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# Australia's potential in the lithium market

Demand for lithium is expected to rise rapidly in the future, and Australia has a unique opportunity to make the most of it.

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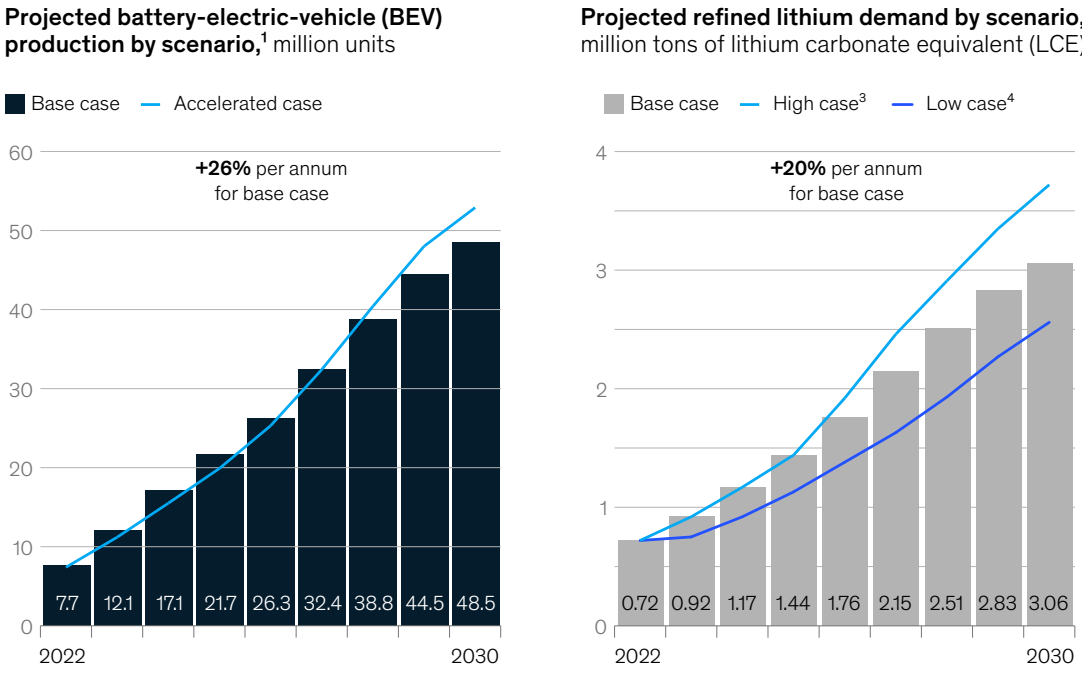
**Global demand growth** in lithium-based power offers a significant—but limited-time—opportunity for the Australian resources sector as countries and companies are establishing their roles in the batteries value chain, and decisions made now are determining how the global industry will look in the 2030s.

Demand for lithium-based power will rise rapidly with the growth of the electric-vehicle (EV) market. Forecasts by Tesla suggest the company will need approximately 1,000 kilotons of lithium carbonate equivalent (LCE) per year by 2030, or 16 times its 2022 needs and 30 percent more than the world currently produces.[1] Overall, the global passenger EV market, which relies on lithium-based batteries, is expected to grow annually by 26 percent through 2030[2] (Exhibit 1).

Australia is already the world's largest producer of spodumene—the base material for lithium hydroxide and lithium carbonate—and has the second largest lithium ore reserves globally.[3] For now, however, Australia has limited capability and capacity to

Exhibit 1

## Electric-vehicle production is growing 26 percent annually, resulting in lithium demand growth of 20 percent per annum.




[1]Indicative; doesn't include hybrids, commercial vehicles, or 2 and 3 wheelers that also use lithium ion batteries.
[2]High case scenario assumes that lithium (Li) metal anodes will start to be visible on the market as of 2026.
[3]High case for Li demand is based on base BEV production case, with higher Li content for battery cells.
[4]Low case for Li demand is based on slower BEV production case.
Source: McKinsey Battery Insights; McKinsey Center for Future Mobility; McKinsey MineSpans

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[1] "Tesla 2023 investor day," YouTube, March 1, 2023.
[2] "What is an EV?," McKinsey, February 6, 2023.
[3] Nnamdi Anyadike, "New discoveries: Raising the profile of lithium in Australia," *Mining Technology*, December 5, 2022; "These countries are driving lithium production," McKinsey, May 25, 2022.

refine spodumene into the lithium hydroxide needed for lithium-based batteries.

The opportunity for Australia is twofold: rising lithium demand *and* the country's capacity to produce lithium hydroxide. The lithium hydroxide market may generate up to $10 billion[4] per year in additional revenue for market participants by 2030—with the potential to create jobs, diversify Australia's raw-materials industry, and support Australia's push toward green energy.

Such an opportunity could be within reach of those market participants. This article explores the following pertinent factors:

— the nature and extent of Australia's lithium hydroxide opportunity

— Australia's potential advantages in cost, accessible markets, and renewable energy

— challenges in securing Australia's place in a competitive global market

## Australia's lithium hydroxide opportunity

Global demand for lithium is expected to grow strongly through the 2030s and beyond: although the chemical composition of EV and non-EV batteries varies, lithium is included in all compositions. If Australia were to extend its lithium extraction into refining, that would lead to new revenues and margins—and contribute to national income and employment.

### Rising global demand for lithium

Lithium is expected to remain the primary raw material for batteries for the foreseeable future. Historically, battery technology relied on lithium carbonate. More recently, better-performing high-nickel NMC batteries (composed of lithium nickel manganese cobalt oxide), which instead rely on lithium hydroxide, have been introduced. Accordingly, demand for lithium hydroxide is on the rise as EV producers increasingly shift to using high-nickel NMC batteries. Our analysis shows demand for lithium hydroxide to be higher than lithium carbonate by 2030 (Exhibit 2). Most of the future battery technologies, which are currently in early stages of development, also require lithium in various chemical forms.[5]

Current annual global lithium demand is 0.72 million metric tons of LCE and is forecast to rise by 20 percent annually (31 percent for lithium hydroxide; 13 percent for lithium carbonate) to reach 3.06 million metric tons of LCE by 2030 (Exhibit 3). Current annual supply is 0.75 million metric tons of

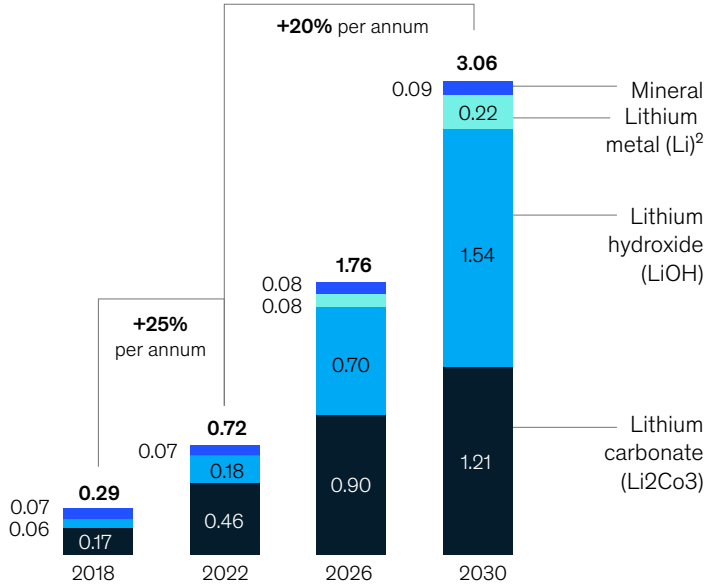
**The opportunity for Australia is twofold: rising lithium demand *and* the country's capacity to produce lithium hydroxide.**

[4] All dollar amounts in this report are US dollars.
[5] For a deeper analysis of the supply–demand and price outlook for lithium, see Marcelo Azevedo, Magdalena Baczyńska, Ken Hoffman, and Aleksandra Krauze, "Lithium mining: How new production technologies could fuel the global EV revolution," McKinsey, April 12, 2022.

Exhibit 2

## Lithium metal and hydroxide demand is expected to grow faster than lithium carbonate demand over the next ten years.

**Projected refined lithium demand by product,**[1] million tons of lithium carbonate equivalent (LCE)




[1]Based on base case demand.
[2]Li metal demand is expected to grow at the fastest pace in the second part of the decade as anode technology changes.
Source: McKinsey MineSpans

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LCE, with another 0.89 million metric tons of LCE scheduled in planned and probable projects by 2030. To meet expected 2030 demand, the world will need to bring an additional 1.42 million metric tons of LCE[6] of annual capacity online above planned and probable projects.

The lithium carbonate spot price hit an all-time high of about $80 per kilogram of LCE in November 2022, before easing back to its current approximately $40 per kilogram of LCE.[7] As current projects can cover anticipated demand through 2026, prices may fall further, potentially reaching $16 to $20 per kilogram of LCE. By 2026, prices are expected to rise again as increasing demand begins to outstrip available supply. Construction and commissioning of the existing Australian lithium hydroxide plants took four to six years, so prospective participants can make investment decisions now to take advantage of this potential upcoming gap between supply and demand.

**Australia, a major producer of spodumene, has commenced lithium hydroxide production**

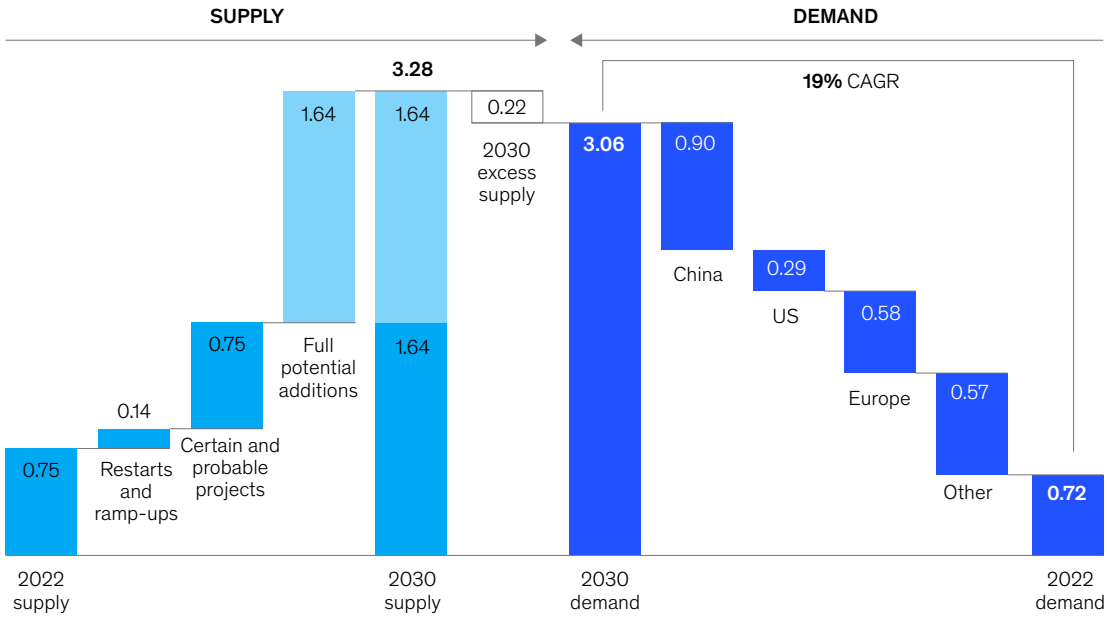
Four countries—Australia, Chile, China, and Argentina—hold 76 percent of the world's lithium

[6] Difference of full-potential additions and 2030 excess supply.
[7] As of May 2023.
[8] "These countries are driving lithium production," May 25, 2022.

Exhibit 3

## By 2030, lithium supply will match (and exceed) demand but only if full additional supply potential comes online.

**Refined lithium demand and mining supply,**[1] million tons of lithium carbonate equivalent (LCE)




[1]Mining production converted to refined metal basis to make supply and demand numbers comparable; secondary supply included in numbers. Demand is divided by region based on predicted regional electric-vehicle production. Breakdowns by region and product done for base demand scenario.
Source: McKinsey MineSpans

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reserves.[8] Australia's lithium reserves (among the highest grades globally) are extracted through hard-rock mining and the ore processed into spodumene, which can then be refined into either lithium hydroxide or lithium carbonate (lithium hydroxide is the preferred route because refining from spodumene is less complex and cheaper than refining lithium carbonate from spodumene). Most South American lithium reserves are brine, which is extracted through heavily water-dependent evaporation ponds. This raw material is predominantly converted into lithium carbonate (because of the greater complexity and cost of conversion to lithium hydroxide). China relies on both extraction methods.

While Australia accounted for 43 percent of global lithium extraction in 2022 (almost all exported to China), it has only just started processing spodumene into the more valuable lithium hydroxide. China, in contrast, accounts for just 17 percent of global lithium extraction, but for 77 percent of global lithium hydroxide refining.[9]

Lithium miners in Australia are now seeking to close that gap. Two major global lithium ore miners operating in Australia—China-owned Tianqi and

[9] McKinsey MineSpans data.

US-owned Albemarle—have both invested in refining plants with Australian joint venture partners (respectively, IGO Limited and Mineral Resources Limited).[10] In 2022, Tianqi launched Australia's first battery-grade lithium hydroxide plant at Kwinana, with total planned capacity of 100 kilotons of lithium hydroxide per year (current capacity is 24 kilotons per year), and Albemarle is commissioning a similar-size plant at Kemerton (current capacity, 50 kilotons per year).

**Lithium hydroxide represents up to a $10 billion opportunity for participants, coupled with strong rates of return**

By 2030, these and other planned Australian lithium hydroxide plants are expected to produce approximately 234 kilotons of LCE of lithium hydroxide annually, from a projected approximately 716 kilotons of LCE of spodumene.[11] Refining the remaining approximately 480 kilotons of LCE of spodumene represents Australia's lithium hydroxide opportunity, with prospective measurable benefits in revenues, margins, and employment.

In a scenario where lithium hydroxide is valued at $10 to $20 per kilogram of LCE more than spodumene in 2030, revenues could rise by approximately $4.8 to $9.6 billion. A more promising revenue scenario may also emerge at the significantly higher 70 to 85 percent margins available to integrated refineries, compared with the 40 to 60 percent margins available to nonintegrated global refiners.[12] Our analysis suggests producing lithium hydroxide at these levels may also create up to 18,000 temporary construction jobs, and 4,000 permanent operational jobs, by 2030.[13]

Our analysis also suggests that existing Australian lithium hydroxide refiners could achieve internal rates of return (IRRs) of about 29 to 36 percent (assuming the LCE price in perpetuity is the analyst consensus average of approximately $24 per kilogram of LCE). Even with the assumption that the LCE price in perpetuity is as low as approximately $15 per kilogram of LCE, the IRR would be 12 to 21 percent, which may still merit consideration by prospective participants.

## Four potential advantages for Australia from expanded lithium hydroxide production

If Australia does choose to refine its available spodumene into lithium hydroxide, four factors could play into any decision. First, the combination of hard-rock lithium reserves and integrated refining could give Australia a strong cost advantage in the eyes of global customers. Second, Australia could become an attractive supplier to multiple markets under free trade agreements and other legislative initiatives. Third, the Australian industry can draw on the developing renewable energy industry to offer low-emission production to a decarbonizing world. Finally, Australia could build and leverage its lithium knowledge base through its lithium production and refining.

**Low-cost, reliable supply**

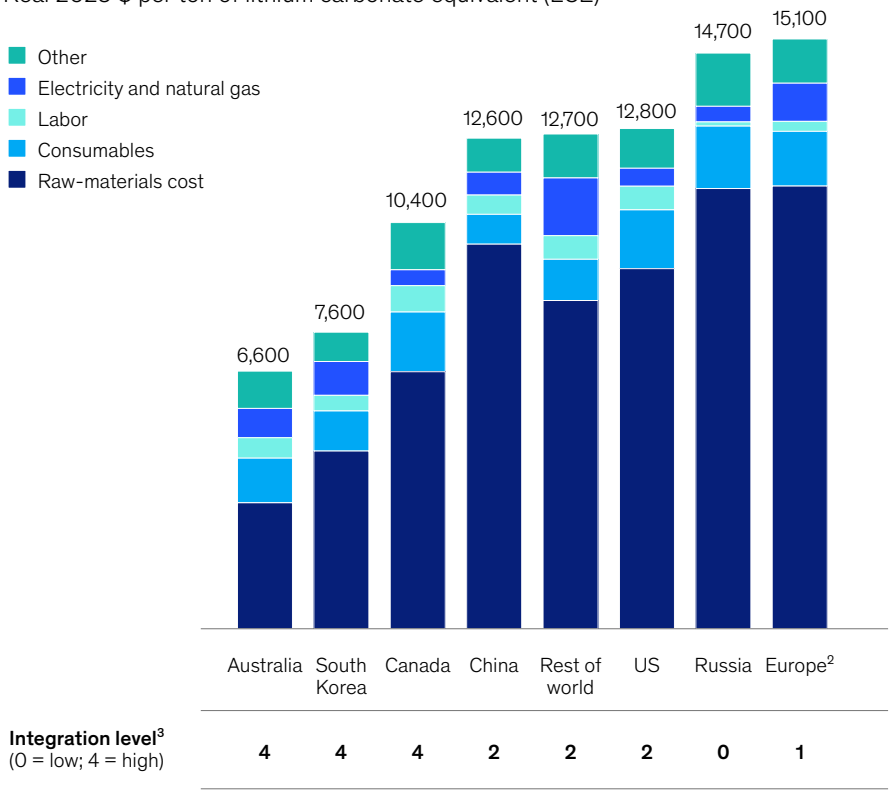
Australian refineries could benefit from reduced transport and energy costs. If those refineries are integrated with mining operations, participants will also benefit from cheaper raw materials (because they will not need to pay market prices for spodumene). As a result, our modeling suggests that Australia could produce lithium hydroxide at approximately $6,600 per ton of LCE (assuming integration with lithium mining), compared with $10,400 per ton of LCE for China (Exhibit 4). Indeed, South Korea and Canada, the closest countries to Australia from a cost perspective, still have costs approximately 24 to 51 percent higher than Australia's. In addition, Australian plants would have the strategic advantage of a secure raw-materials supply.

[10] Tom Parker, "Lithium hydroxide: Australia's way of the future," *Australian Resources & Investment*, March 14, 2023.
[11] McKinsey MineSpans data.
[12] Assuming ±$2 on long-term lithium carbonate spot price of $24 per kilogram of LCE, lithium hydroxide price premium to lithium carbonate of $2–$2.50 per kilogram of LCE, Australian integrated lithium hydroxide refining cost of $4.70–$6.40 per kilogram of LCE, global nonintegrated lithium hydroxide refining cost of $12–$15 per kilogram of LCE.
[13] Assuming 1,800 construction jobs and 400 operational jobs per 50 kilotons per year of refining capacity.

Exhibit 4

## Integrated Australian participants can produce lithium hydroxide at about 52 percent of the cost for the rest of the world.

**Weighted average cost breakdown for lithium hydroxide (LiOH) refining facilities, 2030,[1]**
Real 2023 $ per ton of lithium carbonate equivalent (LCE)




[1]Inclusive of sustaining capital costs, freight.
[2]Europe inclusive of UK.
[3]Level of integration across mining and refinement players within each country (based off number of integrated players).
Source: McKinsey MineSpans

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### Favored status for the growing US market

Two factors suggest Australia and the United States could become stronger trading partners in lithium hydroxide production. First, the United States is expected to be the third largest market for lithium hydroxide by 2030, accounting for an expected 11 percent, or 0.34 million metric tons of LCE, of the expected global demand noted earlier. Second, the 2022 US Inflation Reduction Act (IRA) offers eligible EV purchasers up to $7,500 in tax credits.[14] However, the law stipulates that the battery and EV manufacturers source at least 40 percent of battery minerals locally or from free trade agreement (FTA) countries, rising to 80 percent by 2027.[15]

Australia is particularly well placed to meet US market needs. While Canada and Chile are also FTA countries, Australia can deliver lithium hydroxide at the lowest

[14] Greg Iacurci, "Why the $7,500 EV tax credit may be tougher to get starting in March," CNBC, January 25, 2023.
[15] "The Inflation Reduction Act: Here's what's in it," McKinsey, October 24, 2022.

cost. Chile's brine lithium extraction produces mainly lithium carbonate, whereas Canada's production cost is expected to be $10,400 per ton of LCE, more than 58 percent higher than Australia's.

However, IRA credits may be unavailable to Australian battery minerals produced by companies domiciled in foreign entities of concern—such as Tianqi, Ganfeng, and other Chinese players operating in the Australian lithium industry.[16]

### Low-emission lithium hydroxide for a decarbonizing world

By 2030, raw materials are expected to constitute 25 to 40 percent of battery Scope 3 emissions, and both battery and EV manufacturers will seek to meet ambitious decarbonization targets. As a result, annual demand for low-emission lithium hydroxide may grow from effectively zero today to 0.7 million metric tons of LCE. Assuming an equilibrium or undersupply, we forecast a price premium of approximately 4 to 5 percent over the commodity lithium price for low-emission lithium hydroxide.

Typically, the carbon footprint of hard-rock mining is about 2.5 times that of brine operations. However, Australia can overcome that deficit with lower-emission energy sources. Using coal-fired power, roasting hard-rock lithium generates approximately 9.6 tons of carbon dioxide per ton of LCE. Australia's new refining plants will instead use gas, which could reduce total mining and refining emissions by approximately 50 percent, bringing it almost in line with brine operations emissions. Future innovation may allow plants to power the roasting process with green hydrogen, drawing on the abundant renewable energy that can be co-located at all lithium hydroxide plant sites.

### Leading future lithium knowledge center

By 2030, based on currently announced capacities, about 14 percent of global lithium hydroxide production will occur in the greater Perth area. That would be a meaningful concentration of human capital, which the Australian industry might capitalize on to develop a leading knowledge center for lithium hydroxide. That step could attract investment, which would in turn generate further knowledge in the space.

## Actions required to overcome challenges

Australia may be in a position to produce lithium hydroxide for a growing market, but that development is not guaranteed. Challenges exist throughout all phases of project design, construction, and operation, and they involve the perennial Australian infrastructure risks of labor shortages and cost overruns. Those risks may be partially addressed, and lower operating costs locked in, if owners integrate their refining operations with their own lithium spodumene operations—either directly or through a joint venture. Otherwise, the challenges will need careful attention and innovative approaches for Australian lithium production to retain its advantages.

### Secure sufficient skills and labor

If Australia decides to convert all of its spodumene to lithium hydroxide, nearly 4,000 additional workers will be required to operate Western Australian plants by 2030.[17] However, Western Australia's mining and infrastructure sectors already have severe labor shortages, and the average planned capital expenditures for mining projects are set to grow at around four times the historic eight-year average (Exhibit 5). This growth will exacerbate the labor shortages for both construction and operation of facilities. Coupled with the sheer numbers of laborers, Australia also has a critical need for better recruitment and cultivation of expertise in several key areas: commissioning/operational readiness, mechanical/maintenance engineering (particularly during facility ramp-up), and process/chemical engineering.

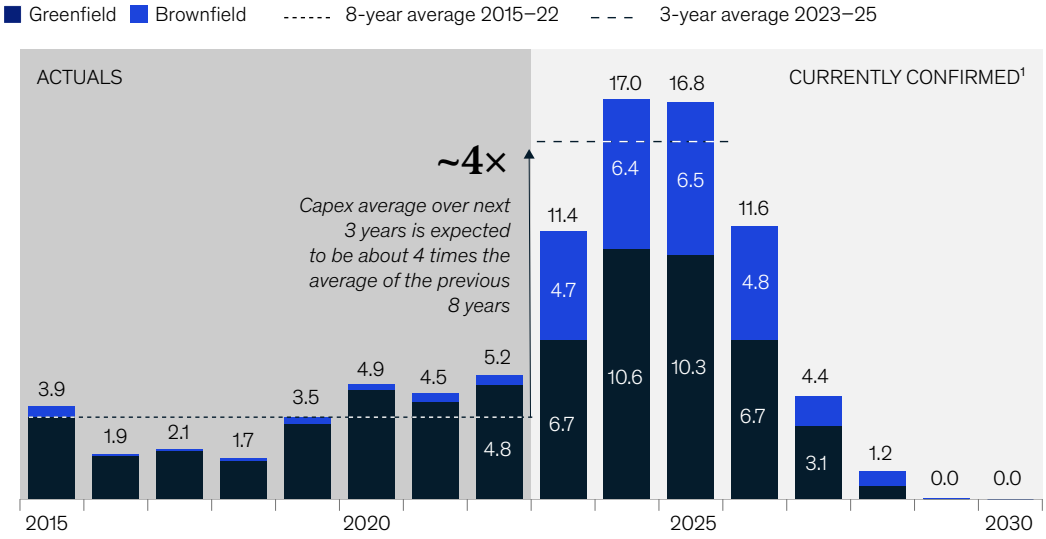
Lithium players will need to develop strong strategies and incentives to acquire, develop, and retain talent in such a tight labor market. They'll need distinctive recruitment strategies for both

[16] James Fernyhough, "US carmakers passing up lithium from Australia's first refinery," Bloomberg, October 31, 2022.
[17] Assuming 400 operational jobs per 50 kilotons per year of refining capacity, and 480 kilotons of additional lithium hydroxide production.

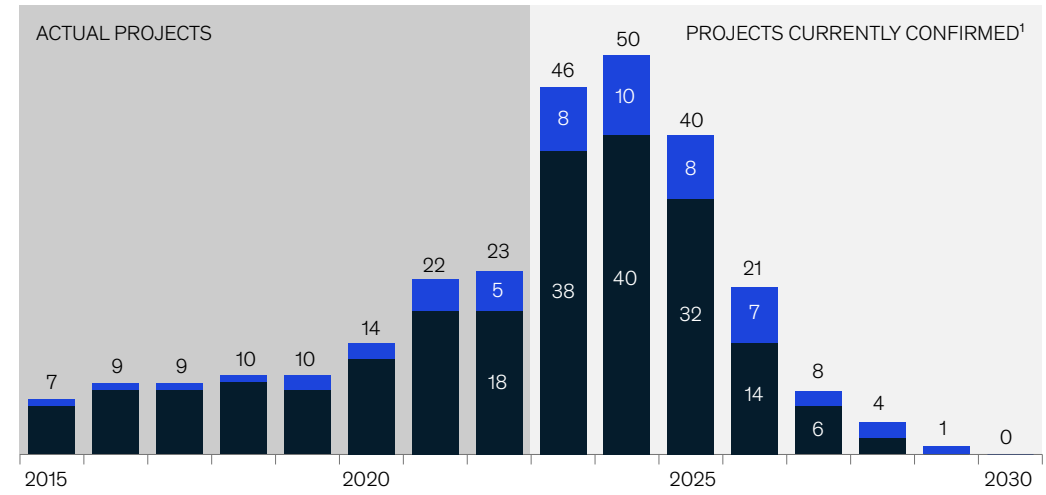
Exhibit 5

## Capex boom in Western Australia is expected to drive labor shortages, capex overruns, and construction delays.

**Construction capex in Western Australia mining sector,** AU $ billion




**Construction capex in Western Australia mining sector,** number of projects




[1]More could be added.
Source: McKinsey Center for Future Mobility; McKinsey MetalSpans; McKinsey Projects Analytics Tool, leveraging data from GlobalData; values and projects related to mining, including metal and minerals extraction, processing, and ore and metal refineries; data extracted only for Western Australia

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fly-in-fly-out and residential talent, attractive living spaces for both talent pools, and selective international expertise. Most lithium facilities are relatively close (by Australian standards) to Perth and the attractive lifestyle it offers.

### Minimize capital expenditure overruns and construction delays

Australia's mines and refineries are currently among the most capital-intensive in the world. Upfront capital costs may be five to ten times that of best-in-class peers, and significant delays in construction often occur. China, for example, builds lithium refineries in less than two years.[18]

Mitigating those challenges is likely to require that all ecosystem players work toward shared goals. That aim may require a deliberate, fresh approach to building both human and social capital within the ecosystem: curiosity to identify problems in advance, communication skills to explore solutions in a collaborative environment, and creativity for cross-functional teams to embed those solutions in replicable, effective, data-driven, innovative processes. Such approaches will have a greater chance of delivering the agility and resilience needed for long-term capital projects.

### Safeguard project commissioning and operations

Large-scale lithium hydroxide processing is a sophisticated and challenging process, and one not yet well established in Australia. Both Tianqi and Albemarle have publicly acknowledged challenges in ramping up their facilities in Western Australia (at the Kwinana and Kemerton plants, respectively).[19] Analysis shows a one-week delay in ramping up operations would cost a 50-kilotons-per-year lithium hydroxide site approximately $23 million to $27 million in revenue.[20]

Lessons in plant design and commissioning from established international players will be invaluable. Further lessons may be gleaned from the processing of other minerals, and from the firms that specialize in such engineering. Of course, these solutions are likely to require investment from the global and local players, and attracting those players is itself another challenge.

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The twofold lithium opportunity for Australia warrants further discussion across an array of stakeholders. It is another potential side to the story of how Australia remains a resource and energy powerhouse, following the transformational shift from fossil fuels to renewable resources. Australia has the skills, capital, and resources to secure that opportunity—if it can marshal those assets efficiently. Refining lithium will therefore require disciplined coordination and collaborative innovation—and in a short timeframe, before the opportunity is lost.

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[18] McKinsey MineSpans: Construction estimates.
[19] Georgia Loney and Jacqueline Lynch, "Albemarle lithium processing plant just weeks from first production already looking to expand," ABC News, May 15, 2022; Sean Smith and Caitlin Paroczai, "IGO posts booming profit as lithium prices jump, but Kwinana plant ramp-up delayed again," *West Australian*, January 31, 2023.
[20] Assuming ±$2 on long-term lithium carbonate spot price of $24 per kilogram of LCE, lithium hydroxide price premium to lithium carbonate of $2–$2.50 per kilogram of LCE.