Western Australian upstream lithium products that is derived from this disruption is derived through a long, complex and opaque supply chain that is not typical of most supply chains for which Western Australian production is associated.
- Final product demand and demand and supply at each stage of the supply chain is heavily distorted by incentives and disincentives imposed by a large number of foreign governments with interests in the industry.

This circumstance renders determining and responding to changes to supply and demand particularly challenging during the early stages of this industry.

Furthermore, the Western Australian Government has 'invested' in the sector. It has been a major advocate of Western Australia's prospects not only in the upstream segments, but along the entire battery value-chain. Indeed, implementation of the Western Australian Government's Future Battery Industry Strategy is a key element of its economic development framework for the State. This has been supported by changes in legislation and an AUD $6.0 million investment in the Future Battery Industries CRC.

While the implementation of draconian anti-free-trade policies that have been adopted by some foreign governments are not expected, desirable or even achievable in Australia, the unique nature of the circumstances in which the Western Australian upstream lithium industry finds its self, combined with the importance of the emerging sector in the Western Australian Government's economic policy platform, presents a case for sensible policy intervention.

Efficacy of Royalty Payments

The outcomes of modelling undertaken as part of this study using actual and forecast industry financial data from sample of producers across the State is contained in Confidential Addendum 1 to this report.

Recommendations

Immediate-term Initiatives

1. **Western Australian Government and industry set and communicate a clear and realistic narrative that promotes the development of Western Australia's upstream lithium industry and encourages relevant cross-sectoral resources to focus exclusively on this effort.**
   The current narrative that is used to communicate Western Australia's prospects in the global lithium-ion value chain is inconsistent and confusing. This is resulting in the misallocation of resources and unrealistic expectations across the community and a range of other stakeholders.

2. **Provide immediate royalty relief for spodumene producers by reducing the amount currently payable under the arrangement proposed in the Confidential Addendum 1 to this report.**
   Royalties paid by spodumene concentrate producers are a significant cost. However, these royalties currently equate to 0.3 percent of total Western Australian Government revenue. While the approximate $80 million paid by the sector is a material amount of money in itself, forgoing or deferring some of this revenue for the short-term to underpin a sector that will continue to grow, employ a disproportionate number of people and pay larger amounts of royalties, payroll tax and other government charges and imposts well into the future, is a prudent investment by the State.

Furthermore, there is significant precedence for the State providing time-bound royalty concessions where sectors have demonstrated financial hardship, are a significant employer, involve significant capital investment or are of other strategic importance to the State. Each of these factors apply to the lithium sector in Western Australia, and modelling indicates that the sector is currently overpaying against the Western Australian Government benchmark return.

Details of this recommendation are contained in Addendum 1 to this report.

3. **Western Australian Government encourage Port Authorities to ensure that fees and charges are stabilised in the current environment**
   While the advent of COVID-19 may create exceptional circumstances that warrant direction from executive government, the provision of direct instructions regarding fees and charges by a Minister is generally not in the spirit of the legislation that governs Port Authorities. However, the Western Australian Government can encourage Port Authorities to stabilise fees and charges in the current uncertain environment.

4. **Western Australian Government establish a special taskforce that is purposed with working closely with all lithium industry projects to expedite their navigation of approvals processes across government**
   Because necessary ongoing regulatory reform will take time and many lithium sector projects will not meet the criteria for Major Projects or Projects of State Significance, a specific taskforce should be established to ensure efficient approvals for these projects.

5. **Western Australian Government advocate to the Commonwealth to ensure that applications for foreign investment pertaining to the Nation's lithium industry are treated as a special case and processed with the utmost efficiency**
   Recently announced reforms to Australia's foreign investment regulatory framework will potentially have a disproportionately detrimental impact on the ability of Western Australian upstream lithium businesses to raise capital, or to become integrated strategic partners in what are by their nature, entirely globally oriented lithium-ion battery supply chains.

Medium-term Initiatives

1. **Industry work with the Western Australian Government to develop a new lithium sector royalty mechanism that is based on the netback principle and which incentivises investment in domestic lithium chemical manufacturing**
   Despite delivering the same economic benefits as investment in downstream metal manufacturing, the current royalty regime does not incentivise or reward equivalent investments in downstream chemical manufacturing, in effect serving to discourage the establishment of a domestic lithium hydroxide manufacturing sector.

2. **Industry work with the Western Australian Government to investigate the merits of and establish a plan to build Western Australian lithium product provenance in key markets and establish a traceability system**
   Western Australian lithium hydroxide production will always struggle to compete on cost with lithium chemical manufacturers in other jurisdictions. However, it can potentially differentiate by targeting markets that seek product attributes such as minimised environmental impact and fair labour in the production of goods. This requires provenance and traceability to be established.

3. **Western Australian Government, local governments and industry work with the lithium industry and other local sectors to identify infrastructure investment priorities and develop shared infrastructure plans and business cases across road, rail, port, electricity, natural gas, water and waste that can be presented to infrastructure funding organisations as investment proposals.**
   Access to adequate infrastructure significantly impacts the viability and productivity of spodumene concentrate producers and lithium hydroxide manufacturers. Investment in proprietary infrastructure is a major cost for projects that can potentially be partially alleviated through prioritised common-use investment..

4. **Western Australian Government encourage the Future Battery Industries CRC to host a forum with participants in the Western Australian upstream lithium industry to identify potential short-term applied research projects that could result in short-to-medium term productivity enhancements, helping build resilience into the industry**
   The research portfolio of the Future Battery Industries CRC has a reasonable focus on projects that are relevant to the upstream sector of the industry. However, given the current circumstances, a more acute focus on projects that could deliver shorter-term productivity improvements to spodumene mining, concentrate production and lithium hydroxide manufacture may help to build resilience into the sector.

Longer-term initiatives

1. **Western Australian Government work with industry to undertake a review of the Strategic Industrial Area framework with a view to rationalising the real-estate portfolio and investing in headworks, infrastructure and approvals tailored for the specific needs of tenanted Strategic Industrial Areas**
   The existence of 'turn-key' industrial areas are a key ingredient in attracting investment in the lithium hydroxide manufacturing sector globally. Western Australia's framework of Strategic Industrial Areas is not competitive with industrial zones in other economies, evidenced by the fact that half of the Strategic Industrial Zones remain untenanted and only a quarter demonstrate active industrial ecosystems.

1. Background and Purpose of the Study

This introductory section provides context to this study, explains its purpose, and assists the reader with navigating the report.

1.1. Background to the study

Western Australia has been a producer and exporter of mineral concentrate products derived from domestic primary production of spodumene, a lithium bearing hard-rock mineral, for decades. Rapid escalation in demand for lithium hydroxide that is critical feedstock for the manufacture of nickel-rich lithium-ion battery chemistries that are increasingly typical of the batteries now used in the manufacture of electric vehicles has created prospect for new industry in Western Australia.

Proponents for this opportunity have included industry participants and representative bodies, governments (local, State and Commonwealth), academia, industry analysists and various other industry, environmental and community interest groups.

The identified scope of this opportunity has ranged from assessments that involve Western Australia becoming a fully integrated global battery manufacturing centre facilitated by a range of policy settings that are generally inconsistent with Australian economic policy principles and regulatory environment (and are in some instances are economically or commercially irrational)[1], to more cautious and arguably realistic assessments identifying potential development of a downstream battery chemicals industry supported by policy initiatives that are more consistent with Australia's economic policy principles, bilateral and multi-lateral trade agreements and regulatory framework[2]. Regardless of ambition most stakeholders have been aligned around the notion that as a result of demand derived from the exploding electric vehicle market and Western Australia's hard-rock lithium resources, an opportunity of sorts is presented.

The prospect of increased primary production and possibility of creating new coveted downstream industry has not surprisingly been particularly attractive to local, State and Australian Governments. Local governments that host lithium production, advanced development projects or existing chemical industries have enthusiastically advocated to attract investment in downstream capacity, and as far as is jurisdictionally possible, the Commonwealth Government pivoted its attention to the sector most notably in attempts to develop sector specific trade arrangements with the United States.

Western Australian Government responses to this opportunity have included the development of a Western Australian battery industries strategy[3] (see Section 7.2.1), investment of approximately AUD $6 million in a successful bid for a Future Battery Industries Cooperative Research Centre based in Perth (see Section 7.2.3) and changes to the *Mining Regulations 1981* (WA) that provide clarity as to the taxing point for lithium royalties applying to spodumene concentrate that is converted to lithium hydroxide or carbonate in a domestic vertically

[1] Smart Strategies, InfraNomics, Curtin University (2018), *Lithium Valley: Establishing the Case for Metals and Battery Manufacturing in Western Australia,* Regional Development Australia

[2] Australian Venture Consultants (2018), WA's Future in the Lithium Battery Value Chain, Chamber of Commerce and Industry Western Australia and Chamber of Minerals and Energy Western Australia

[3] Department of Jobs, Tourism, Science and Innovation (2020), *Future Battery Industry Strategy*, Western Australian Government, Perth

integrated operation (see Section 7.2.2). These initiatives have been welcomed and supported by industry.

However, since the lofty prices of 2017-18 and despite a longer term positive outlook based on strong fundamentals, the global lithium industry has been in a state of flux for the past 18 months, whereby very significant demand and supply side pressures, distortions caused by changes in (foreign) government policies and other externalities have placed sustained downward pressure on the price of lithium. Despite global demand for lithium having increased by 100,000 tonnes of Lithium Carbonate Equivalent (LCE) to 315,000 tonnes LCE in the 12 months to 2019, current spot prices for Lithium Carbonate (the benchmark pricing reference for the metal) are as at April 2020 more than four times below historical peaks[4]. This is illustrated in Figure 1 below.

FIGURE 1 – LITHIUM CARBONATE SPOT PRICE (EX-WORKS-PRC)

This dramatic downturn in the price of lithium is placing the Western Australian spodumene concentrate and lithium hydroxide industry under significant financial pressure. The following Table 1[5,6] indicates that lower prices for Western Australian lithium products will continue for at least the next several years and in fact, the forecasts in Table 1 below are based on spot market expectations, with the actual contracted prices for these products typically substantially less.

[4] Office of the Chief Economist (2020), *Resources and Energy Quarterly – Lithium (March 2020)*, Department of Industry, Science, Energy and Resources, Australian Government, Canberra
[5] Office of the Chief Economist (2020), *Resources and Energy Quarterly – Lithium (March 2020)*, Department of Industry, Science, Energy and Resources, Australian Government, Canberra
[6] Office of the Chief Economist (2019*), Resources and Energy Quarterly – Lithium (December 2019)*, Department of Industry, Science, Energy and Resources, Australian Government, Canberra

TABLE 1 – GLOBAL SPODUMENE PRICING PROJECTIONS AND ESTIMATES

Lithium Products (Spot Market)	Unit	2018	2019	2020 (est)	2021 (est)	2022 (est)	Annual Percentage Change			
							2019	2020	2021	2022
Spodumene concentrate - nominal	US$/t	839	600	469	462	510	-28.5	-21.8	-1.5	10.4
Spodumene concentrate – real	US$/t	854	613	469	452	488	-28.2	-23.5	-3.6	8.0
Lithium hydroxide – nominal	US$/t	17,817	11,400	7,700	8,855	9,625	-36.0	-32.4	+15.0	+8.7
Lithium hydroxide - real	US$/t	18,126	11,654	7,700	8,673	9,212	-37.1	-33.9	+12.6	+6.2

In the case of Western Australia, this dramatic and sustained downturn in lithium and spodumene and lithium hydroxide prices (the current spot price of spodumene concentrate is approximately US$400 to US$430 per dmt CFR PRC) has played out in the form of rationalisation of project expansion plans, project investment deferrals (including indefinite deferrals), delayed commissioning, project shutdowns and industry consolidation (see Sections 3.2.3 and 4.4).

It is most certainly true that as the result of time lags required to bring production capacity on stream in response to increase demand, all minerals industry sectors face the perils of price cycles and volatility. However, in the case of the lithium sector, policy actions of international governments on the demand and supply side of the market for the final product, as well as it each stage of the long and complex supply chain that produces that product are particularly fickle and opaque, creating unusually high levels of short-to-medium term uncertainty, and in some instances an unfair playing field..

This places not only the competitiveness of Western Australian spodumene producers at risk, but also the sustained viability of the State's emerging lithium hydroxide chemical conversion sector. If either sector of Western Australia's emerging upstream lithium-ion battery industry supply chain were to fail any aspirations that the Nation may have with respect to creating domestic mid-stream or downstream lithium-ion battery industry in Australia, fanciful or otherwise, will be negated.

1.2. Purpose of the study

In light of the circumstances summarised in the previous Section 1.1, Western Australia's peak resources sector representative bodies - Chamber of Minerals and Energy Western Australia (CME) and Association of Mining and Exploration Companies (AMEC) - have commissioned Australian Venture Consultants (AVC) to prepare a study that examines in detail recent trends, status and future outlook for the global lithium supply chain, implications for the competitiveness of Western Australia's emerging lithium industry, and initiatives that could be undertaken by government to support the industry.

This analysis will be used as the basis for advocacy that may be undertaken on behalf of industry by CME and AMEC. While changes to the royalty regime are a component of a potential package, the report goes further to examine other supportive action that could be undertaken by government.

1.3. Structure of the report

The following Table 2 sets out the structure of this report.

TABLE 2 – STRUCTURE OF THIS REPORT

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1.4. Acknowledgements

This study has been developed in consultation with the following Western Australian resources industry peak bodies and participants in the Western Australian spodumene concentrate and lithium hydroxide manufacture sectors:

- Albemarle Corporation
- Altura Mining Limited
- Association of Mining and Exploration Companies
- Chamber of Minerals and Energy Western Australia
- Covalent Lithium
- Galaxy Resources
- Liontown Resources Limited
- Mineral Resources Limited
- Pilbara Minerals Limited

2. Trends, status and outlook for demand along the Lithium-ion battery value chain

As illustrated below in Table 3[7], Global demand for lithium (measured as Lithium Carbonate Equivalent (LCE)) amounted to approximately 315,000 in 2019 reflecting an increase of approximately 100,000 tonnes over 2018. Demand from the battery manufacturing sector represented approximately 46 percent of total demand in 2019, compared to 42 percent in 2018[8].

TABLE 3 – ESTIMATED CURRENT DEMAND FOR LITHIUM

Source of demand	Tonnes per annum (LCE)	Market Share
Rechargeable batteries	144,900	46%
Ceramics and glass	81,900	26%
Greases and polymers	34,650	11%
Other uses	34,650	11%
Industrial powders	12,600	4%
Air treatments	6,300	2%
Total Estimated Lithium Demand	**315,000**	**100%**

Illustrated in Figure 2[9] below, the battery sector is expected to continue to be the main driver of demand, accounting for approximately three-quarters of the predicted final demand for LCE by 2021.

[7] Office of the Chief Economist (2020), *Resources and Energy Quarterly – Lithium (March 2020)*, Department of Industry, Science, Energy and Resources, Australian government, Canberra
[8] Australian Venture Consultants (2018), *WA's Future in the Lithium Battery Value Chain*
[9] Office of the Chief Economist (2019), *Resources and Energy Quarterly – Lithium (December 2019)*, Department of Industry, Science, Energy and Resources, Australian government, Canberra

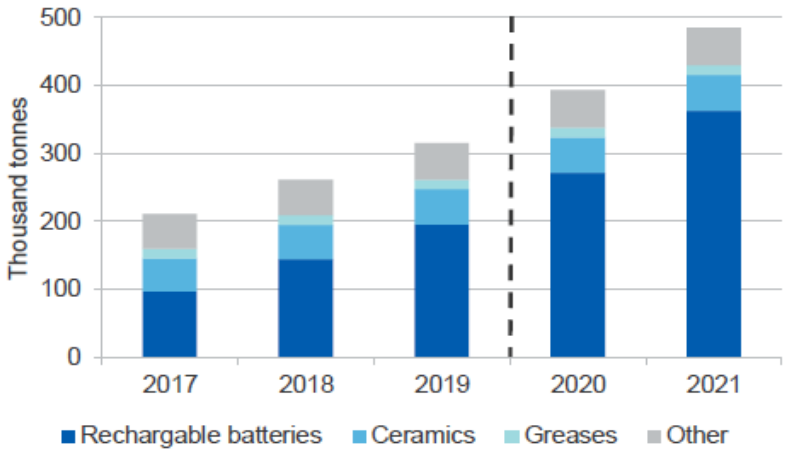

FIGURE 2 - LITHIUM USAGE BY PRODUCT 2017-2021

2.1. Derived demand for lithium materials and chemicals

As illustrated in Figure 3[10] below, demand for lithium that is derived from the battery manufacturing sector is derived from a relatively long supply chain that produces batteries for electric vehicles (EV), energy storage systems (ESS) and portable electronic devices. A major driver of the extent of this demand is decarbonisation policies of governments, resulting in market circumstances whereby government policy has a larger than normal impact on demand.

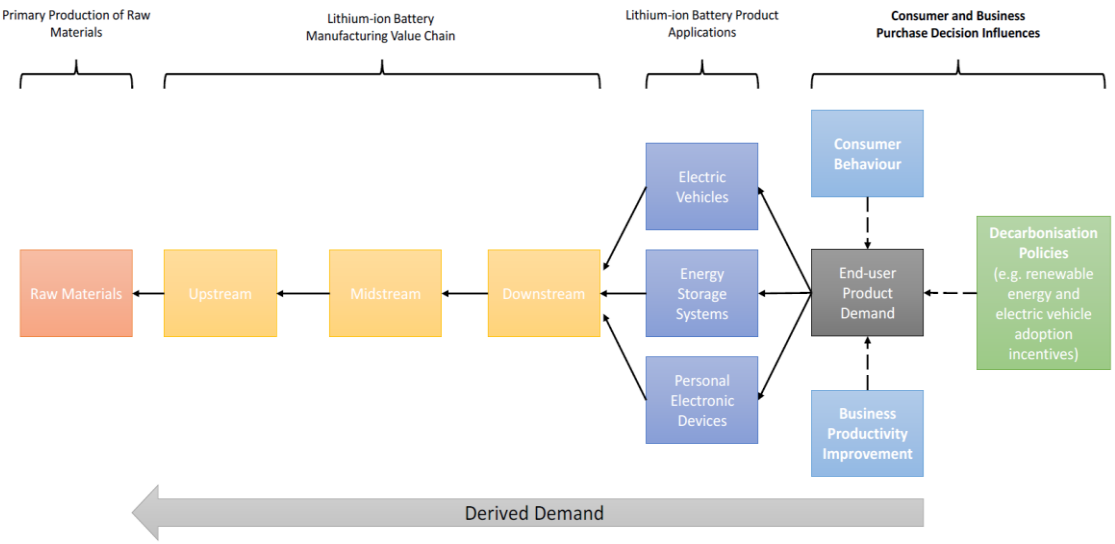

FIGURE 3 – DERIVED DEMAND ALONG THE LITHIUM-ION BATTERY SUPPLY CHAIN

[10] Australian Venture Consultants (2018), WA's Future in the Lithium Battery Value Chain, Chamber of Commerce and Industry Western Australia and Chamber of Minerals and Energy Western Australia

As summarised in Table 4[11] below, the overwhelming majority of the demand for lithium raw materials that is derived from the battery manufacturing supply chain is derived from EVs and grid-scale ESS battery manufacturers.

TABLE 4 – PREDICTED GROWTH OF LITHIUM USED IN BATTERY MANUFACTURE

Sector	2019 final demand (est.) (tons LCE per annum)	2025 final demand (est.) (tons LCE per annum)	Increase
Electric vehicles (all subsectors)	93,000	650,000	557,000 (+599%) CAGR: 38%
Consumer electronics	38,000	70,000	32,000 (+84%) CAGR: 11%
Other mobility applications	26,000	40,000	14,000 (+54%) CAGR: 7%
Grid scale energy storage	9,000	60,000	51,000 (+567%) CAGR: 37%

For the perspective of the supply chain that produces lithium-ion batteries and Western Australia's competitiveness in that supply chain there are three important upstream products:

- **Spodumene concentrate** – is produced from spodumene ore mined almost exclusively in Western Australia. It is a mineral concentrate product that contains approximately 6 to 7 percent lithium oxide content and can be used as a feedstock for producing lithium chemical compounds such as lithium carbonate and lithium hydroxide.

- **Lithium carbonate (Li_2CO_3)** – is historically the dominant traded form of lithium and in 2018 accounted for approximately 60 percent of final demand. Lithium carbonate of various concentrations is a direct product from brine reservoir based production of lithium and is the product that is used as feedstock for most industrial uses of lithium with the exception of lithium-ion battery chemistries with a nickel content of 50 percent or more.

- **Lithium hydroxide ($LiOH.H_2O$)** – is historically a specialist/niche lithium product, the demand for which has grown rapidly in recent years as the preferred feedstock for the manufacture of more nickel-rich lithium-ion battery chemistries. The production of lithium hydroxide is a more costly process. However, by virtue of an additional processing step that is required to convert the carbonate product derived from brine production, a higher quality hydroxide product can be produced cost competitively from hard rock resources such as spodumene. However, the extent to which this competitiveness exists is very much a function of the underpinning price of lithium.

It should be noted that both lithium carbonate and lithium hydroxide are manufactured at technical and battery grade specifications, with technical grade product requiring further processing to be a suitable input to the manufacture of lithium-ion battery cathode precursor material.

[11] Albemarle Corporation (2020), *Investor Presentation March 2020*, 24th March 2020, derived from *Energy Storage Continues to Drive Lithium Demand;* Azevedo, M et al (2018), *Lithium and cobalt – a tale of two commodities*, McKinsey & Company, June 2018

The following Figure 4 briefly summarises in non-technical form the conceptual processing pathways for these different products[12].

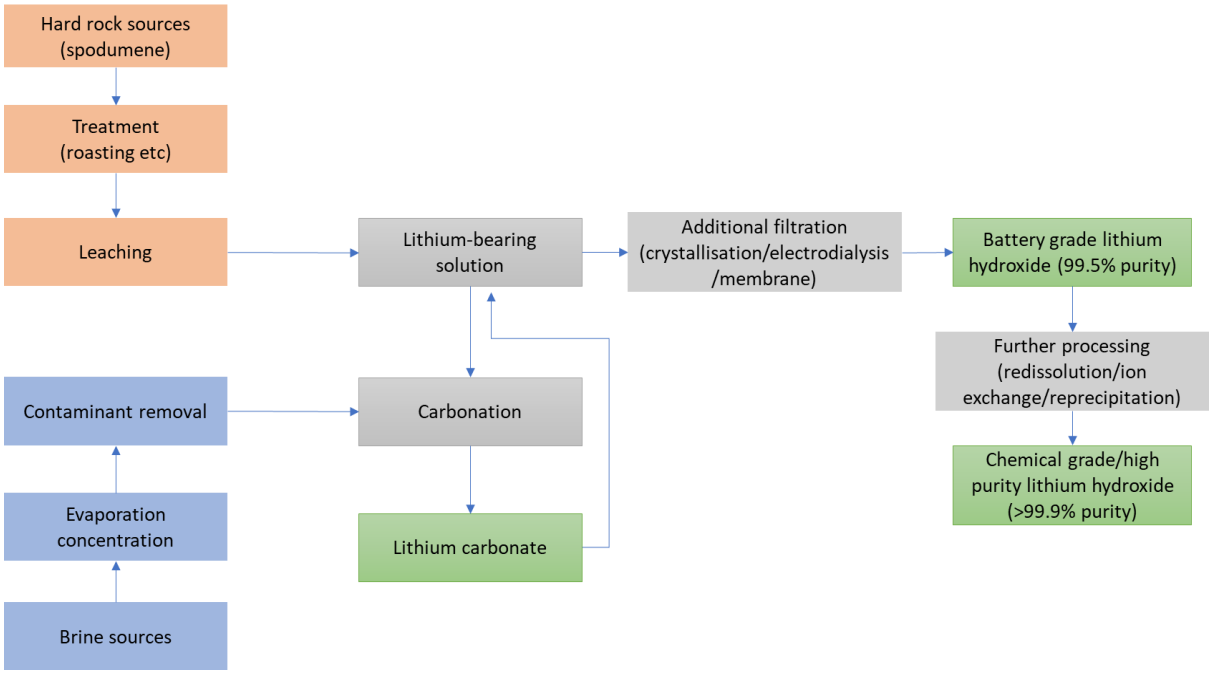

FIGURE 4 – CONCEPTUAL OVERVIEW OF PROCESSING PATHWAYS FOR EARLY STAGE LITHIUM PRODUCTS

The following Figure 5[13] illustrates the feedstock nature of these products in the lithium-ion battery value chain, including examples of entities found at each stage. Upstream elements include the mining of raw material, production of mineral concentrate, technical and battery grade chemical products and cathode precursor materials. Middle stream elements include the manufacture and assembly or battery components and downstream refers to the integration of the battery product into a final product.

[12] Industry is in constant search for production processes that are cheaper, quicker, more efficient, or more suitable for individual end-user needs. Accordingly, this summary flowchart provides a conceptual overview only of the rough process outline, and does not make any attempt to incorporate or address the large number of emerging novel, proprietary and commercial-in-confidence production pathways that are increasingly being adopted by lithium ore, concentrate, and chemical producers globally, including in Australia.

[13] Australian Venture Consultants (2018), *WA's Future in the Lithium Battery Value Chain*

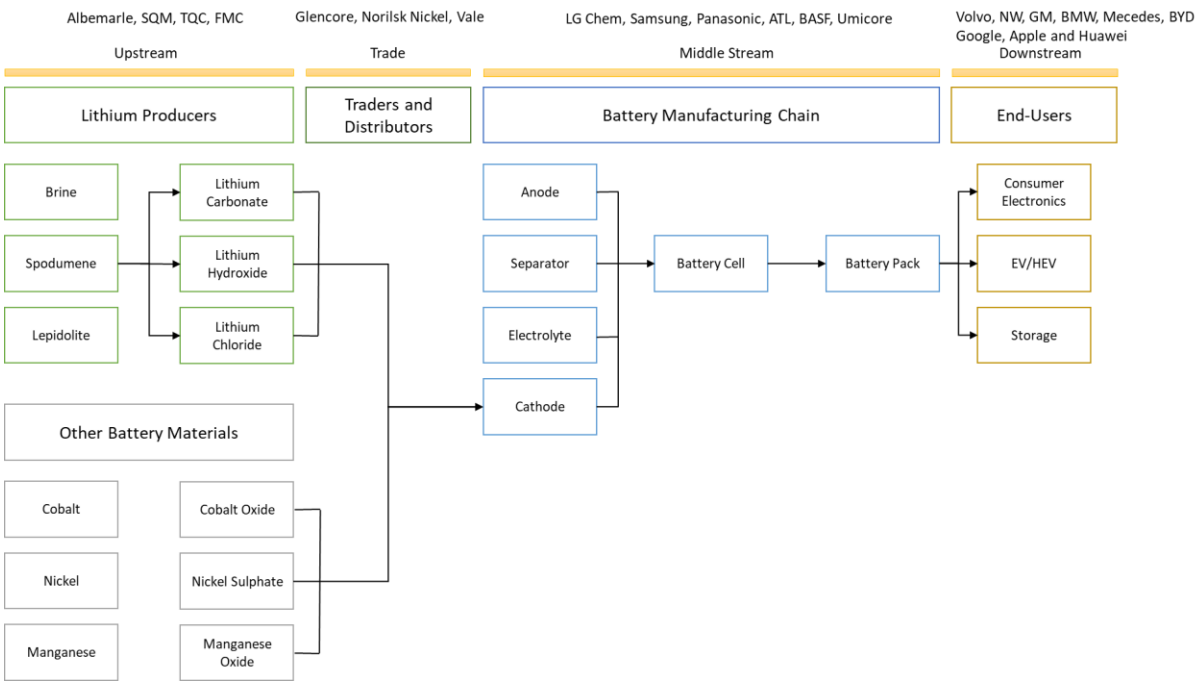

FIGURE 5 - LITHIUM-ION BATTERY SUPPLY AND MANUFACTURING

2.1.1. Electric Vehicles and derived demand for lithium hydroxide and spodumene concentrate

Western Australia's role and competitiveness in the global lithium industry is a function of:

- The competitiveness of spodumene concentrate in the production of higher quality lithium hydroxide;
- That lithium hydroxide being a preferred input to the manufacture of cathode materials for nickel-rich lithium-ion batteries; and
- Nickel-rich battery chemistries emerging as the platform for electric vehicles that require higher-end performance from the battery along characteristics such as energy density, charge rate and range (including mainstream passenger and commercial vehicles).

Currently demand for electric vehicles (EVs) is the main driver of derived demand along the lithium-ion battery supply chain and this expected to remain so for the foreseeable future. Customer valued product attributes such as range, energy density, charge rate, battery lifespan, safety and cost have driven continuous investment in battery technology innovation that optimally deliver on these attributes. Importantly, for the competitiveness of the Western Australian lithium industry, this has resulted in progressively more 'nickel-rich' battery chemistries that favour lithium hydroxide feedstock becoming the platform technology for the EV market.

As lithium-ion battery chemistries have evolved, while the lithium content of the cathode has not changed dramatically, the nickel content has increased substantially, improving battery performance and reducing cost by negating the need for costly cobalt content in the chemistry. For example, as illustrated in Figure 6[14] below the current commercial state-of-the-

[14] Fu, X et al. (2017), *Lithium-Ion Battery Supply Chain Considerations: Analysis of Potential Bottlenecks in Critical Metals*, Joule 1:2, (October 2017), pp 229-243

art nickel-rich chemistry, NMC 811, contains almost twice as much nickel as the early NMC111 and around one quarter of the cobalt content.

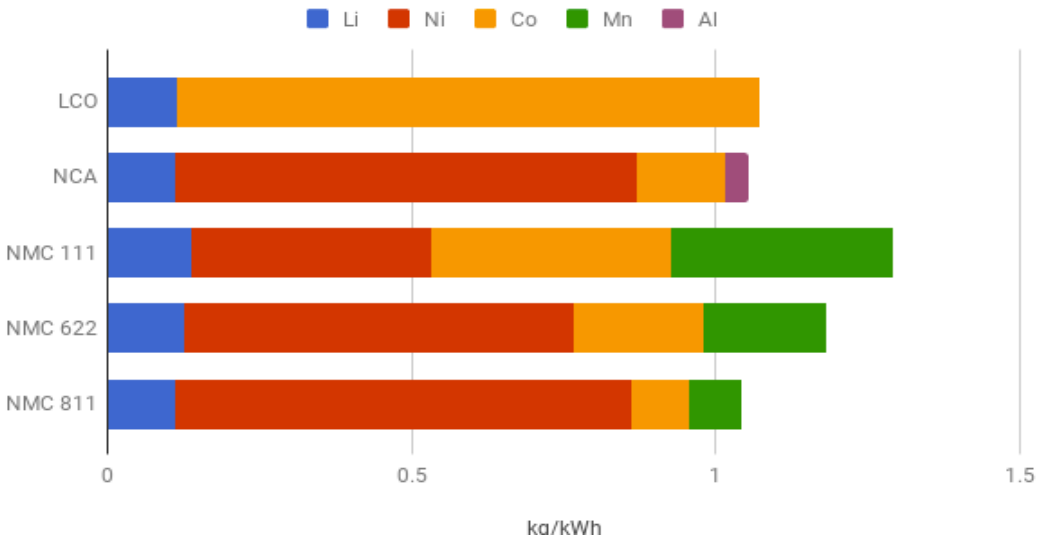

FIGURE 6 – BATTERY CHEMISTRY COMPOSITION

Although the amount of contained lithium does not change significantly between chemistries, this increasing trend towards high nickel content significantly affects the form in which lithium is required by battery manufacturers. Briefly, higher nickel chemistries are more energy-dense but inherently less stable, with a significantly more complicated production process and commensurately lower tolerances. As a result, lithium carbonate is an unsuitable feedstock for the manufacture of nickel-rich lithium-ion battery cathodes to the extent that it is virtually unusable for NMC 811. Accordingly, in normal market conditions continued technological innovation and shifts towards high-nickel EV batteries will support and encourage the existing trend towards production of lithium hydroxide over lithium carbonate, favouring the Western Australian lithium sector.

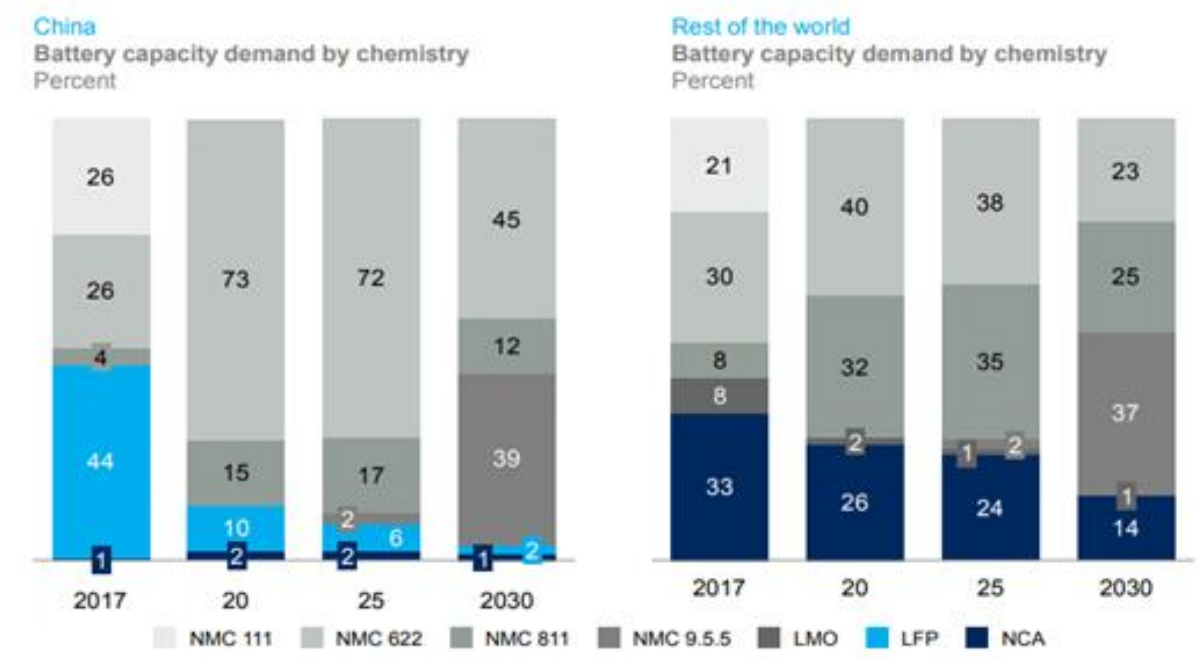

FIGURE 7 – CURRENT AND PROJECTED BATTERY CHEMISTRY DEMAND FOR ELECTRIC VEHICLES

As illustrated in Figure 7[15] above, manufacturers supplying the EV industry have started to or have already switched to cathode materials containing high proportions of nickel. In September 2019, sales of new passenger EVs with NCM 811 battery cells comprised 18 percent of all passenger EV battery capacity deployed in the PRC, up from 1 percent in January that year, and 7 percent of all capacity deployed globally. In pursuit of lower costs and higher energy density, automakers in the PRC have seemingly opted to bypass NCM 622, transitioning instead from LFP or NCM 523 cathode chemistries into high-nickel NCM 811[16].

Because lithium hydroxide has a higher lithium content than lithium carbonate (approximately 29 percent lithium compared to 19 percent in the case of carbonate), and by virtue of its specific chemical characteristics, using lithium hydroxide as an input to the manufacture of nickel-rich battery chemistries is more cost effective and results in a higher quality cathode precursor material. In some very nickel-rich chemistries, lithium carbonate is not a technically viable input.

While this trend favours the competitiveness of Western Australia's spodumene and emerging lithium hydroxide production profile, adoption of nickel-rich battery chemistries in the PRC has not occurred as quickly as some analysts had initially forecast and recent policy-driven declines in some major EV markets (see Section 2.1.1) have resulted in excess capacity.

2.1.2. Energy Storage Systems derived demand

As part of a clear and continuing global trend, uptake of energy storage systems (ESS) is predicted to continue to grow at a rapid pace. Costs of battery energy storage technology have been continually decreasing, with the pace of change growing – over the period 2017-2019, average costs of utility- and grid-scale energy storage has decreased by 50 percent[17]. As shown below in Figure 8[18], worldwide annual energy storage deployments, at around 2 GWh in 2017, were expected to reach just under 8 GWh per annum by end of 2019, led by increasing deployments in the United States, Republic of Korea (ROK), People's Republic of China (PRC) and Japan.

[15] Azevedo, M et al (2018), *Lithium and cobalt – a tale of two commodities*, McKinsey & Company, June 2018; adapted from *Exhibit 2*

[16] Castiloux, R (2019), *Electric Growth: EVs, Motors and Motor Materials*, Adamas Intelligence, November 2019

[17] AIG Energy Industry Group (2018), *Lithium-ion Battery Energy Storage Systems*, American Industry Group (United Kingdom)

[18] St.John, F (2018), *5 Predictions for the Global Energy Storage Market in 29019*, Wood Mackenzie/GreenTechMedia, 11 December 2018, Adapted from *US will regain the top spot from South Korea, as the global market grows to 7.9 gigawatt-hours in 2019*

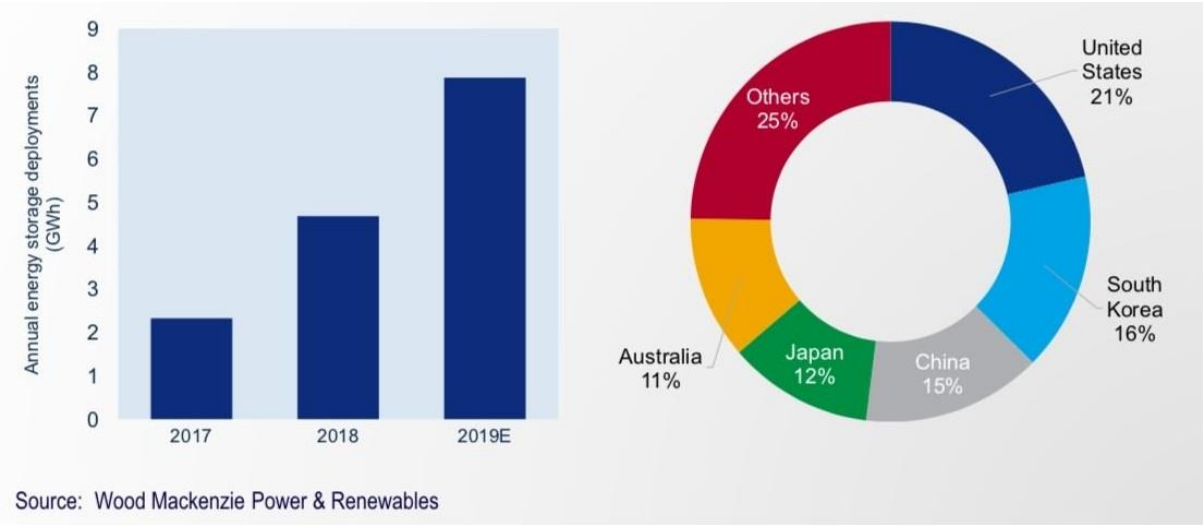

FIGURE 8 - WORLDWIDE LARGE-SCALE ENERGY STORAGE SYSTEM DEPLOYMENTS

Unlike the EV market, the future of grid- and utility-scale ESS is a matter of some continuing debate, with multiple competing technologies and research efforts examining differing pathways, including pumped hydro, hydrogen cells, vanadium flow batteries, zinc-bromine flow batteries, solar salt, oxidisation of magnesium, spin turbines and other novel and emerging technologies.

Nevertheless, the ESS market at present remains dominated by lithium-ion batteries, comprising more than 80 percent of large-scale battery storage capacity[19]. Accordingly, in all likely scenarios over the medium term, derived demand for lithium from the ESS sector will be significant – as discussed above at section 2.1, projected to grow by approximately 51,000 tonnes LCE, an increase of 567 percent. However, the need for batteries with specific performance characteristics that are underpinned by nickel-rich chemistry technology is less for most ESS applications than is the case for the EV market. As result, while still a strong contributor to final lithium demand, the ESS sector will potentially be less of a driver of derived demand for spodumene concentrate and lithium hydroxide with ESS applications being able to be supported by a wider range of battery technologies, including lower nickel content cathode chemistries.

2.2. Demand for lithium chemicals

As lithium-ion battery chemistries continue to dominate total derived demand for lithium – particularly nickel-rich batteries, as discussed in Section 1.4 - demand for lithium hydroxide is increasing, and is likely to continue to do so. While predictions of the pace at which this will occur vary and are highly dependent upon innovations in battery chemistry, on current trends lithium hydroxide demand will increasingly outweigh lithium carbonate over the medium term. As illustrated in Figure 9[20] below, demand for battery-grade lithium hydroxide is likely to exceed 1 million metric tonnes (LCE) by 2030, with predicted lithium carbonate demand rising only marginally to around 220,000 metric tonnes over the same period.

[19] United States Energy Information Administration (2018), *US Battery Storage Market Trends*, United States Government, May 2018

[20] Lu, S; Frith, J (2019), *Will the Real Lithium Demand Please Stand Up? Challenging the 1Mt-by-2025 Orthodoxy*, published Bloomberg New Energy Finance, 28 October 2019; adapted

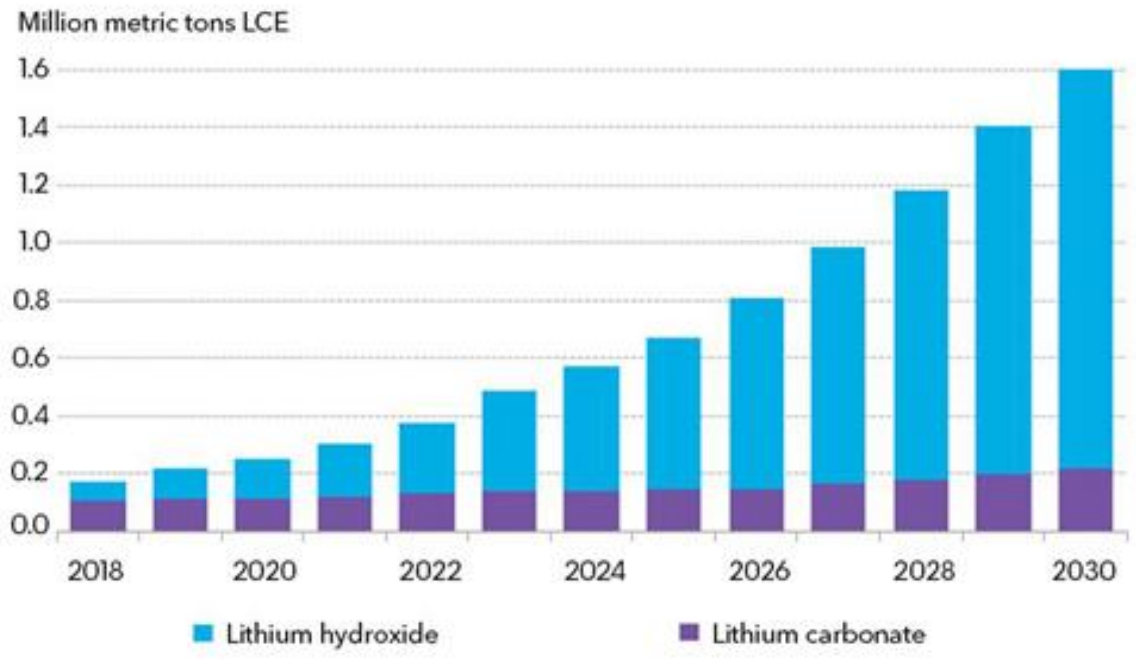

FIGURE 9 - FORECAST DEMAND - LITHIUM HYDROXIDE VS LITHIUM CARBONATE

2.3. Impact of policy changes

Compared to other sectors of the Western Australian resources industries, the State's lithium industry is particularly exposed to volatility created by significant and constant changes in foreign government policies that incentivise or disincentives derived demand for its products.

2.3.1. Electric vehicles

As noted above, lithium is essential for modern technological manufacturing industries, consumer electronics, and products and services enabled by energy storage. As a result, it is also a resource for which both supply and demand is highly susceptible to manipulation and forcing by non-market forces, most obviously in the form of foreign government policy settings, mandates, distortions and incentives relating to the transition to a lower-emissions economy. Nowhere is this more obvious than in the EV sector, the single largest current and likely future source of derived demand for lithium products.

Worldwide growth trajectories for EV adoption trended solidly upwards over the five-year period 2013 to 2018, summarised below in Figure 10[21], supporting historically high prices for lithium products. While estimates varied, by the start of 2018 lithium producers and industry commentators estimated battery demand for lithium in EVs would reach between 700,000 and 1 million tonnes of LCE by 2025[22].

[21] International Energy Agency (2019), *Global EV Outlook 2019 – Scaling up the transition to electric mobility*, technology report published May 2019

[22] [22] Lu, S; Frith, J (2019), *Will the Real Lithium Demand Please Stand Up? Challenging the 1Mt-by-2025 Orthodoxy*, published Bloomberg New Energy Finance, 28 October 2019; Albemarle Corporation (2020), *Investor Presentation March 2020*, 24th March 2020, derived from *Energy Storage Continues to Drive Lithium Demand;* Azevedo, M et al (2018), *Lithium and cobalt – a tale of two commodities*, McKinsey & Company, June 2018

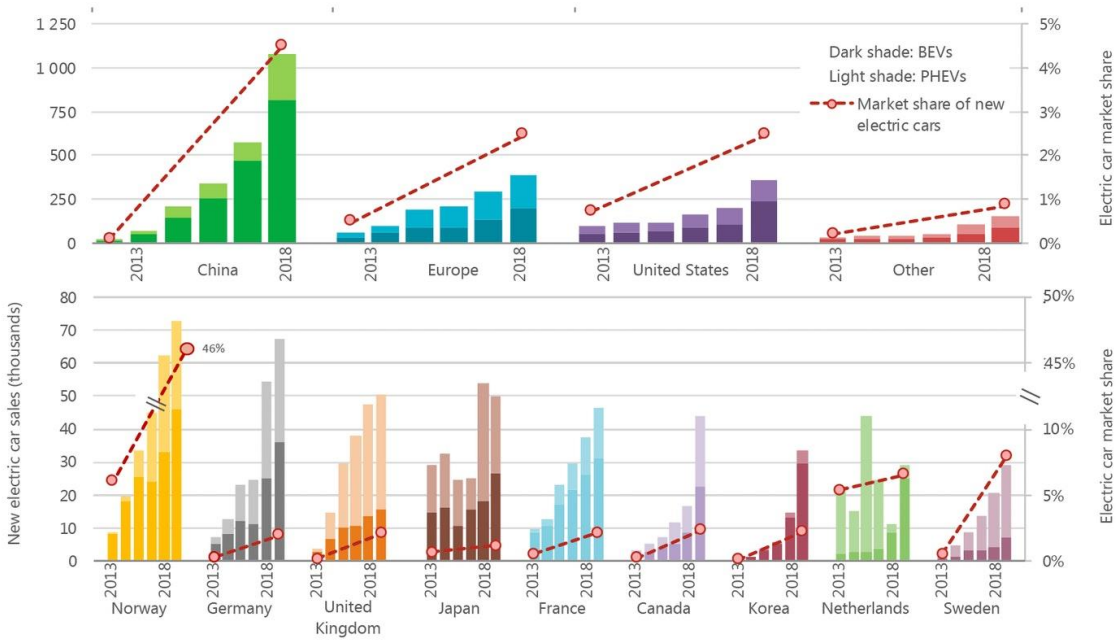

FIGURE 10 - GLOBAL UPTAKE OF ELECTRIC VEHICLES - BY TYPE & REGION

However, developments over the course of late 2018 and 2019 have significantly affected the formerly uniformly positive growth trajectories and introduced significant volatility into EV markets, with 2018-2019 year-on-year growth surging to 44 percent in the European Union (EU), but declining to a mere 3 percent in the PRC and contracting by 12 percent in the United States and 16 percent in Japan[23]. As discussed in the following subsections, policy distortions have contributed significantly to this outcome.

People's Republic of China

The People's Republic of China (PRC) is currently the world's single largest market for EVs. Historically, uptake of EVs in the PRC domestic market has expanded rapidly. However, as illustrated in Figure 11[24] below – which illustrates monthly new EV sales in the PRC between 2016 to 2019 – this trend arrested from mid-2018.

[23] Irle, R (2019), *Global BEV and PHEV Sales for 2019*, index published EV-Volumes, Trollhättan, Sweden

[24] Office of the Chief Economist (2020), *Resources and Energy Quarterly – Lithium (March 2020)*, Department of Industry, Science, Energy and Resources, Australian government, Canberra; Inside EVs (2020), *EV Sales Scorecard*, published period ending January 2020

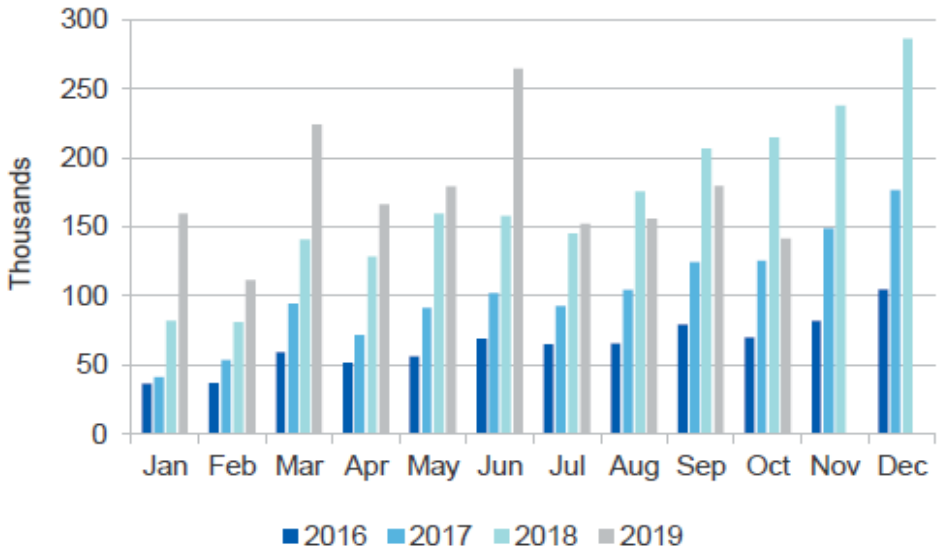

FIGURE 11 – PRC MONTHLY ELECTRIC VEHICLE SALES 2016-2019

Overall, the PRC EV subsidy regime is complex and multi-level, with central, provincial and in some instances even city or local governments operating various policies, often with differing desired outcomes. Further, multiple regimes are in place, combining both 'carrot' price subsidies, tax breaks and other incentives, and 'stick' coercive required sales percentages.

Since 2010, when 'new energy vehicle' (NEV) subsidies were first introduced, EV sales increased dramatically and in line with central government aims to reach 20 percent market penetration by 2025. NEV subsidies peaked at around USD $8,500 per vehicle in late 2015[25], and were a major factor in the rapid expansion of lithium chemical supply discussed in Section 4. However, central and provincial government concerns remained that many vehicles were poor quality and with low range[26], with design and manufacture aimed primarily at maximising eligibility for subsidies. As a result, phased reductions of incentives and progressively tighter eligibility requirements were imposed from 2016 on, culminating in plans announced late 2018 to eliminate subsidies entirely by end of 2020[27].

In 2018-19, the PRC domestic market was estimated as being responsible for over 65 percent of total global sales of EVs[28]. Further, at 2019 end, the PRC was responsible for just under 80 percent of the total lithium hydroxide used in manufacture of EV batteries[29](with much of this hydroxide used in the manufacture of battery materials and batteries that are exported to other vehicle manufacturing sectors), making the PRC market of critical importance for Western Australian spodumene concentrate producers and aspiring hydroxide manufacturers.

[25] Shen, J (2020), *China suspends further electric vehicle subsidy cuts in 2020: ministry*, Shanghai TechNode, 13 January 2020
[26] It is, however, important to note that for Asian markets, where travel distances are typically much shorter than in Europe or the US, and particularly Australia, EV range
[27] Tabeta, S (2018), *China to slash EV subsidies 30% next year*, Nikkei Asia Review, 26 December 2018
[28] Heppel, G (2019), *China EV subsidies face major decline in 2019*, CRU Group, 3rd April 2019
[29] Financial Times (2020), *Coronavirus puts electric carmakers on alert over lithium supplies*, published 10th March 2020

Over the past eight months, however, several policy-related factors have combined to reduce domestic EV demand within the PRC, and hence significantly lower global demand.

While partly offset by a small subsidy increase for longer-range vehicles and a broader requirement that 10 percent of all new sales by manufacturers be compliant NEVs[30], by June 2019 overall subsidies had dropped between 40 and 60 percent, and were scrapped entirely for EVs with a range of less than 250 kilometres, or that utilised lower-tech batteries (such as LMO and NMC 111) with energy density of less than 125Wh/kg[31]. Further, the central government reportedly placed pressure on provincial governments to wind back or cease their own subsidy programmes, aiming to encourage domestic competition and engender increased industry competitiveness with international carmakers[32].

These changes to PRC EV policy had an immediate and dramatic effect on the domestic market, with sales declining by nearly 5 percent year-on-year in June 2019, the first decrease in more than two years, and then recording double-digit declines in every month subsequent, rising to 40 percent year-on-year declines in October and November. While the medium to longer-term outlook for EV demand in the PRC remains positive, early signs of a stabilisation in sales volumes around the end of the year were stymied by the emerging effects of COVID-19 (discussed further in Section 5), with sales volumes falling further in 2020 and reaching a year-on-year decline of 77 percent in February[33].

As part of broader economic recovery efforts, the PRC appears to have changed course, announcing in January 2020 that the previous subsidy cuts would be reversed and subsidies reinstated for the two-year period out to end of 2022. Provincial and city governments have followed suit, with regional-level subsidies implemented in Guangzhou, and Hunan, Ningbo and Changchun provinces[34]. However, the overall response appears to be confused, with analyst and media reporting that while the State Council (the lead executive branch of the central government) is announcing that rebates will be reinstated, Ministry-level and other government bodies are reporting reductions of around 10 percent, combined with tighter eligibility criteria[35]. This mixed messaging is likely to cause further confusion and negative sentiment, delaying any recovery in EV sales.

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[30] Malone, C (2018), *China expected to slash EV subsidies*, Inside EVs, 27 December 2018; Tabeta, S (2018), *China to slash EV subsidies 30% next year*, Nikkei Asia Review, 26 December 2018; Hanley, S (2019), *EV Subsidies going up in Italy, down in China*, CleanTechnica, 3rd January 2019

[31] Kharpal, A (2019), *As China cuts support for its electric carmakers, auto firms could face a 'war of attrition'*, CNBC Markets, 19th June 2019; Heppel, G (2019), *China EV subsidies face major decline in 2019*, CRU Group, 3rd April 2019

[32] Bloomberg New Energy Finance (2019), *Chian cuts Electric-Car Subsidies, Shares of Top EV Makers Drop,* published 26th March 2019; Kharpal, A (2019), *As China cuts support for its electric carmakers, auto firms could face a 'war of attrition'*, CNBC Markets, 19th June 2019

[33] China Passenger Car Association (2020), *National Passenger Car Market Analysis January 2020*, 13th February 2020

[34] Shen, J (2020), *China suspends further electric vehicle subsidy cuts in 2020: ministry*, Shanghai TechNode, 13 January 2020; Shen, J (2020), *Electric vehicle subsidies in China extended to 2022,* Shanghai TechNode, 2nd April 2020

[35] Reported eg. Bloomberg New Energy Finance (2020), *China Weighs Cuts to Electric-Car Subsidies It Just Extended*, 1st April 2020

United States

Second in volume only to the PRC, the United States EV market has also exhibited a dramatic recent decline in sales. While recording record sales growth through 2018, resulting in total sales of nearly 360,000 vehicles, sales were significantly less in 2019, down 12 percent in year-on-year terms. This is illustrated in Figure 12[36].

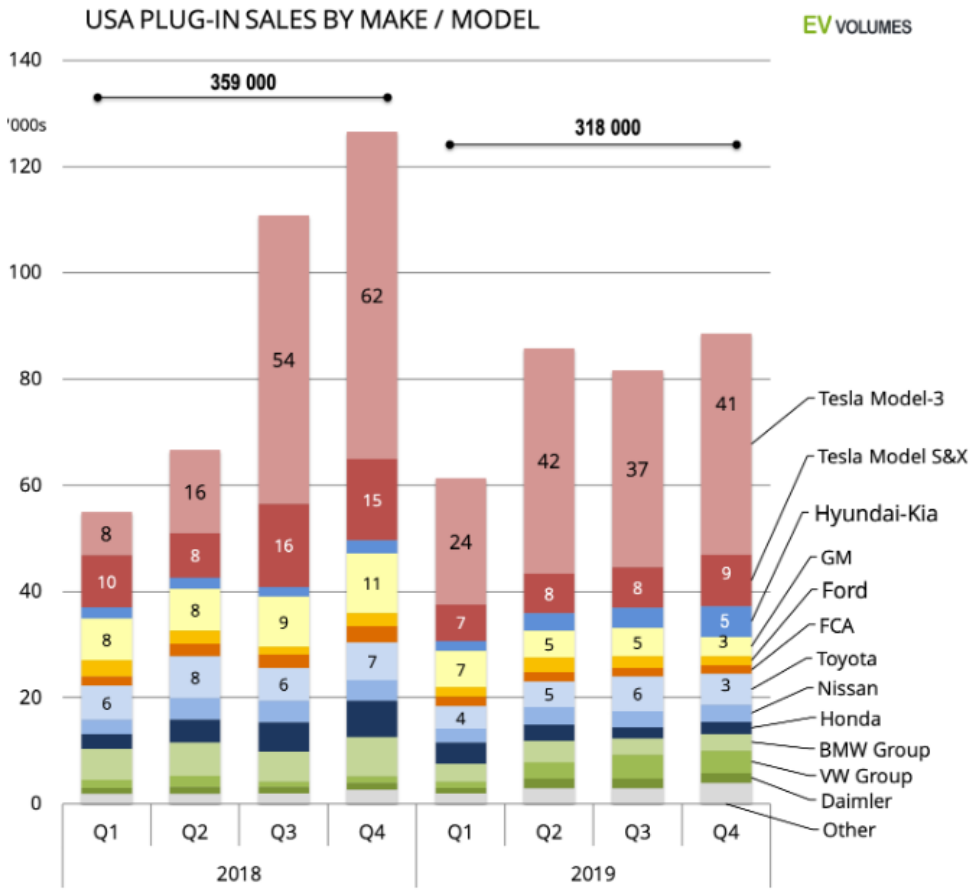

FIGURE 12 – UNITED STATES ELECTRIC VEHICLE SALES (2018 AND 2019)

Notably, the above figures do not include sales data for 2020, and hence the full impact of the COVID-19 pandemic are yet to be reflected. Early figures indicate that overall United States vehicle sales volumes have declined by nearly 40 percent year-on-year in March 2020, and there is little evidence to suggest that EV sales will be contrary to this downward trend[37].

However, the overall United States EV market exhibits two key features that complicate longer-term predictions, and hence reduce the predictability of derived demand for lithium. Firstly, forecasts of EV sales are typically presented as smooth curves, whereas United States year-on-year monthly and quarterly sales exhibit considerable volatility, ranging from a 4 percent

[36] Irle, R (2019), *Global BEV and PHEV Sales for 2019,*, EVvolumes.com, accessed April 25 2020
[37] Feltmate, T (2020), *US Vehicle Sales (March 2020) – COVID-19 impact hit vehicle sales hard in March*, TD Economics, 2 April 2020.

contraction in 2014-2015 to an 85 percent increase in 2018[38]. With EV sales as a share of overall vehicles hovering at around 2.5 percent, and dramatically affected by a wide range of factors including geographic availability, consumer preference, the relatively byzantine United States system of manufacturer-dealership relationships, cost, manufacturing delays and public perception, small changes can produce large effects.

Secondly, the United States EV market is uniquely concentrated, with one manufacturer, Tesla, having a very dominant market share. On industry estimates, in the United States domestic market the Tesla Model 3 alone outsells the next largest competitor, the Chevy Bolt, by a ratio of over 9-to-1, as illustrated below in Figure 13[39].

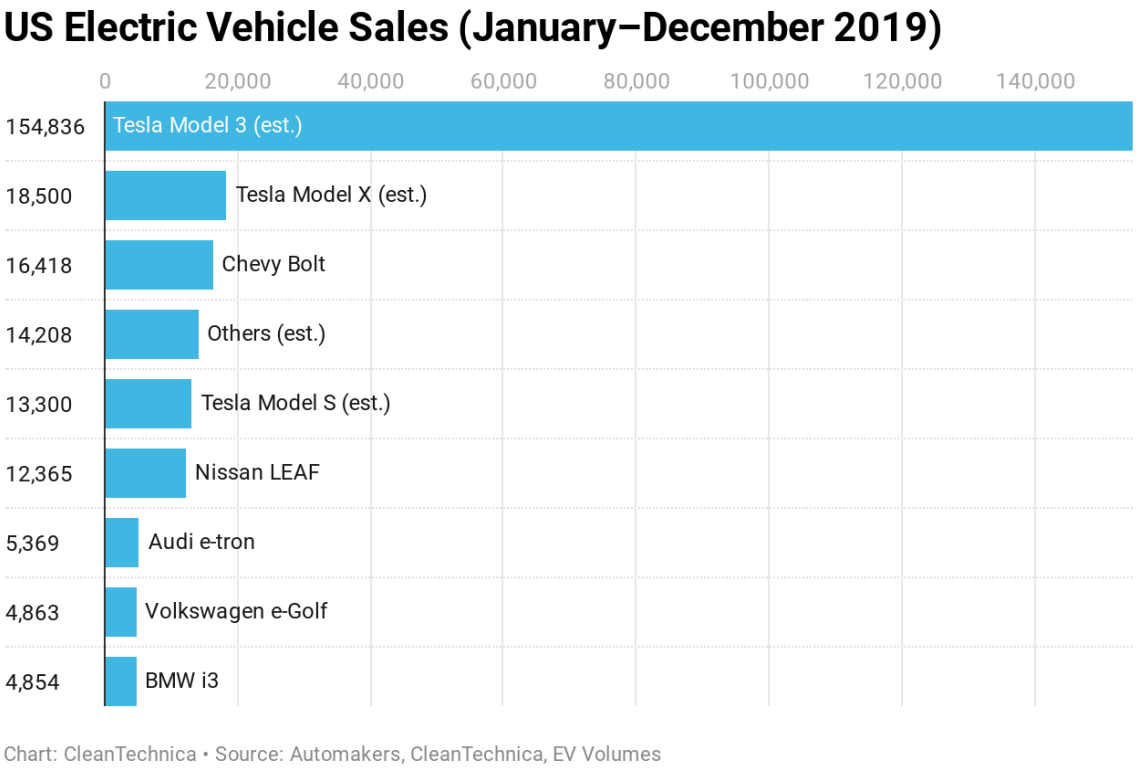

FIGURE 13 - US EV SALES BY MANUFACTURER AND MODEL

Accordingly, any factors specific to Tesla sales will have a disproportional effect on overall United States EV sales. In this light, the ability of Tesla to finally ramp manufacturing production at sufficient scale in 2018 led to a large glut in sales, with backorders dating to 2016 finally filled. Meanwhile, in 2019, Tesla consolidated its product stack and ceased offering 75kWh battery pack versions of its Model S and X, resulting in a minimum price increase of $3,000 ($6,000 for the more expensive Model X) and leading to reduced sales[40].

In the context of the broader lithium industry, Tesla thus has disproportionate impact on derived demand for lithium from the United States, and by virtue of the size of the United State EV

[38] Ritchie, E (2019), *What's Happened to US Electric Vehicle Sales?*, Forbes, accessed April 24 2020

[39] Shahan, Z (2020), *Tesla Gobbled UP 78% of US Electric Vehicle Sales in 2019*, CleanTechnica, 16 January 2020

[40] Irle, R (2019), *Global BEV and PHEV Sales for 2019,*, EVvolumes.com, accessed April 25 2020

market, global demand. While complete details are typically regarded as commercial-in-confidence, Tesla has shown significant appetite to secure lithium hydroxide production from a range of global suppliers, including Ganfeng Lithium (which sources all of its spodumene feedstock from Western Australia), the Mt Holland Wesfarmers/SQM JV (again located in Western Australia), Pure Energy Minerals in Nevada, and the Cadence Minerals/Bacanora Minerals JV in Mexico. Notably, three of these four producers, discussed later at section 3, have yet to reach commercial production.

Despite these unique market features, factors having the greatest effect on consumer behaviour remain government incentives. In the United States, the geographical distribution of new EV sales strongly correlates with the underlying factors of government policy, incentives, charging infrastructure and local policy actions. For example, San Jose, a city which has spent over USD $2 billion[41] on charging infrastructure (more than double spent by any other city) has the highest EV share of new sales for 2019 at 21 percent[42].

More broadly, the single most accurate predictor of EV sales in the United Sates is the Californian Zero Emission Vehicle Program (ZEV)[43]. First adopted in 1990, the Californian Air Resources Board under the ZEV requires that a certain number of vehicles manufactured in California to be ZEV, primarily, battery-powered electric vehicles. As of January 2018, the Program mandates a minimum of 5 million ZEVs by 2030, enabled by a $2.5 billion investment in hydrogen fuelling stations and 10,000 fast-chargers by 2025, and imposes minimum requirements of 16 percent of vehicles manufactured be ZEV by 2025, with a further 6 percent 'transitional' (typically hybrid petrol/electric).[44] Californian policy is widely regarded in the United States as representing best-practice, and hence the ZEV Program and related targets have also been adopted by an additional twelve states within the United States, including most of the western coast.

The ability of California to set its own emissions standards (and the reason for other States choosing to accept them as binding) stems from the United States federalist arrangement. Generally, atmospheric environmental controls and standards fall under Federal government control. Under the federal Clean Air Act, however, the State of California has from 1970 been granted unique authority to impose more stringent environmental protection and emissions reductions standards than would otherwise apply, which other United States states may choose to adopt.[45] This exemption has allowed California to act as a national leader on electric vehicle uptake, and through the mandatory targets has prompted a large domestic battery-enabled industry.

However, the Trump administration has announced its displeasure with this state of affairs, and has since election made ongoing attempts to rescind this exemption and reduce or remove

[41] The International Council On Clean Transportation (2019), Global and U.S. electric vehicle trends, accessed April 27 2020
[42] The International Council On Clean Transportation (2019), Global and U.S. electric vehicle trends, accessed April 27 2020
[43] Cattaneo, L (2019) *Plug-in electric vehicle policy*, Center for American Progress, accessed April 27 2020
[44] *California ZEV law gets simpler, more challenging*, Weissler, P, published SAE International, 7 December 2017; *California Governor orders 5M ZEV target for 2030; more hydrogen fueling and EV charging stations*, published Green Car Congress, 26 January 2018
[45] 42 U.S. Code § 7507 - *New motor vehicle emission standards in nonattainment areas*

other Obama-era vehicle emissions standards.[46] In 2019, the Federal Government proposed the revoking of both post-2020 CO2 standards and wider state authority on emission standards. Meanwhile, existing tax break subsidies awarded to manufacturers to incentivise production are limited to the first 200,000 vehicles produced, a figure both Tesla and GM achieved in late 2019 and affecting profitability of their fleet offerings, likely leading to higher prices as manufacturers seek to recover costs[47].

While this reduction in government support is likely to negatively impact a market further troubled by COVID-19 (See Section 5), broad underlying demand for EVs appears to remain, as by some estimates approximately 60 percent of the United States market lies in cities or states that have announced opposition to this rollback[48]. Automakers are responding to this demand, and are offering significant new electric-powered product ranges – for example, Ford have invested $11 billion[49] into new EVs, including penetration into market segments previously untapped, such through their acquisition of electric truck start-up Rivian, recently securing an early order from Amazon for 100,000 delivery vans[50]. These measures include substantial investments into domestic supply chains, with General Motors and ROK-owned LG Chem announcing plans in December 2019 for a large battery factory in Ohio, investing a combined $2.3 billion[51].

European Union

While the domestic PRC and United States EV markets are depressed and likely to remain so for at least the short-term, European Union markets are increasingly adopting EVs, with penetration rates accelerating dramatically (albeit from a lower base).

In 2019, European sales of EVs increased by 44 percent to just over 600,000 vehicles, representing over 26 percent of global EV sales[52]. Further, the trend towards purely electric vehicles over plug-in hybrids continues, with just under three-quarters of all EV sales in 2019 purely battery-powered[53]. While verified national level data is still being developed, early industry data for 2020 suggests that the pace of adoption is continuing to increase, with some estimates of EV sales for February 2020 up 92 percent over February 2019[54].

As with the PRC and United States, a combination of 'carrot' incentives and 'stick' imposts are combining to drive this market transformation, combined with various country-specific measures.

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[46] *Trump's Fuel-Efficiency Rollback Breaks With 50 Years of Precedent*, Meyer, R, published The Atlantic Magazine, 2 August 2018
[47] Coren, J (2019), *2019 was the year electric cars grew up,* Quartz, accessed April 27 2020
[48] The International Council On Clean Transportation (2019), Global and U.S. electric vehicle trends, accessed April 27 2020
[49] Coren, J (2019), *2019 was the year electric cars grew up,* Quartz, accessed April 27 2020
[50] Coren, J (2019), *2019 was the year electric cars grew up,* Quartz, accessed April 27 2020
[51] Colias, M (2019), *GM, LG to spend $2.3 Billion on venture to make electric-car batteries,* Wall Street Journal, accessed April 28 2020

[52] Hattrup-Silberberg, M. (2020), *Electric Vehicle Index: Europa wird zum Hotspot der Elektromobilität*, McKinsey & Company, 2nd March 2020
[53] Hattrup-Silberberg, M. (2020), *Electric Vehicle Index: Europa wird zum Hotspot der Elektromobilität*, McKinsey & Company, 2nd March 2020
[54] JATO Group (2020), *Volkswagen Golf loses its crown as the top-selling car in Europe in February*, 25th March 2020

Most significantly, under European Commission regulations, the fleet-wide CO_2 emissions of European carmakers have been progressively tightened since 2015, and as at January 2020 are now set at 95g CO_2/km, applying to all but the top 5 percent most emitting vehicles a manufacturer produces. As at 2021, all newly registered vehicles must comply, or face penalties of €95 for each g/km by which a vehicle exceeds this target[55]. By 2025, passenger cars must demonstrate a further 15 percent reduction in emissions, and by 2030 a 37.5 percent reduction, with discounting policies and other incentives provided to encourage further adoption of zero-emissions vehicles into fleet makeups[56].

Ongoing transition from the older New European Driving Cycle (NEDC) assessment of vehicle emissions throughout the EU to the new Worldwide Harmonised Light Vehicle Test Procedure (WLTP) is further accelerating the impact of emissions reductions targets. In a phased rollout commencing September 2017, new vehicles and models were progressively measured utilising the new WLTP suite, which applies more stringent test conditions and hence, for the vast majority of cases, results in higher, more accurate emissions figures for vehicles. As EU vehicle emissions targets noted above are based on older NEDC measures, an ongoing process of conversion and comparison will occur over 2020 to ensure comparable results[57].

At a macro level, the EU is committed to reducing overall greenhouse gas emissions by 40 percent from 1990 levels by 2030. While emissions reduction will occur across many sectors of the overall EU and member state economies, the transport sector will likely see significantly increased attention over the coming decade – over the period 2005 to 2018 reductions have been extremely limited, and for every year since 2014 sector emissions have increased due to the growing demand for passenger and freight transport, while in both 2017 and 2018 the average CO_2 emissions of new passenger cars increased[58]. The European Commission remains concerned that current efforts are not sufficient to meet long term goals[59]. Accordingly, the pressure on regulators to achieve meaningful reductions will likely only increase over the medium term, and hence so too will the demand for lithium derived from the EV sector.

At a national level, individual member states have implemented a variety of incentives, subsidies and other measures to accelerate EV adoption in their domestic economies. While a comprehensive analysis of all measures is beyond the scope of this report, an overview of major national policies is provided in Table 5[60] below. This summary does not include subsidies, benefits, rebates and other incentives that may apply to the provision of EV charging

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[55] European Commission, *Reducing CO2 emissions from passenger cars - before 2020*, published EC Climate Action Division, website accessed April 2020

[56] European Commission, *Reducing CO2 emissions from passenger cars (2020 onwards)*, published EC Climate Action Division, website accessed April 2020

[57] European Automobile Manufacturer's Association, *Transition Timeline: From NEDC to WLTP*, published https://www.wltpfacts.eu/, website accessed April 2020

[58] European Environment Agency (2020), *Member States must cut emissions across all sectors to achieve EU climate targets by 2030*, 10th March 2020

[59] European Environment Agency (2020), *Transport: increasing oil consumption and greenhouse gas emissions hamper EU progress towards environment and climate objectives*, Briefing no.15/2019, published public domain 3rd February 2020

[60] European Automobile Manufacturer's Association (2019), *Electric vehicles: tax benefits and incentives in the EU (2019 update)*, 14th May 2019; Lutsey, N (2017), *Integrating elective vehicles within US and European efficiency regulations*, Working paper 2017-07, International Council on Clean Transportation, 22nd June 2017; Balzhäuser, S (2020), *EV and EV Charger Incentives in Europe: A Complete Guide for Businesses*, Wallbox Corporation, 31st March 2020; industry sources (pers.comm). Table includes UK incentives as at published date.

infrastructure, as this would have only second-order effects on lithium demand. However, these incentives are also in many cases quite substantial, and will likely further contribute to the accelerated future demand for EVs by enabling greater consumer confidence. Nor does Table 5, include policy measures that are COVID-19 stimulus responses such as France's 16 percent increase in private EV subsidies for the period 1 June to 31 December 2020.

TABLE 5 - SUMMARY OF MAJOR EU NATIONAL-LEVEL EV POLICIES

Nation	Purchase subsidies	Taxation & regulatory benefits
Belgium	Wallonia, Flanders: 30% rebate up to €3,500-4,000	Flanders: EVs exempt from registration tax. National: BEVs exempt from ownership tax, 120% cost deductible for corporate fleets.
Denmark	Public sector - Danish Energy Agency subsidises municipality purchases of EV fleets.	80% discount on registration tax until 2022 for vehicles under appx. €54,000; sliding-scale reduction on ownership tax (BEV -> PHEV -> petrol/diesel); EVs exempt from parking fees up to €670 p.a.
Finland	€2,000 rebate on new BEVs under €50,000; semi-regular 'scrapping schemes' (2015, 2017, 2018, expected 2020) offering additional rebate sup to €2,000 when replacing petrol/diesel with BEV.	Eco-tax – since September 2018 fuel tax charged, tripling petrol prices.
France	Subsidies up to €6,000 for low-emissions vehicles; 'scrapping scheme' additional rebate up to €5,000 for replacing old diesel or petrol with EV; €1,000 rebate for PHEVs.	EVs eligible for 50%-100% discount on per-region license plate registration fees; EVs exempt from company car taxes; free EV parking in many municipalities (eg Paris).
Germany	Subsidies up to €6,000 for EVs; one-off subsidy of up to 50% of the cost of purely electric commercial delivery vehicles until 2030.	BEVs exempt from ownership tax for ten-year period following first registration, tax incentives to enable use of company EVs for private purposes.
Italy	Subsides of up to €4,000 for purchase or lease of low emission vehicles in M1 category (regular passenger), rising to €6,000 if scrapping older vehicle.	EVs exempt from 'pollution tax' levied on new vehicle purchases 2019-2021; EVs exempt from registration tax for five year period following first registration, 75% discount thereafter; local free parking schemes.
Republic of Ireland	Subsidies of up to €5,000 for BEVs.	Reduced vehicle ownership and registration taxes on EVs.
Luxembourg	Subsidies of up to €5,000 for zero-emission vehicles, smaller amounts for bikes and mopeds.	Reduction on vehicle ownership tax proportionate to CO_2 emissions; corporate fleet expenses for EVs deductible from corporate income.
Norway	No subsidies on purchase price, but >10,000 public charging points at every 50km on public roads.	No VAT or purchase tax on EVs; up to 90% discount on annual road tax; 50% discount on company car tax for EVs; exempt from acquisition taxes; locality-based exemptions

Nation	Purchase subsidies	Taxation & regulatory benefits
		and discounts for ferries, parking, tolls and other fees.
Spain	Up to €5,500 subsidy for BEV purchases where old petrol/diesel vehicle decommissioned; up to €15,000 for low-emissions heavy commercial vehicles.	No registration tax on BEVs; road tax exemptions or reductions varying by locality; EVs exempt from national highway tolls.
Sweden	Subsidies of 25% of purchase price (up to €6,000) for EVs.	Vehicle tax to be increased for petrol/diesel vehicles from 2019, EVs exempt.
Netherlands	Subsidies up to €6,000 for EV purchases, to be phased down to €2,200 by 2030; further subsidy of up to €2,000 for publicly used EVs.	EVs exempt from purchase tax; BEVs exempt from ownership tax and PHEVs 50% discount; company car tax dropped 18% to 4% total for BEVs; phased rollout of additional vehicle tax for petrol/diesel vehicles; from 2030 only BEVs will be allowed to register (new petrol/diesel banned).
United Kingdom	Subsidies up to 35% of cost of passenger EV (up to £4,500), 20% of cost of van (up to £8,000).	BEVs under £40,000 exempt from road tax; 100% of cost of low-emission vehicles can be written down; lower company car tax rates for low-emissions; locality-based exemptions from congestion and parking fees (eg London).

Despite ongoing uncertainty surrounding the global impact of COVID-19 (see Section 5), the underlying fundamentals of the European EV market strongly support future accelerated growth. While the impact of alternate renewable fuel sources – principally hydrogen fuel cells – may account for some of the projected future demand, the preponderance of subsidies and incentives targeting EV purchase and ownership tend to suggest that the European market will continue to prefer EVs for light passenger and commercial use. Indeed, some commentators and analysts are predicting EV sales in the EU to increase at an annual growth rate of 47 percent over the medium term and the market share of EVs in the EU to surpass 10 percent by end 2020[61].

Accordingly, for as long as the presently aggressive pro EV adoption policy framework remains in place, Europe will form an increasingly important market EV batteries. Importantly, a higher portion of European EV products are those that require the battery performance characteristics that can only be delivered by nickel-rich cathode chemistries.

2.3.2. Energy storage market

While demand for electricity has reduced as a result of COVID-19, related economic shutdowns, slowdowns and project disruptions, the impact on the energy generation sector has not been distributed equally.

In an acceleration of an ongoing trend, renewables have increased their proportional share of total power generation by a large margin. Per European Network of Transmission System

[61] Hattrup-Silberberg, M. (2020), *Electric Vehicle Index: Europa wird zum Hotspot der Elektromobilität*, McKinsey & Company, 2nd March 2020

Operators for Electricity (ENTSO-E) data, coal-based power generation has seen a year-on-year declined of over one-quarter in Q1 2020 compared to Q1 2019, while renewables have increased by around 10 percent. In the United Kingdom and across EU, the share of total generation made up by renewable sources has increased to 43 percent. In a sign this trend may be accelerating, for the one-month period from early March to April 2020 coal generation was down by nearly 30 percent in year-on-year terms, accounting for a share of only 12 percent of the total, while renewables surged by 8 percent to make up 46 percent of total generation[62].

In the main, this trend and proportional growth is easily explained by the dynamics of renewable generation: once initial capital outlays are past, ongoing power generation is, for most forms of renewable energy, essentially free. By contrast, fossil fuel-based generation requires ongoing purchases of feedstock such as coal and oil. In a climate of reduced demand, and hence in most deregulated electricity markets reduced prices, fossil fuel-based generators are incentivised to trim costs and hence reduce supply, an economic calculus applying not at all to renewable generators, or if so to a much lesser degree.

The current circumstance present three potential broad outcomes energy mixture in major economies going forwards, and hence by implication the lithium sector.

Firstly, the unprecedented increase in the proportionate share of renewable generation in Europe, reaching levels not thought to occur under many modelling scenarios until the mid to late 2020s, goes some way towards demonstrating that current transmission grids, load-balancing and associated energy infrastructure are capable of handling high levels of intermittent and variable renewable generation. For example, in Germany, a nation with a notable industrial sector and commensurately high-power needs, renewables are currently providing 60 percent of total power generation[63]. As a result, it is possible that regulators may adopt a higher risk appetite in approaches to increased renewable generation – already accepted globally as the cheapest form of new power generation – than previously exhibited, accelerating the global transition to renewable generation.

Second, with a higher current and likely future share of renewable generation, there may be increased pressure on end users and providers – both national grids and private owner-operator generators – to convert instantaneous generation to stored energy for future usage or arbitrage. While there are varying means of achieving energy storage, using current technology this will naturally lead to a higher demand for lithium for larger and grid-scale battery energy storage systems (ESS).

Thirdly, and alternatively, both policy and industry responses to the post COVID-19 restart of major economies and associated stimulus may, as a result of the priority being immediate activation of large volumes of energy and or an economic or political motivation to stimulate recovery of a domestic fossil fuel and fossil fuel generation industry, result in a return to a pre-COVID generation profile and renewable generation growth rates.

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[62] Wärtsilä Energy Transition Lab (2020), *European responses to COVID-19 accelerate the electricity system transition by a decade*, 17th April 2020

[63] Keating, D (2020), *Renewable Energy Way Up During COVID19 Shutdowns*, Forbes magazine, 17th April 2020

2.4. Summary of the demand outlook

The short and medium term lithium market is likely to be characterised by continued strong growth in demand for lithium in various product forms. Demand for upstream lithium products will continue to be driven primarily by the EV market, with ESS also being a significant, albeit less certain driver of demand. While off to a slower than expected start, expected significant increased adoption of nickel-rich battery chemistries as the preferred technology platform for EV batteries over the coming decade, combined with longer-term continued growth in demand for EVs presents strong underpinning fundamentals for Western Australia's spodumene concentrate, pathway for development of an economically sustainable lithium hydroxide manufacturing sector and potentially future cathode precursor manufacturing, albeit these chemical operations will continue to face significant competition from particularly Asian counterparts (see Section 4)

However, it is abundantly clear from the analysis in this Section 2, that while consumer and business preferences are important factors in demand for electric vehicles and determining the product attributes that are facilitated by the performance characteristics of a vehicle's battery, EV adoption and manufacturing policy incentives and disincentives are by far the major determinant of EV demand and therefore derived demand for upstream lithium products such as spodumene concentrate and lithium hydroxide.

This market paradigm will likely remain the case at least until there is EV and internal combustion engine (ICE) price parity.

Combined with other factors discussed in subsequent sections of this report, the reduced demand from the world's two largest markets for EVs – PRC and United States – that is only partly offset by growing demand in the EU, is resulting in excess supply of lithium chemicals and the mineral and brine feedstock used in their manufacture. .

This is a significant factor in sustained lower lithium product prices that are threatening the financial viability of the Western Australian lithium industry.

3. Trends, status and outlook for lithium raw materials supply

For the purpose of this report, the term 'lithium raw materials' refers to the immediate outputs of the minerals extraction process such as spodumene concentrate and in the case of brine production, unrefined lithium carbonate.

Primarily as a consequence of limited reporting from some producing countries and a reluctance by some companies to disclose detailed commercially sensitive data, published estimates of global lithium reserves and production can lack precision.. Nevertheless, most estimates reinforce the fact that production (and to a lesser extent prospectivity) remains, in the case of brine resources concentrated in the Latin American 'Lithium Triangle' (Bolivia, Argentina and particularly Chile), and for hard-rock resources in (Western) Australia.

3.1. Global reserves

As illustrated in Figure 14[64] below, known and estimated global lithium resources total some 80 million tonnes of lithium content. While Latin American producers are host to a large majority of this resource, significant uncertainty and reduced investment appetite in the region (primarily due to present and historical sovereign risk and policy settings), as well as notoriously protracted project development processes have led to a greater focus over the medium term on activation of Western Australian hard-rock mineralisations from both an exploration and production perspective.

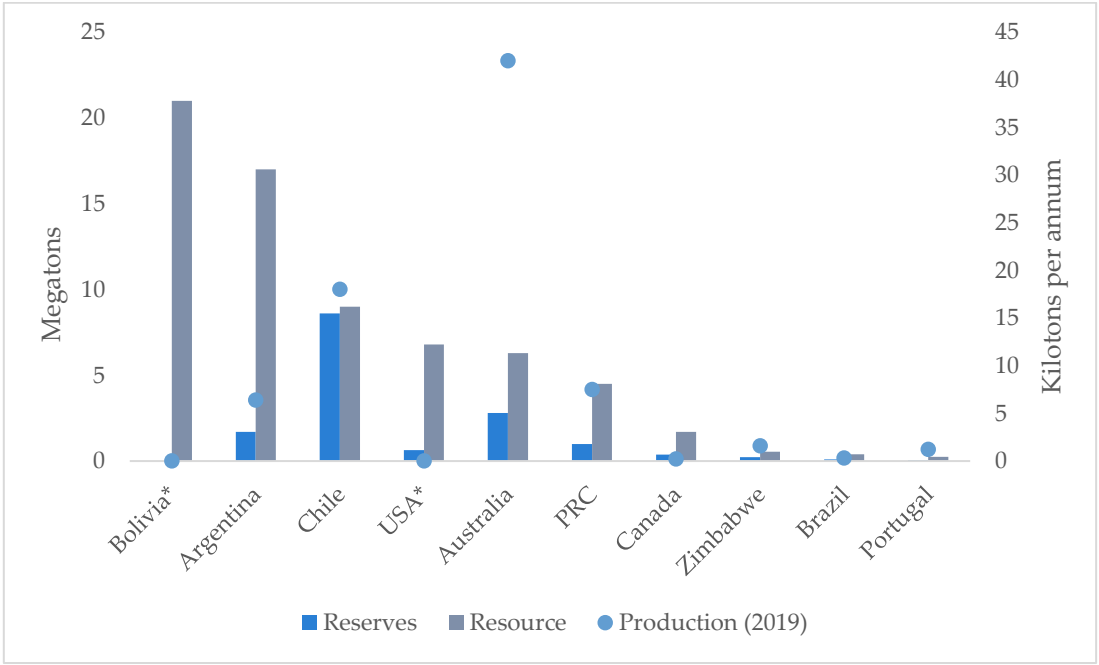

FIGURE 14 - GLOBAL LITHIUM RESOURCES, RESERVES AND 2019 PRODUCTION – MAJOR PRODUCERS (ALL FIGURES EXPRESSED IN TONS OF LITHIUM CONTENT)

[64] Adapted from primary data sourced United States Geological Survey (2020), *Minerals commodity – Lithium (2020)*, United States Government. USA: production figures withheld due to commercial sensitivity. Bolivia: No reliable estimates of mineral reserves; no commercial-scale production and no reliable estimates of state-supported pilot project output.

3.2. Global production

Noting the caution regarding the reliability of production data in the introduction to this section, Table 6[65] below summarises the outlook for lithium production, demand, stocks, strongly indicating that downward pressure on price is likely to continue into the immediate future.

TABLE 6 – GLOBAL LITHIUM PRODUCTION, CONSUMPTION, STOCKS AND PRICE

World	Unit	2018	2019	2020 (est)	2021 (est)	2022 (est)	Annual Percentage Change			
							2019	2020 (est)	2021 (est)	2022 (est)
Lithium production (LCE)	Kt	447	495	439	447	461	10.7	-11.3	1.8	3.1
Consumption	Kt	261	291	343	409	493	11.5	17.9	19.2	20.5
Stockpiles	Kt	638	624	720	758	725	-2.2	15.4	5.3	-4.4
Period of consumption supported by stockpiles	Weeks	127	111.5	109	96.3	76.4	-12.2	-2.2	-11.7	-20.7

Notwithstanding the overall downturn,, as illustrated below in Figure 15[66], industry projections as of late 2019 are that the shift towards hard rock sources for lithium will continue, albeit as a result of the revised production forecasts that are in response to the current oversupply, this will likely occur at a slower pace that initially anticipated by many forecasters.

[65] Office of the Chief Economist (2020), *Resources and Energy Quarterly – Lithium (March 2020)*, Department of Industry, Science, Energy and Resources, Australian government, Canberra
[66] S&P Global (2019), *Lithium supply is set to triple by 20205. Will it be enough?*, published S&P Global, 24 October 2019

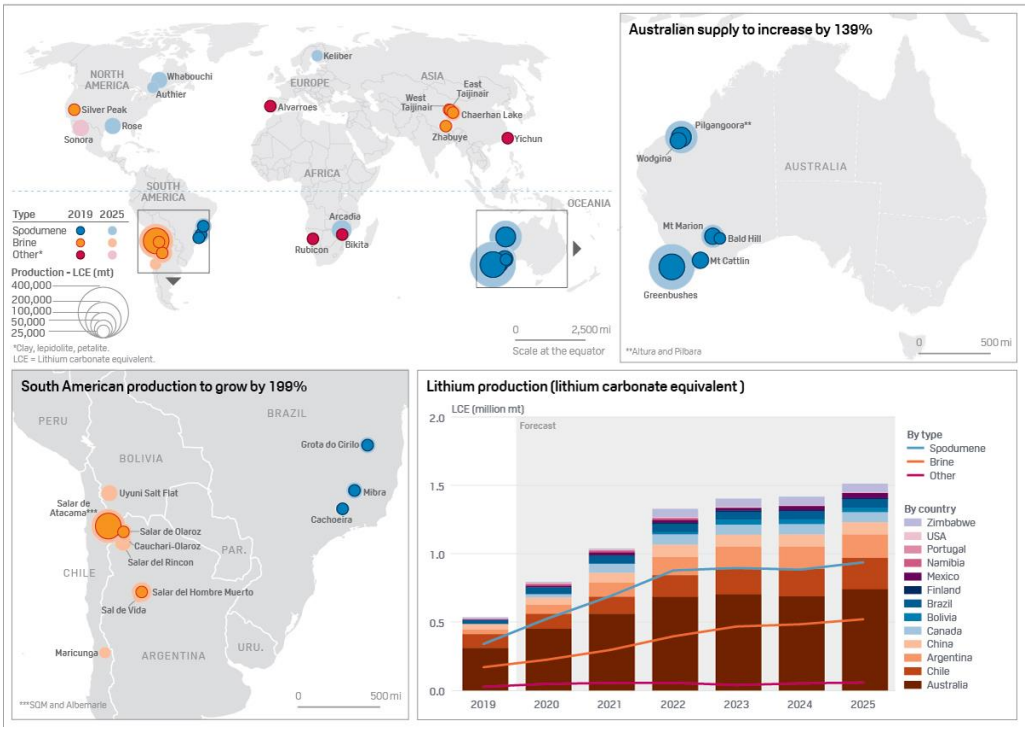

FIGURE 15 - GLOBAL LITHIUM PRODUCTION FORECASTS

3.2.1. Latin American Brine production

While future market requirements may favour alternate production sources and methods (particularly if global markets continue to preference lithium hydroxide over carbonate as mentioned in Section 2.1.1 and discussed in more detail in Section 4), at present production from the 'lithium triangle' is critical for global stocks of the metal. A majority of this supply – approximately one-third of total international supply – derives from deposits in the Atacama region and surrounding playas, situated at the intersection of the Bolivian, Chilean and Argentinian borders.

As shown earlier at Figure 14, while each nation member of the lithium triangle hosts globally significant lithium resources underlying the playas and salt lakes of the region (estimated at over half of global resources), the vast majority of current Latin American production derives from Chilean operations sited on the Salar de Atacama and operated by Sociedad Quimica y Minera de Chile (SQM) and Albemarle (and prior owner Rockwood).

While a detailed historical summary of the production climate in the region is beyond the scope of this report, primarily this circumstance has come about as the result of historical differences in attitudes to foreign investment in and control of resources extraction, paired with sovereign risk factors between the three nations - while their known resources are approximately double the size of those in Chile, until recent years Argentina and Bolivia have been notably less 'open for business' than Chile – and notoriously long project development phases associated with large-scale brine projects.

Chile

While political development in Chile over the past five years have presented a challenging environment, investments in increased Brine production capacity have continued with Albemarle having recently invested USD $800 million in expanding capacity and SQM similarly

having expanded, indicating intentions to expand further. . As Chile is generally considered to present the least sovereign risk of the Lithium Triangle jurisdictions, recent events that affect perceptions of sovereign risk in Chile are worth noting in the context of this study.

Commencing in around 2014, relations between the then-Chilean Bachelet government and former state-owned miner SQM became strained across a number of regulatory and policy fronts. Fellow Chilean producer Albemarle also encountered difficulties, as negotiations with the Chilean State development agency, Corporación de Fomento de la Producción (CORFO, responsible for setting production quotas) bogged down, and changes to environmental regulation and policies impacted operations of both lithium miners[67].

In December 2016, negotiations between CORFO and Albemarle concluded successfully, with Albemarle being permitted to increase brine production to 2 million metric tonnes LCE, and up to 80,000 metric tonnes of battery grade lithium salts (carbonate and chlorides) from its La Negra facilities. However, Albemarle is required to offer up to 25 percent of total annual production to domestic Chilean lithium refiners and battery chemicals manufacturers at a preferential rate, and is subject to a new royalty system under which royalty rates can rise as high as 40 percent of the portion of FOB sale value attributable to materials sold at values over USD $10,000 per tonne (LCE)[68].

An outcome similarly favourable to the Chilean government was reached with SQM in 2018, with SQM permitted to produce an additional 1.86 million metric tonnes LCE over the period out to 2030 and triple annual production to 216,000 tonnes per annum, in exchange for settling arbitration for USD $17.5 million, providing $15 million in funds to support local communities, committing up to USD $18.9 million in in-country R&D expenditure, and providing 25 percent of output to Chilean-based downstream manufacturers on similar terms to Albemarle, as well as committing to a reportedly very similar sliding royalty scale[69].

As a result, the potential output of Chilean production has increased significantly. Although the new royalty structure carries some increased pricing risk, lithium salt production costs remain significantly lower than hard-rock production costs. Furthermore, even with a more 'nationalised' approach to lithium industry development policy (including pursuit of an opportunistic 'case-by-case' approach to royalties[70]), investment in production capacity is ongoing.

Bolivia and Argentina

Outside of Chile, while Bolivia and Argentina remain highly prospective for lithium production, over the short term it is unlikely that any significant increase in brine output will occur before mid-2022. Apart from country-specific and historical issues noted below, further complicating

[67] Esposito, A (2016), *Chemicals firm SQM asks Chile to block Albemarle lithium project,* Reuters, 6th May 2016

[68] McCormick, M (2017), *Albemarle to pay Chile royalties on lithium* sales, Industrial Minerals, 10th January 2017; Sherwood, S (2018), *Chile weighs arbitration with top lithium producer Albemarle*, Reuters, 4th October 2018

[69] Roskill (2018), *Lithium: CORFO and SQM settle differences, agree new Salar de Atacama licence*, published 24th January 2018

[70] Cambero, F (2019), *Royalties for lithium to be set case by case in Chile – minister*, Reuters, 30th April 2019

matters are mandatory national quarantines enacted in both nations in response to COVID-19.

In Bolivia, the policy of '*¡100 percent Estatal!*', originally implemented in 2008, seeks to ensure that the Bolivian State will retain full ownership of mineral resources and production. As a result, there were no realistic prospects of Bolivian lithium production until 2018, when ACI Systems Alemania announced a USD $1.3 billion joint venture partnership to develop the Salar de Uyuni, the world's largest known lithium brine resource. However, political instability soon prevented any further action, with the centre-leftist Morales government rescinding the joint venture by decree on 4th November 2019, a coup on 10th November, and a new Añez centre-right government installed reported to be sympathetic to resuming previous arrangements, although yet to make any formal announcement.

Meanwhile in Argentina, the 100 percent Ganfeng Lithium owned Caucharí-Olaroz project (formerly a 50 percent joint venture with Lithium Americas), with a nameplate capacity of 40,000tpa lithium carbonate, has incurred delays sourcing components from the PRC and as a result estimated completion has been deferred to end of 2021. Accordingly, full production is not expected until 2022[71] and will likely ramp over that year. Galaxy's Sal de Vida project is understood to still be at pilot stage, with Final Investment Decision (FID) not expected until late 2020 and first production not before 2022[72], although already delivering returns for Galaxy with the unproven northern tenements (not forming part of project reserves) sold to POSCO for USD $280 million[73]. The Arizaro and Sal de los Angeles projects, now also majority owned by Hong Kong-based Nextview New Energy following a 2018 takeover of Canadian-listed Lithium X, are understood to be still in scoping and exploration, while Albemarle's Antofalla project is still at exploration stage and as at end of 2019 the resource has still not yet been fully defined[74].

Accordingly, the sole Argentinian producer of significant scale remains Orocobre, with production of approximately 12,000 tonnes per annum of lithium carbonate from the Olaroz project as at end of 2019. Expansion works are ongoing, with a USD $300 million Stage 2 expansion under way to increase nameplate capacity to approximately 25,000 tonnes per annum, albeit commissioning is not expected until the second half of 2021[75]. The company is simultaneously consolidating its lithium stake in Argentina, acquiring former joint venture partner Advantage Lithium in a share buyout to take 100 percent ownership of the Cauchari prospect adjacent to Orocobre's existing operations (containing a JORC-compliant measured resource of 4.8 million tonnes LCE)[76].

3.2.2. Prospective North American production

At present, North America is not a globally significant producer of lithium, with negligible production from the United States. A small number of projects appear likely to deliver small-

[71] Webb, M (2020), *China equipment delay hits Caucharí-Olaroz construction timeline,* Mining Weekly, 13th March 2020
[72] Galaxy Resources (2020), *Galaxy corporate strategy and projects update*, ASX release 18 November 2019
[73] Creagh, B, *Galaxy makes US$280m lithium deal with POSCO*, Australian Mining, 29th May 2018
[74] Abermarle Corporation (2019), *Albemarle Resource – Antofalla*, in *Albemarle Investor Day* presentation, 12 December 2019
[75] Orocobre Ltd (2020), *Olaroz Stage 2 Expansion Project 25% Complete* in *2020 Half-Year Financial Results*, ASX release 21 February 2020
[76] Orocobre Ltd (2020), *Orocobre Agrees to Acquire Advantage Lithium Corp.* , ASX release published 19th February 2020

scale commercial production of predominantly lithium carbonate over the mid-term, however some uncertainty remains given recent development history and novel production processes proposed to be utilised.

Meanwhile, Canada and Mexico, both once highly prospective for lithium and an exploration target for a number of established and junior miners, have seen little development in recent years. While significant volatility remains in the sector, investor appetite appears depressed, and outside the already well-advanced James Bay and Authier spodumene projects, commercial production over the mid-term is thought unlikely.

United States

While the United States holds sizeable lithium reserves, it has never achieved significant production levels, currently responsible for less than 2 percent of global supply[77]. The Albemarle Silver Peak brine operation in the state of Nevada, with an output of up to 5,000 tonnes per annum[78] LCE, is currently the sole domestic lithium producer[79]. With United States based industry thus largely dependent upon international partners to meet lithium demand, this situation has resulted in sporadic but recurring public and private-sector interest in boosting domestic production, increasingly so with the proliferation of lithium-exposed and reliant sectors.

Under the mercantilist policies of the Trump administration, self-sufficiency has become a particular focus. In response to the December 2017 *Executive Order 13817* issued by the Trump Administration, the United States Department of Commerce has developed a 'Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals', released in June 2019, which identifies particular priority areas[80]. 31 of 35 minerals designated by the Department of the Interior as 'critical' are regarded as heavily import-reliant, including lithium[81], with high levels of imports from Chile and Argentina required to meet demand from domestic manufacturers. The Strategy establishes a number of short- and medium-term goals to boost domestic supply and to encourage local industry to occupy more of the upstream mining and metallurgical extraction lithium supply chain, and prospectively the downstream chemical refining, cathode precursor and cell manufacture supply chain.

However, the prospects of any significant production increase from the United States appears mixed over the short term and are primarily focused on further development of existing known resources in the Nevada region. Most prospective lithium operations are based on brines located in the Clayton Valley region, adjacent to the existing Silver Peak project, and include Pure Energy Minerals (PEM), Marquee Resources Limited, Spearmint Resources, Cypress Development Corporation, Noram Ventures and ioneer.

Pure Energy Minerals

A relatively recent market entrant, Vancouver-based Pure Energy Minerals (PEM) is majority owned by Lithium X and has pursued an accelerated project acquisitions process targeting

[77] Cypress Development Corp. (2020), *Projects: Clayton Valley Lithium Project – From Drilling to PEA in under 2 years*, accessed April 23 2020
[78] *Investor Presentation* (2020), Albemarle Corporation, April 23 2020
[79] *Mineral Commodity Summary: Lithium* (2020), United States Geological Survey, April 23 2020
[80] Department of Commerce (2019*), A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals,* United States Government, 4 June 2019
[81] *Lithium Deposits in the United States: U.S. Geological Survery data release* (2019) ScienceBase-Catalog, 22 April 2020

Nevada brines. An asset purchase agreement in late 2017 allowed PEM to acquire the Clayton NE claim blocks from Advantage Lithium and Nevada Sunrise, providing the impetus for a later earn-in agreement penned in May 2019[82] between PEM and Schlumberger Technology Corporation (SLB). Under the agreement, SLB holds options to acquire all of PEM's lithium interests, providing a pilot plant is constructed, tested and developed by SLB at their own cost, and must demonstrate capacity to process lithium-bearing brines at a specified rate, while PEM are entitled to 3 percent of net returns on production from Clayton Valley[83]. Once operational, the mine is expected to produce an estimated 10,000 tonnes LCE per annum[84], with PEM announcing in November 2019 that SLB had commenced initial steps to develop the Clayton Valley project[85].

Cypress Development Corporation

Cypress Development Corporation, also based in Vancouver, completed a Preliminary Economic Assessment (PEA) for their Clayton Valley project at the end of 2018, with a total measured and inferred Mineral Resource of 5.1 million tonnes of LCE[86]. In early 2020 the company commenced a pre-feasibility study for the project, aiming to further demonstrate the battery suitability of high purity lithium carbonate and hydroxide produced by the project and define a mineral reserve.

Marquee Resources

Marquee Resources (MRL) currently hold mineral claims that sit near the south-eastern edge of the Clayton Valley salt pan[87]. The company has the right to acquire the claims at any point, stating their goal to uncover one or more economic deposits and develop these opportunities into production in the future[88]. However, in December 2019, MRL announced that no additional exploration had been undertaken in the second half of the year, after consultation with their geologists[89], followed by further announcements in April 2020 that no additional exploration work had been carried out in the quarter[90]. The company did, however, suggest that negotiations had taken place with unnamed parties interested in the potential acquisition of the project[91].

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[82] Pure Energy Minerals (2019), *Pure Energy Minerals provides update on the Clayton Valley Project*, accessed April 23 2020
[83] International Mining (2019), *Schlumberger eyes up Nevada lithium brine project,* accessed April 23 2020
[84] Mining Technology (2019), *Clayton Valley Lithium Project, Esmerelda County, Nevada*, accessed April 23 2020
[85] Pure Energy Minerals (2019), *Pure Energy Minerals provides update on the Clayton Valley Project*, accessed May 4 2020
[86] Cypress Development Corp. (2020), *Projects: Clayton Valley Lithium Project – From Drilling to PEA in under 2 years*, accessed April 23 2020.
[87] Marquee Resources (2020), *Clayton Valley – Lithium (100%) USA,* Marquee Resources Ltd, accessed May 4 2020
[88] Marquee Resources (2020), *Clayton Valley – Lithium (100%) USA,* Marquee Resources Ltd, accessed May 4 2020
[89] Marquee Resources (2019), *Interim Financial Report,* Press release, 31 December 2019
[90] Marquee Resources (2020), *Quarterly Activities Report March 2020,* Press release, 29 April 2020
[91] Marquee Resources (2020), *Quarterly Activities Report March 2020,* Press release, 29 April 2020

PrivateCo/Spearmint Resources

In 2016, Canadian-based Spearmint Resources Inc. acquired 100 percent of shares in PrivateCo, holder of two properties bordering PEM Clayton Valley project thought to be prospective for rich lithium brine[92]. The two separate claim blocks, known as Elon and McGee, cover approximately 800 acres[93]. In April 2018 Spearmint announced it had completed exploration drilling on its Clayton Valley Lithium Prospects[94], although though no overall mineral resource estimate has yet been reached, and in January 2020 the company released an update declaring their plans to initiate operations on its lithium claims[95].

Noram Ventures

Located adjacent to Albemarle's Silver Peak project lies the Zeus lithium property owned by Noram Ventures[96]. Four phases of exploration works between 2016 and late 2019 have firmed a total indicated and inferred resources of 1.18 million tonnes (LCE)[97]. In late February 2020 Noram announced plans were in place for a further Phase 5 drilling works to be carried out[98], with intentions to proceed to a PEA in 2021[99].

Ioneer

The Rhyolite Ridge Lithium-Boron Project is situated 25km west of the Silver Peak lithium mine, halfway between Reno and Las Vegas, southern Nevada. New owners Australian-based ioneer Ltd secured ownership in 2017[100], with a pre-feasibility study completed in October 2018 supporting a two-stage mine development and a mine life of 30 years[101]. In late 2018 a maiden JORC-compliant mineral reserve was announced[102], later to be upgraded in June 2019[103] and April 2020 to 580,000 tonnes contained LCE[104].

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[92] Newsfile Corp. (2016) *Spearmint Announces acquisition of Nevada lithium claims,* CEO.CA, 13 July 2016
[93] Spearmint Resources Inc. (2020), *The "Clayton Valley Lithium Prospects"*, Projects, accessed 1 May 2020
[94] Spearmint Resources Inc. (2020), *The "Clayton Valley Lithium Prospects"*, Projects, accessed 1 May 2020
[95] Spearmint Resources Inc. (2020), *Spearmint looking to recommence operations on its Clayton Valley lithium prospects in Nevada*, Press release, 30 January 2020
[96] Noram Ventures (2019) *Updated resource estimate significantly expands Noram's Zeus Lithium deposit, Clayton Valley, Nevada,* Press release, 21 February 2019
[97] Noram Ventures (2019), *Noram announces new resource estimate for Zeus lithium deposit,* Press release, 5 February 2020
[98] Noram Ventures (2020), *Noram announces plans for Phase 5 drilling of Zeus lithium deposit,* Press release, 26 February 2020
[99] Noram Ventures (2020) *Advancing lithium properties in North and South America,* Corporate Presentation, April 2020
[100] Ioneer (2017), *Company History*, accessed 4 May 2020
[101] Ioneer (2018), *Rhyolite Ridge Drilling Update and Maiden Ore Reserve*, ASX release, 21 December 2018
[102] Ioneer (2018), *Rhyolite Ridge Drilling Update and Maiden Ore Reserve*, ASX release, 21 December 2018
[103] Ioneer (2019), *Rhyolite Ridge Mineral Resource Upgrade,* ASX release, 26 June 2019
[104] Ioneed (2020), *Rhyolite Ridge Ore Reserve Increased 280% to 60 million tonnes*, ASX release, 30 April 2020

A pilot lithium processing plant has been built, with first output in June of 2019[105] supporting a definitive feasibility study that was finalised and announced on 30th April 2020. With construction planned to commence in mid-2023, the DFS suggests a mixed hydroxide/carbonate design, with 20,000 tonnes per annum of lithium carbonate over years 1-4 of operation converting to 22,000 tpa lithium hydroxide from year 4 onwards[106]. Leveraging the value of contained boron, ioneer estimate an all-in sustaining cost of approximately $2,510/tonne, placing the Rhyolite Ridge project at the bottom of global cost curve for lithium carbonate production[107]. On the strength of offtake agreements with unnamed parties[108], commissioning and product shipment is expected in the second quarter of 2023[109].

Non-Nevada brines and other sources

Outside the Clayton Valley, four additional projects are at a reasonable level of development, representing a combined approximately 100,000 tonnes per annum of nameplate lithium production (LCE) by the mid-2020s if all proceed to construction.

The Thacker Pass Lithium Project, formerly known as the King Valley project, is now 100 percent owned by Lithium Americas through subsidiary Lithium Nevada, following a merger with former owner Western Lithium in 2015. Located in Humboldt County in Northern Nevada, the deposits of lithium-rich clays are thought to be one of the largest single deposits known in the United States, with initial estimates placing the measured and indicated resource at 5.98 million tonnes of contained LCE[110]. All major permits expected by end of 2020[111] and a DFS to be completed by mid-to-late 2020. A staged construction process is envisaged, with Phase 1 (nameplate 30,000 tonnes per annum LCE) construction set to commence in 2021 and be operational by 2023, followed by Phase 2 expansion to 60,000 tonnes per annum by 2026[112]. While initial plans have focused on lithium carbonate production, Lithium Americas is reportedly considering switching to hydroxide production instead, at around 20,000 tonnes per annum of lithium hydroxide, to be informed by ongoing discussions with potential customers as to market demand[113].

Located in the North Carolina Tin-Spodumene Belt, joint ASX- and NASDAQ-listed Piedmont Lithium is developing a potential North American spodumene mine, focused on domestic lithium hydroxide production[114]. As of early 2020, exploration undertaken has defined a mineral resource of 27.9 million tonnes @ 1.11% lithium[115], with company representatives suggesting

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[105] Ioneer (2019), *Battery-grade lithium hydroxide successfully produce from Rhyolite Ridge lithium-boron ore,* ASX release, 11 June 2019
[106] Ioneer (2020), *Rhyolite Ridge Definitive Feasibility Study Announcement,* ASX release, 30 April 2020
[107] Ioneer (2020), *Rhyolite Ridge Definitive Feasibility Study Announcement,* ASX release, 30 April 2020
[108] Ioneer (2019), *Pilot Plant and DFS Developments,* ASC release, 1 October 2019
[109] Ioneer (2020), *Rhyolite Ridge Definitive Feasibility Study Announcement,* Investor Presentation, 30 April 2020
[110] Lithium Americas (2020), *Thacker Pass,* accessed April 23 2020
[111] Lithium Americas (2019), *Cauchari-Olaroz 40,000 TPA DFS & Thacker Pass Update*, Press Release, 1 October 2019
[112] Lithium Americas (2020), *Thacker Pass,* accessed April 23 2020
[113] Litjhium Americas (2020), *Lithium Americas receives Notice of Intent for the Thacker Pass Lithium Project,* Press Release, 21 January 2020
[114] Piedmont Lithium (2020), *About*, Piedmont Lithium, accessed 5 May 2020
[115] Piedmont Lithium (2020), Piedmont reports new spodumene pegmatite discoveries and final Phase 4 drill results, ASX release, 28 January 2020

scope for further increases. A scoping study carried out in mid-2019 supports a mine and concentrator producing 160,000 tonnes per annum of 6 percent spodumene concentrate, supplying an on-site hydroxide chemical plant with a nameplate capacity of 22,700 tonnes per annum lithium hydroxide[116]. An updated PFS is currently in progress, expected to be completed by mid-2020[117].

Control Thermal Resources Limited (CTR), joint headquartered in California and Brisbane, have embarked upon a joint venture with US start-up Lilac Solutions to explore geothermal lithium underlying at Salton Sea in Imperial Valley, south-east California[118]. Termed the Hell's Kitchen Lithium and Power Project[119], the partners aim to deploy novel ion exchange bead technology to extract lithium from brine resources while generating power from the underlying geothermal resource, and have received a USD $20 million investment from Breakthrough Energy Ventures to develop the technology[120]. Still in early exploration and scoping, the parties are optimistic regarding cost of production[121], with projected production expected of around to 17,350 tonnes per annum LCE at Stage 1 reaching 34,000 tonnes per annum LCE once Stage 2 is complete[122]. While no definitive timelines appear to have been set, as of early 2020 the parties aim for construction of the Stage 1 integrated lithium extraction and power generation facility to be completed by 2023, with Stage 2 completed by 2025[123].

Through subsidiary Lithium Inc, Perth-based Anson Resources are developing a brine project in the Paradox Basin, situated at the intersection of Utah, Colorado, Arizona and New Mexico[124]. Again in partnership with Lilac Solutions[125], Anson proposes to utilise ion exchange technology to liberate lithium from brines, in either hydroxide or carbonate form, with pilot production in 2019 proving successful and samples sent to potential offtake partners[126]. Preliminary Economic Assessment (PEA)for the project is expected to be completed by end of April 2020, to be followed by a pre-feasibility study, both of which will focus on the first stage of development, the construction of a 700 tonne per annum lithium and 15,000 tonne per annum bromine chemicals pilot plant[127]. If feasible, Stage 2 development will use revenue generated from the first stage to complete a 15,000 tonne per annum lithium and 60,000 tonne per annum bromine plant[128].

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[116] Piedmont Lithium (2019), *Updated scoping study extends project life and enhances exceptional economics,* ASX release, 7 August 2019
[117] Piedmont Lithium (2020), *March 2020 Quarterly Report,* ASX Release, 29 April 2020
[118] CTR (2020), *CTR and Liliac Solutions set to unlock massive clean lithium resource in the U.S.,* Press release, accessed May 4 2020
[119] CTR (2020), *Projects,* accessed 5 May 2020
[120] Roth, S (2020), *Lithium start-up backed by Bill Gates seeks a breakthrough at the Salton Sea,* Los Angeles Times, 16 March 2020
[121] CTR (2020), *CTR and Liliac Solutions set to unlock massive clean lithium resource in the U.S.,* Press release, accessed May 4 2020
[122] CTR (2020), *Projects,* cthermal.com, accessed 5 May 2020
[123] CTR (2020), *Project Light – Lithium & Power: Information Memorandum*, Press Release, Q12020
[124] Anson Resources (2020), *A unique lithium project in an excellent jurisdiction,* Anson Resources, accessed 6 May 2020
[125] Anson Resources (2020), *A unique lithium project in an excellent jurisdiction,* Anson Resources, accessed 6 May 2020
[126] Anson Resources (2020), *Half-Year Report,* ASX release, 31 December 2019
[127] Anson Resources (2020), *Anson advances Project to PEA/PFS,* ASX release, 29 January 2020
[128] Anson Resources (2020), *Anson advances Project to PEA/PFS,* ASX release, 29 January 2020

Canada

Although once a significant focus of exploration and development activity, over the medium term few Canadian projects have transitioned to development, with total production in 2019 of only 200 tons of contained lithium[129], down from 2,400 in 2018, virtually all of which was sourced from the Abitibi and Whabouchi spodumene mines, both now in insolvency or liquidation proceedings.

Québécois hard-rock deposits

One of only two lithium projects formerly producing commercial scale output in Canada, North American Lithium's (NAL) Abitibi spodumene project in Québec has seen a stop-start history, and production has currently been halted since early 2019. Construction on the project first began in 2012 under former owners Québec Lithium (later RGB Energy), but with the company's cash depleted in 2014 before commissioning could be completed RB Energy entered liquidation with debts in excess of CAD $180 million[130]. Through the newly-created NAL entity, the mine and assets were acquired in late 2015 by PRC-based Jilin Jien Nickel Industry Co (JJNI), with state development body Investissement Québec taking a 25 percent stake. While small-scale production restarted in 2017, and some shipments were made to PRC-based customers, by 2018 JJNI had entered bankruptcy, on-selling NAL to PRC-based peer Contemporary Amperex Technology Co. Ltd (CATL; one of the world's largest lithium-ion battery manufacturers) before commissioning was finalised[131]. NAL resumed operations shortly thereafter, but halted production in February 2019 in response to softer spodumene prices[132], seeking bankruptcy protection in May 2019 before entering into court-ordered liquidation in September[133]. While proceedings are currently stayed pursuant to further court orders, Australian-owned mining company Sayona submitted a bid in February 2020 to overtake operations from NAL, citing potential synergies with their hard rock lithium project in Authier, Québec, expecting to derive a nameplate production capacity of 180,000 tonnes per annum (LCE)[134].

The Authier Lithium Project, adjacent to the Abitibi project approximately 45km northwest of mining service centre Val d'Or, was acquired by Sayona in July 2016 from former owner Glen Eagle for a purchase price of CAD $4 million[135]. Following conclusion of a definitive feasibility study in late 2018, Sayona announced a JORC-compliant mineral reserve (proven and probable) of 12.1 million tonnes @ 1.00%, supporting annual production of 87,400 tonnes of spodumene concentrate over an 18-year life-of-mine[136]. An update in November 2019 increased projected mine output to 114,000 tonnes of 6% concentrate over a 14-year lifespan,

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[129] United States Geological Survey (2020), *Minerals commodity – Lithium (2020)*, United States Government

[130] Liu, T (2017), *Jilin Jien and IQ owned North American Lithium closes QT financing*, Private Capital Journal (Canada), 29 October 2017

[131] Roskill (2018), *Lithium: Chinese companies step-up their pursuit of lithium resources*, 19 March 2018

[132] Facada, M (2019), *Lower prices push North American Lithium to pause spodumene production*, Fastmarkets, 21 February 2019

[133] Proceedings relating to North American Lithium Inc, published Raymond Chabot Inc. (in role as Monitor under CCAA), accessed May 2020

[134] Argus Media (2020), *Sayona submits bid for North American Lithium*, accessed April 23 2020

[135] Sayona Mining (2020), *Projects – Authier Lithium Project,* Sayong Mining Ltd., accessed 6 May 2020

[136] Sayona Mining (2018), *Boost for Authier Project as JORC Ore Reserves expand,* ASX release, 24 September 2018

with reduced capital and operating costs[137]. Sayona is understood to be continuing to assess feasibility of on-site lithium carbonate and/or hydroxide conversion facilities in pursuit of a vertically integrated operating model[138], and aims to start construction of the spodumene mine in the near-term, pending regulatory approvals[139].

Located in northern Québec lies the Rose Lithium-Tantalum deposit, owned by Critical Elements Lithium Corporation (CELC). Initial exploratory drilling operations commenced in 2009[140], however it was not until 2017 that a feasibility study was completed, defining an indicated mineral resource of 31.9Mt at 0.93% supporting annual production of around 220,000 tonnes per annum of spodumene concentrate over a 17-year life-of-mine, although only 50,000 tonnes of which would be battery-grade[141]. A factor in the extended development history of the mine is understood to be ongoing consultation with the Cree Nation of Eastmain, seeking to ensure the environmental and social sustainability of the project and an equitable share of benefits realised to the local community[142].

Also located in northern Québec, the James Bay lithium pegmatite project is 100 percent owned by Galaxy Resources. Development of the project is understood to have become a strategic priority for Galaxy[143], and series of feasibility and technical studies over 2019 have defined an Indicated Mineral Resource of 40.3 million tonnes at 1.4%, with the company seeking to model production pathways requiring reduced capital and delivering lower operating costs[144]. Federal and provincial approvals have been sought over 2019[145], while a Pre-Development Agreement with the Cree Nation of Eastman was reached in Q4, with discussions regarding the right to initiate construction and production on native land continuing[146]. As of March 2020, additional engineering works continue to define lowest-cost production pathways from the project[147].

The final significant Québécois project, Nemaska Lithium's Whabouchi project, is located nearby to the Galaxy James Bay project. From a mineral resource (indicated and inferred) of 36.6 million tonnes at 1.30%[148], Nemaska envisaged an integrated production process, with annual production of 215,000 tonnes of spodumene feeding a Shawnigan-based hydroxide

[137] Sayona Mining (2019), *Revised Authier DFS Shows Boost To Profitability*, ASX release, 11 November 2019
[138] Sayona Mining (2018), *Positive Authier Definitive Feasibility Study reaffirms potential of sustainable new lithium mine,* ASX release, 24 September 2018; Sayona Mining (2020), *Expansion strategy – Investor Presentation,* ASX release, 20 April 2020
[139] Sayona Mining (2020), *Projects – Authier Lithium Project,* Sayong Mining Ltd., accessed 6 May 2020
[140] Genivar Inc. (2011) *Technical Report and Preliminary Economic Assessment on the Rose Tantalum-Lithium Project,* Press release, 10 December 2011
[141] CE Corp. (2017), *Feasibility Study – Technical Report,* Press release, 29 November 2017
[142] CE Crop. (2020), *Critical Elements Lithium Corporation's Rose lithium-tantalum project: project update,* Press release, 4 March 2020
[143] Galaxy Resources Limited (2019), *Annual Report,* ASX release, 31 December 2019
[144] Galaxy Resources Limited (2019), *Annual Report,* ASX release, 31 December 2019
[145] Galaxy Resources Limited (2019), *Annual Report,* ASX release, 31 December 2019
[146] Galaxy Resources Limited (2019), *Annual Report,* ASX release, 31 December 2019
[147] Galaxy Resources Limited (2020), *March 2020 Quarterly Activities Report,* ASX release, 23 April 2020
[148] Nemaska Lithium (2019), *Report on the Estimate to complete for the Whabouchi Lithium Mine and Shawinigan Electrochemical Plant Nemaska Project,* Press release, 31 May 2019

plant with nameplate capacity of 37,000 tonnes per annum of lithium hydroxide[149]. A pilot plant commissioned in 2017 has produced small quantities of hydroxide output, with samples reportedly sent to 20 potential offtake partners[150]. However, capital costs to complete the project exceeded the resources of Nemaska, and despite a CAD $1.1 billion finance package negotiated with Japan-based SoftBank Group in April of 2018[151], Nemaska filed for bankruptcy protection in December 2019 as capital costs continued to climb while spot prices declined[152]. In February 2020, senior company figures resigned[153], while as at April 2020 insolvency proceedings continued with no clear exit pathway yet disclosed[154].

Novel petro-chemical lithium sources

Lithium development company E3 Metals Corp (E3) is targeting the development of petrolithium, sourced from mineral-rich brine solutions brought to the surface during oil and gas exploration and production, found in the Leduc Formation in Alberta, Canada[155], recently forming a strategic partnership with Livent Lithium[156]. Scoping works completed during 2017 and 2018 support a total mineral resource of 6.7 million tonnes LCE[157] (measured and inferred). While no firm project timeframe has yet been publicly disclosed, the partners have announced an intention to continue evaluation, exploration and pilot project works over 2020[158], eventually supporting a total project output of approximately 20,000 tonnes per annum (LCE)[159].

Mexico

While Mexico has no commercial-scale production of lithium, two prospective projects are at a reasonably advanced stage – the Salar del Diablo brine project, and the Sonora lepidolite mine. Neither project has yet reached final investment decision stage.

Salar del Diablo

Located in Baja California, the Salar del Diablo project covers approximately 103,000 hectares of underlying lithium brines. Current 60 percent owners Vancouver-based One World Lithium (formerly One World Investments and One World Minerals) acquired the project from former owners Lithium Investments Ltd in July 2017[160], and hold rights to acquire an additional 30

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[149] DRA/Met-Chem (2019), *NI 43-101 Technical Report: Report on the Estimate to Complete for the Whabouchi Lithium Mine and Shawinigan Electrochemical Plant Nemaska Project*, Nemaska Lithium, 31 May 2019

[150] Nemaska Lithium (2019), *Update on Overall Whabouchi Project*, press release, 13 February 2019

[151] Nemaska Lithium (2018), *SoftBank Group to make strategic investment in Nemaska Lithium*, press release, 5 April 2018

[152] Proceedings relating to Nemaska Lithium Inc (and related parties), published PricewaterhouseCoopers Inc. (Canada) (in role as Monitor under CCAA), accessed May 2020

[153] Nemaska Lithium (2020), *Important Change in Management at Nemaska Lithium*, press release, 20 February 2020

[154] Nemaska Lithium (2020), *Update on Nemaska Lithium's Restructuring Efforts Under the CCAA*, press release, 1 April 2020

[155] E3 Metals (2020), *Projects,* E3 Metals Corp, accessed 6 May 2020

[156] E3 Metals (2020), *Unlocking a new source of lithium in Alberta,* Press release, 21 January 2020

[157] E3 Metals (2018), *E3 Metals adds third Petro-Lithium Inferred Mineral Resource, Press release, 3 May 2018*

[158] E3 Metals (2020), *Unlocking a new source of lithium in Alberta,* Press release, 21 January 2020

[159] E3 Metals (2020), *Unlocking a new source of lithium in Alberta,* Press release, 21 January 2020

[160] One World Minerals (2017), *One World Minerals Inc. Announces Closing Of Option To Acquire Up To 90% Interest In Salar Del Diablo Property*, CSE release, 28 July 2017

percent interest through exploration works and issuance of a bankable feasibility study[161]. While initial completion timeframes of 2018 were not met, One World began pre-drilling operations in May 2019[162], with new project operators Montgomery & Associates (M&A), appointed in August 2019 and a four-phase drilling and exploration program put in place, aiming to define the underlying resource and support completion of feasibility studies[163]. While phase one and two have since been completed, third-phase drilling works have been postponed due to Mexican government restrictions prompted by the COVID-19 pandemic, with operations not expected to resume until June 2020[164].

Sonora

A hard-rock lepidolite resource located in northern Sonora, the Sonora Lithium Project is an incorporated joint-venture between London-based Bacanora Lithium (77.5 percent) and Ganfeng Lithium (22.5 percent)[165]. The Project incorporates ten mining concessions, all majority- or wholly-owned by the joint venture entity, and containing a mineral reserve of 8.8 million tonnes (LCE) supporting a 19-year life of mine with annual output of 17,500 tonnes per annum of lithium carbonate, rising to 35,000 tonnes in Stage 2[166]. With production estimated to begin in 2022, all of nameplate stage-1 production capacity has been secured by 10-year offtake agreements, half each with Japan-based Hanwa Corp and Ganfeng Lithium, while between half and three-quarters of projected Stage 2 capacity is subject to a further extended offtake agreement with Ganfeng[167]. Mexican state environmental approvals and water licence permits have been granted[168], with financing discussions still under way.

3.2.3. Western Australian spodumene production

Australia (Western Australia) still dominates global production, with spodumene sourced from Western Australian mines accounting for approximately 50 percent of supply on a LCE basis. However, as summarised in Table 7[169], [170] below, Western Australian production is notably down from earlier peaks in 2017-18 , when Western Australian product represented around 56 percent of global production on a LCE basis.

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[161] One World Lithium (2020), *One World Lithium announces plans to start next phase of drilling and an update from the Mexican Federal Government,* Press release, 29 April 2020
[162] One World Lithium (2020), *Projects – Salar del Diablo Project*, One World Lithium, accessed 7 May 2020
[163] One World Lithium (2020), *Projects – Salar del Diablo Project*, One World Lithium, accessed 7 May 2020
[164] One World Lithium (2020), *One World Lithium announces plans to start next phase of drilling and an update from the Mexican Federal Government,* Press release, 29 April 2020
[165] Bacanora Lithium (2020), *Projects – Sonora Lithium,* Bacanora Lithium, accessed 7 May 2020
[166] Bacanora Lithium (2018), *Technical report on the feasibility for the Sonora lithium project, Mexico,* Press release, 25 January 2018; Bacanora Lithium (2020), *Building a World-Class Lithium Producer*, investor summary, April 2020
[167] Bacanora Lithium (2020), *Building a World-Class Lithium Producer*, investor summary, April 2020
[168] Bacanora Lithium (2020), *Building a World Class Lithium Producer – Bacanora Presentation*, Press release, 1 April 2020
[169] Office of the Chief Economist (2020), *Resources and Energy Quarterly – Lithium (March 2020),* Department of Industry, Science, Energy and Resources, Australian Government, Canberra
[170] Office of the Chief Economist (2019*), Resources and Energy Quarterly – Lithium (December 2019)*, Department of Industry, Science, Energy and Resources, Australian Government, Canberra

TABLE 7 – WESTERN AUSTRALIAN LITHIUM PRODUCTION

Australia	Unit	2017-18	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21
Mine Production (LCE)	Kt	251	249	243	289	-1.0	-2.3	18.9
Export Volume (spod.conc)	Kt	1,105	1,338	1,576	1,859	21.1	17.7	18.0
- Nominal value	A$m	1,582	1,616	1,366	1,579	2.1	-15.5	15.6
- Real value	A$m	1,636	1,643	1,366	1,550	0.5	-16.9	13.5

Western Australian production of lithium has increased dramatically over the medium term as a result of the significant increase in the number of operating projects. Total spodumene increased by 20 percent to 1.3 million tonnes over the 2018–19 period (albeit primarily as a result of direct shipments of ore from newly-established projects), and is forecast to increase from around 1.6 million tonnes in 2019–20 to approximately 1.9 million tonnes by 2020–21, as illustrated in Figure 16[171].

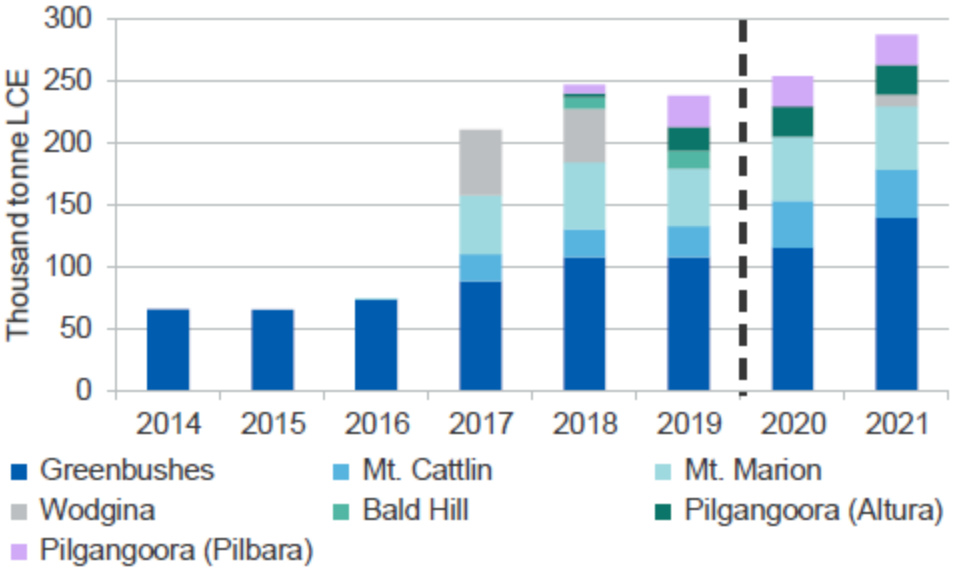

FIGURE 16 – WESTERN AUSTRALIAN SPODUMENE ORE PRODUCTION

However, spodumene concentrate is expected to face challenging market conditions in the immediate term, and this has resulted in a trend for Western Australian producers to delay planned expansions and focus on improving the productivity of existing operations.

As illustrated in the below Table 8, Western Australia's position as the predominant producer of lithium spodumene concentrate is underpinned by significant established and prospective production capacity from nine separate projects. However, as a result of the global developments summarised in this report, many of these projects are facing commercial stresses and are taking measures to protect project profitability and viability. Such measures include renegotiating offtake agreements, delaying planned expansions, altering project

[171] Office of the Chief Economist (2019*), Resources and Energy Quarterly – Lithium (December 2019)*, Department of Industry, Science, Energy and Resources, Australian Government, Canberra

pathways and timeframes, refinancing and in some cases placing operations into care and maintenance.

While the lithium sector is currently operating in a continually and rapidly developing environment, and in many cases the full details of commercial decisions taken by industry are not in public domain, at the date of this report the known current status and likely future outlook of individual projects are summarised in further detail below.

TABLE 8 – WESTERN AUSTRALIAN LITHIUM CONCENTRATE PRODUCTION AS AT APRIL 2020

Project	Proponents	Resource/Reserve	Region	Production (2019) (tonnes per annum)	Status
CURRENT SPODUMENE (LITHIUM) CONCENTRATE PRODUCTION					
Bald Hill	Alita Resources	11.3mt @ 1.01% (Reserve)	Coolgardie	N/A (placed into care and maintenance)	Under administration – production halted
Greenbushes	Tianqi Lithium & Albemarle	n.a.[172]	Greenbushes	750,000 (with nameplate capacity of 1.3 million)	Planned expansions delayed
Mt Cattlin	Galaxy Resources & Traka Resources	8.2mt @ 1.29% (Reserve)	Ravensthorpe	191,000	Temporary pause, drawing down stockpiles
Mt Marion	Neometals & Jianxi Ganfeng	71.3mt @ 1.37% (Resource)	Coolgardie	450,000	Production steady, examining downstream hydroxide production
Pilgangoora	Pilbara Minerals	108.2mt @ 1.25% (Reserve)	East Pilbara	330,000	Temporary pauses, drawing down stockpiles
Pilgangoora	Altura Mining	37.6mt @ 1.08% (Reserve)	East Pilbara	220,000	Production
Wodgina	Albemarle & Mineral Resources	151.9mt @ 1.17% (Reserve)	Port Hedland	N/A (placed into care and maintenance)	Care and maintenance
ASPIRING SPODUMENE (LITHIUM) CONCENTRATE PROJECTS					
Mt Holland	Wesfarmers & SQM	94.2mt @ 1.5% (Reserve)	Yilgarn	N/A	Scoping & feasibility
Kathleen Valley	Liontown Resources Limited	156mt @ 1.4% (Resource)	Goldfields	N/A	N/A
Buldania	Liontown Resources Limited	14.9mt @ 0.97% (Resource)	Goldfields	N/A	N/A

[172] Not disclosed in the public domain

Bald Hill (Alita Mineral Resources (under administration))

The Bald Hill project is located near Kambalda in the Goldfields Region and has seen a turbulent recent history. Pursuant to a deed of arrangement and share buyout in December 2018, Alliance Mineral Assets acquired 100 percent of the Bald Hill mine from former 50:50 joint venture partner Tawana Resources[173].

Offtake agreements with previous exclusive partner Burwill were renegotiated to allow Alliance to sell to other customers, while the Burwill offtake rights and obligations were transferred to a new entity, PRC-based Jiangxi Bao Jiang Lithium Industrial (a 50:50 joint venture between Burwill and Jiangte Special Electric Motor)[174]. Alliance soon after embarked upon an expansion program at the site, with infill and exploratory drilling converting the known inferred resource to reserve status and upgrading this to 11.3 million tonnes[175], while an exploration target of 17 to 24 million @ 1.25-1.40% was announced in May 2019 for the Pegmatite 3 West area[176].

Over the course of 2019, the merged entity – renamed Alita Resources in July - encountered financial difficulties resulting from high operating costs in a climate of declining lithium prices, operating at a loss for January-March, May and June, despite record production of approximately 38,000 tonnes of spodumene concentrate for Q1[177]. Reportedly, approximately AUD $325,000 in progress payments are still owed to principal Bald Hill mining contractor Primary Group under an EPC contract[178]. Meanwhile, following a history of several default events, Alita entered into a standstill agreement with its principal creditors (a consortium managed by Tribeca Investment Partners) in relation to the USD $28 million (principal) secured loan facility on 16th August, before that loan facility was acquired by Alita largest shareholder Galaxy Resources later that month[179], securing Galaxy's equity and capital stake.

With new creditor Galaxy declining to continue to extend the previously negotiated standstill period, on 28th August the Alita board appointed administrators from KordaMentha, while Galaxy appointed KPMG as receivers and managers pursuant to the terms of the loan agreement[180]. In a report prepared by KordaMentha, Deloitte Financial Advisory and SRK Consulting[181], Alita were found to have debts that exceed the total value of its remaining assets. In particular, administrators found that Alita continued to operate and produce at a consistent level even after sole major offtake agreement partner Jiangxi Bao Jiang Lithium

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[173] Alliance Mineral Assets Ltd (2018), *Implementation of Scheme of Arrangement with Tawana Resources* (2018), ASX release, 14 December 2018

[174] *Alliance Mineral to add market pricing, drop exclusivity in restructured offtake deal* (2019), Ng, R.J, published The Business Times (Singapore), 15 January 2019

[175] Alliance Mineral Assets Ltd (2019), *Resource Drilling Recommences at Bald Hill Mine*, ASX release,18 March 2019

[176] Alliance Mineral Assets Ltd (2019), *New Exploration Target identified at Bald Hill* (2019), ASX release, 10 May 2019

[177] Alliance Mineral Assets Ltd (2019), *Record Quarterly Production at Bald Hill, Lithium Production Up 68%*, ASX release, 8 April 2019

[178] Zhou, V (2019), *Alita Resources moves into voluntary administration*, Australian Mining, 30 August 2019

[179] Galaxy Resources (2020), *Acquisition of senior secured debt facility – Alita Resources Ltd*, ASX release, 27 August 2019

[180] Galaxy Resources (2019), *Appointment of receivers and managers to Alita Resources Ltd*, ASX release 29 August 2019

[181] Alita Resources (2020), *Shareholder Update – 1) Release of Explanatory Statement and Expert's Report and 2) Response to the SGX RegCo's Notice of Compliance*, ASX release, 14 January 2020

Industrial from May 2019 onwards refused to receive shipments from Alita due to "unforeseen circumstances" preventing them from being able to fulfil their contractual obligations[182].

Initially prospects were raised of Galaxy Resources taking over Bald Hill operations, with Galaxy tendering an offer of a Deed of Company Arrangement (DoCA) to administrators. However, this offer was declined. Instead, administrators and shareholders chose to recapitalise Alita under a DoCA with PRC-based China Hydrogen Energy (a special purpose vehicle for an unidentified PRC entity with existing lithium stakes) and its Australian subsidiary Liatam Mining[183], utilising funds received from these entities to repay Galaxy in full on 29th November[184] and resolving on 19th December to approve the acquisition of Alita for nil consideration. The application to commence this process was approved by the Supreme Court of WA in March 2020[185], with the final transfer to new owners awaiting Australian Securities and Investment Commission (ASIC) and Foreign Investment Review Board (FIRB) approval.

Operations at Bald Hill remain on care and maintenance.

Greenbushes (Talison Lithium)

Located immediately adjacent to the town of Greenbushes in Western Australia's southwest, the Greenbushes spodumene mine is the largest and longest operating spodumene mine in Western Australia. The mine has changed ownership several times over the past three decades, and is currently the subject of a 51:49 joint venture between Tianqi Lithium Corporation and Albemarle Corporation trading as Talison Lithium, with the vast majority of spodumene concentrate production from Greenbushes used as feedstock for the respective supply chains of its joint venture partners. Spodumene ore is processed at the Greenbushes mine site to produce a 6.0 percent lithium oxide concentrate, currently transported by rail to Bunbury Port before shipping out to the PRC. Both Tianqi and Albemarle are constructing lithium hydroxide conversion plants in Western Australia (see Section 4.4.1) and when operational will source their spodumene feedstock from the Talison joint venture.

Following completion of the 'CGP2' expansion, increasing nameplate production to a possible 1.34 million tonnes per annum of spodumene concentrate, Talison Lithium announced a 'pause' on the next stage 'CGP3' expansion in September 2019, only weeks after securing environmental approvals[186]. In announcing the pause, Talison noted that the timing of construction was being delayed to ensure the timing of expansions aligns with changes in demand from downstream customers, including the joint venture partners.

Mt Cattlin (Galaxy Resources)

Located near Ravensthorpe in the Great Southern Region, Mt Cattlin is Western Australia's second largest lithium mine. First operating between 2009 and 2012, the mine was reactivated in 2016 on the strength of high global spot prices. Following additional capital works designed

[182] Reported eg. Thompson, B (2020), *Failed lithium miner under nose of corporate watchdog*, Australian Financial Review, 5 February 2020
[183] Ng, R.J (2019), *Alita Resources creditors approve rescue plan from potential new owners*, Singapore Business Times, 19 December 2019
[184] Galaxy Resources (2019), *Alita senior secured debt facility repaid by administrators*, ASX release, 2 December 2019
[185] Alita Resources (2020), *Shareholder Update – Section 444GA Orders made and other matters*, ASX release, 8 March 2020
[186] Pancia, A. (2019), *Lithium's teething troubles put WA workforce on shaky ground*, ABC News, 18 April 2019

to upgrade the processing plant and double potential ore throughput, first concentrate production shipped through Esperance Port in early 2017[187]. The Mt Cattlin project is underpinned by five separate offtake agreements with conversion plants across Asia[188] (understood to be predominately with PRC converters[189]) that together account for virtually all current and planned production out to end of 2022.

As of Q3 2019, output of 50,014 dry metric tonnes (dmt) of lithium concentrate at a cost of approximately USD $387/dmt[190] places Mt Cattlin as one of the lowest cost lithium concentrate operations in the world. However, following an internal strategy review in late 2019 in response to broader lithium market conditions, Galaxy is prioritising value over volume, protecting operating cash margins, and preserving resource life. While aiming to cautiously ramp Argentinian production from its Sal de Vida project (discussed earlier in this report), operational plans for Mt Cattlin are reportedly to slow production, reduce mining volume, and reduce local stockpiles to lower operating costs[191]. Q4 2019 saw a decline in production to 43,222 dmt[192] of lithium concentrate, albeit at slightly increased cost of production at USD $406/dmt. Projections estimate dmt of concentrate produced to be between 90,000 and 105,000 in 2020, compared to the 191,569 dmt produced in 2019[193].

Following continued downturn in the lithium market, Galaxy announced a six-week pause in operations, reducing stockpiled spodumene inventory by slightly over half. Operations resumed in mid-February 2020, with Galaxy utilising the downtime to conduct capital works and upgrade ore sorting equipment, allowing for low-grade ore previously stockpiled to be utilised in processing and further reducing operating costs[194]. While offtake partners had previously requested ore sold in late 2019 not be shipped, likely in response to rising downstream converter inventory levels discussed in Section 0 this report, Galaxy reports that normal shipments have resumed and all ore should be shipped by the end of April 2020[195].

Galaxy has further explored several other options over the medium term to generate free cashflow and reduce operating costs. Unconventional lithium producer Lepidico has secured access rights to the Mt Cattlin tailings, and has announced test work production of 99.8 percent pure lithium carbonate utilising a proprietary recovery process[196].

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[187] Lucas, J (2017*), Galaxy Resources waves off first lithium shipment from Mt Cattlin mine*, ABC Rural News, 3 January 2017

[188] Galaxy Resources (2017), *Galaxy signs binding long-term offtake agreements for Mt Cattlin*, ASX release, 29 November 2017

[189] Mickleboro, J. (2017), *Galaxy Resources Limited shares storm higher on massive offtake agreement*, The Motley Fool, 29 November 2017

[190] Galaxy Resources (2019), *September Quarter 2019 – Quarterly Activities Report*, ASX release, 24 October 2019

[191] Galaxy Resources (2019), *Galaxy Resources Investor Strategy Day – Transcript*, ASX release, 21 November 2019

[192] Galaxy Resources (2020), *December 2019 – Quarterly Activities Report*, ASX release, 23 January 2020

[193] Galaxy Resources (2020), *December 2019 – Quarterly Activities Report*, ASX release, 23 January 2020

[194] Galaxy Resources (2020), *March 2020 – Quarterly Activities Report*, ASX release, 23 April 2020

[195] Galaxy Resources (2020), *March 2020 – Quarterly Activities Report*, ASX release, 23 April 2020

[196] Nicholas, L. (2018), *Lepidico uses L-Max technology to create 99.8% pure battery grade lithium from Galaxy's Mt Cattlin tailings*, published SmallCaps, 1 March 2018

Mt Marion (Jiangxi Ganfeng Lithium/Mineral Resources)

Located south-west of the town of Kalgoorlie in the Eastern Goldfields region, the Mt Marion project is one of the world's largest known high-grade spodumene resources. Formerly a three-way joint venture, ownership of the Mt Marion project was consolidated in March 2019, with minority stakeholder Neometals divesting its interest for a reported AUD $104 million[197] to leave Ganfeng and Mineral Resources each 50 percent shareholders in the project joint venture[198]. Although Jiangxi Ganfeng Lithium secured a life-of-project binding offtake agreement for 100 percent of production[199], Neometals retains a life-of-mine offtake agreement of 57,000tpa spodumene concentrate produced by the Mt Marion project at market-linked prices[200].

Production levels have remained relatively stable, with 194,000 tonnes of spodumene concentrate shipped in the first half of FY2020, 65 percent of which was higher-grade at 6 percent contained lithium[201]. Mineral Resources expect Mt Marion to operate at steady state for second half, with production guidance of between 170,000 and190,000 tonne with 70 percent of this being 6 percent concentrate product[202].

From a financial perspective, the Mt Marion project is similarly affected by global lithium market conditions, reporting a 44 percent decline in spodumene concentrate prices from 2H FY2019, although ahead of some industry competitors at an average of A$674 per wet tonne[203]. The focus for the joint venture partners remains on securing profitability by reducing production and operating costs associated with the Mt Marion project.[204].

Investing in downstream production and capitalising on existing relationships with Wodgina joint venture partner Albemarle, Minerals Resources are hoping future growth stems from a 40 percent stake in Albemarle's new 50,000 tonne per annum[205] lithium hydroxide plant under construction in Kemerton (see Section 4.4.1). Mineral Resources anticipates growth in supply chain efficiency via their stake in this hydroxide plant, and under the terms of the Mt Marion offtake agreement with joint venture partner Ganfeng, post February 2020, Mineral Resources can exercise an option to take up to 51 percent of total per-annum production[206].

Pilgangoora (Pilbara Minerals)

Located in the Pilgangoora region of the Pilbara, approximately 140 kilometres south of Port Hedland, the 100 percent Plibara Minerals owned Pilgangoora Lithium-Tantalum Project is a

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[197] Neometals (2018), *Neometals agrees the sale of Mt Marion equity for A$104 million and retains offtake rights*, ASX release, 21 December 2018

[198] Mineral Resources (2019), *Mineral Resources completes purchase of additional Mt Marion equity*, ASX release, 18 March 2019

[199] Venna, S. (2017), *Reed Industrial Minerals signs offtake and funding deal with lithium producer Jiangxi*, Mining Technology; InvestorIntel (2017), *Neometals sends maiden shipment to "lithium giant" Ganfeng,* 9 February 2017

[200] Neometals (2018), *Neometals agrees the sale of Mt Marion equity for A$104 million and retains offtake rights* , ASX release, 21 December 2018

[201] Mineral Resources (2020), *1H20 Financial Results*, ASX release, 12 February 2020

[202] Mineral Resources (2020), *1H20 Financial Results*, ASX release, 12 February 2020

[203] Mineral Resources (2020), *1H20 Financial Results*, ASX release, 12 February 2020

[204] Mineral Resources (2020), *1H20 Financial Results*, ASX release, 12 February 2020

[205] Mineral Resources (2020), *JP Morgan High Yield Conference*, presented 25 February 2020, Miami, Florida, USA

[206] Mineral Resources (2020), *JP Morgan High Yield Conference*, presented 25 February 2020, Miami, Florida, USA

globally significant hard rock spodumene resource. The mine's initial output involved direct shipping ore (DSO) under an agreement with Atlas Iron from Port Hedland in June 2018[207], and first lithium concentrate exports on 1 October 2018[208]. The majority of spodumene concentrate produced is the subject of offtake agreements with General Lithium Corporation, Ganfeng Lithium, Great Wall Motors, POSCO and Yibin Tianyi[209].

Production of spodumene concentrate at the Pilgangoora Lithium-Tantalum Project site was declared commercial in April 2019 and had reached 85 percent of nameplate capacity by May at 22,375 dry metric tonnes for that month. Over the course of early 2019 Pilbara Minerals also focused on securing additional offtake partners to support previous expansion plans, and in March 2019 exercised its option to enter an incorporated joint venture with offtake partner POSCO to take a up to 30 percent joint venture stake in a 40,000 tonne per annum LCE carbonate and hydroxide conversion plant based in the Republic of Korea (ROK), to be supplied by the Pilgangoora mine (estimated at 315,000 tonnes per annum dry spodumene concentrate over the life of the mine)[210] through a Stage 2 expansion. However, delays in commissioning offtake customer downstream conversion plants in the PRC resulted in Pilbara Minerals moderating production in June 2018 to align with revised ramp-up timelines, while the sustained global downturn saw operating capacities reduced to avoid overproduction[211], as well as revisiting the development of the Stage 2 expansion to ~850,000 tpa spodumene concentrate to reduce capital risk and better align with customer volume requirements.

Pilbara Minerals is now progressing studies for a phased and incremental approach for the delivery of its 'Stage 2' expansion plans[212]. Pilbara Minerals is still pursuing the joint venture with South Korean company POSCO, with formal board approval extended to September 2020, after POSCO requested more time to complete further technical evaluations of the facility design[213]. During this moderated production environment, Pilbara Minerals have been focussing on plant modifications and capital works to reduce operating costs and increase recovery. In November 2019, Pilbara Minerals announced that recovery rates had improved to over 60 percent and in March 2020 Pilbara Minerals delivered recovery rates largely in line with plant design criteria of 72-78 percent, which continue to reduce operating costs toa target cost of USD $320-350 per dry metric tonne landed in PRC (CFR) by mid-2020[214].

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[207] Creagh, B. (2018), *Atlas ships first lithium DSO from Pilbara Minerals' Pilgangoora,* Australian Mining, June 2018 Edition

[208] Zhou, V. (2018), *Pilbara Minerals' first shipment from Pilgangoora to set sail*, Australian Mining, October Edition 2018

[209] Creagh, B. (2018), *Pilbara Minerals a step closer to production at Pilgangoora*, *Australian Mining*, May Edition; McKinnon, S. (2018), 'Pilbara Minerals calm on fears of global lithium glut', *Diggers and Dealers*; Pilbara Minerals (2018), '*Development and offtake in Pilgangoora Lithium-tantalum Project.*

[210] Pilbara Minerals (2019), *POSCO and Pilbara Minerals to evaluate larger downstream chemical facility in line with continued growth of Pilgangoora*, ASX release, 2 January 2019; Pilbara Minerals (2019), *Pilbara Minerals exercises option to continue progressing downstream JV with POSCO* (2019), ASX release, 18 March 2019

[211] Pilbara Minerals (2019), *Pilgangoora Production and Sales Update* (2019), ASX release, 17 June 2019

[212] Pilbara Minerals (2020), *Half Yearly Report and Accounts - Interim Financial Report*, ASX release, February 20 2020

[213] Pilbara Minerals (2020), *Half Yearly Report and Accounts - Interim Financial Report*, ASX release, February 20 2020

[214] Pilbara Minerals (2019), P*lant Performance Update – Strong Recovery Performance*, ASX release, 14 November 2019

Most recently, in an announcement on 25th March 2020, Pilbara Minerals revealed a new five-year offtake agreement has been signed with PRC-based Yibin Tianyi, with first shipment of 20,000 tonnes per annum completed in that month[215]. The agreement entails an initial delivery to Yibin Tianyi of 60,000 tonnes per annum of high-quality spodumene concentrate in 2020, to be followed by a minimum of 75,000 tonnes per annum thereafter.

Pilgangoora (Altura Mining)

Also located in the Pilgangoora region, Altura's Pilgangoora project delivered first shipments of spodumene concentrate to offtake partner LionEnergy in October 2018[216]. Raising a combined AUD $38.5 million finance via institutional placement and securities purchase offer in early 2019[217], Altura invested in the further development of 'Stage 1' processing at its Pilgangoora site and completed commissioning in March, reaching 83 percent of nameplate capacity and declaring commercial production[218]. Offtake agreements have been secured for 100 percent of Stage 1 capacity with PRC based battery chemical producers[219], while Ganfeng Lithium has optioned 50 percent of proposed Stage 2 capacity, with negotiations ongoing with other offtake arrangements[220]. As at end of March 2020, Altura reports quarterly sales of 34,000 dmt spodumene concentrate from the project, below previous guidance of 40, 000 to 50,000 dmt[221].

With production at the Pilgangoora plant underway and offtake agreements secured, Altura is investigating expansion possibilities in the region, concluding an earn-in agreement with lithium prospect Sayona Mining over Sayona's nearby tenements in the Pilgangoora region in August 2019. Under the terms of the agreement, Altura proposes to spend $1.5 million over three years in exploration activities to earn a 51 percent interest in the project[222].

Since declaring commercial production in March 2019, Altura has continued to scale-up production, targeting nameplate capacity of 220,000 tonnes per annum and stockpiling excess product. Altura's cost structure sees disproportionate decrease in unit costs when operating at or near nameplate capacity, thus pushing its cost profile further down the cost-curve.

Most recently, Altura has announced successful refinancing with its current lenders, extending maturity dates for its existing USD $161 million loans out to 2023, deferring 2020 interest payments to the following year, and securing an additional at-call $50 million in standby equity

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[215] Pilbara Minerals (2020), *Additional Offtake in Place at Pilgangoora* (2020), ASX release, 25 March 2020

[216] Australian Mining (2018), *Altura's first lithium shipment leaves the Pilbara*, Australian Mining, 9 October 2018

[217] Altura Mining (2019), *Completion of heavily-oversubscribed SPP* (2019), ASX release, 21 March 2019

[218] Altura Mining (2019), *Altura declares commercial lithium production* (2019), ASX release, 13 March 2019

[219] Karinja, F. (2017), *Altura scores two lithium offtake agreements in China*, Small Caps, 10 July 2017; Altura Mining (2020), *Delivering High-Quality Low-Cost Lithium*, Investor presentation 9 March 2020

[220] Altura Mining (2019), *Altura Investment Highlights - Lithium and Battery Metals Conference*, investor presentation, 21 March 2019

[221] Altura Mining (2020), *Shipping and operations guidance update*, ASX release, 27 March 2020

[222] Altura Mining (2019), *Altura enhances development growth with agreement with Sayona for Pilbara lithium assets*, ASX release, 8 August 2019

finance, in exchange for payment of USD $1.6 million in waiver fees and a 9.9 percent equity stake[223]. Reportedly, the impetus for refinancing was to secure capital headroom to allow the company to better deal with sustained market weakness.

Wodgina (Albemarle/Mineral Resources)

Located in close proximity to Pilgangoora south of Port Hedland, the Wodgina Lithium Project reached commercial production in late 2019, and is capable of producing 750,000 dry metric tonnes of 6 percent spodumene concentrate per annum[224]. Formerly a 100 percent owned Mineral Resources project, in November 2019 a 60 percent interest in the Wodgina Lithium Project was transferred to Albemarle for a cash payment of USD $820 million, subject to adjustments, and a 40 percent interest in two 25,000 tonne per annum lithium hydroxide modules in Kemerton (see Section 4.4.1). As a result, the operating entity for the project is now a 60:40 unincorporated joint venture trading as MARBL Lithium, with Albemarle marketing 100 percent of the output from the Wodgina mine [225].

The Wodgina mine has since been placed on care and maintenance. As of March 2020 Albemarle has reported the Wodgina project as representing an available resource capacity of 100,000 tonnes per annum LCE, with future plans uncertain at this time[226].

Mt Holland (Covalent – Wesfarmers and SQM)

The Mt Holland Lithium Project is commercialising the Earl Grey deposit located 105 kilometres south of Southern Cross. Previously developed by Kidman Resources operating in 50:50 joint venture with SQM, the project revolves around a resource estimate of 189 million tonnes @ 1.50% lithium, or 7.03 million tonnes of LCE[227]. In December 2018, Kidman Resources completed a pre-feasibility study based on a reserve of 94.2 million tonnes at 1.5 percent, supporting a mine life of 40 years and supplying a lithium hydroxide conversion plant to be established in Kwinana with a nameplate capacity of 45,000 tonnes per annum of lithium hydroxide[228].

In September of 2019, Wesfarmers acquired Kidman Resources for $776 million[229]. The joint venture partners are understood to have postponed final investment decision on the Mt Holland lithium project until the first quarter of 2021. Further work will be undertaken including optimising project design to reduce capital and operating costs, improving utility and infrastructure solutions for the project and investigating initiatives to further leverage Wesfarmers' existing, particularly chemical sector, capabilities[230].

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[223] Altura Mining (2020), *Altura balance sheet strength underpinned by new financing package*, ASX release, 6 March 2020
[224] *Wodgina Lithium*, Mineral Resources, website accessed April 20 2020
[225] Mineral Resources (2019), *Mineral Resources and Albemarle Corporation complete Wodgina Lithium Project Transaction, establish JV and agree on way forward*, ASX release, 1 November 2019
[226] Albemarle Corporation (2020), *Investor Presentation March 2020*, ASX release, 24 March 2020
[227] Kidman Resources (2018), *Substantial Increase in Earl Grey Lithium Mineral Resource Estimate,* ASX release, 19 March 2018
[228] Kidman Resources (2018), *Integrated Pre-Feasibility Study completed on schedule and maiden Ore Reserve declared for Mt Holland Lithium Project,* ASX release, 18 December 2018
[229] Zhou, V (2019), *Wesfarmers takes control of Kidman Resources,* Australian Mining, 24 September 2019
[230] Wesfarmers (2020), *Mt Holland Lithium Project update*, ASX release, 23 January 2020

Kathleen Valley (Liontown Resources)

The Kathleen Valley Lithium Tantalum Project is located approximately 680km north-east of Perth in the central Goldfields region. In late 2018, Liontown announced its discovery of what it characterised as a new high-grade lithium deposit, containing a measured and inferred 21.2 million tonnes of lithium at 1.4%[231]. Over the course of 2019, further exploratory works and scoping studies firmed up the resource, and in June 2019 Liontown revised the known resource significantly, with a 354% increase to 74.9mt @ 1.3%[232].

Completion of a pre-feasibility study in December 2019 confirmed commercial viability of the Kathleen Valley project, with a JORC-compliant Reserve of 50.4 million tonnes @ 1.2%Li_2O supporting an output of 295,000 tonnes per annum of 6 percent spodumene concentrate over a 26-year life of mine.[233] High-grade ore and an indicated cost of production around the lower end of the cost curve suggest the project is viable even in current lithium market conditions, with a total all-inclusive cash operating cost of around $610/dmt of spodumene concentrate (exclusive of tantalum credits) and payback period estimated at 4 years following initial production, with production to commence in 2024[234].

In May 2020 the underlying Mineral Resource was upgraded further to 156 million tonnes @ 1.4% Li_2O, with an updated pre-feasibility study expected to be completed in Q4 2020 followed by a definitive feasibility study due in 2021[235].

Buldania (Liontown Resources)

Situated just south of the Mt Marion and Bald Hill projects, the Buldania Project is also located in the Goldfields region, just northeast of Norseman. Known to be prospective for lithium for some time, the project has been assembled from a variety of former tenement holders since 2017.

The largest portion of the project area is subject to the Buldania Lithium Rights Agreement (BLRA), and was acquired by Liontown in late 2017 from Avoca Resources Pty Ltd in exchange for a significant share issue to parent entity RNC Minerals (formerly Westgold Resources). Under the agreement, Avoca were initially entitled to 1.5%of gross sales receipts, and set to be paid $2 per tonne for all lithium ore mined[236]. However, in July 2019 Liontown announced the discharge of these rights and royalties in exchange for a lump sum payment of A$2 million[237].

The Killaloe area of the project lies west of the BLRA, comprising a number of exploration licences and one mining lease acquired from Matsa Resources for 20,000,000 Liontown shares and an ongoing 1 percent royalty applying to all mineral production from the tenement areas.

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[231] Liontown Resources (2020), *Kathleen Valley Lithium Project*, accessed April 20 2020

[232] Liontown Resources (2019), *Kathleen Valley Lithium Resource jumps 353% to 74.9Mt @ 1.3% Li_2O,* ASX release, 9 July 2019

[233] Liontown Resources (2020), *Kathleen Valley Pre-Feasibility Study confirms potential for robust new long-life open pit lithium mine in WA,* ASX release, 2 December 2019

[234] Liontown Resources (2020), *Kathleen Valley Pre-Feasibility Study confirms potential for robust new long-life open pit lithium mine in WA,* ASX release, 2 December 2019

[235] Liontown Resources (2020), *Kathleen Valley Lithium Project*, accessed April 20 2020

[236] Liontown Resources (2018), *More strong assays confirm significant lithium discovery at Buldania Project in WA*, ASX release, 26 March 2018

[237] Liontown Resources (2019), *Liontown acquires Buldania royalty from Westgold Resources,* ASX release, 24 July 2019

Following acquisition and assembly of the tenement package, Liontown engaged in firming and exploratory drilling. A maiden Mineral Resource Estimate for the Buldania project was announced in November 2019, with an independent assessment by Optiro showing a JORC-compliant Resource (indicated and inferred) of 14.9Mt @ 0.97% Li_2O[238]. Further scoping works are understood to be in progress.

3.3. Summary of raw material production outlook

As summarised below in Table 9 (with Western Australian production appearing earlier at Table 8), global lithium primary production outlook remains somewhat uncertain. While current lithium prices may see further mine closures and result in delays in the commissioning of new production, there is significant capacity that can be bought on stream should market conditions improve.

TABLE 9 - GLOBAL LITHIUM PRIMARY PRODUCTION OUTLOOK

Project	On-stream	Current Lithium Production Capacity (metric tons p/a)	Potential Lithium Production Capacity (metric tons p/a)
LATIN AMERICA			
Salar de Atacama (SQM)	Operating	70,000 (carbonate) 13,500 (hydroxide)	216,000 LCE (all product streams)
La Negra (Albemarle)-Phase 2	Operating	20,000 LCE	
La Negra (Albemarle)-Phase 3 & 4	Under construction/phased commissioning 2021	38,000 LCE	>80,000 LCE
Caucharí-Olaroz	Projected 2022	N/A	40,000 (carbonate)
Sal de Vida	Projected 2022	N/A	25,000 (carbonate)
Olaroz	Operating	12,000 (carbonate)	25,000 (carbonate)
Cauchari	Undisclosed	N/A	25,000 (carbonate)
Sal de Los Angeles	Exploration	N/A	N/A
Antofolla	Exploration	N/A	N/A
NORTH AMERICA			
Clayton Valley (PEM)	Undisclosed	N/A	10,000 LCE (all product streams)
Clayton Valley (Cypress)	Undisclosed	N/A	20,000 (carbonate)
Clayton Valley (Spearmint)	Exploration	N/A	N/A

[238] Liontown Resources (2019), *Liontown announces maiden Mineral Resource Estimate for its 100%-owned Buldania Lithium Project, WA*, ASX release, 8 November 2019

Project	On-stream	Current Lithium Production Capacity (metric tons p/a)	Potential Lithium Production Capacity (metric tons p/a)
Clayton Valley (Marquee)	Exploration	N/A	N/A
Clayton Valley (Noram)	Exploration	N/A	N/A
Rhyolite Ridge	2019 (pilot plant) Projected 2023	N/A	20,000 (carbonate) (years 1-4) 22,000 (hydroxide) (years 5-30)
Thacker Pass	Projected 2023 (Phase 1) Projected 2026 (Phase 2)	N/A N/A	30,000 LCE 60,000 LCE
Piedmont	Undisclosed	N/A	22,700 (hydroxide)
Hell's Kitchen	Projected 2023 (Phase 1) Projected 2025 (Phase 2)	N/A N/A	17,350 LCE 34,000 LCE
Paradox Basin	Undisclosed	N/A	Stage 1 700 LCE Stage 2 15,000 LCE
Abitibi	Operating	114,000 (spod.conc.)	180,000 (spod.conc)
Authier	Undisclosed	N/A	114,000 (spod.conc)
Rose	Undisclosed	N/A	Up to 220,000 (spod.conc)
James Bay	Undisclosed	N/A	N/A
Whabouchi	2017 (pilot plant) Undisclosed	N/A	215,000 (spod.conc) 37,000 (hydroxide)
Leduc	2020 (pilot plant)	N/A	20,000 LCE
Salar del Diablo	Exploration	N/A	N/A
Sonora	2022	N/A	Stage 1 17,500 LCE Stage 2 35,000 LCE

While Latin American production remains constrained by perceptions of sovereign risk, these perceptions or not preventing investment, with new capacity expected to come on stream from Chile and Argentina from around 2022.

In the United States that is designed to focus attention on developing domestic supply of lithium raw materials has not materialised in any significant way and potential projects in Canada and Mexico have not progressed substantially as a result of current market conditions and COVID-19 restrictions.

Western Australian production has been similarly affected. With the exception of Altura's Pilgangoora project, all Western Australian spodumene concentrate projects have announced intentions to significantly slow or cease production. While medium-term price

recovery will likely see a return to capacity expansion, it is also likely that Western Australian spodumene producers will be doing so in a more competitive global market. Actions taken now will have a significant impact with respect to the future competitiveness of the Western Australian spodumene concentrate sector.

4. Trends, status and outlook for lithium chemical manufacture

A further major development in the global lithium sector has been a recent significant uplift in lithium chemical manufacturing capacity, predominately in the PRC, that has been followed by a delay in commissioning and mothballing of some capacity as lithium chemical manufacturers respond to the demand environment discussed in Section 21.4.

4.1. People's Republic of China

Since 2015, PRC lithium chemical production has more than doubled, growing from an estimated 160,000 tonnes of LCE to 285,000 tonnes in 2018 and 350,000 tonnes by end of 2019[239]. Some estimates have current global lithium chemical manufacturing capacity at around 540,000 tonnes, with around 56 percent of that capacity using mineral (primarily Western Australian spodumene concentrate) as feedstock, and the balance using brine-sourced carbonate as feedstock. The PRC accounts for around 99 percent of conversion plants using mineral feedstock, and the vast majority of those using brine-sourced feedstock[240].

While the majority of PRC lithium chemical production is subject to domestic battery manufacture supply chain offtake arrangements, the PRC has also seen a significant and sustained increase in the export of lithium chemicals, with estimated year-on-year lithium carbonate exports up six times to over 11,000 tonnes and lithium hydroxide increasing by approximately 40 percent to just under 6,000 tonnes[241].

Reliable estimates of output and expansion plans, particularly for Tier 2 and Tier 3 PRC lithium chemical manufacturers, are challenging. At market peak, notable PRC lithium chemical manufacturers had announced construction of an additional approximately 391,000 tonnes per annum (LCE) of capacity at nameplate, potentially almost doubling total output.

However, while visibility over internal PRC production dynamics is challenged, industry observers have noted that over the short-term the pace of expansion has slowed, previously announced targets have in many cases not been achieved, and the expanded capabilities of some facilities are operating under – in some cases significantly under – capacity. This is summarised below in Table 10[242].

[239] Benchmark Mineral Intelligence (2019), *Lithium's Price Paradox*, 30th July 2019
[240] Roskill
[241] Benchmark Mineral Intelligence (2019), *China Becomes Major Lithium Carbonate Exporter*, 25th February 2019; Liu, F (2019), *Prices of lithium hydroxide to extend declines*, published Shanghai Metal Markets News, 27th February 2019
[242] Benchmark Mineral Intelligence (2019), *Lithium's Price Paradox*, 30th July 2019; industry sources (pers. comm.)

TABLE 10 - ESTIMATED PRC DOWNSTREAM EXPANSIONS

Producer	Target capacity (TPA)	Completion originally due	Status (Q3 2019)	Expansion utilisation (est.) (Q3 2019)
		Tier 1		
Ganfeng (Xinyu)	20,000	2018	Production	>90%
Albemarle	20,000	1H 2019	Production	>95%%
Ganfeng (Ningdu)	17,500	2018	Production	>90%
Livent	9,000	2019	Production	>90%
Tianqi	24,000	2019	Commissioning	-
		Tier 2		
General Lithium	16,000	Q4 2018	Production	75%
Yahua	20,000	Q4 2018	Construction	-
Lanke	20,000	Q4 2019	Construction	-
		Tier 3		
Jiangte Motor	25,000	Q2 2018	Production	28%
Zhiyuan	13,000	2018	Production	60%
Dingsheng	10,000	Q2 2019	Commissioning	-
Minmetals Salt Lake	10,000	Q2 2019	Commissioning	-
Guangxi Tianyuan	25,000	Q3 2019	Construction	-
Tangshan Xinfeng	20,000	Q3 2019	Construction	-
Liaoning Hongjing	20,000	2019	Construction	-
Wuli Jinhaiwan	20,000	2019	Construction	-
Youngy	20,000	2019	Construction	-
Inner Mongolia Zhili	15,000	Q4 2019	Construction	-
Hebei Tianyuan	12,000	2019	Construction	-
Qinghai Lithium	10,000	2019	Construction	-
Guanzhou Yuanhuitong	10,000	Q3 2019	Construction	-
Jiangxi Yunwei	10,000	Q3 2019	Construction	-
Zangge	10,000	2019	Construction	-
Nanshi	10,000	2019	Construction	-
Sichuan Siterui	5,000	Q1 2019	Construction	-
TOTAL	391,500			

Outside of Tier 1 chemical manufacturers, at last estimates most previously announced expansions had been either delayed or put on hold, even before the latest impacts of the COVID-19 pandemic (see Section 5). Further, it is likely that as the result of required new plant optimisation processes a lag-time will be observed between the successful commission of new capacity and full production of battery-quality output being reached. As a result, the anticipated oversupply situation may not as yet have fully eventuated.

Of note is that investment decisions by PRC chemical manufacturers indicate and support an increased market share for lithium hydroxide, with approximately three-quarters of additional capacity reported as targeted at hydroxide production[243]. This has been a major driver of offtake agreements with Western Australian spodumene producers, whereby the vast majority of Western Australian production is the subject of contracted offtake with PRC lithium chemical manufacturers.

However, the dramatic decline in the lithium price over particularly the past 12 months has significantly decreased the portion of the cost of manufacturing lithium hydroxide that is attributable to the feedstock, potentially rendering the more costly process of producing lithium hydroxide from brine-sourced lithium carbonate a viable option.

4.2. Japan

While energy production narratives in Japan have tended to focus on hydrogen fuel cells, some domestic concerns regarding supply chains has seen renewed interest in lithium chemical production. Joint venture partners lithium producer Orocobre (75 percent) and Toyota Tsusho Corp (TTC; a subsidiary of Toyota Group; 25 percent) commenced construction on the 10,000 tonne per annum Naraha Lithium Hydroxide Plant in August 2019, receiving a subsidy of JPY3 billion (USD $27.1 million) from the Japanese government (representing over 33 percent of total capital costs for the project)[244], in an attempt to reduce Japanese industry reliance on lithium imports.

The Naraha Plant, the first of its kind in Japan, will source feedstock from the Caucharí-Olaroz project (discussed in detail in Section 3.2.1), converting the industrial grade carbonate output of that facility to battery-grade hydroxide. However, completion of the Olaroz Stage 2 Expansion has been delayed by the COVID-19 pandemic, with siteworks ceasing on 20 March 2020 due to government restrictions, and thus delays may eventuate in sourcing feedstock materials[245]. Commissioning of the overall project was previously expected to occur in the first half of 2021; as at 31 March 2020 Orocobre reports that over 50 percent of works are now complete and construction has not been affected by COVID-19, however it expects the final completion of the project to be delayed by approximately two months due to a delay in equipment deliveries[246].

[243] Benchmark Mineral Intelligence (2019), *Lithium's Price Paradox*, 30th July 2019
[244] Orocobre Limited (2019), *Annual Report – 2019*, 23 August 2019
[245] Orocobre Limited (2020), *March 2020 Quarterly Report*, 22 April 2020
[246] Orocobre Limited (2020), *March 2020 Quarterly Report*, 22 April 2020; Orocobre Limited (2019), *Naraha Lithium Hydroxide Plant Groundbreaking Ceremony*, ASX release, 6 August 2019

Orocobre estimates operating costs (excluding the cost of lithium carbonate feedstock) to be approximately USD $1,500/tonne for the plant[247]; assuming feedstock is drawn from the Olaroz brine project (reported operating costs of USD $4,302/tonne for the same period) a total operating cost for the Naraha facility would be therefore be expected in the neighbourhood of USD $5,800 per tonne.

A majority of production is expected to be delivered to domestic Japanese lithium-ion battery manufacturers, with existing relationships between TTC and the wider Toyota Group likely to support future offtake agreements.

4.3. Republic of Korea

While a significant producer of battery precursor materials, cells and packs, the Republic of Korea (South Korea) has until recently not had any domestic lithium chemical production capacity. In 2016, industry leader POSCO commenced construction of the first commercial-scale plant in the ROK, with first production of lithium carbonate from the PosLX (Posco Lithium eXtraction) plant located in Gwangyang, South Jeolla, occurring in February 2017 and ramping up to 1,000 tonnes per annum over that year[248]. In April 2018, POSCO pivoted to production of lithium hydroxide instead to better suit industry demand, with production ramping over time to reach approximately 2,600 tonnes per annum nameplate capacity by 2020[249].

Efforts to secure feedstock for the POSCO plant continued over 2018 and 2019, resulting in the announcement in August of a joint venture with Pilbara Minerals (taking a minority 30 percent stake) to build and operate a second 40,000tpa lithium hydroxide plant, to also be located in the Gwangyang Free Economic Zone[250]. The new plant will utilise spodumene concentrate sourced from Pilbara Minerals' Pilgangoora project (see Section 3.2.3), under a binding offtake agreement ramping up to 315,000 tonnes per annum over 20 years (or the life of the mine)[251]. While a binding terms agreement has been executed between the parties, the status and timeframe for the proposed plant remains uncertain, with POSCO reportedly continuing to evaluate the timing of construction in light of lithium market conditions and downstream manufacturing requirements[252].

4.4. Western Australia

As summarised in Table 11 below and discussed in the following subsections, the yet to commission nascent Western Australian lithium chemicals industry is at a precarious place.

[247] Orocobre Limited (2019), *Annual Report – 2019*, 23 August 2019
[248] POSCO (2017), *POSCO Opens its First Lithium Production Plant for Battery Manufacturing*, Press release, 7 February 2017
[249] Pilbara Minerals (2020), *Pilgangoora – positioned for the future of lithium raw material supply*, Investor presentation, 7 May 2020
[250] Pilbara Minerals (2019), *Binding Terms Agreed for POSCO JV*, ASX release, 27 August 2019
[251] Pilbara Minerals (2020), *March 2020 Quarterly Activities Report,* ASX release, 28 April 2020
[252] Pilbara Minerals (2020), *March 2020 Quarterly Activities Report,* ASX release, 28 April 2020

TABLE 11 - WESTERN AUSTRALIAN LITHIUM CHEMICAL PRODUCTION PROFILE

Project	Proponents	Region	Feedstock source	Production (tonnes per annum)	Status
CURRENT LITHIUM CHEMICAL PRODUCTION					
Kwinana	Tianqi	Kwinana	Greenbushes	Initial test production runs over period Q4 2019 - Q1 2020; output unknown.	Stage 1 commissioning on hold Stage 2 construction halted.
ASPIRING LITHIUM CHEMICAL PROJECTS					
Kemerton	Albemarle / Mineral Resources	Bunbury	Greenbushes	Nameplate 50,000 (LiOH) (2 X 25,000 tpa trains)	Construction
Kwinana	Wesfarmers / SQM	Perth	Mt Holland	Nameplate 45,000 (LiOH)	FID delayed

4.4.1. Committed capacity

Kwinana (Tianqi)

Located in the Kwinana Strategic Industrial Area just south of Perth, the Tianqi-owned processing plant will be the largest of its kind in the world when completed, and when construction commenced was set to be the first lithium hydroxide plant outside of the PRC[253]. Once completed, the plant will employ two individual production trains to produce an annual 48,000 tonnes of battery-grade lithium hydroxide, with feedstock sourced from the Greenbushes spodumene mine (see Section 3.2.3)[254].

Stage 1 construction works commenced in October 2016[255], with practical completion three years later in October of 2019[256]. In a staggered process, construction of Stage 2 began in December of 2017 of the same year[257], with engineering works well advanced by late 2018[258].

The Stage 1 process train received first deliveries of spodumene from the recently expanded Greenbushes mine[259] in Q3 2019, with first production of lithium hydroxide in September, and expected to ramp to nameplate 24,000tpa capacity over the following 12-18 months. On the strength of expected production ramp, Tianqi signed offtake agreements with ROK-based LG Chem, and later Swedish battery maker Northvolt, together accounting for roughly one-fifth

[253] Tianqi Lithium (2020), *Tianqi Lithium in Australia,* accessed 1 May 2020
[254] Tianqi Lithium (2020), *Tianqi Lithium in Australia,* accessed 1 May 2020
[255] Ingram, T (2017), *Tianqi Lithium approves $300m Kwinana lithium plant expansion*, Australian Financial Review, 27 October 2017
[256] MSP Engineering (2019), *Practical completion achieved at LHPP Project,* Media Release, 17 October 2019
[257] MSP Engineering (2017), *Construction commences on Stage 2 Tianqi Lithium Hydroxide processing plant project,* Media Release, 13 December 2017
[258] MSP Engineering (2018), *Georgiou completes work of Tianqi Lithium Hydroxide processing plant,* Media Release, 3 August 2018
[259] Thompson, B (2019), *Tianqi puts brakes on landmark WA lithium plant expansion*, Australian Financial Review, 10 September 2019

of total annual capacity[260]. However, with market conditions continuing to weaken, reports later that month suggested Tianqi had put work on the partially built $300 million second stage on hold to focus on the commissioning of Stage 1[261].

While test production continued to ramp over the end of 2019, Tianqi announced in March 2020 that commissioning of the first phase of its flagship operation in Kwinana had been postponed[262]. Reportedly, Tianqi faces rising liquidity problems stemming from sustained low lithium prices, a high debt-to-assets ratio, and the need to service loans taken out to finance the purchase of a 23.8 percent stake in Chilean miner SQM[263].

Kemerton (Albemarle/Mineral Resources)

Located approximately 17 kilometres north-east of Bunbury in the south-west region of Western Australia, the Kemerton Lithium Hydroxide Conversion Plant will process spodumene ore transported from the Greenbushes mine. Initially solely owned by Albemarle, in November 2019 a 40 percent stake in the hydroxide plant venture was acquired by Mineral Resources in exchange for a 60 percent interest in the Wodgina spodumene mine (discussed further elsewhere in this report)[264].

The plant will consist of two processing trains, each capable of producing 25,000 tonnes per annum[265]. Original designs for production at the plant projected 75,000 tonnes per annum, however the joint venture partners have scaled that back to 50,000 tonnes per annum in order to time supply with shifting demand requirements of customers that are the result of the current excess supply of product.

Construction on the plant commenced in March 2019[266], with commissioning to occur in stages over the first half of 2021[267].

4.4.2. Prospective capacity

Kwinana (Wesfarmers/SQM)

In addition to the Mt Holland spodumene mine and concentrator plant (discussed in detail in Section 3.2.3), aspiring lithium joint venture partners Wesfarmers and SQM had previously announced plans to develop a lithium hydroxide processing plant to be based in the Kwinana Industrial Area, resulting in an integrated supply chain producing premium, battery-grade

[260] Reuters (2019), *Tianqi Lithium in supply deal with Sweden's Northvolt*, Reuters business news, 24 September 2019
[261] Hastie, H (2019) *World's biggest lithium plant switched on south of Perth,* The Sydney Morning Herald, 11 September 2019
[262] Daly, T, Zhang, M (2020), *China's Tianqi postpones commissioning of Australia lithium plant amid liquidity problems,* Reuters, 22 March 2020
[263] Daly, T, Zhang, M (2020), *China's Tianqi postpones commissioning of Australia lithium plant amid liquidity problems,* Reuters, 22 March 2020
[264] Mineral Resources (2019), *Mineral Resources and Albemarle Corporation complete Wodgina Lithium Project Transaction, establish JV and agree on way forward*, ASX release, 1 November 2019
[265] Mineral Resources (2020), *1H2020 Financial Results*, ASX release, 12 February 2020
[266] Mining Technology (2019), *Albemarle starts construction of Kemerton lithium hydroxide plant,* Mining-technology.com, 28 March 2019
[267] Albemarle (2020), *2019 Annual Report,* ASX release, 26 February 2020

lithium hydroxide[268]. First production from the refinery – with a nameplate capacity of 45,000 tonnes per annum of lithium hydroxide – was previously planned to commence in FY2022[269].

However, in January 2020 Wesfarmers announced there would be a delay on a final investment decision regarding the Mt Holland project and conversion plant until 2021[270], following the completion of a definitive feasibility study.[271] Both partners have agreed to undertake additional work before making a final investment decision, hoping to optimise project design, reduce capital and operating costs, as well as consulting key customers to ensure correct product specifications and align output with likely demand[272].

4.5. International Government Incentives for Downstream Investment

The scale of the opportunity created the EV disruption in the automotive industry and ESS in the energy sector is reflected in the economic development policies of many if not most industrialised nations. Across the EU, Asia and the America's national, provincial and even local governments have and continue to put in place initiatives designed to attract international and domestic investment in productive capacity in various elements of the lithium-ion battery supply chain.

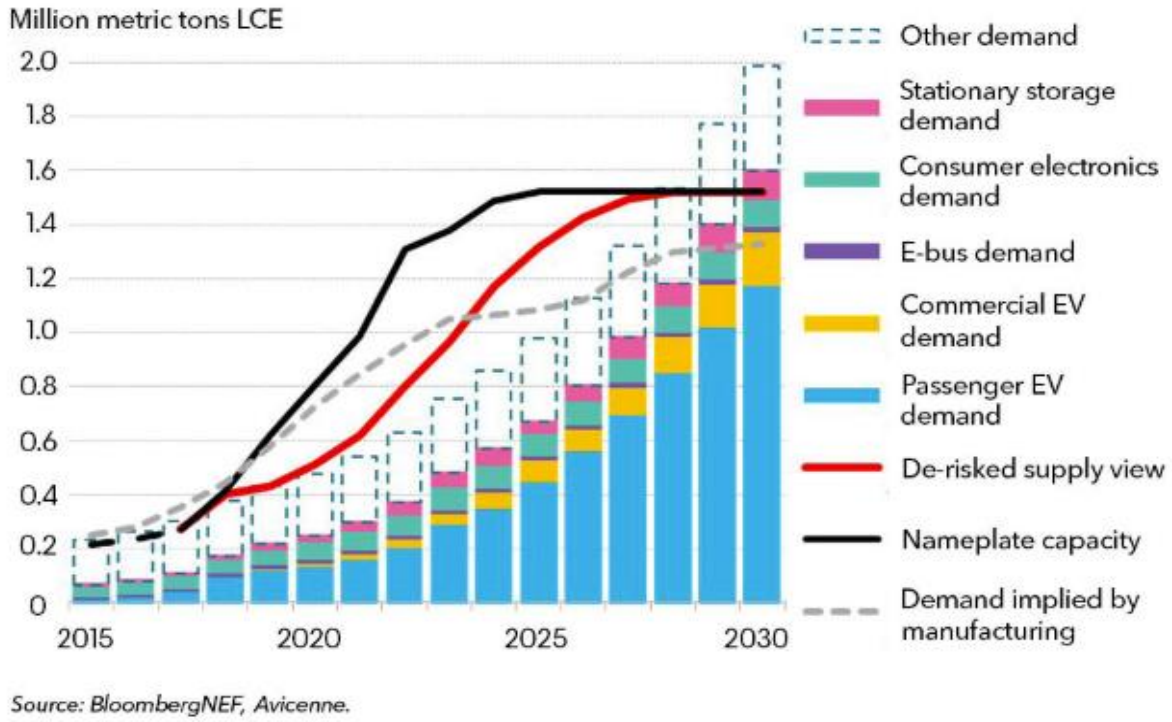
The nature of these interventions are wide ranging and can include the deployment of public funds to underwrite, incentivise or otherwise directly financially assist a venture; relief from government taxation and charges; and trade restrictions that encourage investment in local capacity or support the existing domestic industry. It is important to note that these measures are common, often opaque and exist in both developed and developing economies[273].

Aspiring Western Australian hydroxide manufacturers compete directly with industrial ecosystems that benefit from such direct government support.

4.6. Lithium chemical demand and supply forecasts

As illustrated in Figure 17[274] below, there is potentially periods of significant over-supply of lithium chemicals during the 2020s that is the result of a mismatch between chemical manufacturing capacity and projected total derived demand.

[268] Wesfarmers (2019), *Proposal to acquire Kidman Resources,* ASX release, 2 May 2019
[269] Wesfarmers (2019), *Proposal to acquire Kidman Resources,* ASX release, 2 May 2019; Covalent Lithium (2020), Our Project - *Refinery,* accessed 1 May 2020
[270] Zhou, V (2019) *Wesfarmers delays Mt Holland final investment decision,* Australian Mining, 24 January 2020
[271] Zhou, V (2019) *Wesfarmers delays Mt Holland final investment decision,* Australian Mining, 24 January 2020
[272] Wesfarmers (2019), *Proposal to acquire Kidman Resources,* ASX release, 2 May 2019
[273] Australian Venture Consultants (2018) *WA's Future in the Lithium Battery Value Chain*, Chamber of Commerce and Industry Western Australia.
[274] Lu, S; Frith, J (2019), *Will the Real Lithium Demand Please Stand Up? Challenging the 1Mt-by-2025 Orthodoxy*, published Bloomberg New Energy Finance, 28 October 2019



Source: BloombergNEF, Avicenne.

FIGURE 17 – LITHIUM CHEMICAL DEMAND AND SUPPLY FORECASTS OUT TO 2030 (LCE)

From current operating and committed lithium chemical manufacturing capacity (see Sections 4.1, 4.2, 4.3 and 4.4) there may be an over-commitment to lithium carbonate production. As of late 2019, industry estimates place approximately 80 percent of brine-sourced and 65 percent of hard-rock sourced lithium feedstock as directed towards carbonate production, with an estimated total final output of some 195,000 tonnes compared to only 70,000 tonnes of hydroxide[275]. The majority of this production is consumed by the PRC battery industry.

Although precise figures are frequently considered commercial-in-confidence, ROK is understood to currently be the predominant importer of high-grade lithium carbonate, followed by Japan and the United States, with most carbonate inputs sourced from Chilean brines and the balance ex-works from the PRC. Broadly, lithium carbonate supply chains are mature and entrenched, with strong trade links across the East Asian region between the PRC, Japan and the ROK.

By contrast, while hydroxide sales are also dominated by imports into Japan and the ROK, suppliers are more varied. PRC downstream chemical suppliers (discussed above at 4.1 above) remain responsible for the balance of hydroxide supply, drawing on feedstock predominantly sourced from Western Australian mines combined with some further beneficiation of lithium carbonate from a variety of sources.

4.7. Summary of lithium chemical manufacturing outlook

Not surprisingly, the dramatic increase in demand for lithium-ion batteries has driven a significant increase in lithium battery chemical manufacturing capacity, including, as a result

[275] Albemarle Corporation (2019), *Albemarle Investor Day*, presentation given 12 December 2019

of increased prevalence of nickel-rich battery chemistries in the EV market, lithium hydroxide capacity.

While some new capacity has either come on stream or is under development in Japan and ROK and as discussed earlier, some North and Latin American countries have plans to establish lithium hydroxide and/or carbonate manufacturing capacity, the vast majority of this capacity has been in the form of new plants or plant expansions in the PRC. While the majority of PRC lithium chemical production is absorbed by its extensive domestic battery manufacturing supply chains, the PRC has now become an exporter of both lithium carbonate and hydroxide.

While Western Australian spodumene concentrate production is a major supplier to the PRC lithium chemical manufacturing industry, lower prices render the manufacture of lithium hydroxide from brine produced carbonate competitive. Further, the expansion of the PRC chemical manufacturing industry has outstripped demand, resulting in some mothballing of capacity, below nameplate production and delays in commissioning new lithium chemical manufacturing capacity. Current forecasts indicate that this dynamic may result in extended periods of over-supply and excess capacity in lithium chemical manufacturing.

Global over-capacity in lithium chemical manufacturing has played out in Western Australia's nascent lithium hydroxide sector in the form of delayed commercial commissioning of Stage 1 and suspended investment in development of Stage 2 of Tianqi's Kwinana Plant and downsizing of Albemarle and Mineral Resources Kemerton plant which is currently under construction.

There will always be a geopolitical motivation for lithium-ion battery supply chains to have some ex-PRC sources of upstream feedstock (and indeed these motivations may be amplified in the current geopolitical climate). However, in this context, Western Australian lithium hydroxide manufacture competes with other ex-PRC locations that demonstrate more competitive cost structures (including cost structures that are influenced by government financial incentives) and are in some cases better integrated with major automotive manufacturing sectors.

Regardless, given existing excess capacity in the global lithium chemical manufacturing sector, it is difficult to see circumstances in the short-term that would support further investment in lithium hydroxide manufacturing capacity in Western Australia.

5. Impact of COVID-19

The defining event of 2020 will be the global pandemic caused by the COVID-19 coronavirus. The impacts of the pandemic are still unclear, and the full range of outcomes will likely not be known for some time. Nevertheless, it is now apparent that what started as a supply-side shock to the PRC in late 2019 has, by the end of the first quarter of 2020 resulted in global economic circumstances that are equivalent to the Global Financial Crisis and which may rival the Great Depression in their severity.

Estimates suggest that during government imposed lockdowns global economies can expect to see up to a 40 percent decline in economic output[276], while OECD projections are for worldwide global growth to decline by a full 1.5 percent, more than halving from the 2.9 percent growth seen in 2019. This equates to approximately USD $1.5 trillion in economic activity lost in the aftermath of the pandemic, with particularly severe impacts to be felt in economies notable for their position in the lithium industry supply chain – the PRC, Japan, the ROK and Australia[277].

Public health responses to the pandemic will be significant and will likely result in shifts and changes in consumer behaviour and purchasing decisions. While these will likely have some impact on demand for products based on lithium-ion battery technology, their impact on the supply chain will likely be second order in nature. The principal effects impacting the lithium sector are instead likely to stem from outlook, responses, trends and pressures affecting the manufacturing and energy sectors. Broadly, while manufacturing has seen significant disruption, the consequences of which will be felt by the lithium sector over at least the remainder of 2020, subject to government responses a potential large increase in the proportionate share of renewables in energy generation could provide significant impetus in the adoption of utility- and grid-scale energy storage systems, and hence derived demand for batteries.

5.1. Declining wealth impact on EV demand

Significant segments of the EV market, particularly those that are dependent on high performing battery technology, represent discretionary consumer and business purchases. Even in a heavily subsidised environment, consumers make a choice to purchase a new vehicle, and then in many markets to pay a premium for an EV over an internal combustion engine vehicle or a relatively high performing EV over a less expensive EV option.

Reduced incomes and uncertainty caused by COVID-19 will almost certainly affect discretionary spending in both consumer and business markets. Consumers and businesses will have less spending power and be inclined to adopt more conservative spending patterns.

These circumstances will almost certainly result in a period of depressed demand for EVs, particularly those that are based on higher performing nickel-rich batteries which is the primary source of derived demand for Western Australia's upstream lithium industry.

[276] International Energy Agency (2020), *Global Energy Review 2020*, April 2020
[277] OECD (2020), *Coronavirus: the world economy at risk*, OECD Economic Outlook: March Interim Report, 2 March 2020

5.2. Manufacturing

Globally, manufacturing output has decreased significantly as a consequence of the COVID-19 pandemic. As illustrated in the below Figure 18[278], PMI index data suggests the largest and sharpest decline since the Global Financial Crisis is currently under way, with no bottom yet in sight. Data from MAKE UK suggests that more than three quarters of manufacturers have seen a decrease in sales, more than 80 percent have seen a decrease in orders (and 20 percent have seen orders decrease by more than half), and 20 percent have furloughed more than one-quarter of their staff[279].

With data still under preparation and financial reports yet to be lodged for many companies, the full impact of the pandemic is not yet fully clear, and hence any estimates of the differential impact on lithium-exposed sectors are subject to uncertainty. However, a clear overall picture is emerging for manufacturing more generally, from which it is very unlikely that lithium-exposed subsectors will deviate. Indeed, as noted below, some early evidence suggests that such sectors may face greater impacts than others, mostly as a consequence of the impacts on the key subsectors of consumer electronic devices and particularly relevant to Western Australia's upstream industry, electric vehicle manufacture.

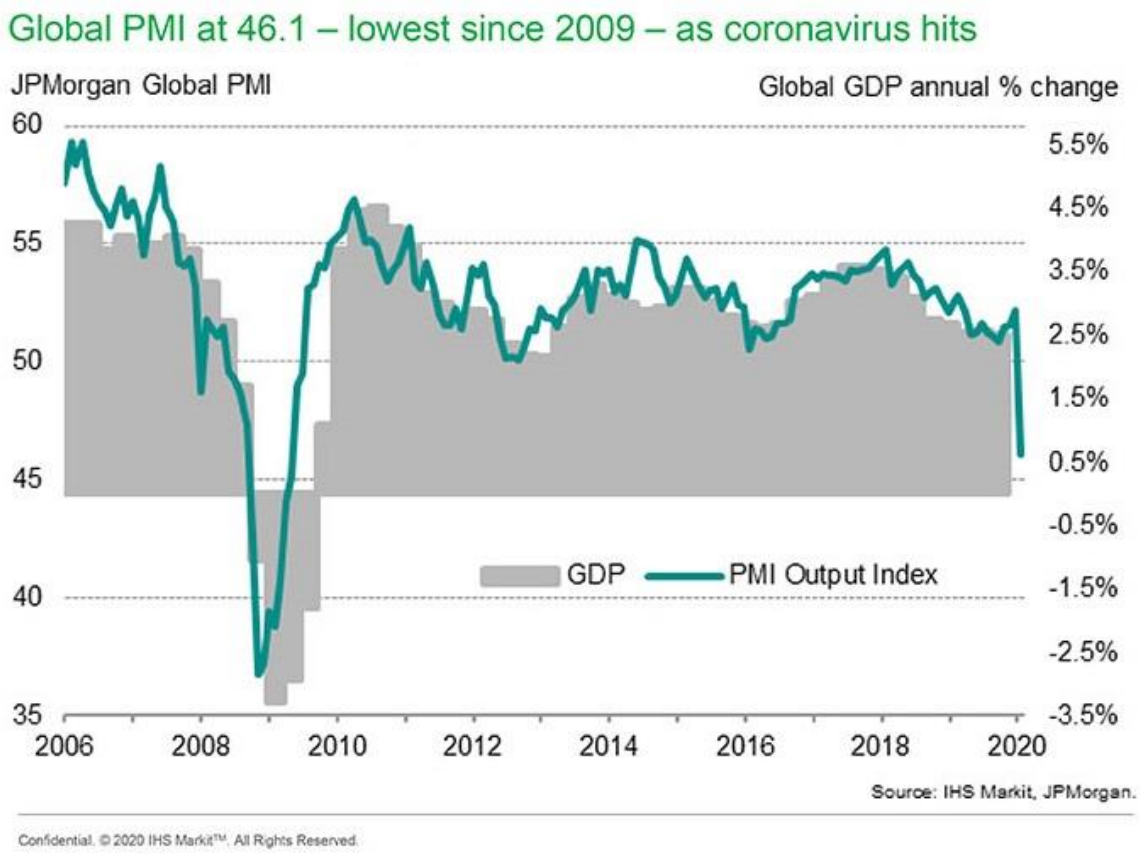


FIGURE 18 - MANUFACTURING PURCHASING MANAGERS' INDEX (PMI)

[278] IHS Markit/JPMorgan (2020), reported Zevin, A (2020), *Coronavirus Impacts Are Clear on Global Manufacturing Index*, Engineering News-Record, 6 March 2020
[279] MAKE UK (2020), *COVID-19 Manufacturing Monitor – May Update*, 4 May 2020

5.2.1. People's Republic of China

Broadly, impacts in the PRC will disproportionately affect the global lithium-ion battery supply chain, and hence the lithium industry more broadly. In 2019, of the 316 gigawatt-hours of lithium cell manufacturing capacity worldwide, 73 percent was located in the PRC – the next largest supplier was the United States, with only 13 percent[280].

As the epicentre of the COVID-19 outbreak, manufacturers in the Wuhan/Hubei region have been most directly and severely affected. Further, with tighter movement controls, combined with uncertainty regarding start-up dates, many enterprises that rely on temporary or seasonal labour will face ongoing difficulties in resuming full-scale production. While in terms of manufacturing scale the region has lower output than the Yangtze or Pearl River Deltas, it is a major automobile and EV production hub, accounting for around 9 percent of national output, and hosting factories for major domestic brands, such as Dongfeng Motor, and international vehicle manufacturers, as well as auto-parts manufacturers from Japan, the

United Kingdom, United States and the EU[281]. Shutdowns, slowdowns and supply uncertainties affecting the province will hence have a proportionally greater impact on lithium demand. Sales of EVs have recorded a 77 percent year-on-year decline in February and 66 percent in March[282], while it was not until mid-March that provincial regulators began easing bans on factory production[283]. While sales are trending upwards again, fostered by re-implemented NEV subsidies (see Section 2.1.1), it will likely be some time before industry capacity and consumer sentiment fully recovers.

PRC shutdowns have had a particularly severe impact on Japanese automobile manufacturers, with the Japanese Ministry of Economy, Trade and Industry (METI), Japan Automotive Manufacturers Association (JAMA), and Japan Auto Parts Industries Association (JAPIA) establishing a Novel Coronavirus Countermeasure Study Council for Automotive Industry to assess and ameliorate the impacts. Tier-one manufacturers, such as Nissan, Honda, Mazda and Toyota, have been forced to shut down assembly lines, delay deliveries, or procure parts from alternative sources (such as Mexico) at higher costs, impacting production of EVs[284].

5.2.2. European Union and United Kingdom

As of mid-March, every major United Kingdom and EU carmaker had announced plans to curtail or halt production as a result of pandemic impacts and quarantine measures, while in the United States General Motors, Ford and Fiat Chrysler have negotiated rotating shutdowns with unions and Tesla has halted Californian production and most recently Shanghai production entirely[285]. Further, industry pressure is being brought to bear against regulators and decision-makers, with the European Automobile Manufacturers' Association advocating for a

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[280] Ryser, J (2019), *Possible US tariffs could hike battery storage system costs 15-18%: analysts*, S&P Global, 6 June 2019

[281] Zhang, J (2020), *Coronavirus' impact on Chinese manufacturing*, Control Engineering, 16 March 2020

[282] Shen, J; Udemans, C (2020), *EV sales start to recover from virus hit*, China TechNode, 23 April 2020

[283] Shen, J (2020) *Hubei auto plants begin to stir*, China TechNode, 13 March 2020

[284] Banker, S (2020), *The Coronavirus' impact on Japanese manufacturers*, Forbes, 5 March 2020

[285] Reported eg Jolly, J (2020), *Every major UK and European carmaker to stop or cut production*, The Guardian Newspaper, 21 March 2020; Lambert, F (2020), *Tesla prepares to return to work at Fremont factory, Shanghai temporarily closes again*, Electrek, 7 May 2020

relaxation in mandatory emissions standards and electrification deadlines enshrined in EU legislation in light of the COVID-19 pandemic. If these measures were relaxed, the record pace of EV adoption in EU markets (see Section 2.1.1) may slacken, flowing through to demand for lithium.

5.2.3. South East Asia

Across South-East Asia, the PRC is the largest source of imports for 90 percent of economies. Early stage reports indicate that Vietnam is particularly vulnerable, with automotive and consumer electronics manufacturers reporting difficulties securing battery cells and packs. Unconfirmed reports suggest that Samsung mobile phone assembly lines in the country are running at only 50 percent capacity due to a shortage of parts[286], while the mobile giant has halved parts orders across all product lines and decreased total output by more than half, reducing monthly output for April from 25 to 10 million units[287].

5.2.4. Impact on demand for lithium

As a result, the derived demand for lithium is expected to shrink markedly over the course of at least the first half of 2020, disrupting previous growth trends. Reductions in EV sales to date represent approximately 2,800 tonnes (LCE) of lost lithium demand, with steady increases in EU sales more than offset by decreases in the United States and PRC, while respected industry commentators are reducing 2020 final demand predictions by nearly one-quarter[288]. In all scenarios, however, these temporary reductions present short-term constraints on lithium demand growth, with underlying demand out to the late 2020s predicted to exceed 18 percent year-on-year increases[289].

5.3. Energy supply and storage

The impacts of the COVID-19 pandemic on global energy supply and demand are complex and multifactorial. While an in-depth analysis of global energy markets and policy falls outside the scope of this report, broadly, the significant decline in global economic activity has resulted in a commensurate decline in energy requirements, resulting in large excess stocks of hydrocarbons.

Per International Energy Agency assessments, by early April more than 54 percent of the global population, representing 60 percent of global GDP, were subject to mandatory lockdown measures, resulting in the most severe shock to energy demand since World War II – a 6 percent decline in global energy usage which is seven times greater than in the depths of the Global Financial Crisis, the largest proportionate drop in 70 years and the largest ever absolute decline[290].

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[286] Gill, B (2020), *Coronavirus impacts manufacturing supply chains in Southeast Asia*, Logistics Viewpoints, 10 March 2020

[287] Adnan, F (2020), *Samsung cuts parts orders by half as COVID-19 crashes phone demand,* SAMMobile, 24 April 2020

[288] Merriman, D (2020), *Lithium: demand downgraded amidst COVID-19 pandemic, slow EV sales and weaker global economic performance*, Roskill, 6 April 2020

[289] Roskill (2020), *Lithium: Outlook to 2030, 17th Edition*, preprint summary Roskill Market Reports, accessed 8 May 2020

[290] International Energy Agency (2020), *Global Energy Review 2020*, April 2020

As illustrated in the below Figure 19[291], this will place fossil fuel sources under extreme pressure, with renewable energy predicted to be the only generation sector to grow. United States crude oil (West Texas Intermediate) prices famously hit negative values for the first time in history in late April 2020, falling to USD $38 per barrel as rising stockpiles of crude overwhelmed storage facilities, with Brent crude hitting 21-year lows, while Asian spot LNG prices declined over 60 percent to reach historic lows of USD $2.66/MMbtu.

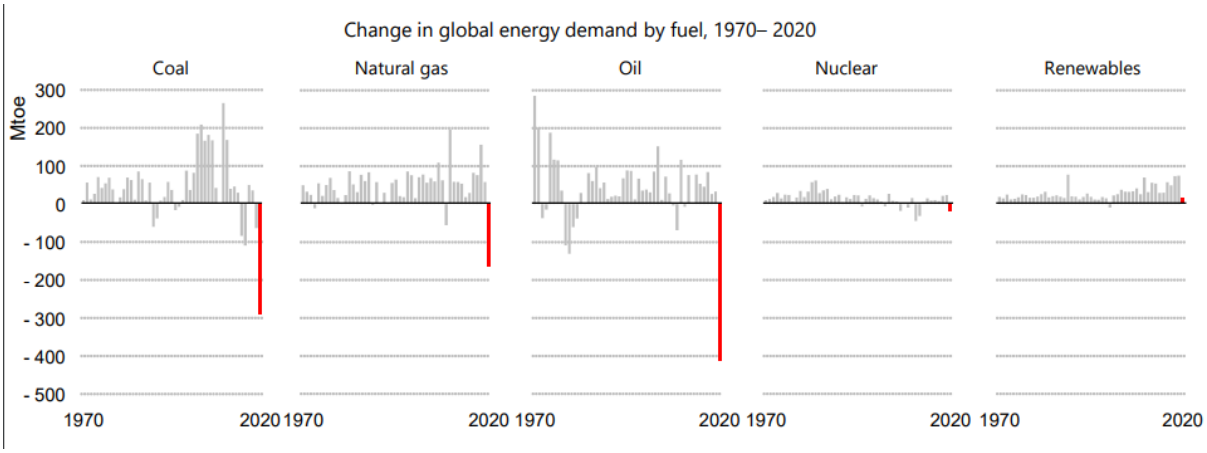

FIGURE 19 - IEA ENERGY DEMAND BY FUEL

While prices of both have since recovered, mostly as a result of historic production curtailment agreements between OPEC nations, Brazil, Canada, Norway and the United States reducing global supply by 20 percent[292], the trajectory of hydrocarbon energy sources is clear. Over the course of 2020, low-carbon energy sources are expected to increase to 40 percent of total generation capacity under most recovery scenarios[293].

Per European Network of Transmission System Operators for Electricity (ENTSO-E) data, coal-based power generation has seen a year-on-year declined of over one-quarter in Q1 2020 compared to Q1 2019, while renewables have increased by around 10 percent. In the United Kingdom, and across EU as a whole, the share of total generation made up by renewable sources has increased to 43 percent. In a sign this trend may be accelerating, for the one-month period from early March to April United Kingdom/EU coal generation was down by nearly 30 percent in year-on-year terms, accounting for a share of only 12 percent of the total, while renewables surged by 8 percent to make up 46 percent of total generation[294].

To date, global forecasts and analysis of energy trends concur that the outlook for hydrocarbon fuels remains poor for the duration of 2020 and throughout the recovery phase of the COVID-19 pandemic. Despite deep and historically unprecedented OPEC+ production cuts, as of midway through Q2 2020 the supply/demand imbalance for crude oil remains close to 15 million barrels per day, and the number of operating oil rigs has declined by over 36 percent[295]. Under all projected recovery scenarios, even optimistic modelling assuming

[291] International Energy Agency (2020), *Global Energy Review 2020*, April 2020, adapted from *Fossil Fuels are set for a dismal 2020*
[292] Reuters (2020), *Big cuts in oil production from OPEC and others*, Reuters Business News, 13 April 2020
[293] International Energy Agency (2020), *Global Energy Review 2020*, April 2020
[294] Wärtsilä Energy Transition Lab (2020), *European responses to COVID-19 accelerate the electricity system transition by a decade*, 17th April 2020
[295] Reported eg. Enverus (2020), *COVID-19: Oil and Gas Fundamentals Update*, May 2020

continually declining new cases already potentially endangered by a recurrence of outbreaks in mid-May seen in the PRC, Russia and the ROK, hydrocarbon demand will likely not recover to demand levels reached in 2019 until 2022. As illustrated in the below Figure 20[296], long-term demand will likely remain below historical trends even once global economies open fully, reflecting lost demand and structural damage.

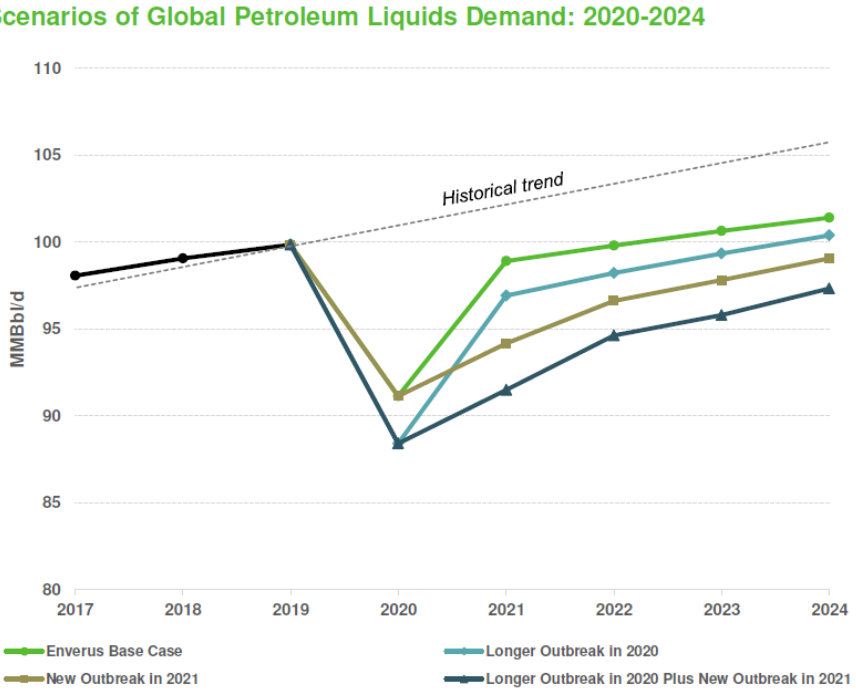

FIGURE 20 - SUGGESTED HYDROCARBON DEMAND PATHWAYS

In the main, this trend and proportional growth is explained by the dynamics of renewable generation: once initial capital outlays are past, ongoing power generation is, for most forms of renewable energy, essentially free. By contrast, fossil fuel-based generation requires ongoing purchases of feedstock such as coal and oil. In a climate of reduced demand, and hence in most deregulated electricity markets reduced prices, generators with an oversupply of energy and ongoing costs are incentivised to trim those costs through curtailing purchase of feedstock. While global economies will be highly motivated to accelerate demand and growth, and therefore energy consumption, large-scale shut-ins, massively built up stockpiles, and a decline in key demand industries (such as logistics) will pose demand headwinds. Further, decisions to delay or reduce CAPEX taken in the current reduced demand climate – for example, in Australia approximately AUD $80 billion in LNG investment decisions have been delayed or put on hold[297], while in the United States expenditure decisions by major oil and gas providers have been revised down by a total estimated USD $47 billion (an average of 32 percent) since early March[298] - are likely to lock in lower levels of supply for the short-term and reduce the ability of industry to quickly ramp production in the event demand recovers.

[296] Enverus (2020), *COVID-19: Oil and Gas Fundamentals Update*, May 2020
[297] Morton, A (2020), *Australia's booming LNG industry stalls after fall in oil prices amid coronavirus*, The Guardian Newspaper, 13 April 2020
[298] Enverus (2020), *COVID-19: Oil and Gas Fundamentals Update*, May 2020

5.3.1. Impact on demand for lithium

There are several possible consequences of this dynamic for energy markets going forward that have implications for derived demand along the lithium supply chain.

Firstly, the unprecedented increase in the proportionate share of renewable generation, reaching levels not thought to occur under many modelling scenarios until the mid to late 2020s, goes some way towards demonstrating that current transmission grids, load-balancing and associated energy infrastructure are capable of handling high levels of intermittent and variable renewable generation. For example, in Germany, a nation with a notable industrial sector and commensurately high-power needs, renewables are currently providing 60 percent of total power generation[299]. As a result, it is likely that regulators may adopt a higher risk appetite in approaches to increased renewable generation than previously exhibited, accelerating the global transition to renewable generation.

Second, with a higher current and likely future share of renewable generation, there will be increased pressure on end users and providers – both national grids and private owner-operator generators – to convert instantaneous generation to stored energy for future usage or arbitrage. While there are varying means of achieving energy storage, using current technology this will naturally lead to a higher demand for lithium for larger and grid-scale battery energy storage systems (ESS). While the impacts of the COVID-19 pandemic on ESS production are significant in the short term – predicted to cost the PRC battery manufacture industry around 26GWh of lost output in 2020 – the longer term outlook for battery uptake is positive, with virtually all global economies expected to implement ESS regimes to regulate and support the uptake of renewable generation and around 1,000GWh of planned capacity by the late 2020s[300].

Thirdly, and potentially constraining these eventualities is a possibility that industry and government decisions in the world's largest economies will prioritise accelerated economic development that has the most significant immediate impact across their wider economies. In large energy intensive economies, particularly those with large domestic fossil fuel industries, this may involve rapid reactivation of hydrocarbon generated energy simply for the purpose of bringing large volumes of energy on quickly and supporting the recovery of large domestic hydrocarbon industries. In some circumstances growth in renewable generation may not be as aggressive.

5.4. Summary of likely impact of COVID-19

The decline in manufacturing generally will result in a further short-term decline in derived demand for lithium-ion batteries, further exacerbating the current environment of over supply in lithium raw materials and chemicals.

The decrease in EV manufacturing in particular will have a direct effect on demand for spodumene concentrate and lithium hydroxide.

Depending on industry and government policy responses to COVID-19 recovery in major energy intensive economies, current energy market dynamics that are the result of COVID-19

[299] Keating, D (2020), *Renewable Energy Way Up During COVID19 Shutdowns*, Forbes magazine, 17th April 2020

[300] International Energy Agency (2019), *Status of Power System Transformation 2019*, May 2019; Global Data Insights (2020), *Coronavirus outbreak to impact China's battery storage production*, Power Technology, 20 March 2020

shutdowns may see increased demand for ESS, supporting higher levels of battery demand in the medium term.

6. Implications for the Western Australian lithium industry

Western Australia has a medium-to-long-term opportunity to embed its spodumene concentrate production as a the key supplier of mineral feedstock to supply chain partners particularly in the PRC and other parts of Asia and establish a differentiated lithium hydroxide manufacturing sector as a source of ex-PRC supply. Success in this regard may subsequently provide the basis for a small domestic cathode precursor sector, albeit this a more substantive challenge[301].

However, as demonstrated by the analysis in Sections 2through 5 of this report, current global lithium market, supply chain and industry dynamics present Western Australia's upstream lithium industry with formidable short-to-medium term challenges.

6.1. Strong medium-term outlook

On all indications global demand for lithium-ion batteries, particularly from the EV and to a lesser extent the ESS markets will continue to grow strongly. This is an irreversible macro-trend that presents a significant opportunity for Western Australia's upstream lithium industry.

While Western Australia's total manufacturing cost disadvantage will continue to present a barrier to investment in downstream manufacturing aspects of the lithium-ion battery supply chain[302], the State's comparative advantage in the production of spodumene concentrate and opportunities to leverage that advantage into the manufacture of immediate downstream lithium chemicals presents significant opportunity for ongoing economic growth and diversification.

However, efforts do this will face significant competition from excess capacity in lower cost PRC lithium chemical manufacturing plants and a general trend to concentrate upstream, midstream and downstream aspects of the lithium-ion battery manufacturing supply chain in close proximity to major EV manufacturing centres. Because Western Australia's higher total product manufacturing costs are embedded in the structure of the economy and Australia is not likely to have an automotive manufacturing industry for the foreseeable future, the competitiveness of a Western Australian lithium chemical manufacturing sector will need to be underpinned by other customer valued factors (such as environmentally sustainable production, fair labour etc.) that differentiate its product.

Furthermore, depending on the specific nature of post COVID-19 stimulus investments by governments in major industrial economies, stronger demand for batteries could indeed become structurally entrenched in some sectors, resulting in further medium-to-longer-term derived demand for Western Australia's upstream products.

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301 Australian Venture Consultants (2018) *WA's Future in the Lithium Battery Value Chain*, Chamber of Commerce and Industry Western Australia.

302 Australian Venture Consultants (2018), WA's Future in the Lithium Battery Value Chain, Chamber of Commerce and Industry Western Australia and Chamber of Minerals and Energy Western Australia

6.2. Short and medium term threats

As discussed in previous sections, there can be no doubt that as a result of current global market conditions along the supply chain, Western Australia's spodumene concentrate production and emerging lithium hydroxide manufacturing sectors are in the midst of significant disruption and are likely to face circumstances that will continue to challenge the competitiveness of the sector for at least until the mid-2020s:

- **Foreign government policy remains the main driver of final demand**
  While rapid growth in adoption of EVs plays to Western Australia's competitiveness as a provider of superior feedstock for the manufacture of nickel-rich batteries that are clearly emerging as the platform technology for EVs, it is clear from recent declines in demand in the world's two largest EV markets, PRC and United States, that government policy incentives and restrictions remain by far the most significant driver of final demand for EVs. This policy framework across major markets for EVs is significant, opaque and very fickle, placing Western Australian production at the mercy of policy decisions of foreign governments.

- **Brine and other hard-rock resources may become a significant competitor as feedstock to lithium hydroxide manufacture**
  Lower lithium prices mean that the portion of the total cost of manufacturing lithium hydroxide that is attributable to the cost of raw material feedstock is less, reducing the competitiveness of spodumene in the manufacture of lithium hydroxide.. The full potential capacity of Latin American brine production has been fettered historically by perceived sovereign risk. Regardless investment in projects has continued, resulting in increased production coming on stream from 2022.Similarly, there are hard-rock and brine resources that are in the process of being commercialised in North America and to a lesser extent Mexico. In the case of both North and Latin America, some of this primary production is the subject of planned domestic chemical manufacture.

- **Significant excess capacity in the PRC chemical manufacturing sector is likely to remain for the medium-term**
  While it is advantageous that Western Australian spodumene concentrate is integrated with the PRC lithium-ion battery supply chain, current global over-supply and significant excess lower cost lithium chemical manufacturing capacity in the PRC will make it very difficult for Western Australian lithium hydroxide manufacturing capacity to compete with PRC supply on any basis other than perceptions of geopolitical risk or undesirable input profiles associated with PRC supply. Even in the event of rising demand for ex-PRC supply, this can be sourced from jurisdictions other than Western Australia.

- **COVID-19 related decline in spending and manufacturing exacerbates the issues in the short-term**
  The challenges facing the Western Australian industry that are a manifestation of current market conditions are only exacerbated in the short-term by reduced spending and the current manufacturing downturn that is result of COVID-19 economic shutdowns across the globe.

6.3. Significant Western Australian spodumene concentrate production and hydroxide manufacture is at risk

As demonstrated by the analysis in Confidential Addendum 1 to this report, the circumstances described in the preceding sections of this report have resulted in market conditions that place significant volumes of Western Australian spodumene concentrate production at risk.

Furthermore, the fact that a single hydroxide plant has been constructed and that another is under construction does not in any way imply that Western Australia has established a competitive lithium chemical manufacturing industry:

- Firstly, lithium chemical plants are frequently mothballed in the PRC and elsewhere (see Section 4) and it is inevitable that if Western Australian lithium hydroxide plants cannot supply product competitively, they too will be mothballed.
- Secondly, Western Australia has a long history of significant investment in downstream processing plants that either fail to commission, or quickly become redundant as a result of being unable to supply product that is competitive in global markets. Irrespective of the significance of the macro-drivers in the lithium-ion battery supply chain, there is every likelihood that similar circumstance may eventuate in Western Australia's emerging lithium hydroxide manufacturing sector.

7. Western Australian Government policy settings

This section sets out previous recommendations made by Western Australian industry to the Western Australian Government as to policy initiatives that the Western Australian Government could pursue to underpin the competitiveness of Western Australian industry in the lithium-ion battery supply chain, as well as the Western Australian Government's current policy settings.

7.1. Industry recommendations

In mid-2018 the CME Chamber of Commerce and Industry Western Australia (CCIWA) with support of the CME, Synergy, BHP, City of Kwinana and Neometals commissioned AVC to undertake a study to explore the competitiveness of Western Australian industry in the lithium-ion battery value chain[303]. Not surprisingly, this comprehensive study determined that Western Australian industry is competitive in the production of spodumene mineral concentrate, possibly competitive in the manufacture of lithium hydroxide and potentially competitive in the manufacture of some battery cathode pre-cursor materials. It also concluded that as a result of structurally high total product manufacturing costs, Western Australia was unlikely to be competitive any other mid or downstream sectors of the lithium-ion value chain.

Accordingly, the policy recommendations made in this study focused on enhancing industry competitiveness in these upstream areas of the supply chain, using policy tools that are consistent with general Australian economic policy principles. These recommendations are summarised in the following Table 12.

TABLE 12 – 2018 POLICY RECOMMENDATIONS MADE BY INDUSTRY TO THE WESTERN AUSTRALIAN GOVERNMENT

Recommendation	Details
Set the right narrative	1. The Western Australian Government and participants in the Western Australian lithium-ion battery supply chain should work together to establish a clear strategy designed to allow Western Australia and Western Australian industry to optimally capitalise on its competitive advantage in the global lithium-ion supply chain and sustain that competitive advantage.
	2. Government and industry leadership should use an agreed narrative to promote Western Australia's prospects in the lithium-ion battery supply chain that is evidence-based, realistically achievable, clearly linked to the strategy, and very importantly recognises the importance of Western Australia's mining and emerging chemical processing industries as the fundamental source of Western Australia's competitive advantage in the lithium-ion battery supply chain, supporting their social licence to operate.
Build on existing trade relationships	3. Western Australian Trade Commissions, Austrade and the Commonwealth Department of Foreign Affairs and Trade should work with the various nations with which Western Australia and Australia already have extensive trade relationships and existing or prospective facilitative agreements, to optimise Western Australian supply of upstream products to the global lithium-ion battery supply chain and

[303] Australian Venture Consultants (2018), WA's Future in the Lithium Battery Value Chain, Chamber of Commerce and Industry WA and Chamber of Minerals and Energy Western Australia

Recommendation	Details
	to attract FDI that builds upstream production capacity in Western Australia.
Project investment and operational certainty	4. The primary mechanisms for optimising project investment and operational certainty for the upstream lithium-ion battery industry in Western Australia should be in the form of specific improvements to the Strategic Industrial Area policy framework and the implementation of a time-bound machinery of government mechanism that facilitate all advanced lithium-ion battery supply chain projects under the existing Lead Agency Framework.
New Industry Development Incentives	5. To incentivise investment in conversion plants and upstream lithium-ion supply chain chemical manufacturing in Western Australia, the Western Australian Government should give consideration to the following: ▪ In accordance with the net-back principle that applies to the design of Western Australia's minerals royalty regime, operations to convert a mineral concentrate directly to a marketable chemical that has a higher primary constituent content should be charged a prescribed royalty rate that is between the current netback principle based mineral concentrate rate (5.0 percent) and the metal rate (2.5 percent). ▪ Conduct further analysis and modelling to determine if there is an economic case for using the royalty regime to incentivise investment in Western Australian battery chemical precursor production capacity. ▪ Ensure Western Australia's overall taxation framework optimises the productivity of Western Australian industry.
Targeted Research and Development	6. While there may be discrete areas of battery technology innovation where Australian science is at the cutting-edge, the proposed Future Battery Industries CRC should ensure its resources are targeted at underpinning and expanding Australia's (primarily Western Australia's) competitive advantage in lithium-ion battery supply chain, as articulated by the study. 7. The Commonwealth Government considers revoking the recently impose $4m cap on cash rebates for smaller business under the R&D Tax Incentive Scheme.

7.2. Lithium sector specific policy settings

Specific policy initiatives that the Western Australian Government has implemented to support the Western Australian lithium sector are summarised in the following subsections.

7.2.1. Future Battery Industry Strategy: Western Australia

In 2019, the Western Australian Government launched its Future Battery Industry Strategy with a vision that by 2025, Western Australia will have a world leading, sustainable, value-adding future battery industry that provides local jobs, contributes to skill development and economic diversification and benefits regional communities.

The Strategy sets the objective of Western Australia being recognised as a leading producer and exporter of future battery materials, technologies and expertise by:

- Improving the competitiveness of Western Australia's future battery minerals and materials industry
- Expanding the range of future battery minerals extracted and processed in Western Australia
- Increasing the scale of processing, manufacturing and service activities across the breadth of the battery value chain in Western Australia
- Increasing research and development activities focused on the battery materials high technology energy sectors in Western Australia

To give effect to these objectives the Strategy sets out X action themes. These are summarised in the following Table 13.

TABLE 13 – FUTURE BATTERY INDUSTRY STRATEGY ACTION THEMES AND INITIATIVES

	Action Theme	Initiatives
1.	Investment attraction	The Western Australian Government will promote Western Australia as a prime destination for investment in the battery value chain: ▪ Develop and implement an investment attraction strategy ▪ Develop relationships with investors and manufacturers in global battery electric vehicle supply chains ▪ Facilitate access to pre-competitive geological information
2.	Project facilitation	The Western Australian Government will continue to facilitate the establishment of new future battery projects in Western Australia: ▪ Facilitate projects in the future battery industry through the State's approvals process ▪ Support future battery materials projects to establish in Strategic Industrial Areas by o Proving support with project scoping and interagency coordination o Offering advice and assistance to address State policies and processes ▪ Ensure policies are in place to facilitate timely access to adequate energy and water supplies for future battery industry projects in the State ▪ Assess and develop strategies to address current and future skills gaps. ▪ Help Western Australian projects to access State and Federal Government financial assistance, where available.
3.	Research and technology sector development	The Western Australian Government will continue to support research into future battery materials and technologies: ▪ Support the Future Battery Industries Cooperative Research Centre bid or State-based Battery Industry Research Priority Program if the CRC bid does not progress ▪ Work with the Federal Government on adequate research and development tax incentives ▪ Facilitate access to infrastructure and funding for technology SMEs
4.	Adoption of battery technology – new opportunities	The Western Australian Government will explore opportunities associated with the uptake of batteries in Western Australia and globally:

Action Theme	Initiatives
	▪ Explore domestic and export opportunities associated with the assembly, installation and management of energy storage systems. ▪ Assess recycling needs, opportunities and regulatory requirements. ▪ Explore manufacturing opportunities associated with the demand for niche battery products.

7.2.2. Lithium royalties

In Western Australia all lithium primary production is transacted ex-mine gate as a spodumene concentrate product. In accordance with Regulation 86 of Part V Division 5 of the *Mining Regulations 1981* (WA) the Western Australian Government charges a royalty rate of 5.0 percent of the invoice value of the spodumene concentrate. This is consistent with the netback principle of the Western Australian royalty regime.

The emergence of vertically integrated downstream processing of spodumene concentrate to lithium hydroxide whereby spodumene concentrate is produced by an entity owned or related to the lithium hydroxide manufacturer that is processing the spodumene introduced uncertainty as to the taxing point.

This has been resolved by the introduction of Section 86AE to the *Mining Regulations 1981* (WA) whereby for the purposes of calculating royalty payable under Regulation 86 for lithium (spodumene concentrate) that is sold to a related party and used as feedstock in the production of lithium hydroxide or lithium carbonate the Minister may from time to time determine a method for working out the royalty value of lithium concentrate of the same or similar grade to the lithium concentrate concerned.

7.2.3. Future Battery Industries Cooperative Research Centre

In 2018, a consortium of approximately 60 government, research and industry partners led by Curtin University with substantial support from the Western Australian Government made an application to Round 20 of the Commonwealth Government's Cooperative Research Program to establish a Future Battery Industries Cooperative Research Centre (FBICRC). The successful bit with the FBICRC to be hosted in Western Australia was announced in April 2019.

While headquartered in Western Australia, the FBICRC is national in scope with a mandate to facilitate research that contributes to Australia becoming a central player in the value-added export of battery minerals, materials, technologies and expertise.

As summarised in Figure 21 below, the largest category of participants are businesses and industry organisations operating in the battery supply chain upstream (mineral exploration, mining, processing and aspiring manufacturers of immediate battery chemical products). The next largest category and research and education organisations comprising 24 percent of participants, followed by general climate, energy and supply chain businesses (19 percent) and government (11 percent). While businesses operating in the battery supply chain mid and downstream account for a mere 4 percent and recycling 6 percent of participants.

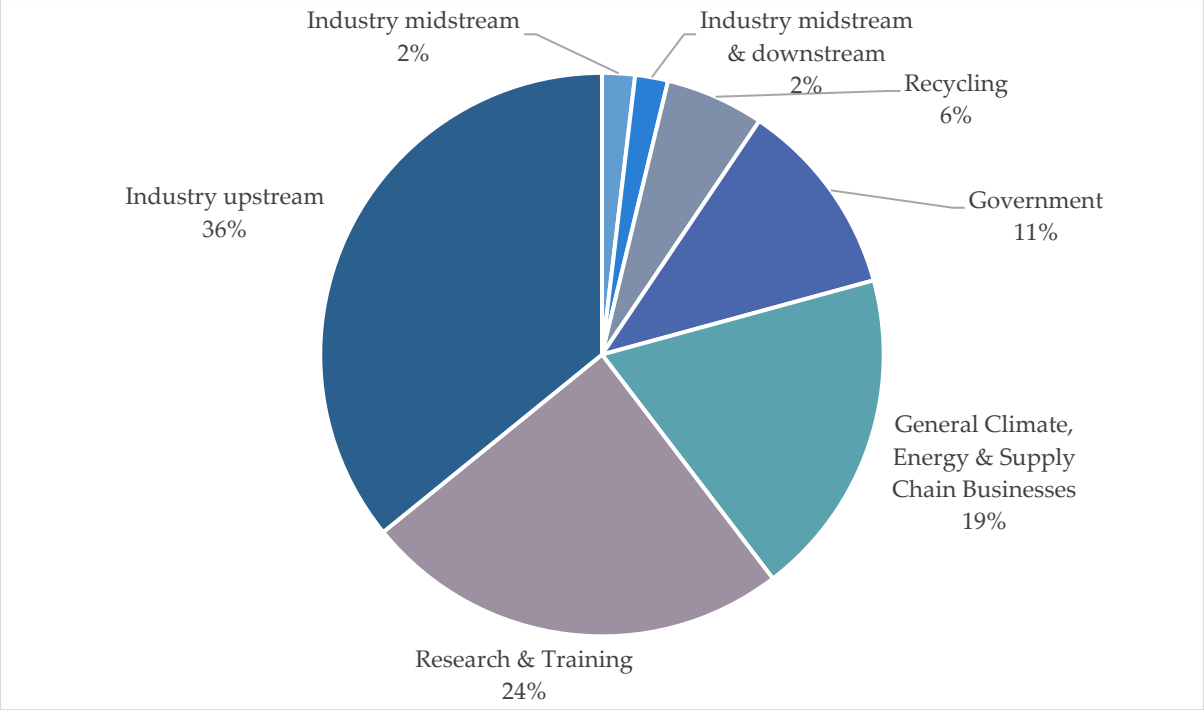

FIGURE 21 – SECTOR PARTICIPATION IN THE FUTURE BATTERY MINERALS CRC

Collectively, the partners have contributed $55 million in cash and $72 million in-kind to be invested in research according to the following research streams over six years:

- **Industry development**
  This stream is focused on providing evidence-based advice to inform government policies and regulations and to secure public trust for new energy technologies. In doing so it aims to develop measures, policies, procedures and mechanisms to catalyse the rapid development of battery deployment in the market and through vertically integrated Australian battery industries. It has a specific focus on optimising regulatory frameworks for rapid battery-based industrialisation uptake of Australian batteries from traceable Australian resources and the development of a policy framework that incentivises cradle-to-grave investment in the battery industry. Research is conducted under the themes of:
    - Battery market and value chain development
    - Battery supply chain integrity
    - Energy grid optimisation with batteries
    - Transitional impact of batteries on society and the economy
    - Optimising battery industry ecosystems

- **Resources, processing and recycling**
  This stream is focused on developing innovative pathways to mine, extract, refine and recycle battery minerals, metals and materials to produce battery grade products, as well as demonstrating feasible precursor production in Australia and pilot plant testing for battery manufacturing. The aim is to develop sustainable, traceable, cost-effective production pathways for refined battery metals from their primary (natural) and secondary (recycled) resources, ensuring Australian provenance throughout the value chain. Research is conducted under the themes of:
    - Environmental and waste management strategies from extraction of materials to the end of life of batteries
    - Cost-competitive resources processing of battery minerals
    - Premium quality battery grade materials
    - Battery recycling, re-purposing and reuse

- Battery component precursor production

- **Manufacturing, testing and deployment**
  This stream aims to develop Australian battery fabrication capabilities, enhance battery testing facilities and develop new battery energy storage systems. Research is conducted under the themes:
  - Cell manufacturing and testing capability
  - Battery energy storage systems manufacturing and testing capability
  - Battery development for deployment-specific applications
  - Smart battery management systems
  - Battery safety and security

8. Lithium sector royalty efficacy

Exploring the potential to modify the royalty regime that applies to the Western Australian upstream lithium industry was recommended by industry in 2018 (see Table 12) and immediate short-term royalty relief and longer-term modification are recommendations of this study (see 9.3.2 and 9.4.1).

A key factor considered by the Western Australian Government in assessing the case for changes to the royalty regime that applies to a particular sector is the extent to which royalties paid by that sector are efficacious in meeting the State's return expectation of 10 percent of mine-head value.

This section discusses the return expectation and based on a sample of actual industry data demonstrates the extent to which the sector is currently over-paying with respect to the State's benchmark return.

8.1. Efficacy with the Royalty Regime

8.1.1. Western Australian Government Return Expectations

In 1981, the Western Australian Government determined that the State's minerals royalty regime should return to the State an amount 'in order of' 10 percent of the value of the ore 'ex mine'[304, 305] as compensation for the exploitation of State-owned resources. This benchmark was reinforced by the 2015 Royalty Review and is one of several mechanisms used by the Western Australian Government to determine whether a particular royalty rate or the royalty regime overall is equitable.[306]

There is limited information available as to how the benchmark rate of 10 percent was determined. The two most commonly espoused views are:

- The tender process for the first Western Australian iron ore mine, Goldsworthy, indicated that a rate of 7.5 percent of mine revenue was the maximum government charge that the market could bear at the time, and the Government arbitrarily determined that the cost of crushing and screening was equivalent to approximately 2.5 percent of the market value, resulting in a benchmark rate of 10 percent of mine-head value; and/or
- 10 percent of the wellhead value was the traditional royalty levied against petroleum production and this was simply translated across to minerals royalty policy framework[307].

[304] Minister for Mines (1981), IN: Department of State Development and Department of Mines (2015), *Mineral Royalty Rate Analysis – Final Report,* Western Australian Government, Perth
[305] Mine-head value is the value of the ore at the first point at which the ore could be stockpiled once extracted from the mine, which in most cases is the Run-of-Mine (ROM) stockpile.
[306] Department of Mines and Petroleum (2015), *Mineral Royalty Rate Analysis – Final Report,* Western Australian Government, Perth
[307] Guj, P. (2013), *Western Australian Royalty Review: Some Key Policy and Administration Considerations,* Centre for Exploration Targeting

Despite a lack of clarity as to the historical foundations of the 10 percent benchmark, the 2015 Review[308] by the Western Australian Government further reinforced its relevance. In particular, in a tiered system (discussed further below), the view of the State is that a benchmark allows the fair comparison of royalties in and between industries, and over time, accords with community expectations, and strikes a reasonable balance between equity, efficiency and competitiveness. Many in industry also support the benchmark return, as it serves as quantitative 'anchor' that requires government to demonstrate a quantitative justification for increasing royalties and provides industry with a quantitative basis on which cases for changes to royalty rates can be mounted.

For the purposes of calculating mine-head value, the value of ore at the Run-of-Mine (ROM) stockpile is typically used as a proxy for 'ex-mine' or the 'mine-head'. It is also worth noting the benchmark return of 10 percent is, by necessity, approximate rather than absolute.

8.1.2. Netback principle

Consistent with the public policy principles underlying royalties, the *ad valorem* royalty rate applying to a mineral commodity is a tiered system, dependent on the amount of downstream processing that is undertaken by the operator within Western Australia. While nominally four tiers exist, as a matter of practicality no operations in Western Australia sells ore directly from the ROM stockpile (i.e. even in the case of Direct Shipping Ore products, there is a crushing process before the ore is loaded onto ships), and therefore no mineral commodities in Western Australia are charged a royalty rate of 10 percent.

Table 14 below lists the in-principle rates that apply to mine output that has been subject to different stages of downstream processing from the mine-head (or ROM stockpile), frequently referred to as the Netback Framework.

TABLE 14 – IN PRINCIPLE MINERAL ROYALTY RATES

Stage	In Principle Rate
Benchmark Return: Mine-head (ROM Stockpile)	10.0%
Bulk material (Crushed and Screened)	7.5%
Mineral concentrates	5.0%
Minerals in metallic form	2.5%

Downstream processing of minerals production within the State is desirable from a public policy perspective. It results in a higher value product, additional employment, new skills development, native expertise, economic diversification, regional activation, and other desirable socio-economic benefits. The discounting of the applicable rate as the raw mineral product is progressively processed into a metal (as set out in Table 14 above) is designed to both recognise the additional capital investment and risk undertaken by companies that invest in downstream processing, and to incentivise that investment.

[308] Department of State Development and Department of Mines (2015), *Mineral Royalty Rate Analysis – Final Report,* Western Australian Government, Perth

It should be noted that capital investment required and financial return generated will differ drastically from sector to sector and among operations within a sector, and hence these tiered royalty rates can only ever be an approximation. While other methods of formulaic differentiation could be pursued, and are at times advocated by industry, the complexity associated with such methods may compromise other public policy objectives such as efficiency, simplicity, transparency and administrative burden. Accordingly, at present a prevailing consensus exists between the State and peak industry bodies that is broadly supportive of the tiered netback system as a whole[309].

8.1.3. Methodology for calculating 'mine-head value'

Determining whether the prevailing royalty rate is efficacious with respect to compensating the State at the benchmark return requires a methodology for calculating the netback discussed in the previous section.

During the 2015 review process[310] there was considerable contention between industry and the Western Australian Government as to the precise nature of the formula that should be used to calculate mine-head value. Industry has consistently advocated for a formula that calculates true mine-head value, incorporating all industry incurred costs in creating that value, including a return on capital and an appropriate measure of return of capital. In other words, a method that is consistent with professional asset valuation standards.

However, the Western Australian Government has been reticent to formally accept the adoption of such a methodology, albeit in its final report from the 2015 Review, it did concede that the netback calculation should at least include an allocation of return on capital.

Industry continues to maintain that its proposed methodology calculates mine-head value accurately, and that any formula that does not include all cost categories or calculate costs in accordance with international valuation standards under-represents industry's investment in creating value from *in situ* mineral resources. The following Figure 22 compares industry's netback calculation methodology with the original methodology proposed by the Western Australian Government and the in-principle revised Western Australian Government methodology.

[309] Eg. The Chamber of Minerals and Energy of Western Australia (2013) *Submission to Inquiry – State Mineral Royalty Rate Analysis*, Perth, Western Australia

[310] Department of State Development and Department of Mines (2015), *Mineral Royalty Rate Analysis – Final Report,* Western Australian Government, Perth

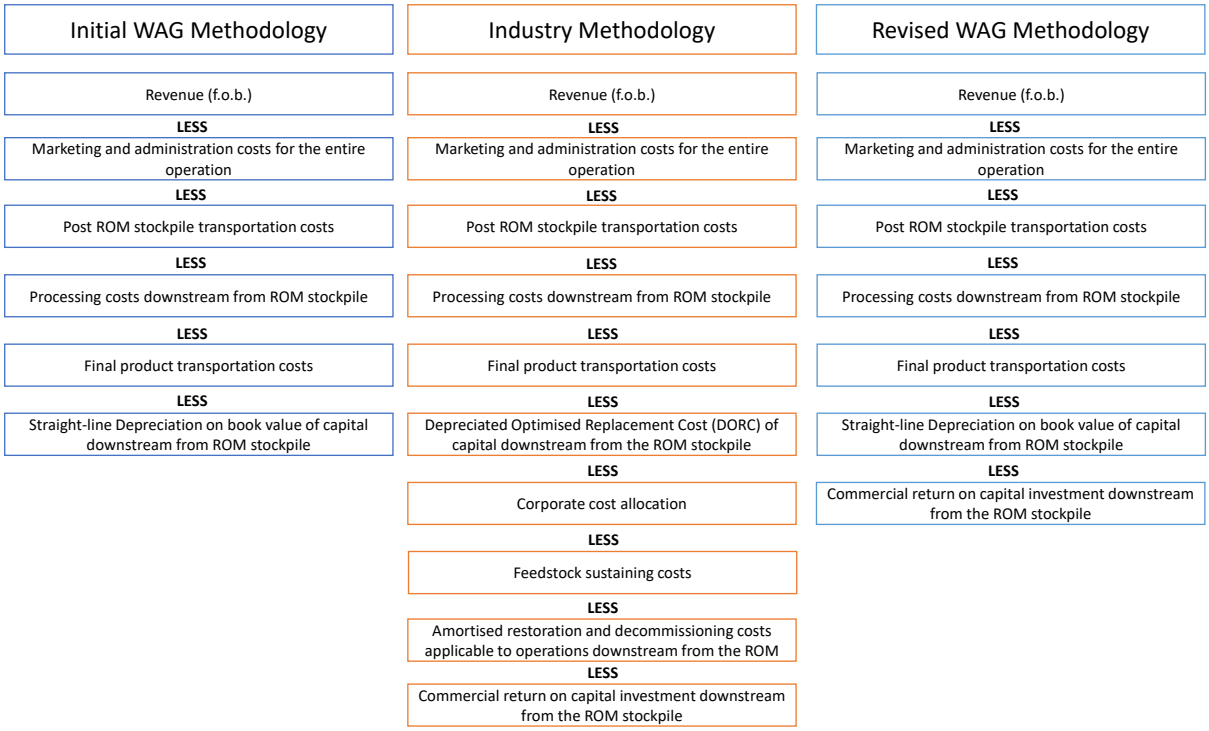

FIGURE 22 – GOVERNMENT VERSUS INDUSTRY METHOD FOR CALCULATING MINE-HEAD VALUE

Formal acceptance by the Western Australian Government of an accurate method for calculating mine-head value remains an outstanding issue. However, Ernst &Young taxation and valuation group have reviewed the methodologies and determined that the Western Australian Government methodology is flawed and that the methodology proposed by industry is consistent with valuation and accounting principles for determining value.

8.2. Western Australian lithium sector efficacy

8.2.1. Modelling

The Confidential Addendum 1 to this report contains the outputs from modelling undertaken using actual industry data from a sample of spodumene producers across Western Australia. Based on this sample, the modelling quantifies an estimate of the sector's efficacy with respect to meeting the Western Australian Government's benchmark return of 10 percent of mine-head value under each of the methodologies summarised in Figure 22.

9. Recommendations

This final section of the report sets out recommendations to the Western Australian Government as to immediate, medium and longer-term policy initiatives that it can undertake in collaboration with industry to optimise the likelihood that Western Australia develops a competitively sustainable upstream lithium-ion battery industry

9.1. The case for policy intervention

The preceding discussion in Sections 2, 3, 4, 5 and 6 clearly demonstrates on an evidence-basis, that the emerging Western Australian upstream lithium-ion battery industry is at significant risk of faltering. Such an eventuality would place Western Australia's position as a key player in upstream sectors at risk and totally negate any prospect of Western Australian industry progressing further down the lithium-ion battery value chain.

9.1.1. Not the average commodity price cycle

A free-market economist could be forgiven for suggesting that circumstances in which the Western Australian spodumene production and emerging lithium hydroxide manufacturing industry currently find themselves is typical of a resources industry investment cycle and therefore, policy intervention is not warranted.

Briefly, in markets for most minerals price volatility in the form of reasonably foreseeable price cycles are caused by the differential between relatively rapidly increasing demand and the time lag in supply response that is a function of the necessary protracted approvals, investment, construction and commissioning of large-scale resources industry capital. Basically, when derived demand for a mineral product increases, prices rise. Supply then responds by investing in the construction of more productive capital, but because this takes time, supply that is activated earlier meets demand, with lagged supply leading to over-supply as it comes on stream, placing downward pressure on prices, potentially rendering production assets with high cost structures that were viable at higher prices no longer so.

This phenomenon is a fundamental and somewhat unavoidable characteristic of the resources industries. Resources industry policy makers are cognisant of it in the design and implementation of resources industry policy, and professional resources industry executives are adept at managing risk associated with it.

However, the circumstances in which the Western Australian lithium industry currently finds itself are somewhat different:

- **Responding to a significant disruption in a major global industry**
  Increases in supply of lithium raw material and chemicals have been primarily in response to demand derived from a significant disruption in a major global industry – the automotive industry. This has seen rapid exponential growth, with global lithium production increasing by 250 percent over the two-year period 2016 to 2018 (on a LCE basis), with increases in Western Australian spodumene production being a major driver of this dramatic increase in feedstock capacity. Most certainly, the Western Australian resources industry has historically navigated similar rapid expansions such as in the iron ore sector (2007 to 2016), nickel sector (2003 to 2008) and natural gas (2010 to 2017). However, none of these previous expansions have been (a) from such a very limited existing domestic production base; (b) caused by such a significant global industry disruption; and (c) resulted in such a dramatic expansion of capacity in such a short timeframe.

- **Demand is derived through a long, complex and opaque supply chain**
  The actual demand for Western Australian upstream lithium products (spodumene concentrate and lithium hydroxide) is derived from final product demand (primarily electric vehicles) via a long, complex and opaque supply chain that, with perhaps the exception of some rare earth products, is not characteristic of other sectors of the Western Australian resources industry. At each stage of this supply chain – battery pack, cell, cathode material, anode material, electrolyte material, separator material cathode precursor, battery and technical grade chemical manufacture – prices are determined by a mix of market and contractual supply arrangements that are both complex and opaque, and defined by varying degrees of vertical integration. This means that upstream operators have very limited visibility over factors along the supply chain that will ultimately impact demand for their products.

- **Significant and unpredictable foreign government policy distortions along the supply chain**
  Finally, and most importantly, final product demand and demand and supply at each stage of the supply chain is heavily distorted by incentives and disincentives imposed by a large number of foreign governments with interests in the industry. This includes policies designed to encourage the adoption of EVs (including specific types of EV) and policies designed to attract investment in domestic production capacity along the supply chain. This preponderance of foreign government policy is complex, fickle and in many instances opaque.

As such, the circumstances in which the Western Australian spodumene concentrate and lithium hydroxide manufacturing industry currently find themselves is not a function of exuberant expansion investments, but rather the consequence of navigating a significant global market disruption in a new supply paradigm (long and complex supply chains) and in a context where uncertainty is amplified by a complex and unpredictable matrix of government policy distortions along the supply chain. These circumstances will abate as this new sector matures and normalises around more free-market settings. However, for now they remain a significant challenge to investment decisions made by participants in Western Australia's emerging upstream lithium sector.

9.1.2. Western Australian Government has a vested interest in the sector

The Western Australian Government has been a major proponent of the prospects for Western Australian industry in the global battery industry.

Indeed, Western Australia's participation in the global lithium-ion battery value chain has been a major focus of the Western Australian Government's economic policy platform[311], with the energy sector being identified as a priority and the development of a domestic battery oriented industry identified as a key government initiative under this prioritised sector. This is

[311] Government of Western Australia (2019), *Diversify WA: Strong Economy Creating Jobs Diverse Industry*, Government of Western Australia, Perth

illustrated in Figure 23 below with the Western Australian Government's commitment to this demonstrated by the policy initiatives and investments discussed in Section 7.

FIGURE 23 – WESTERN AUSTRALIAN GOVERNMENT ECONOMIC DEVELOPMENT FRAMEWORK

The implementation of draconian anti-free-trade policies that have been adopted by some foreign governments are not expected, desirable or even achievable in Australia. However, the unique nature of the circumstances in which the Western Australian upstream lithium industry finds itself, combined with the importance of the emerging sector in the Western Australian Government's economic policy platform, supports the case for sensible policy intervention.

9.2. Nature of these recommendations

These recommendations are designed to provide the Western Australian Government with policy initiative options that underpin immediate survival and build longer term resilience into the sector. The presented options are designed to be readily implementable and as such are consistent with:

- Western Australia and Australia's legal framework; and

- The broad, bi-partisan principles that guide economic development policy across Australian governments.

9.3. Immediate-term initiatives

The initiatives discussed in this section are actions that the Western Australian Government should undertake now to maximise the likelihood of Western Australia's spodumene concentrate production and lithium hydroxide manufacturing sectors surviving current market circumstances.

9.3.1. Set and communicate a clear and realistic narrative

The current narrative is inconsistent and unclear

As per Table 12, in 2018 industry called on the Western Australian Government to work with it to develop a shared narrative that clearly articulates the opportunity presented to Western Australia by the explosion in demand for EVs.

Over the course of the past four years, the narrative used by Australian governments (as well as by some industry participants and other interest groups) to indicate prospects and direction of Western Australian industry in the global lithium-ion battery supply chain have become increasingly unclear. They have included unrealistic assertions that Western Australia will naturally become a fully integrated battery manufacturing centre, that a battery chemical manufacturing sector is a *fait accompli*, that the focus needs to be on developing midstream capability, that Western Australia should be able to offer a 'full-cycle' offering by developing domestic recycling capacity and that defence relationships between the United States and Australia will see formalised, State sanctioned, lithium trade relationships established between these jurisdictions.

Industry has been very clear and public since at least 2018 that Western Australia is unable to be competitive as a battery manufacturer and establishing domestic competitive capacity in battery chemical manufacturing, let alone battery precursor manufacturing will face significant challenges[312]. As per the analysis in this report, it is now abundantly clear that this is the case.

In setting economic policy governments must take into account the perspective of not only constituents with actual commercial investments in the industry, but also other primary stakeholders such as communities and the research sector and may be influenced by other interest groups[313,314]. It can also be argued that, irrespective of how fanciful the notion might be, promotion of a fully integrated domestic battery industry supports a culture of enthusiasm that serves to support the sector more broadly. However, the reality is that a lack of clarity around the narrative with respect to Western Australia's prospects in the global lithium-ion battery supply chain is resulting in distorted investment decisions by secondary stakeholders such as local governments and research organisations, detracting policy attention from the key real challenges and creating a sense of opportunity that will not be met. The net effect of

[312] Australian Venture Consultants (2018), WA's Future in the Lithium Battery Value Chain, Chamber of Commerce and Industry Western Australia
[313] For example - http://www.lithiumvalleywa.com.au/
[314] Wilson, J. (2020), Strategies for Securing Critical Material Value Chains, Perth USAsia Centre

this is that it dilutes focus on where it is needed – establishing a competitively sustainable lithium hydroxide manufacturing sector, an objective that is clearly not a *fait accompli*.

Recommendation

It is recommended that the Western Australian Government work with the Western Australian lithium industry to develop an agreed narrative that revolves around the following:

Western Australia is and will continue to be a key component of the upstream (mineral products and technical and battery grade chemicals) lithium-ion battery supply chain that will be integrated with supply chains that primarily (but not exclusively) service the Asian automotive manufacturing industry. While a Western Australian battery chemicals industry will struggle to compete with Asian counterparts in scale and cost, Western Australia will continue to pursue the development of a smaller, niche chemical manufacturing sector that differentiates itself on customer-valued factors other than cost.

9.3.2. Provide immediate royalty relief for spodumene producers

This recommendation is designed to provide immediate financial relief in current market conditions. Section 9.4.1 recommends a subsequent permanent restructure of the royalty regime that applies to the sector to encourage investment in chemical manufacture.

Key characteristics of royalties

Any discussion around changes to royalties needs to be framed by the following characteristics of the Western Australian royalty regime:

- **Royalties are a price**
  To the extent that they are a government impost on the earnings of business, royalties operate as a tax. However, because by virtue of Australian constitutional law the rights to *in situ* minerals vest with the State, royalties are in fact a price paid by a counter-party to the State for the right to commercialise *in situ* mineral resources that are legally owned to the State. The implication of this is that the State has an obligation to ensure that Western Australia is appropriately compensated for granting a third party the right to extract and sell its, in this case, non-renewable resources.

- **Royalties are a significant source of revenue for the Western Australian Government**
  In the case of Western Australia, government revenue in the form of royalties is significant accounting for between 20 and 25 percent of total Western Australian Government revenue each year. This means that the Western Australian Government must give consideration to the impact of any royalty relief provided on its ability to meet its public expenditure and debt repayment requirements and obligations. Of the AUD $6.5 billion of royalty revenue received by the Western Australian Government in 2018-19, the lithium sector accounted for 1.3 percent, or AUD $83.2 million[315]. While AUD $83.2 million is a material amount, it represents less than 0.3 percent of total Western Australian Government revenue in 2018-19, meaning that a reduction in the royalty rate applying to lithium production in Western Australia will not have a dramatic impact on the Western Australia's Government's ability to fulfill its fiscal obligations.

[315] Department of Mines, Industry Regulation and Safety (2019), *Western Australian Mineral and Petroleum Statistics Digest 2018-19*, Western Australian Government, Perth

- **The State receives many other benefits from investment in resources projects**
  When new resources projects are constructed and commissioned, the State receives economic benefits way beyond the immediate fiscal revenue associated with royalty payments. Operations pay other taxes directly to the State such as payroll tax, taxes to the Commonwealth Government from which the State benefits (such as GST and income tax) and fees and charges to local governments. Most importantly, the construction and operation of minerals projects are significant employers and by virtue of significant procurement and relatively high direct wages, they deliver significant employment multipliers[316]. The Western Australian lithium industry is a relatively employment intensive sector of the Western Australian resources industry. While its output is equivalent to around 1 percent of total Western Australian resources industry GVP, the 3,600 people working on operations in the lithium sector account for just under 3.5 percent of the industry's operational workforce[317].

- **Royalties are a significant cost to industry**
  While third-parties commercialising *in situ* resources that are the property of the State must clearly pay a price for those resources, and an *ad valorem* system is equitable in the sense that the price is only paid when the resource is sold and the government shares market risk with the project proponent, they are a significant component of a resources project's cost structure. In the case of spodumene concentrate projects, the price received is immediately discounted by 5.0 percent. Lithium hydroxide manufacturers do not pay a royalty on their hydroxide product, but the cost of the royalty that is incurred by the spodumene producer is embedded in their cost structure through the price they pay for the spodumene concentrate. This means that the provision of royalty relief can have a material impact on the financial viability of lithium operations when market conditions result in tight operating margins.

- **Stability and predictability in the royalty regime is important to the attracting investment**
  Western Australia has a global reputation as a competitive environment for investment in resources operations, consistently ranking among the most attractive according to international benchmarks. Indeed in 2019, Western Australia was ranked the most attractive destination according to the Fraser Institute Investment Attractiveness Index[318]. While Western Australia's world-class natural resources is a major factor, high rankings are also heavily impacted by measures of the effectiveness of Western Australian Government policy. Therefore, ensuring that Western Australia remains a premier resources industry investment destination requires stability and predictability in its royalty regime. This does not mean that royalties cannot be changed, just that when they are changed those changes should be consistent with established and transparent precedence and principles.

Precedence

In the vast majority of instances Western Australian royalties are levied as an *ad valorem* charge on the invoice value of the final product that is sold by a company. The specific rate is determined according to a simple netback method, whereby product that is sold as crushed ore pays a rate of 7.5 percent, product sold as a mineral concentrate 5.0 percent and product sold as a refined metal 2.5 percent (see Section 8.1.2). These specific netback rates apply to

316 Regional Development Australia (2012), *Pilbara Report: Exploring Opportunities in the Nation's Powerhouse,* Australian Government Canberra
317 Department of Mines, Industry Regulation and Safety (2019), *Western Australian Mineral and Petroleum Statistics Digest 2018-19*, Western Australian Government, Perth
318 Fraser Institute (2020), Annual Survey of Mining Companies – 2019, Fraser Institute, Vancouver, Canda

production that accounts for the vast majority of the value of output from the Western Australian minerals industry.

The Western Australian royalty regime is designed in recognition of the fact that, from time-to-time governments may need to modify royalties on a temporary or permanent basis in order to serve the best interests of the State. The *Mining Act 1978* (WA) and *Mining Regulations 1981* (WA) provide for ministerial and parliamentary processes through which this achieved, and in instances where royalty rates are prescribed by State Agreements, those agreements either reference the *Mining Regulations 1981* (WA) for the purposes of prescribing a rate (in which case the rate can be modified through processes prescribed by the *Mining Act 1978* (WA)), or where a specific rate is prescribed by a State Agreement, those agreements provide for a negotiation process.

Through permanent changes to the *Mining Regulations 1981* (WA), State Agreements and ministerial powers prescribed by the *Mining Act 1978* (WA), successive Western Australian Governments have made temporary and permanent changes to royalties where a State interests case has been established. Examples of such circumstances are summarised in the following Table 15.

TABLE 15 – HISTORICAL ROYALTY RELIEF PROVIDED BY THE WESTERN AUSTRALIAN GOVERNMENT

Sector	Theoretically Applicable Rate	Concessional Rate	Primary Policy Rationale	Instrument
Gold	2.5%	Various concessions over time including full exemption, partial exemption and concessional rates	Strategic mineral (historical importance of gold reserves) and financial hardship	Mining Regulations
Alumina	2.5%	1.65%	Scale of investment, financial hardship and significant employer	State Agreements
Diamonds	7.5%	5.0%	Financial hardship and significant employer	State Agreements
Iron ore fines	7.5%	5.625%	New market development	State Agreements
Magnetite	5.0%	12 month (and extended) 50% concession	Financial hardship	Ministerial
Iron ore juniors	7.5%	Repayable 50% rebate	Financial hardship	Ministerial
Salt	Amount A (currently 73 cents per tonne)	7.5 cents per tonne, sliding scale dependent on output	Renewable resource	State Agreements

As summarised in Table 15, circumstances that have been taken into account by the Western Australian Government in providing royalty relief include a combination demonstrated

financial hardship in the sector and clear strategic advantage for the State which may take the form of significant investment, employment or diversification outcomes.

These criteria are entirely consistent with the circumstances in which the Western Australian upstream lithium industry currently finds itself.

Principles

Regardless of the merits of a case for royalty relief, any change to the royalty that applies to a sector should be guided by the same principles that apply to the royalty regime more generally and which are the result of multiple reviews of the State's royalty regime[319]:

- **Equity** – changes to the royalty should apply to all sector participants equally and there should be a clear pathway to ensuring that the State continues to receive fair compensation for the sale of its non-renewable resources.
- **Efficiency** – changes to the royalty should not reduce the productive capacity of the economy, or unduly deter or distort employment and investment decisions.
- **Adequacy** – the changes should not undermine the ability of the State to continue to meet its fiscal spending requirements and obligations.
- **Stability and predictability** – the rationale for change should be transparent and economically rational and the pathway for return to consistency with the norms of the royalty regime clear and predictable.
- **Transparency and simplicity** – the change should be simple to implement and administer for both the government and industry, and simple for industry and society to comprehend and understand.

Recommendation

It is Recommended that the Western Australian Government provide spodumene concentrate producers with immediate royalty relief as detailed in the confidential Addendum 1 to this report.

9.3.3. Encourage stability in port charges

Western Australian spodumene producers export product through Esperance Port, Fremantle Port, Bunbury Port and Port Hedland. Aspiring lithium hydroxide producers will export product through Bunbury Port and Fremantle Port, and all Western Australian upstream projects are dependent on these ports for supply of inputs, particularly reagents.

Ports charge a range of fees that add to the costs of Western Australian lithium operations and there has been recent escalation of charges at several Western Australian ports.

The pathway for port charge relief is complex

Fremantle Port (including the outer harbour) is an operational asset of the Fremantle Port Authority, Esperance and Bunbury Ports are operational assets of the Southern Ports Authority and Port Hedland an operational asset of the Pilbara Port Authority. Any discussion pertaining to the potential for the Western Australian Government to influence port charges needs to be had with an understanding of the governance arrangements pertaining to Port Authorities.

[319] 1984-86;1994; 2013-2015

The functions of Port Authorities are prescribed by Section 30(1) of the *Port Authorities Act 1999* (WA) as follows:

- Facilitation of trade within and through the ports under its administration and plan for future growth and development of those ports;
- Encourage and facilitate the development of trade and commerce generally for the economic benefit of the State through the use of its ports and related facilities;
- Control business and other activities in its ports or in connection with the operation of its ports;
- Be responsible for the safe and efficient operations of its ports;
- Be responsible for maintaining the property of its ports;
- Be responsible for the security of its ports;
- Protect the environment of its ports and minimise the impact of the operation of its ports on the environment;

Port Authorities are, by design, semi-autonomous government trading enterprises (GTEs), the nature of which is defined by a combination of the *Port Authorities Act (WA) 1999* and the *Port Legislation Amendment Act (WA) 2014,* various other state and commonwealth legislation and by virtue of the powers afforded to the State Government under the Act, the political will of the incumbent government. This is a complex governance framework, which ultimately results in Port Authorities not simply being instruments of government policy.

Section 4(2) prescribes that a Port Authority is a body corporate. Section 5 goes further to ensure that a Port Authority is not an agent of the Crown and Section 6 prescribes that a Port Authority is not a public sector body under the *Public Sector Management Act 1994* (WA). Section 32 provides Port Authorities with exclusive control over their ports (subject to any direction given by the Minister for Transport). Section 34 also compels a Port Authority to perform its functions in accordance with prudent commercial practice and to endeavour to make a profit.

Section 37 specifically allows a Port Authority to levy and collect in relation to its functions, fees for licenses and approvals as are provided for in the regulations and such port charges as determined. This section also compels a Port Authority to set fees and charges in accordance with prudent commercial principals and to allow for the making of a profit and depreciation of capital.

Section 49 requires a Port Authority to submit to the Minister each year a draft Strategic Development Plan with a forecast period of five years. This plan must set out the Port Authorities medium to long-term objectives (including economic and financial objectives), and operational targets and how those objectives and targets will be achieved, as well as an environmental management plan for its ports. Section 33 also requires a Port Authority to perform its functions in accordance with an annual Statement of Corporate Intent which must be agreed to by the Minister in concurrence with the Treasurer.

While the Minister for Transport can, in accordance with Section 72, provide specific directions to a Port Authority (and must table such directions before Parliament), including directions pertaining to fees and charges, such direct intervention is not in the spirit of the Act and would only be contemplated in exceptional circumstances. Furthermore, the exercising of powers afforded to the Minister under Section 72 has, by virtue of the obligation to table directions in Parliament, the potential to politicise the operations of the port and hence will generally only be exercised with caution.

Uncertainty that is the result of COVID-19 may create an operating environment that justifies 'exceptional circumstances'.

The dividends for industry are limited

While any cost relief is of assistance, and a pattern of escalating port charges is of concern to industry, at the end of the day, they comprise a relatively small portion of overall costs.

Recommendation

It is Recommended that, given the complexity associated with directing Port Authorities with respect to charges and fees and the relatively small portion of overall costs, the Western Australian Government encourages Port Authorities to ensure that fees are stabilised in the current environment.

9.3.4. An effective lead agency model

Red tape continues to constrain project development

Multiple, protracted and uncertain approvals processes continue to plague the construction and commissioning of new capital in the Western Australian spodumene concentrate and lithium hydroxide manufacturing sector, with several projects having faced delays as a result.

While industry appreciates that 'red-tape' reform is an ongoing process across the Western Australian Government, this process, by virtue of its complexity, is taking too long placing projects at risk. There is currently no circumstances that would see processes improved dramatically in the short-term.

Current initiatives design to assist the navigation of approvals aren't working

Significant development projects can be designated by the Western Australian Government as a *Major Proposal* or State *Significant Proposal*, whereby they are assigned a lead agency of the Western Australian Government to assist with efficient planning and navigation of various statutory approvals. A *Major Proposal* is one that is deemed by the lead agency to meet criteria to warrant more intensive case management. A *State Significant Proposal* is one that is deemed by the Cabinet of the Western Australian Government to be critical to the advancement of the State of Western Australia or the Nation based on environmental, social, economic or heritage considerations.

Once a project is designed as a Major Proposal, or State Significant Proposal, the Department of Jobs, Tourism, Science and Innovation will be appointed as the *Lead Agency* for that project. In this role, the Lead Agency is responsible for:

- Providing proponents with information on statutory requirements through agency guidelines and referrals;
- Case managing and coordinating approvals applications across government for proposals; and
- Assisting proponents to identify the potential impacts of the proposal on matters such as infrastructure, the environment and regional communities as well as the social considerations that arise from the proposal.

The categories of projects that qualify for this status are summarised in Table 16[320] below.

TABLE 16 – MAJOR PROJECT OR PROJECT OF STATE SIGNIFICANCE DESIGNATION

Project Level	Description	Status	Lead Agency Role
1	Project that is moderate in scale and capable of being accommodated through existing environmental, social and economic processes.	Major Project	Provide initial advice and support through an appointed project officer. Services include referral and introduction to relevant departments.
2	The project is a new proposal or expansion of an existing project where the proposed investment is significant or of strategic importance.	Major Project	A project manager will be assigned to assist with Government related aspects of proposal definition, infrastructure, industrial land, regional issues, coordination and interaction with agencies in relation to key statutory approvals.
3	The project is a proposal that is very large and/or complex with particular strategic importance to the State Government.	Project of State Significance	A senior project coordination team is appointed to assist with Government related aspects of proposal definition, infrastructure, industrial land, regional issues, coordination of key statutory approvals and if requested by Government, negotiation of a State Agreement.

TABLE 17 – MAJOR PROJECT OR PROJECT OF STATE SIGNIFICANCE DESIGNATION

The major lithium-ion battery supply chain projects will qualify for Major Project Status (Level 1 or 2) described in Table 16 above. However, if Western Australia is to fully capitalise on the opportunity to create a competitively sustainable chemical conversion and precursor manufacturing industry, it is likely that a more coordinated and strategic approach across the industry will be required.

Using the Lead Agency and SIA frameworks as the tools, and in recognition of the strategic importance of the opportunity and its time bound nature, Industry has previously recommended that a time bound (five year) special working group (taskforce) be established within the Lead Agency, and in accordance with the general Lead Agency framework, that assists all lithium-ion battery supply chain projects that have definitive feasibility study as though they were Level 1 or 2 projects (see Table 12).

Recommendation

It is recommended that the Western Australian Government establish a special taskforce that is purposed with working closely with all lithium industry projects to expedite their navigation of approvals processes across government.

[320] Department of Premier and Cabinet, *Lead Agency Framework,* Government of Western Australia, Perth

9.3.5. Advocate for priority treatment under the new Foreign Investment Review Board Regulations

Foreign investment reforms will likely have a disproportionate impact on the Western Australian lithium industry

Western Australian resources projects generally are heavily dependent on access to foreign capital markets to finance the construction of capital-intensive infrastructure that is characteristic of the industry.

In early June 2020, the Commonwealth Government announced significant reforms to the regulatory framework that applies to foreign investment approvals in Australia[321]. This package includes a number of reforms around stronger protection of Australia's national security; a risk-based approach to approvals processes in certain circumstances; stronger penalties, compliance and enforcement powers; and greater transparency and regulations around instruments and structures that give effect to foreign investment.

Reforms that are of particular interest to the subject of this study are summarised as follows:

1. The Government will introduce a new national security test which will:
    - enable the Treasurer to impose conditions or block any investment by a foreign person on national security grounds regardless of the value of investment;
    - require mandatory notification of any proposed investment by a foreign person in a sensitive national security business;
    - require mandatory notification where a business or entity owned by a foreign person starts to carry on the activities of a sensitive national security business;
    - allow any investment that would not ordinarily require notification to be 'called in' for screening on national security grounds;
    - allow investors to voluntarily notify to receive investor certainty from 'call in' for a particular investment or apply for an investor-specific exemption certificate; and
    - allow the Treasurer to impose conditions, vary existing conditions, or, as a last resort, require the divestment of any realised investment which was approved under the FATA where national security risks emerge.
2. The Government will exempt certain investments made by entities which are currently classified as 'Foreign Government Investors'. This exemption will be non-discriminatory and apply only where no foreign government investor has or could be perceived to have influence or control over the investment or operational decisions of the entity or any of its underlying assets.

For the following reasons, access to capital for Western Australia's upstream lithium industry will potentially disproportionately and significantly constrained by these reforms:

- By virtue of the concentration of the downstream battery manufacturing industry in the PRC, PRC domiciled entities are particularly natural investors in projects;
- In the current geopolitical environment, it is likely that in certain instances some organisations in the PRC will be perceived as being potential risks to the national security; and
- It is likely that in many cases by virtue of the nature of the potential PRC organisation contemplating the investment, streamlined approvals processes will not be accessible.

[321] Treasury (2020), *Foreign Investment Reforms*, Australian Government, Canberra

Additionally, the supply chains in which the Western Australian upstream sector is endeavouring to strategically integrate with are entirely global by nature. Often, longer-term supply chain relationships involve equity relationship between partners. The FIRB reforms will likely complicate such arrangements and render equity-based participation in strategic global lithium-ion battery supply chains more difficult.

These circumstances risk constraining the capacity of the upstream lithium industry in Western Australia to access finance required to grow the sector and the participate as a strategic partner in global lithium-ion battery supply chains.

Recommendation

It is Recommended that the Western Australian Government advocate to the Commonwealth to ensure that applications for foreign investment pertaining to the Nation's lithium industry are treated as a special case and processed with the utmost efficiency.

9.4. Medium-term initiatives

9.4.1. Restructure of the Royalty netback principle to recognise downstream investment in non-metal production

A fundamental principle of the royalty regime is that it should recognise and incentivise downstream investment

As discussed in Sections 7 and 9.1.2, the creation of new jobs and diversification of Western Australia's industrial base are fundamental pillars of the Western Australian Government's economic development policy platform. The likely only way Western Australia will achieve industry diversification is through horizontal or vertical differentiation from established industry where it has a clear competitive advantage in international markets. In the context of its globally significant mineral resources industry this includes the development of new sectors that value-add to primary production.

This is recognised by a fundamental tenet of the Western Australian royalties regime – the netback principle (see Section 8.1.2).

Value-adding doesn't necessarily mean producing a high purity metal

There are several new sectors of the Western Australian minerals industry that involve a value-add pathway that produces high value mineral concentrates or chemical products and which require investment in downstream capital that is akin to that which produces a high purity metal product. There is concern that the failure of the current netback framework to recognise or incentivise this investment will become increasingly problematic for Western Australia's competitiveness in these sectors.

Such sectors include magnetite concentrates, potash products and of course, lithium hydroxide.

Resources and chemical industry demarcation is largely academic

There has been some resistance in government to explore adjusting the royalty framework to recognise significant downstream investment that does not result in the production of a high purity metal on the basis that the development of a high value concentrate product is still a mineral concentrate and therefore should attract the 5.0% rate and that the manufacture of

chemical product crosses over the chemicals industry and therefore the mining regulatory environment does not apply.

While these assertions might be correct from a technical or legislative perspective, adherence to these definitions is undermining a key objective of the royalty regime – to incentivise downstream processing. The economic outcomes of downstream investment in high value concentrates and chemical manufacture are the same as they are for high purity metal manufacture – diversification, jobs, additional government revenues and jobs, with the added benefit of positioning Western Australian industry in new major global industrial sectors.

In can be complex in practice

While the principle of adjusting the royalty regime that applies to the sector in order to incentivise downstream investment in the manufacture of lithium chemicals is obvious, ensuring efficacy with the intent is somewhat more complex:

- Determining values on which they royalty should be levied when transactions are often relatively opaque presents challenges in determining a fair royalty amount; and
- Depending on the differential between the price of spodumene concentrate and lithium hydroxide, a lower rate of hydroxide may result in a higher gross royalty liability than a higher rate on spodumene concentrate.

These are key issues that need to be considered in the design of restructure of the regime that applies to the lithium sector with the intent of incentivising downstream investment.

Recommendation

It is Recommended that industry work with the Western Australian Government to develop a new lithium sector royalty mechanism that is based on the netback principle and which incentivises investment in domestic lithium chemical manufacturing.

9.4.2. Differentiating Western Australian lithium hydroxide product

Western Australian lithium hydroxide cannot compete on price

As discussed throughout this report and detailed in previous reviews[322], as a result of structurally high total product manufacturing costs, Western Australian lithium hydroxide production will never likely be able to compete on price with Asian, particularly PRC based chemical plants. As such, Western Australian lithium hydroxide will need to differentiate itself on other criteria.

While there may be some demand that is derived from supply chains seeking some ex-PRC supply security, Western Australian production will still compete with other ex-PRC sources for these customers, many of which will exhibit lower cost structures.

Western Australian production can potentially be differentiated based on strong environmental and labour market criteria that are a result of the robust regulatory framework in markets that value such product attributes. However, to be effective, this will require the establishment materials provenance and traceability. This is the intended purpose of an

[322] Australian Venture Consultants (2018), *WA's Future in the Lithium Battery Value Chain*, Chamber of Commerce and Industry Western Australia

Australian ethical minerals certification scheme that will have broader application than just battery minerals and which is currently under development.

Recommendation

It is Recommended that industry work with the Western Australian and Australian Governments to investigate the merits of and establish a plan to build Western Australian lithium product provenance in key markets and establish a traceability system.

9.4.3. Common use infrastructure packages

Infrastructure is a key driver of viability and productivity

Access to adequate infrastructure significantly impacts the viability and productivity of spodumene concentrate producers and lithium hydroxide manufacturers. Key infrastructure areas include efficient access to:

- Suitable roads and port infrastructure for the transport or reagents and other operational inputs and export of product
- Reliable and affordable electricity and thermal energy
- High quality water (particularly for lithium hydroxide manufacture)
- Waste (including Class III waste) management solutions.

The business case is mainly for shared infrastructure

In the absence of shared infrastructure, many if not most projects have to establish their own infrastructure, representing a significant cost. Most lithium sector operations in Western Australia are located in areas that exhibit other industrial activity, usually mining sector or agricultural activity. This potentially creates the case for shared infrastructure business cases.

Recommendation

It is Recommended that the Western Australian Government, local governments and industry work with the lithium industry and other local sectors to identify infrastructure investment priorities and develop shared infrastructure plans and business cases across road, rail, ports, electricity, natural gas, water and waste that can be presented to Infrastructure funding organisations as proposals for investment.

9.4.4. Refocusing of the research effort

Research has been the Western Australian Governments largest investment in the sector

In terms of cash commitment, the Western Australian Governments investment of approximately AUD $6.0 million in the Future Battery Industries CRC (see Section 7.2.3) represents the Governments most significant investment in the emerging sector by far.

It is therefore important, that this investment is optimally targeted at ensuring that outcomes flow for the benefit of industry.

While it is true that a significant portion of the Future Battery Industry CRC's current research portfolio is targeted at issues aligned with the upstream lithium-ion battery value chain, it is probable that it could work more closely with operators to address more immediate productivity challenges in spodumene mining, concentrate production and lithium hydroxide

manufacture in Western Australia that deliver 'dividends' that underpin the medium-term resilience of the upstream sector.

It is also true that the Western Australian Government's ability to influence the direction of the Future Battery Industries CRC is limited by the fact that the CRC has a national and battery-industry-wide remit, as well as contractual arrangement with the Commonwealth Government and other participants in the CRC.

Recommendation

It is Recommended that the Western Australian Government encourage the Future Battery Minerals CRC to host a forum with participants in the Western Australian upstream lithium industry to identify potential short-term applied research projects that could result in short-to-medium term productivity enhancements, helping build resilience into the industry.

9.5. Longer-term initiatives

9.5.1. Development of competitive industrial areas

The Strategic Industrial Area (SIA) policy framework was developed by the Western Australian Government partly as a land planning and management framework, and partly to offer project proponents greater certainty. While compared to developing industry on land in Western Australia that is not the subject of a SIA they arguably present some benefit, SIAs are not competitive with industrial zones in economies with which Western Australia's lithium hydroxide manufacturing sector competes.

Strategic Industrial Area policy framework

SIAs are areas of land in strategic locations that are set aside, or 'quarantined', for industrial use in order to attract investment in downstream processing, heavy industry and other industrial activity associated with the State's main upstream primary industries. This is given effect through a coordinated, 'whole-of-government' approach to planning for SIA areas.

SIA's are delivered through LandCorp, with some project communication activity coordinated through the relevant Regional Development Commission, but with the Department of Jobs, Tourism, Science and Innovation performing a lead agency role. The land that is the subject of an SIA is either held freehold by LandCorp and leased to a tenant, or is Crownland that converts to freehold land and is vested in LandCorp, once a tenant is prepared to enter into a lease. Most SIA's form part of state regional planning strategies and are appropriately zoned within the relevant local government area jurisdiction.

There are currently 12 SIAs operating or under development. The approximate location of the current SIA's is illustrated in Figure 24 below.

FIGURE 24 – WESTERN AUSTRALIAN STRATEGIC INDUSTRIAL AREAS

The SIAs are located in close proximity to key upstream Western Australian natural resources industries and are connected (or intended to be connected) to important infrastructure such as road, rail or ports. SIAs are, in effect, planned and protected industry hubs, designed to facilitate the downstream processing of natural resources (minerals, petroleum and agriculture) that are located in proximity to the specific SIA. They are also generally located close to local workforce and town site amenities, and are protected by planning buffer zones that provide some long-term comfort as to the viability of the area as an industrial site, regardless of other long term developments in the area.

Proponents interested in establishing facilities on a SIA are required to submit a business case the Department of Jobs, Tourism, Science and Innovation that articulates details of the project and the project's strategic alignment with the specific SIA. The Department of Jobs, Tourism, Science and Innovation then acts as the lead agency to assist the applicant in determining whether their proposal is suitable for the intended purpose of the SIA and if so, navigating the issuing of lease and the development of the project more generally.

SIAs are not competitive with industrial zones in competing jurisdictions

Of the 12 gazetted SIAs in Western Australia, six remain untenanted, and three have two or fewer tenants. The two lithium hydroxide plants that are currently under construction in Western Australia are located in SIAs – Kwinana and Kemerton.

While clearly preferential to a greenfields development site, SIAs are not competitive with 'turn-key' industrial sites that are offered to downstream battery supply-chain operators in many other jurisdictions. As has recently been demonstrated, projects can still encounter significant uncertainty and delays in project approvals and require significant investment in head-works and other infrastructure, a situation that does not typically arise in 'turn-key' industrial estates globally.

In 2018, industry recommended that the Western Australian Government review the SIA policy framework to render these important zones more competitive with industrial zones internationally (see Table 12).

Recommendation

It is Recommended that the Western Australian Government work with industry to undertake a review of the Strategic Industrial Area framework with a view to rationalising the real-estate portfolio and investing in headworks, infrastructure and approvals tailored for the specific needs of tenanted SIAs.