Charging Ahead

Australia's battery powered future

Final Report

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FUTURE BATTERY INDUSTRIES CRC

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About Future Battery Industries CRC

FBICRC was established in 2019 through the Australian Government's Cooperative Research Centre Program. It brings together partners with a presence across the battery value chain from Australia's established strength in mining through to processing, manufacture, services and recycling and reuse of batteries. Through investment with its partners in a portfolio of research, development and education programs it seeks to address challenges associated with the energy transition and capture the significant economic opportunities for Australia from the rising demand for batteries.

Many of these issues can only be addressed in collaborative efforts along the value chain. The FBICRC provides a platform to enable this collaboration. It is the largest partnership of industry, government organisations and research partners focused on battery industries in Australia with 73 participants.

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Executive summary

Australia now has the opportunity to build thriving domestic battery industries that will provide $16.9 billion in gross value added and support 61,400 jobs by 2030

The growth of global battery industries has accelerated rapidly, and the opportunity for Australia is now more than double previous forecasts.

The rapid growth of global demand and the increased forecast value of battery packs has amplified the opportunity for Australia. Diversified battery industries in Australia could now contribute A$16.9 billion gross value added (GVA) and 61,400 jobs to the economy by 2030, which is more than double the GVA contribution of A$7.4 billion forecast in *Future Charge*.

The demand for batteries has grown significantly. We now forecast that demand for batteries in 2030 is 64% higher than previous estimates, with the annual growth rate of battery demand accelerating from 24% to 34%.

Material shortages have driven long-term price increases for batteries. Lithium, nickel, graphite and cobalt all face structural supply shortages by 2030. This expected shortage has increased the 2030 forecast price of lithium-ion battery packs by 35%.

Major global economies are now vying for greater shares of the battery value chain, creating both opportunities and challenges for Australia's battery industries.

Globally, governments are adopting increasingly ambitious industry policies to grow their battery industries. This has narrowed Australia's window of opportunity to compete on an international scale.

China is currently the dominant player across the battery value chain. However, many countries are now seeking to diversify their battery supply chains, creating opportunities for alternative suppliers such as Australia.

Australia's strategic and defence partnerships in the Asia-Pacific region have strengthened, creating an opportunity for Australia to partner with its allies to develop its battery industries.

Australia will need to lean into its comparative advantages of mineral diversity, reliability, security and ESG credentials to be competitive across the value chain.

Australia has key sources of differentiation across the value chain and is cost comparable with peers, but global subsidies are eroding Australia's cost position, particularly in battery manufacturing.

To drive greater competitive advantage, Australia will need to leverage its:

- Critical mineral wealth; to drive cost synergies through vertical integration and co-location, and to provide unique supply diversity.
- Reliability and security; to position Australia as an alternative secure source of supply, enabling countries to diversify their supply chain and secure materials for their growing domestic battery industries.
- Environmental, social and governance (ESG) credentials; to differentiate Australia against rivals as a responsible provider of battery materials and products.

Governments must act quickly and decisively to capture midstream and downstream value in global battery industries.

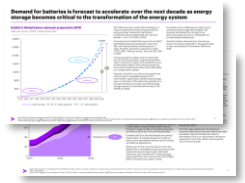
The dynamics of the global battery industries have changed rapidly, and Australia must act quickly and decisively to capture the economic and strategic opportunity of diversified battery industries.

There are six key policy strategies that Australian governments should implement to build an internationally competitive battery industries at speed and scale:

- Alliances and incentives
- Industry attraction
- Industry coordination
- Regional export partnerships
- Increase domestic demand
- Specialist battery institute.

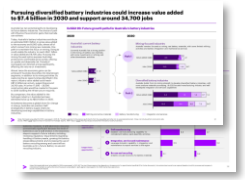
The dynamics of global battery industries have rapidly changed, and Australia must act quickly to capture the economic and strategic opportunity

***Future Charge* highlighted the opportunity for Australia in the global battery market, and provided a high-level path for Australia to capture that value**



Highlighted a rapidly growing market for batteries
When *Future Charge* was released in 2021, the global battery market was forecast to grow at 24% per annum to 2030, increasing nine to tenfold compared to 2020.

Identified how Australia could compete across the value chain
The report identified how Australia could compete globally by leveraging upstream cost advantages, its position as a reliable nation and through specialisation opportunities.



Evaluated the economic opportunity for Australia
Future Charge estimated that diversified battery industries could contribute A$7.4 billion in GVA and 34,700 jobs to the Australian economy by 2030.

Provided an overview of key policies for government consideration
Four key policy objectives were laid out, with high-level recommendations for government to meet each objective.

Since *Future Charge*, the global battery market has taken off, and Australia must act now if it wants to compete and capture the greater-value opportunity now at stake

The demand for batteries is growing much faster than anticipated

Global battery demand is now forecast to grow at 34% per annum to 2030, increasing 18-fold on 2020 levels. This represents **a 64% increase in demand in 2030 relative to previous forecasts**.

The market for batteries is now far more competitive

Major global governments have accelerated their efforts to capture value in the global battery market and build their sovereign capabilities. **Australia will need to lean into its comparative advantages, particularly mineral wealth, to be competitive.**

The size of the economic opportunity is now much larger

The growth in global demand for batteries, coupled with supply shortages of key critical minerals, has greatly increased the size of the opportunity for Australia. **Diversified industries could now contribute A$16.9 billion and 61,400 jobs to Australia's economy.**

Quick and decisive action from government is required if Australia wants to capture the economic opportunity available

Given the accelerated pace with which battery industries are developing and consolidating, **Australian governments will need to act quickly to support battery industries** to capture shares in high-value market segments.

Australia's battery industries could contribute $16.9 billion to the economy by 2030, more than double previous forecasts

		Future Charge 2030 forecast	Updated 2030 forecast
Path 1	**Mining-focused industries** Australia remains focused on capturing opportunities from mining raw battery materials, which have expanded based on the rapid uptake of batteries globally and subsequent increases in raw material prices.	**$8.9 billion** in additional GDP **$4.1 billion** in gross value added **18,700** direct jobs	**$25.8 billion** in additional GDP **$10.4 billion** in gross value added **31,600** direct jobs
Path 2	**Diversified battery industries** Australia builds from its mining strength to capture the opportunities from developing diversified battery industries, including downstream activities. These opportunities have expanded due to the growth in global and domestic demand for batteries.	**$23.6 billion** in additional GDP **$7.4 billion** in gross value added **34,700** direct jobs	**$55.2 billion** in additional GDP **$16.9 billion** in gross value added **61,400** direct jobs

Notes: Figures in Australian currency. *Future Charge* released in 2021. Modelling assumptions are in the appendix.
Source: FBI CRC (2021); IEA (2022a, 2022b, 2022c, 2022d); McKinsey (2022); BNEF (2022a, 2022b, 2022c); AEMO (2022a, 2022b, 2022c, 2022d); Wood Mackenzie (2022); Renew Economy (2022a, 2022b); Energy Storage News (2022); SolarRun (2022); Department of Energy and Public Works (2022); Batteries Europe (2021); CSIRO (2021); Accenture analysis.

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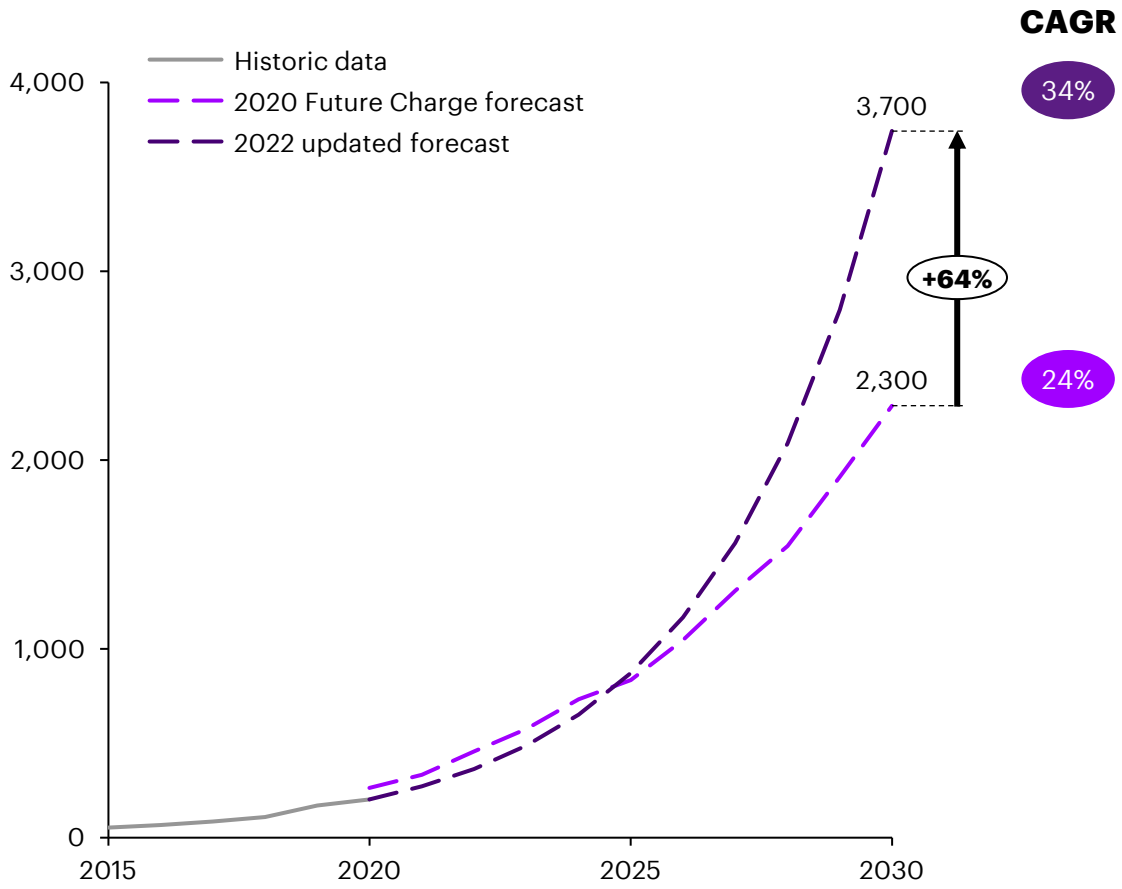
01

With the accelerating growth of the global battery market, diversified battery industries could now contribute A$16.9 billion to the Australian economy by 2030

Growth in global demand for batteries has accelerated since 2020 forecasts, with 64% additional demand expected by 2030

Exhibit 1: Global battery demand, projected to 2030

GWh per annum, 2020 = latest actual data



Global battery demand is now forecast to increase by 18 times from 2020 to 2030, compared to the previous forecast of a nine to tenfold increase.

The revised demand projection can be attributed to increased adoption of electric vehicles and stationary storage, and a global acceleration in the energy transition.

Increased adoption of electric vehicles is the key driver behind the forecast growth in battery demand, with demand for batteries in stationary storage also contributing to global battery demand. Global EV uptake in 2030 is now forecast to be 94% higher than was forecast in 2021. EVs include electric buses, two-wheelers, commercial vehicles and passenger EVs. Passenger EVs represent the largest share of forecast EV uptake. In addition, forecasts of stationary storage installations have increased by 4% since 2020 forecasts.

Governments globally have accelerated the energy transition, in part by subsidising their domestic battery industries. For example, the US's *Inflation Reduction Act* (IRA) will deploy at least US$369 billion into clean energy investments over the next ten years, providing tax incentives across all battery value chain segments. Averaging over US$36 billion in investment per year, the IRA investment surpasses previous clean energy subsidy programs, such as China's wind and solar subsidies which were less than US$10 billion per year.

Other countries and jurisdictions are also investing heavily in their battery industries. The European Union has approved over US$6 billion in public funding to support innovative projects across the battery value chain, while India has allocated over US$2 billion in grants to support gigafactory construction.

Notes: The 2022 updated forecast is an evenly weighted average of three scenarios: the McKinsey Base Case Scenario, BNEF Economic Transition Scenario and the IEA Sustainable Development Scenario. The 2020 Future Charge forecast is the 2020 Roskill projection as it was used for market sizing in the report.
Sources: IEA (2022, 2022, 2022, 2022); McKinsey (2022); BNEF (2022); EY (2022); ICCT (2022); BNEF (2022); US Congress (2022); European Commission (2019, 2021).

Supply of key battery materials is not forecast to keep up with increasing demand

There are supply concerns regarding several critical battery materials, particularly lithium, nickel, cobalt and graphite.

The supply of lithium is forecast to fall short of demand by 2030. Strong demand for EVs is expected to drive lithium demand over the next decade. However, new supply is not coming online at the rate needed to match surging demand. This is due to low lithium prices in 2018-2020 causing an under-investment in lithium mining. Furthermore, the capabilities and expertise required to refine lithium into battery chemicals are concentrated in a handful of countries, which is limiting new potential production.

Current nickel production is forecast to not meet demand in 2035. Mining and processing industries are struggling to keep up with the demand for battery-grade nickel used in EV batteries. In addition, global supply chain disruptions caused by the Russia-Ukraine war have also contributed to the shortage of nickel. Nickel is expected to remain in a supply deficit for the third straight year in 2023.

Cobalt is forecast to be in a supply deficit by 2026, and graphite is forecast to be in a supply deficit by 2025. Graphite shortages are expected due to a combination of a limited number of graphite mines in the world and under-investment into graphite projects. For these critical minerals, Benchmark Mineral Intelligence forecast that at least 231 new mines and 54 factories are needed by 2035 to equate supply and demand forecasts.

Lead times in mining are much longer than other parts of the supply chain, with mining requiring exploration, proof of viability for extraction, and extensive permitting. According to the IEA, mines that started operations between 2010 and 2019 took on average 16.5 years to develop from exploration to extraction.

Exhibit 2: Forecast global lithium supply and demand

Mt lithium carbonate equivalent (LCE), 2020 = latest actual data

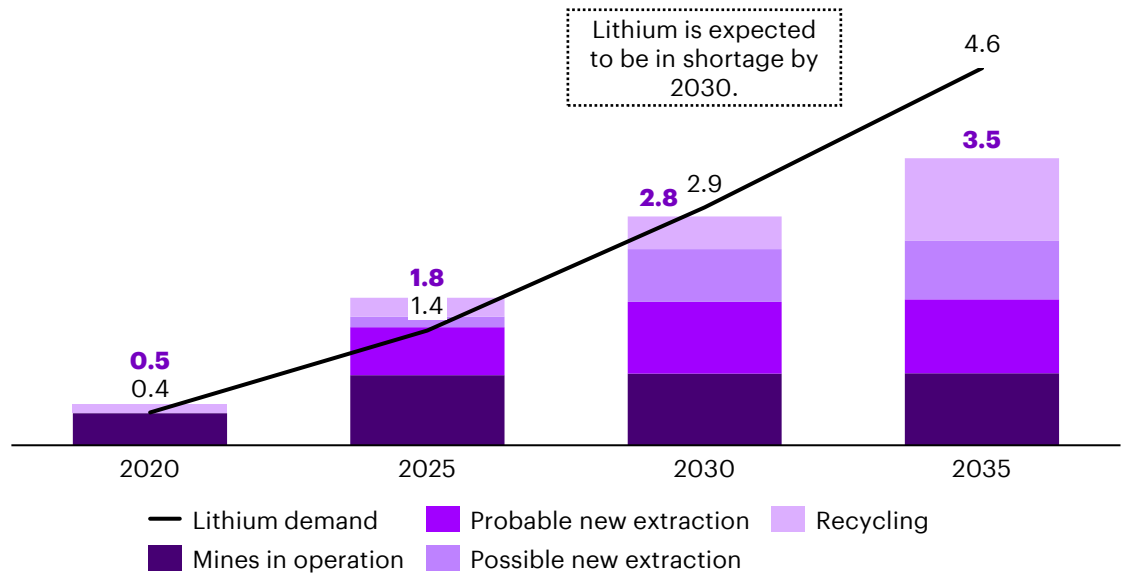


Exhibit 3: Expected date of shortage for nickel, graphite and cobalt

	Nickel	Graphite	Cobalt
Year of expected shortage	Currently in shortage	2025	2026

Notes: Forecast supply and demand for nickel, cobalt and graphite are in the appendix.
Sources: IEA (2021, 2022, 2022); BCG (2022); S&P Global (2022); Benchmark Minerals Intelligence (2022); NRDC (2022); Reuters (2022, 2022); Frontier Group (2022); Cobalt Institute (2022, 2022); World Bank (2022); Sumitomo Metal (2022); Stratas Advisors (2022); Resources Rising Stars (2022); World Economic Forum (2022); International Graphite (2022); Benchmark Mineral Intelligence data (2022, 2022, 2022); Wood Mackenzie data (2022); Industrial Metal Service (2022); Walkabout (2022); Utility Dive (2022); Accenture analysis.

The price of battery packs in 2030 is expected to be 35% higher than previously forecast

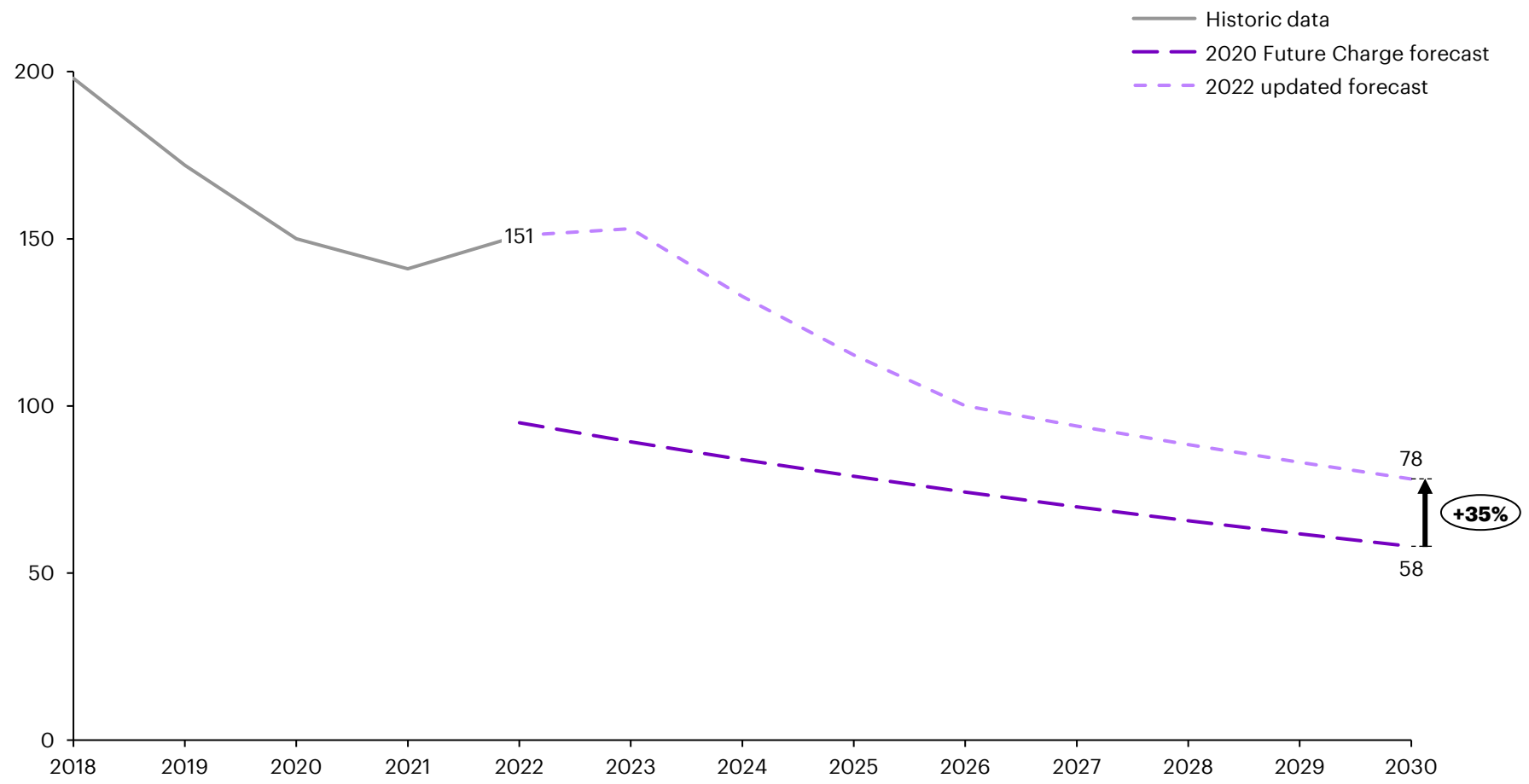
Due to the increased demand and forecast shortage of critical minerals, the major metals used to produce batteries have all experienced price increases. In turn, this has increased the forecast price for lithium-ion battery packs.

Between December 2021 and December 2022, lithium, nickel and cobalt prices increased by 499%, 117% and 56% respectively. Battery pack material costs – of which critical minerals are a key contributor – make up between 50% and 70% of the total battery pack price. While critical mineral prices are expected to increase throughout 2023, forecasts beyond this are less certain.

While increased prices of critical minerals are putting inflationary pressure on pack prices, pack prices are forecast to decline between 2024 and 2030. Continued technology improvements,[2] increased uptake of LFP cathodes, adoption of alternative cheaper battery chemistries, and manufacturing scale are putting downwards pressure on prices. Battery packs are expected to cross the US$100/kWh threshold in 2026.

Exhibit 4: Price forecasts for lithium-ion battery packs

Real US$ per kWh, 2022 = latest actual data[3,4,5]



Notes: 1. For LFP modules and NMC-811 packs. 2. Including changes in module and pack design, such as cell-to-pack designs. 3. BNEF forecasts are used for battery pack prices, but battery prices are influenced by the underlying commodity prices and are subject to change. 4. The forecast pack price of $78/kWh in 2030 implies a lithium carbonate price of around $70/kg. A lithium carbonate price of $70/kg in 2030 is around current prices, which have ranged from $69-79 over the past month. 5. 2022 forecast in 2022 dollars, 2020 forecast in 2020 dollars to align with Future Charge estimates.
Sources: BNEF (2022,2022); IEA (2022); VisualCapitalist (2022); SQM (2022); InvestorIntel (2022); Trading Economics (2022a, 2022b, 2022c, 2022d, 2022e).

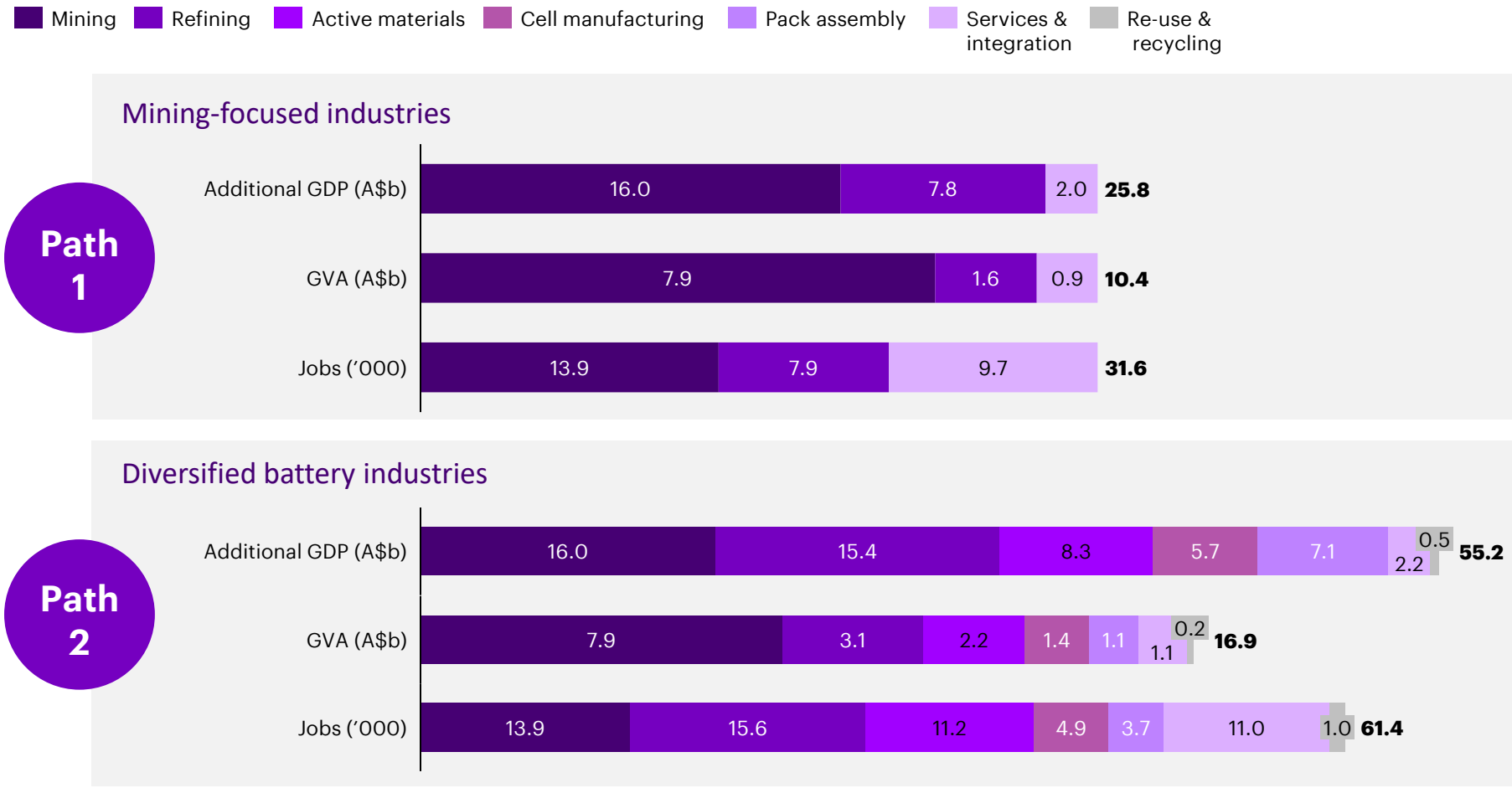
The accelerating growth in the battery market has more than doubled Australia's economic opportunity by 2030

		Future Charge 2030 forecast	Updated 2030 forecast	Increase
Path 1	Mining-focused industries	$8.9 billion in additional GDP	$25.8 billion in additional GDP	2.9x
	Australia remains focused on capturing opportunities from mining raw battery materials, which have expanded based on the rapid uptake of batteries globally and subsequent increases in raw material prices.	$4.1 billion in gross value added	$10.4 billion in gross value added	2.6x
		18,700 direct jobs	31,600 direct jobs	1.7x
Path 2	Diversified battery industries	$23.6 billion in additional GDP	$55.2 billion in additional GDP	2.3x
	Australia builds from its mining strength to capture the opportunities from developing diversified battery industries, including downstream activities. These opportunities have expanded due to the growth in global and domestic demand for batteries.	$7.4 billion in gross value added	$16.9 billion in gross value added	2.3x
		34,700 direct jobs	61,400 direct jobs	1.8x

Notes: As the value of mined products for the battery value chain has increased significantly since *Future Charge*, the gross value added per job for the mining industry has increased, decreasing the number of jobs associated with a given level of gross value added for mining. Figures in Australian currency.
Sources: FBI CRC (2021); IEA (2022a, 2022b, 2022c, 2022d); McKinsey (2022); BNEF (2022a, 2022b, 2022c); AEMO (2022a, 2022b, 2022c, 2022d); Wood Mackenzie (2022); Renew Economy (2022a, 2022b); Energy Storage News (2022); SolarRun (2022); Department of Energy and Public Works (2022); Batteries Europe (2021); CSIRO (2021); Accenture analysis.

Pursuing diversified battery industries could increase gross value added to A$16.9 billion in 2030 and support around 61,400 jobs

Exhibit 5: Additional GDP, gross value added and jobs[1] by value chain segment, pathway 1 and pathway 2, 2030



Australia could either pursue mining-focused industries, which would generate raw materials needed for batteries, or diversified battery industries.

A mining-focused strategy would create A$25.8 billion in additional GDP by 2030, generating A$10.4 billion in GVA and supporting 31,600 jobs. The majority of the gross value added and jobs would be in mining, with some refining activity, along with services and integration to address the demand for batteries from Australia. Achieving a mining-focused strategy would require around A$20-25 billion of capital investment between 2020 and 2030. The investment requirements for a mining-focused strategy have approximately doubled since *Future Charge*, driven largely by the increased GVA in 2030 for the mining and refining industries.

A diversified battery strategy would create A$55.2 billion in additional GDP by 2030, generating A$16.9 billion in GVA and supporting 61,400 jobs. This pathway would involve greater refining and services and integration activity than pathway 1, along with activity in active materials, cell manufacturing, pack assembly and re-use and recycling. A diversified battery strategy will require around A$30-35 billion of capital investment between 2020 and 2030, approximately A$10 billion more than would be needed for a mining-focused strategy.

Notes: 1. Direct jobs required to operate and maintain activity. Does not include temporary construction jobs.
Sources: FBICRC (2021); IEA (2022a, 2022b, 2022c, 2022d); McKinsey (2022); BNEF (2022a, 2022b, 2022c); AEMO (2022a, 2022b, 2022c, 2022d); Wood Mackenzie (2022); Renew Economy (2022a, 2022b); Energy Storage News (2022); SolarRun (2022); Department of Energy and Public Works (2022); Batteries Europe (2021); CSIRO (2021); Accenture analysis.

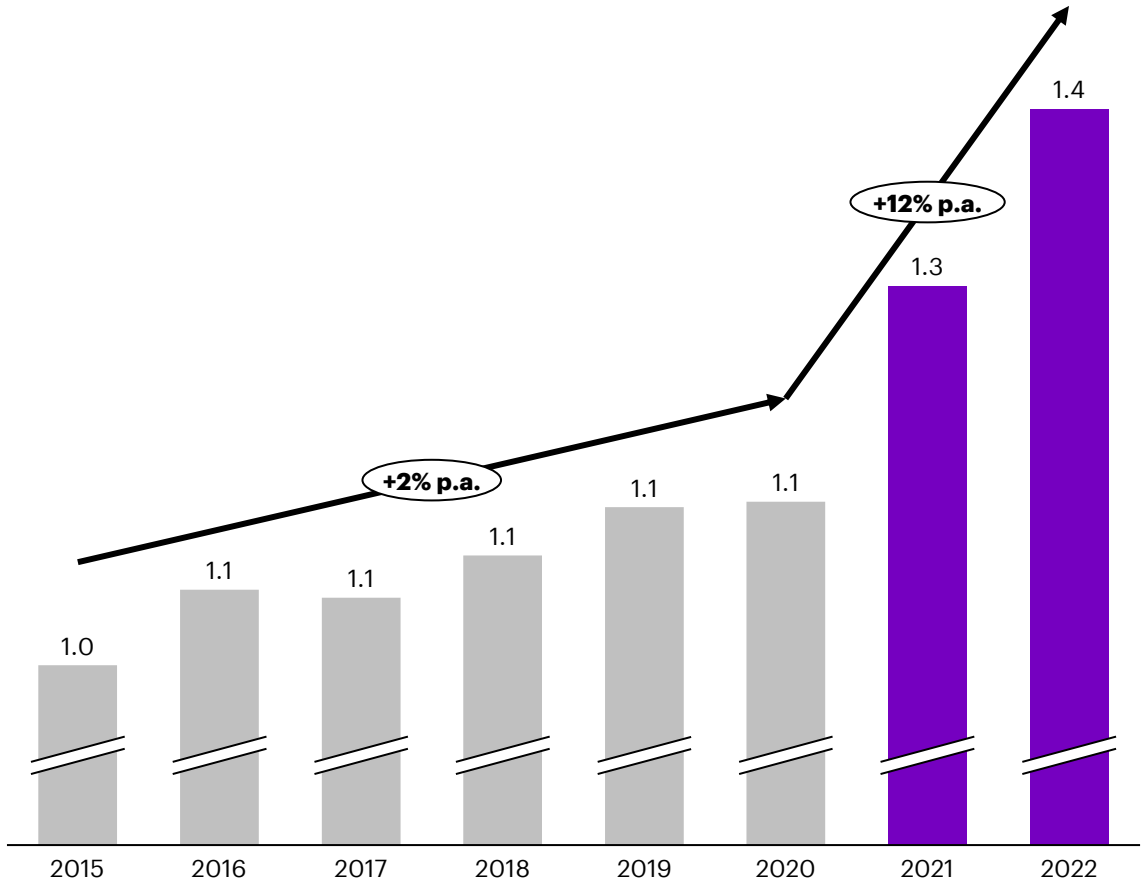
02

As competition between global battery industries has intensified, Australia must now expedite more targeted and comprehensive policies to compete

Australia is facing intensified global competition, as governments have accelerated efforts to build sovereign clean energy capabilities

Exhibit 6: Global government spending on clean energy projects

US$ trillions (2021 dollars)



Governments have accelerated their push to build sovereign clean energy capabilities in the last two years, with public spending on clean energy projects increasing from 2% per year in 2015 – 2020 to 12% per year in 2020 – 2022.

Three global shifts since 2020 have accelerated battery demand growth: intensified rivalry between the world's largest economies for economic and technological leadership, the recent global energy crisis, and increased public and private pressure to accelerate the transition.

Governments from the world's largest economies have accelerated clean energy spending in the pursuit of economic leadership. From 2020 to 2022, government spending on clean energy increased by 14% in China, and 22% across North America. Competition between these economies has continued to intensify since the start of the US-China trade war in 2018.

The global energy crisis has exposed energy security vulnerabilities, hastening the development of sovereign energy capabilities. From 2021 to late 2022, European gas prices increased tenfold. This was primarily due to an 80% reduction in Russian gas supply, which previously accounted for 40% of the gas used in the EU. This energy crisis prompted governments to accelerate investments in energy security.

Politicians, citizens, investors and employees have demanded faster progress on the energy transition.

For citizens and politicians, this translated to an increase in influence of Green parties. In 2022, Green parties were represented in the national legislatures of 24 countries, and formed part of a governing coalition in five of these countries. The growth of Green politics is particularly pronounced in the EU. In the 2021 German election, the Green party (Bündnis 90) received 15% of the vote, over 60% higher than the previous election.

Investors are demanding faster progress on the energy transition, with environmental, social and governance (ESG) funds growing from 3% of global assets under management in 2015 to over 16% in 2021.

Employees are also pushing for their employers to accelerate the transition, with two-thirds of workers being more willing to work for organisations that they consider are environmentally sustainable.

Sources: International Energy Agency (2022); Council on Foreign Relations (2022); BBC News (2022); International Monetary Fund (2022, 2023); Deutche Welle (2021); BCG (2022); PwC (2022); IBM (2022).

Efforts to build sovereign energy capabilities align with a broader global trend towards economic nationalism

Exhibit 7: Global trade intensity

Trade as a % of gross world product

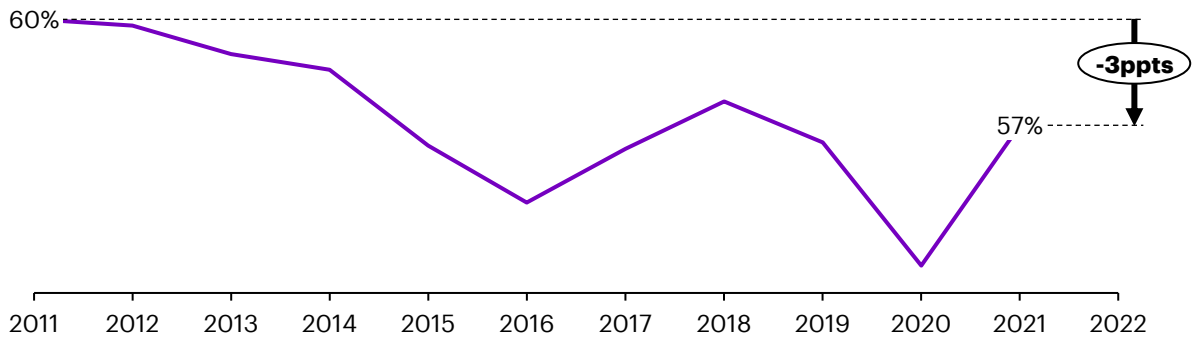
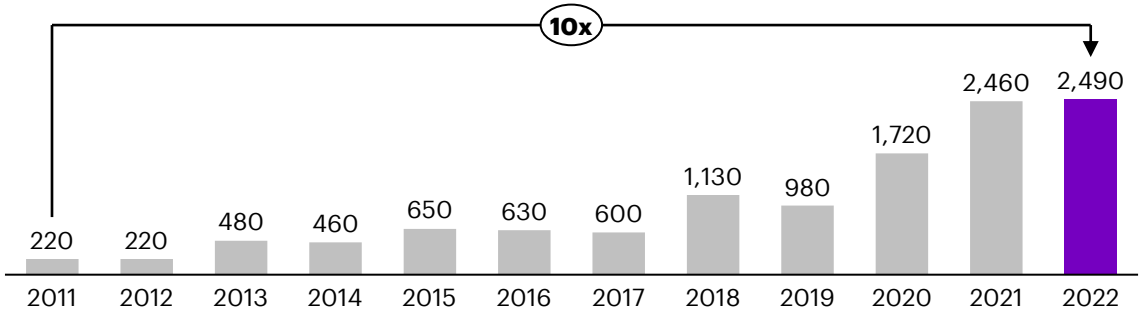


Exhibit 8: Global trade and investment barriers

Estimated number of barriers imposed



Australia is now competing in a globally competitive landscape that has shifted from a paradigm of free trade to one of increasing economic nationalism.

Global trade has declined over the past decade, led by trade tensions between the two largest economies. Trade as a proportion of gross world product declined from 60% in 2011 to 57% in 2021. The two largest economies, the US and China, have led the decline. Between 2015 and 2020, US imports as a percentage of GDP fell by 1.1 percentage points, with a reduction in imports from China accounting for over half of the decline. Over the same period, China's imports as a percentage of GDP fell by 0.5 percentage points, with a reduction in imports from the US accounting for about 80% of this change.

Since 2011, the number of global trade and investment barriers imposed increased tenfold. The proliferation in protectionist policies, including national security measures like export controls and trade policies like tariffs, has been driven by advanced economies. In 2021, 76% of national investment policy measures in advanced economies restricted foreign investment, compared to only 19% of policies from developing countries.[1] The ongoing trade war between the US and China has accelerated growth in protectionist trade policies such as tariffs. While less than 1% of trade between the US and China was subject to tariffs at the start of 2018, over 50% of bilateral trade was subject to tariffs by 2022.

The shift towards economic nationalism has made it harder for Australia's battery industries to compete internationally. Intensified global competition and international industry policies have narrowed the window for Australia to act to deliver globally competitive, export-oriented and diversified battery industries. However, the shift opens up opportunities for closer, strategic supply relationships between aligned nations who seek economic alliances in their own interest.

Notes: 1. 'Advanced economies' refers to Europe, North America and 'other developed countries'. 'Developing countries' refers to Asia, Africa and Latin America and the Caribbean, but excludes 'other developed countries'.
Sources: International Monetary Fund (2023); United Nations Conference on Trade and Development (2022); Peterson Institute for International Economics (2022); World Bank (2021); Accenture analysis.

While China's battery industries are dominant, the US and EU are adopting strategic industrial development policies to catch up

While China is currently dominant in battery production, other economies including the US and EU are now implementing strategic industrial development policies to accelerate the growth of their battery industries.

China owes its current dominance in battery manufacturing to its early implementation of strategic industrial development policies. China is the dominant player in battery manufacturing, accounting for 79% of global lithium-ion battery manufacturing capacity in 2021.

China gained an advantage in battery manufacturing through its early introduction of substantial EV subsidies. While China and the US both introduced subsidies in 2009, China's subsidies were more ambitious. While the US offered tax credits of up to US$7,500 per vehicle, Chinese consumers were offered subsidies of up to almost US$10,000 from the central government, plus additional subsidies from some local governments, and exemptions from purchase taxes from 2014 to 2017.

The EU and the US are now attempting to catch up to China by implementing strategic industrial development policies. The European Commission has recently approved over US$6 billion in state aid to support research and innovation projects across the value chain, as an 'Important Project of Common European Interest'. The US has committed US$369 billion in clean energy investment, including more than US$14 billion in subsidies for electric vehicle projects.

Exhibit 9: Key industrial development policies from the three largest economies

Li-ion manufacturing capacity (GWh 2021, % of global)	**Forecast increase in capacity by 2031**	**Key examples of industrial development policies** (year of policy introduction)
China 558 (79%)	**5-10x**	▪ **World-leading EV adoption subsidies (2009):** US$50b in subsidies over the past decade to accelerate the adoption of EVs ▪ **Made in China 2025 policy (2015):** Industrial development policy to increase domestic content of core materials in manufacturing to 70% by 2025
EU 65 (9%)	**15-25x**	▪ **Innovation-focused state aid (2019 and 2021):** Over US$6b in state aid to support research and innovation projects across the value chain ▪ **Net-Zero Industry Act (2023)**: Proposed temporary amendment to EU state aid rules which make it easier for member states to deliver subsidies to domestic firms
US 44 (6%)	**15-25x**	▪ **Inflation Reduction Act (2022):** US$369b in investment in energy security and climate change projects, with significant local content requirements for some subsidies ▪ **Invocation of Defense Production Act (2022):** Additional financial support for critical mineral industries, while requiring government bodies and companies to prioritise domestic contracts with these industries

Notes: Forecast capacity increase based on estimates from S&P Global and Cowen.
Sources: Financial Times (2022); China Briefing (2022); S&P Global Market Intelligence (2021); European Commission (2019, 2021); International Energy Agency (2022); Accenture analysis.

China currently dominates most of the value chain due to its strategic EV subsidies and its certification scheme that favours local firms

Exhibit 10: China's market share by battery value chain segment

% share of total revenue, latest available[1]

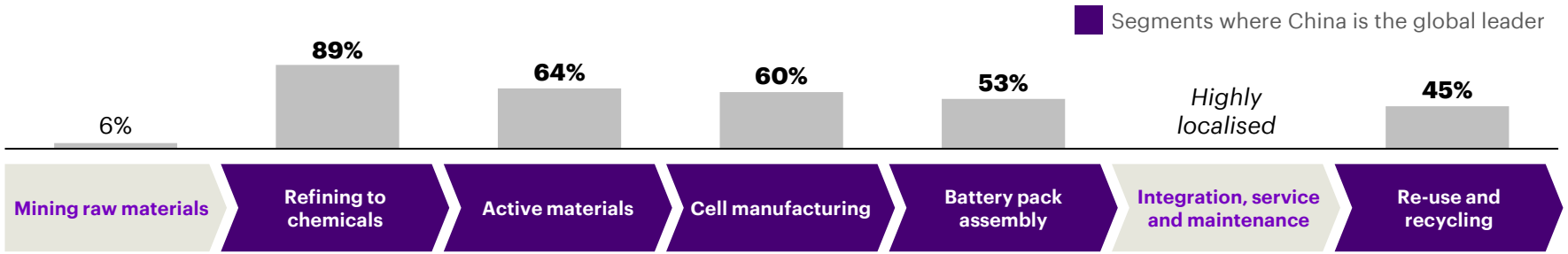


Exhibit 11: China's policies to accelerate the growth of its battery industries

Policies	Description
World-leading EV subsidies	▪ Over **US$50b in government subsidies** for EV purchases from 2009 to 2023, with the maximum per-vehicle subsidy in China being over 30% larger than the maximum subsidy offered in the US. ▪ In 2016, regulations were introduced which restricted subsidy eligibility to EVs with batteries from manufacturer with at least 8GWh capacity, **favouring Chinese incumbents over overseas entrants while promoting industry consolidation**.
Certification scheme	▪ In 2015, almost all EV battery manufacturers that were certified to operate in China were Chinese. ▪ Many foreign companies were refused certification, suggesting that the certification scheme was implemented in a way that **insulates Chinese companies from foreign competition**.

China currently dominates most segments of the global battery value chain, with support from over US$50 billion in government subsidies and a certification scheme that advantages Chinese firms over foreign competitors.

China currently dominates most segments of the global battery value chain. It is most dominant in refining, capturing 89% of global refining revenue and producing over 80% of the world's lithium hydroxide. China also has a strong presence in active materials, cell manufacturing and pack assembly.

China has established its supply chain dominance through its conditional EV subsidies and its certification scheme. China has accelerated the growth of its integrated battery industries through government subsidies. In 2016, the Chinese government restricted subsidy eligibility to vehicles with batteries from plants with over 8GWh in production capacity. This favoured large Chinese incumbents (like CATL and BYD) over foreign entrants, while encouraging industry consolidation which further protected Chinese producers from competition. This saw a decline in demand for South Korean batteries from LG Chem. China's certification scheme has also protected local industry. In 2015, almost all 57 of the battery manufacturers that were granted certification were Chinese, with many foreign companies refused certification. This has largely insulated Chinese manufacturers from foreign competition.

Notes: 1. Data for mining, refining, cell manufacturing and assembly are for 2017. Data for active materials is the average of country market share for anode, cathodes and electrolytes in 2019, and data for recycling uses distribution of leading recycling companies in 2019.
Sources: AusTrade (2018) The Lithium-ion Battery Value Chain: New economy opportunities for Australia; Roskill (2020) Lithium-ion Batteries: Outlook to 2029, Tables 18-21 and Chapter 14; Merics (2018); China Briefing (2022); OneCharge (2022); Accenture analysis.

The US aims to eclipse China's dominance through US$369 billion in investments through its Inflation Reduction Act (IRA)

Exhibit 12: Selected IRA incentives across the battery value chain

	Value chain segment	Selected IRA incentives
Battery industries	**Mining**	▪ **Up to US$500 million** in federal support for US mining and refining of critical minerals for batteries. ▪ Tax credits of **up to 30%** of the amount invested in establishing or upgrading a refining facility.
	Refining	
	Active materials	▪ Tax credits of **up to 10%** of the costs incurred to produce electrode active materials.
	Cell and pack manufacturing	▪ **Up to US$45/kWh** in tax credits for cell and module manufacturing.[3]
	Recycling	▪ Tax credits of **up to 30%** of the amount invested in establishing or upgrading a recycling facility.
Adjacent industries	**EV manufacturing**	▪ Tax credits of **up to US$7,500** for the manufacture of clean vehicles, subject to supply chain requirements, with an estimated total value of **US$7.5 billion over 10 years**.
	EV adoption	▪ Tax credits of **up to 30%** for businesses to adopt clean vehicles. ▪ US$3 billion for the US Postal Service to purchase zero-emission delivery vehicles.

The IRA includes over US$369 billion in clean energy investments over 10 years, including significant investments across many segments of the battery value chain.

The most substantial battery subsidies focus on cell and pack manufacturing. These subsidies include up to US$45/kWh in tax credits for US cell and module manufacturers. This subsidises up to half of the operating cost of manufacturing a battery pack.

The IRA also includes modest subsidies for refining and active materials, while enabling greater investment in US mining. This includes tax credits for electrode active materials production and critical mineral refining costs. The IRA also authorises the enhanced use of the *Defence Production Act* to support critical mineral mining.

The IRA also supports local demand for batteries through its EV manufacturing and adoption subsidies. This includes about US$7.5 billion in tax credits for clean vehicle manufacturing, which subsidises about 25% of the cost to manufacture an EV. Over ten years, these subsidies are worth more than half the GVA of Australia's battery industries in 2030 under a diversified industries scenario.

These announced policy changes have already attracted significant investment. In the three months after the IRA was enacted, companies committed over US$13.5 billion in US battery investment, compared to US$7.5 billion in the previous three-month period. The IRA is already drawing investment away from competitors like the EU. Northvolt (a European battery manufacturer) has reportedly reconsidered its plans to establish a German plant in favour of the US due to the IRA.

Sources: IRA §§. 30001, 45C, 45X, 45W, 13401, 70002; US Joint Committee on Taxation (2022); Inside EVs (2020); McKinsey & Company (2019); Accenture (2021); Financial Times (2022); The Economist (2023); Accenture analysis.

The IRA creates opportunities for Australia in mining, refining and active materials but presents significant challenges in cell and pack manufacturing

IRA EV subsidies allow content from free-trade partners, but also offer tax credits that benefit their domestic upstream and midstream industries. The biggest impact is from the IRA's US$45/kWh tax credit on US made battery packs, which substantially weakens Australia's competitiveness.

The IRA could benefit Australia's mining, refining and active materials industries. The IRA offers up to US$7,500 in tax credits for US clean vehicle manufacturers if the vehicles contain over a threshold amount of critical minerals and battery components that are produced in the US, or in a country that has a free trade agreement (FTA) with the US. As one of only 7 OECD countries with an FTA with the US, Australia is well positioned to supply battery inputs to US value chains. Further, the IRA excludes vehicles with components that were processed in selected countries, including China. China has over 60% of global market share in refining and active materials, so countries are expected to diversify away from China in order to take advantage of IRA subsidies. Australia has the opportunity to capture additional market share in these segments.

However, the IRA's large subsidies on cells and modules greatly weakens Australia's cost competitiveness in manufacturing. The IRA offers tax credits on battery packs of up to US$45/kWh, which subsidises up to half the cost of manufacturing a battery pack in the US.

Exhibit 13: Impact of the IRA on Australian battery value chain

Opportunity ● ● ● ● ● Challenge

Value chain segments	Mining	Refining and active materials	Cell and pack manufacturing	Integration and recycling
% of global market[1]	50% (Australia) / <10% (Excluded countries)	60-70%	25-35%	*More localised opportunity where exports are less relevant*
	Australia has existing strengths in mining	*Australia has the greatest opportunity to capture market share from countries that are excluded from clean vehicle incentives (e.g., China)*		
Implications for Australia	Australia could **benefit from the IRA's friendly-country requirements for critical minerals** that require clean vehicles to have a minimum proportion of critical minerals sources from a country with a US free-trade agreement US-FTA.	The US could import over 60% of cathode and anode active materials by 2030, and may require substantial refined material imports. **Australia is well-placed to capture market share from China** as a supplier of refined and active materials, as China is excluded from IRA subsidies.	The IRA **weakens Australia's cost competitiveness** in manufacturing by subsidising up to half the cost of manufacturing a battery pack.	As the IRA is expected to significantly accelerate the decline in the price of renewables, Australia can **accelerate EV and ESS adoption** and provide regulatory support to grow Australia's battery integration and recycling segments.

Notes: 1. Market shares represent the proportion of global revenue captured by a group in each value chain segment. Excluded countries are China, Russia, Iran and North Korea. Clean vehicles that involve any of these countries in supply chains are disqualified from clean vehicle incentives. Sources: World Bank WITS (2022); Future Smart Strategies (2017); Roskill (2020); USGS (2021); KPMG (2022); S&P Global (2022); Accenture analysis.

The EU proposes to respond to the IRA by accelerating state aid, complementing its existing suite of industrial policies

Exhibit 14: EU policies to accelerate the growth of its battery industries

	Policies	Description
Existing suite of industrial policies	**Innovation-focused state aid**	In 2019 and 2021, the EU approved over **US$6 billion in state aid** to support research and innovation projects across the battery value chain.
	Announced Critical Raw Minerals Act	The EU plans to introduce legislation to **strengthen the EU's access to critical raw minerals** such as lithium and rare earths.
Response to IRA	**Announced changes to state aid rules**	The EU has announced the Net-Zero Industry Act which will temporarily amend state aid rules to **make it easier for member states to deliver subsidies to domestic firms**.

Before the IRA was enacted, the EU supported the growth of its battery industries through rules of origin and state aid. The EU has since announced plans to respond to the IRA with rules that will accelerate European subsidies, further weakening Australia's cost position.

The EU has authorised state aid to accelerate the growth of its battery industries. In 2019 and 2021, it approved over a combined US$6 billion in state aid to support battery innovation across the value chain as an 'Important Project of Common European Interest'. This project is designed to promote collaboration between research organisations and industry to develop sustainable and innovative solutions in extraction, refining, active materials and cell technology. Further, the EU is aiming to strengthen its access to critical raw materials through its announced *Critical Raw Materials Act*. This will establish a network of raw minerals agencies across EU member states to identify strategic critical mineral supply chain priorities, and expedite funding and permits for strategic projects.

The EU has recognised the competitive threat of the IRA to the growth of its battery ecosystem, and has responded with proposed rule changes that will accelerate industry subsidies. European leaders were quick to criticise the IRA as an attack on the EU's battery industries. French president, Emmanuel Macron, called the IRA 'super aggressive' and a 'killer for [Europe's] industry'. European Commission President, Ursula von der Leyen, labelled the IRA and other global subsidies 'aggressive attempts to attract [Europe's] industrial capacities away'. In response, the European Commission announced a *Net-Zero Industry Act*. This includes temporary changes to state aid rules, aiming to accelerate state subsidies to 'counter relocation risks from foreign subsidies'. These subsidies will further weaken the cost competitiveness of Australia's battery industries.

Sources: European Commission (2019, 2021, 2022, 2023); Euronotes (2023); The Faraday Institution (2021).

To compete, emerging markets like Indonesia, India and Thailand are also implementing ambitious policies to grow their industries

Several developing countries are also attempting to capture a share of the global battery opportunities by implementing a range of industrial development policies.

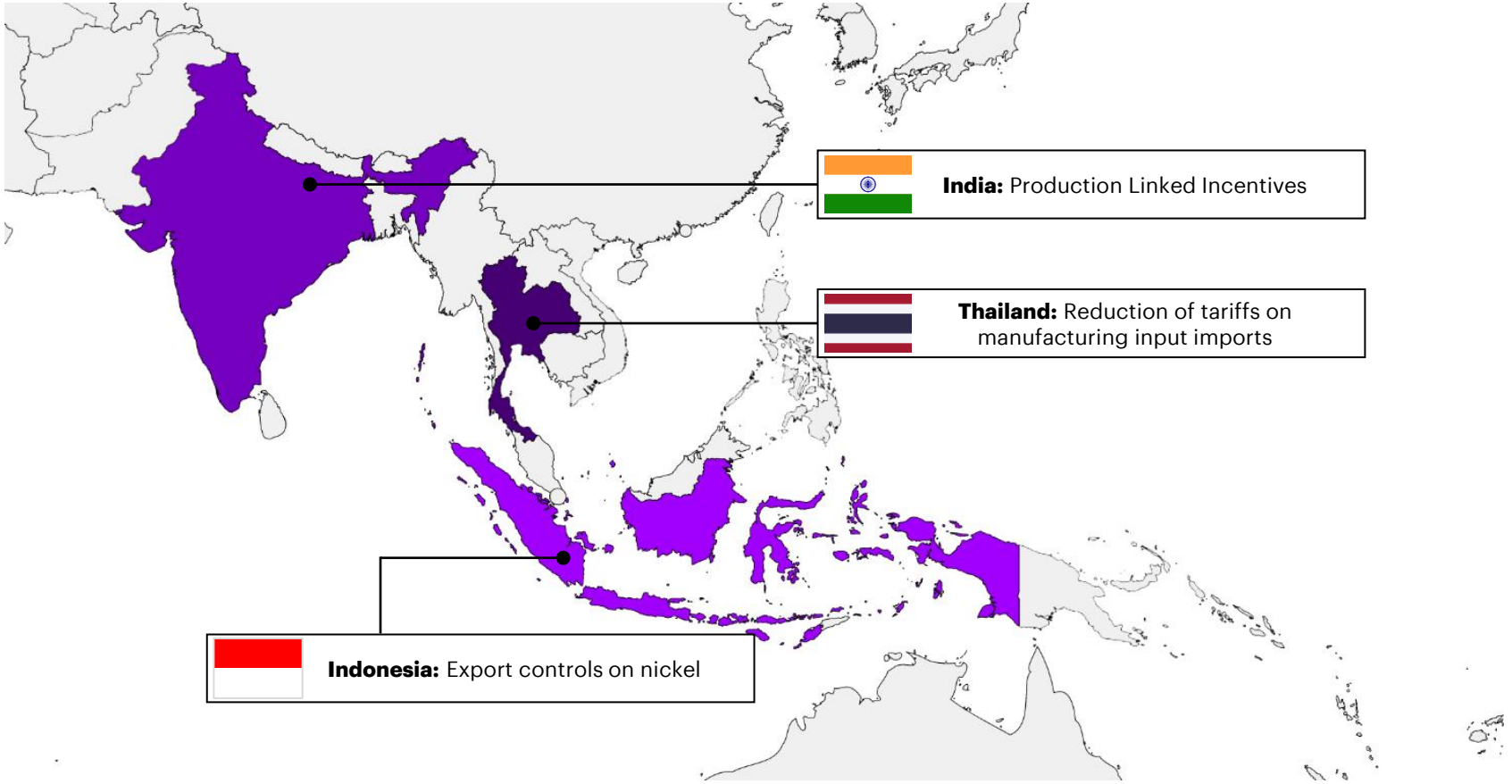
India, Thailand and Indonesia have all adopted different approaches to attract investment and accelerate industry growth.

India's Production Linked Incentives allocates over US$2b in grants to support plans to build 5GWh+ gigafactories. In 2022, the program provided grants for 50GWh in battery manufacturing capacity and aims to support growth in capacity to 100GWh by 2030.

Thailand has reduced import tariffs on inputs for battery manufacturing. This includes battery manufacturing equipment and 'raw and essential materials' for battery manufacturing. By doing so, Thailand hopes to unlock low-cost inputs and accelerate the development of its battery manufacturing industry.

Since 2020, Indonesia has banned exports of nickel ores. As Indonesia has 22% of global nickel reserves, and nickel is a key but scarce input in EV battery cathodes, Indonesia is aiming to leverage its exclusive supply of nickel to grow domestic value added segments such as nickel refining and cathode production.

Exhibit 15: Selected emerging market battery policies



Sources: International Energy Agency (2022); National Bureau of Asian Research (2022); Mining Technology (2017); Energy Storage News (2022); The Nation Thailand (2022); Tilleke & Gibbins (2022); ISEAS (2022).

High supply chain concentration and rising geopolitical turbulence is prompting a new approach to China

Exhibit 16: National measures to diversify supply chains

Economies	Examples of measures to diversify supply chains
 **US**	US producers are **ineligible for the IRA's clean vehicle subsidies** if battery components are manufactured or processed in China.
 **UK**	The UK introduced the *National Security and Investment Act* in 2021 to **screen foreign investments**. It has so far blocked or reversed at least three Chinese technology investments.
 **EU**	The EU has announced the *Critical Raw Minerals Act* to **strengthen its access to critical raw minerals**.
 **Canada**	In 2022, the Canadian Government ordered several Chinese companies to **sell their shares** in three Canadian lithium mining companies.
 **Vietnam**	Vietnam has entered into **free trade agreements** such as the Comprehensive and Progressive Trans-Pacific Partnership to expose the Vietnamese economy to diverse trading partners.
 **India**	India entered into the **Quad dialogue** with the US, Japan and Australia to insulate itself from China's economic influence.

As geoeconomic dynamics continue to shift, many countries are seeking to reduce their exposure to China as the world's largest exporter. These countries are also likely to seek diversified supply chains for their battery industries.

Countries are wary of the energy security risks of concentrated supply chains amid rising geopolitical turbulence, which may leave them vulnerable to trade or natural disruptions. For example, Japan currently depends on China for most of its rare earths supply, a critical input for electric motors and other clean technologies. In 2010, China abruptly cut off rare earths supply to Japan during a fishing trawler dispute. More recently, Russia reduced its gas supply to the EU by 80%. As the EU relied on Russia for almost half of its gas supply, this caused European gas prices to increase tenfold from 2021 to late 2022. Such instances of retortion restricting critical imports have motivated many countries to seek to diversify their supply chains.

The US has tied IRA tax credits to supply chain provenance requirements to incentivise supply chain diversification away from China. US manufacturers miss out on up to US$7,500 in tax credits per clean vehicle if battery components are manufactured or assembled in China, or if critical minerals are extracted, processed or recycled in China. In this way, the US incentivises producers to diversify away from Chinese supply chain partners.

Several countries, including the UK and Canada, have introduced or strengthened their investment screening processes which often target investments from China. In 2021, the UK introduced a new investment screening regime. Three of the four deals that this process blocked or unwound in its first two years of operation were Chinese technology investments. Canada is also looking to strengthen its investment screening process after requiring several Chinese companies to sell their shares in Canadian lithium mining firms.

Emerging markets like Vietnam and India are also looking to diversify their trading partners through networks of economic and strategic agreements with other countries. Vietnam, which currently relies on China for over 30% of its imports, has entered into free trade agreements with other countries to diversify its trading partners. These agreements include the Comprehensive and Progressive Agreement for Trans-Pacific Partnership and the EU-Vietnam Free Trade Agreement. India has sought to reduce its reliance on China, its largest import partner, by forming a strategic alliance with the US through the Quad dialogue.

Sources: The Economist (2023); ISEAS (2021); CNBC (2010); World Bank (2021); Financial Times (2022); BBC News (2022).

Australia's alliances in the Indo Pacific have strengthened, creating international partnership opportunities for Australia's battery industries

Australia has the opportunity to build regional export partnerships with its geopolitical allies in the Indo Pacific region.

Since 2017, Australia has entered into five key economic, strategic and defence agreements in Asia-Pacific: Quad, AUKUS, IPEF, IA-CEPA, and ECTA.

Through the Quad and AUKUS, Australia can partner with India, Japan, the US and the UK to develop supply chain security. The Quad dialogue was re-established in 2017 to strengthen the strategic influence of Australia, India, Japan and the US in the Indo-Pacific, while the AUKUS alliance was formed in 2021 to deepen defence ties between Australia, the US and the UK. As these strategic alliances prioritise energy and supply chain security, Australia has a strong opportunity to form export partnerships with these countries, allowing Australia and its strategic allies to accelerate the development of their battery ecosystems.

Australia also has the opportunity to develop supply chain relationships with the Indo-Pacific nations of IPEF, including Indonesia, Japan, the US, India, South Korea, Malaysia, Thailand, and New Zealand. The agreement includes a focus on transparency, diversity, security and sustainability in supply chains, along with a focus on clean energy technologies, which could benefit Australia's efforts to develop trade relationships in the battery value chain.

Australia can leverage its recently formed free trade agreements with Indonesia and India to develop strong export partnerships. The Indonesia-Australia Comprehensive Economic Partnership Agreement (IA-CEPA) came into force in 2020. This agreement increases the proportion of Australian tariff-free exports from Australia to Indonesia from 85% to 99%.

As part of this agreement, Indonesia and Australia established Katalis, a government-backed business development program. Katalis is now exploring the potential for Australia and Indonesia to partner to develop globally competitive battery industries. Australia could build off IA-CEPA to develop a strong battery partnership with Indonesia. The Australia-India Economic Cooperation Agreement (ECTA) came into force in late 2022. This free trade agreement is part of a broader Cooperation Agreement between Australia and India. It eliminates tariffs on over 85% of Australian exports to India, and 96% of Indian exports to Australia. While ECTA can act as an important foundation for a strong Australia-India export partnership, India retains 15% tariffs on Australian lithium-ion battery imports, and 7.5% tariffs on lithium hydroxide and lithium carbonate. The removal of these tariffs could accelerate and strengthen an export partnership between Australia and India.

Exhibit 17: Key developments in Australia's alliances in the Indo Pacific since 2017

Year	Countries	Development
2017		The **Quad dialogue** is re-established to strengthen strategic partnership between Australia, US, India, and Japan.
2020		The **Indonesia-Australia Comprehensive Economic Partnership Agreement (IA-CEPA)** came into force.
2021		The **AUKUS alliance** formed between Australia, US and UK to promote defence cooperation between these countries.
2022		The **Indo-Pacific Economic Framework (IPEF)** was formed between Australia and 13 other nations.[1]
2022		The **Australia-India Economic Cooperation and Trade Agreement (ECTA)** came into force.

Notes: 1. The founding members of the IPEF were Australia, Brunei Darussalam, Fiji, India, Indonesia, Japan, Malaysia, New Zealand, the Phillipines, Singapore, South Korea, Thailand, the United States, and Vietnam.
Sources: Department of Foreign Affairs and Trade (2019, 2021, 2022a, 2022b, 2022c); The Guardian (2022); White House (2022); US Department of Commerce, (2022).

Recent geopolitical shifts in global battery industries have four key implications for Australian battery policy

1. Our window of opportunity to compete has narrowed.

The acceleration of global investment in battery industries means that Australia needs to pursue more substantial policy initiatives, faster.

2. We need to adopt more ambitious policy options to succeed.

As Australia's competitors increasingly adopt a stance of economic nationalism, we may need to adopt more ambitious industrial development policies to compete.

3. We need to target markets that are seeking to diversify their supply chains.

As an alternative source of battery or battery materials supply, Australia should focus on export opportunities in countries that are seeking new supply chain partners.

4. We need to partner with our geopolitical allies to grow our battery industries.

Australia should leverage its strong relationships with countries in Asia-Pacific, including US, India and Japan, to help develop its domestic battery capabilities.

03

Australia must leverage its comparative advantages of mineral diversity, supply chain reliability and high ESG standards to compete internationally

Australia must leverage its three comparative advantages to compete on cost or differentiation to capture the battery opportunity

Australia has three distinct sources of comparative advantage: having significant breadth and depth of critical mineral wealth, offering reliability and security as an export partner and having strong ESG credentials.

Australia has greater diversity and reserves of critical minerals than its global peers. It is the world's leading producer of lithium, and has reserves of lithium, cobalt and nickel ranking in the world's top three countries. Australia's mining wealth positions it to be a secure source of supply, enabling upstream integration and co-location opportunities which reduce operating and capital costs.

Australia's relative reliability and security makes it an attractive partner for countries wishing to diversify their supply chains. Internationally, Australian government institutions are perceived to be credible, effective and largely independent of political influences. In fact, Australia ranks in the top 10% of all nations by the World Bank's Government Effectiveness Index, above peers like the US and EU. Australia's reliability as a supply chain partner is also shown through its diversified access to global markets. Australia has extensive free trade agreement coverage, especially across the Indo Pacific. This makes Australia an appealing partner for allied countries wishing to 'friendshore' operations.

Australia also has the opportunity to use its strong ESG credentials to unlock export markets with ESG requirements. Australia's strong environmental standards are upheld through its commitment to rigorous environmental impact assessments such as the WA Government's environmental impact assessment and greenhouse gas emissions reporting. Additionally, Australian mining companies have increasingly been adopting renewable energy, with Oz Minerals' West Musgrave Nickel project having the largest renewable micro-grid in the world. Australian companies are also innovating to further reduce their carbon footprint and strengthen their ESG positioning. For example, EcoGraf and Pure Battery Technologies have innovative methods to produce low-carbon products. Australia also has world-leading social and governance practices, with enforced regulations such as the Fair Work Act, the Modern Slavery Act and the National Anti-Corruption Commission Act. Australia has an opportunity to accentuate this comparative advantage by working with its geoeconomic allies to develop secure supply chains which have strong end-to-end ESG credentials.

Exhibit 18: Australia's comparative advantages

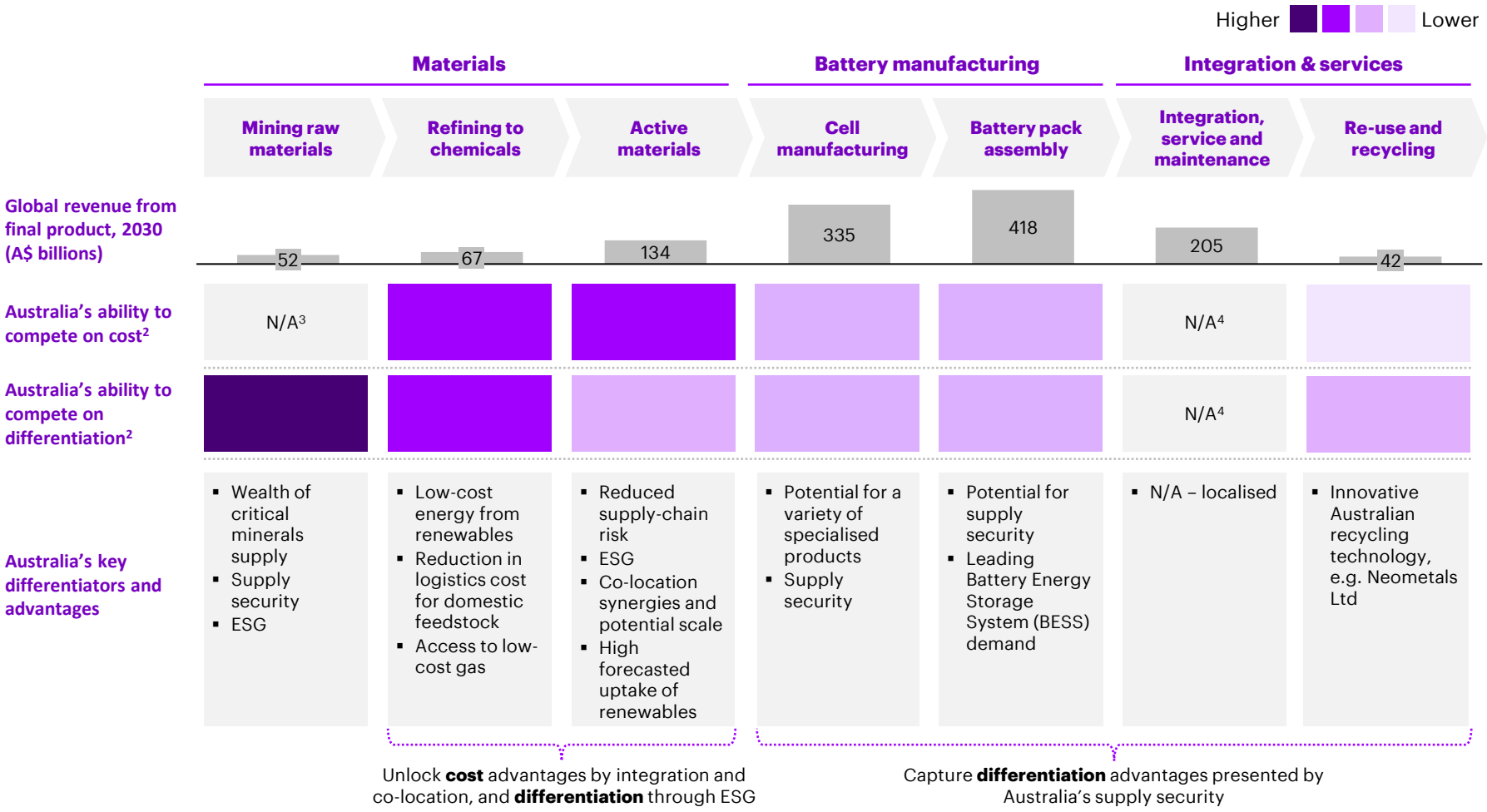
($) Cost opportunity Differentiation opportunity

Comparative advantages	Description	Impacts on Australia's ability to compete
Significant breadth of critical mineral wealth	Australia has **greater diversity of critical mineral wealth than its global peers**, with mineral potential due to moderate or large reserves of lithium, cobalt, nickel, copper and graphite, in addition to policy potential.	($) **Upstream integration and co-location** reduces operating and capital costs. **Enables security of supply,** particularly with active materials production which combines multiple refined materials.
Reliability and security	Australia's **effective governance and extensive free trade agreement coverage**, particularly in the Indo Pacific, makes it a reliable and secure export partner.	Ability to produce **battery products for export markets seeking supply chain diversification**, particularly in Asia.
ESG credentials	Australia's **strong environmental, social and governance standards**, along with forecast high renewable energy adoption compared to peers, enable Australia to create products that meet ESG requirements.	($) Enables **cost competitive access to markets with carbon pricing** (e.g., EU under the CBAM).[1] Unlocks **export markets that have ESG requirements**, especially for mined materials.

Notes: 1. CBAM refers to the Carbon Border Adjustment Mechanism.
Sources: U.S. Geological Survey (2022a, 2022b, 2022c, 2022d, 2022e); World Bank (2022); WA Government (2022); Renew Economy (2022); EcoGraf (2022); Pure Battery Technologies (2022); Safe Work Australia (2022); Australian Government (2018, 2022).

Australia has the greatest ability to compete on cost upstream, and has key sources of differentiation to compete across the value chain

Exhibit 19: Australia's ability to compete on cost and differentiation across the battery value chain[1]



Across the battery value chain, Australia's strategy to compete can be divided into two parts. Australia is cost competitive and differentiated in the upstream components of the value chain and can offer sources of differentiation from cell manufacturing onwards.

Australia's wealth of critical minerals is the key driver of upstream cost competitiveness, enabling firms to vertically integrate and co-locate adjacent value chain steps. The ownership and proximity enable firms to supply inputs at cost price, maximise operational synergies, and minimise additional costs, such logistics and recycling.

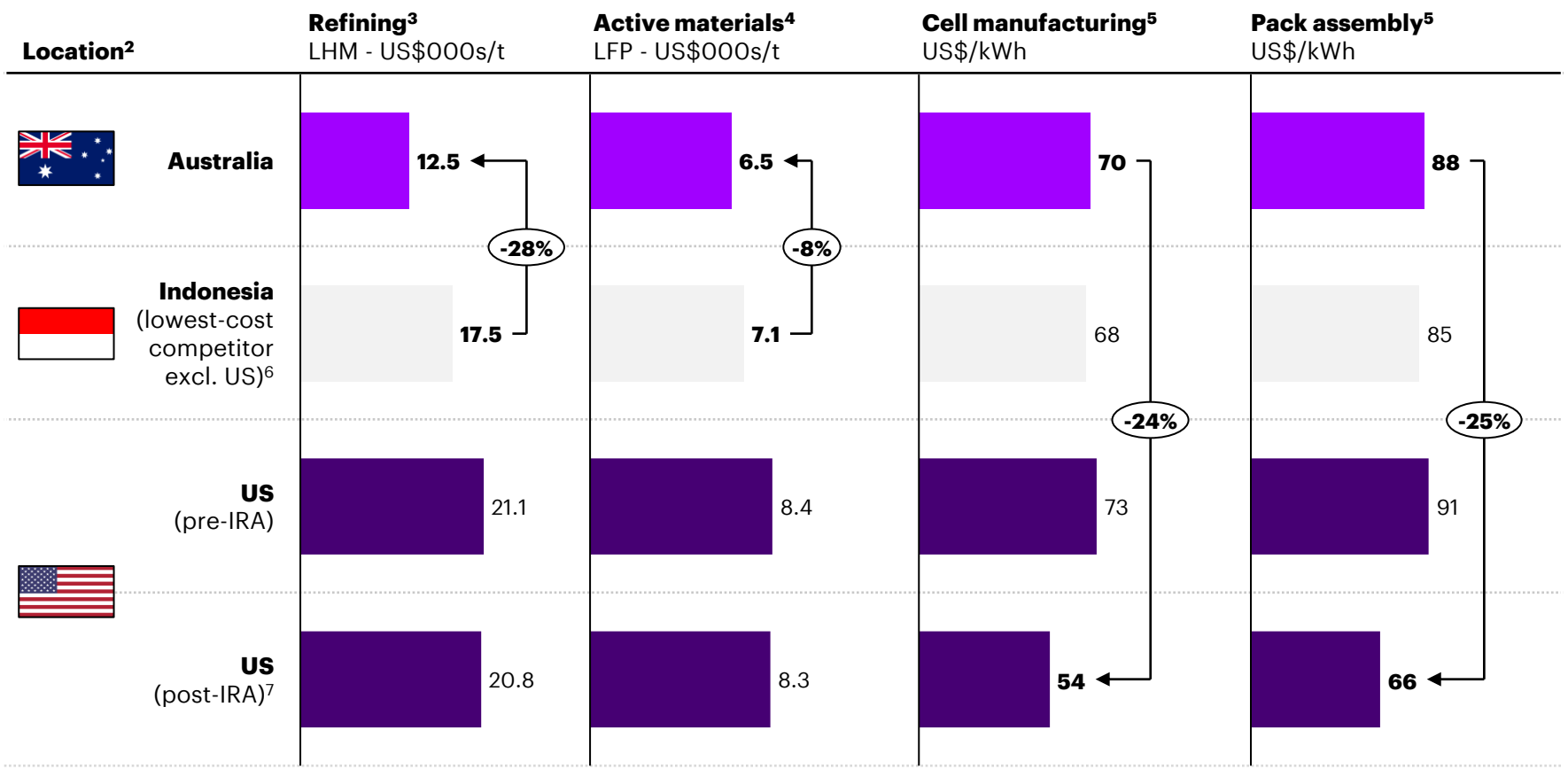
ESG and reliability also play a key role upstream, positioning Australia's products as a clean and secure alternative for countries wishing to diversify their supply chains. With multiple major economies looking to develop domestic manufacturing capabilities with high ESG standards and a diversified supply chain, Australia is well positioned to deliver cost comparable and differentiated raw, refined and active materials.

Australia's key downstream differentiator in cell manufacturing and battery pack manufacturing is its ability to offer secure supply into regional markets. This will be particularly relevant for nations with growing ESS demand, or growing EV manufacturing industries, that will require a reliable source of high-quality cells and packs.

Notes: 1. Australia's current capabilities in mining, refining, active materials and battery manufacturing are detailed in the appendix. 2. Ability to compete takes into account global subsidies. 3. Mining cost is deposit specific and cannot be directly compared on a country-to-country level. 4. Activities will be localised in Australia, so a competitive position is not applicable.

Australia can become cost competitive in refining and active materials if it unlocks cost advantages, but the IRA weakens competitiveness downstream

Exhibit 20: Potential production costs for refining, active materials, cell manufacturing and pack assembly if integration benefits are unlocked[1]



Australia could be globally cost competitive in refining and active materials due to its ability to integrate lithium mining and refining operations. Downstream, the IRA has reduced Australia's cost competitiveness in cell manufacturing and pack assembly.

Australia has the potential to be the cheapest producer of lithium hydroxide monohydrate (LHM) through upstream integration in the supply chain. Australian LHM refining is currently 12% more expensive than its lowest-cost competitor (Indonesia). However, Australia's abundant reserves of lithium allows it to integrate lithium mining and refining to become the lowest-cost global producer of LHM (28% cheaper than Indonesia). See Slide 31 for further detail.

While Australia's active materials capabilities are currently nascent, it has the potential to be the cheapest producer of lithium iron phosphate (LFP), being 6% cheaper than the next cheapest competitor (Indonesia).

Excluding IRA subsidies, Australia could be cost comparable to the lowest-cost manufacturers in cell manufacturing and pack assembly. The IRA significantly weakens Australia's cost position relative to the US, with a post-IRA cost differential of -24% in cell manufacturing and -25% in pack assembly.

Notes: 1. A detailed breakdown and analysis of potential production costs for LHM, LFP, cell manufacturing and pack assembly across eight competitor cities is in the appendix. 2. Cities used to evaluate cost position are Perth (refining), Brisbane (active materials, cells and packs), Jakarta (Indonesia) and Phoenix (US). More detailed breakdowns of production costs for several global cities are included in the appendix. 3. Australia is assumed to have integration in refining, meaning it can purchase domestic spodumene at cost, Other global producers are assumed to not have integration in refining as they are expected to remain as net importers of lithium in the future. 4. Lithium iron phosphate (LFP) is analysed here because it is forecast to be the dominant battery chemistry for ESS in 2030, while remaining an important chemistry for EV batteries in 2030. 5. Cell manufacturing and pack assembly are for modules for a 1 x 4 GWh/a LFP line. 6. Apart from Australia and US (post-IRA), we have identified Indonesia as the lowest-cost producer across LHM refining, LFP production, cell manufacturing and pack assembly. 7. Post-IRA costs assume that production attracts the maximum IRA subsidy.
Source: S&P Global Market Intelligence (2022); The Economist (2023); Wood Mackenzie (2020); Accenture analysis.

Despite our cost disadvantage, cell manufacturing should be a priority as it provides three valuable strategic benefits for Australia

Facilitates value chain development

Cell manufacturing helps foster growth in other parts of the value chain.

The impact of cell manufacturing on the value chain is illustrated by the influence of gigafactories on the dynamics of battery industries. More tier 1 cell manufacturers are looking to vertically integrate through upstream partnerships with material suppliers. This reduces supply chain risk and gives product certainty to their buyers.[1]

Cell manufacturing:

- Brings together **active materials** into an integrated product, creating local demand for upstream materials.
- Reduces the risk for **pack assembly** facilities of difficulty in obtaining cells,[2] and reduces the costs of transporting heavy and hazardous cells.
- Serves as a source of demand for **recycled** materials, and provides production scrap materials for recycling.[3]
- Provides a focal point for R&D.

Provides supply chain sovereignty

Domestic cell manufacturing will be critical to Australian-made battery packs.

The origin of the cell and active materials which go into the cell are an important factor in the **supply chain origins** of a battery pack, as is demonstrated by the local content rules for the EU and US.

Developing commercial cell manufacturing capabilities would enable Australia to produce locally made batteries. **This capability would give Australia greater national control** in meeting its battery demand for critical activities, such as storage requirements for the energy transition and defence.

Drives technology improvements

Cell manufacturing leads innovation in cells and active materials.

Cells are a **key determinant of battery performance**, as the cell quality impacts the pack life and durability. The relative importance of improvements in battery cell technology is demonstrated by the international focus on cell manufacturing innovation. There are almost double the number of patents for cells compared to the combined number of patents related to other battery developments.

Cell manufacturers also **dictate the specifications for active materials**, which are the other key primary determinant of battery performance.

Notes: 1. As illustrated by the upstream integration strategies of CATL, BYD, Northvolt and Verkor, the planned joint venture between Volkswagen's cell factories and Umicore, and downstream vertical integration with cell manufacturing for companies like BYD, Tesla and Northvolt. 2. Particularly given the expected global cell shortage from sources other than China. 3. Without production scrap, recycling will take longer to emerge due to the time delay in local batteries being ready for recycling.
Sources: Bridge & Faigen (2022); The White House (2022); IEA (2022); IPCEI (2022); Batteries Europe (2022); IEA (2022); Accenture analysis

Australia has significant reserves of all critical battery minerals, and is the global leader in lithium production

Australia has greater diversity of critical mineral wealth than its global peers, with large resources of lithium and nickel, and moderate resources of cobalt, copper, graphite and manganese.

This comparative advantage provides additional upstream security for battery supply chains.

Rival countries are limited in their production and/or reserves of critical minerals:

- **United States**: The US has begun to invest in lithium mining operations but does not currently produce a significant amount. The US also has low levels of reserves compared to Australia.
- **China**: China has world leading capabilities in production and reserves of critical minerals except for cobalt production, but offers a lower level of supply security.
- **Germany**: Germany has negligible levels of mining and resources.
- **Canada**: Canada has reserves in all critical minerals and does not mine lithium but has plans to commence lithium mining.
- **Chile**: Chile is a world leader in lithium mining and mining of non-battery metals, but does not have nickel, bauxite and graphite reserves. China also has reserves and mining of manganese.

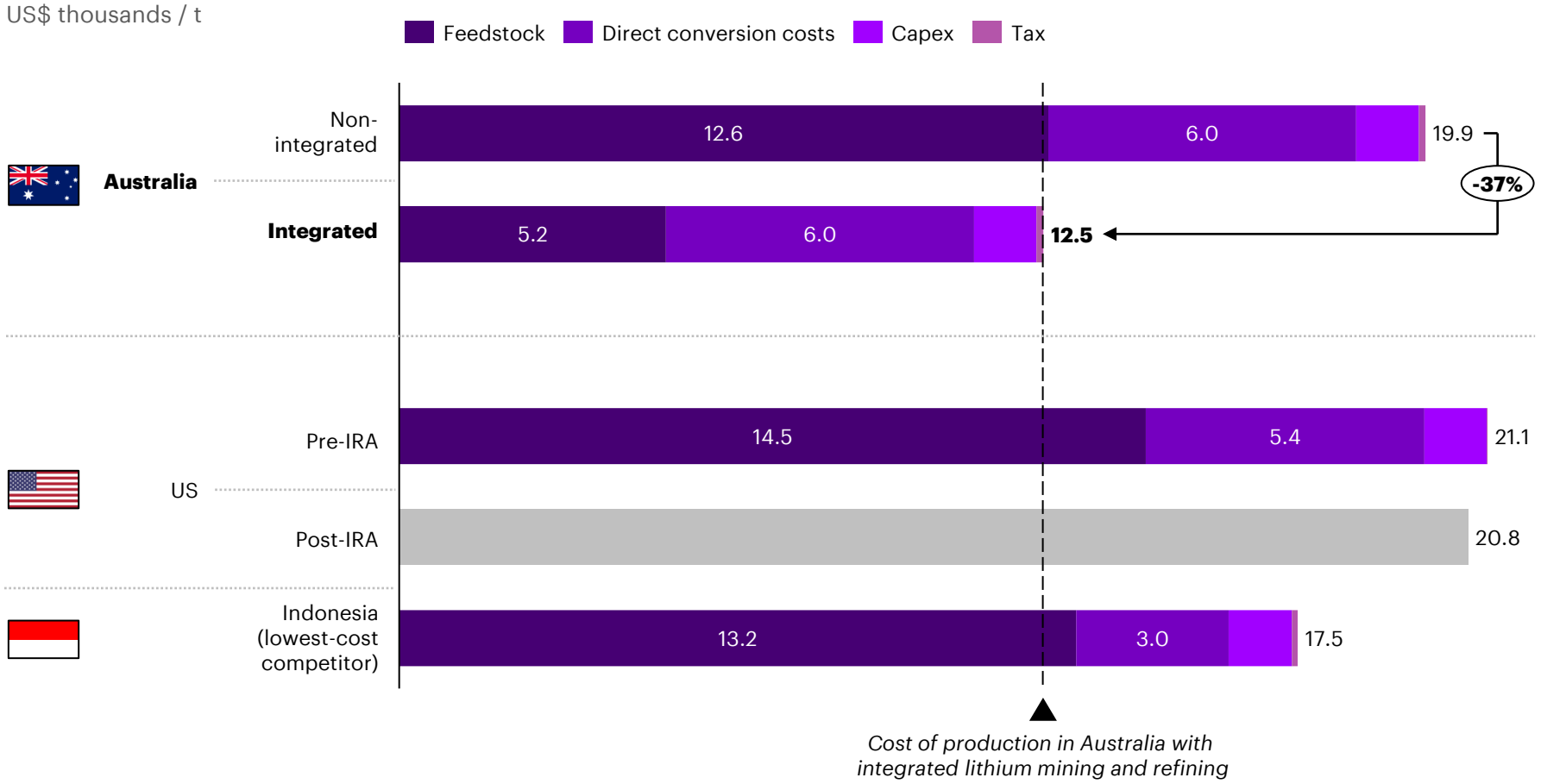
Exhibit 21: Comparison of leading mining countries by mineral production and reserves in 2021

Percentage of world total

Notes: 1. The total global percentage this has been calculated from excludes the USA's production of lithium in 2021. 2. USGS's latest data shows 'Other countries' as having 20 million worth of nickel reserves. The rankings for the US, China and Canada may be lower in actuality.
Sources: U.S. Geological Survey (2022a, 2022b, 2022c, 2022d, 2022e, 2022f); Geoscience Australia (2020); Medium (2022); CBC (2022); Government of Canada (2022a, 2022b).

Australia can leverage its critical mineral reserves to vertically integrate upstream, allowing Australian lithium refining to be globally cost competitive

Exhibit 22: Production costs for LHM[1]



Australia's breadth of critical mineral reserves creates the opportunity for domestic lithium refining costs to be reduced by 37% by vertically integrating mine production with lithium refining, making Australian lithium refining cost comparable with the cheapest producers in Asia.

With regards to lithium refining, Australia has a distinctive advantage in having large reserves of domestic critical minerals. The wealth of minerals provides the opportunity to vertically integrate, which would reduce refining costs by 37%. This advantage is not shared by competitors, which are expected to remain net importers of lithium in the future. Vertical integration would allow Australia to refine lithium at much lower cost than many of its peers, being 40% cheaper than Australia's lowest-cost competitor (Indonesia).

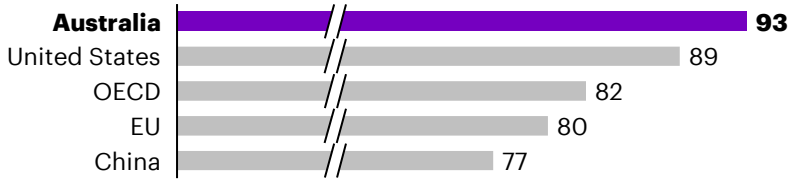
However, Australian lithium refining, which is not currently integrated with lithium mining, is not yet cost competitive. It is currently 12% more expensive to refine lithium to LHM in Australia than it is in the lowest-cost country (Indonesia).

Notes: 1. Materials for Australia are taken at cost rather than market prices. The specific energy consumption for spodumene decrepitation (SC6) is estimated by Albemarle to be 43 GJ/t. Perth's cheap domestic gas provides an advantage over regions reliant on imported gas and LNG – Europe, India, China. However, the competitive advantage may not be as significant in Asia if coal is used as fuel. This requires further analysis and has not been carried out in this report.
Source: Accenture analysis.

Australia's effective governance and preferential access to export markets offers reliability to customers looking to diversify their supply chains

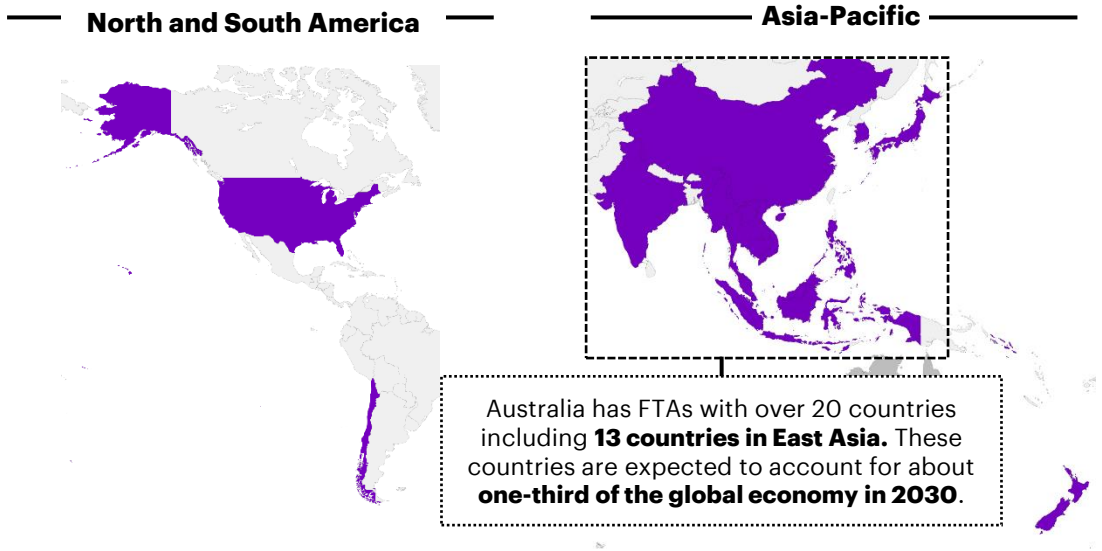
Exhibit 23: Government Effectiveness

Percentile,[1] 2021



This index measures perceptions of the **quality**, **independence** and **credibility** of policymaking and public services.

Exhibit 24: Australia's free trade agreement coverage



Australia has FTAs with over 20 countries including **13 countries in East Asia.** These countries are expected to account for about **one-third of the global economy in 2030**.

International perceptions of Australia as a secure and reliable trading partner creates an opportunity for Australia to target markets that are looking to diversify their supply chains.

Australia's strength as a reliable and secure supply chain alternative is reflected in perceptions of its effective governance and its preferential access to key export markets.

Australian government institutions are internationally perceived to be high-quality, credible and independent from political pressures. This is shown through Australia's top 10% ranking in the United Nation's Government Effectiveness Index. Australia ranks above many of its international peers, including the US, EU and China, making Australia an attractive export partner for countries seeking to diversify their supply chains away from a single dominant partner.

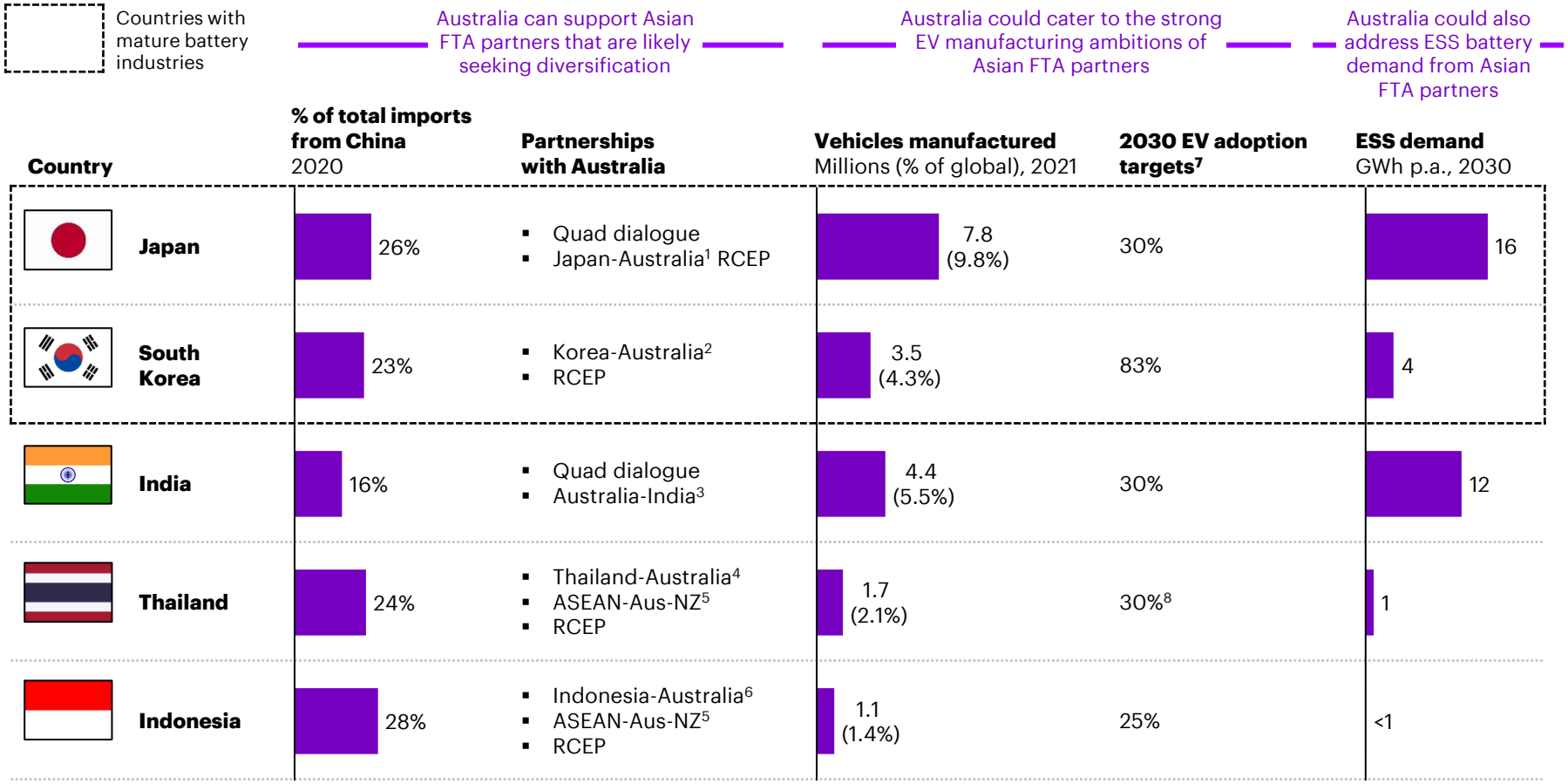
Australia can also leverage its extensive free trade agreement coverage to develop new export partnerships. Australia currently has diverse free trade agreements (FTA) with 29 countries, including key strategic partners in the Indo Pacific like the US, China, India and ASEAN. It has particularly strong coverage in Asia, covering 13 countries that are expected to account for about one-third of the global economy in 2030.

The diversity of Australia's strong economic relationships, which includes the two largest economies (the US and China), insulates Australia from supply chain concentration. Australia is less exposed to the risk of supply chain disruptions arising from individual country policy choices, company decisions or natural disasters. This presents an opportunity for Australia to position itself as a stable and attractive export partner for markets that are over-reliant on a single trading partner.

Notes: 1. Government effectiveness percentiles are based on the 209 countries with a Government Effectiveness Index score in 2021. OECD and EU percentiles are averages of member states.
Sources: World Bank (2021); ABC News (2022); Benchmark Mineral Intelligence (2022); Paultan (2022); Lowy Institute (2021, 2022); Department of Trade and Foreign Affairs (2023); International Energy Agency (2021); Accenture analysis.

Australia's reliability creates the opportunity to export batteries and materials to Asian FTA partners with growing demand for EVs and ESS

Exhibit 25: Key opportunities for Australia to export batteries or materials to Asia



Australia should focus on opportunities to export batteries or battery materials to Asian FTA partners who have demand for EV and ESS batteries.

Export opportunities for Australia include markets in Japan, South Korea, India, Thailand and Indonesia - all of which are heavily reliant on Chinese supplies and may be seeking diversification in trading relationships.[9]

Australia has FTAs with Japan, South Korea, India, Thailand and Indonesia, in addition to the Quad strategic relationship with Japan and India. These agreements and relationships could be utilised to develop a trading relationship for batteries or battery materials. The minimisation of tariffs on Australian products would also serve to improve Australia's cost competitiveness.

Japan and South Korea have mature battery manufacturing industries, which presents an opportunity for Australia to export battery components.

There is also an opportunity for Australia to supply batteries or battery materials to India, Thailand and Indonesia, and to service the demand for batteries which is not supplied by local production.

Note: 1. JAEPA. 2. KAFTA. 3. ECTA. 4. TAFTA. 5. AANZFTA. 6. IA-CEPA. 7. Targets for EV, passenger EV or light duty vehicle EV sales; 8. Target for light duty vehicle production. 9. India has aligned with the US through Quad, and has preferenced other countries over China in offtake agreements. Thailand has entered 15 FTAs to diversify trade partnerships, but its government aims to strengthen trade ties with China. Indonesia has entered 14 FTAs to diversify, but has received significant investment in the battery value chain from Chinese companies.
Source: DFAT (2022); Australian Government PMC (2022); OICA (2021); IEA (2022a, 2022b); AHK (2022); KPMG (2021); ITA US Department of Commerce (2022); Reuters (2022).

Australia is forecast to reach 82% renewable energy generation in 2030 and has strong ESG policies and regulation in mining

Australia's developing strengths in renewable energy generation and strong ESG credentials in mining gives Australia an advantage in producing green battery materials over its competitors.

By 2030, 82% of Australia's energy is forecast to come from renewable sources. This is significantly more than forecasts for the EU, China and US. Australian mines such as the Kathleen Valley lithium mine and Oz Minerals' West Musgrave nickel project are adopting renewable energy sources in the form of wind-solar battery storage and the world's largest renewable micro-grid respectively due to the low-cost nature of renewables. In addition, IGO's Nova Operation is adding 10MW of solar panels and 10MWH of battery storage to its existing 6.7MW solar farm.

Australia has leading ESG practices and policies. The carbon emissions from major facilities are regulated through the National Greenhouse and Energy Reporting Act, with many ASX200 and ASX100 companies also undertaking voluntary ESG reporting through the Task Force on Climate-related Financial Disclosures (TCFD) and Global Reporting Initiative (GRI) standards. Australian mining also has many Social and Governance policies, including the Modern Slavery Act, Safe Work Australia and ASX Corporate Governance Council Principles and Recommendations.

Australia is relatively strong in social and governance compared to China (which has had low-quality ESG reporting) and Chile (who does not have mandatory ESG reporting requirements).

Australia could utilise its ESG credentials to produce green battery materials. There is growing demand for battery materials that are produced with lower emissions, and that have have a responsible and sustainable impact on biodiversity, local water supplies, and communities, which Australian mining could cater to.

Exhibit 26: Renewable energy generation forecast for 2030

Renewable energy as a % of total energy generation

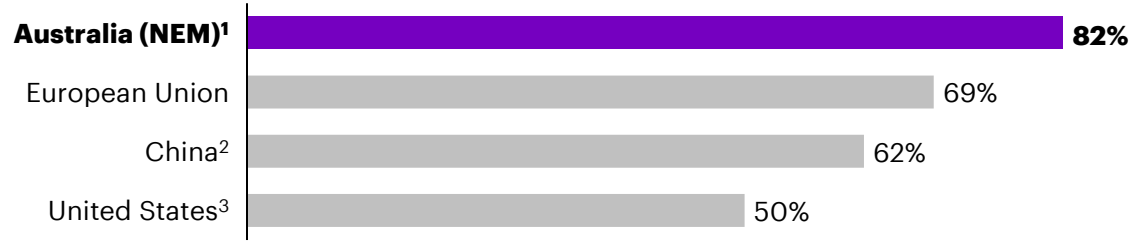


Exhibit 27: ESG performance in mining[4]

High Low

Category	Sub-category	Australia	China	Chile
Environmental	Environmental impact assessments			
	GHG emissions reporting			
	Water management			
Social	Workers' rights and labour law			
	Human rights			
	Traditional ownership		N/A	
Governance	Ethics and transparency standards			
	Anti-bribery and corruption standards			

Notes: 1. 82% renewable penetration in the NEM is consistent with AEMO's Step Change scenario, which has been identified as the most likely future for the NEM. 2. The 2030 forecast for China has applied the low-cost renewables scenario from CarbonBrief (2022), alongside expectations that it will comfortably reach its 2025 target of 33%. 3. 50% is the upper bound scenario for EIA and FERC's forecasts. The lower bound is 33% in 2030. 4. Green refers to the policy being in place and enforced. Yellow refers to the policy being in place but improperly enforced. Red refers to either the policy not being in place, or that severe issues occur. A detailed assessment is in the appendix.
Sources: Clean Energy Council (2022a, 2022b); Climate Council (2022); DISER data (2021); US EIA (2022); Renewables Now (2021); S&P Global (2022); AEMO (2022); Canada Energy Regulator (2021); Enerdata (2022); Clean Energy Wire (2022); Fraunhofer ISE (2022); ICLG (2023a, 2023b); Mondaq (2022); Renew Economy (2022a, 2022b); Minerals Council of Australia (2022), IGO, (2022); IEA, (2021).

Australia's strong environmental credentials provide an advantage in selling to ESG-sensitive customers

Battery chemicals sourced in Australia have a lower environmental impact than in competing jurisdictions. This could provide Australia with an advantage under the EU's Carbon Border Adjustment Mechanism (CBAM).

Up to 77% of CO_2e emissions in a nickel-based battery supply chain occur upstream of battery manufacturing[1], coming from the mining and refining of materials, and the manufacturing to active materials; areas of the value-chain where Australia is well positioned to be carbon competitive.

Australian production of lithium and nickel has a low environmental impact by global standards.

Australian lithium mining avoids some of the environmental concerns associated with lithium mining in competitor countries. For example, lithium brine operations in Chile carry the risk of permanently lowering the local water table. While Australian lithium mining is potentially more energy intensive than in competitor countries, recent large-scale investments in renewable energy presents a pathway for Australian miners to reduce their carbon intensity.

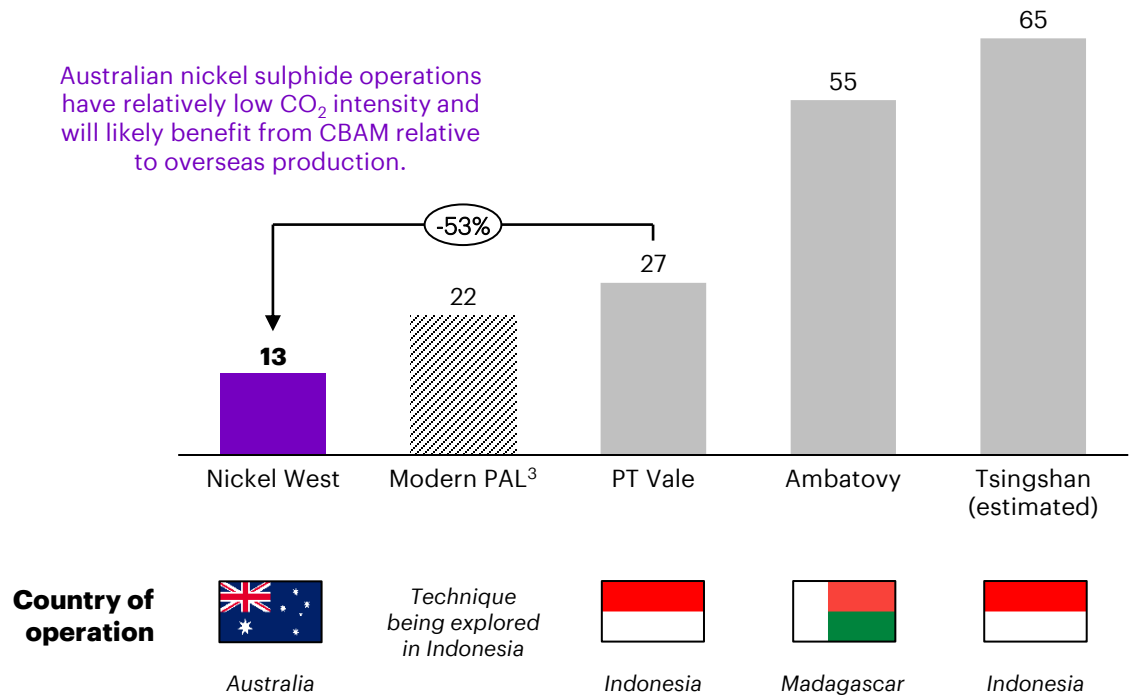
Australian nickel operations produce nickel at a lower environmental impact than competitors. For example, the carbon intensity of Nickel West (Australia) is less than half that of large producers in Indonesia (including PT Vale and Tsingshan) and Madagascar (Ambatovy). Modern pressure acid leaching (PAL) techniques are being explored in Indonesia and possibly will in Australia in the future. Modern PAL techniques also have a relatively low carbon intensity by international standards.

Australian nickel operations also avoid other significant environmental impacts that are present in competitor countries. Most Indonesian nickel operations have significant impacts on habitats, biodiversity loss and tailings management. Tailings management challenges are also encountered in Madagascar.

Australia's low-carbon production of nickel products is expected to provide a cost advantage when exporting to the EU under the CBAM. The CBAM requires companies from non-EU and non-European Free Trade Association (EFTA) countries will be required to purchase 'CBAM certificates' to pay the difference between the carbon price paid in the country of production and the price of carbon allowances in the EU Emissions Trading Scheme (ETS). As the EU Parliament aims to include all ETS products into the CBAM by 2030, including metals such as nickel, Australia may have a cost advantage over its competitors when exporting nickel into the EU.

Exhibit 28: CO_2 intensity of Class 1 and laterite-based matte nickel production[2]

kg CO_2-e / kg Ni



Notes: 1. Further detail in appendix, slide 64 2. Nickel laterite production costs are detailed in the appendix. 3. PAL refers to 'pressure acid leaching'. The carbon intensity of nickel production through PAL can be closer to 15kg/t Ni if renewable and / or waste heat power, low limestone use, and high grades combine. Currently, new PAL projects in Indonesia (the largest nickel producer globally) are expected to use coal-based power bought across the fence.
Sources: Eurometaux (2022); EU Parliament (2022); European Commission (2022); Argus (2022); Politico (2022); Carbon Chain (2022); Deloitte (2022); KPMG (2022); CNBC (2022); NRDC (2022); IUCN (2022); Accenture analysis.

Australia could focus on targeting domestic demand for ESS, which will cumulatively amount to 55-65 GWh by 2030

Domestic stationary storage battery demand could be supported with the production of cells and packs in Australia.

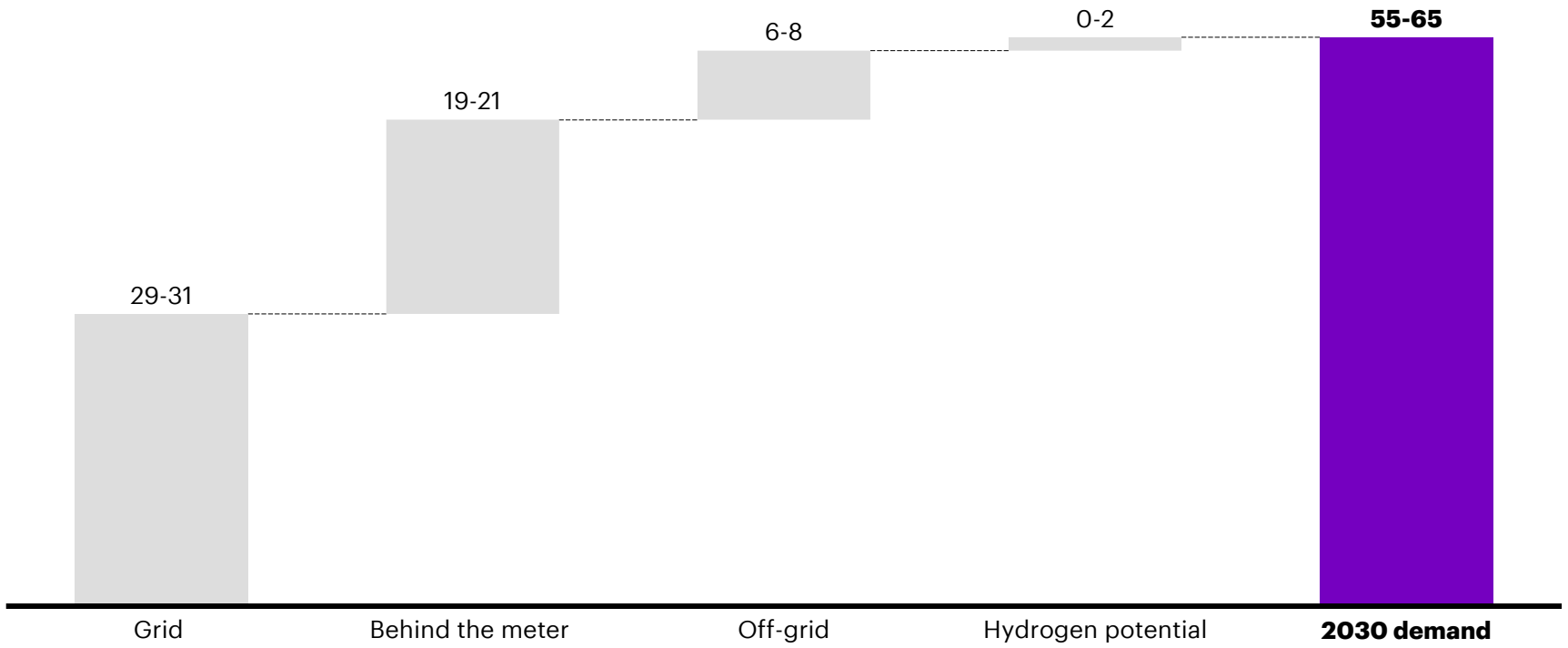
Australia has the opportunity to cater to domestic demand for stationary storage through battery manufacturing. In total, Australia will require 55-65GWh of battery storage between 2023 and 2030. The majority of Australia's stationary storage requirements are for grid storage (approximately 40% of demand), but there will also be domestic demand for behind the meter and off-grid storage. There may also be demand for batteries to support the production of green hydrogen.[3]

Policy intervention could support the domestic production of batteries for Australian stationary storage demand. In particular, procurement policies for grid storage could assist with the development of domestic battery manufacturing capabilities. Other consumer focused initiatives may serve to provide incentives to purchase domestically produced batteries.

Whilst innovation will lead to changes in battery chemistry in the next 10 years, there is likely to be a role for LFP batteries and flow batteries to support demand for grid storage, and for LFP batteries to support behind the meter storage demand. Australia could develop its capabilities in battery manufacturing, including for flow batteries, to target domestic stationary storage demand.

Exhibit 29: Cumulative demand for ESS in Australia, 2023-2030[1,2]

Total storage capacity required, GWh



Notes: 1. Domestic demand includes East Coast demand, which is based on the AEMO Step Change scenario. 2. Demand up to the end of the 2029-30 financial year is included. 3. Batteries used for short term smoothing of renewable output.
Sources: Wood Mackenzie (2020); Wood Mackenzie (2022); Renew Economy (2022); Energy Storage News (2022); SolarRun (2022); Department of Energy and Public Works (2022); AEMO WEM Electricity Statement of Opportunities (2022); AEMO Distributed Energy Resources Roadmap (2022); Renew Economy (2022); Expert interviews and Accenture analysis.

Lithium-ion is expected to stay the dominant technology in ESS, but flow batteries are an emerging technology where Australia may have an advantage

Exhibit 30: Alternative ESS technologies

	Description	Expected demand in global ESS market, 2030[1] (GWh, market share)	Australia's relative[2] strength in technology (High – Low)
Lithium-ion	Primary technology used globally for scale production of batteries in ESS applications, using NMC, NMA and LFP[1] chemistries.	270 (90%)	**Materials:** Significant advantage, with leading production and reserves of multiple critical minerals for Lithium-ion batteries. **Capabilities:** Emerging, such as Recharge Industries planned 6GWh production facility, Feline, Bardan Cells, Pure Battery Technologies, VSPC, and others.
Flow Batteries[3]	Emerging technology used specifically for longer duration storage, with battery life typically anticipated to be 25 years.	12 (4%)	**Materials:** Advantage, with world leading vanadium reserves. **Capabilities:** Emerging, such as Vecco Group plans for 100MWh per annum of vanadium electrolyte production, ESI Asia Pacific's plans to manufacture iron redox flow batteries in Maryborough Queensland, activities from Australian Vanadium, Technology Metals Australia, and Ultra Energy, and the field deployment of VSUN and Ultra Energy vanadium redox flow batteries at the IGO Nova Operation.
Sodium-ion	Similar features to lithium-ion batteries, but with improved temperature tolerance and safety features; currently suited for applications that prioritise power density.	6 (2%)	**Materials:** Some material advantages for cathode materials such as nickel.[3] **Capabilities:** Some emerging, such as Zero Emissions Development's (ZED) production of a sodium-ion battery in Queensland, along with research and a planned pilot production line at Deakin University's BatTRI-Hub.
Sodium-sulphur	Molten-salt battery, with high energy density and suitability for longer duration storage. Developed with inexpensive and non-toxic materials.	<6 (<2%)	**Materials:** No distinct material advantage because sodium and sulphur are globally abundant. **Capabilities:** Emerging, including R&D at the University of Sydney which is focused on reducing the cost of Na-S technology, along with a BASF & QUT pilot deployment project, and the field deployment of a BASF battery at the IGO Nova Operation.

Notes: 1. The market shares for some alternate technologies increase by ~1-2% by 2035, but 2030 has been used for consistency with other time periods used in the report. 2. Relative to alternate technology opportunities within Australia. Capabilities are based of publicly available information and are not exhaustive. 3. Vanadium redox flow batteries are explored in more detail in the appendix. 4. However, Australia does not have a distinct material advantage for sodium, as it is readily available globally.
Sources: Clean Energy Institute (2022); Yadlamalaka Energy (2022); Sacramento Municipal Utility District (2022); USA Department of Energy (2022); Vena Energy Australia (2022); Energy Storage News (2022); Graphene Manufacturing Group (2022); Century Batteries (2022); Vecco Group (2022); The Faraday Institution (2020a, 2020b, 2021); Li-S Energy (2022); The Market Herald (2022); NGK (2022); BASF (2020); Schmidt et al., (2019); Schmidt (2017); Wood Mackenzie (2022); University of Sydney (2022); Business Wire (2023); Printed Energy (2022); UQ (2020); FBICRC (2020); ESI-AP (2020); U.S. Geological Survey (2022a, 2022b, 2022c); Institute for Frontier Materials, (2018, 2022); IGO (2022).

Emerging technologies, particularly flow batteries, present an opportunity for Australia.

Lithium-ion has 90% of the ESS market, and it is expected lithium ion will be the predominant technology in 2030. Australia has 26% of global lithium reserves, which could be utilised to provide lithium hydroxide for domestic manufacturing of electrolytes, active materials and batteries.

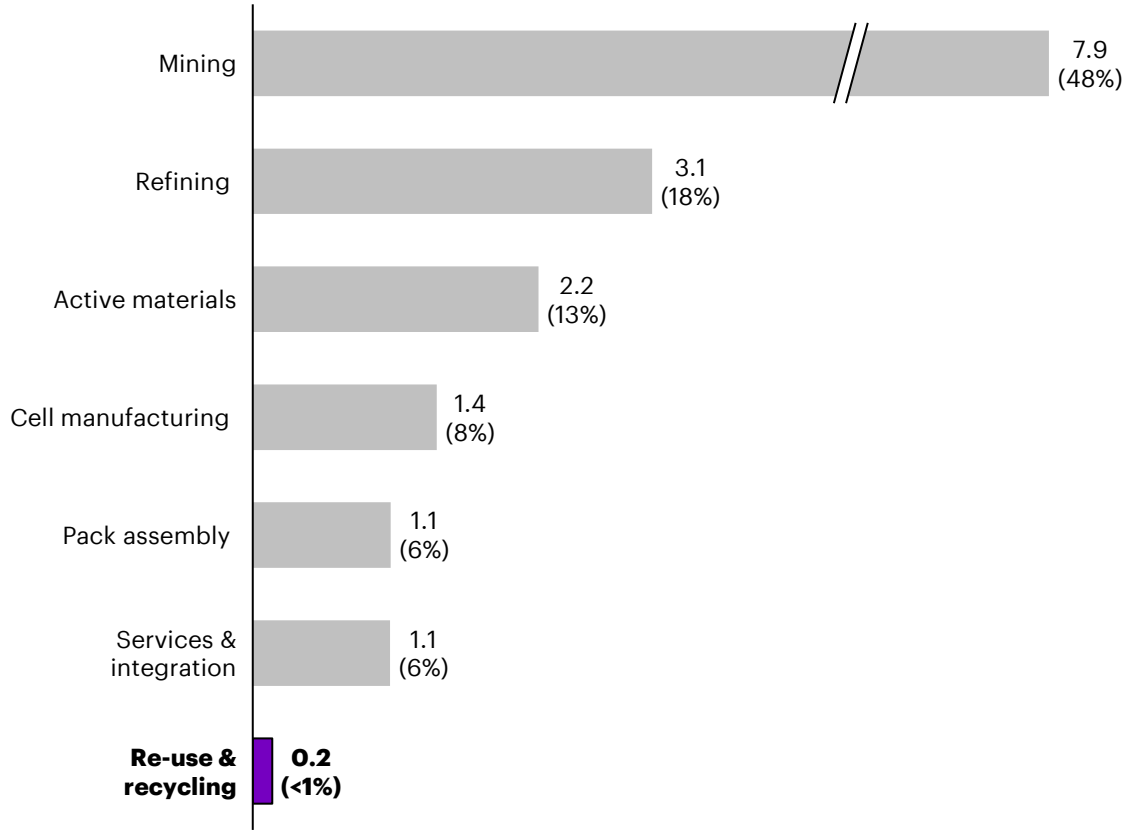
Redox flow batteries are also gaining market share, and are expected to be increasingly used for stationary storage. Australia has a raw material advantage for vanadium redox flow batteries, which could be used to provide supply chain security and reduce logistics costs for midstream and downstream capabilities. Given that Australia has 25-30% of global vanadium reserves, domestic vanadium electrolyte production could utilise local sources of raw material.

There are other alternative technologies which may have increases in commercial adoption for stationary storage applications in the next decade. Sodium-ion and sodium-sulphur have the potential to be a lower cost alternative to lithium-ion. Australian researchers have completed promising work looking into both sodium-ion and sodium-sulphur battery technologies, and Australia may have an advantage in sodium-ion due to resource wealth.

Recycling is a limited opportunity for Australia in the short term, but will be more attractive as domestic battery feedstock volumes increase over time

Exhibit 31: Projected GVA of Australia's battery industries under a diversified industries scenario, 2030

A$ billions (% of value chain)



As battery recycling relies on end-of-life batteries as feedstock, growth in Australia's battery re-use and recycling industries will naturally lag growth in production and adoption. As such, the Australian recycling opportunity is limited in the short term, but larger as more batteries reach end-of-life.

Australia's battery re-use and recycling opportunities are expected to be limited in the short term, with the segment expected to account for only A$200 million in GVA, or less than 1% of the GVA of the domestic chain in 2030.

In the next decade, most battery recycling will be dependent on waste feedstocks from cell manufacturing facilities, in addition to some recycling from end-of-life batteries. Given that Australia is expected to have limited cell manufacturing, Australia's battery recycling will largely depend on end-of-life batteries for feedstock. While the lifespan of a battery depends on its chemistry, typical lithium-ion battery lifespans can exceed 10 years for both ESS and EV applications. This means that the development of a strong domestic recycling industry could lag widespread domestic battery adoption by over a decade.

However, with strong domestic demand expected over the next few years, Australia's battery recycling market is expected to be much more developed by mid-2030s. Strong domestic demand is driven by both ESS and EV applications.

Australia is expected to demand about 55-65GWh of ESS capacity cumulatively from 2023 to 2030, with about half of this capacity coming from grid-scale batteries. Australian EV battery demand is expected to grow sharply over the next decade, with around 3 million EVs expected to be on our roads by 2030.[1] This strong projected demand over the next decade is likely to drive investment and growth in Australia's re-use and recycling markets in the medium-term, from the mid-2030s and beyond.

Policies to support repair, reuse and recycling, including right-to-repair for EV and ESS, and limiting the export of battery wastes in accordance with the Basel convention should be considered to support EV owners and develop an internal circular economy.

Notes: 1. Electric vehicle forecasts under AEMO Step Change scenario.
Sources: CSIRO (2022); Wood Mackenzie (2022); Accenture analysis.

04

To build diversified battery industries, fast and comprehensive action from government is required

To develop strong end-to-end capabilities in the battery value chain, Australia will need to focus on leveraging its upstream strengths

Australia should focus on supporting active materials and cell manufacturing as these will be the most challenging segments to develop domestic capabilities.

Australia's overall priority (in Exhibit 32) reflects the existing strengths in mining, and the challenge that industries face in developing midstream and downstream capabilities, particularly in active materials and cell manufacturing.

Australia has critical mineral resource wealth and is already an effective mining nation. Australia has competitive advantages for refining which indicate only moderate support is necessary.

Australia has lower levels of comparative advantage in cell manufacturing and active materials, but both have significant economic and strategic value. These segments support jobs and industrial complexity, and should be prioritised by government. For both segments, attracting an established leader with access to markets is essential to delivering at pace.

Pack assembly requires less prioritisation from government, as it will naturally develop alongside cell manufacturing capability.

Recycling is currently a low priority, as it has limited short-medium term value for Australia. As recycling volumes increase in Australia in future, there is likely to be a greater opportunity to develop the segment.

Exhibit 32: Strategic priorities, by value chain segment

Level of focus Higher ■ ■ ■ ■ Lower

Overall priority:	**Australia should aim to leverage its upstream strengths in mining to establish strong mid and downstream capabilities in refining, active materials, and battery manufacturing**					
	Mining	**Refining**	**Active Materials**	**Cell Manufacturing**	**Pack Assembly**	**Recycling**
Segment priority:	**Expedite exploration and development of critical raw material wealth**	**Leverage mining strength to continue building refining capabilities in high-value products**	**Attract and build leading capability at pace, leveraging upstream activity to maximise co - location and integration value**	**Attract and build leading capability at pace, leveraging upstream strength, supply security and regional partnerships**	**Leverage cell manufacturing attraction to build capability, and support innovative domestic companies**	**Implement relevant policies to promote recycling uptake**
	▪ Focus on lithium, nickel, cobalt, aluminum, graphite, vanadium, manganese ▪ Support indigenous engagement, approvals, time to market	▪ Potential focus on biggest, most attractive markets: lithium hydroxide, lithium carbonate, nickel sulphate, cobalt sulphate, HPA, manganese sulphate	▪ Attract lighthouse tenant leveraging refinery capacity ▪ Focus could include NCM, NCA leveraging lithium hydroxide strength and LFP using lithium carbonate ▪ Build partnerships to accelerate the technology transfer and build capability at speed	▪ Attract lighthouse tenant leveraging supply security and partnerships with ASEAN nations ▪ Continue to support attractive domestic emerging technologies e.g. VRFB, iron flow, LiS, ZnBr, Al graphene cells	▪ Pack assembly will naturally flow from attraction of cell manufacturing capability	▪ Limited medium-term focus given small magnitude of opportunity ▪ Develop policies that enable recycling to develop naturally alongside the rest of the value chain

Policy action is needed to enable industries to address trade protection, access key inputs, and to support value chain coordination

Exhibit 33: Enablers and challenges by value chain segment

Access to key inputs

Enablers	Description	Challenges for industry: Mining raw materials	Refining to chemicals	Active materials	Cell manufacturing	Battery pack assembly	Re-use and recycling
Overcome trade protection	Relative attractiveness of investing in Australia			Significant industrial development policy measures in competing jurisdictions limit the relative attractiveness of Australia.			
Access to capital	The ability of firms to access sufficient volumes of capital	Small Australian companies engaged in critical minerals mining, refining, active materials and cell manufacturing have generally have limited access to capital.					
Access to technology	Firms ease of access to the technology and IP required to develop the segment		Significant technology investment is required for active materials and some refining activities, and technology transfer is needed for cell manufacturing.				
Access to a large customer base	The ability of firms to access and secure large scale customers	There are limited domestic options for scale offtake.		Australia has a limited customer base with no domestic scale OEMs, limiting the domestic demand for active materials, cell manufacturing and pack assembly.			
Access to feedstock	The ease with which firms can access key production feedstock and coordinate relationships with suppliers		The lack of domestic feedstock available to Australian refiners limits the ability of subsequent value chain steps to source domestic supply. This exposes domestic firms to high import costs and supply risk.				
Access to a skilled workforce	The availability of skilled employees and access to workforce training facilities		There is limited availability of talent across refining, active materials and cell manufacturing due to specialised talent requirements, international competition and in some segments, high talent costs.				
Coordination support	Firms' ability to access coordinated and centralised support	There is a lack of coordination across the value chain, with fragmented public and private sector efforts to develop parts of the value chain and to encourage firms to develop domestic feedstock supply relationships with each other. Mining faces challenges relating to land use, environmental approvals and indigenous participation.					

Notes: Challenges for industry are detailed in the appendix.

Six policy strategies are required to build global-scale, internationally competitive battery industries in Australia at speed and scale

Builds industry at speed and scale

Domestic industry focus

Policy strategies	Enablers supported	Key interventions	Targeted segments (Higher ■■■■ Lower)
1. Alliances and incentives	• Overcoming trade protection	Subsidies and/or tax incentives for domestic producers, with local content conditions	
2. Industry attraction	• Access to capital • Access to technology • Access to a large customer base • Access to skilled workforce	Identify international producers to attract as lighthouse tenants	
		Offer targeted firms a globally competitive and low-risk investment pathway (with incentives like industrial development pre-approvals and offers of supply chain security)	
		Establish syndicated finance facilities with foreign governments in exchange for supply guarantees	
3. Industry coordination	• Access to feedstock • Access to coordination support	Establish an industry co-ordination body that connects supply chain stakeholders	
		Develop battery hubs to facilitate industry co-location, and develop shared infrastructure for hubs	
		Introduce incentives for producers to trade with domestic supply chain partners	
4. Regional export partnerships	• Overcoming trade protection • Access to a large customer base	Establish strategic relationships with key regional trade partners	
		Re-negotiate bilateral trade agreements with regional trade partners	
		Provide support for Australian businesses to enter export markets	
		Facilitate partnerships between Australian and foreign companies for project development	
5. Increase domestic demand	• Access to a large customer base	Adopt government procurement policies for Australian-made batteries	
		Incentivise domestic businesses and consumers to purchase Australian-made batteries	
6. Specialist battery institute	• Access to capital • Access to technology • Access to skilled workforce	Develop common use R&D and prototyping facilities	
		Develop a training facility to grow specialised workforce capabilities	
		Facilitate industry-academia collaboration	

Alliances and incentives will level the playing field for Australia with other jurisdictions as an attractive location for investment in battery industries

What are alliances and incentives?

Alliances and incentives are the bilateral relationships with, and alignment of Australia's policy support measures to, other major global jurisdictions in the battery industry.

Its purpose is to level the playing field, make battery value chain investment in Australia equally as attractive as in other nations.

Why are alliances and incentives needed?

For Australia to attract and retain mid- and downstream battery value chain investment, commensurate policy measures from government are likely required.

Australia has been made a relatively less competitive location for investment due to the incentives being offered in other global jurisdictions, particularly in battery manufacturing. Notable global incentive measures include the US's IRA and India's Production Linked Incentives.

These incentives have had a sizeable impact on business decisions about where to invest and operate. For example, in the three months after the IRA was enacted, companies committed about US$13.5 billion worth of battery investments, compared to US$7.5 billion in the previous three-month period.

The IRA has also already drawn investment away from competitors like the EU. Northvolt (a European battery manufacturer) has reportedly put on hold plans to establish a manufacturing plant in Germany as it considers redirecting its investments to the US to capture IRA incentives.

How could alliances and incentives work in Australia?

Design considerations should emulate equivalent policies from global peers

Seek concessions from international allies: Where Australia's international allies have applied industry support measures (e.g., the US IRA), Australia should seek concessions to ensure that all firms from allied countries can compete on a level playing field.

The size of incentives should be competitive with those used overseas: Australian incentives should be sufficient and comprehensive, so as to be competitive with overseas offers such as the IRA subsidy of US$45/kWh for cell and module manufacturing.

Target key segments, particularly cell manufacturing: Alliances and incentives will need to focus on cell manufacturing, as this segment is the priority target for competing governments' support packages. However, support for active materials and refining is also needed.

Apply appropriate delivery mechanisms, like tax offsets or subsidies: Tax offsets or production subsidies are likely to be the most effective mechanisms, and are commensurate to strategies implemented by other jurisdictions such as the US (IRA) and India (Production Linked Incentives).

Consider using local content conditions: Local content conditions should be placed on the incentives to ensure the development of a domestic ecosystem. A staged 'ramp-up' of local content targets could be used to enable low initial barriers to entry, but ensuring that domestic supply is increasingly used over time. For example, a condition could require a manufacturer to source 20% of inputs from domestic suppliers, ramping up to 40% after 5 years of production to maintain the subsidy.

Sources: Financial Times (2022); The Economist (2023); India Ministry of Heavy Industries (2022).

Industry attraction policies that attract lighthouse tenants for active materials and cell manufacturing would develop Australia's capabilities

What is industry attraction?

Industry attraction is a selection of policies and financial incentives designed to attract players for industry development. In the Australian battery value chain, industry attraction would support Australian refining capabilities, and lighthouse tenants in active materials and battery manufacturing.

Financial incentives for industry attraction could take the form of debt, equity, grant and syndicated financing.

Why are industry attraction measures needed?

Australia requires industry attraction to develop capabilities at pace. By attracting established international producers and supporting world-scale projects, Australia can overcome barriers to entry such as access to technology, markets and expertise.

Targeted attraction is the most common way that national governments have built their industries. For Australia to capture the market, it is likely that it will need to adopt similar measures. Australia should act at pace as the industry is rapidly consolidating, and efforts are being made by global players to secure market share. Australia needs scale to be globally cost competitive, and to have an established customer base with suppliers.

Where possible, attraction policies should encourage joint ventures between foreign and local companies. Local companies, with construction experience in Australia can assist foreign entrants limit construction risk.

How could Australia's industry attraction policies work?

Industry attraction can be delivered through three policies

A more detailed discussion of global industry attraction incentives is in the appendix.

Identify strategic international producers to attract to Australia as 'lighthouse tenants': Austrade's Global Business and Talent Acquisition Team, in collaboration with a battery industries coordination body, could identify established international producers to target with industry attraction measures. Targeted producers would likely operate in the active materials or cell manufacturing segments, where Australia's battery industries requires the most support to deliver at pace.

Offer targeted firms a globally competitive and low-risk investment pathway: Australian governments should provide highly competitive and curated incentives to targeted firms to attract their investment. These incentives could include free land in pre-approved industrial precincts, offers of supply chain security, significant financial incentives (e.g., loans, grants or equity financing) or government-facilitated procurement. Incentives could be conditional on local content and local sales requirements, similar to those employed in the *US Defence Production Act*.

Establish syndicated finance facilities with allied governments for battery projects: The Clean Energy Finance Corporation (CEFC), National Reconstruction Fund (NRF) or EFA (Export Finance Australia) could establish syndicated finance arrangements for Australian battery projects with an allied government in exchange for supply guarantees of Australia's critical minerals, refined chemicals and cells. Facilitated approvals during the financing process can allow projects to receive financing faster. These syndicated finance facilities could, for example, be used to accelerate the rate of mining development to alleviate the expected critical minerals shortage.

Sources: Queensland Government (2022); Invest & Trade Western Australia (2023); SMM (2022); ARENA (2023); MMI (2020); CEFC (2023).

Industry coordination policies will help Australia's battery supply chain to develop strong end-to-end industry capabilities

What are industry coordination policies?

Industry coordination policies are measures to grow end-to-end industry capabilities by orchestrating effort across the whole supply chain.

These policies strengthen interfaces between organisations that operate within different segments of the Australian battery value chain.

Why are industry coordination policies needed?

Australia's battery industries will deliver the greatest value when the battery value chain is secure and coherent. However, value is currently lost from Australia's battery industries due to weak interfaces between value chain segments.

For example, the development of Australia's lithium refining industry has been stymied by a lack of available domestic feedstock, with much of Australia's domestic feedstock being reserved for exports through offtake agreements. This disconnect between the Australian mining and refining industries highlights the need for industry coordination policies that addresses cross-segment supply chain issues.

Industry coordination policies are also needed to orchestrate national efforts to develop battery industries. While there are currently public and private sector efforts to grow Australia's battery industries, these efforts are fragmented.

Effective industry coordination can be achieved through the use of industry 'hubs' or clusters'. These hubs facilitate co-location of firms and researchers from across the value chain. This accelerates the development of the entire battery industries ecosystem by facilitating access to shared infrastructure, suppliers and specialised workers. These hubs also support informal knowledge exchange through their network of firms and researchers, catalysing innovation across the value chain.

How could industry coordination policies benefit Australia?

Three key policies can promote battery industry coordination

A more detailed discussion of industry coordinating bodies and battery hubs is in the appendix.

Support industry coordination through a dedicated body that connects stakeholders from across the value chain: This body should connect stakeholders from throughout the value chain and from both the public and private sector, to identify and address whole-of-supply-chain priorities. The coordinating body could host cross-segment workshops, conduct research and invite submissions from members, which could be directly addressed to governments. Similar coordinating bodies have been established in the US (Li-Bridge) and the EU (EBA250).

Develop battery hubs which co-locate firms and researchers from across the value chain: Battery hubs are industry centres that invite producers and researchers from across the value chain to co-locate and collaborate. These hubs are often equipped with important shared infrastructure such as off-grid renewable energy, and offer tenants expedited approvals. Similar hubs have been developed in the Finland (Harjavalta battery cluster) and the UK (NEPIC).

Introduce incentives for producers to trade with domestic supply chain partners: To ensure strong and secure interfaces between segments of the battery value chain, governments can incentivise producers to trade with domestic supply chain partners. For example, lithium miners can be offered expedited approval if they have contracted to supply its spodumene to a domestic lithium refiner.

Sources: Argonne National Laboratory (2021. 2022); European Commission (2022); EBA250 (2022); Brookings Institution (2018).

Building regional partnerships would help Australia reach a larger market for exporting batteries and battery materials

What are regional export partnerships?

Regional export partnerships would allow Australia to develop trade relationships for products in the battery value chain with other countries and foreign companies.

In particular, Australia could focus on building relationships with ASEAN nations and FTA partners in the Indo Pacific to export of active materials, cells and packs.

Why are regional export partnerships needed?

Australia should build regional export partnerships in order to expand the demand that Australia can cater to, create certainty around offtakes, access foreign capital, and collaborate with experienced firms. These regional export partnerships can be a significant source of foreign direct investment.

Partnerships with foreign companies can also de-risk domestic batteries projects by creating certainty around offtakes. Further, overseas firms located in Australia may supply Australia's domestic market with specialised technology technology and unique expertise, while unlocking access to new export markets. This supports the growth of Australia's battery industries.

While Australia has a domestic stationary storage market that will require around 55-65GWh between 2023 and 2030, the lack of an Australian automobile manufacturing industry will limit the potential to produce batteries for domestic electric vehicles. Catering to the demand for active materials and batteries in nations with large electric vehicle or stationary storage markets will help Australian firms produce at a cost competitive scale.

How could regional export partnerships work?

Regional export partnerships could be progressed through four initiatives

Establish strategic relationships with key regional trade partners: Australian governments could improve Australia's ability to be an export partner for batteries and battery materials, with a focus on countries in the Indo Pacific region that will require batteries for electric vehicle or stationary storage applications.

Re-negotiate bilateral trade agreements with regional trade partners: Renegotiations should focus on ensuring trade agreements with key regional trade partnerships are mutually beneficial, which includes an emphasis on relevant tariffs for active materials and battery exports. This could involve working with South Korea, Japan, Indonesia, or Thailand, and reducing the 15% tariffs on Australian batteries with India through ECTA.[1]

Support Australian businesses with exports: Australian governments should assist domestic businesses that are aiming to export products to other countries in the region, including through export grants and targeted mentoring programs. Organisations could include Export Finance Australia and other international trade development banks (e.g., Japan Bank for International Cooperation).[2]

Facilitate partnerships between Australian and foreign companies for project development: Encourage partnerships between Australian and foreign companies for projects in the battery value chain. Making changes to approvals processes is one policy option to encourage partnerships. Previous partnerships include POSCO Lithium Solutions,[3] the Tianqi/IGO joint venture, and the Mt Holland project.[4]

Notes: 1. In addition to 7.5% tariffs on lithium hydroxide and lithium carbonate. 2. Examples of support within Australia include the $92 million paid so far by Austrade for the Export Market Development Grants and the $9.3bn in financing which Export Finance Australia has provided support on. 3. A joint venture between POSCO and Pilbara Minerals. 4. The Mt Holland project is a joint partnership between SQM and Wesfarmers.
Sources: Government of South Australia (2022); Austrade (2021); Export Finance Australia (2022); Austrade (2022); DFAT (2022); SQM Lithium (2022); Albemarle (2022).

Increasing domestic demand through government procurement policies and adoption incentives can further develop Australia's battery industries

What is domestic demand policy?

Domestic demand-side policy aims to support local industry development by ensuring that Australian producers have access to a secure stream of demand from both the public and private sector.

Strong demand for Australian-made batteries provides producers from across the value chain with the confidence to invest and produce at scale.

Why is domestic demand policy needed?

Australia is expected to demand about 55-65GWh of ESS capacity cumulatively from 2023 to 2030.[1] Australia will also have significant demand for EV batteries, with over 2 million EVs expected to be on our roads by 2030. This creates an opportunity for Australia to support its local battery industries by creating a secure and stable stream of demand for locally-made batteries.

Governments have a significant opportunity to adopt Australian-made batteries through grid-scale ESS and government fleets. Government-owned energy corporations, including Energex and Stanwell, could adopt Australian-made ESS to support their energy networks. With grid-scale ESS expected to account for about half of Australian ESS demand by 2030, investment in local batteries by state energy companies could drive meaningful demand for Australian battery industries. With NSW expected to electrify its fleet of 12,000 vehicles by 2030, governments also have the opportunity to adopt Australian-made EV batteries for their fleets. This allows governments to 'lead by example', encouraging Australian businesses and consumers to adopt Australian-made batteries.

Australia can also encourage consumers and businesses to adopt Australian-made batteries through conditional adoption incentives. This is a significant opportunity, with Australia expected to adopt about 19-21GWh of behind the meter ESS cumulatively from 2023 to 2030.

How could Australian domestic demand policy work?

Domestic demand policy could focus on both governments and private demand

Adopt government procurement policies to harness government demand: Government procurement policies could require relevant government contractors to produce or use batteries or battery components with a minimum proportion requiring the involvement of Australian battery industries. This would allow Australian governments to 'lead by example', encouraging Australian businesses and consumers to also adopt Australian-made batteries. A similar scheme is currently in place for large Australian defence tenders, and in the US for its critical minerals industries through the *Defence Production Act*.

Incentivise businesses and consumers to purchase Australian-made batteries: Governments could provide adoption subsidies for battery products that have a minimum proportion of involvement in Australia's battery industries. This could be structured similarly to US clean vehicle subsidies under the IRA, where businesses are offered tax credits of up to 30% of the vehicle price if a minimum proportion of battery components and critical minerals are processed in the US or an allied country. One means of implementing this could be through the luxury car tax, which applies a tax to the import or sale of a vehicle above a specified threshold. The threshold could be raised for EVs with a minimum Australian battery content.

Notes: 1. From 2023 to 2030.
Sources: Argonne National Laboratory (2021, 2022); European Commission (2022); EBA250 (2022); Western Australian Department of Jobs, Tourism, Science and innovation (2020); Queensland University of Technology (2022).

A specialist battery institute could help accelerate the commercialisation of batteries and battery materials

What is a specialist battery institute?

A specialist battery institute could provide support for research, training, prototyping and contract manufacturing facilities to reduce barriers to entry for Australian businesses.

A battery institute could be similar to specialist institutes used in other countries (e.g., UK and Germany) to attract and build deep expertise alongside cutting-edge pre-commercial facilities. These institutes also become focal points for industrial collaboration across a value chain.

Why is a specialist battery institute needed?

A battery institute is needed to help advance battery materials and batteries to be ready for commercial production. There is an immense increase in scale from lab to gigafactory. Many of the material and manufacturing processes are difficult to scale. Integrated facilities can accelerate scaling, product prototyping and design.

Facilities of this type often cost up to US$750 million to set up,[1] which is out of reach of individual emerging manufacturing costs can reduce barriers to entry.

A battery institute could also focus on multiple battery technologies, including lithium ion, vanadium redox flow, and potentially others such as graphene aluminium-ion.

How could a specialist battery institute be structured for success?

A specialist battery institute could serve three key functions:

A discussion of international specialist battery institutes is in the appendix.

Providing common use R&D and prototyping facilities: A battery institute could help to prototype and scale early stage battery technologies, like vanadium flow batteries. Infrastructure like the vanadium common user facility in Queensland or the prototyping production lines available through the UK Battery Industrialisation Centre enable businesses to prove a technology at low-cost before scaling up their own production lines.

Providing workforce training: A battery institute could also facilitate training of skilled labour in the manufacturing of active materials, electrolytes, cell manufacturing and pack assembly. Efforts to upskill the workforce could include partnerships with universities to develop apprenticeship programs. A battery institute could collaborate with other industry organisations to create strategies for developing manufacturing skills, following the example of the UK Battery Industrialisation Centre's partnerships with other institutions.[2]

Facilitating industry-academia collaboration: A battery institute could bring together industry and academia to research and commercialise battery technologies. As an example, the Fraunhofer Research Institution for Battery Cell Production aims to move battery cell production at TRL 5-6 to TRL 8-9 through applied industrial research.[3] Intellectual property arrangements would need to be carefully designed to ensure effective collaboration between industry and research institutions.

Notes: 1. For example, Finland's Northvolt Labs invested about US$750 million in its R&D facilities. 2. Including the Advanced Propulsion Centre, the Engineering and Physical Sciences Research Council, the Faraday Institution, Innovate UK, and the UK Automotive Council.
3. Technology Readiness Levels indicate the maturity of a technology, ranging from TRL 1-9. TRL 1 indicates early stage research has occurred, and TRL 9 indicates is a technology that has been proven in operation.
Sources: PwC (2018); Kampers et al. (2022); UKBIC (2022); Fraunhofer (2022a, 2022b, 2022c); Deakin University (2022); Accenture analysis.

05

Appendix

Assumptions used in analysis

Assumptions used for battery industries growth scenarios

	Mining focused scenario	Diversified industries scenario
Mining raw materials	▪ Australia's global share in mining raw battery materials decreases from 50% to 31%	▪ Australia's global share in mining raw battery materials decreases from 50% to 31%
Refining to chemicals	▪ Current investments will be the only operating refinery plants by 2030. Refining capacity is 14% of all mined battery minerals in Australia	▪ Refining capacity will be 50% of all mined battery minerals in Australia
Active materials manufacturing	▪ No activity	▪ 40% of refined materials will be used to produce active materials
Cell manufacturing	▪ No activity	▪ Cells will be manufactured for products to supply domestic and ASEAN markets. Focus on ESS and industrial vehicles (mining and defence)
Battery pack assembly	▪ No activity	▪ Battery packs will be assembled for products to supply domestic and ASEAN markets. Focus on ESS and industrial vehicles (mining and defence)
Integration, service and maintenance	▪ ESS installing services for domestic and ASEAN markets ▪ EV battery maintenance for 2.75 million EVs in Australia	▪ ESS installing services for domestic and ASEAN markets ▪ EV battery maintenance for 2.75 million EVs in Australia
End-of-life	▪ No activity	▪ 80% of all batteries are recovered in Australia ▪ 50% of batteries are recycled in Australia

Assumptions used for battery demand forecast

Domestic sources of demand and growth		
Source		***Assumption***
1	Grid	Grid ESS forecast includes medium and shallow storage required to 2030 under the AEMO Step Change scenario.
1	Behind the meter	Behind the meter forecast includes distributed and coordinated storage required to 2030 under the AEMO Step Change Scenario.
3	Off-grid	Off-grid forecast assumes 2% of Australians live off grid. Electrification demand is factored into Step Change demand forecasts.
4	Batteries to support Green Hydrogen production	Hydrogen-related ESS forecasts assume that 1 GWh of batteries can support 10 GW of hydrogen fuel capacity.
5	Niche EV's	Niche EV forecast assumes that Australia could cater to domestic demand for batteries to support the electrification of trucks, buses, mining vehicles, and defence vehicles.

International sources of demand and growth		
Source		***Assumption***
5	Growth in regional ESS export markets	Regional ESS forecasts assume that ASEAN, Asian FTA partners, and NZ's forecast share of global forecast ESS demand is equal to a weighted average of ASEAN's forecast share of global solar generation (80% weighting) and global wind generation (20% weighting). These weightings reflect the relative prevalence of announced solar- and wind-related large-scale battery projects, and the expected increased uptake of rooftop solar with battery storage in the region.
6	Growth in regional niche EV export markets	Niche EV forecast assumes that Australia could cater to ASEAN and NZ demand for batteries to support the electrification of trucks, buses, mining vehicles, and defence vehicles.

Source: AEMO (2022a, 2022b, 2022c, 2022d); Wood Mackenzie (2022); Renew Economy (2022a, 2022b); Energy Storage News (2022); SolarRun (2022); Department of Energy and Public Works (2022); Batteries Europe (2021); CSIRO (2021); Accenture analysis.

Appendix - Chapter 1

Global nickel, cobalt and graphite supplies are forecast to be in shortage by 2040

Exhibit A1: Forecast global nickel supply and demand

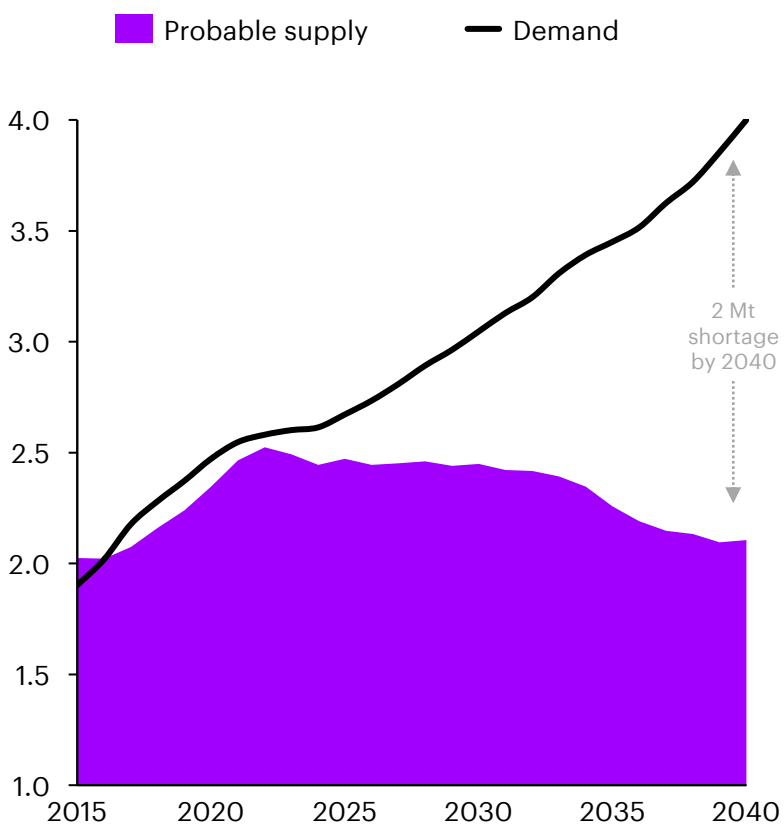


Exhibit A2: Forecast global cobalt supply and demand

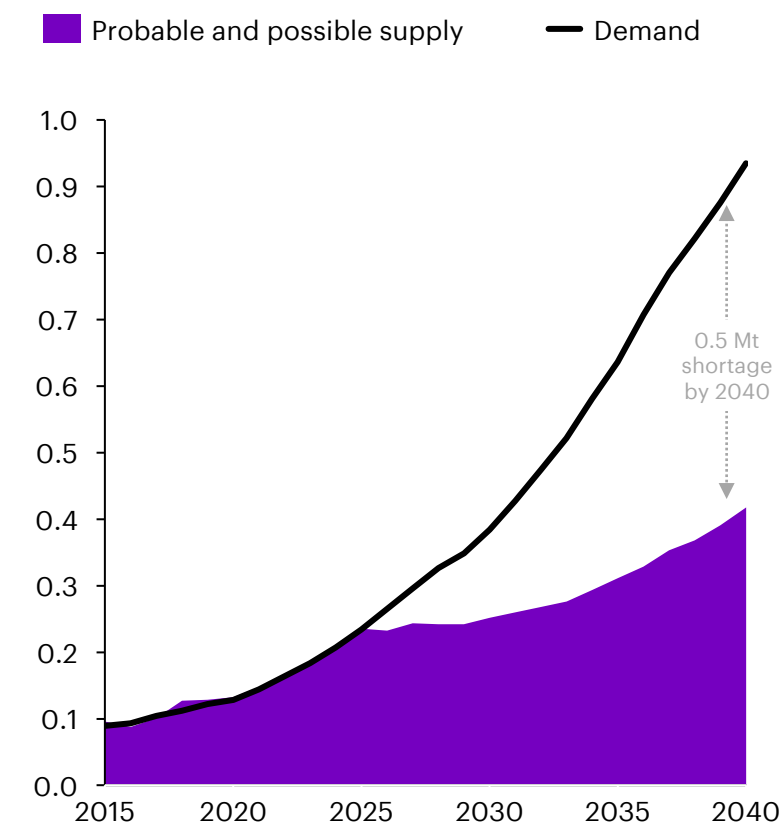
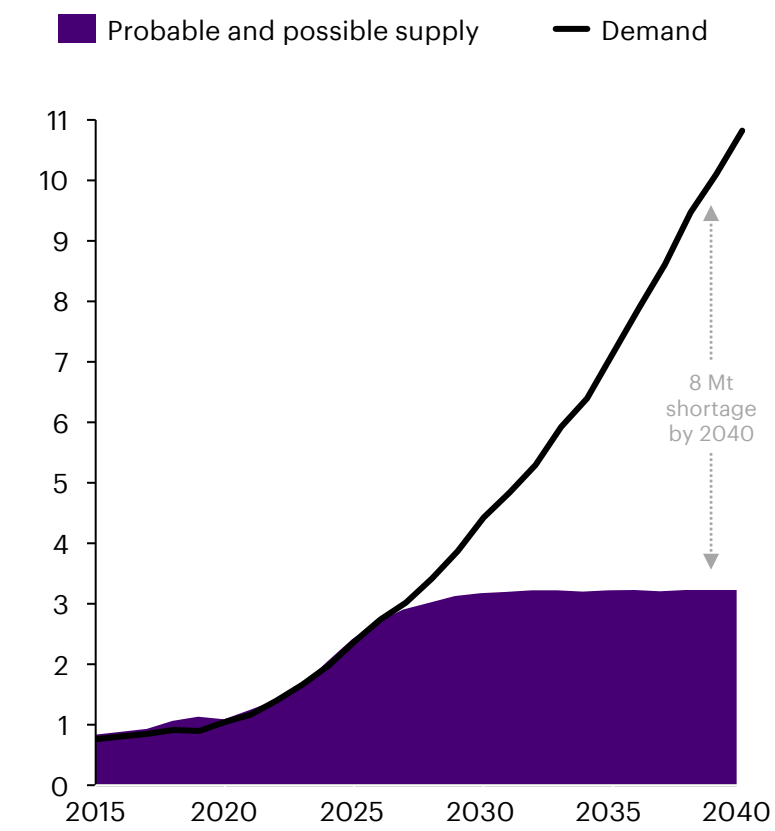


Exhibit A3: Forecast global graphite supply and demand



Source: International Graphite (2022); Benchmark Mineral Intelligence data (2022); Wood Mackenzie (2022).

Appendix - Chapter 3

Current capabilities

Australia has leading quantities of all key battery materials: lithium, cobalt, nickel, copper and graphite

Among the critical minerals used to produce batteries, Australia has leading quantities of mineral reserves. This positions Australia in a unique position to provide supply security to key trading partners.

While Australia is the world's leading producer of lithium, it is also looking to expand its production of other metals as demand for batteries and EVs increase. Cobalt discoveries have occurred in copper mine waste sites such as Mt Isa, and new nickel mines such as Oz Mineral's A$1.7 billion West Musgrave project are also being set up. Australia does not currently produce any graphite, but there are multiple projects looking into graphite production such as Renascor's Siviour and Mineral Commodities' Munglinup projects. Australia also has current production of manganese through Consolidated Minerals' Woodie Woodie project, GEMCO's Groote Eylandt project, and OM Manganese's Bootu Creek project, with further projects from Element 25, Firebird Metals, and Black Canyon in the pipeline.

Exhibit A4: Australia's current presence in mining key battery materials

Higher ■ ■ ■ ■ Lower

Mining

	Lithium	Cobalt	Nickel	Copper	Graphite	Manganese
Australia's global market share, 2021	55%[1] (Ranked 1st)	3% (Ranked 3rd)	6% (Ranked 6th)	4% (Ranked 6th)	0%	17% (Ranked 3rd)
Australia's share of global reserves	26% (Ranked 2nd)	18% (Ranked 2nd)	22% (Equal 1st)	11% (Ranked 2nd)	2% (Ranked 8th)	18% (Ranked 2nd)
Example companies in Australia	▪ Alta Resources ▪ Mineral Resources ▪ Albemarle ▪ Pilbara Minerals ▪ Galaxy Resources	▪ Glencore ▪ Cobalt Blue ▪ Ardea Resources ▪ Panoramic Resources ▪ Australian Mines	▪ BHP ▪ Glencore ▪ IGO ▪ First Quantum Minerals ▪ Ardea Resources	▪ BHP ▪ Newcrest Mining ▪ Glencore ▪ Oz Minerals	Pipeline: ▪ Renascor ▪ iTech Minerals ▪ Mineral Commodities ▪ Lithium Energy ▪ EcoGraf[2]	▪ Consolidated Minerals ▪ GEMCO[3] ▪ OM Manganese Pipeline projects: ▪ Element 25 ▪ Firebird Metals ▪ Black Canyon

Notes: 1. The total global percentage this has been calculated from excludes the USA's production of lithium in 2021; 2. Tanzanian natural graphite project. 3. Groote Eylandt Mining Company.
Sources: U.S. Geological Survey (2022a, 2022b, 2022c, 2022d, 2022e, 2022f); Geoscience Australia (2020, 2022a, 2022b); Mining Technology (2021a, 2021b, 2022a, 2022b); Financial Times (2022); Investing News (2022).

Australia has limited current refining activity, but there is significant investment in building capability

Exhibit A5: Australia's current presence in refining key battery materials

Higher Lower

	Lithium hydroxide	Nickel sulphate	Cobalt sulphate	High purity alumina	Vanadium pentoxide	Lithium phosphate
Material cost as % of average pack price	10-20%	8-12%	2-4%	1-2%	*(Specialised use)*	-[2]
Australia's global market share, 2022	1%	<1%	0%	<1%	0%	0%
Committed investments, 2016-2022	A$7 billion	>A$4.25 billion[1]	>A$1.1 billion[1]	>A$583 million[1]	A$871.2 million	A$50 million
Current investment focus	▪ 4+ production plants, producing 210kt+ p.a.	▪ 4x production plants, producing 175kt p.a.	▪ 4x production plants, producing 35kt p.a.	▪ 4x production plants, producing 72kt p.a.	▪ 3x production plants, producing 33.9kt p.a.	▪ 1+ production plant, producing >3kt p.a.
Example companies in Australia	▪ TLEA / IGO ▪ Wesfarmers / SQM ▪ Albemarle / Mineral Resources ▪ Liontown Resources	▪ BHP ▪ Queensland Pacific Minerals ▪ Sunrise Energy ▪ GME Resources ▪ IGO and Wyloo Metals	▪ Cobalt Blue ▪ TECH Project ▪ Sunrise Energy ▪ GME Resources	▪ Alpha HPA ▪ FYI Resources / Alcoa ▪ iTech Minerals ▪ ChemX ▪ Alchemy Resources ▪ Lava Blue	▪ Australian Vanadium ▪ Richmond Vanadium ▪ QEM Ltd ▪ King River Resources ▪ Multicom	▪ Lithium Australia (LIT) ▪ Pilbara Minerals / Calix ▪ Aleees ▪ Alvenira

While Australia currently only produces lithium hydroxide and nickel sulphate, significant investment into building refining capabilities for all chemicals in the battery value chain have been made. This gives Australia a strong base to provide supply security with high capacities outside of traditional powerhouses in East Asia.

Australian companies have also invested significantly in plants which produce a variety of chemicals, including the Queensland Pacific Minerals Townsville Energy Chemicals Hub project. Producing nickel sulphate, cobalt sulphate, high purity alumina (HPA) and iron, the TECH project is expected to be a significant contributor of nickel sulphate when operational, producing over 30,000 tonnes per year. Sunrise Energy Metals' Battery Materials Complex and GME Resources' NiWest Nickel Cobalt Project are also expected to both produce nickel and cobalt sulphate.

Cobalt Blue's Broken Hill project is expected to be the world's largest cobalt project outside of Africa. Additionally, to meet an expected increase in demand for high purity alumina, Australian companies are developing capabilities in HPA. Vanadium pentoxide and lithium phosphate capabilities have also experienced investments to develop domestic strengths.

Notes: 1. Projects which produce multiple refined materials have their total investment amount considering their refined product's percentage of the total annual output of the refinery. 2.Significant variability depending on pack.
Sources: DISR (2022); KPMG (2022); Resources Rising Stars (2022); BNEF (2020); AFR (2022); Sharecafe (2022); Australian Mining (2021); WA Today (2021); IGO (2022); NSS (2022); Queensland Pacific Minerals (2022); WA Government (2021); Franklin Smith (2022); Australian Mining (2022); Market Index (2022); PV Magazine (2021); GME Resources (2022); Austrade Cobalt – Reliable, Responsible, Australian (2021); Renew Economy (2022); Saving with Solar (2021); Richmond Vanadium (2021); IM Mining (2022); FBICRC (2021); Pure Battery Technologies (2021); Market Herald (2021); Australian Vanadium (2022); QEM (2022); Calix (2022); Goldman Sachs: Equity Research (2022); ABC (2022); Energy Storage News (2022).

Australia currently has limited activity in active materials but has an emerging focus on cathode precursors

Australian companies have planned production of cathodes, anodes and vanadium electrolyte. Planned projects include:

- VSPC's production of 10,000t per year of cathode materials
- Syrah Resources' production of 11.25kt per annum of anode materials due to the Vidalia expansion, with the potential to expand to 45kt per year in 2025 - 2026
- Australian Vanadium's production of 1.5 million litres of vanadium electrolyte per year

Exhibit A6: Australia's current presence in manufacturing active materials and electrolytes

Higher  Lower

	Active materials and electrolytes			
	Cathode precursors	**Cathode**	**Anode**	**Vanadium electrolyte**
Australia's global market share, 2022[1]	<1%	<1%	<1%	<1%
Committed investments, 2016-2022[2]	>A$478 million	A$190 million	>A$300 million	>A$65 million
Example companies in Australia	▪ Pure Battery Technologies (PBT) ▪ FBICRC	▪ VSPC ▪ Calix	▪ AnteoTech ▪ EcoGraf ▪ Syrah Resources ▪ Talga	▪ Vecco Group ▪ Australian Vanadium ▪ Technology Metals Australia ▪ Multicom ▪ QEM
Example vertical integration strategies	▪ PBT: Plans to build a $460M pCAM Hub refinery in Kalgoorlie, with potential access to Poseidon Nickel's feedstock from their Black Swan mining operations	▪ Calix: Supply of materials from their BATMn reactor in Baccus Marsh to BatTRI-hub at Deakin University	▪ AnteoTech: Planned use of AnteoTech binder ▪ EcoGraf: Planned use of graphite refined by EcoGraf	▪ Vecco Group: Planned use of vanadium from the Vecco Debella mine ▪ Australian Vanadium: Planned use of vanadium from the Australian Vanadium Project mine

Note: 1. Production in 2022. 2. Committed investments for current and future projects from VSPC, PBT, EcoGraf, Syrah Resources, and Vecco Group.
Source: Lithium Australia (2022); EcoGraf Annual Report (2022); Syrah Resources Annual Report (2022), Vidalia Final Investment Decision and Equity Capital Raising; Australian Vanadium (2022); Diggers and Dealers Presentation, Pure Battery Technologies (2022); Calix (2022).

Australia has limited cell manufacturing capability, with companies focusing on pack assembly for both lithium-ion and redox flow batteries

Australian companies have current and planned production of cells and battery packs. Projects include:

- Energy Renaissance has planned production of 66MWh per annum, which is planned to eventually rise to 5.3GWh per annum
- ESI Asia Pacific is planning to produce 400MW per annum of batteries in the new Maryborough facility

Exhibit A7: Australia's current presence in manufacturing batteries

Higher Lower

	Battery Manufacturing			
	Cell Manufacturing		Pack Assembly	
	Lithium ion	Lithium sulphur	Lithium ion	Redox flow
Australia's global market share, 2022	<1%	0%	<1%	<1%
Committed investments, 2016-2022	>A$0	>$5 million	>A$100 million	>A$75 million
Example companies in Australia	▪ Feline ▪ Calix ▪ Recharge Industries	▪ Li-S ▪ Gellon ▪ GMG ▪ Allegro	▪ Switch Batteries ▪ Vaulta ▪ Feline ▪ Sonnen ▪ RedEarth ▪ Magellan ▪ Energy Renaissance	▪ Ultra Energy ▪ ESI Asia Pacific ▪ VSUN ▪ Redflow

Source: Calix (2019); Calix (2022); Li-S (2022a, 2022b); AMGC (2022); RedEarth (2019); Energy Renaissance (2020); Redflow (August, 2022); Redflow, (November, 2022); ESI Asia Pacific (2022); Sonnen (2018); Magellan (2021); FBICRC (2020).

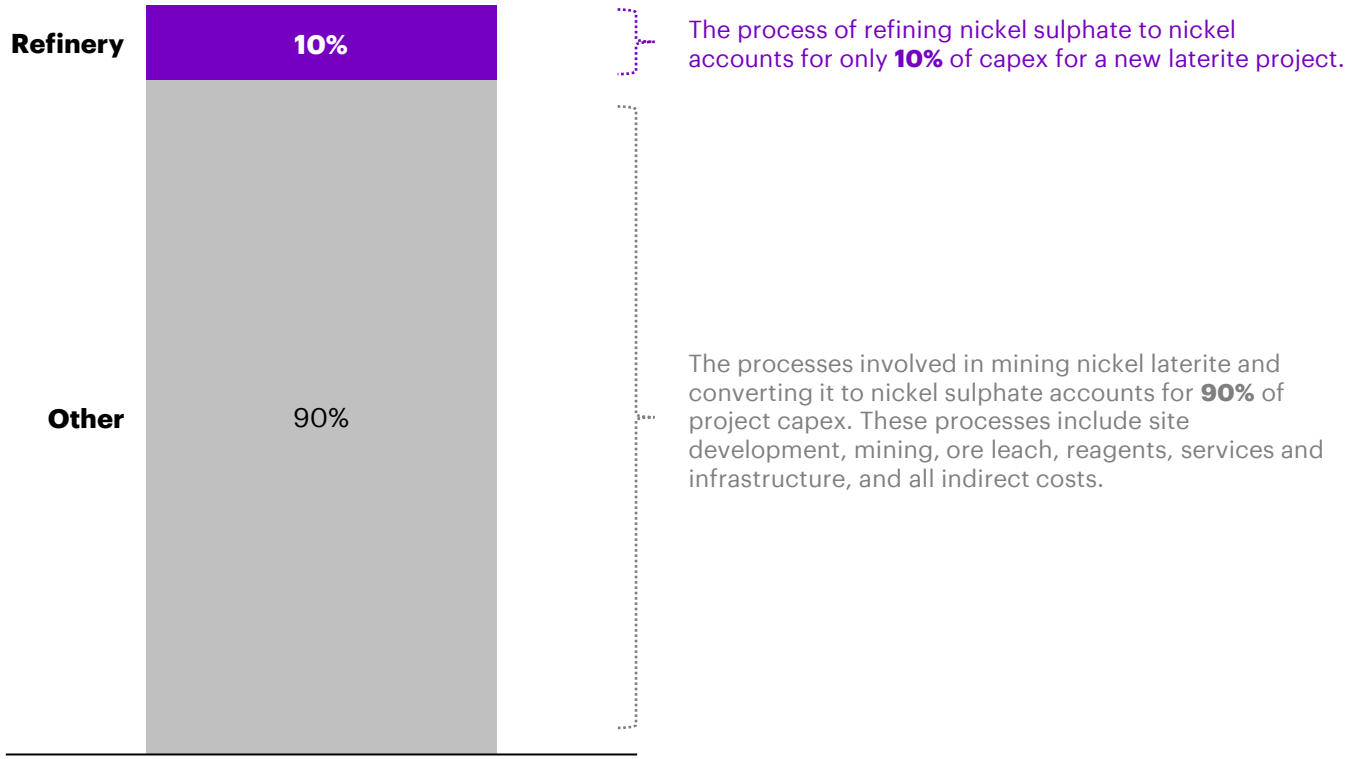
Appendix – Chapter 3

Cost and ESG analysis

Nickel chemical plants are likely to be integral parts of the associated mines (for laterite operations), or require common user facilities (for sulphide)

Exhibit A8: Breakdown of capital costs for a circuit processing 2.5 Mtpa feed

% of capital costs in Australia



Key comments

- In developing a new laterite project, the incremental capex to build the refining and crystallisation circuit is about 10-20% of total capex in a jurisdiction like Australia.
- This means that nickel sulphate plants in the future will be integral parts of existing laterite operations. This is so because the bulk of the costs are incurred in getting the nickel right up to the stage before final refining.
- Sulphide projects can also integrate downstream to the sulphate. However, in practice this may be limited by short mine lives, since exploration costs for sulphide operations are substantial.
- In future, common user facilities may be required to process excess sulphide ore in-country as an alternative to sending concentrate overseas. Alternatively, a single major player could invest in refining to the chemical, and source excess concentrate from third parties. The use of new hydrometallurgical routes can help produce not just the nickel chemical, but the precursor cathode active material (pCAM).

Notes: Assumes US$500/t SC6 price FOB Port Hedland.
Source: Accenture analysis, First Quantum RNO NI 43101.

Australian cities (Perth and Brisbane) could be the lowest-cost producers of LHM and LFP if Australian mining and refining are integrated

Exhibit A9: Potential production costs for LHM (refining)

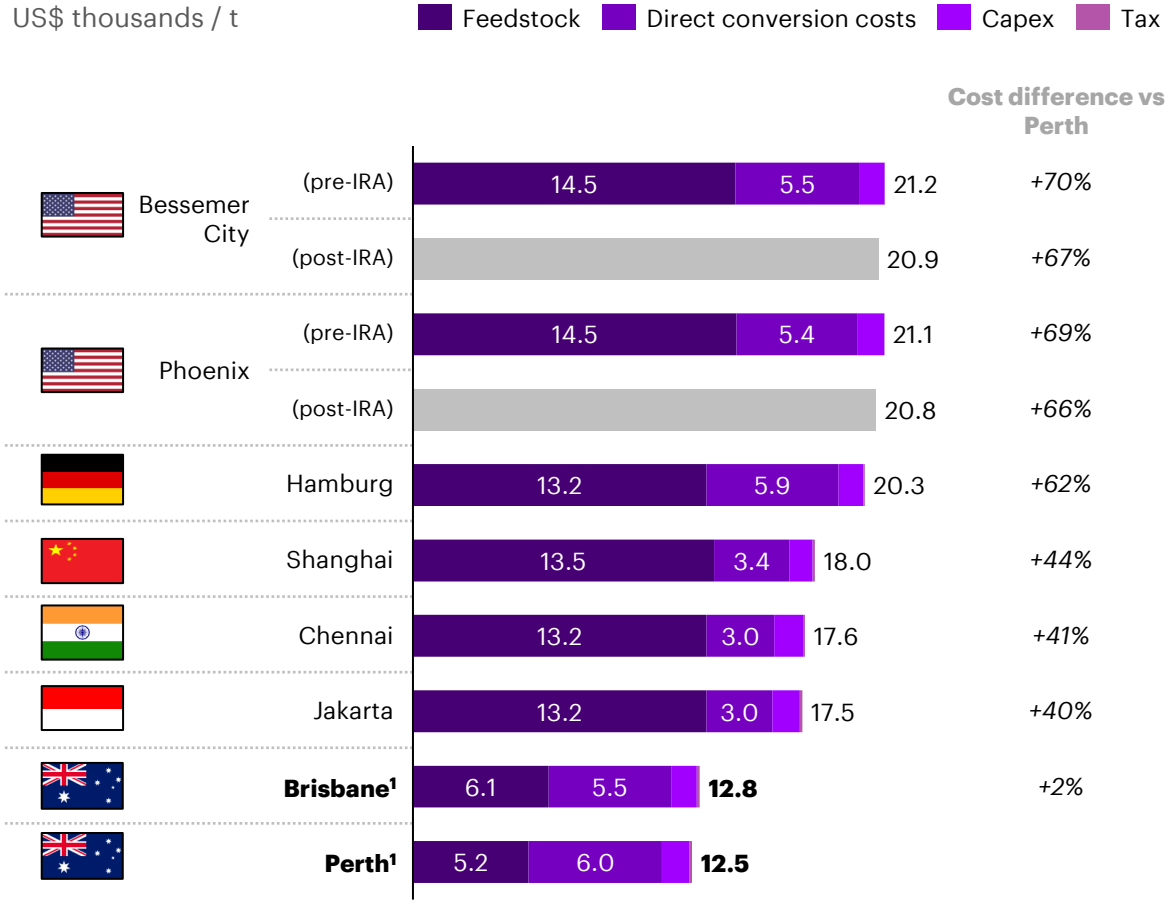
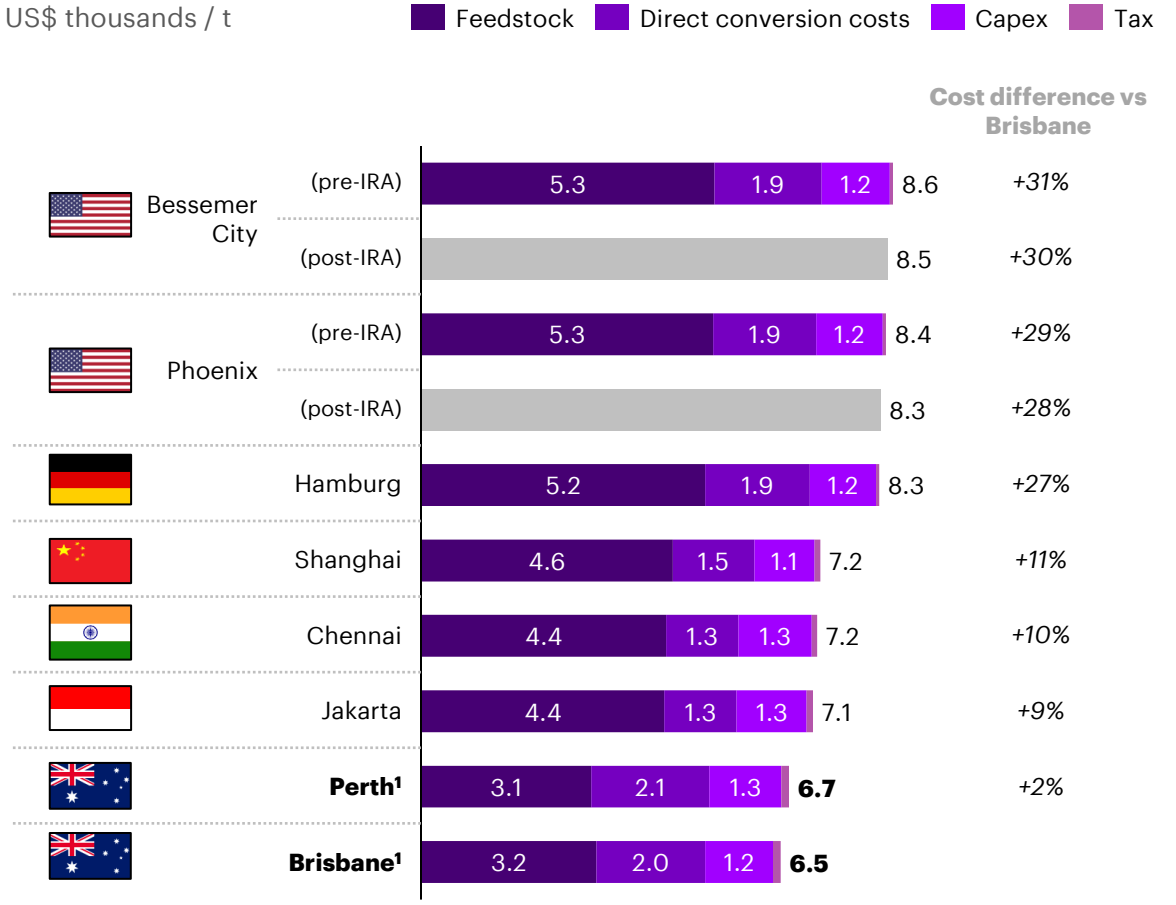


Exhibit A10: Potential production costs for LFP (active materials)



Notes: 1. Australian cities can benefit from upstream integration, reducing costs. Assumes feedstock (SC6 procured from Australia in all cases, and an SC6 market price of US$1800/t vs US$740/t for Australia) LFP cost calculated assuming manufacturing of Lithium carbonate in the same country using Australian SC6 feedstock. IRA tax credits are assumed to be accruable by the holding company of the refiner or active materials producer, so can exceed the value of tax on the refining or active materials production activity. Assumes in-country production of sulphuric acid.
Source: Accenture battery costing model.

Australia could be cost comparable for cell manufacturing and pack assembly; however, the IRA has given the US a significant cost advantage

Exhibit A11: Potential production costs for cells

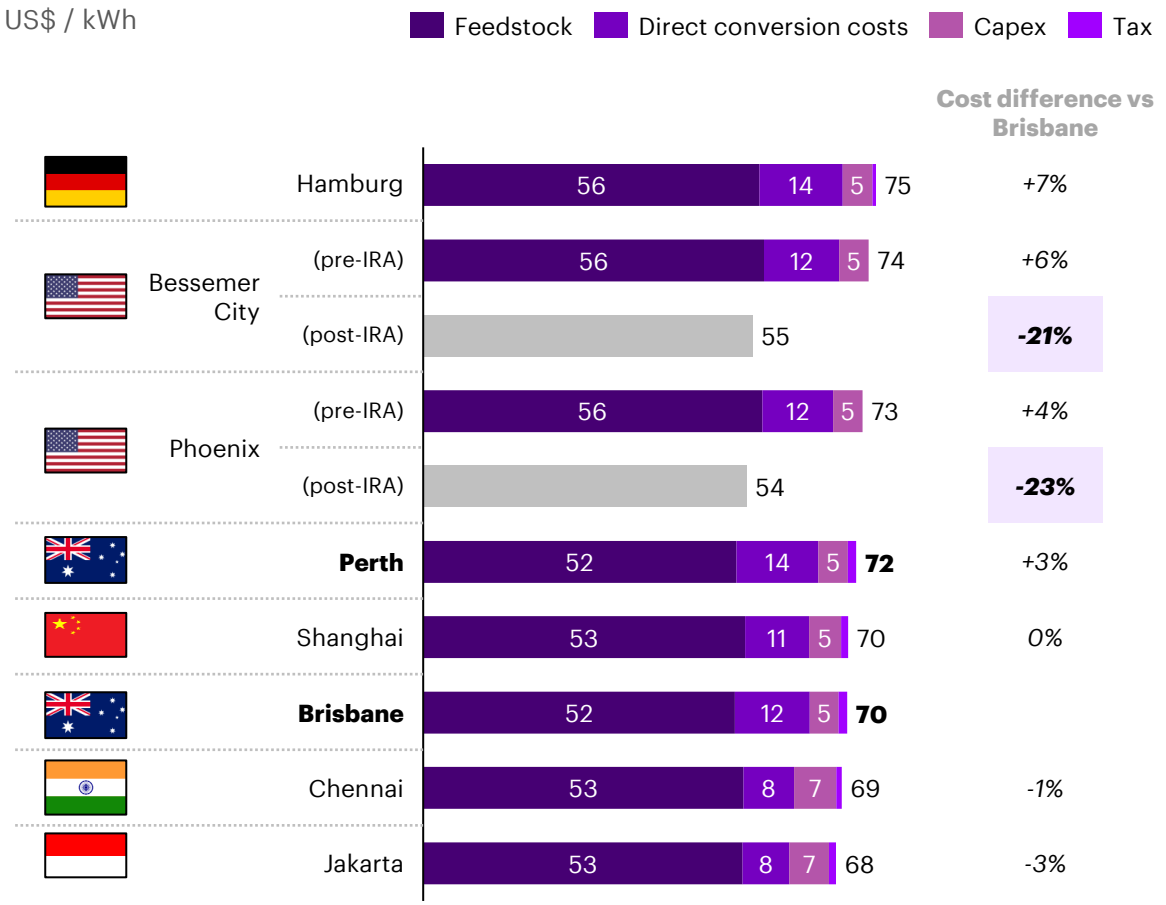
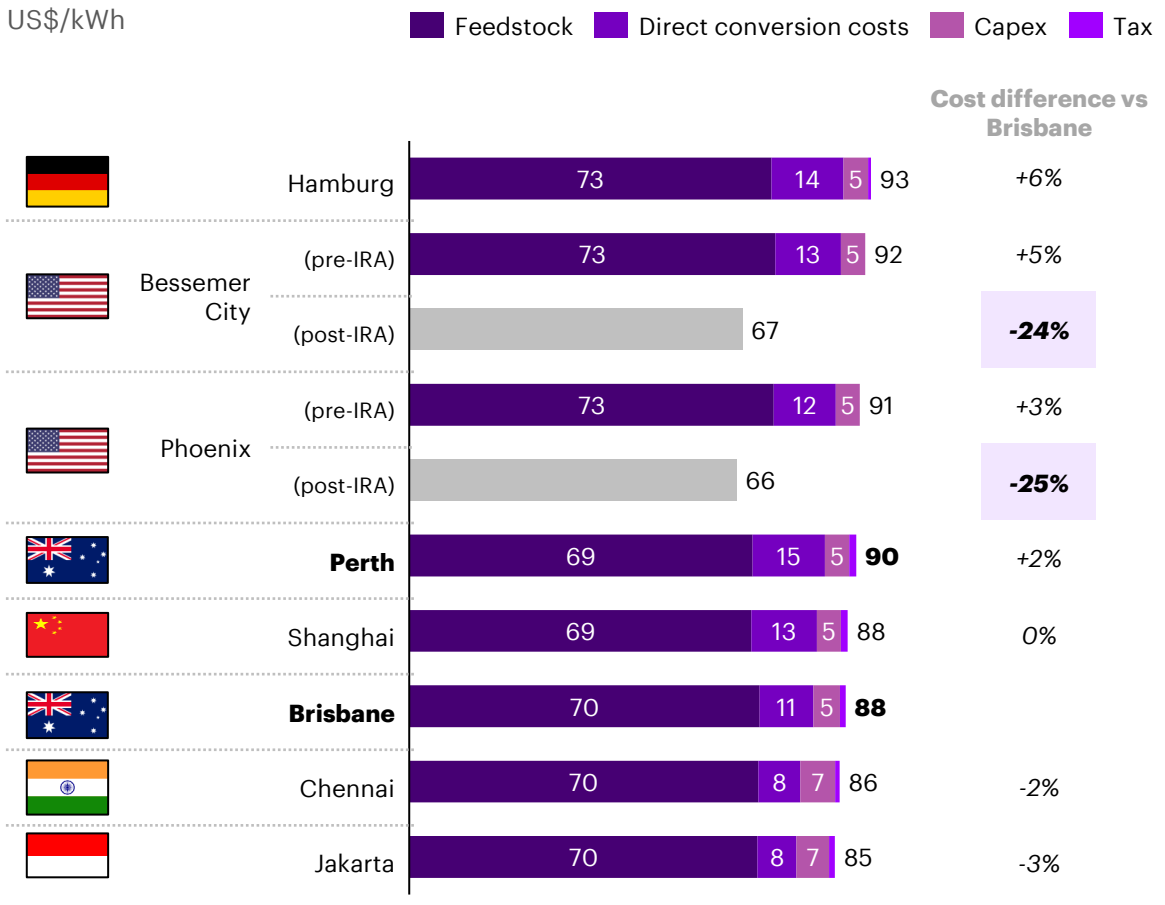


Exhibit A12: Potential production costs for packs



Notes: Assumes cells and packs are 1 x 4 GWh / a LFP line. IRA tax credits are assumed to be accruable by the holding company of the refiner or active materials producer, so can exceed the value of tax on the refining or active materials production activity. Costs are significantly lower than at present because of feedstock and in-country value chain assumptions.
Source: Accenture battery costing model.

There is substantial scope for Australian producers to reduce cell costs for vanadium redox flow batteries by reducing electrolyte costs

Exhibit A13: Cost to manufacture vanadium redox flow batteries

US$ / KWh, 4 GWh

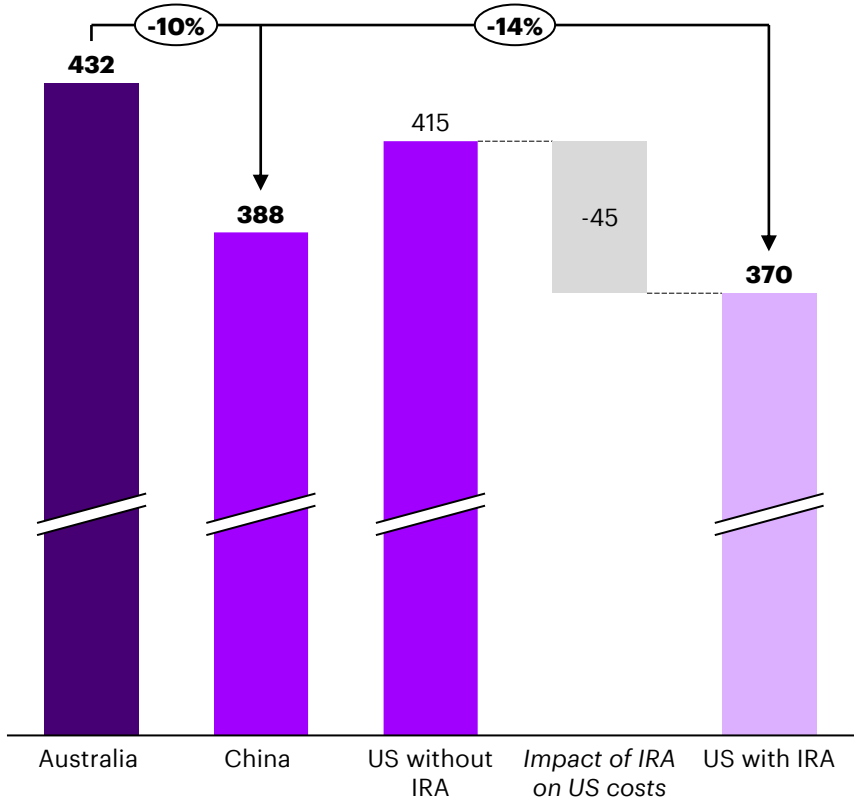
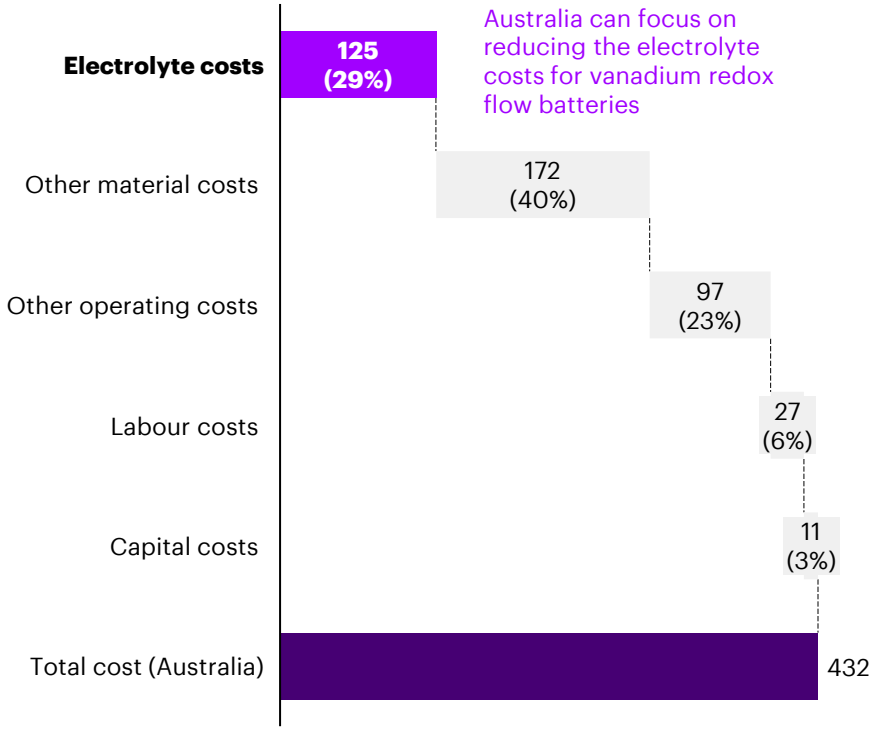


Exhibit A14: Composition of Australian vanadium redox flow battery manufacturing costs

% of costs in US$ / KWh, 4 GWh production line



Key comments

- Australia has higher costs to manufacture vanadium redox flow batteries than China or the US. However, Australia can utilise its abundant reserves of vanadium to develop domestic vanadium electrolyte capabilities and reduce materials costs.
- The cost for manufacturing vanadium redox flow batteries is 10% lower in China and 14% lower in the US than in Australia. The difference in manufacturing costs between Australia and competitors countries is due to capital costs, labour costs, and the impact of IRA subsidies on US production costs.
- While Australia has higher capital and labour costs than the US and China, it has the potential to reduce its cost to manufacture vanadium redox flow batteries. Australia has 25-30% of the world's vanadium reserves, which would enable domestic vanadium mining, refining and electrolyte production. This gives Australia a distinct opportunity to reduce the cost of vanadium electrolyte, which makes up 29% of the cost to manfacture vanadium redox flow batteries. As Australia develops upstream capabilities for vanadium, it can reduce its materials and logistics costs for vanadium redox flow battery manufacturing and improve its cost competitiveness.

Sources: Seungbum & Gallagher (2015); Kear & Shah (2011); Zhang et al. (2016); USGS (2022); Accenture analysis.

Australia performs strongly in legislation and policies against competitor countries in various environmental, social and governance parameters

Exhibit A15: Example legislation and policies across ESG areas in Australia, China and Chile (non-exhaustive)

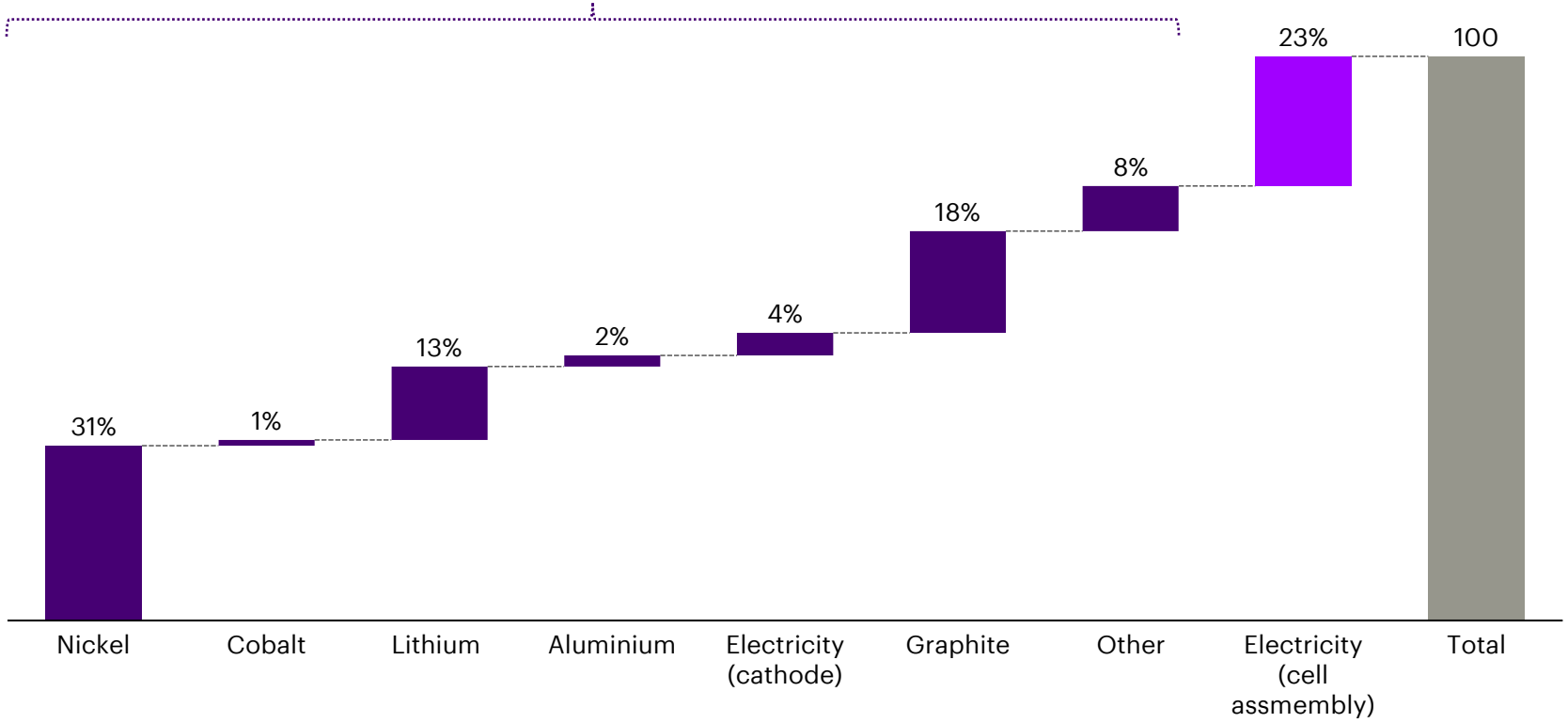
Category	Sub-category	Australia	China	Chile
Environmental	Environmental impact assessments	▪ All States and Territories have environmental impact assessments for project planning	▪ Environmental Protection Law	▪ Decree 40 of the Ministry of Environment - Environmental Impact Assessment System
	GHG emissions reporting	▪ National Greenhouse and Energy Reporting Act ▪ Climate Change Act	▪ Poor quality of ESG reports, irregular ESG ratings	▪ No general mandatory reporting requirements on ESG issues, other than those applicable by the CMF (Financial Market Condition)
	Water management	▪ Minerals Council of Australia Water Accounting Framework	▪ The Water Law	▪ A Water Code is in place but severe issues in water-stressed regions occur
Social	Workers' rights and labour law	▪ Safe Work Australia ▪ Respect@Work ▪ Mental Health Blueprint – Minewell	▪ Labour Law exists but labour rights abuses occur in international mines	▪ Chile's Labour Code ▪ Law 21,015, disability inclusion ▪ Law 16,744, social insurance for occupational hazards
	Human rights	▪ Modern Slavery Act 2018	▪ No domestic Modern Slavery law in China	▪ Article 19(2) of the Constitution prohibits slavery
	Traditional ownership	▪ Voluntary Reconciliation Action Plans ▪ First Nations Partnerships	▪ N/A	▪ Articles 34, 79 and 191(2) of the Constitution establish significant rights to indigenous people, but ownership issues still occur in the Salar de Atacama
Governance	Ethics and transparency standards	▪ ASX Corporate Governance Principles and Recommendations	▪ Incomplete information disclosure is a known issue in ESG reporting	▪ CMF requires the submission of ESG compliance as part of companies' mandatory financial reporting
	Anti-bribery and corruption standards	▪ Government Effectiveness Index: 15/192 ▪ National Anti-Corruption Commission Act	▪ Government Effectiveness Index: 44/192 ▪ Criminal Law of the PRC, Anti-Unfair Competition Law, Supervision Law	▪ Government Effectiveness Index: 50/192 ▪ Law 20,393, regulating criminal liability of legal entities ▪ Codigo Penal Law 18,575, anti-corruption law

Sources: ICLG (2023a, 2023b); Mondaq (2022); K&L Gates (2022); Dezan Shira & Associates (2022); Safeguard Global (2022); World Bank (2022); Invest Vic (2023); Queensland Government (2023); NSW Government (2023); WA Government (2023); ACT Government (2023); TAS Government (2023); SA Government (2021); NT Government (2022); Chambers and Partners (2022); Minerals Council of Australia (2022); Anti-Slavery Law (2022a, 2022b).

Up to 77% of emissions occur in mining, refining and active materials; areas where Australia is well positioned to be carbon competitive

Exhibit A16: CO_2e contribution from materials and processes within nickel-based battery supply chain

Tesla's 2021 impact report found that **77% of CO_2e emissions in a nickel-based battery supply chain occur upstream of battery manufacturing**, coming from the mining and refining of materials, and the manufacturing to active materials



Key comments

- Australian nickel sulphide operations have low CO_2 intensity relative to peers and will be well positioned to support lower carbon battery production in nickel-based battery supply chains.
- Australia's strong forecast growth in renewable energy, and adoption of on-site renewable energy sources in mines, will enable more carbon competitive extraction and processing of all key battery materials.
- There is significant research in Australia dedicated to decarbonising industrial processing of materials. Notably, the Heavy Industry Low-carbon Transition Cooperative Research Centre has a program of work dedicated to process technology, and Calix is re-engineering a low carbon, electric calciner.
- The FBI CRC has multiple research streams which will markedly increase the efficiency of mining activity, such as; lithium beneficiation, nickel/cobalt extraction, mining decarbonisation (mobile mine electrification and stationary mine electrification).

Sources: Tesla (2021); HILTCRC (2023); Calix (2023); FBI CRC (2023)

Appendix – Chapter 4

Detailed barriers

Policy action is needed to support industry to address trade protection, high capital costs, limited key inputs, and lack of coordination

Challenges: Trade protection; High capital costs; Limited access to technology; Limited access a to large customer base; Limited access to feedstock; Limited access to skilled workforce; Limited supply chain and policy coordination

Challenges	Mining	Refining	Active Materials	Cell Manufacturing	Pack Assembly	Recycling
Major challenge			**Significant technology investment required** **Distance to OEM's**: Co-design and validation more challenging	**Significant international industry attraction measures**: Major capital grants and subsidies (e.g., IRA) **Limited domestic customer scale:** Can't reach cost competitive economies of scale without export **Distance to OEM's**: Co-design and validation more challenging	**Content restrictions:** (e.g., IRA)	**Lack of product volume from end-of-life batteries and from manufacturing scrap**: Low volume makes profitable activity challenging
Medium challenge	**Exploration and development costs** **Must develop export offtake:** No domestic options **Indigenous participation** **Environmental and land use**	**Poor capital formation for industry in Australia:** Domestic capital less inclined to invest relative to mining opportunities **High cost for industrial R&D/prototyping facilities** **Technology not broadly available** **No prototyping capability** **Limited talent availability:** Specialised talent, high cost, limited availability **Lack of supply chain orchestration**	**Moderate international industry attraction measures:** E.g., tax offsets **Poor capital formation for industry in Australia:** Domestic capital less inclined to invest relative to mining opportunities **High cost for industrial R&D/prototyping facilities** **No prototyping capability** **Limited domestic refining:** Need feedstock at scale to attract lighthouse tenant **Limited talent availability:** Specialised talent, high cost, limited availability **Lack of supply chain orchestration**	**Poor capital formation for industry in Australia:** Domestic capital less inclined to invest relative to mining opportunities **High cost for industrial R&D/prototyping facilities** **Technology transfer required** **No prototyping capability** **Limited domestic manufacturing:** High import cost, supply risk **Limited talent availability:** Specialised talent, high cost, limited availability **Lack of supply chain orchestration**	**Import competition** **Very limited domestic cell manufacturing:** high cell import costs, limited influence on quality **Lack of supply chain orchestration**	**Lack of supply chain orchestration**
Minor challenge		**Contracted supply of feedstock:** Domestic supply of feedstock contracted out for export **No training facilities**	**No training facilities**	**No training facilities**		

Appendix – Chapter 4

Policy case studies

To attract lighthouse tenants, Australia could offer incentives industrial pre-approvals, supply chain security and financial incentives

What could be included in a curated policy package to attract lighthouse tenants?

Measures to attract lighthouse tenants could include:

Free land in designated industrial precincts with pre-approvals for industrial development and use

Governments could reduce the risk of administrative delays by offering industrial pre-approvals and expedited permitting processes for potential lighthouse tenants. In 2014, Storey Country in Nevada, US, was able to attract a Tesla gigafactory with an incentive package that included heavy industry zoning status pre-approval and expedited building permits which were typically processed in under two weeks.

Offers of supply chain security through guaranteed offtake and government-facilitated procurement

To reduce supply chain risks, governments could offer potential lighthouse tenants guaranteed offtake of key inputs, and government-facilitated procurement to ensure a reliable pipeline of demand. For example, governments could offer a potential global cell producer preferential access to Australian active material supplies. Governments could also offer to add the producer to a 'preferred supplier' shortlist.

Financial incentives, including tax exemptions and subsidies

Financial incentives are common across the US and Europe, with some incentive packages exceeding US$1 billion. To compete with these large incentives from competitor countries, Australia could either match the scale of these incentives, or package financial incentives with other measures like pre-approvals or guaranteed offtake.

Exhibit A17: Industry attraction case studies in peer economies

Nevada, US

In 2014, Tesla began construction of their Gigafactory 1 in the Taho Reno Industrial Centre (TRIC) in Nevada. Panasonic co-invested to begin battery cell production in 2017. Tesla has since invested over US$6.2 billion in the plant, and their partnership with Panasonic has delivered benefits such as co-location and economies of scale. These established manufacturers were attracted to TRIC and Nevada by:

- Over US$1.4 billion in government incentives
- Government commitments to fast permitting and planning approvals
- The county agreeing to facilitate all government dealings for the developers to ensure no construction delays.

Hungary

Hungary is positioning itself as an emerging player in the battery manufacturing space by attracting several lighthouse tenants, including BYD (from China) and SK Innovation (from South Korea). These manufacturers were drawn to Hungary by large cash subsides, including €209 million offered to SK Innovation to establish a 30 GWh battery manufacturing plant. As a result of its industry attraction measures, Hungary has received over €14 billion in its battery industries in the last six years.

Sources: FBICRC (2021); Tesla (2022); Northvolt (2020, 2021a, 2021b, 2022); European Investment Bank (2020); Inside EVs (2022), Electrive (2019); European Commission (2022); Euractiv (2022); European Commission (2022); Good Jobs First (2022); Cleantechnica (2021).

An industry coordinating body connects stakeholders from across the value chain to develop a coherent national approach to industry development

How could Australia's industry coordinating body work?

Australia's industry coordinating body could serve three key functions

Connect stakeholders from across the entire battery value chain and across Australia

Stakeholders should include industry participants, government bodies and researchers. Australia's industry coordination body could be an independent body that is established as a private-public partnership to encourage participation from a range of stakeholders.

Identify gaps in Australia's battery supply chain and co-develop strategies to address these gaps with stakeholders.

To identify gaps and develop strategies, the industry coordination body can host workshops, invite consultation and conduct research.

Coordinate with international counterparts, such as Li-Bridge and EBA250 to establish secure international supply chains between allied countries.

Australia should engage coordination bodies in allied countries to harmonise industrial policies and further strengthen supply chain security.

Exhibit A18: Industry coordinating bodies developed in peer economies

Li-Bridge, at Argonne National Laboratory (US)

Li-Bridge (US) is a private-public partnership that connects industry, national labs and federal government to develop robust and cohesive national supply chains. It coordinates over 600 industry stakeholders from all segments of the value chain to develop solutions across six whole-of-supply-chain challenges, including 'Demand, Supply & Availability' and 'Workforce & Communities'. In 2021, Li-Bridge published the *National Blueprint for Lithium Development 2021 – 2030* which sets out a unified end-to-end strategy for battery value chain development in the US.

EBA250 (EU)

EBA250 coordinates over 800 actors from industry, academia and project finance to develop an 'unbroken value chain' for batteries. It connects stakeholders from all segments of the battery value chain to develop initiatives to grow a unified European supply chain across multiple dimensions, including technology, business models, skills and industry regulation. To ensure that policy is responsive to the emerging needs of the battery ecosystem, EBA250 addresses its policy recommendations directly to the European Commission.

Sources: Argonne National Laboratory (2021, 2022); European Commission (2022); EBA250 (2022); Western Australian Department of Jobs, Tourism, Science and innovation (2020); Queensland University of Technology (2022).

Battery hubs are most effective when tenants have access to expedited permitting, key infrastructure and collaboration opportunities

How could Australian battery hubs work?

Australia's battery hubs could have three main qualities

Expedited permitting and zoning status preapproval

Battery hubs can promote flexible and rapid supply chain development by expediting or pre-approving building or industrial use permits. This can enable hubs to promptly attract strategic tenants and respond flexibly to emerging needs. Expedited approvals were used to attract key tenants in the Tahoe Reno Industrial Centre in the US.

Access to key infrastructure, including renewable energy

Effective battery hubs provide tenants with access to key infrastructure, including renewable energy, water and housing for a trained workforce. Hubs should attract tenants that supply key materials for production (e.g., sulphuric acid for refining).

Collaboration opportunities facilities through the adoption of an appropriate hub model, such as 'hub-and-spoke'

To accelerate the development of industry expertise 'from scratch', Australian battery hubs could consider a 'hub-and-spoke' model. This places a lighthouse tenant at the hub's centre to maximise diffusion of knowledge and expertise from the lighthouse tenant to less established firms that co-locate at the hub.

Exhibit A19: Examples of industry hubs

Battery hub

Harjavalta battery cluster (Finland)

The Harjavalta cluster houses a nickel and cobalt refinery, which supplies refined material to a cathode active materials producer. A battery recycling plant is also under construction. Access to renewable energy, skilled labour and industrial infrastructure underpin the success of the cluster.

Other industry hubs

North East of England Process Industry Cluster (NEPIC, UK)

NEPIC is an organisation that supports a chemical processing cluster. Its members include firms that perform a range of interconnected functions, including manufacturing, logistics and business services. NEPIC collaborates with researches and public bodies to support the needs of its members.

Tahoe Reno Industrial Center (TRIC, US)

TRIC is a multi-industry centre which offers tenants expedited permit approvals. Through the co-location of Panasonic's cell manufacturing plant and Tesla's pack production facility, TRIC streamlines manufacturing operations and creates economies of scale.

Sources: Argonne National Laboratory (2021. 2022); European Commission (2022); EBA250 (2022); Western Australian Department of Jobs, Tourism, Science and Innovation (2020); Queensland University of Technology (2022); Länsireitti (2020); UK Department for Business, Energy & Industrial Strategy (2017); Wall Street Journal (2014); ZDNet (2014); Governing (2017); Taho Reno Industrial Center (2021).

A specialist battery institute should focus on multiple applications, address knowledge gaps, and support innovation with its intellectual property design

What could a battery institute learn from other battery institutes?

A battery institute should be developed with the lessons of global experience in mind

A battery institute should focus on multiple applications for batteries, including stationary storage applications

Organisations such as the UK Battery Industrialisation Centre have not historically focused on stationary applications, which will potentially need to be changed. Given Australia's relative strengths in stationary storage in comparison to mobility applications,[2] it is important that Australia includes batteries for stationary storage applications in its Battery Institute.

A battery institute should address gaps in knowledge about industrial scale production

There is likely to be knowledge gaps in the workforce about battery manufacturing which a specialist battery institute can focus on improving. LiPlanet, which is a European network of pilot scale production lines for cell manufacturing, has found that there are significant knowledge gaps about industrial scale production which pilot scale lines can help address.

A battery institute should carefully design the set-up of intellectual property ownership to promote innovation and collaboration

Intellectual property rules for a battery institute have the potential to stifle collaboration between industry and academia, as it can disincentivise parties from sharing information. A specialist battery institute should be structured so that industry and academia are encouraged to share technological expertise.

Exhibit A20: Examples of other battery institutes

UK BATTERY INDUSTRIALISATION CENTRE

UK Battery Industrialisation Centre (UKBIC)

The £130 million UKBIC aims to assist industry with scaling up and commercialising electrodes, cells, modules and packs in order to reach high volume manufacturing. The UKBIC has supported over 140 battery developers, and provides facilities for pilot scale battery production, engages in battery manufacturing training for a variety of skill levels, training of engages in piloting of battery production, and engages in research projects with industry and academia.[1]

Fraunhofer BATTERIEN

Fraunhofer Battery Alliance

The Fraunhofer Battery Alliance has 20 institutes that engage in research on batteries and other energy storage devices. Pilot plant and small-scale production of cells is available at some of the institutes. One of the Battery Alliance institutes is the Fraunhofer Research Institution for Battery Cell Production FFB, which attempts to accelerate innovation and commercialisation of battery production.

Notes: 1. For example, UKBIC is involved in the Nextrode project, which focuses on improvements in electrode manufacturing. 2. Due to the demand for solar PV and ESS in Australia, the lack of an automotive manufacturing industry which could transition into an electric vehicle manufacturing industry, and the availability of vanadium for vanadium redox flow batteries.
Sources: UK House of Lords (2021); LiPLANET (2022); UKBIC (2022a, 2022b); Fraunhofer Batterien (2022a, 2022b); Fraunhofer FFB (2022); expert interviews.

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