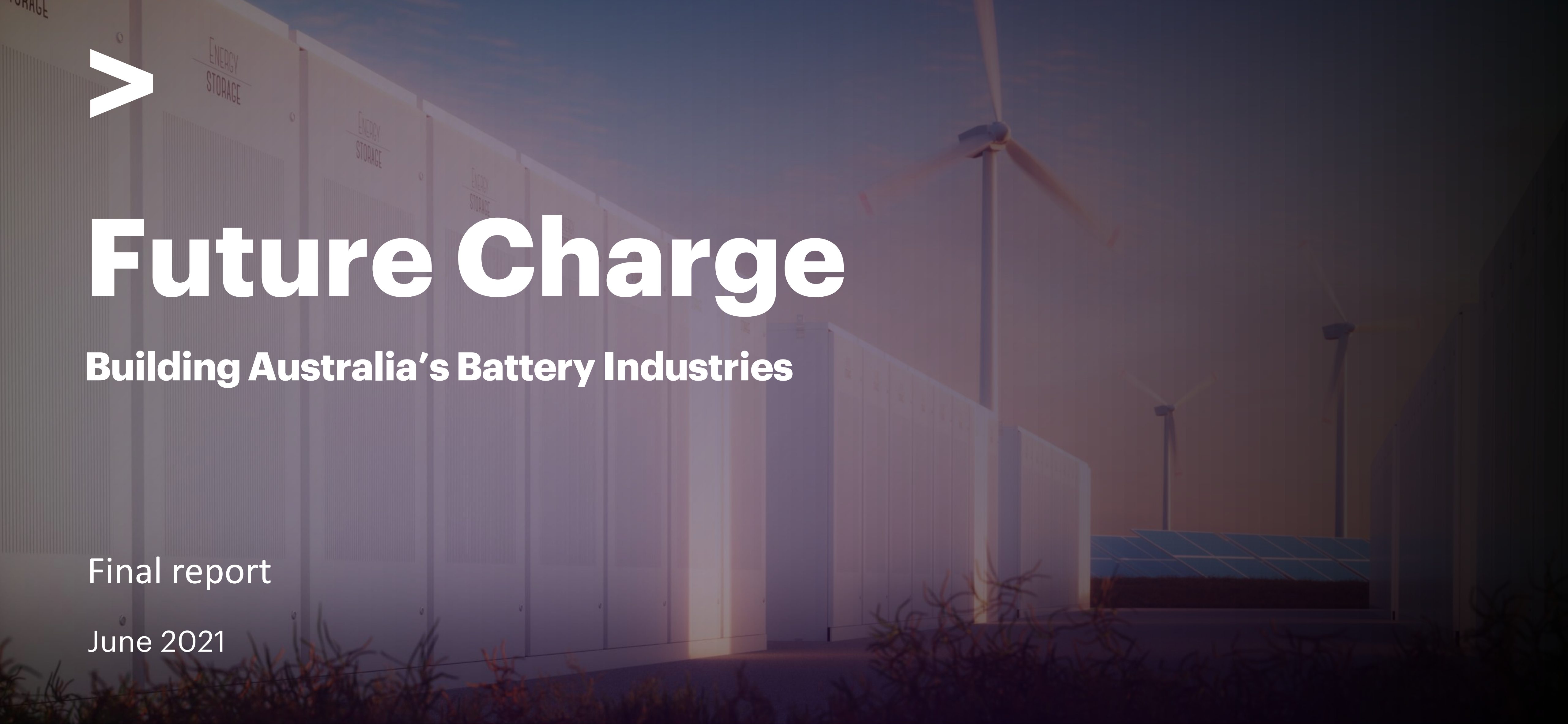

Future Charge

Building Australia’s Battery Industries

Final report

June 2021

accenture

Commissioned by
FUTURE BATTERY INDUSTRIES CRC

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- Queensland University of Technology
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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 more than 60 participants.

Visit us at fbicrc.com.au

Executive summary

Batteries are predicted to play a transformative role in our energy future

Over the next decade, batteries are expected to be critical to the transformation of our energy system to a low-carbon footing. Their adoption is being driven by three interrelated forces: technological improvements making batteries more affordable and usable, increasing demand for energy storage as the use of renewables grows, and regulatory interventions to reduce carbon emissions.

Battery technology and manufacturing has matured rapidly since 2010, with unit prices decreasing by 88%. Batteries are now the preferred technology for electric vehicles, massively outpacing hydrogen fuel cells and increasingly cost competitive with internal combustion engine vehicles. In stationary energy storage, batteries account for almost half of all new projects globally. Advances in re-use and recycling are creating the potential for a battery circular economy.

As a result, demand is now forecast to accelerate, increasing 9- to 10-fold over the next decade – more than solar PV grew over the last decade. Sales of batteries are expected to reach US$133-151 billion by 2030. The largest segment will likely be electric vehicles, but on-grid energy storage appears set to be the fastest growing.

The combination of booming demand and geopolitical shifts creates an opportunity for our domestic industry

Batteries are manufactured through a complex global value chain from mining and then refining of raw materials, through manufacturing of cells then battery packs into integration, service and maintenance.

Currently, Australia is the dominant player in the mining of battery materials – with around half the global lithium market and a leading role in other key metals. Beyond this point, China overshadows at almost every point along the chain.

But across the globe, governments are reconsidering their reliance on concentrated supply chains in light of recent trade tensions and the disruption from COVID-19. As global leaders seek to diversify, new sources of supply will need to come online to meet the growing demand for batteries.

Several countries around the globe including Germany, the UK, Finland and Canada are already vying to fill this emerging gap – however, none have the access to raw materials Australia has, supported by our reputation as a clean and reliable supplier.

Australia is also rapidly adopting batteries for energy storage, creating another advantage for local industries

Our other advantage is our rapid adoption of batteries for energy storage, to complement strong rooftop solar as well as wind and solar in our electricity grids. While we lag our peers in EV sales, we are world-leading in stationary energy storage uptake.

However, Australia has missed opportunities in clean energy manufacturing before. Despite world-leading research on solar PV and rapid uptake by households, Australia never established a significant PV manufacturing industry.

The most immediate opportunities are for Australia to expand into the refining of battery materials – where substantial investments are already being made – and then production of active materials, both segments where colocation with raw materials can generate cost advantages.

Over time, Australia could also develop its own battery manufacturing industry, specialising in energy storage systems for domestic and regional markets. Opportunities in battery integration and re-use and recycling will also emerge as demand increases.

Government has a key role to play in supporting batteries and unlocking substantial economic value

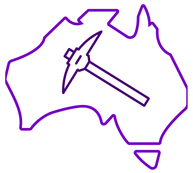
While governments across the country are already taking steps to encourage battery installation in homes and businesses, government should also support the development of our battery industries. The establishment of the Future Battery Industries CRC is an important step, but more investment will be needed if we are to keep pace with our peers.

Hydrogen is currently attracting much of the focus of clean energy policy support, and it is an exciting technology. But Australia will need to develop more than one clean energy industry. The technologies are also complementary – batteries can support 24/7 green hydrogen production, meaning that both industries can prosper.

The economic logic of diversification is strong. With booming demand, the value added from batteries is likely to grow strongly over the next decade even if we remain on a mining-focused path. But taking a diversified path could almost double the economic gains between now and 2030, resulting in AU$7.4 billion in value added and around 34,700 jobs.

Two paths for the future development of Australia’s battery industries

2020



Australia’s current battery industries

Currently Australia has a strong position in the mining of battery raw materials, with some investments in refining and other downstream activities

$1.3 billion
in gross value added

6,000
jobs

2030

Path 1

Mining-focused industries

Australia remains focused on mining raw battery materials, with some limited refining activities and battery integration and maintenance services

$4.1 billion
in gross value added

18,700
jobs

Path 2

Diversified battery industries

Australia builds from its mining strength to develop diversified battery industries, with more onshore materials processing, an ESS-focused manufacturing industry and well developed integration and services capabilities

$7.4 billion
in gross value added

34,700
jobs

Source: Accenture analysis

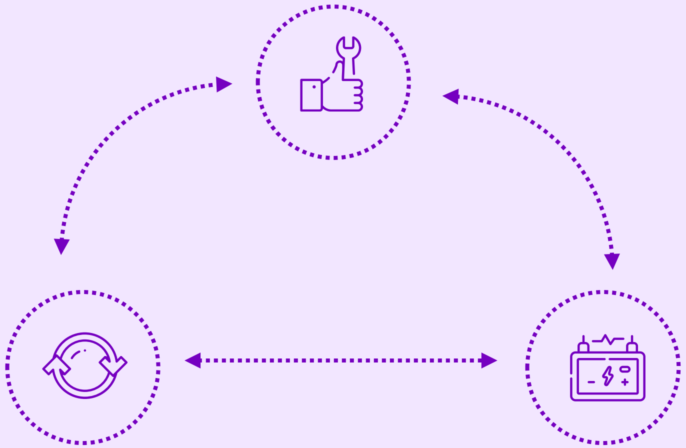
Contents

01

Global battery demand is expected to grow at least 9-fold over the next decade

Batteries are predicted to play a transformative role in our energy future, with three forces driving their adoption

Three mutually-reinforcing trends are expected to drive significant adoption of (and investment in) battery technology over the next decade.



1 Technological improvement

Battery technologies have improved substantially in recent years, with increases in the energy density of cells and improving performance, such as faster charging and wider temperature operating window. Combined with efficiencies in manufacturing, this has driven down the price of lithium-ion battery packs in particular.

2 Demand for energy storage

New forms of energy storage are becoming important as we reduce our reliance on carbon-based fuels. EVs are an increasingly attractive product, with market growth pioneered by Tesla and other manufacturers now following. Strong global growth in renewable energy has increased the demand for energy storage to manage the variability of wind and solar.

3 Regulatory changes

Policy to drive the transition to lower emissions is accelerating in major markets, with an increasing use of emissions targets and standards to drive systemic change. There is also a growth in more direct policy interventions supporting use of batteries, such as the proposed ban on the sale of internal combustion engine vehicles in the UK from 2030.

Source: Trahey et al. (2020) Energy storage emerging: A perspective from the Joint Center for Energy Storage Research, PNAS; Accenture analysis.

Battery technology and manufacturing has matured rapidly since 2010

Technological and manufacturing improvements and increasing scale in production have led to dramatic reductions in battery prices of 88% over the past decade. Lithium-ion battery pack prices were over US$1,100 per kilowatt-hour (kWh) in 2010 and have fallen significantly to US$137 per kWh in 2020.

The decrease in battery pack prices has been driven by three main factors:

1. Lower manufacturing costs: increased automation of battery manufacturing has reduced labour costs and overheads. Growth in demand has led to economies of scale in production, and reductions in the prices of some key components. Further savings in manufacturing costs will be harder to generate.

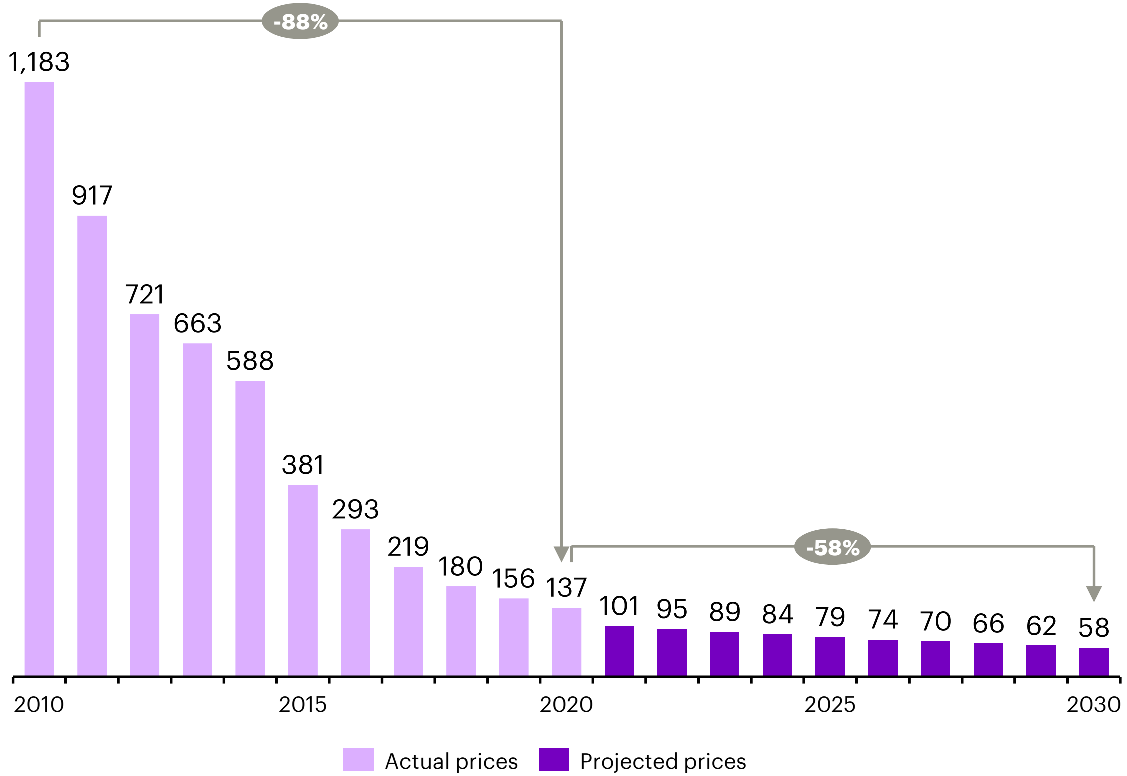
2. Higher energy density: the cost of a battery pack has been reduced as a result of increased energy density in battery components. Changing chemistries of cathode and anode materials could further increase energy density (e.g., by increasing nickel content in cathodes).

3. Lower scrappage: increasing efficiency in manufacturing and quality control reduced waste in the production. Non-destructive quality control techniques lowered the scrap rate in battery manufacturing.

Over the next decade, battery production improvements are expected to be more modest but still significant, with price forecast to fall 58% from 2020 to 2030. The slowing price reductions indicates the maturity of battery technology and suggests the industry is now at an inflection point – the majority of cost savings have been achieved, and further savings will be more difficult. This greater stability in the cost of technology makes it more attractive for mainstream investors, and suggests the importance of this moment for industry development.

Exhibit 1: Global price for lithium-ion battery packs, projected to 2030

Real US$ per kWh, 2020 = latest actual data

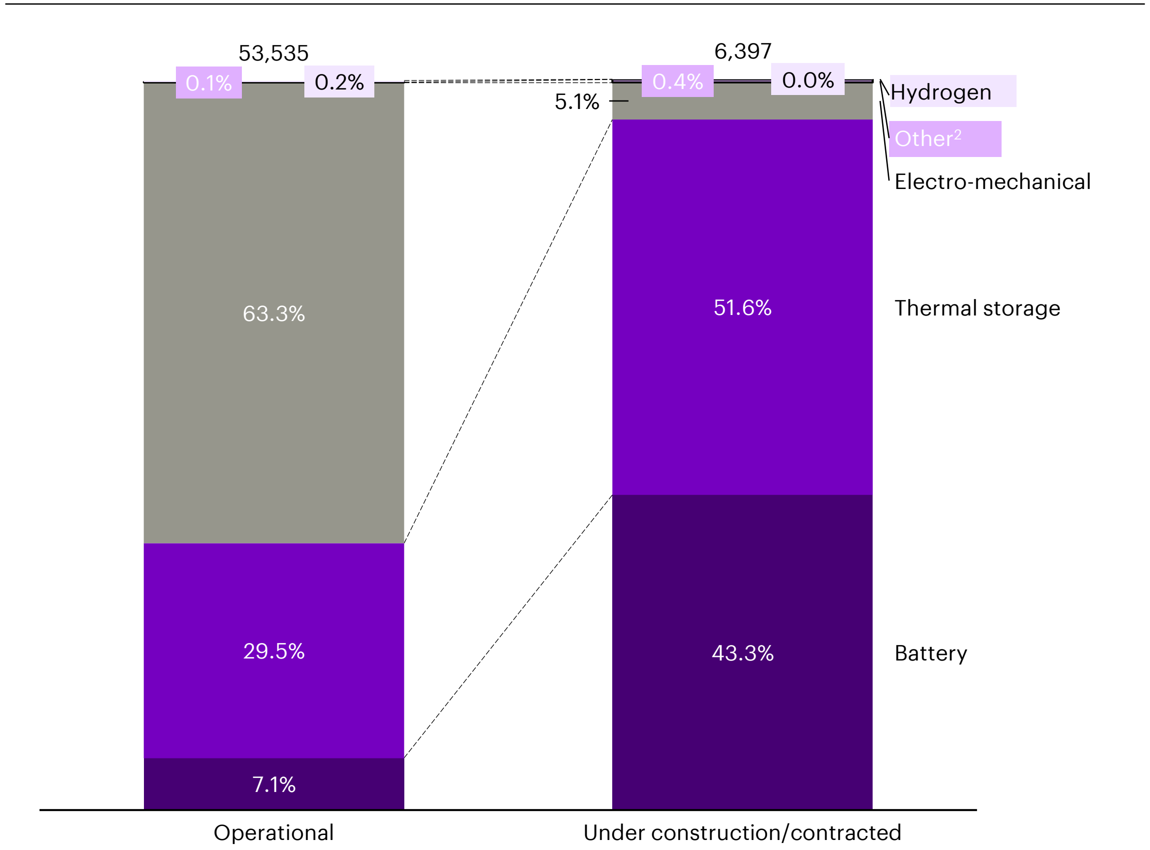


Notes: Actual battery pack prices from 2010 to 2020. Forecast from 2021 to 2030. Note that these prices do not represent the full price of finished batteries. There are often additional costs associated with energy management, integration and safety systems.
Source: Bloomberg NEF (2020) Battery Pack Prices Cited Below $100/kWh for the First Time in 2020, While Market Average Sits at $137/kWh; Roskill (2020) Lithium-ion Batteries: Outlook to 2029, 4th Edition; JOM (2017) Toward Low-Cost, High-Energy Density, and High-Power Density Lithium-Ion Batteries; Accenture analysis.

Batteries are already becoming a dominant energy storage technology in both stationary and mobile applications

Exhibit 2: Technology share of global grid-connected (non-pumped hydro) energy storage[1]

MWh, 2020



The maturation of battery technology is driving a growing preference for their use in energy storage both in electricity grids and transport systems.

Batteries are increasingly favoured as a stationary energy storage technology. Of the 53,535MWh of grid-connected (excluding pumped hydro) energy storage that was operational globally in 2020, just 7.1% relied on batteries. However, batteries make up 43.3% of the 6,397 MWh of projects that are currently under construction or contracted globally.

The potential of hydrogen technology is attracting attention from governments around the world. However, it is still an immature technology in grid-connected storage with only a handful of small projects operational (all in Europe) and two more contracted.

While pumped hydro has long been the dominant energy storage technology for electricity grids, its limitations – namely a scarcity of suitable sites – are evidenced in the few pumped hydro projects coming online. Currently, pumped hydro accounts for 96.7% of operational grid-connected capacity but just 0.1% of capacity under construction/contracted.

Batteries are also the dominant technology in the electrification of vehicles. Battery electric vehicles (EVs), including plug-in hybrid EVs, make up over 99% of the global passenger EV fleet and they are forecast to continue to be the dominant technology, making up 97% of the passenger EV fleet by 2050.

Fuel-cell EVs, which typically use hydrogen as a fuel, are an alternative to battery EVs. Fuel-cell EVs currently make up less than 1% of the passenger electric vehicle fleet.

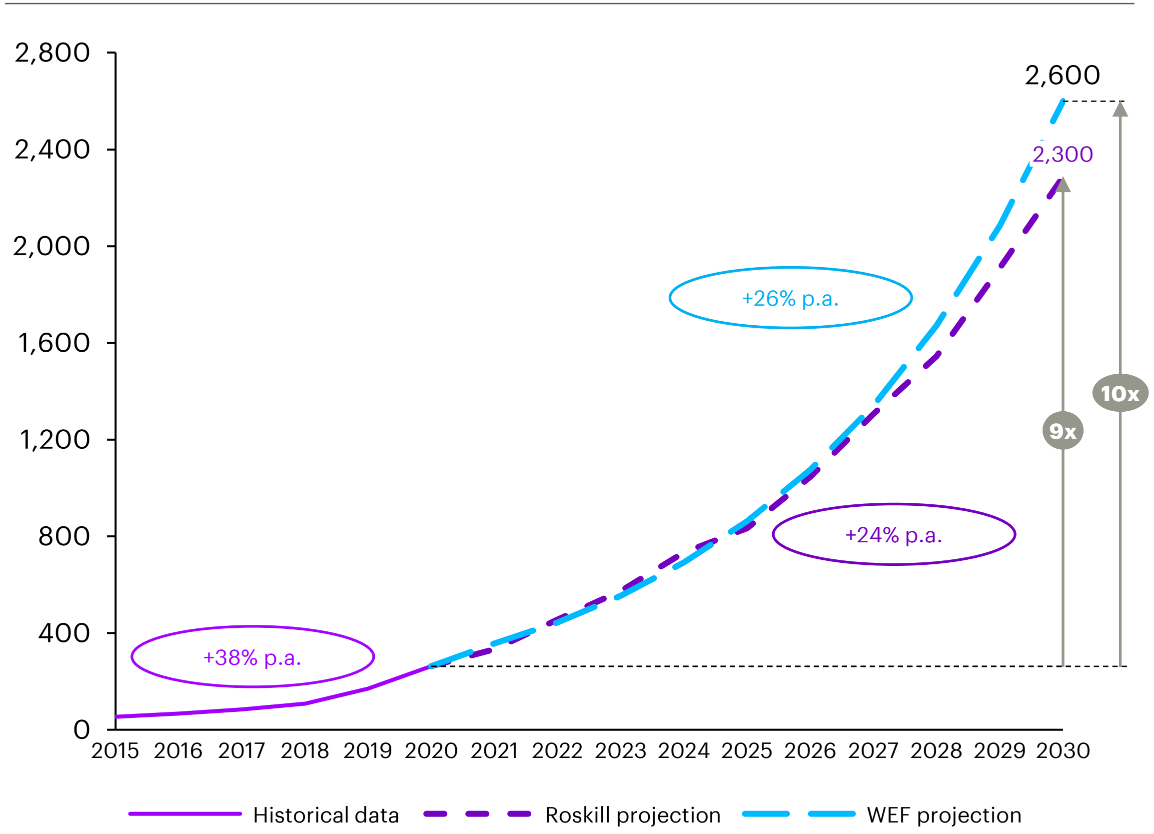
Their share is forecast to reach just 3% of the passenger EV fleet by 2050, according to Bloomberg's New Energy Outlook (2020). While fuel cell vehicles have some advantages over battery EVs for applications involving heavier loads and long distance travel, the cost of the technology and the cost of green hydrogen fuel makes wide-scale adoption less likely.

Notes: 1. Pumped hydro is excluded from Exhibit 2 because its contribution to future energy storage is limited by availability of suitable sites 2. Other includes Lead-Carbon, Liquid air energy storage and Compressed air energy storage.
Source: US Department of Energy (2020) DOE OE Global Energy Storage Database; BloombergNEF (2020) New Energy Outlook 2020; International Energy Agency (2021) Global EV Data Explorer; Accenture analysis.

Demand for batteries is forecast to accelerate over the next decade as energy storage becomes critical to the transformation of the energy system

Exhibit 3: Global battery demand, projected to 2030

GWh per annum, 2020 = latest actual data



With batteries now a preferred technology in a range of applications and increasing need for energy storage, demand for batteries is projected to grow substantially over the next decade – by 9- to 10-fold to 2030.

Forecasts from the World Economic Forum (WEF) and Roskill project annual growth rates of 24-26%, with demand almost doubling every 3 years. By 2030, demand is expected to reach 2,300-2,600 GWh per annum, from just 263 GWh in 2020.

Energy storage has always been an important part of the energy system, supporting portable uses of energy in transport and equipment, such as electronics. Most of that energy storage has occurred through liquid carbon fuels that enable our transportation system.

However, the shift in our electricity supply from coal and gas to renewable energy that is intermittent in generation makes energy storage now a critical part of the electricity grid also. It is forecast the amount of grid-connected energy storage capacity in Australia will increase to 20-22GWh by 2030.

This leads to twin challenges of replacing our existing energy storage technologies, and meeting new demand for storage in our electricity system to ensure renewables can provide dispatchable power.

Growth in battery demand over the next ten years is forecast to be similar to the growth seen in solar photovoltaic (PV) between 2008 and 2018.

Notes: IRENA's high scenario forecast used for ESS in Roskill projection. Growth rates in exhibit are compounding annual growth rates.
Source: World Economic Forum (2019) A vision for a Sustainable Battery Value Chain in 2030; Roskill (2020) Lithium-ion Batteries: Outlook to 2029, 4th Edition; International Renewable Energy Agency (2017) Electricity storage and renewables: Costs and markets to 2030; International Energy Agency (2021) Global EV Data Explorer; Jäger-Waldau (2019) Snapshot of Photovoltaics—February 2019; Accenture analysis.

With strong demand forecast, sales of batteries are expected to reach US$133-151b by 2030

Despite continued falls in prices, soaring demand over the next decade is expected to drive a 3.5- to 4-fold increase in battery sale revenues. The global battery market size was valued at US$36 billion in 2020 and is forecast to grow to US$133-151 billion by 2030. That would make the battery market almost as large as today's PC market.

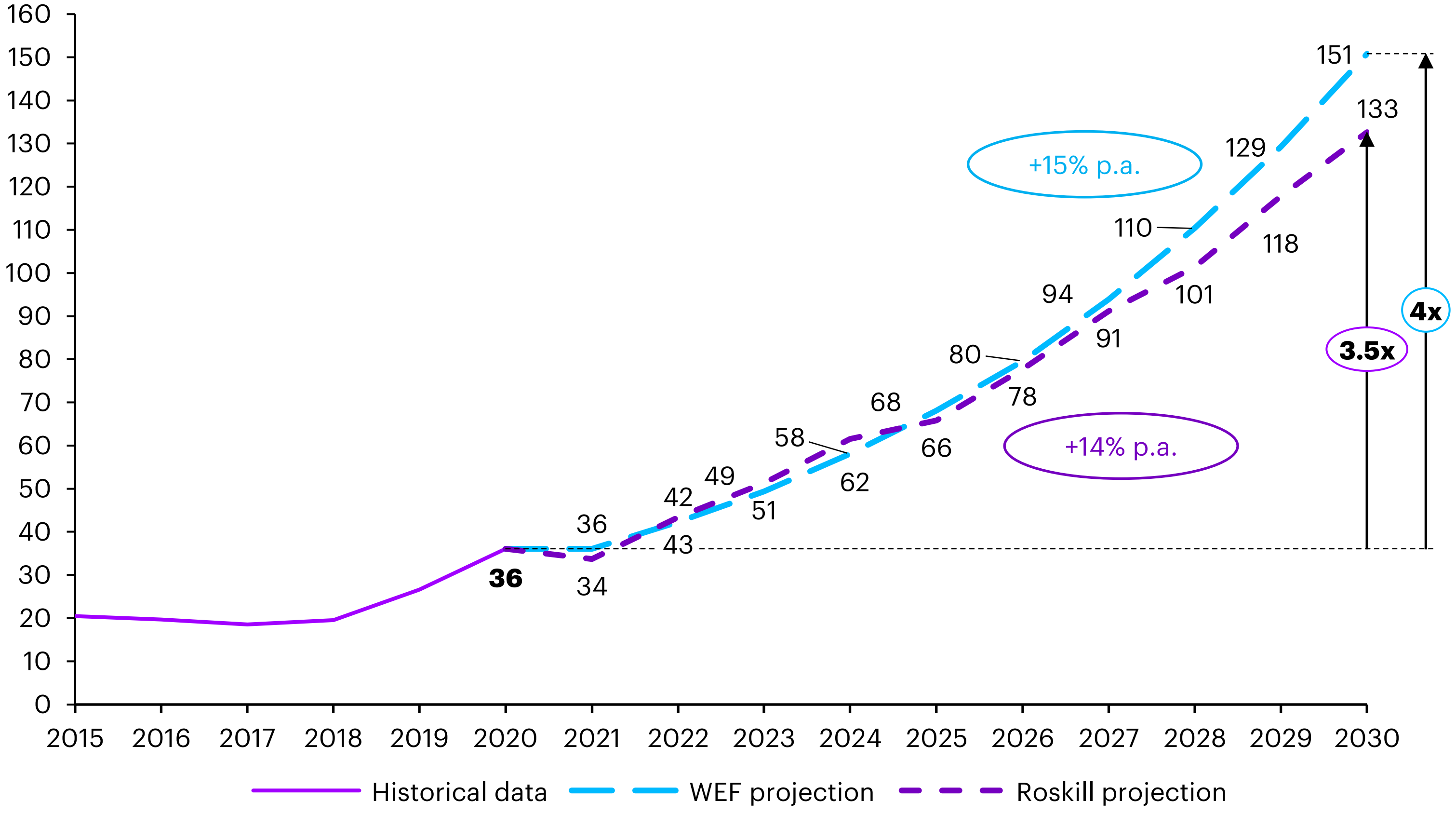
There is a slight flattening in the sales of battery packs between 2020 and 2021 as a result of both a large shift in the price of battery packs, as well as the reduced demand for EVs arising from the COVID-19 pandemic.

Given the long horizon of these forecasts, it is important to acknowledge risks to the industry's growth trajectory. A massive expansion in supply will be required to meet the forecast 9- to 10-fold demand growth, and it is possible that supply is not able to keep up with such robust demand. This could lead to price inflation, flattening demand.

However, the greater risk may be over-investment in capacity, or aggressive industrial policy and market subsidies by countries concerned about battery supply. Either of these scenarios would lead to a more rapid decline in prices than is anticipated, damaging margins for producers and reducing market size in 2030.

Exhibit 4: Global battery sales, projected to 2030

US$ billion (in 2021 dollars) per annum, 2020 = latest actual data

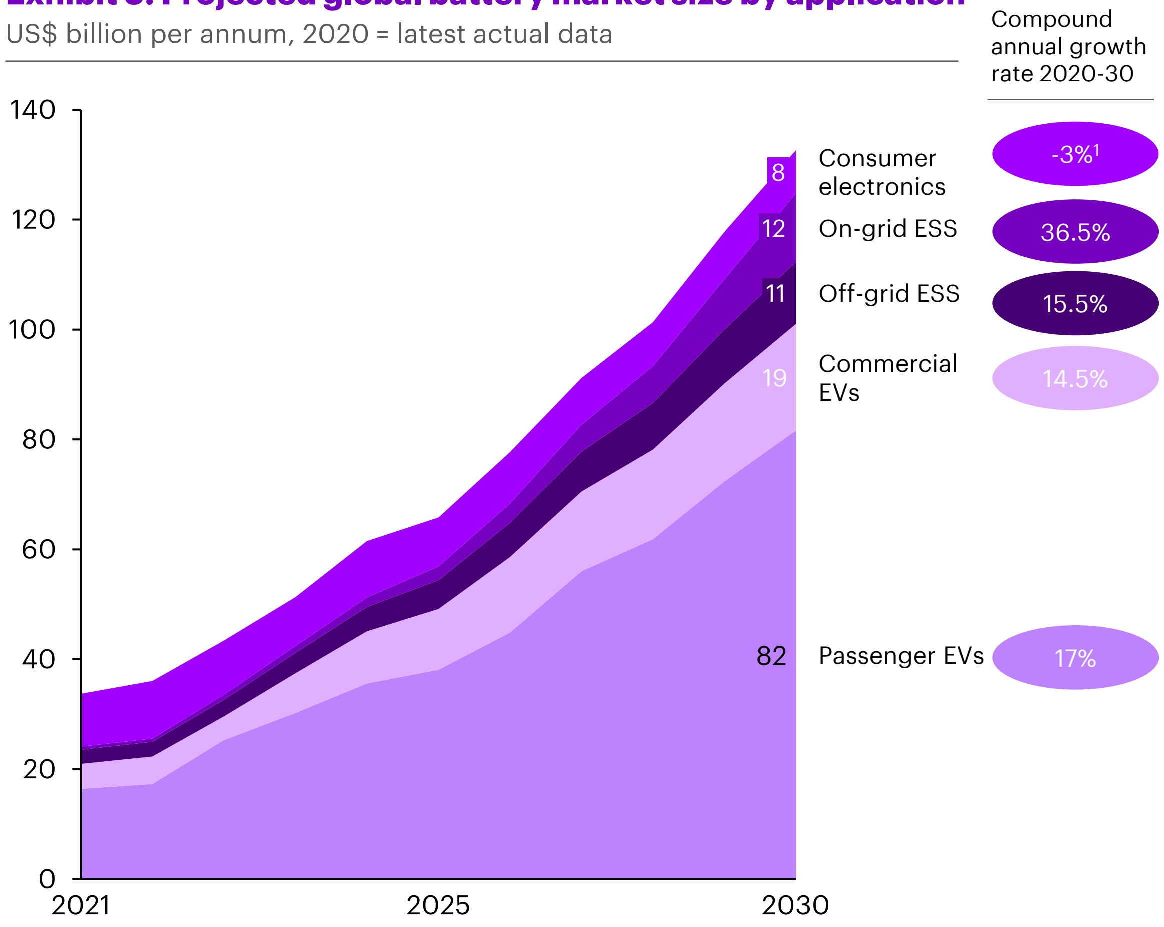


Notes: Roskill projection is used for further analyses. Growth rates in exhibit are compounding annual growth rates.
Source: World Economic Forum (2019) A vision for a Sustainable Battery Value Chain in 2030; Roskill (2020) Lithium-ion Batteries: Outlook to 2029, 4th Edition; Accenture analysis.

The largest application will likely be electric vehicles, but on-grid energy storage is the fastest growing

Exhibit 5: Projected global battery market size by application

US$ billion per annum, 2020 = latest actual data



The forecast growth in battery pack sales over the next decade is driven by three applications of energy storage: mobile, stationary and consumer electronics.

The electrification of transport, both passenger and commercial, presents the largest opportunity for batteries. Passenger EVs are estimated to capture 62% (US$82 billion) of battery pack sales in 2030, while commercial vehicles make up 15% (US$19 billion).

The growth in demand for passenger EVs reflects increasing affordability of the products as battery costs come down, but is also supported by strong policy incentives. Most OECD currently countries offer subsidies or incentives to increase the adoption of EVs. Sales of EVs are quite sensitive to these subsidies – after China removed half of its financial incentives for buyers in 2019, sales of new EVs fell by 30%. EVs are forecast to capture 54% of the global passenger-car fleet by 2050 and 73% of all vehicle sales.

Commercial EVs is the next largest use case by market value. It includes buses and trucks, as well as more specialised vehicles used in mining and defence applications.

While much of the focus has been on EVs, the global shift to renewable energy sources and the required energy storage is also substantial. Stationary use of batteries for energy storage systems (ESS) are set to account for 18% (US$23 billion) of battery pack sales in 2030.

The market for ESS is split between on-grid ESS, where either large-scale or small residential batteries are connected to the electricity grid, and off-grid applications. On-grid ESS is forecast to be the fastest growing use case over the next decade at 36.5% p.a.

Australia is a key market for both on-grid and off-grid ESS, and already ranks fifth in the world by market size according to the International Energy Agency (IEA). This is because Australia's strong investment in renewables needs to be supported by energy storage. It has already established several large-scale renewables projects, and there is very high uptake of rooftop solar PV. Renewables were responsible for 26% (55GWh) of Australia's electricity generation in 2020. Several other large-scale renewable projects are underway, expected to deliver a further 11GW to the grid by 2023.[2]

The final major application of batteries is consumer electronics, the most mature use case at present. Here the market size is set to decrease by 3% p.a. as reductions in prices are expected to more than offset volume growth over the next decade.

Notes: Roskill projections are supplemented with IRENA data ('high' case) for this analysis. 1 Reductions in battery prices are expected to more than offset volumes growth over the next decade in consumer electronics. 2. Projects underway are those that have secured finance or begun construction.

Source: Roskill (2020) Lithium-ion Batteries: Outlook to 2029, 4th Edition; International Renewable Energy Agency (2017) Electricity storage and renewables: Costs and markets to 2030; Accenture analysis.

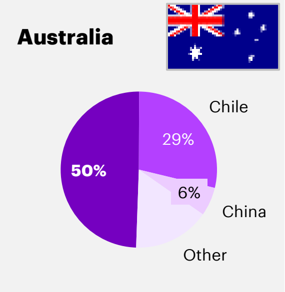
Batteries are produced through a complex global value chain, with Australia strong in mining and China dominant downstream

Exhibit 6: Battery value chain segments and market shares

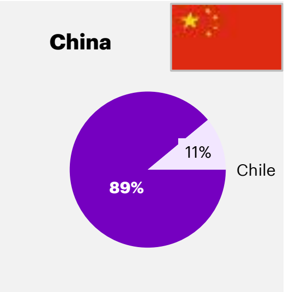
	Materials			Battery manufacturing		Integration & services	
	Mining raw materials	**Refining to chemicals**	**Active materials**	**Cell manufacturing**	**Battery pack assembly**	**Integration, service and maintenance**	**Re-use and recycling**
Description	Extraction of raw materials as ores or brines. Raw materials include: ▪ Lithium ▪ Graphite ▪ Nickel ▪ Manganese ▪ Cobalt ▪ Vanadium ▪ Copper ▪ Aluminium	Refining of raw materials to highly purified chemical salts. Steps include extraction of chemicals, solubilisation and crystallisation. Refined chemicals include: ▪ Lithium hydroxide ▪ Lithium carbonate ▪ Nickel sulfate	Production of precursors and finished active materials. Active materials include componentry such as: ▪ Cathode: LiNMC, LFP ▪ Anode: Graphite, Silicon	Manufacturing of the battery cell including electrode chemical processing, cell assembly and cell finishing. These three components are critical for the performance and quality of the battery pack.	Production of the battery pack consisting of many individual cells that are interconnected. Battery pack testing is an integrated part of battery pack manufacturing.	Integration and service of batteries for different applications, including installation and grid connection for on-grid ESS and maintenance for EVs.	Re-use and recycling of batteries materials through repurposing of degraded batteries, refurbishment or recycling to recover raw materials.

Share of segment by country (share of revenue, %)

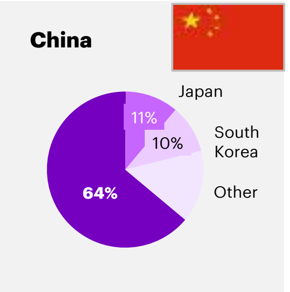
Australia



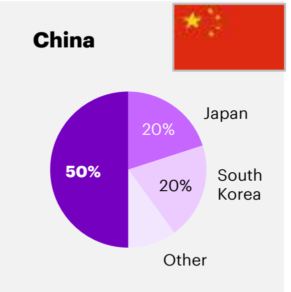
China



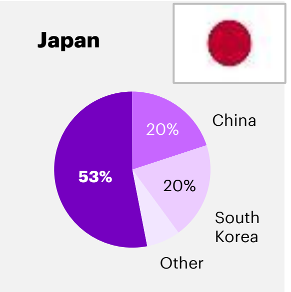
China



China



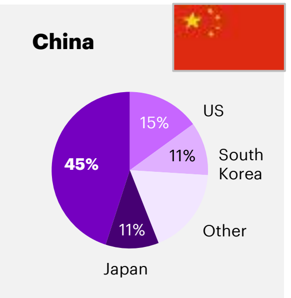
Japan



No dominant countries

Highly localised

China



Notes: 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.
Source: 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; Accenture analysis.

There are also emerging opportunities for the battery value chain to become more circular, reinforcing the technology’s green credentials

Batteries – due to their composition of valuable metals and varied use cases – are well-suited to form a circular economy. Proper circularity in battery use can redouble the environmental benefits of battery uptake by reducing the turnover on batteries in use, and by satisfying the demand for materials to produce new batteries. Three key approaches can facilitate this – re-use, refurbishment and recycling.

Re-use of batteries involves repurposing batteries which are no longer suitable for their original use case. For instance, lithium-ion batteries used in EVs degrade significantly during the first 8 to 12 years of operation, making them no longer suitable for use in an EV, but they still have sufficient capacity to be reused for stationary energy storage. Research and pilots, including at Sandia National Laboratory in the US, are collecting used EV batteries and repurposing them for ESS deployment, with appropriate assembly.

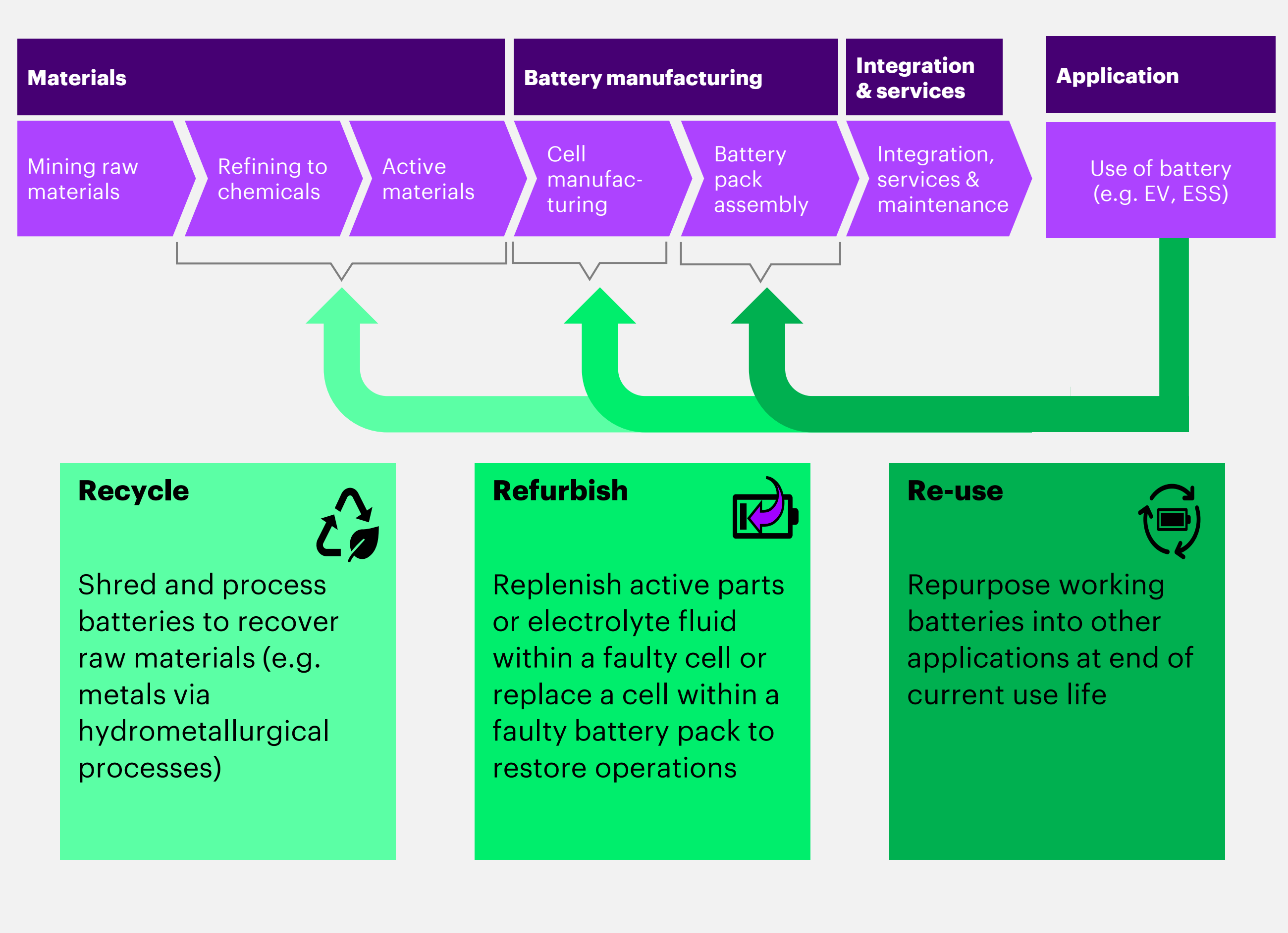
Refurbishment is a process in which the electrolyte (e.g. in a flow battery) is changed or a faulty cell is replaced to restore the effectiveness of a battery when it has lost its ability to hold charge. Revitalising a cell may also restore the function of the battery, for example, by removing or reversing the build up of metal plating at the anode.

Battery recycling involves the decommissioning of the battery to recover its constituent materials. Cathode metals are recovered through pyrometallurgy or hydrometallurgy, while other processes are used to recover electrolytes (e.g. washing) and graphite anodes (e.g. thermal treatment).

While these are nascent technologies, the potential for a circular economy is promising. The recycling rate for lead-acid batteries, which have been around for decades, is greater than 95%. Lithium-ion batteries have already shown the potential for 90% recovery in recycling processes. As collection and sorting improve and processes for different battery chemistries develop, less waste and better efficiency can be expected from battery products, maximising the technology’s environmental benefits.

Extending the useful life of batteries reduces the need for new batteries; and using materials already in circulation decreases the need for new materials. Importantly, a circular economy can also reduce the net waste produced from batteries.

Exhibit 7: Recycling and re-use opportunities along the battery value chain



Materials

- Mining raw materials
- Refining to chemicals
- Active materials

Battery manufacturing

- Cell manufac-turing
- Battery pack assembly

Integration & services

- Integration, services & maintenance

Application

- Use of battery (e.g. EV, ESS)

Recycle

Shred and process batteries to recover raw materials (e.g. metals via hydrometallurgical processes)

Refurbish

Replenish active parts or electrolyte fluid within a faulty cell or replace a cell within a faulty battery pack to restore operations

Re-use

Repurpose working batteries into other applications at end of current use life

Source: CSIRO (2021) Australian landscape for lithium-ion battery recycling and reuse in 2020; Accenture analysis.

02

Australia has sources of competitiveness that it can develop along the value chain

Australia is already seeing investment in several segments beyond mining raw materials

Australia's presence in the battery value chain is currently limited to mining raw materials, but there are emerging investments further downstream in the value chain.

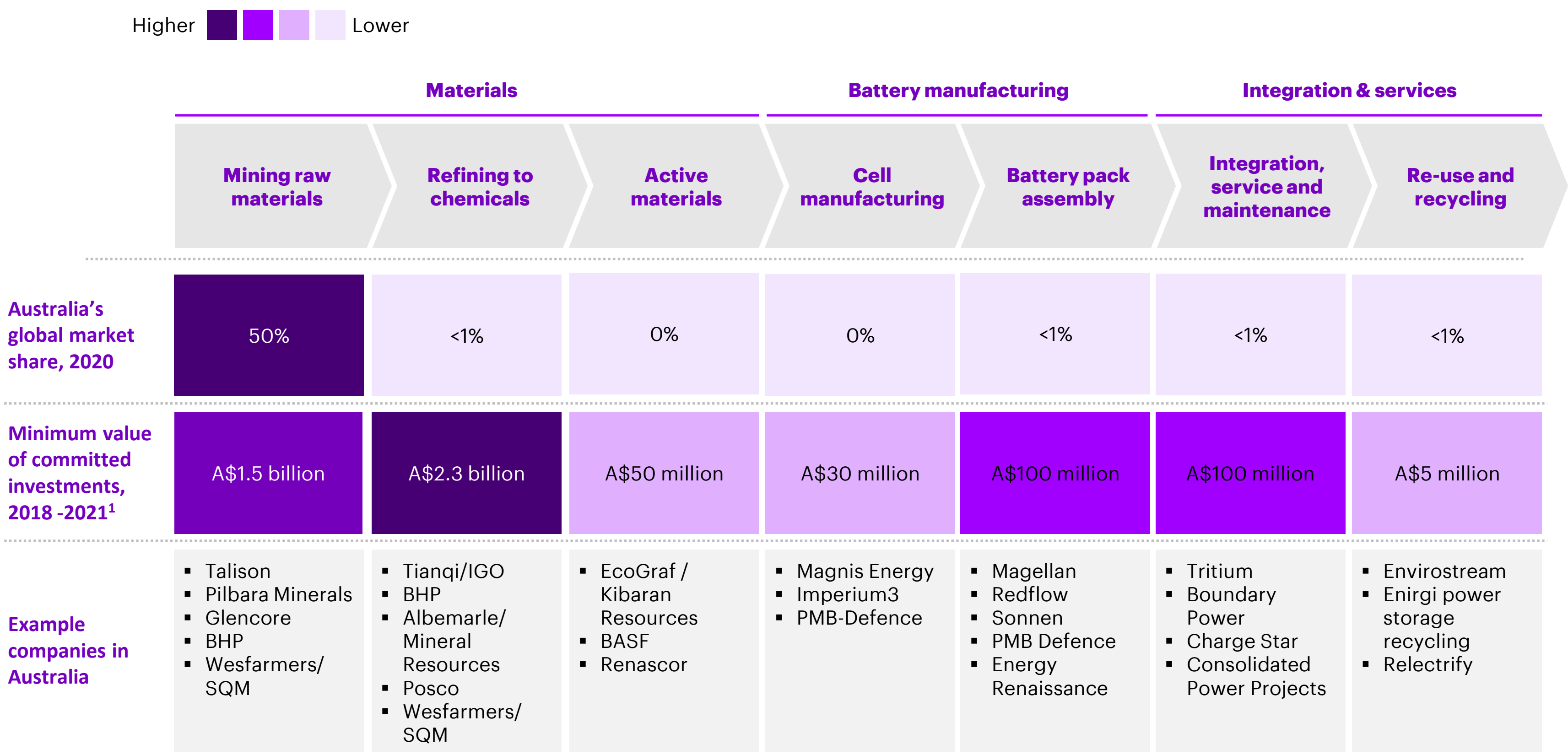
There are several large investment in materials, particularly in refining. The two most mature investments are for refining plants at Kwinana and in Kemerton. In active materials, EcoGraf is spearheading sustainably produced carbon anodes for export to global supply chains. BASF is also developing a pilot domestic processing plant for precursor to active materials.

In battery manufacturing, there are projects underway in both cell manufacturing and battery pack assembly. Magnis Energy has completed a feasibility study for a gigafactory in Townsville which is projected to have capacity to produce 15GWh of lithium-ion battery cells annually.

Energy Renaissance have proposed a domestic battery assembly plant in the Hunter Valley, targeting the needs of Australian customers, with construction scheduled to begin in 2021.

While investments upstream have tended to be more significant, some companies down the value chain are already creating export opportunities. Examples include Tritium, which has developed a fast-charging technology for EVs. It has now installed more than 3,000 charging points worldwide and in May 2021 listed on the NASDAQ with a A$2.2 billion enterprise value.

Exhibit 8: Australia's current presence in the battery value chain



Higher ■ ■ ■ ■ Lower

	Materials			Battery manufacturing		Integration & services	
	Mining raw materials	**Refining to chemicals**	**Active materials**	**Cell manufacturing**	**Battery pack assembly**	**Integration, service and maintenance**	**Re-use and recycling**
Australia's global market share, 2020	50%	<1%	0%	0%	<1%	<1%	<1%
Minimum value of committed investments, 2018 -2021[1]	A$1.5 billion	A$2.3 billion	A$50 million	A$30 million	A$100 million	A$100 million	A$5 million
Example companies in Australia	▪ Talison ▪ Pilbara Minerals ▪ Glencore ▪ BHP ▪ Wesfarmers/ SQM	▪ Tianqi/IGO ▪ BHP ▪ Albemarle/ Mineral Resources ▪ Posco ▪ Wesfarmers/ SQM	▪ EcoGraf / Kibaran Resources ▪ BASF ▪ Renascor	▪ Magnis Energy ▪ Imperium3 ▪ PMB-Defence	▪ Magellan ▪ Redflow ▪ Sonnen ▪ PMB Defence ▪ Energy Renaissance	▪ Tritium ▪ Boundary Power ▪ Charge Star ▪ Consolidated Power Projects	▪ Envirostream ▪ Enirgi power storage recycling ▪ Relectrify

Notes: 1. Actual investment only. List of project investment counted: Greenbushes mine (Talison Lithium); Wodgina Lithium (Albemarle, Mineral Resources Ltd); Kemerton Lithium Plant (Albemarle); Kwinana Lithium Processing Plant (Tianqi); Nickel West Kwinana (BHP); Pilgangoora expansion (Pilbara Minerals); Covalent Lithium Mt Holland Lithium mine and Kwinana refining project, subject to approvals (Wesfarmers/Sociedad Quimica); Graphite Processing Facility (EcoGraf); Submarine Battery Plant (PMB Defence); Elizabeth battery factory (sonnen). Other investment counted has been received by: Evergen Solar Service Group; Relectrify; RedEarth Energy Storage; Envirostream; Redflow; Tritium; Redback Technologies Energy; Evie Networks; and, Chargefox.

Source: Queensland Government (2021) Imperium 3; Roskill (2020) Lithium-ion Batteries: Outlook to 2029; OECD.Stat (2020) Input-Output Tables 2018 edition; AusTrade (2018) The Lithium-ion Battery Value Chain: New economy opportunities for Australia; CSIRO (2020) State of Play: Australia's Battery Industries; AFR (2021) Tritium charges to $2b NASDAQ listing; Accenture analysis.

To diversify beyond its current strengths, Australia needs to develop global competitiveness – on cost, reliability or through specialisation

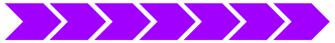
Expanding beyond our existing strength in mining battery minerals will not be easy. There are attractive opportunities across with the value chain, with a combined US$352 billion in revenue up for grabs in 2030. But battery industries are already globally competitive, with countries vying for positions of strength as growth is forecast to rapidly accelerate.

To succeed, Australia will need to be selective in where it focuses and prioritise segments where it can develop sustainable competitive advantage.

Cost is central to competitiveness but it is not the only factor to consider. Another important factor in batteries in particular is reliability, especially as customers look to diversify their supply chains away from the current concentration in the refining and active materials segments.

Competitiveness can also be achieved through specialisation, focussing on parts of the market where Australia is likely to be able to produce a distinctive or premium product. That could be in areas where demand in Australia is more mature than elsewhere and our producers are therefore likely to develop higher quality products faster.

Exhibit 9: Potential sources of competitive advantage for Australia

Factor		Description	The Australian advantage	
…on costs	Operating costs	Costs including (e.g. labour, energy, logistics, tax and materials)	Australia has some cost advantages from its dominant role in the extraction of raw materials, such as: • Ability to achieve process and production efficiencies by co-locating raw materials, refining and precursor manufacturing activities • Security of raw materials supply Australia's higher costs in low-skill labour present less of a challenge for batteries than in some areas of manufacturing due to high degrees of automation, though our high construction costs is a potential barrier	 Australia's **cost** advantage supports: • Mining raw materials • Refining chemicals • Active materials and their precursors
	Capital costs	Availability and cost of capital (e.g. wages, materials)		
…on reliability		Australia's ability to be a reliable and secure supplier to help customers diversify their supply chains	Australia can position itself as a reliable participant in the global battery value chains because of three key characteristics: • A wide breadth and abundance of key minerals • Openness to trade • Low sovereign risk	 Australia's **reliability** advantage supports: • All points in the value chain
…through specialisation		Australia's ability to provide and manufacture distinctive and better products for specialised use cases. Specialisation could be in areas where demand is already mature, or where it will mature ahead of peer countries	Australia can develop specialist capability in areas that are expected to mature faster in Australia than abroad including ESS, commercial vehicles, and batteries suited to Australia's unique conditions	 Australia's **specialisation** advantage supports: • Cell manufacturing • Battery pack assembly • Integration, service and maintenance

Source: Accenture analysis.

While Australia has relatively high labour and energy costs, they are comparable with major OECD peers developing battery industries

Labour

Australia's labour force is unlikely to be cost competitive with economies such as China and Poland, due to higher wage rates for both low- and high-skilled professions. However, Australia is comparable with key OECD peers when it comes to labour costs.

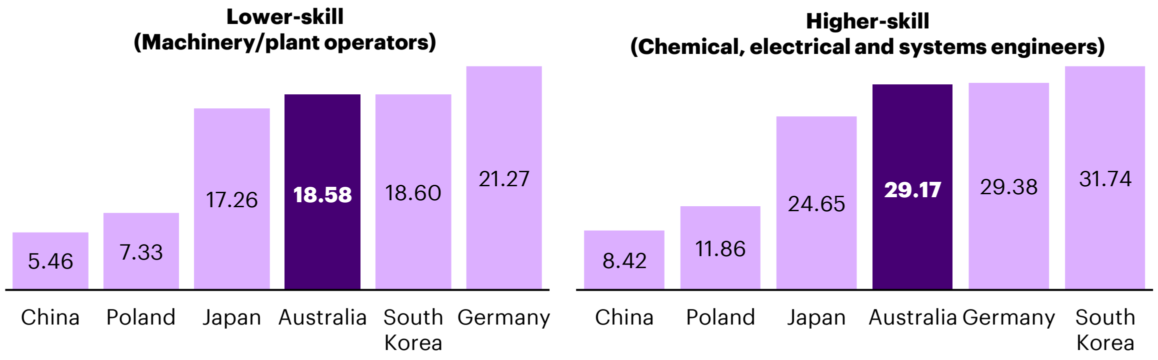
In lower-skill occupations such as machinery and plant operators, Australian wages are higher than Japan and similar to South Korea. Further, production is becoming less reliant on low-skill labour as factories and plants become more automated.

In higher-skill occupations (for example, engineers), Australia's costs are similar to those of Germany and below South Korea.

Availability is likely to be a greater challenge than cost. The supply of high-skill labour in Australia is vulnerable to shocks due to reliance on migrant labour and the periodic booms and busts of the resources sector placing upward pressure on wages in adjacent sectors, as discussed in Chapter 5.

Exhibit 10: Average wages for selected occupations, Australia and global peers

US$/hr, 2019



Energy

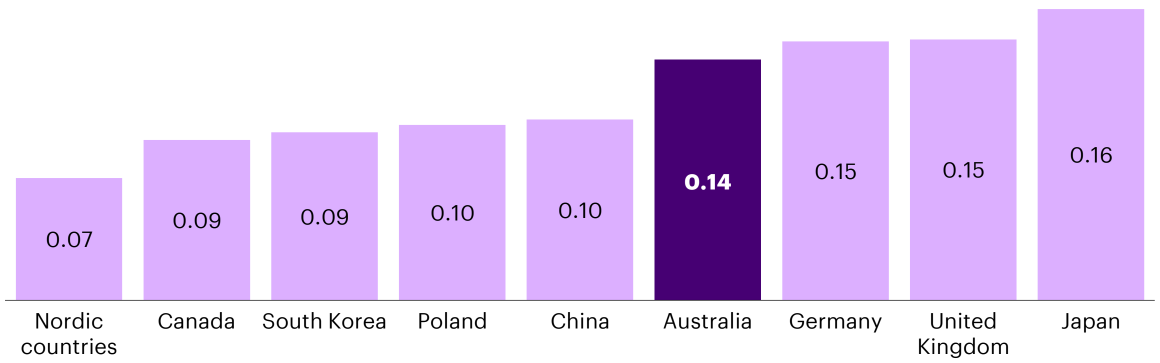
Another factor impacting Australia's cost competitiveness is the cost of energy. Energy prices in Australia are among the highest in the OECD, and can present a significant cost burden, especially in industries with high energy needs such as in chemical processing and manufacturing.

However, most of our key OECD peers in batteries – Germany, Japan and the UK – face comparably high energy costs as Australia. Each of these countries are growing their battery industries – the UK and Germany are primarily active in cell and battery manufacturing and EV integration, and Japan is a significant player throughout the value chain, but especially in assembly and electronics integration.

In 2019-20, Australian businesses paid US$0.14 per kilowatt hour, placing Australia among the top third most expensive OECD countries for industry electricity prices (see Exhibit 11). This has been driven by an undersupply of consistent generation capacity (as renewables come online and coal plants retire), the costs of maintaining an extensive transmission network, and the retail margins charged by utility providers.

Exhibit 11: Electricity prices for industry, Australia and global peers

US$/kWh, 2019-20



Notes: Australian average weekly cash earnings are pre-tax, though exclude salary sacrifice. German wage data is aggregated from Payscale, Glassdoor, Erieri, Salary expert and Paylab data and validated from national statistics.
Source: ABS (May 2018) Employee earnings and work hours, Category 6306.0 Employee Earnings and Hours; Destatis Statistisches Bundesamt (2021) Earnings and earnings differences; Ministry of Employment and Labour (2021) Survey Report on Labor Conditions by Employment Type, Wages and Working Hours by size and industry type; National Statistics Institute of China (2020) Average Annual Wage of Employed Persons in Different Positions; Statistics Bureau of Japan (2019) Japan Statistical Yearbook 2019; Statistics Poland (2019) Employment, wages and salaries in the national economy in 2019 – preliminary data; International Energy Agency (2020) Energy Prices and Taxes for OECD Countries, latest release includes data from 2019; World Petrol Prices (Sept 2020) Business Energy Prices; Laidlaw and Deans (2019) Energy challenges; Accenture analysis.

Australia may be able to achieve operating cost advantages over OECD peers in refining and active materials – cell manufacturing will be harder

	Case study 1: Refining metals			Case study 2: Active materials			Case study 3: Cell manufacturing		
	% of unit cost (benchmark)		Australia's position compared with OECD peers	% of unit cost (benchmark)		Australia's position compared with OECD peers	% of unit cost (benchmark)		Australia's position compared with OECD peers
Labour[1]	6	🟡	Australia has the relevant skill profiles but faces competition with mining sector	12	🟡	Labour costs are higher than peer countries at lower skill levels but comparable at higher skill levels	10	🟡	Labour costs are higher than peer countries at lower skill levels but comparable at higher skill levels
Materials	55	🟡🟢	Some potential for cost advantage through proximity to key minerals, though processing chemicals still be imported	47	🟢	Australia can achieve cost savings in metal materials by integration with domestic metal refiners, though some chemicals still need to be imported	55	🟡	Many inputs will need to be imported from current global suppliers – though that could change if upstream capabilities develop locally
Energy[2]	17	🟡🔴	Energy costs in Australia are broadly similar to Taiwan but more expensive than South Korea	15	🟡	Australia has access to lower cost energy than Germany but faces higher costs than South Korea	6	🟡	Australia has access to lower cost energy compared with South Korea but higher cost compared with Japan
Logistics	6	🟢	Australia can achieve cost saving as high-volume ore does not need to be shipped	9	🟢	Co-location with refinery offers a 25-30% savings in freight costs	6	🟡	Australia is likely to be cost neutral on transport, depending on supplier location
Tax[3]	16	🔴	Australia has a higher corporate tax rate (30%) than Taiwan (20%) and Korea (25%)	17	🔴	Australia has a higher corporate tax rate (30%) than Germany (16%) and Korea (25%)	23	🔴	Australia a higher corporate tax rate (30%) than Korea (25%) and Japan (23%)
Total cost	**100**	🟡🟢	Overall, Australia's advantage on materials and logistics may mean that it is able to generate a cost advantage	**100**	🟡🟢	Overall, Australia's advantage on materials may mean that it is able to generate a cost advantage	**100**	🟡	Australia is unlikely to be able to achieve a unit cost advantage in cell manufacturing compared to OECD peers

🟢 Advantage

🟡 Neutral

🔴 Disadvantage

Assumptions:

- **Australia:** Refining is located in a domestic battery hub.
- **Benchmark:** Taiwan and South Korea

Assumptions:

- **Australia:** Refining and active materials manufacturing are co-located within a domestic battery hub.
- **Benchmark:** Germany and South Korea

Assumptions:

- **Australia:** Plant is highly automated.
- **Benchmark:** South Korea and Japan

Notes: 1. Labour estimates do not account for effective productivity. 2. Energy costs have been compared on a cost per kilowatt-hour basis. 3. Headline tax figures provided by PwC Tax Country Profiles do not include local tax (e.g. maximum 2.5% local tax in Korea)
Source: Roskill (2020) Lithium-ion Batteries: Outlook to 2029; ABS (2020) Australian Industry, 2018-19, Catalogue 8155.0; PwC (2021) Tax Summaries: Germany, Japan, Republic of Korea, Taiwan; Expert interviews and Accenture analysis.

Australia does face significantly higher capital costs associated with establishing plants and facilities, largely driven by construction wages

The capital expenditure required to establish new mines, factories, or production facilities is significantly higher in Australia, primarily due to the high wages paid to construction workers.

Construction workers in Australia earn over 30% more than their best-paid peers among benchmark countries, primarily due to the small Australian labour force and high activity in the construction sector. There is also significant volatility in the pipeline of construction projects, with construction booms influencing demand for construction workers and creating further wage inflation.

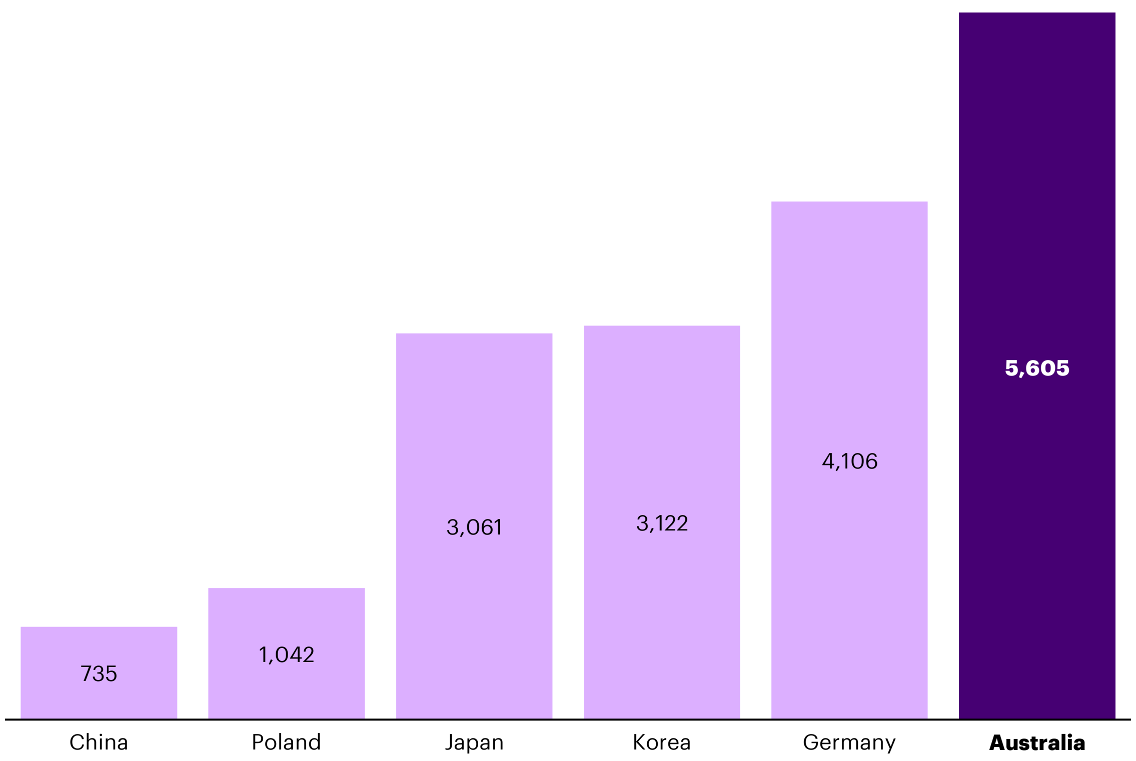
Aside from wages, materials can cost substantially more in Australia than elsewhere around the globe. For large concreting jobs, the price in Australia is more than 70% higher than the UK, at US$2,570 per 1,000 units and higher than many OECD peers and competitors such as Korea, China, Japan, Poland and the United Kingdom. For significant construction projects, structural steel beams cost $1,750 per tonne, more than double the price in Japan ($794) though cheaper than the UK price of $2,842. Bricks in Australia cost up to seven times as much in Australia as elsewhere (e.g. Korea). High material costs are driven in part by significant geographic isolation, which raises the cost of importing materials.

While expensive, material costs in Australia are not the highest among OECD peers. On a range of materials, including concrete, steel, reinforcement bars, bricks and copper pipes, the material costs of construction are higher in Germany than in Australia. Nevertheless, Germany is a leading manufacturing location globally, and sustains significant industrial investment.

Overall, the costs of construction in Australia are high compared to many of our peers. While some countries in Europe do face higher construction costs, these are often offset by generous government incentive schemes. For instance, the German Government has established a €1.5 billion battery fund and in 2020 awarded BASF €175 million and Varta €300 million to set up in Germany.

Exhibit 12: Average wages in the construction sector

US$/month 2018-19, in 2019 USD



Notes: Material prices for construction for each country taken as the average price in cities located in the country surveyed by Turner & Townshend.
Source: International Labour Organisation (2021) Mean nominal monthly earnings of employees; National Statistics Institute of China (2020) Average Annual Wage of Employed Persons in Different Positions; Statistics Poland (2019) Employment, wages and salaries in the national economy in 2019 – preliminary data; Turner & Townshend (2019) International Construction Market Survey; Accenture analysis.

Australia offers reliability and security to customers looking to diversify their supply chains

With increasing concern about the risks of geographic concentration of the battery value chain, Australia can position itself as a reliable and secure alternative producer of processed materials.

Refining, active materials production, and cell manufacturing are very concentrated in a small number of countries. At present, almost 90% of refining activity in the battery value chain occurs in China. Similarly, over 50% of the production in active materials and cells occurs in China.

As batteries become a more important part of the energy system and the geopolitical environment is put under stress, as seen in recent trade wars, concern about the current structure of the value chain is growing.

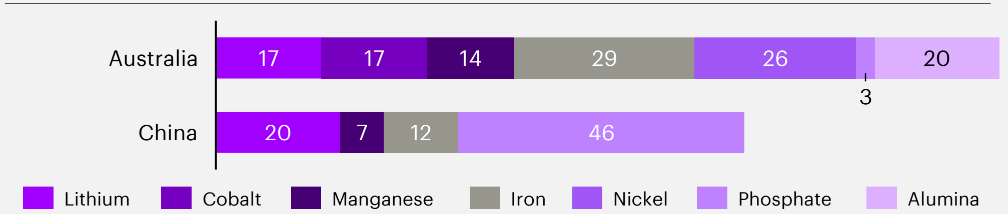
In response, major countries have already begun to diversify their supply chains and demand more sustainable and transparent battery life cycles. The EU has announced a new Sustainable Batteries Regulation with a range of requirements, including sustainable and responsible supply of raw materials. The US has developed a Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals.

Australia can position itself as a reliable alternative in global battery value chains. It is well positioned because of its wide breadth and abundance of key minerals, openness to trade, and low sovereign risk. These factors, combined with Australia's long history of successful participation in mining exports and global supply chains, position Australia well for the next phase of industry growth.

1. **A wide breadth and abundance of key minerals:** Australia's abundance of minerals and battery materials, and an established mining industry that operates to high environmental and ethical standards, provide a sustained source of inputs into downstream segments.

Exhibit 13: Share of global battery minerals reserves

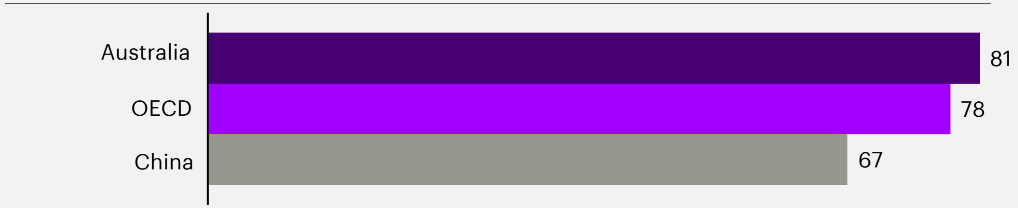
%, 2018



2. **Openness to trade:** Compared to current global leaders and even other OECD members, Australia has relatively low barriers to trade (both tariff and non-tariff). We have no recent history of protectionist intervention – rather, the small size of our economy means we are reliant on keeping global supply chains open and functioning.

Exhibit 14: Openness to trade

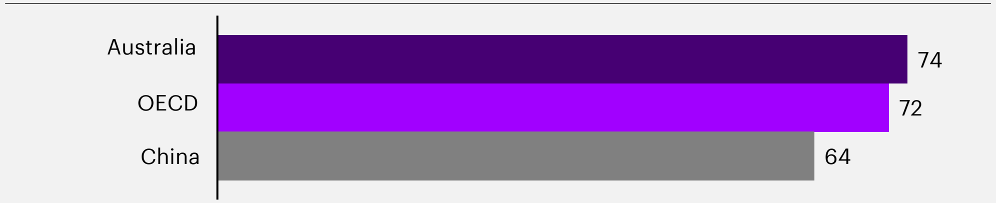
Index, 2020



3. **Low sovereign risk:** the robust, stable economy and political landscape for international investment in Australia, as well as transparent policy making, make us an attractive destination to build industry capacity.

Exhibit 15: Transparency of government policymaking

Index, 2020



Source: AusTrade (2018) The Lithium-ion Battery Value Chain: New economy opportunities for Australia; World Economic Forum (2020) Global Competitiveness Report; Accenture analysis.

Australia's climate, geography, defence and transport needs point to areas of potential specialisation

While cost competitiveness will always be important, manufacturers can improve their competitiveness by developing a distinctive, premium product that meets specific needs.

For domestic battery manufacturers, this can be achieved by focussing on innovation and technological improvements that address a particularly Australian problem, such as high-heat applications of batteries, or the needs of local customers.

Australia can establish itself as a global leader in battery safety and reliability standards. High-heat is a critical safety issue in the wide scale uptake of batteries, and by developing a solution to mitigate battery fires that is effective in the Australian climate, Australian manufacturers could also access export markets in other warm climate countries.

Other domestic examples include defence and transport applications. Defence is potentially a cornerstone customer for specialised batteries that require hardening or wide operating temperature ranges, or where supply chains must be tightly controlled for security reasons. Expert interviews also suggest that there may be a willingness to pay a price premium for domestically manufactured equipment too support local industry. Governments looking to electrify their fleets also may consider criteria other than price, including local jobs and industry development potential, when electrifying their public transport fleets.

These opportunities depend on the market developing in such a way that supports specialisation. If the market becomes commoditised, producers will compete on price only, reducing the scope for Australia to be competitive through specialisation.

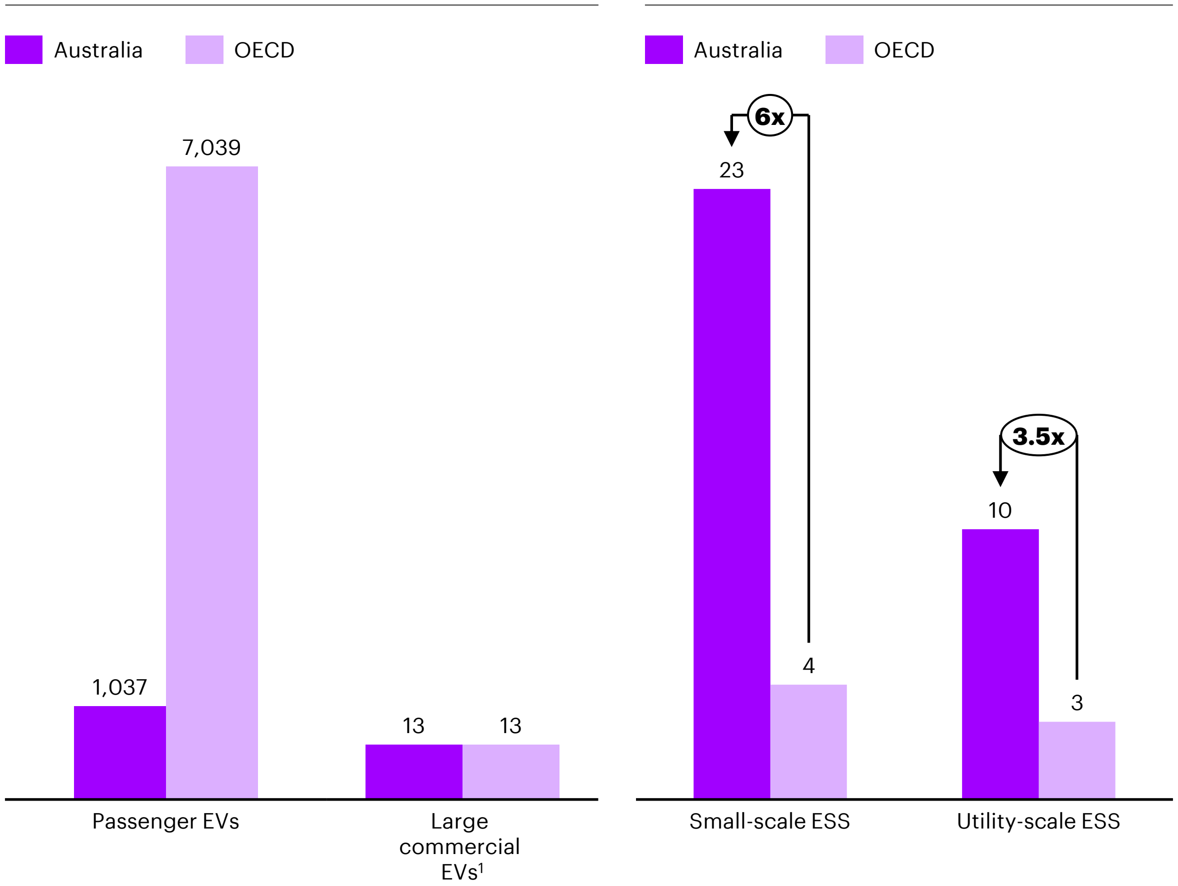
Exhibit 16: Australia’s specialisation opportunities in battery manufacturing

	Climate	**Geography**	**Defence**	**Transport**
				
The opportunity	Australia’s extreme conditions make safety a key concern for the domestic market meaning Australia can act as a global leader in safe batteries, particularly in the mitigation of battery fires	Australia has significant off grid energy storage requirements both in remote communities and a number of industry sectors due to the vast distances between cities	Creating sovereign defence industrial capability is a key priority for government, and batteries are likely to become an increasingly important technology in defence in both stationary and mobile uses	State and territory governments are already beginning to transition public transport fleets away from internal combustion engines and prioritising supporting local industry
Key customers	• Agricultural sector • Mining sector • Defence sector • Regional/remote households	• Mining sector • Remote households • Defence sector • Regional diesel-reliant neighbours (e.g. Pacific nations) • Telecommunications	• Defence sector	• State governments • Freight sector
Industry segments involved	• Battery pack assembly • Cell manufacturing • Battery integration & services	• Battery pack assembly • Cell manufacturing • Battery integration & services	• Battery integration & services • Battery pack assembly • Cell manufacturing	• Battery pack assembly • Cell manufacturing • Active materials

Source: Expert interviews and Accenture analysis.

Australia’s more developed demand in ESS could help local producers build a competitive advantage

Exhibit 17: Adoption of batteries for different applications



Number of vehicles per million people, 2020

Number of MWh per million people, 2020

Australia can also develop specialisation by targeting battery use cases where domestic demand is expected to mature faster than in peer countries.

Australia already has a higher uptake that our peers in both small-scale (6x higher than OECD peers) and grid-scale (3.5x higher than OECD peers) ESS. This reflects our very high penetration of residential solar installations, and the overall share of renewables in our grid (26%).

Our strength in stationary ESS looks set to continue with IHS Markit forecasting Australia to comprise 7% of global installations by 2030, making it the third largest market. A recent flurry of new grid-scale ESS announcements from utilities support this forecast with AGL’s grid-scale batteries in NSW, Victoria and South Australia, EnergyAustralia’s Gannawarra and Ballarat Energy Storage Systems, Vena Energy’s 100MW battery in Queensland and CEP Energy’s 1,200MW battery project, which would be the world’s largest battery. Such projects could support the establishment of viable domestic battery pack and integration and services industry.

By serving these rapidly maturing domestic markets, Australian manufacturers could develop unique technology and products that may become globally competitive.

Australia’s regional neighbours (e.g. ASEAN, the Pacific) are also potential export customers for both residential and grid-scale ESS, especially given the island geography and diesel-reliance of many of these countries.

Australia’s uptake of large commercial EVs is on par with the OECD average. However, based on tenders released by state and territory public transport networks, Australia is set to lead the OECD average in electric bus registrations, with at least 10 electric buses per million compared to the OECD average of 7. This is driven largely by NSW and ACT commitments to electrify their bus fleets.

While forecasts suggest that electric vehicles will be the largest source of battery demand in 2030. domestic adoption of passenger EVs substantially lags the OECD average, and several state governments have recently introduced new road usage charges for EVs that are likely to further slow progress. Combined with our lack of domestic automotive manufacturing, this suggest EV batteries are unlikely to be a major application for Australian cell and battery producers.

Notes: Populations recorded by OECD in 2018 used. Statistics include OECD member countries with available ESS or EV data, and reflect at least 65% of total OECD population.
1. Australian commercial EVs are not recorded by IEA, so State of EV lists were used for a count of committed commercial EV fleets.
Source: IEA (2021) Global EV data explorer; Electric Vehicle Council Australia (August 2020) State of EVs; Australian states and territory government media releases; Wood Mackenzie, via Green Tech Media (2020) Australia’s energy storage capacity more than doubles; European Association for Storage of Energy (2021) EMMES 5.0; WoodMackenzie (2021) US Energy Storage Monitor; US Department of Energy (2020) DOE OE Global Energy Storage Database; IHS Markit (2021) 2030 ESS Forecast; Accenture analysis.

03

Diversified battery industries could contribute $7.4 billion annually to Australia’s economy in 2030

Australia can expand its presence throughout the value chain, with some opportunities being more immediate than others

There are prospective opportunities for Australia in every step of the value chain, but the nature and size of those opportunities varies.

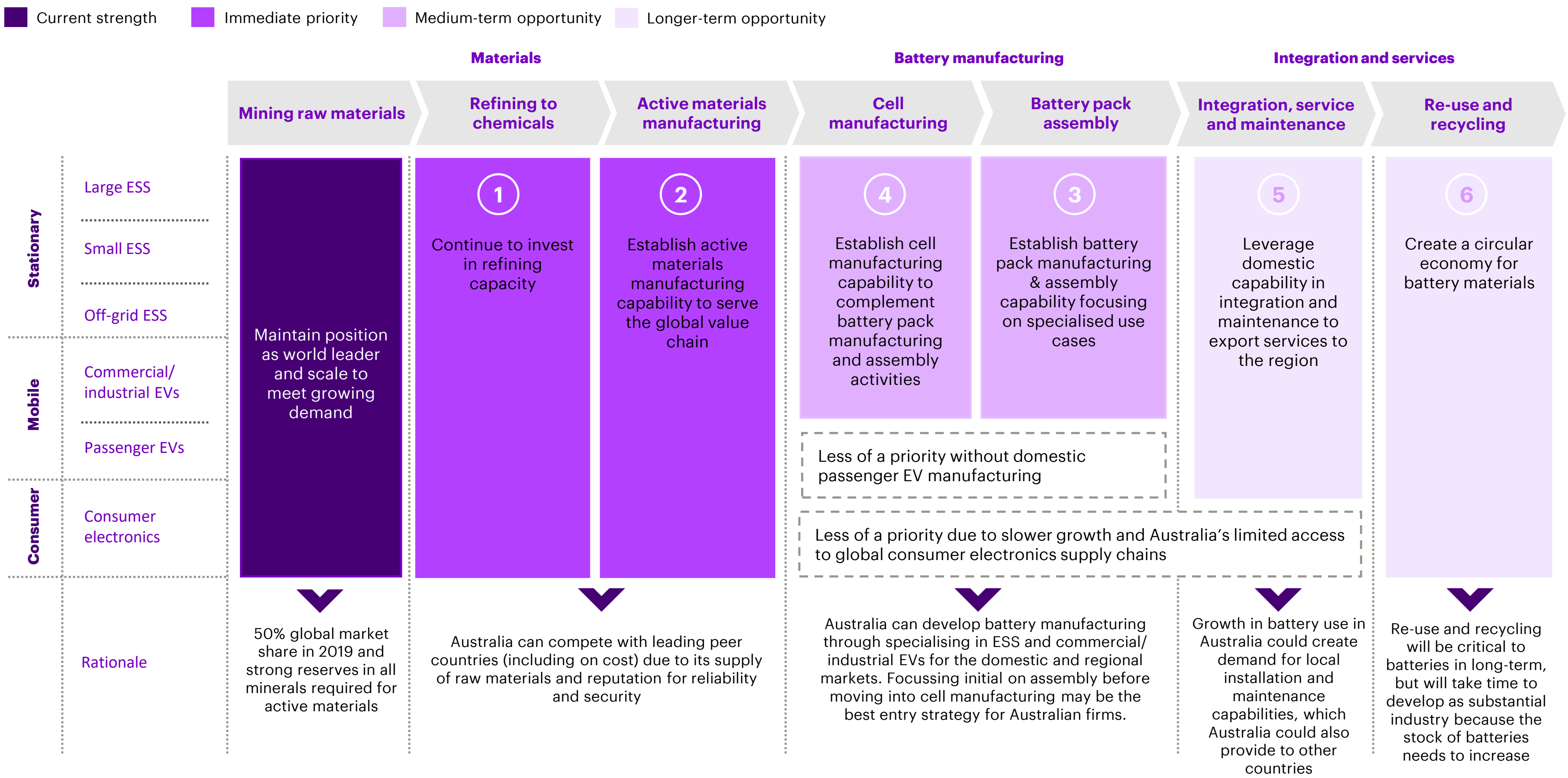
Immediate priorities for Australia include segments that Australia can enter more readily (for example, those that leverage Australia's raw materials strengths or build on existing activity and investment).

Medium-term opportunities are those that can still have a significant impact on the Australian economy, however they may require longer to mature and additional support to grow as they are not an existing domestic strength.

Longer-term opportunities are less accessible today and likely to develop later in the decade, but where Australia has a strong potential to compete in the long-run.

While these opportunities appear most prospective based on fundamental criteria, the industry environment is evolving rapidly and Australia's strategy needs to remain dynamic.

Exhibit 18: Australia's opportunities for future battery industries by 2030



■ Current strength ■ Immediate priority ■ Medium-term opportunity ■ Longer-term opportunity

Materials | **Battery manufacturing** | **Integration and services**

Mining raw materials | **Refining to chemicals** | **Active materials manufacturing** | **Cell manufacturing** | **Battery pack assembly** | **Integration, service and maintenance** | **Re-use and recycling**

Stationary: Large ESS; Small ESS; Off-grid ESS

Mobile: Commercial/ industrial EVs; Passenger EVs

Consumer: Consumer electronics

Maintain position as world leader and scale to meet growing demand

① Continue to invest in refining capacity

② Establish active materials manufacturing capability to serve the global value chain

④ Establish cell manufacturing capability to complement battery pack manufacturing and assembly activities

③ Establish battery pack manufacturing & assembly capability focusing on specialised use cases

⑤ Leverage domestic capability in integration and maintenance to export services to the region

⑥ Create a circular economy for battery materials

Less of a priority without domestic passenger EV manufacturing

Less of a priority due to slower growth and Australia's limited access to global consumer electronics supply chains

Rationale

50% global market share in 2019 and strong reserves in all minerals required for active materials

Australia can compete with leading peer countries (including on cost) due to its supply of raw materials and reputation for reliability and security

Australia can develop battery manufacturing through specialising in ESS and commercial/ industrial EVs for the domestic and regional markets. Focussing initial on assembly before moving into cell manufacturing may be the best entry strategy for Australian firms.

Growth in battery use in Australia could create demand for local installation and maintenance capabilities, which Australia could also provide to other countries

Re-use and recycling will be critical to batteries in long-term, but will take time to develop as substantial industry because the stock of batteries needs to increase

Source: Accenture analysis.

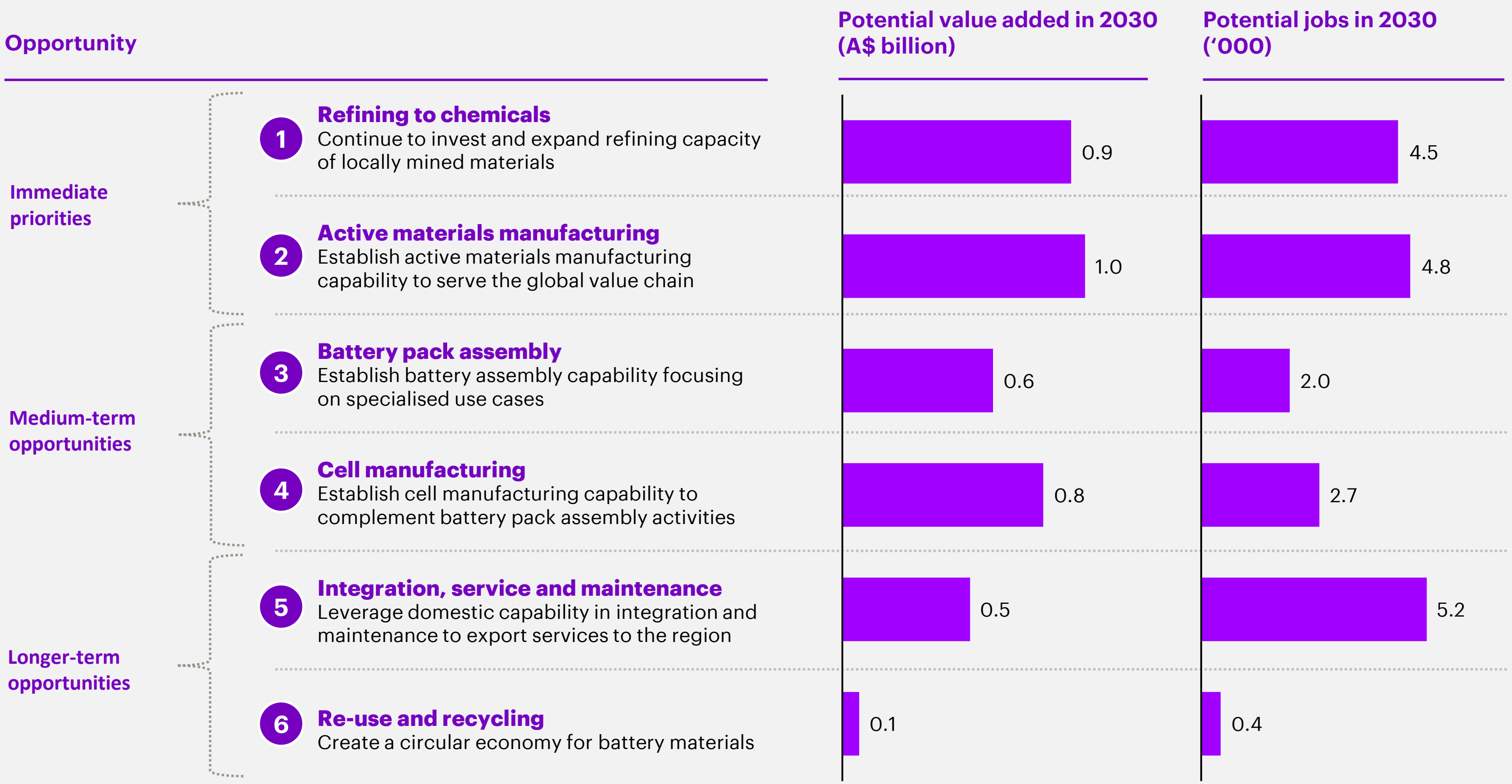
Each opportunity can deliver additional value added and jobs in 2030

Australia could harness substantial benefits from expanding its current presence in the battery value chain. Each of the six opportunities identified could generate additional value added for Australia and support jobs in our economy.

The two immediate opportunities – which relate to refining and active materials – could deliver $1.9 billion to the economy and support 9,300 jobs in 2030. Manufacturing is also substantial over the medium term, with the potential for a combined $1.4 billion in value added and almost 5,000 jobs in 2030.

Integration, service and maintenance and recycling present longer term opportunities for Australia. Together, they could potentially contribute $600 million in value added and a further 5,600 jobs. Re-use and recycling is a particularly important opportunity to demonstrate our commitment to ethical use of batteries. However, it will take time to become economically significant because the stock of batteries in use is still limited. In the meantime, steps to support a future industry including reviewing regulatory requirements regarding handling of battery waste, growing the battery stewardship scheme and increasing the use of battery recycling among end-users will set Australia up for a future battery re-use and recycling industry.

Exhibit 19: Potential value of the opportunities in 2030



Opportunity			Potential value added in 2030 (A$ billion)	Potential jobs in 2030 (‘000)
Immediate priorities	1	**Refining to chemicals** Continue to invest and expand refining capacity of locally mined materials	0.9	4.5
	2	**Active materials manufacturing** Establish active materials manufacturing capability to serve the global value chain	1.0	4.8
Medium-term opportunities	3	**Battery pack assembly** Establish battery assembly capability focusing on specialised use cases	0.6	2.0
	4	**Cell manufacturing** Establish cell manufacturing capability to complement battery pack assembly activities	0.8	2.7
Longer-term opportunities	5	**Integration, service and maintenance** Leverage domestic capability in integration and maintenance to export services to the region	0.5	5.2
	6	**Re-use and recycling** Create a circular economy for battery materials	0.1	0.4

Notes: Estimated additional value added for 2030 are expressed in 2021 A$. The size of these opportunities depends on the opportunity for specialisation (see Slide 22 for further discussion), the market share Australia can capture (based on its ability to access and compete in international markets), as well as the ratio of revenue to value added in each segment. See Appendix for 2030 market share aspirations.
Source: Accenture analysis.

Pursuing diversified battery industries could increase value added to $7.4 billion in 2030 and support around 34,700 jobs

Australia has two potential paths to developing its future battery industries. The choice of path will influence the economic gains that Australia can achieve.

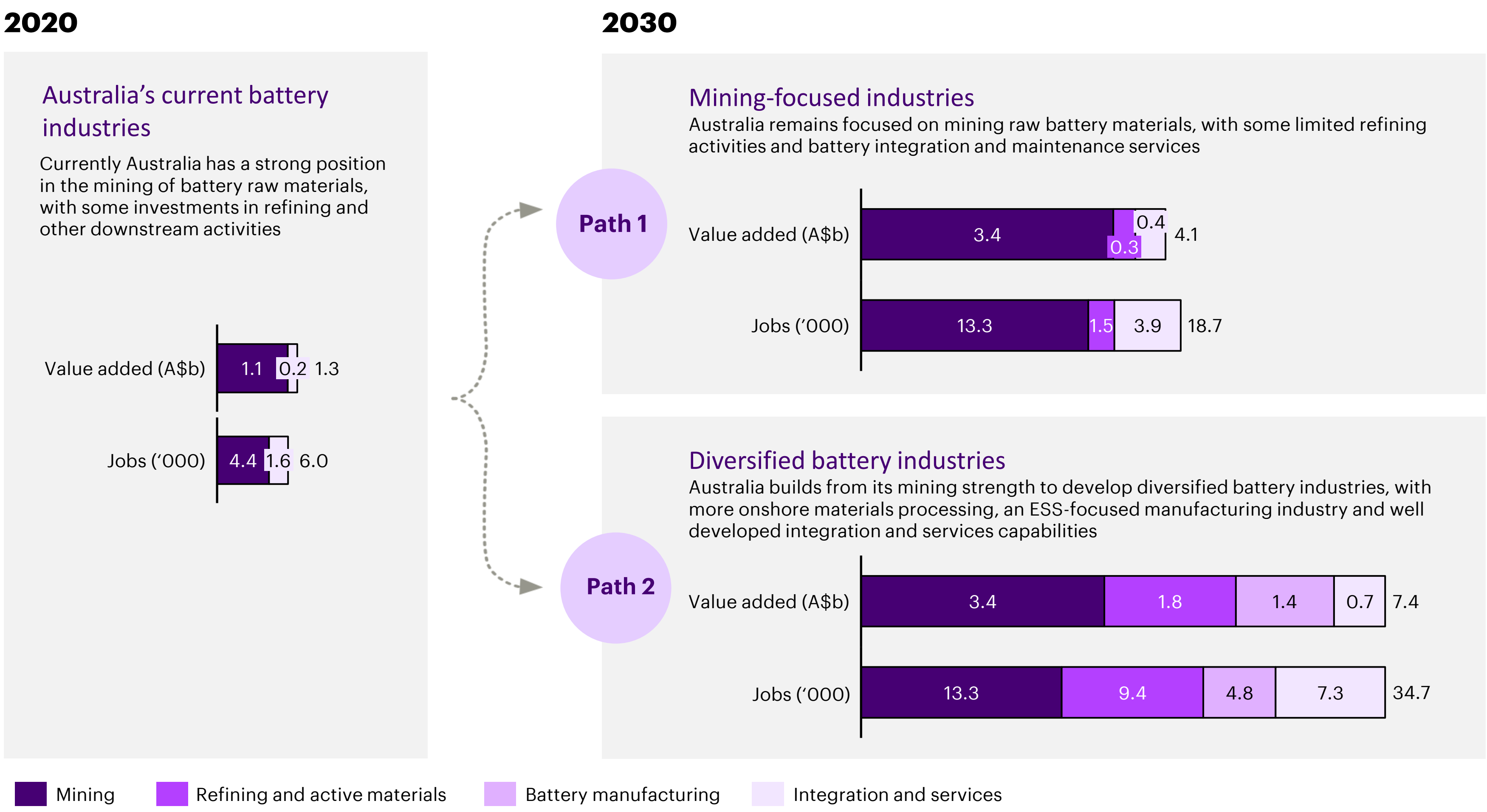
Today, Australia's battery industries contribute an estimated A$1.3 billion in gross value added to the economy and 6,000 jobs, almost all of which comes from mining raw materials. One path is to maintain this focus on mining. Doing so could enable the industry to reach A$4.1 billion in value added and 18,700 jobs. Pursuing the mining-focused option exposes Australian producers to commodity price cycles, offering an upside and downside risk. Periods of oversupply can diminish prices significantly, affecting the returns on investment.

Almost twice the economic gains can be achieved if Australia diversifies into downstream segments, in addition to its mining activities. By capturing the six opportunities identified in this report, industry value added could reach A$7.4 billion per annum, supporting around 34,700 jobs. A further 17,000 – 20,000 construction jobs would be created in the years to 2030 building the infrastructure required.

By comparison, the value added for the hydrogen industry in Australia has been estimated to be up to A$0.9 billion in 2030.

As batteries becomes a global driver for change in energy, Australia can position itself strategically in battery supply chains by developing sovereign capabilities in battery industries.

Exhibit 20: Future growth paths for Australia's battery industries



2020

Australia's current battery industries

Currently Australia has a strong position in the mining of battery raw materials, with some investments in refining and other downstream activities

2030

Path 1

Mining-focused industries

Australia remains focused on mining raw battery materials, with some limited refining activities and battery integration and maintenance services

Path 2

Diversified battery industries

Australia builds from its mining strength to develop diversified battery industries, with more onshore materials processing, an ESS-focused manufacturing industry and well developed integration and services capabilities

Notes: Estimated value added for 2030 is expressed in 2021 A$. The jobs supported in this analysis result directly from the value added and refer only to sustained employment. It does not include upfront construction jobs.
Source: ARENA (2018) Opportunities for Australia from hydrogen exports, NSW Treasury (2020) AUS Input-Output Employment Multipliers; Accenture analysis.

04

To diversify downstream, Australia will need to address capital availability, improve collaboration and build a skilled workforce

Five elements will be critical to diversify the sector: access to technology, sufficient capital, materials, a skilled workforce and access to customers

Challenges by value chain segment

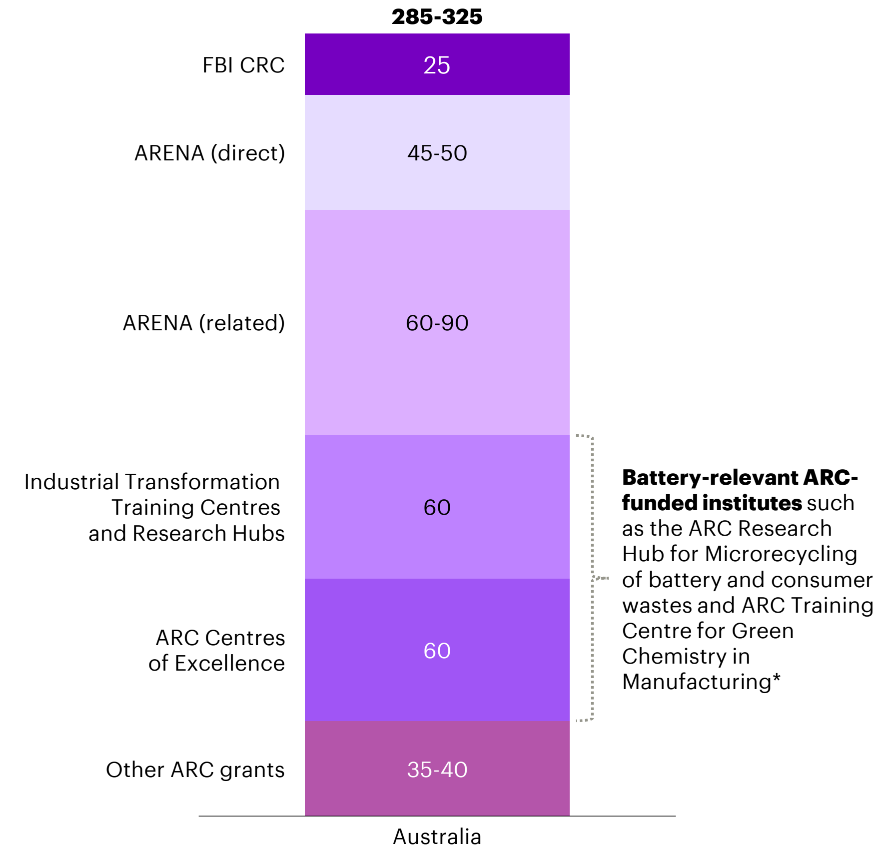
<table>
<tr><th rowspan="2">The elements required for diversified battery industries are…</th><th colspan="3">Materials</th><th colspan="2">Battery manufacturing</th><th colspan="2">Integration and services</th></tr>
<tr><th>Mining raw materials</th><th>Refining to chemicals</th><th>Active materials manufacturing</th><th>Cell manufacturing</th><th>Battery pack assembly</th><th>Integration, service and maintenance</th><th>Re-use and recycling</th></tr>
<tr><td>1. Access to technology
Ease of access to IP and technology required to develop the segment.</td><td></td><td></td><td colspan="3">Australia has limited battery-related R&D ready for commercial use but can access foreign technology through licensing and partnerships.</td><td></td><td></td></tr>
<tr><td>2. Sufficient capital
Volume of capital available (local and international) and risk appetite of capital providers for Australian industry projects.</td><td></td><td></td><td colspan="5">Australia invests strongly in mining but projects in manufacturing have weaker access to domestic capital due to difficulties demonstrating proof of concept.</td></tr>
<tr><td>3. Access to supplies and suppliers
Availability of intermediate inputs required for production, and coordination and relationships with suppliers.</td><td></td><td></td><td colspan="5">From a strong primary materials base, Australia’s battery industries need to coordinate and collaborate to become competitive internationally.</td></tr>
<tr><td>4. A skilled workforce
The consistent availability of skilled employees through a pipeline of industry-ready graduates from world-class universities in relevant study areas.</td><td colspan="5">The occupations the battery workforce demands rely on migration and are prone to shortages, and Australian universities are not yet focused on fostering the future battery workforce.</td><td></td><td></td></tr>
<tr><td>5. Access to customers
The readiness for international and domestic customers to purchase intermediate and final batteries products from Australian industries.</td><td></td><td></td><td colspan="3">To transition Australia’s supply chain role from material inputs to manufactured goods, companies will need to meet OEM specifications and end-user needs.</td><td></td><td></td></tr>
</table>

Source: Accenture analysis.

The Federal Government has invested around $300 million into battery-related R&D since 2015

Exhibit 21: Federal Government investments in battery R&D since 2015

A$ millions, (not exhaustive)



While government has supported battery-related R&D through various channels, Australian investment has been overshadowed by that of our competitors.

The Federal Government has invested approximately A$300 million (US$200 million) since 2015; in comparison, nearly US$740 million of funding has been provided by the UK Government, including through its dedicated Faraday Battery Institute and UK Battery Industrialisation Centre, which together make up 33% of battery-specific R&D in the UK. The United States invested US$700 million in the last year alone, on top of longstanding commitments which included a $2.4 billion package to develop the EV battery manufacturing industry allocated in 2009.

ARENA has funded at least $71 million of battery projects across its lifetime, making up approximately 4% of total ARENA spend. As Australia's dedicated clean energy and renewables grant agency, seed funding from ARENA leverages significant financial weight through the commercialisation process. Additionally, the Future Battery Industries CRC (FBICRC) will inject $130 million cash and in-kind contributions – including a $25 million contribution from the Federal Government –to R&D throughout the value chain over its six year life.

Federal funding for battery-related R&D is funnelled through a number of bodies and channels, posing challenges for coordination and scale. Compared to our peers, funding is quite diffuse. The Federal Government also supports businesses to invest in R&D through the R&D Tax Incentive which allows businesses to offset the cost of R&D.

The different funding bodies have differing mandates: the Australian Research Council provides grants for university research while ARENA and the FBICRC span academia (e.g. QUT's National Battery Testing Centre), small business commercialisation (e.g. Evie Fast Charging) and technology development by established businesses (e.g. Lithium Australia's VSPC tram batteries).

The FBICRC, through its partnerships with and investment from research, government and industry, is well placed to coordinate R&D support and could become an ongoing vehicle for research collaboration across the battery value chain.

Notes: Full list of ARC-funded institutes is: ITTCs for The Global Hydrogen Economy, Green Chemistry in Manufacturing, Surface Engineering for Advanced Materials, Chemical Industries, Alloy Innovation for Mining Efficiency; ITRH for Transformation of Reclaimed Waste Resources to Engineered Material, New Safe and Reliable Energy Storage and Conversion, Microrecycling of battery and consumer wastes, Integrated Energy Storage Solutions, Graphene Enabled Industry Transformation, transforming waste directly in cost-effective green manufacturing; and CoE for Electromaterials Science and Future Low-Energy Electronics Technologies.

Source: ARENA (2021) ARENA at a glance; FBICRC (April 2020) Status summary of current research projects and proposals; ARC (2021) Scheme Round Statistics for Approved Proposals; OECD (2021) Measuring Tax Support for R&D and Innovation; Accenture analysis.

Australia can grow its access to technology in the short-medium term by utilising licensing and partnership arrangements

In developing access to technology to support diversified battery industries, there is a tradeoff between the uniqueness of the IP and the time it takes to access it.

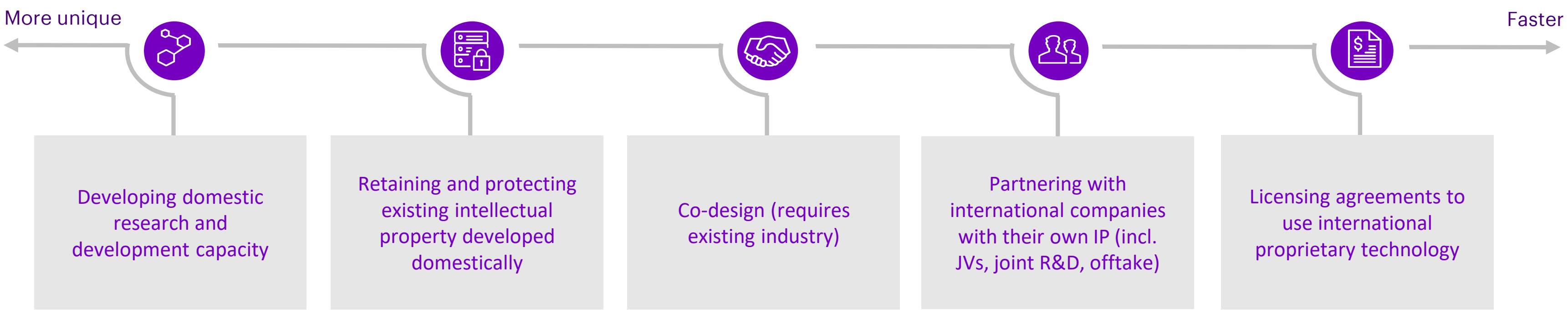
Unique or distinct IP requires a long lead-time, a developed domestic research ability and capacity to commercialise breakthroughs. For instance, the first patent for one of Australia's great technology success stories – WiFi – was lodged in the early 1990s by the CSIRO but it wasn't until 2001 that the product reached the market.

A quicker way to access IP is to buy licenses to use patented technology. Licencing is desirable only as a short-term solution, as a critical drawback of licensing is that the IP is less likely to be unique and thus may not provide a competitive edge. Further, a risk with this approach is that licenses may outlast the period that a technology is market-leading.

Alternatively, Australian businesses may use partnerships, as Magnis Resources has done for the Imperium 3 gigafactory planned in Townsville. Partnerships can be conducted in a range of ways including offtake agreements, joint ventures and joint R&D efforts.

Partnering and licencing provide tactical solutions to technology and IP challenges facing the industry in the short term. To ensure sustainability and longer-term competitiveness, Australia will also need to develop its capacity to retain and commercialise domestic IP.

Exhibit 22: Methods of accessing technology



More unique

Faster

- Developing domestic research and development capacity
- Retaining and protecting existing intellectual property developed domestically
- Co-design (requires existing industry)
- Partnering with international companies with their own IP (incl. JVs, joint R&D, offtake)
- Licensing agreements to use international proprietary technology

Partnering case study: Imperium 3

Magnis Resources, Boston Energy and Innovation and Charge CCCV LLC have entered into a joint venture to build and operate a battery manufacturing gigafactory in Townsville (QLD), with construction scheduled to start in 2022.

Through the joint venture, Magnis Resources is integrating its active materials production of LIB cathodes and graphite anodes through the manufacturing and battery design segments of the value chain, Charge CCCV is providing the design for next generation cells and Boston Energy will assist with project structuring, capital raising and global expansion.

Source: Lema and Lema (2012) Technology transfer? The rise of China and India in green technology Sectors; Lema, Schmitz and Song (2011) Competition and Cooperation between Europe and China in the Wind Power Sector', table 5.4; AMSC (2010) AMSC and Sinovel Expand Strategic Partnership; GTM (2011) 'A Tale of Intrigue and IP Theft in the Wind Market; AMSC (2008) AMSC Receives New Orders for Wind Turbine Electrical Components from Canada and China; Karstan Neuhoff (2014) International Support for Domestic Climate Policies in Developing Countries, p. 559; Renew Economy (2017) 'Boston Energy consortium advances plans for Queensland battery Gigafactory; IP Australia (2016) CSIRO WLAN Patent; Accenture analysis.

Finance is a critical ingredient to establishing diversified battery industries, with $6-9b in additional capital likely to be required by 2030

Investment will be required for Australia to capture new economic opportunities in the battery value chain and keep pace with increasing demand for batteries and battery minerals.

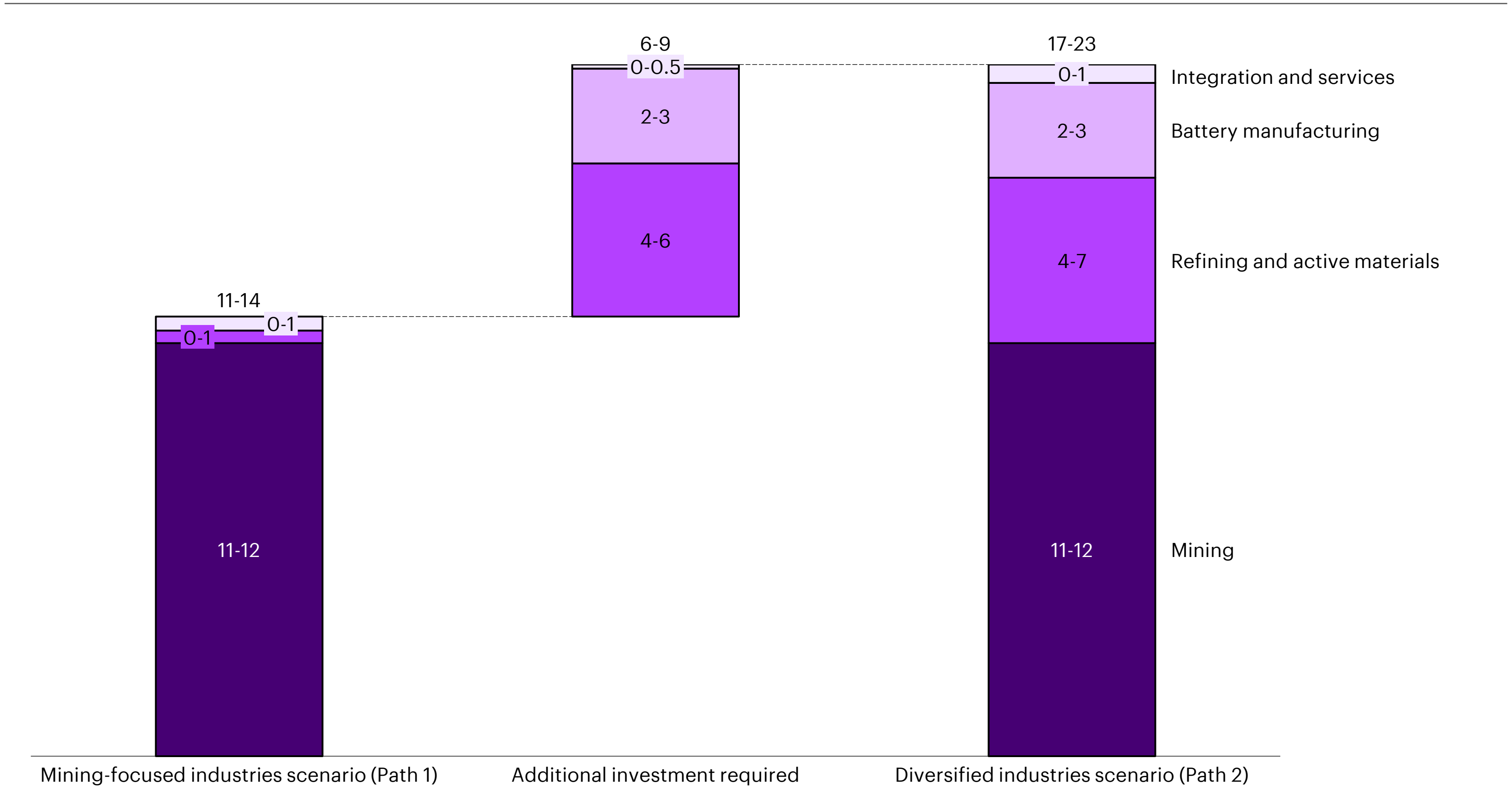
Around $11-14 billion in investment will be necessary even if Australia remains mining focussed in our battery industries. This is in addition to existing committed investments.

It is estimated that an additional $6-9 billion in capital investment will be required by 2030 to support a diversification into downstream segments. The additional investment required consists of $4-6 billion for refining and active materials, $2-3 billion for battery manufacturing and up to $500 million for integration and services.

The total investment required by 2030 to support diversified industries is likely $17-23 billion.

Exhibit 23: Additional capital required by 2030

A$ billions



Notes: See appendix for assumptions used.
Sources: ABS (2021) Australia's System of National Accounts, Category 5206.0 Table 58; ABS (2021) Australian Industry 2019-20, Category 8155.0 Tables 2-4; Accenture analysis.

While Australia invests strongly in mining, capital is less available in cell and battery manufacturing due to our limited experience

A range of sources of capital will be important to support diversified battery industries, but there are barriers that need to be addressed – especially in manufacturing. Without a proof of concept, domestic debt and equity confidence in manufacturing projects is limited, especially when technology is licensed. Local capital markets are typically more supportive of mining projects, which are better understood and typically led by larger and more well-established local companies. Investors tend to be enthusiastic about Australian materials due to their high quality and stable political environment – though our materials tend to have a higher carbon footprint than elsewhere due to our coal-dominated energy production.

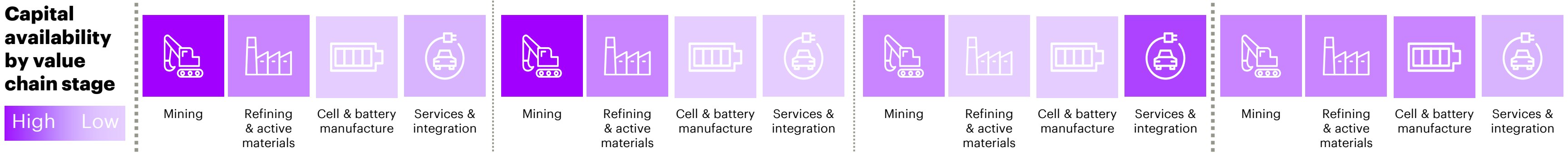
The Federal Government's major renewable funding bodies, ARENA and the CEFC, have provided significant support for grid-scale battery deployment. The CEFC has also supported lithium mining projects. However, they have not prioritised midstream industry development. These projects have a less obvious fit with their program remits, and the commercial case is often viewed as riskier due to international competition and the demand for bespoke products (with IP protections) from OEMs. This limits Government's ability and readiness to invest in the active materials, cell and battery manufacturing segments.

In contrast, FDI is more supportive of manufacturing in Australia, possibly due to being less disposed to Australian biases regarding our minerals-based economy and bringing its own expertise and experience to the project. Around 24% of FDI was directed towards manufacturing between 2017 and 2019, more than any other industry including mining.

Exhibit 24: Selected sources of capital in the battery value chain

	Domestic sources			International sources
	Debt	**Equity**	**Government**	**FDI**
What is it	Banks and other lenders finance projects through debt (e.g. **loans or bonds**), Companies can also issue **corporate bonds** to investors (e.g. ETFs, mutual funds)	**Institutional investors,** private investors, VC funds, and private equity firms can finance projects by taking **shares in ownership**, including through share purchases at IPOs, mergers and joint ventures	Government provides capital through multiple channels, including but not limited to: • The **CEFC**'s debt and equity finance • Grants via **ARENA** • **State government support** through grant, debt and equity programs	Foreign investment comes via companies **establishing** in Australia, entering into **JVs** or **acquiring Australian subsidiaries** or through foreign financiers investing directly into Australian firms
What investors look for	• **Adequate compensation for the risk of default** • **Expected return** on investment • **Historic performance** of the industry • Increasingly, **green and ESG credentials**, e.g. super fund choices of investment vehicles (e.g. green bonds, sustainability funds)	• **Returns which match the risk of the investment**, with higher compensation for volatile or emerging markets without proven track records of long-run growth • **Historic performance** of the industry • Venture capital funds tend to seek high ROI projects with **low capital intensiveness**, so is not suited to manufacturing	• Projects that meet **government investment guidelines** • **Commercial merit** or business viability, including meeting ROI targets for taxpayer funds (CEFC funding decisions are made in line with a mandate for self-sustainability) • **Market failure** indicating a role for government	• **Low sovereign risk, favourable logistics and a high-skilled workforce** • Industry participants such as OEMs look for **vertical integration** to their downstream processes, • Foreign financiers largely mirror domestic banks and financial lenders, but may be **less disposed to Australian biases** • **Green and ESG credentials**

Capital availability by value chain stage



Sources: CEFC (2020) Quarterly Investment Reports, accessed April 2021; ARENA (2021) Projects; ABS (2020) International Investment Position, Australia, Catalogue 5352.0; ABS (2021) National Accounts, Catalogue 5206.0; DFAT (2020) Australian industries and foreign direct investment; Accenture analysis.

Australia has strong access to minerals, producing 8 out of 9 key materials used in the battery value chain, and is the largest lithium producer

Australia is already a leading producer of battery minerals, which presents an opportunity to leverage our strength in access to raw materials to move further downstream.

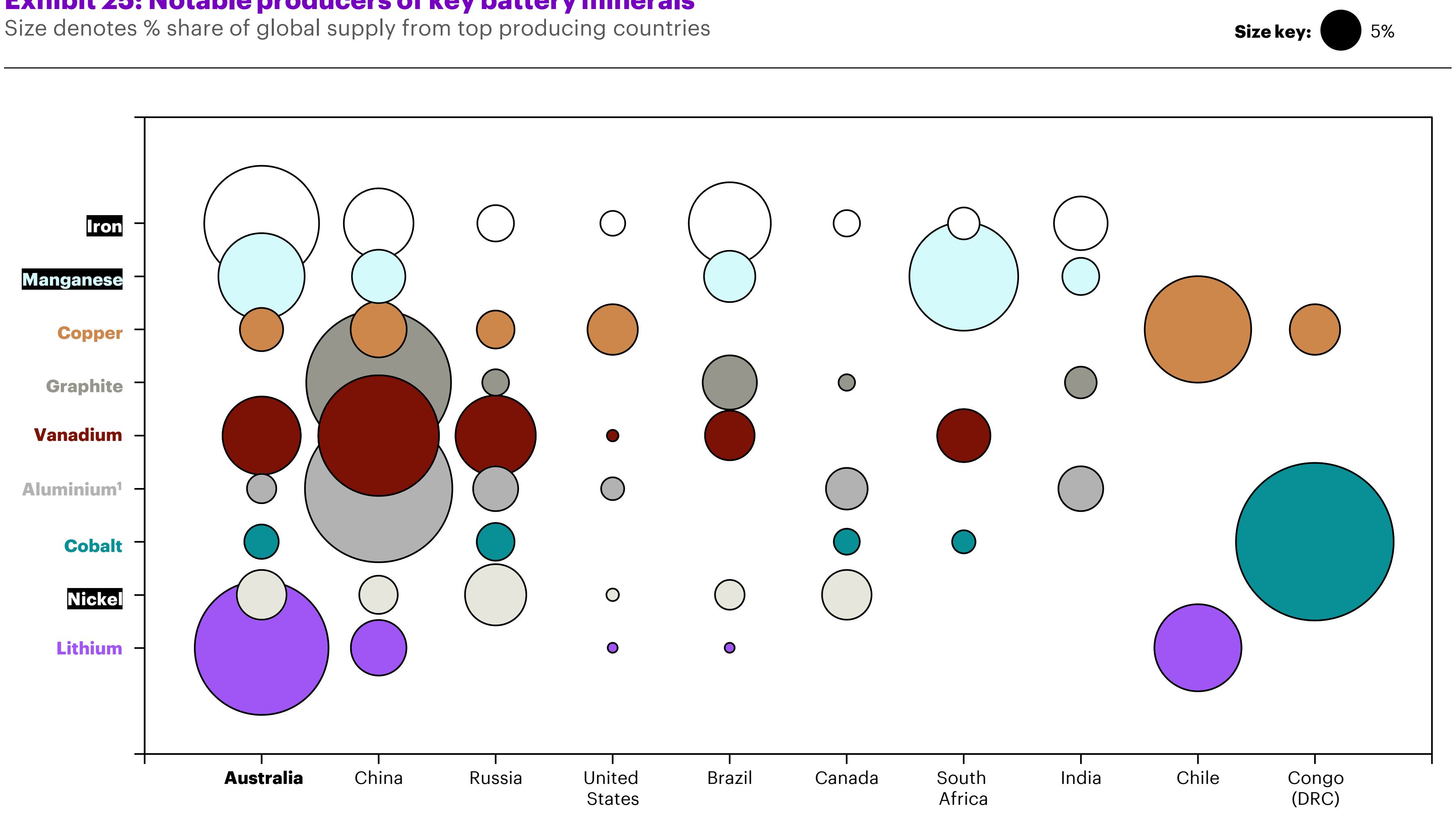
Over 50% of the world's lithium is extracted in Australia, and hard rock resources are generally regarded as better suited to battery production because of the ability to refine them directly to lithium hydroxide. As our refining and active materials segments develop, they will have access to quality resources.

Australia also is a significant producer of iron (40% of global supply), manganese (23% of global supply) and vanadium (19% of global supply). Our share of nickel is smaller but still substantial and BHP is currently investing in refining capacity to produce nickel sulphate at Kwinana.

China plays a similarly significant role in producing battery minerals. While both Australia and China produce leading quantities of the eight of the battery minerals displayed in Exhibit 25, the two countries' mineral strengths are complementary. Some of Australia's strongest minerals (iron, manganese, lithium and nickel) are some of China's weakest, and vice versa.

Exhibit 25: Notable producers of key battery minerals

Size denotes % share of global supply from top producing countries



Notes: Countries displayed are those that are in the top 10 producers for at least two battery minerals. This list also includes Norway, Madagascar, Cuba and Ukraine however their contributions are relatively small. 1. Aluminium production is ranked by smelter production of aluminium metal, rather than the mining of raw minerals such as bauxite (used to produce alumina) or cryolite.
Source: Investing News (2020-21) Top Lithium, Nickel, Cobalt, Aluminium, Vanadium, Graphite, Copper, Manganese and Iron producing countries; Accenture analysis.

As Australia diversifies down the battery value chain, coordination within supply chains will be more important

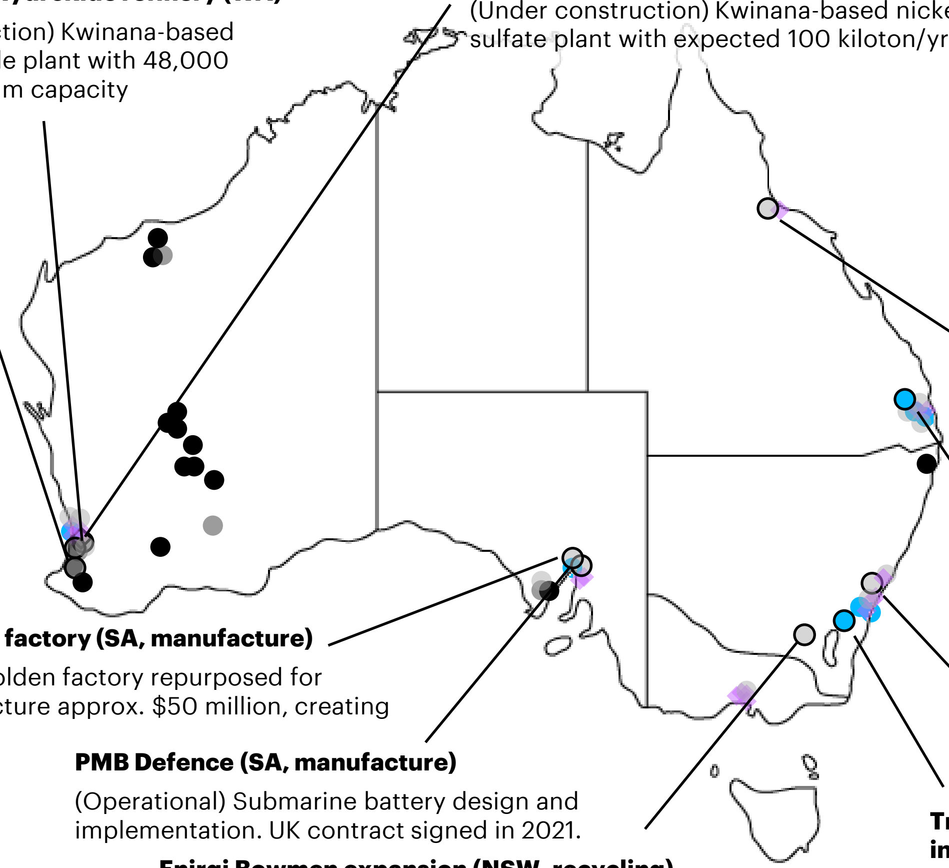
Coordination across the supply chain is an essential element of diversified battery industries, to enable sourcing of supply from trusted suppliers.

Co-locating steps of the value chain can yield several benefits, from reduced logistical costs (e.g. transportation), certainty of demand (e.g. through assured offtake), coordination across the business (e.g. when deciding to suspend and restart operations, as Mineral Resources Ltd. did in 2019) and more flexible use of personnel between integrated business units. These benefits can accrue both within companies (e.g. LG Chem's Gigafactory in Wrocław, Poland, which produces electrodes, cells, modules and final packs) or between companies (e.g. the proximity of Kwinana to a port).

Co-location can help ensure the products in one segment of the value chain meet the required specifications downstream. Co-location enables coordination by reducing frictions in product R&D and ongoing testing. For electrochemical parts such as active materials, cells and batteries, extensive testing is required, especially in the R&D phase – this can be made more efficient through shared testing facilities.

There is a risk that the spread of battery activity across the country, as illustrated in Exhibit 26, does not facilitate collaboration between battery industries. A more coordinated approach to future growth in the industries' activity would reduce inefficiencies in transport and transfers and support a collaborative battery ecosystem.

Exhibit 26: Battery value chain locations in Australia



Tianqi Lithium Hydroxide refinery (WA)

(Under construction) Kwinana-based lithium hydroxide plant with 48,000 tonnes per annum capacity

Albemarle Lithium Hydroxide factory (WA)

(Announced) Kemerton-based lithium hydroxide plant to scale to 50,000 tonnes per annum once operational

BHP Nickel West refinery (WA)

(Under construction) Kwinana-based nickel sulfate plant with expected 100 kiloton/yr output

Key

Industry location for…
● mines
● refining
● manufacturing & assembly
● services & integration
Non-industry center…
◆ university
◇ research hub

Imperium3 (QLD, manufacturing)

(Announced) Cell manufacture of Charge CCCV's market-leading designs for international and domestic sale

Tritium Charging (QLD, integration)

(Operational) Tritium has proprietary fast-charging technology and has commercialised with international traction

Sonnen battery factory (SA, manufacture)

(Operational) Holden factory repurposed for battery manufacture approx. $50 million, creating 430 jobs

Renaissance One (NSW, battery manufacture)

(Announced) Energy Renaissance facility to be built in Hunter region in 2021

PMB Defence (SA, manufacture)

(Operational) Submarine battery design and implementation. UK contract signed in 2021.

True Green Mobility Moss Vale EV Hub (NSW, integration)

(Announced) Chinese firm BYD building $700m precinct to develop low-cost EV options in Australia

Enirgi Bowmen expansion (NSW, recycling)

(Announced) Metal recovery and recycling plant proposed for processing 120,000 used lead-acid batteries

Source: EBRD (2019) LG Chem battery gigafactory in Poland to be powered by EBRD; sonnen (2018) sonnen to invest in South Australia; PMB Defence (2020) PMB Defence's future subs battery race looking strong; NSW Planning (2020) Enirgi Battery Recycling Facility; True Green (2021) Chinese company BYD wants to build electric utes in Australia; Energy Renaissance (2020) Australia's first battery factory to be in the Hunter; AFR (2021) Tritium charges to $2b NASDAQ listing; imperium3 (2019) Australasia – Townsville Project; Accenture analysis.

Current market leaders achieved their position through vertical integration after establishing themselves in related industries such as EVs and electronics

Exhibit 27: Background and level of vertical integration among market leading battery manufacturers

	CATL	LG Chem	TESLA	BYD	Panasonic	northvolt
Country	**China**	**South Korea**	**USA**	**China**	**Japan**	**Sweden**
Company background	• CATL was a department of ATL, the largest Lithium Polymer Battery manufacturer in the world • It was also a former subsidiary to Japanese electronics company TDK	• LG Chem is the 10th largest chemical company in the world (2017) and is part of the LG Corporation • LG is also a leading producer of electronics and telecommunication devices	• Founded in 2003, Tesla is a leading electric vehicle and clean energy company	• Started as a battery manufacturer in the 1990s • By 2003, the second-largest rechargeable battery producer globally • Entered automotive market in 2005	• Panasonic group is one of the largest electronics and semiconductor manufacturers in the world • Panasonic started making batteries in the early 1920s	• Former Tesla executive Peter Carlsson founded Northvolt (formerly SGF) in 2015 • Carlsson's background was in EV and battery storage
Success factors	• **Partnerships:** CATL has relationships with many customers, including Tesla, BMW, Daimler, Geely, Great Wall, Honda, Hyundai, Volkswagen, and NEVS • Honda acquired 1% share in CATL in 2020	• **Low labour costs**, with factories in China, the US, and Poland • **Strong internal technology and raw materials input**, including producing their own nickel-cadmium cathodes • Significant internal R&D • Major **supply partnerships**, including with Tesla	• **Access to finance:** Received $465m in US Govt concessional loans in 2010, paid back in 3 years, as part of the Advanced Technology Vehicle Manufacturing program • **Market-leading EV design and manufacturing**	• **Alliances:** BYD-Toyota EV Tech Co ltd was founded in 2020, a JV in EV manufacturing • **Supported by Chinese government subsidies** per vehicle sold, approx. $190m per year (2019); total government support of ~$US450m from 2010-15	• **Strong R&D collaboration** with Toyota • Major battery supplier to Tesla (sole supplier for U.S-made vehicles) • **Upstream partnerships** with Sumitomo Metal Mining	• **Financing:** In 2019, received US$1B investment from European Investment Bank • **Supply agreements** with BMW and Volkswagen as major supplier – in 2021, signed $14b battery order with VW
Current supply chain role	●1 ●2 ●3 ●4 ●5 ●6 ●7	○1 ●2 ●3 ●4 ●5 ●6 ◐7	◐1 ◐2 ◐3 ●4 ●5 ●6 ●7	○1 ○2 ○3 ●4 ●5 ●6 ◐7	◐1 ●2 ●3 ●4 ●5 ●6 ●7	○1 ○2 ○3 ○4 ◐5 ◐6 ◐7

Key: ○ Not involved. ◐ Plans ● Operating

Segments: 1 Mining raw materials 2 Refining to chemicals 3 Active materials manufacturing 4 Cell manufacturing 5 Battery pack assembly 6 Integration, service and maintenance 7 Recycling

Source: CATL (2021); Mining.com (2021) CATL to make additional investment in Neo Lithium; Electrive (2019) CATL & Brunp launch joint venture; S&P Global (2021) CATL to instal two battery projects in Texas; CATL (2021); Inside waste (2019); Roskill Interactive (2021) Company Profiles; Archive.com LG Chem; The Street (2020) History of Tesla; Investopedia (accessed 2021) The Economics of Tesla Batteries; Smit (2020) Car battery tech powers ahead; BestMag (2021); Financial Times (2019); BYD website (accessed 2021); Panasonic 'About Us' (accessed May 2021); Metal Bulletin (2019); BloombergNEF (2020); Australian Mining (2021); Accenture analysis.

Graduates in engineering and industrial chemistry will be important to support development of diversified battery industries

Diversified battery industries will require a skilled workforce of university graduates, tradespeople and VET-trained operators to support the materials, refining and active materials processes, and of highly skilled technical experts, with backgrounds in industrial chemistry and engineering, to support the electrochemical processes in refining, active materials and cell and battery manufacture and testing.

With a current workforce of 6,000, and 34,700 workers required by 2030 to support diversified battery industries, Australia will need a pipeline of skilled workers to fill nearly 3,000 additional jobs per year.[1]

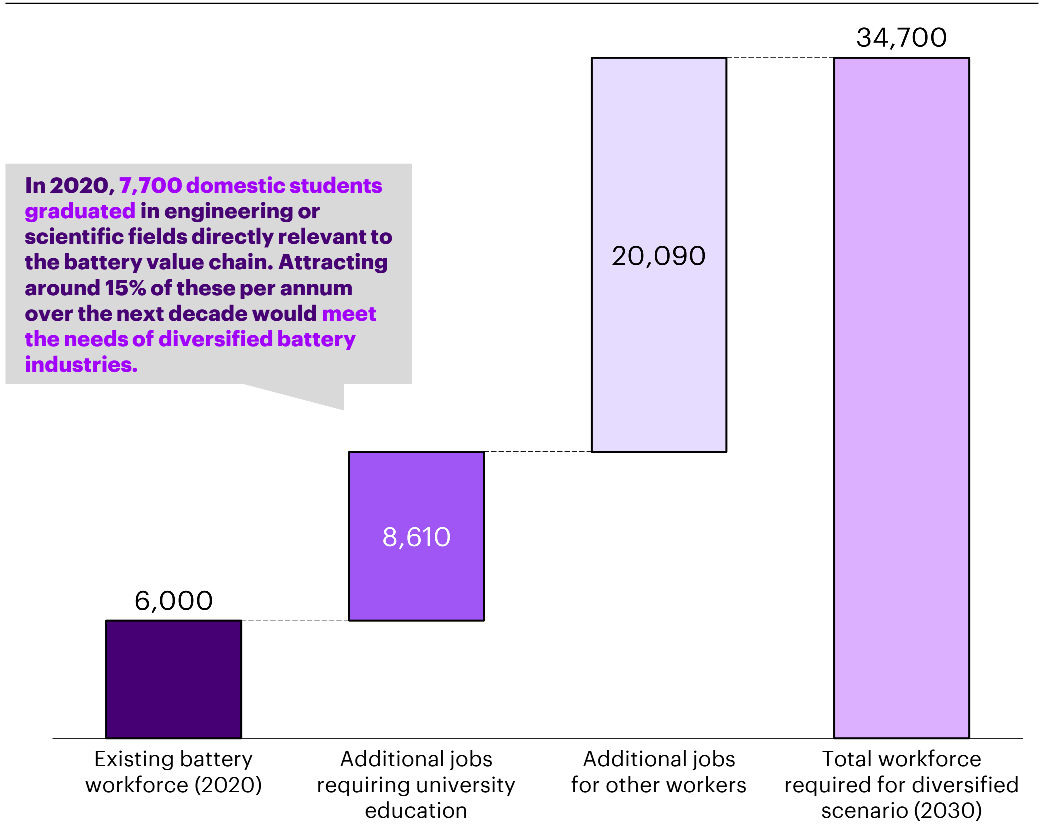
Approximately 30% of jobs throughout the battery value chain (equivalent to 1,200 jobs per year) will require a university-educated professional, for example engineers, industrial metallurgists and electrochemists. Upstream, highly-trained workers will design and facilitate processes related to effective mineral extraction, refining and processing.

These skilled workers will also be critical downstream in the segments of the value chain that require significant testing, such as active material production and cell and battery pack manufacturing. Elsewhere in the value chain, automated processes will require oversight from technical experts such as robotics technicians, software engineers, mechanical and electrical engineers and finally electrochemists.

It is likely that these requirements – in terms of quantity – could be met on current trajectories. In 2020, 11,300 engineering students graduated from Australian universities. Of these, 1,700 were specialised process and resources engineers, 2,000 were mechanical engineers and 2,300 were electrical and electronic engineers. Engineering domestic graduate numbers are growing at 3% annually. In the chemical sciences, 1,700 graduates completed their university studies in 2020, with the broad field of natural and physical sciences growing at 5% annually.[2] It is therefore expected the high-skilled jobs could be filled by Australian 1,200 university graduates, even noting the competition between industries. Around 15% of graduates from key specialisations would be sufficient to meet the demands of the diversified scenario.

Exhibit 28: Current and required labour force

Number of workers



In 2020, 7,700 domestic students graduated in engineering or scientific fields directly relevant to the battery value chain. Attracting around 15% of these per annum over the next decade would meet the needs of diversified battery industries.

Notes: 1. This is a linear interpolation of the gap between existing jobs (2021) and total jobs required for a diversified industry (2030). In reality, the more the industry grows in scale, the more jobs will be required. 2. Chemical science graduates derived from DESE Higher Education Data, using an 8% share of natural and physical science graduates from both (A) proportion of chemical science graduates in Australia (ABS Census, 2016) to the total number of graduates from university and VET in science fields and (B) Chemistry share of US 2019 graduates in natural and physical sciences (Biology, Physical Science, Math and Stat and Chemistry). 2. Exhibit 28 counts the jobs directly employed in the battery sector, where value is added from the products. It does not count the significant indirect employment in transportation, business administration and other fields facilitating this value add.
Source: Department of Education (2020) Higher Education Statistics; QILT (2020) Graduate Outcomes Survey; Engineers Australia (2020) The Engineering Profession: A statistical overview 14th edition; Accenture analysis.

Reliance on migration, impact of mining booms and lack of specialist training are all risks to building the skilled workforce required

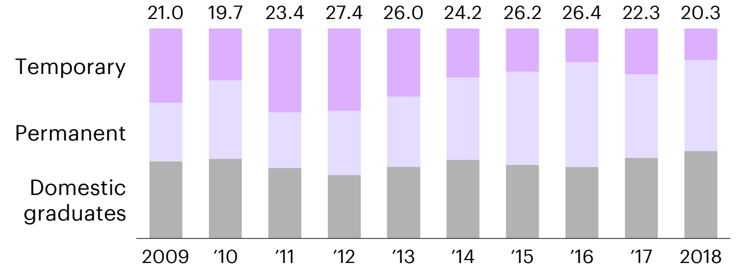
1

Since 2009, two thirds of new engineering supply in Australia each year has come from migration

Labour from migration, through skilled work visas or permanent residency pathways, has been the dominant source of meeting the demand for new engineers over the last decade, but is precarious given changes in government policy. The COVID-19 pandemic has also shown that borders can close overnight, effectively shutting off this source of labour at limited notice.

Exhibit 29: Sources of supply of professional engineers

Thousands of visa holders or graduates



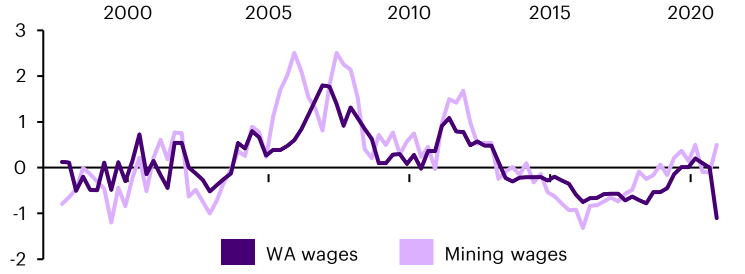
2

Skills shortages during mining booms lead to dramatic wage inflation

The boom-and-bust cycles of the mining industry lead to significant surges (or downfalls) in labour demand, especially in Western Australia. Due to the wage pressure from a tighter job market, certain segments of the value chain may lose workers upstream during booms; alternatively, upstream jobs may be cannibalized by significant booms in other mining industries (e.g. oil, gas, coal). This can lead to wage inflation both inside the sector and in the state's economy as a whole. For example, in April 2021, mining giant Gold Fields committed to a 6% pay rise for Australian employees to address current skills shortage.

Exhibit 30: Difference in wage growth rates from national rate

Percentage points, sector and state wage growth rate



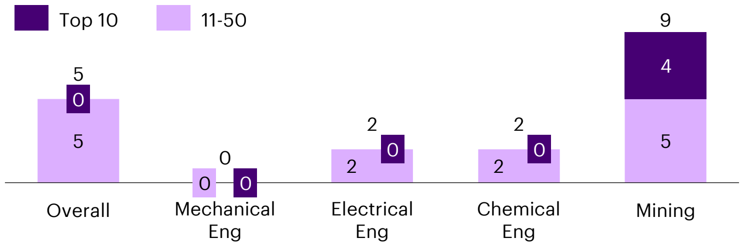
3

Universities don't have a focus on battery skills

Stakeholders have identified the most in demand occupations at each stage of the value chain: chemical engineers in materials segments; electronic engineers in the manufacturing segments; and industrial chemists in the recycling and re-use segment. Australian universities tend to overperform in mining relative to their general performance, but underperform in mechanical and chemical engineering, according to QS rankings. A general lack of courses in Industrial Engineering which focus on cost effective mass production poses a specific threat to a manufacturing sector.

Exhibit 31: Australian presence among top unis by degree

Number of Australian universities by ranking band, 2021



Notes: In Exhibit 29, 2016-17 and 2017-18 data for number of permanent visas granted to engineers is the average of previous years, due to data availability. In Exhibit 30, wage price index for ordinary time hourly rates of pay excluding bonuses used.
Source: ABC (2021) Mining giant Gold Fields gives Australian workers 6 per cent pay rise as skills shortage bites; Engineers Australia (2020) The Engineering Profession, 14th edition; ABS (March 2021) Wage Price Index, Category 6345.0 Table 09b and 08b; QS (2021) University Rankings 2021; Accenture analysis.

To move downstream in the value chain, companies will need to develop stronger understanding of customer needs

Understanding the needs of customers along the value chain will be critical for Australia if it is to move downstream from its existing sources of strength and capture new demand.

For mining, established relationships between mines, refiners and vertically-integrated manufacturers provide significant domestic and overseas demand for Australian goods. Australian miners which expand into refining would have a strong position to renegotiate their existing roles in the supply chain.

For active materials, access to supply chains as preferred provider, such as through offtake agreements, will be critical to secure demand. Despite Australia already being a trusted materials producer, in active material it will be important to be able to meet proprietary design specifications through developing direct relationships with manufacturers. Customer need for high-ESG inputs, especially in Europe, will be a challenge to our ability to form these relationships – despite our strong sustainability record in mining, the carbon footprint associated with our energy mix remains high.

When meeting the needs of end users, Australian battery manufacturers will need to ensure they can match or better international competitors’ offerings with regards to safety, warranty and quality. Nascent technologies with Australian champions, such as vanadium flow (e.g. Multicom Resources) and lithium iron phosphate batteries (e.g. Lithium Australia) promise longer lifecycles and a solution to thermal runaway, though their commercial production is yet to be finalised.

Installation, servicing and maintenance customers will be highly localised, with a wide spread of geographic demand across the country. For re-use and recycling, technology and scale developments are required to meet the demand projected by a rapidly maturing battery market; and demand for recycled materials as inputs can be cultivated in active materials producers (e.g. vertical integration of EcoGraf in recycling anode material recovery).

Exhibit 32: Customer needs throughout the supply chain

Supply chain - Broad segment	Key customers	Customer needs
Mining	• Domestic refining and active material producers • Overseas vertically integrated battery makers	• Reliable & consistent supply • Strong ESG credentials • Fits bespoke needs (e.g. mineral purity)
Refining & active materials	• Domestic and overseas cell and battery manufacturers	• Reliable & consistent supply • Strong ESG credentials • Fits use case applications (e.g. design and configuration)
Cell & battery manufacturing	• Utilities, telecommunications and mining companies and regional communities	• Product safety, heat-resistance • Longer charge and lifecycle • Warranties on performance and reliability • Local maintenance capability
	• Defence forces, domestic and overseas	• Domestic supply chain • Sovereign maintenance capacity • Long lifecycle
	• Public transport fleets	• Domestic sourcing • Long lifecycle
	• Household ESS consumers	• Safety (fire-resistant) • Local maintenance capability • Low prices (highly-price sensitive)
Services & integration	• Domestic battery end-users	• Local expertise in all applications (e.g. EV, grid, residential installation)
	• Refining and active material producers, often vertically integrated battery makers	• Circular economy (e.g. recycling arrangements with OEMs) • Fits use case application (e.g. purity)

Notes: Passenger EVs are unlikely to be a significant component of demand for Australia’s battery industries.
Source: Expert interviews and Accenture analysis.

Cumulative demand for ESS in the region is forecast to grow to 40-52 GWh by 2030, with more than a third coming from NZ and ASEAN

There is a growing demand for energy storage, both in Australia and in our region, that provides an addressable market for Australian battery manufacturing.

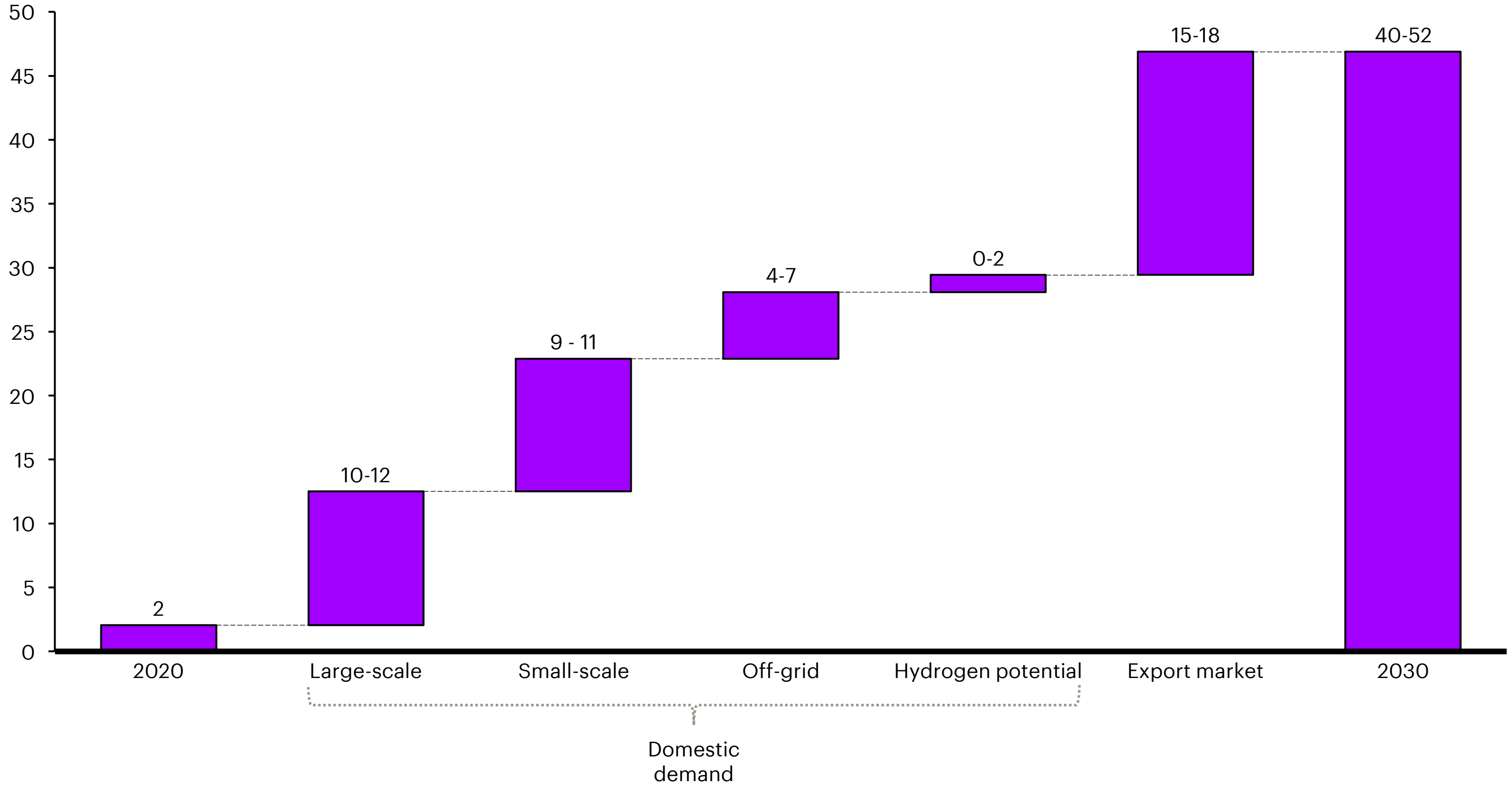
Locally, Australia has significant and growing energy storage demand, driven primarily by large-scale ESS (approximately 45% of Australian demand), followed by small-scale (including residential and commercial batteries) and off-grid (primarily through mining, telecommunications and remote communities). There is also potential demand for batteries to support 24/7 production of green hydrogen, but the size of this use case is not yet well understood given the immaturity of that industry.

Export markets including the ASEAN and NZ also provide a potential source of demand for Australian-made batteries. Many of Australia's neighbouring countries are beginning to transition their energy systems and without strong existing local battery industries, Australia could position itself to be a key supplier.

Australian battery manufacturers are already developing niches that will support continued access to customers. For example, WA-based Magellan Power is building battery enclosures suitable for the Australian environment, such as a Stand Alone Power System for a remote town in South Australia that will be charged by the town's generators during the day to then power the town overnight. The system is expandable to include solar in the future. Such technology could be suitable in some export markets.

Exhibit 33: Cumulative demand for ESS in Australia, NZ and ASEAN 2020-2030

Total storage capacity required, GWh



Notes: See appendix for assumptions.
Source: AEMO (2019-2020) ISP Assumptions and Inputs; AEMO (2020) WEM Electricity Statement of Opportunities; AEMO (2021) NEM Generation Information; AECOM (2014) Australia's Off-Grid Clean Energy Market; Wood Mackenzie (2020) Australia Energy Storage Market Outlook; Clean Energy Council (2020) Clean Energy Australia Report; ARENA (2021) Projects; IRENA (2020) Global Renewables Outlook; CSIRO (2019) Projections for Small Scale Embedded Energy Technologies; Expert interviews and Accenture analysis.

05

There is a key role for government in driving the development of diversified battery industries in Australia

A comprehensive national battery industries policy should focus on four objectives critical to future success

Taking advantage of the $7.4 billion battery opportunity will require a concerted effort from state and Federal Governments. Currently, there are a range of policies to both grow demand for batteries and to support the battery industry. However, Australia could benefit from a more unified vision.

State governments have implemented a range of schemes incentivising the installation of household batteries. State governments are also driving demand through a number of mechanisms including through the electrification of their public transport fleets and installing ESS on government buildings.[1] WA is the only state that currently has a battery industry development strategy; focused on growing WA's role in global supply chains and diversifying downstream.
The Federal Government addresses batteries in a range of different roadmaps, strategies and policies:

- Australia's First Low Emissions Technology Statement (2020)
- Australia's Critical Minerals Strategy (2019)
- Modern Manufacturing Strategy (2020), under 2021 Roadmaps for both Recycling and Clean Energy; and Resources Technology and Critical Minerals Processing

The major government initiative in the past few years has been the establishment of the FBICRC, which is an important step towards focusing R&D and creating a more cohesive industry. To build on that, the Federal Government should develop and implement a Battery Industries Development Policy with four objectives;

1. Financially viable businesses throughout the value chain have access to capital from a variety of sources
2. Australia has battery industry expertise to support diversified growth
3. Australian-made batteries and battery inputs are in demand, both nationally and globally
4. The battery industries, research organisations and education institutions collaborate to drive growth

Objectives for Australia's battery industries

Australian Battery Industries Development Policy

Objective 1

Financially viable businesses throughout the value chain have access to capital from a variety of sources

Objective 2

Australia has battery industry expertise to support diversified growth

Objective 3

Australian-made batteries and battery inputs are in demand, both nationally and globally

Objective 4

The battery industries, research organisations and education institutions collaborate to drive growth

Notes: 1. See appendix for details of state schemes.
Source: Accenture analysis.

A range of policy measures are being implemented around the world to grow domestic battery industries

Canada

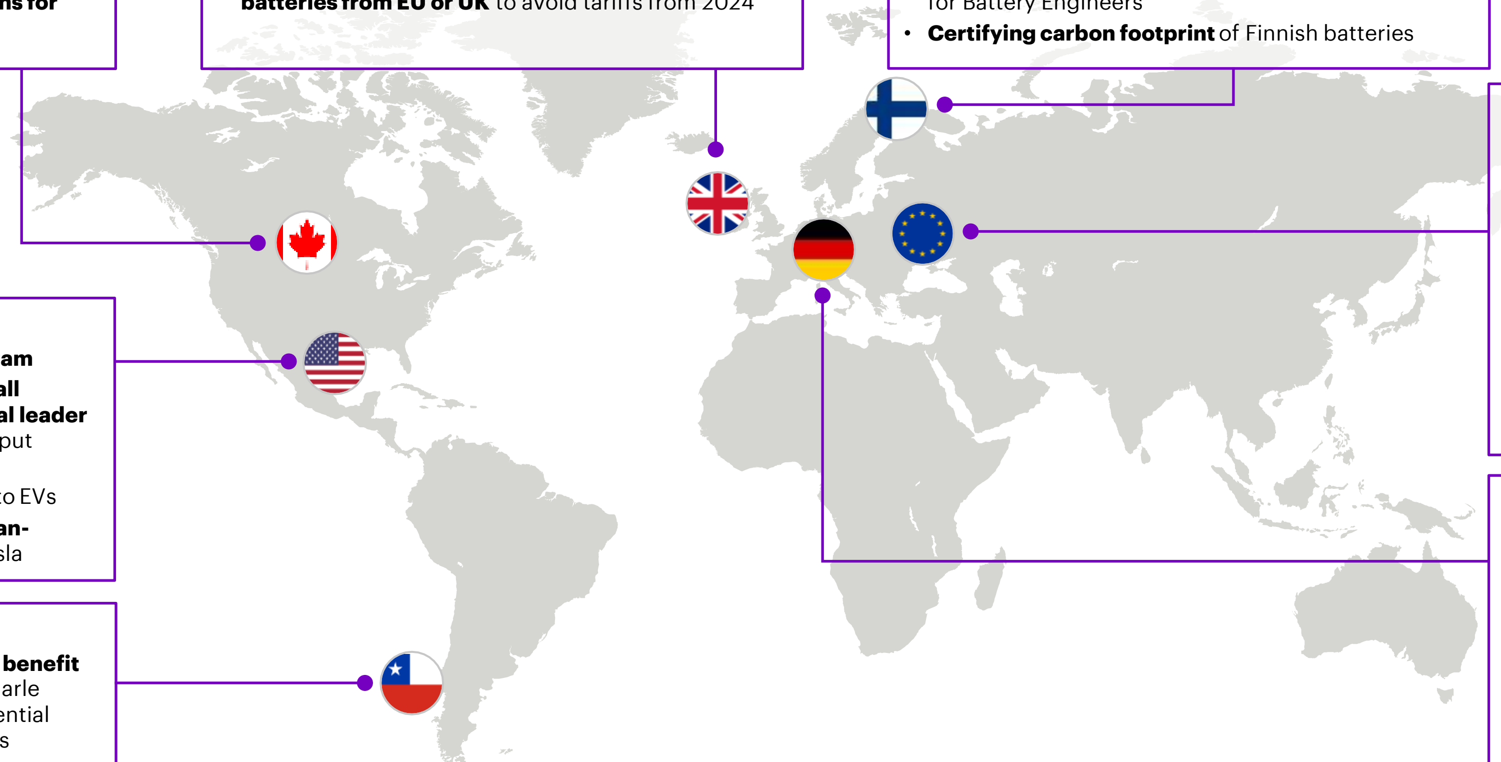
- **Strategic partnership** with US to ensure critical mineral security
- **Significant investments** in battery manufacturing facilities
- $300 million for **charging stations for EVs**

UK

- **Internal-combustion engine vehicles ban** from 2030
- **British Faraday Challenge** grants focusing on design, development and manufacturing of batteries
- UK carmakers to **source 50% of materials for batteries from EU or UK** to avoid tariffs from 2024

Finland

- **€300 million allocated to attracting investments**
- Comprehensive **national battery strategy**
- **Domestic skilling program** including a virtual campus, a doctoral school and a specialised program for Battery Engineers
- **Certifying carbon footprint** of Finnish batteries



US

- **Government-funded R&D program**
- Current administration will use "**all levers" to make America a global leader** in the manufacture of EVs and input materials.
- **Converting Government fleets** to EVs
- **Federal loan guarantees for clean-energy companies** including Tesla

Chile

- **Conditional deals with mines to benefit downstream industry** i.e. Albemarle expansion conditional on preferential pricing for battery manufacturers operating in Chile

EU

- Created **European Battery Alliance** in 2017 which has **attracted around €100 billion in investment commitments**
- **$3.5 billion to subsidise companies to produce batteries in Europe** including Tesla and BMW
- **Trade agreements** to secure supply of raw materials
- European Investment Bank **funding cell manufacturing projects to incentivise, leverage and de-risk private sector investment**

Germany

- Battery value chain a **national priority,** aiming to take 30% of global battery market
- Development bank KfW **providing finance for batteries** used in conjunction with PV systems
- **Levy and grid tariff exemptions** to grid-connected ESS
- German Battery 2020 programme provides **co-funding for projects advancing batteries**
- Up to **€1bn for cell manufacturing** projects

Source: Canadian Government (2020) New commitment to battery-electric vehicle manufacturing in Ontario; Invest in Canada (2020) Canada's battery supply chain will power the electric vehicle revolution; Newswire (2021) Major investments by Canada and Quebec in electric vehicle battery assembly; Finland Government (2021) National Battery Strategy; European Commission (2018) Battery Promoting Policies in Selected Member States; Reuters (2019) Chile, once the world's lithium leader, loses ground to rivals; The Economist (2019) Chile and lithium: Just-in-brine production; The Guardian (2021) UK carmakers have three years to source local electric car batteries; CBC (2021) What experts say Canada needs to do to become a leader in the electric vehicle industry; Energy Post (2019) The European Battery Alliance is moving up a gear; European Commission (2018) Europe on the move; Accenture analysis.

To support diversified battery industries, government should increase access to capital and intensify promotion of FDI opportunities

OBJECTIVE 1:

Financially viable businesses throughout the value chain have access to capital from a variety of sources

Battery projects currently face challenges in accessing the necessary capital investment required to scale, especially in manufacturing.

Domestic capital tends to be prioritised towards mining activities, where Australia's traditional strength lies.

Australia has funding agencies that support our clean energy industry – ARENA and the CEFC – but they have not invested significantly in battery projects because of their limited mandate.

Without intervention, the scarcity of seed funding for downstream battery activities will make it challenging to diversify.

Recommendations

1. **Make grant funding available for Australian-based battery businesses to develop their products and scale-up projects that focus on stationary energy storage**
    - Short-term funding to assist new battery projects establish and reach scale will provide businesses an opportunity to develop scale and to become competitive with global peers
    - Funding through the Modern Manufacturing Initiative may be suitable for some projects along the value chain
2. **Increase access to government-sponsored capital by broadening the mandate of the CEFC and ARENA to include industry development**
    - Expanding the mandate of ARENA and CEFC to consider industry development as an objective will facilitate long-term structural changes to the Australian economy
    - Successful government-supported projects can act as proof of concept, paving the way for private investors
    - Government-provided affordable debt will improve the equity investment proposition
3. **Increase investment attraction activities to promote Australia's battery industries to key FDI markets**
    - Working with industry to identify and address barriers to FDI such as perceived environmental credibility, domestic capability and financial incentives will grow funding to the sector
    - Foreign funding sources have traditionally been more supportive of Australian manufacturing projects than domestic sources

CEFC funds Pilbara Minerals Lithium-Tantalum project (Pilgangoora, WA)

By July 2020, the CEFC had funded over A$67m of a nearly A$150m lithium mining and processing project, producing spodumene concentrate for export sale.

This was the first upstream project in the battery supply chain supported by the CEFC, indicating the difficulty such projects face in both falling within CEFC's remit and being eligible for funding under the CEFC's investment profile.

In the 2020 announcement, it was noted by the CEFC that the investment would encourage institutional investors to participate in Australia's lithium sector.

Source: CEFC (2020) Pilbara Minerals sets sights on growing lithium demand as CEFC lifts investment; Mining Technology (2020) Pilgangoora Lithium Tantalum project Pilbara; Accenture analysis.

Developing the scale and capability of our domestic workforce will be critical to the growth of Australian battery industries

OBJECTIVE 2:

Australia has battery industry expertise to support diversified growth

Industry professionals are concerned about a skills gap facing Australia's battery industries.

Australia is already seeing declining graduate numbers in some of the most specialised battery-relevant fields, while a growing industry will require more talent.

Additionally, there has historically been very high reliance on migrant labour – especially in the engineering profession – posing a further threat with uncertainty regarding international travel.

Australia's finite labour force can rapidly contract in times of resources booms and construction growth, putting significant pressure on wages.

To grow diversified battery industries that is competitive internationally, Australia needs to foster a domestic workforce that can establish, operate and support activities across the value chain.

Recommendations

4. **Establish and fund, in partnership with universities and industry, specialist battery training programs at leading universities**

- Working with industry will be critical to identifying emerging skills gaps and areas of focus, especially in light of new technologies
- A Government-funded program will ensure we have the domestic workforce to support the industry, future-proofing from external shocks such as COVID-19
- Skilling domestically will open up new employment opportunities for Australians
- Existing funding allocations could be used by Government to implement this recommendation.

5. **Work with industry and VET providers to identify opportunities to upskill existing workforce and reskill workers from declining industries, informed by the FBICRC national workforce development strategy**

- Working with industry, VET providers are well placed to provide training that ensures trainee skills match industry needs.
- Short courses will enable workers in adjacent industries to upskill efficiently, and for workers in declining industries to transition
- The Boosting Apprenticeships Commencements wage subsidy may be suitable to support this recommendation

Academic Centres of Cyber Security Excellence

As part of the Cyber Security Strategy, the Federal Government committed $1.9 million to establish academic centres of excellence in University of Melbourne and Edith Cowan University.

The University of Melbourne Centre offers cyber security courses for Masters-level students and conducts field-leading research in four priority areas: Cybersecurity management; Network security and analytics; Privacy and government; and Verification and formal methods.

They also run competitions for students, maintain a network of industry partners, and host executive cyber security training.

THE UNIVERSITY OF MELBOURNE

Source: The University of Melbourne (2020) Centre for Cyber-security Excellence; Accenture analysis.

Government can also play a role in growing the demand for batteries to develop markets for Australian industries

OBJECTIVE 3:

Australian-made batteries and battery inputs are in demand, both nationally and globally

While there is strong demand for Australia's battery materials, demand for downstream battery products needs to be fostered as the industry develops.

Australia's demand for stationary energy storage solutions is forecast to grow significantly, largely due to Australia's high take-up of rooftop solar. Additionally, Australia's neighbours including ASEAN members, Pacific nations and NZ are all forecast to have a growing demand for batteries. Opportunities also exist in commercial applications such as defence, where having a sovereign supply chain is especially important and mining which has specialised needs.

Measures to drive demand for Australian-made battery products, both in Australia and internationally, will assist the industry to reach a globally-competitive scale and capture these demand opportunities.

Recommendations

6. Maintain and strengthen state and territory government financial incentives for household ESS	• Currently most state and territory governments provide some support for household ESS • These incentives should be ramped up to support an Australian battery industry once it has been established
7. Assist industry to develop and market the "Green, Reliable, Ethical" Australian battery brand and simplify the credentialling process	• Battery sustainability and sourcing is becoming more important globally • Promoting the virtues of Australian batteries, including carbon footprint and ESG credentials, will give the industry an advantage, especially over low-cost competitors
8. Increase specificity in local content rules for government procurement	• The electrification of bus fleets and transition of government buildings to net zero emissions will require significant purchasing • Procuring from Australian industry would play a significant role in supporting an Australian battery industry, especially in the electric bus market
9. Work with energy market regulators and the Energy National Cabinet Reform Committee to ensure there are no disincentives to battery deployment in energy markets	• Currently many of the benefits of batteries (largely grid-scale) are not reflected in remuneration in the system, thus resulting in perverse incentives

South Australia's Home Battery Scheme

Since 2018, the South Australian government has supported South Australian homes to install a home battery. The maximum subsidy available is $3,000, from select providers (such as locally-produced sonnen batteries).

The South Australian government initially allocated $100 million to subsidies, with the CEFC allocating the same amount for interest-free loans, to enable a planned 40,000 homes to go online.

A requirement of the Scheme is that eligible home battery systems are capable of being part of South Australia's Virtual Power Plant, which is seeking to scale to 50,000 South Australian homes over time.

Home Battery Scheme

Source: Plenti (2018) SA Home Battery Scheme Powers On; SA Government (2021) South Australia's Home Battery Scheme; Accenture analysis.

Establishing battery hubs and attracting international market leaders as ‘anchor tenants’ would stimulate the development of the battery ecosystem

OBJECTIVE 4:

The battery industries, research organisations and education institutions collaborate to drive growth

Australia’s battery industries face challenges in coordination and collaboration among suppliers.

Battery activity is spread out across the country, thousands of kilometres apart. This limits collaboration and creates inefficiencies in transport and transfers, which will only worsen as the industry grows.

An opportunity exists to co-locate activities across the value chain, where practical. Key linkages between segments exist across the supply chain, for example between producing active materials and cell design or battery manufacture and integration. One option is to use existing fossil fuel generation sites that utilities are looking to rehabilitate as hubs for battery development and deployment.

Supply chain collaboration will enable cost-reducing synergies and enhance product specificity and innovation.

Recommendations

10. **Work with state and territory governments to identify sites for battery materials and manufacturing hubs**
    - Hubs enable key benefits of vertical integration, such as reducing transport and infrastructure costs, fostering innovation, creating economies of scale and shortening the feedback loop (and time to market) on innovations
    - Hubs would also provide sufficient employment opportunities to stimulate labour supply and training
    - The FBICRC could play a key role in convening industry and government to develop the hubs
    - The materials hub may be located in WA, taking advantage of WA’s existing strength and possibly make use of decommissioned mine sites. The manufacturing hub’s location should be determined in consultation with industry

11. **Attract critical anchor tenants to battery hubs, with a focus on established international firms**
    - Attracting a small number of key anchor tenants, especially in the manufacturing space, will kickstart a local industry by skilling the local workforce and providing opportunities for knowledge transfer, joint ventures and offtake agreements
    - While the required attraction package would likely be significant, the one-off investment would have substantial spill-over benefits to local SMEs and the broader economy
    - Universities, training facilities, research bodies and local industry players should also be represented at battery hubs

Travis County secures Tesla Cybertruck assembly plant

After a selection process involving candidate cities such as Tulsa (OK) and Nashville (TN), Tesla is building a Gigafactory for its Tesla Cybertruck in Travis County, Texas. The project is set to bring 5,000 jobs to the region, and Tesla has committed to at least 50% of those jobs going to country residents.

To secure the facility, which totals $1.1 billion of investment, Travis County offered Tesla reduced property-tax rates (~$14m), a property-tax break of $46m and committed to a cap on taxable value of the plant of $80m, meaning Tesla will not have to pay beyond that maximum.

The Tesla factory, Gigafactory Texas, is expected to be operational by end-2021.

TESLA

Source: Bloomberg (2020) Tesla Texas plant deal advances with County incentive approval; Accenture analysis.

06

Appendix

Most state and territory government policies focus primarily on growing demand for batteries, especially for residential ESS

Exhibit 34: Existing state and territory policy supporting battery industry

Key: ✓ In place ✖ Not currently in place

		Battery industry development measures		Home battery rebate schemes	Other notable battery demand programs
ACT	✖	• No notable industry development measures	✓	• **Next Generation Energy program**, ~$4,000 grants support for 5,000 homes and businesses	• Connected 700 houses to ACT Virtual Power Plant • Plans to convert its entire bus fleet to electric by 2040 • Offering 2-years free registration and stamp duty exemption for EVs
NSW	✖	• No notable industry development measures	✓	• **Empowering Homes loan program**, up to $14,000 interest-free loan support for 300,000 homes	• Installed rooftop solar and smart batteries on state buildings • Supporting at least $15m of proposed utility-scale battery projects • Plans to convert its entire bus fleet to electric by 2030
NT	✖	• No notable industry development measures	✓	• **Home and Business Battery Scheme**, grants up to $6,000 for 500 homes	• Procured Darwin-Katherine grid battery energy storage system, investing approximately $30m
QLD	✓	• $3.1m for **Imperium3** manufacturing plant, $2.5m to **Tritium EV** charging & $1.96 to **RedEarth** Energy Storage	✓	• **Economic Development Queensland Tesla Offer**, a $5,000 rebate for Tesla Powerwall • **Queensland Government Solar PV & Battery Grant**, (now closed) saw 4,000 batteries installed through the program through $3,000 grant or $6,000 loan	• Placed 5 community batteries at regional substations • Developing a $6 million Micro-grid and Isolated Systems Test (MIST) facility in Cairns and a Virtual Power Plant in Townsville through state-owned utility providers
SA	✖	• No notable industry development measures	✓	• **Home Battery Scheme**, $3,000 grant for up to 40,000 homes	• Allocated a $50 million Grid Scale Storage Fund, including $12.5m to SA Virtual Power Plant • Developing $320 million of projects involving batteries by state-owned utility SA Water
TAS	✖	• No notable industry development measures	✖	• No battery grant or loan program currently in effect	• Trialing zero-emissions buses (including battery electric) • Supported the $8m Consort Bruny Island battery trial through TasNetworks
VIC	✓	• $200k to **Envirostream battery recycling**	✓	• **Solar Homes Program,** $2,000 rebates for batteries to over 2,500 homes annually and interest free loans	• Contributed over $10m to utility-scale batteries at Ballarat and Gannawarra • Installed batteries for government buildings • Trialling regional microgrids in Mallacoota, Omeo and Corryong
WA	✓	• **Future Battery and Critical Minerals Industries Strategy** • $5m **Exploration Incentive Scheme** • $6m funding for **FBICRC**	✖	• No battery grant or loan program currently in effect	• Contributed over $15m to microgrid and utility-scale battery programs, including $8.8m to Magellan Power (WA power system manufacturer)

Source: Accenture analysis.

Assumptions used in analysis

Assumptions used for battery industry growth scenarios (Exhibits 19 and 20)

	Mining focused scenario	Diversified industries scenario
Mining raw materials	▪ Global mining demand increases 5 to 6-fold ▪ Australia's global share in mining raw battery materials decreases from 50% to 31%[1]	▪ Global mining demand increases 5 to 6-fold ▪ Australia's global share in mining raw battery materials decreases from 50% to 31% [1]
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 (capturing 5% of global demand) 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 (5% of global demand) and industrial vehicles (mining and defence)
Integration, service and maintenance	▪ ESS installing services for domestic and ASEAN markets ▪ EV battery maintenance for 1 million EVs in Australia	▪ ESS installing services for domestic and ASEAN markets ▪ EV battery maintenance for 1 million EVs in Australia
End-of-life	▪ No activity	▪ 80% of all batteries is recovered in Australia ▪ 22% of batteries is recycled in Australia

Assumptions used for battery demand forecast (Exhibit 33)

Domestic sources of demand and growth

Source		***Assumption***
1	Large scale	Large-scale ESS forecast based on presently announced and operational ESS. Forecast assumes that 75% of projects that are committed or under construction, and 50% of other announced projects will be operational by 2030. Forecast does not account for projects that will be announced in the future.
2	Small scale	NEM small-scale ESS forecasts based on AEMO Fast Change scenario. SWIS small-scale ESS forecasts based on AEMO High scenario.
3	Off-grid	Off-grid ESS forecasts assumes that the proportion of total Australian battery demand which is off-grid grows from 10% to 20% from 2020 to 2030.
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.

International sources of demand and growth

Source		***Assumption***
5	Growth in regional export markets	ASEAN and NZ ESS forecasts assume that ASEAN 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. IRENA's High Remap scenario used to forecast global ESS demand.

Notes: Exhibit 19 on slide 26, exhibit 20 on slide 27 and exhibit 33 on slide 40.
Source: 1. Roskill projection (2020) Global Lithium demand is expected to climb to 1.79Mt by 2030; Accenture analysis.