Battery Supply Chains

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Table of contents

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Executive summary

Rapid clean technology deployment can cut Australia's emissions by 81% this decade - this includes an ambitious roll-out of batteries for stationary energy and electric vehicles.[1] The same story applies around the globe, and Australia must act quickly and decisively to capture the economic and strategic opportunity within the fast growing battery supply chains. As its fossil fuel exports face decline, Australia will need political will and policy intervention to help it secure strategic roles in high growth supply chains in which it has a natural competitive advantage.

The scale of the opportunity

The rapid roll-out of batteries can reduce Australia's national emissions by 23% by 2035 across the stationary energy and transport sectors. Batteries enable renewables to be stored to power our cars, homes and communities. Batteries also play a vital role in firming the energy grid, enabling it to reach 100% renewable energy and underpin decarbonisation in other sectors.

By 2050, to keep global decarbonisation in line with a 1.5°C pathway, the world will require 280TWh of battery energy storage for transport and electricity systems. Today, China produces 1.2TWh of batteries a year, commanding a 75% share of the battery supply chain. Current projections forecast that the world's battery manufacturing will grow to 6.1 - 9.1TWh by 2030.[2,3]

As global economies shift to renewable energy and electric transport, no country alone can provide the manufacturing capacity required to meet global energy storage needs. This leaves significant scope for the development of battery supply chain ecosystems globally. Notably, South Korea has stepped up its production capacity to become the second largest battery manufacturer in the world. The United States of America (USA) and other countries are now investing heavily in this space. Australia is at a defining moment, and it risks stumbling at the starting gate.

Beyond Zero Emissions' (BZE) Deploy report identified the **need for 2 TWh of batteries by 2035 to meet both stationary energy and electric vehicle requirements** in line with 1.5°C of warming.[1] This demand presents a significant opportunity to establish a domestic battery industry in Australia.

What this means for the economy

Australia's opportunity to move down the battery value chain and grow Australia's economic prosperity is sizable. The market for batteries is growing rapidly. The **lithium battery market worldwide is estimated to be worth $1.25 trillion by 2030, jumping to $1.9 trillion by 2035**, not including the market opportunity for recycling.[4,5] BZE modelling shows **an Australian lithium battery industry could deliver over $57 billion in GDP and 44,000 jobs in 2035 alone[1a2a].**

[1a] Jobs figures not inclusive of mining, non-lithium refining & services and integration
[2a] See appendix B

BZEs *Export Powerhouse* report forecast that the **climate targets of Australia's key trading partners will wipe $128bn a year off Australia's exports** unless it invests in alternatives[6]. Australia must seize these opportunities quickly - within the next five years - to ensure that it captures significant long term economic growth, energy security, and export markets to replace fossil fuels and to capitalise on its abundant critical mineral and renewable energy resources.

Current capability - where Australia sits

Australia is the only country in the world to host all the minerals required to produce current Battery Energy Storage Systems (BESS) technologies and electric vehicle batteries; this should mean that Australia is positioned to play a dominant role in the high stakes markets along the supply chain. Currently, Australia's economic participation is one of 'top and tail'. It digs and ships at one end of the lithium-ion battery supply chain, and assembles them from imported components at the other. This means that although Australia captures over half of the global market share of raw lithium materials, it only captures 4% of the supply chain value. Australia sends its raw material to overseas destinations who capture 96% of the supply chain value through processing and component manufacture.[4]

Key Opportunities

This paper identifies two significant opportunities in the battery supply chain which must be seized quickly, requiring policy drivers and investment in the near term (next five years). The first is:

1. **Growing Australia's onshore lithium battery supply chain**
    - **Refining and processing** lithium to add value to Australia's raw materials and reduce the emissions impact of shipping offshore for processing.
    - **Develop export-competitive battery manufacturing hubs** to capture the largest share of the value chain.
    - **Concentrating zero-emissions battery supply chains around Australia's existing industrial regions** or Renewable Energy Industrial Precincts (REIPs)
    - **Capturing circular economy** to optimally manage materials.

Australia's world leading rooftop solar has placed it at the leading edge of grid-decarbonisation and brought about an immediate need to scale the deployment of grid-scale batteries. This demand is currently being met by offshore suppliers, with redox flow batteries and lithium-ion batteries ready to meet medium duration energy storage needs. It is important for Australia to diversify and build redundancy into its energy storage supply chains to minimise the impact of projected lithium material constraints and potential supply shortages by onshoring manufacturing. This will also ensure that both energy storage needs can be met and that Australia can take advantage of local innovation for export markets. The risks to energy security presents the second significant opportunity:

2. **Building onshore capacity to manufacture lithium and alternative battery technologies** to support grid modernisation and energy security:
    - **Investing in cell manufacturing** - to complete the supply chain and ensure domestic energy security

- **Develop parallel capacity by manufacturing alternative battery technologies -** to ensure access to stationary energy storage to mitigate the risk of potential lithium shortages.
- **Accelerating domestic deployment of household, heavy vehicle and medium duration batteries** - secure early demand and assist industries to scale to export quantities.

Recommendations

Recommendation 1: Moving from "dig and ship" to value-add to Australia's mineral processing.

1a. Introduce a 10% production t ax credit (PTC) for the refining of lithium. An additional credit should be offered to refiners utilising novel green technologies to accelerate decarbonisation.

1b. Introduce a 10% PTC for processing of active materials.

Recommendation 2: Establish cell manufacturing capacity and support non-cell technologies to capture maximum value in the battery supply chain.

2a. Introduce a 28% PTC for cell manufacturing.

2b. Introduce a 15 % PTC for non-cell battery technology.

2c. Deploy $2B of equity funding in cell facilities and non-cell battery technology to unlock the full supply chain

Recommendation 3. Stimulate demand for Australian-made batteries.

3a. Expand the Capacity Investment Scheme's (CIS) 6GW target to 12GW by 2030 and extend the scheme to 24GW by 2035 and include preferential treatment for Australian-manufactured batteries.

3b. Include battery storage systems in the Small-Scale Renewable Energy Scheme (SRES).

Recommendation 4: Secure supply chain inputs and pool demand.

4a. Develop international partnerships to ensure that key trading partners have the inputs they need and to pool demand for Australia's medium scale batteries.

4b. Implement pre-emptive rights for domestic business to further incentivise onshoring.

Recommendation 5: Establish battery hubs in Renewable Energy Industrial Precincts

5. Identify and pre-approve appropriate locations for battery supply chain operations within REIP locations.

Recommendation 6: Ensure that Australia is well placed to meet the circular economy opportunity.

6a. Include black mass under the Hazardous Waste Act (1989) to retain feedstock for domestic recyclers.

6b. Map and plan the end of life logistics for batteries, including appropriate aggregation and recycling locations.

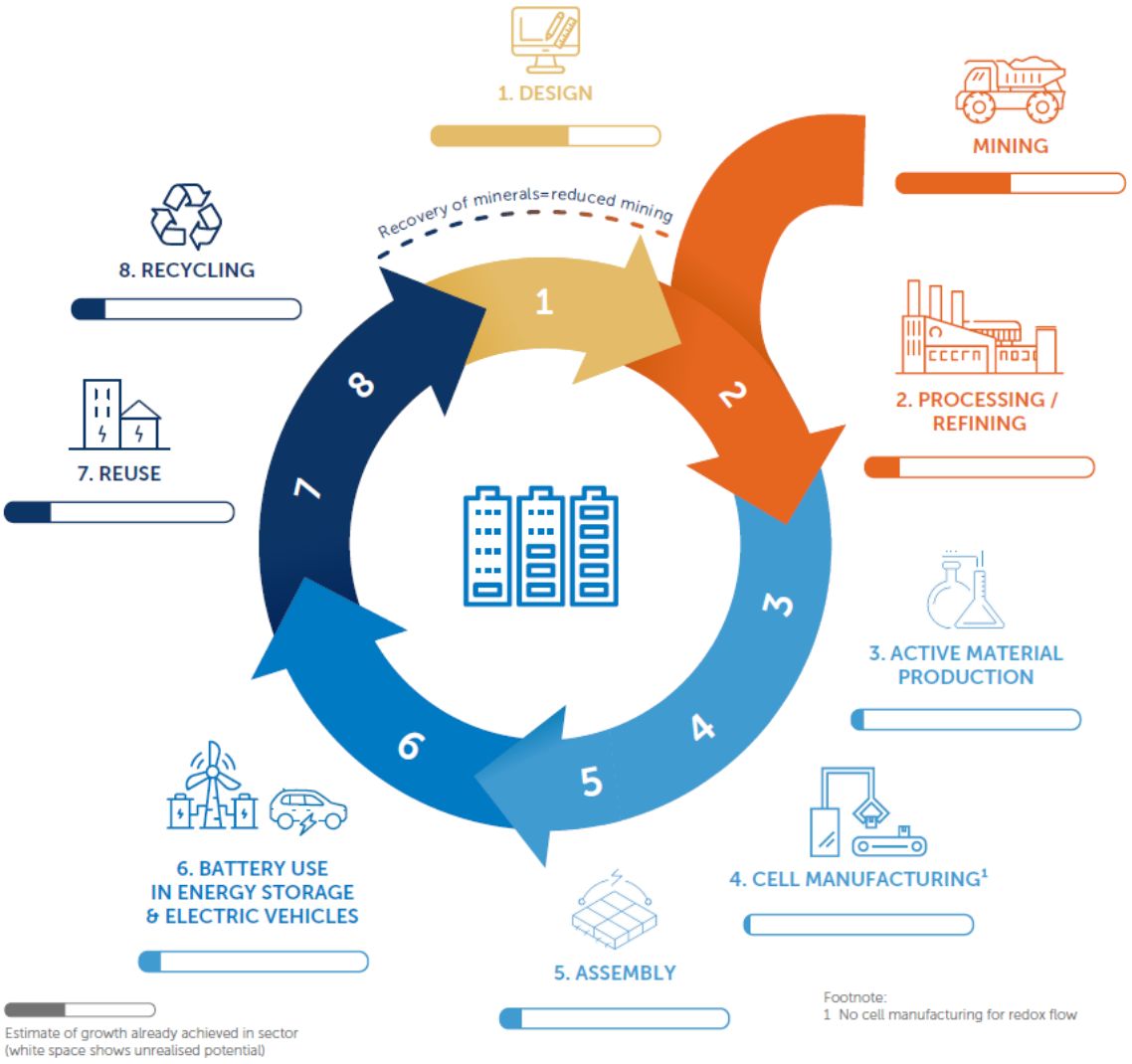
The Battery Supply Chain

As the penetration of low cost, zero-emission renewables rapidly increases and more electric vehicles (EVs) hit the roads, battery storage will play a central role in Australia's, and the World's, energy reliability and security. Batteries can reduce Australia's emissions by 23% across stationary energy and transport sectors, leading to an overall 81% cut in emissions this decade.[1]

Battery energy storage systems refers to technologies that provide the means to store variable or intermittent wind and solar generation. It enables 'excess' energy to be captured for use when renewable energy is not generating and when peak energy demand from users requires additional energy (that would traditionally be provided by fossil fuels, notably gas). Similarly, batteries allow renewable energy to be stored and used to decarbonise transport, from passenger vehicles to buses, trucks and mining vehicles.

Recent geopolitical tensions have highlighted the risks to energy supply and affordability resulting from exposure to global energy markets. The Russia-Ukraine war raised energy prices dramatically around the globe. Battery storage can provide energy security and affordability by storing low cost renewable energy.

Australian Battery Supply Chain



	Description of current growth and future opportunities
1. DESIGN	Strong R+D capability in battery chemistry and design for circular economy
MINING/EXTRACTION	Established mining sector with relatively good ESG, zero-carbon approaches emerging
2. PROCESSING/REFINING	Mineral processing industry nascent, significant opportunity for immediate growth
3. ACTIVE MATERIAL PRODUCTION	Nascent industry, significant opportunity for immediate growth
4. CELL MANUFACTURING	Non-existent, opportunity to establish globally significant battery cell manufacturing
5. ASSEMBLY	Growing industry in energy storage systems and bespoke heavy EV applications, major area for growth
6. BATTERY USE	Demand for storage and EVs set to grow significantly
7. REUSE	Emerging second-life battery industry
8. RECYCLING	Strong lead-acid recycling capacity, emerging lithium recycling industry

The Scale of the Opportunity

Materials are in short supply

The global supply of materials is falling short of meeting net-zero targets. A shortage in the supply of critical minerals and processed minerals is one of the key challenges for battery manufacturing. Global efforts to ramp up lithium-ion battery manufacturing are accelerating from 0.6TWh at present, to between 6.1 and 9.1TWh by 2030. However, by 2030, it is forecast that there will only be sufficient material supply to manufacture 3.2TWh of batteries.[3] This will mean half of global battery manufacturing capacity will sit idle by 2030 if material supply is not increased.

Given the dramatically faster than expected uptake in EVs worldwide, insufficient supplies of battery materials risks slowing the pace of EV deployment.[9] EVs will represent **more than 90% of battery material demand globally by 2030[7].** If material supplies do not increase to match net-zero production rates, deployment of the equivalent of up to 81 million EVs will be delayed[3a].

Accelerated emissions reduction can drive growth of local manufacturing

Australia can drive local battery manufacturing by following an ambitious emissions reduction pathway. By 2035, Australia will need in total almost 2 TWh of batteries across stationary energy, homes and communities, and embedded in both passenger and commercial EVs[1].

Australia is already making batteries for stationary energy, homes and communities as well as commercial electric vehicles (CEVs) such as trucks (for mining and haulage), vans and buses. The areas where Australia is already making batteries **represent 1.1 TWh of demand by 2035, over 50% of Australia's battery demand[1].**

If Australia were to produce enough batteries for domestic energy storage and CEV needs from now to 2035, **Australia could support up to five gigafactories[4a].** This would position Australia to be export competitive, ensuring Australia can supply zero-emissions batteries for global decarbonisation. Our research shows these factories alone would **create 20,000 advanced manufacturing jobs and add $17 billion to the economy in 2035[5a].**

Value chain component share of total value

By 2030, the global lithium value chain will be worth $1.25 trillion. Figure 2 shows that 60% of the value chain is concentrated across cell and battery pack assembly. Australia currently captures less than 1% of this value chain.[10]

[3a] See appendix B
[4a] See appendix B
[5a] See appendix B

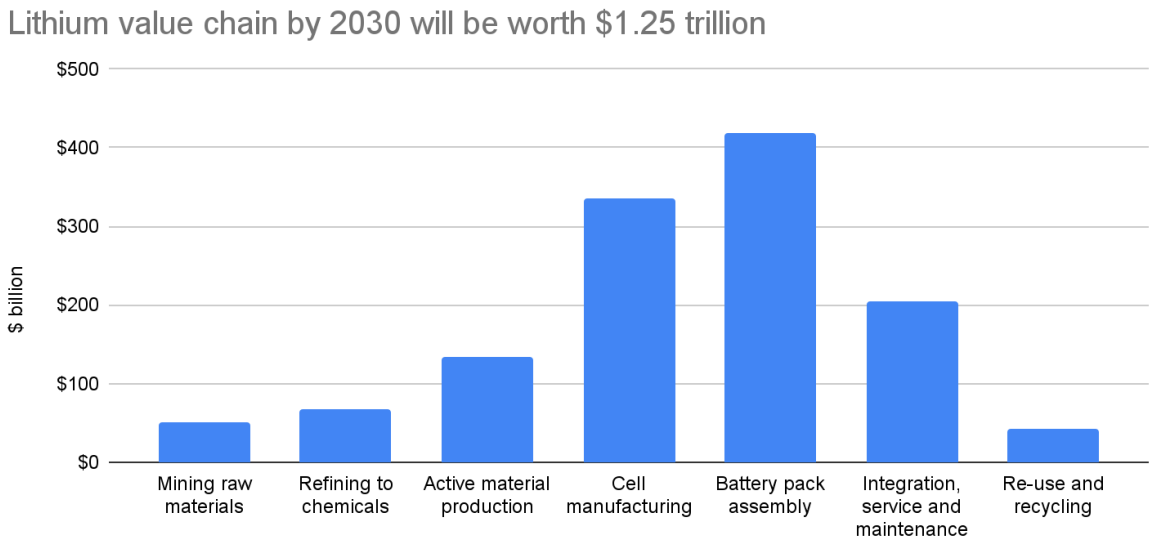


*Figure 2. 2030 forecasted global lithium value chain across each supply chain stage (**Reproduced from** FBICRC, Charging Ahead).*[4]

Key opportunities for Australia

Australia has a significant share of the battery materials required to supply the global ramp up of battery manufacturing. As demand for batteries and their materials skyrocket, Australia has a huge opportunity to move down the value chain (from “dig and ship” to “value add”) for significant economic reward. This will also ensure timely deployment of domestic batteries, particularly utility scale batteries for grid support and energy security.

Two significant opportunities in this moment are:

1) **Growing Australia’s onshore lithium battery supply chain**
2) **Building onshore capacity to manufacture lithium and alternative battery technologies**

Opportunity 1: Growing Australia’s onshore lithium battery supply chain

Leveraging Australia’s critical mineral resource advantage

Australia is uniquely positioned as the only country with all the raw ingredients to build lithium-ion batteries, ranking amongst the world’s highest concentration of critical mineral reserves (see Figure 3). Australia ranks second for lithium reserves, second for cobalt, equal first for nickel, second for copper, and second for manganese.[11] Australia can capitalise on this massive, global, geopolitical advantage to deliver economic prosperity for Australia whilst supplying the critical minerals for global decarbonisation.

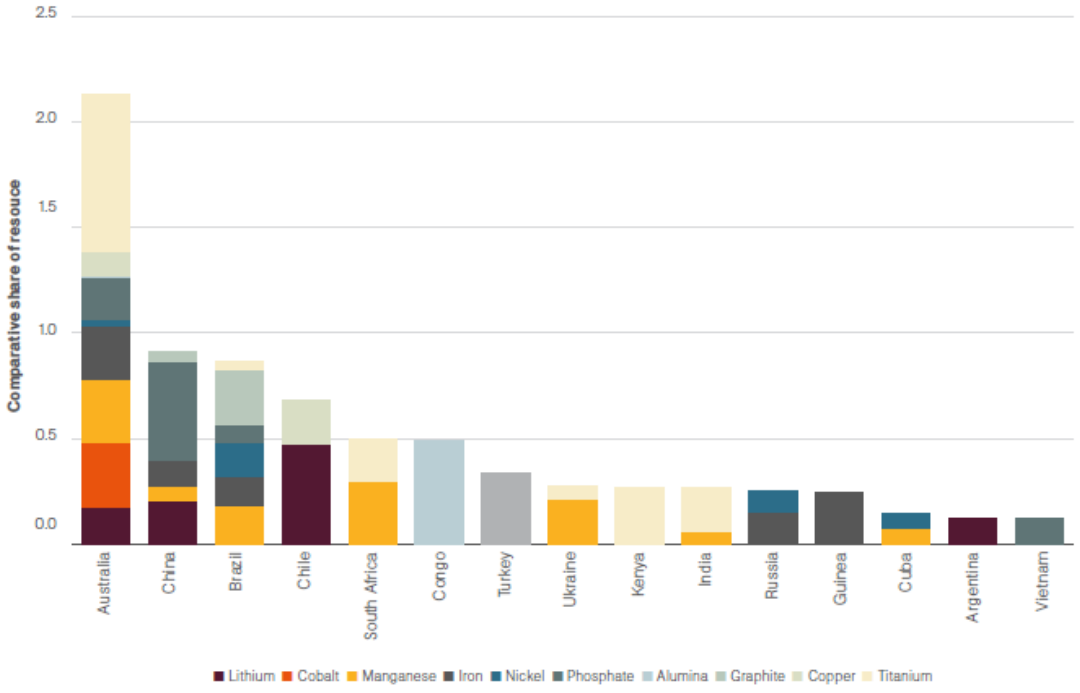


Figure 3. Comparing mineral resource reserves relevant to manufacturing lithium-ion batteries by country (reproduced from Austrade) .[12]

Australia has a significant opportunity to help meet material shortages by leveraging its strong resource base. **Australia has enough lithium to supply at least 18% of global net-zero battery demand[6a] .** However, digging and shipping raw lithium only delivers marginal benefit when compared to stepping down the supply chain to lithium refining.

Raising Australia's refining ambition by moving down the value chain with lithium hydroxide

Australia has a significant economic opportunity by moving down the battery value chain. To illustrate the type of opportunities that exist down the value chain, BZE has modelled moving down from exporting raw lithium to refined lithium hydroxide (moving down one step of the supply chain). Lithium hydroxide is a key material that goes into making cathodes for electric vehicles.

By 2030, the price of purchasing raw lithium is forecast to be $2,452/t compared to $44,191/t for lithium hydroxide.[13] In 2023, the price of lithium hydroxide was as much $96,555/t.

If Australia refined all its lithium before exporting, our research shows that by 2035, the value of Australian-made lithium hydroxide is $53 billion compared to $16.5 billion if it were to continue business as usual. This would also create an additional 11,000 regional jobs[7a].

To capture this opportunity, Australia will need to grow its hydroxide refinery operations from three facilities to over 23 by 2035[8a] . Doing this would make Australia a substantial supplier of lithium hydroxide.

This represents just the first stage of moving down the supply chain. There is enormous value to be unlocked at every stage of the supply chain, as 96% of the value chain lies downstream of mining. Australia can continue its outsized role as exporter of energy and mineral resources if it moves to seize this opportunity.

Cell manufacturing and assembly battery hubs

One of the most significant value chain opportunities is cell manufacturing and assembly, which captures 60% of the value chain (see Figure 2). The best way to support cell and assembly growth is to establish battery hubs.

Battery hubs are the co-location of different stages of the battery supply chain. There are efficiencies to be unlocked through the clustering of battery industries, such as reduced logistics costs, knowledge sharing, common use facilities, and shared infrastructure. This is already taking shape in Kwinana, with different stages of processing already underway. The Hunter valley is poised to become a manufacturing hub, with downstream companies including Ampcontrol, 3ME Technology, and Energy Renaissance already established there.

[6a] BZE analysis of Geosciences 2022 dataset
[7a] See appendix B
[8a] Assuming 50ktpa facility size

Australia can leverage large battery demand through a rapid zero-emissions pathway to establish a battery manufacturing industry. Australia's demand for energy storage and CEV batteries will be in total 1.1 TWh by 2035. The majority of this demand will be for CEVs such as buses and trucks. This level of demand is large enough to catalyse an Australian battery manufacturing industry with a focus on meeting its domestic needs and maximising export opportunities.

Cell manufacturing can support Australia's growing battery assembly industry. Australian companies are already making batteries for homes, industry, the electricity grid, commercial vehicles, defence, and mining vehicles. By making cells, Australian battery assemblers can gain supply security and access to cost-competitive zero-emissions cells.[14] The economies of scale for battery demand generated by pursuing a rapid emissions reductions pathway is sufficiently large to support up to five gigafactories that are export competitive in Tier 1 economies.

In pursuing a rapid zero-emissions pathway, Australia can establish an export competitive battery manufacturing industry. Our research shows **a cell and assembly industry in Australia can add $18 billion to the economy in 2035, in addition creating 25,000 advanced manufacturing jobs[9a] .**

Australia can develop a zero-emissions battery supply chain

Battery manufacturing is an energy intensive process. Australia's opportunity in the rapidly growing lithium processing and battery manufacturing market should include leveraging its enormous, low cost renewable energy resources to produce zero-emission battery materials and batteries.

Shipping emissions account for 4-5% of emissions across the supply chain.[15] Moving down the supply chain to the processing of critical minerals will reduce shipping emissions significantly. For example, of the raw lithium material sent offshore for processing, over 90% of it is waste rock. By onshoring refining, shipping a refined product becomes much more efficient, removing the need to ship a large amount of waste. Further opportunities to decarbonise mining operations have been detailed in recent work from Climate Energy Finance, which looks at decarbonising mining transport and machinery.[16]

With all batteries sold in Europe required to have a battery passport by 2027, zero-emission supply chains with high Environmental, Social and Governance (ESG) standards will be a competitive advantage for Australia in global markets.[17]

Renewable Energy Industrial Precincts (REIPs) offer an opportunity to locate battery hubs within precincts to help enable production of zero-emissions batteries.

Renewable Energy Industrial Precincts

Renewable Energy Industrial Precincts (REIPs) are an efficient way to revitalise Australia's industrial centres with low-cost renewable energy to power the industries of the future. They are clusters of energy-intensive manufacturing facilities in one location, powered by

[9a] See appendix B

100% renewable energy and connected to each other using modern energy management tools. This proposed model minimises the cost of shared infrastructure and allows manufacturers to benefit from economies of scale and efficiencies. Ideally, REIPs should be located in existing industrial centres to benefit from the skilled workforces, ports and roads, and rail and energy infrastructure.

REIPs need good renewable energy resources and access to green hydrogen production and clean heat. REIPS will enable the low-carbon goods of the new economy. They can support energy-intensive businesses such as green aluminium and steel, hydrogen, ammonia and other chemical production, and recycling and battery manufacturing, which means a REIP model would work best in Australia's regional manufacturing heartlands. REIPs can also provide a home for manufacturers of the large amounts of clean technologies we need to deploy, such as wind turbines, electric vehicle chargers, batteries, electrolysers, electric buses and mining equipment, boosting manufacturing in Australia.
Many organisations are calling for the REIPs including WWF and Climateworks Centre.

Case study: Tahoe Reno Industrial Center, USA

The Tahoe Reno is a large industrial complex in the state of Nevada USA that has 26 colocated anchor tenants.[18] The industrial complex is a Public Private Partnership, with Storey County providing services to the companies that buy land. It is the site of Tesla's first gigafactory. From the start Tesla had clear plans to power its gigafactory with renewable energy, declining to connect to the complex's 1100 MW gas fired power station.[19] Several US states competed to secure the gigafactory and offered Tesla an extremely generous range of incentives. The State of Nevada offered Tesla benefits to the value of almost $1.3 billion to locate in Nevada, plus rapid approvals, deployment and construction.

Panasonic, a global electronics manufacturer based in Japan, formed Panasonic Energy of North America (PENA) to partner with Tesla. PENA is a major supplier of cells to Tesla and has recently announced its intention to increase production by 10% to 39 GWh per annum. In addition, Redwood Materials has been collecting scrap from the Nevada site and recycling them as a supplier to Panasonic.[20]

With shared infrastructure, clustering with synergies and powered by 100% renewable energy, the Tesla/Panasonic collaboration in the gigafactory meets the definition of a Renewable Energy Industrial Precinct. Other ingredients to Tesla's success in its rapid deployment and scale up of its gigafactory also include massive government support. The State of Nevada was prepared to share the risk with Tesla, and now share the rewards. Tesla also received federal support, making total government backing for Tesla at the Nevada site alone US$1.65 billion.[21]

There are many similar elements of this style of collaboration in the Hunter Region of NSW, especially in the Tomago Industrial Precinct. Energy Renaissance said it can

become a cell manufacturer with government support. This means the Hunter region could become the cell supplier to support Australian battery manufacturing.

Australia must capture the circular economy for batteries

Circularity in battery supply chains will be key to managing material constraints, battery waste, and long term mining impacts on communities, First Peoples, and biodiversity conservation. **By the mid-2030s, battery recycling must be fully functional to recycle onshore battery manufacturing waste and as the first adopter wave of EVs turn over their car batteries.** Australia is well placed to meet this challenge, with its expertise in mining, equipment, technology and science (METS), growing recycling capabilities, and waste management practices.

Setting the foundations for a lithium battery recycling industry is key to meeting battery recycling and material demand over the next decade.

- By 2030, a recycling industry will add at least A$500 million in GDP and create one thousand jobs for the Australian economy.[4]
- By 2030, the global value of recycling will almost be at parity with mining, $42 billion versus $52 billion.[4] As the global battery supply chain matures, it can be expected that recycling could outcompete mining and refining. Recycled batteries also lower emissions by up to 70% compared to mining and refining.[22]

Recycling processes are improving and higher rates of recovery are being demonstrated. Australian company Renewable Metals has achieved 95% recovery rates in two pilot projects for various battery chemistry types.[23] By 2040, the IEA modelling shows 12% of battery materials will be from recycled and reused sources from an estimated 350 million EVs and other sources.[24]

Case study: Vaulta

Vaulta is a battery casing technology company that understands end of life begins with design. Vaulta's world-first no-weld design means modules can be easily assembled and disassembled, cells reused and recycled, and new cells added as battery technology continues to evolve. Ease of disassemblage means that end of life batteries can be recycled much more quickly and efficiently than traditional battery technology. Vaulta's batteries have a range of applications, from stationary storage, to electric vehicles to defence applications.

Case study: Infinitive

Zenobe started in 2017 in the UK and expanded to Australia in 2020. Their business model focuses on end-to-end bus fleet management, with a focus on electric buses.[25] They help to remove the financial, technical and operational risks of the energy transition by managing finance, charging infrastructure (including upgrades) and software.

Recently, they helped to deliver Australia's largest electric bus project, in the Leichhardt (Sydney) depot, housing Australia's largest single fleet of 59 electric buses. The site has stationary batteries installed that enable charging when energy is cheapest to buy and

discharging when the site can sell energy back.

Their model prolongs the use of EV batteries by repurposing them in stationary uses like bus depots or other commercial sites. This can increase the life of batteries by up to 50%. This also buys more time for the recycling industry to mature.

Australia must move now to capture the opportunity

Australia can capture this opportunity, but it needs to act quickly. The generous subsidies of the USA's Inflation Reduction Act has narrowed Australia's window of opportunity to move down the supply chain. However, the window is not shut. The natural endowment of battery minerals, abundant renewable energy, and stable governance make Australia an appealing place to invest. But the new economic reality means that this is no longer sufficient; government intervention will be required if Australia wants to onshore and move down the battery supply chain.

Opportunity 2: Building onshore capacity to manufacture lithium and alternative battery technologies

Energy security is the cornerstone of Australia's ability to bring down emissions and become a renewable energy and export powerhouse. Battery storage underpins Australia's road to a National Supergrid and 81% emissions reduction by 2030.[1] These storage systems are one of the most pressing needs for the grid to deliver energy security, reliability and lower energy prices.[26]

Concentrated global battery supply chains and projected lithium shortages represent a risk to energy security, but can become an opportunity for Australia if it invests in battery manufacturing now. Australia can build parallel capacity in lithium battery manufacturing and alternative battery technologies to de-risk access to energy storage critical to Australia's 100% renewable energy future.

Grow lithium battery manufacturing in Australia

Lithium batteries are currently the only proven, mature, and affordable solution for energy storage for the electricity system and vehicles. The possibility of lithium battery supply chain disruptions risks slowing Australia's energy transition. Australia can future proof the deployment of lithium batteries in its economy by investing in manufacturing Australian-made batteries.

Australia needs 2 TWh by 2035 to deliver rapid emissions reductions. To help meet this demand and mitigate the risk of supply shortfall, Australia can leverage its unique global wealth of battery materials to develop a pit-to-plug battery supply chain. One of the key ways Australia can insulate itself from supply risks is to invest in up to five gigafactories. This would build capacity to make cells and assemble batteries at a scale sufficient to meet most of Australia's battery needs.

Building capacity in alternative battery technologies

Projected lithium shortages represent a risk to global decarbonisation efforts, but can become an opportunity for Australia if it invests in alternative battery technologies now to help meet global stationary energy storage deployment.

At present, lithium-ion batteries are the sole battery solution at scale for both electric vehicles and battery energy storage systems. Building parallel capacity de-couples stationary energy storage from the lithium supply chain, easing supply shortages and ensuring energy security.

The emergence of lithium alternative grid-scale batteries, such as redox flow batteries, have the potential to fill some of the gap that lithium shortages could create, particularly in stationary energy which is less constrained by factors such as energy density compared to electric vehicles. A key technology that can help meet this gap is redox flow batteries made with chemistries such as vanadium, zinc-bromine, or iron. Australia can leverage its resource advantage to build onshore redox flow battery manufacturing to ensure that it has access to this battery technology.

Redox flow batteries are technologically mature. They are a growing market with a less developed global supply chain compared to lithium.[27] **Australia has an opportunity to build up parallel capacity for energy storage that is not reliant on the lithium supply chain as it has all the minerals required to produce redox flow batteries.** By establishing local manufacturing for redox flow batteries, Australia will be the catalyst for the commercial maturation of an already mature technology.

Redox flow batteries can step up to deliver stationary energy and future proof Australia's energy security moving forward

Redox flow batteries have several advantages that benefit both Australia's energy sector and consumers. Flow batteries are modular and scalable, non-flammable, provide unlimited storage duration, 100% discharge, 20+ year operability and are fully recyclable.[28]

Flow battery applications:

- Utility battery storage
- Residential, commercial and industrial battery storage
- Agriculture and mining
- EV vehicle charging
- Telecommunications and stand alone power systems

Several Australian companies are establishing, or looking to establish, manufacturing domestically to take advantage of Australia's mineral and renewable energy resources:

- Vanadium Australia
- North Harbour Clean Energy
- Redflow
- Allegro Energy
- Vecco Group
- VSUN Energy

Longer duration storage entering the spotlight in Australia's battery deployment

Australia is at the leading edge of grid decarbonisation. Australia's National Electricity Market and the South West Interconnected System are among the fastest decarbonising grids globally.[29,30] This, coupled with its coal-plant closure schedule, means that Australia urgently needs to deploy batteries for energy storage at scale to ensure grid reliability. Attention is now turning to longer duration storage.[26]

Longer duration battery storage technologies have not been deployed at scale anywhere globally and Australia's need for longer duration storage is immediate (see Figure 4). This challenge is also an opportunity. Australia is a world leader in demonstrating what's possible, catalysing the world to follow. When the Hornsdale battery was installed in South Australia, it proved the viability of utility scale battery storage and helped pave the way for lithium-ion deployment across the globe. In 2022, the Hornsdale battery delivered another first-of-its-kind achievement, becoming the first approved battery in the world to deliver grid-forming services, demonstrating that big batteries can deliver vital power security.[31]

Australia now has an opportunity to lead the way in medium duration grid batteries by deploying hundreds of megawatt-hour sized projects to deliver the next "Hornsdale moment" on the world stage for longer duration battery technologies.

Medium duration storage will be important for performing vital intraday load management, ensuring generated renewable energy is not wasted (curtailed) and is available to supply the grid during peak demand. According to the Australian Energy Market Operator (AEMO), medium storage capacity could represent 24% of overall installed energy storage capacity by 2035 and grow to 62% by 2050 (see Figure 4), excluding Snowy 2.0.[32]

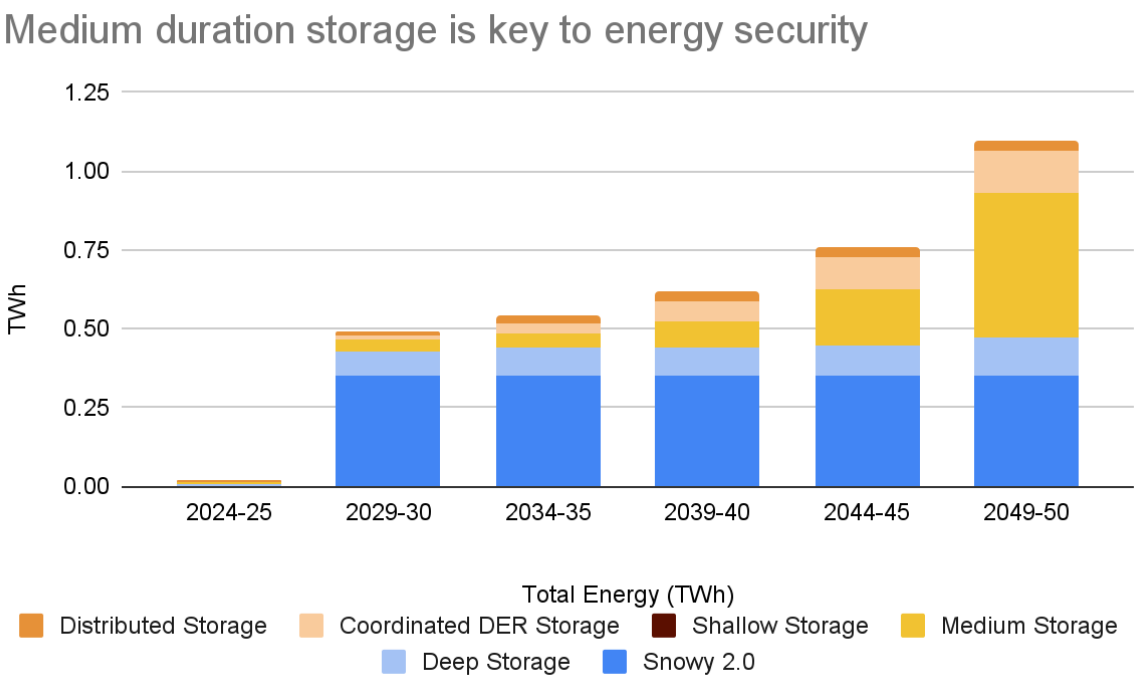


Figure 4. Running total of installed energy storage by duration category, Hydrogen Superpower (AEMO ISP hydrogen superpower).[32] Distributed storage, co-ordinated DER and shallow storage are all less than 2 hours. Medium is between 4-12 hours. Deep storage and Snowy are 12+ hours.

How batteries can deliver energy security

Grid Firming Energy Storage

Battery technology is a highly valuable grid asset that offers the energy security, traditionally delivered by coal and gas, to enable renewable generation to power Australia's electricity grid. Batteries are extremely versatile, delivering a range of functions that strengthen Australia's grid:

- Combined with renewables, batteries deliver the lowest cost electricity.[33,34]
- They are key to managing curtailment and increasing the penetration of renewables, as recently demonstrated by the Kwinana big battery in Kwinana, WA.[35]
- Batteries can deliver rapid grid-stabilisation services and system strength including frequency control, inertia, and grid forming which traditional energy sources provide.[33]
- As battery innovation continues to develop, the ability of batteries to deliver power system security will underpin Australia's and the World's energy security.

As Australia ramps up deployment of renewable energy and builds a National Supergrid, battery energy storage will serve as a vital cornerstone of Australia's energy security while lowering energy prices and reducing emissions.

Hornsdale Power Reserve

The Hornsdale Power Reserve is a 150MW/194MWh lithium-ion battery energy storage system located in Hornsdale, South Australia. Built in 2017 by Neoen, Hornsdale is the world's first commercial-scale battery energy storage system.[36]

The battery plays a critical role in supporting the integration of renewable energy sources, such as solar and wind, into the grid. It does this by storing electricity when it is generated from renewable energy sources and delivering it to the grid when it is needed.

The battery has had a significant impact on the South Australian energy market. It has helped to reduce wholesale electricity prices, improve the reliability of the electricity supply, and reduce greenhouse gas emissions.

The Hornsdale Power Reserve is a landmark project that is helping to shape the future of renewable energy in Australia and around the world. It is a shining example of how battery energy storage technology can be used to support the transition to a cleaner and more sustainable energy future.

WA's Big Battery

Synergy, Western Australia's state-owned electricity provider, has commissioned a 100 MW/200 MWh big battery to smooth out the duck curve from high levels of rooftop solar. It can store enough energy to power 160,000 homes for up to two hours. Synergy plans to further develop a second battery at the same location with 800 MWh of storage and a capacity to absorb or supply energy at a rate of 200 MW. The proposed second battery is part of Synergy's commitment to build 1,100 MWh of medium-duration energy storage by 2030.[37]

The WA Big Batteries are expected to have a significant impact on the Western Australian energy market, including:

- Reduced wholesale electricity prices
- Improved reliability of the electricity supply
- Reduced greenhouse gas emissions
- Job creation and economic growth

The construction of the batteries created hundreds of jobs, and the operation of the batteries is expected to create ongoing jobs in the maintenance and management of the systems.

What this means for the economy

Australia's $128 billion fossil fuel industry is at risk

Global decarbonisation plans are set to see demand for fossil fuel exports subject to continual decline through to 2030 while creating boom conditions for zero-carbon commodities. BZE's Export Powerhouse 2021 report forecast that the climate targets of Australia's key trading partners will wipe $128bn a year off Australia's exports unless it invests in alternatives. The choice is clear: over the next two decades Australia will lose a

third of total commodity export revenue and the jobs that go with them without investment in new export industries.[6]

Opportunity to grow economic prosperity by moving down the value chain

BZE modelling shows an Australian battery industry could **deliver over $57 billion in GDP and 44,000 jobs in 2035[10a].**

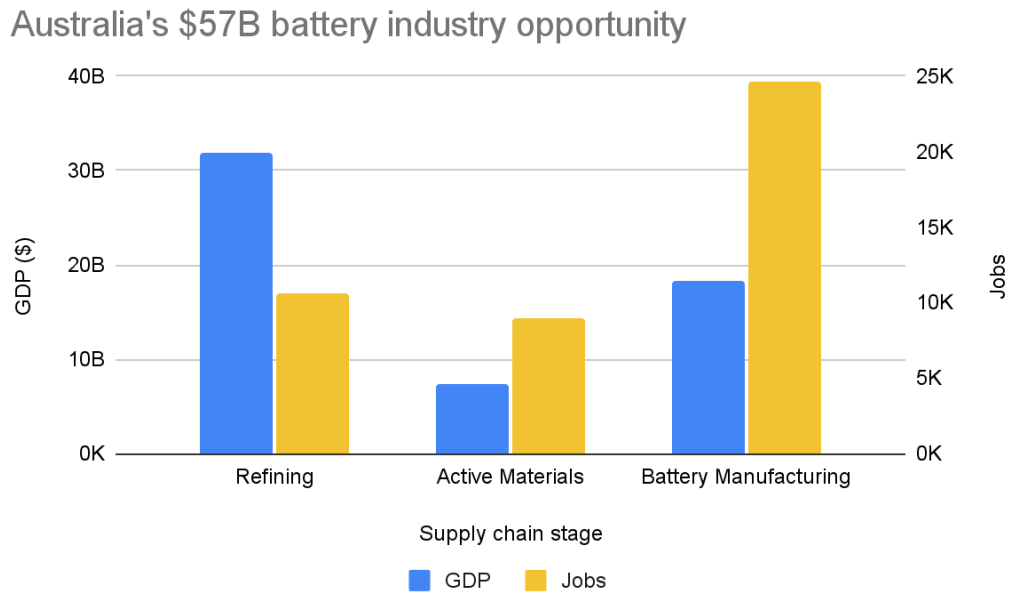


Figure 5. BZE modelling of Australia's battery value chain opportunity in 2035. Modelling does not include every aspect of the battery supply chain, and instead illustrates the key opportunities down the value chain beyond mining.

Australia's opportunity to move down the battery storage value chain and grow its economic prosperity is sizable. The market for batteries is growing rapidly. The lithium battery market is estimated **to be worth $1.25 trillion** globally by 2030, jumping to $1.9 trillion by 2035, not including the market opportunity for recycling.[4,5]

[10a]See appendix B

Australia's current capability

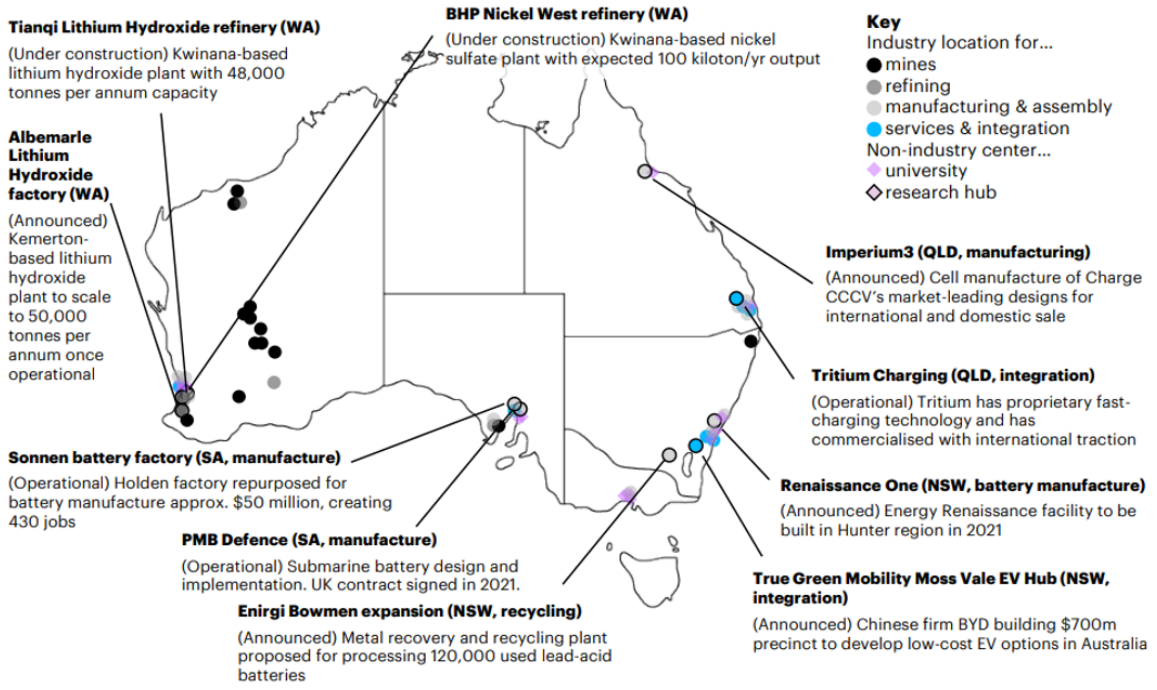


Figure 6. Map of Australia's battery supply chain up to 2022 (FBI Future Charge).[38]

Australia's supply chain capabilities

Australia will continue to hold a resource advantage over other countries through its unique wealth and diversity of minerals required for batteries. Australia is a significant global supplier of **raw materials** for battery manufacturing, supplying 50% of global lithium for battery manufacturing and ranking in the top 6 countries for supply of other critical minerals.[11]

Beyond mining extraction, Australia has developed very limited capabilities in refining, cell manufacturing, battery pack assembly and recycling with between 0-1% of the global market share captured (see Figure 7).[4] This is beginning to change with over $2.5 billion of committed private capital investment in downstream capabilities in Australia's lithium supply chain (see Figure 6).[4]

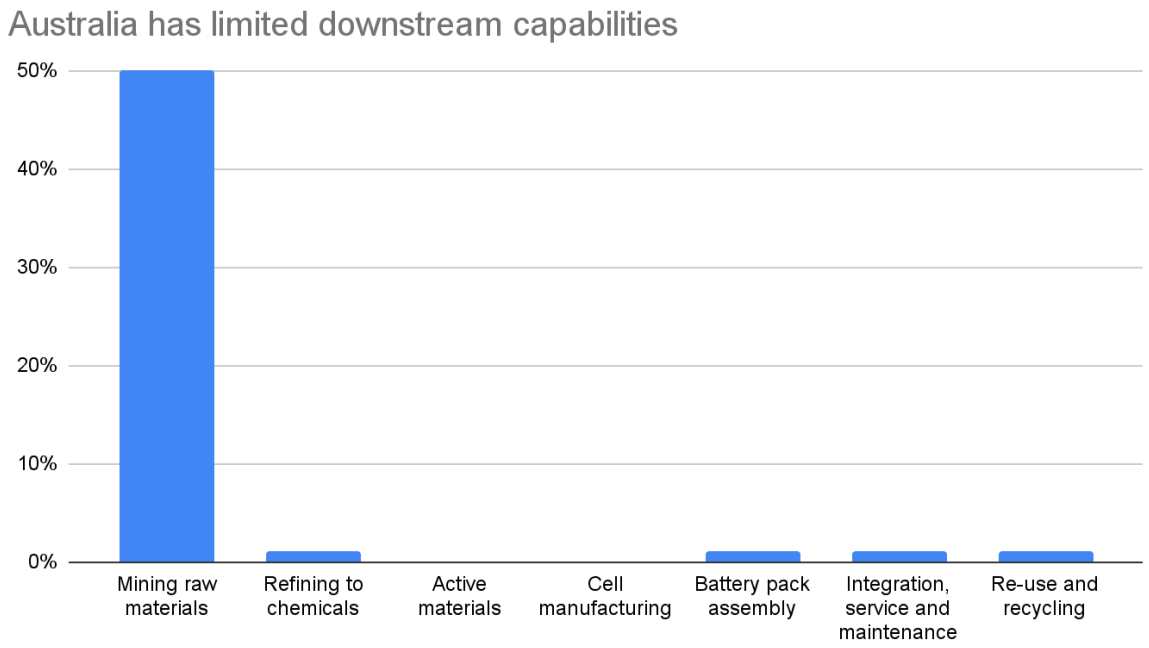


Figure 7. Australia's market share of the global lithium battery value chain in 2020. (Reproduced from FBICRC, Future Charge).

Refining

The most significant area of investment in capability is occurring in refining with over $2.3 billion in committed investments.[4] These investments are predominantly targeting the production of lithium hydroxide in Western Australia (WA). These industries are emerging and have yet to reach production capacity.

Current lithium refining operations include:

- Tianqi Lithium Corporation (TLC) opened Australia's first lithium hydroxide plant with a 100 ktpa capacity in Kwinana, WA in 2022.[39]
- Albemarle has completed a similar sized plant in Kemerton, WA in 2022 and has invested in expanding the facility to double its output.[40,41]
- Covalent Lithium are constructing a 50ktpa plant to be completed by 2024.[42]
- Iluka is developing Australia's first fully integrated rare earth refinery (one of a few integrated refineries globally) at Eneabba, WA.[43,44]

Potential for growing the production of active materials are yet to be realised

Plans to build Australia's first cathode precursor facility were announced in 2022, by Pure Battery Technologies.[45] Once completed, the Cathode Precursor Production Pilot Plant in Western Australia will enable Australia to build cathode precursor manufacturing facilities on a commercial and industrial scale.[46] Ausvolt are also planning to build a precursor cathode active materials (pCAM) facility at the Bentley Technology park in WA.[47] Avenira and Alees aim to develop Australia's first integrated lithium-iron-phosphate (LFP) battery cathode project in the Northern Territory.[48] Wyloo Metals and IGO also have plans to build a precursor facility for EV batteries.[49]

Battery cells are a major capability gap for Australia

Energy Renaissance batteries are 97% Australian manufactured, the only imported component being the cells. Energy Renaissance and others have strongly expressed the need for Australian-made cells. Energy Renaissance plans to become Australia's first cell manufacturer and vertically integrated battery manufacturer from mineral to plug, but this will require government support.[29] Australian-made cells are critical to sovereign capability, energy and national security.

Battery pack assembly is a key growth area

Energy Renaissance will become Australia's first GWh battery pack assembly plant supplying to both domestic and global markets.[50] Energy Renaissance alongside Allegro, Evo Power, Magellan Power, PowerPlus, RedEarth Energy Storage, Sonnen, Vaulta and Zenaji are assembling residential and/or utility scale batteries locally.

Other manufacturers, such as SEA Electric, Janus Electric, Volvo Australia, Ampcontrol, Vaulta and 3ME Technology, are producing batteries for commercial vehicle batteries, mining and defence vehicles.

Australia has developing reuse and recycling capabilities

Australia has had success in the battery recycling industry historically. With over 90% of lead acid batteries already being recycled, Australia is on the way to setting up a similar success story for lithium-ion battery recycling.[51] Companies such as Envirostream, Ecobatt, and Evolve Renewable Materials are already recycling lithium batteries. Zenobe and Infinitev are giving second life to damaged or depleted batteries. Australian companies such as Renewable Metals and Battery Pollution Technologies are poised to capitalise on Australian expertise, developing next generation recycling technology.[23,52]

Case study: Australian-made batteries

Energy Renaissance (ER) now operates Australia's first lithium-ion gigafactory and has taken a two-stage approach to realising its goal of an all-Australian 'mineral to manufacture and export' model. The gigafactory, known as Renaissance One, was built in Tomago in the Hunter Valley in 2021. At capacity it will manufacture 1,020 MWh per year, valued at $663 million. It currently employs 25 FTE staff.

STAGE ONE is large-scale battery manufacturing of batteries made for tough, hot, Australian conditions for indoor and outdoor locations. Applications include agriculture, defence, mining and transport. The highly secure battery management system was coded in collaboration with CSIRO and ER has designed their batteries for easy recycling.

STAGE TWO is large-scale cell manufacturing. The ER team has spent years developing plans for cell manufacturing and is ready to go when significant Government support emerges. The Tesla gigafactory in Nevada includes cell manufacturing in a collaboration with Panasonic Energy of North America (PENA). Tesla received about US $1.6 billion in incentives and government support for its Nevada gigafactory. Tesla's success

demonstrates what can be achieved when all levels of government align behind a common vision to support the growth of this manufacturing sector.

ER are the only Australian company actively pursuing this large-scale end-to-end model. ER's overarching ambition is that every part of a Renaissance superStorage™ battery system will be manufactured here in Australia. The ramifications are manifold – from fortifying Australia against global supply chain disruptions to leveraging its vast natural resources to create substantial employment and economic opportunities.

Redox flow battery supply chain capabilities

There is a small but growing supply chain in Australia for flow batteries, with **Australia having the second largest global reserve of vanadium, hosting 20% of known global reserves**.[11] This industry would be considered an emerging industry with Australia in the early stages of developing a local flow battery supply chain from mining through to manufacturing.

Key players include the following:

- Australian Vanadium is building one of the most advanced projects in the world with an estimated reserve totaling 239 Mt.[53] This project is a fully integrated battery hub from mining and refining to manufacturing in Kwinana, WA. Australia's first commercial-scale vanadium flow battery electrolyte manufacturing facility is operated in Townsville by Vecco Group.[54]
- Australian storage investor North Harbour Clean Energy has plans to build Australia's first vanadium flow assembly and manufacturing facility in eastern Australia with an initial capacity of 40MW/160MWh.[55] At full scale production, the facility can produce up to1000MW/8000MWh of medium duration storage needs totalling 8 hours, making it Australia's largest gigafactory. The Queensland Government has also committed $24 million to fund local manufacturing of flow batteries.[56]
- Idemitsu traditionally has a coal mining presence in Australia and is now pursuing critical minerals. Idemitsu Renewables is developing redox flow batteries by vertical integration and has made major investments in Vecco and the Critical Mineral Group that have vanadium interests at Julia Creek.[57] It is also seeking to invest in original equipment manufacturers and will deploy a 1MW battery at its Boggabri coal mine in 2024. Idemitsu sees the massive need for storage and energy security in Australia as a major opportunity and is looking to deploy redox flow batteries to grid scale.
- Allegro Energy is a Hunter Valley-based startup that has developed a unique water-based electrolyte for its redox flow batteries. Allegro will pilot a long duration storage redox flow battery at the Eraring power station site.[58]

Allegro Energy

Allegro Energy is a start-up company that has developed a redox flow battery with a water-based electrolyte. They also make fast charging supercapacitors. They have recently established their factory in Thornton, in the Hunter Valley and currently have 10 FTE employees. Allegro's advantage is that it uses a water-based electrolyte that has a significantly lower cost with high energy density. The batteries are mild in pH and non-flammable so they offer improved safety. All the raw materials available in Allegro batteries are abundantly available at GW scale so these batteries are not vulnerable to supply chain shocks and are fully recyclable at the end of life.

Allegro's redox flow batteries are suitable for medium to long duration grid scale storage. Origin Energy has taken a 5% stake in Allegro and will pilot a long duration storage redox flow battery at the Eraring power station site. At present Allegro are working on manufacturing batteries on a project by project basis.

Vecco Group

Vecco Group's Townsville Vanadium Battery Manufacturing Facility is Australia's first commercial-scale vanadium flow battery electrolyte manufacturing facility. It began production in 2023 and has the potential to scale up to 350 MWh annually, catering to the growing demand for energy storage.

Currently employing 21 individuals, the facility is poised to create a substantial impact on the region's economy. Vecco Group's ambitious plan is to create 500 regional jobs within two years by integrating mining, processing, and manufacturing of vanadium batteries. Vanadium used in production will initially be imported, but the new manufacturing facility will also support the development of Vecco's Debella Critical Minerals Mine, located near Julia Creek.

The facility will supply state government-owned Energy Queensland with a 250 kW/750 kWh vanadium flow battery that will be connected to the grid at its Berrinba depot in South Brisbane as part of a trial of the technology. Vecco has contracted Sumitomo to supply the battery hardware for the Berrinba battery while the vanadium electrolyte will be produced at Vecco's new facility.

Recommendation 1: Moving from “dig and ship” to value-add to Australia's mineral processing.

China dominates the world in lithium refining, and with the generous subsidies of the Inflation Reduction Act (IRA), the United States is increasing their share of refining. Due to the introduction of the IRA, battery mineral refining and processing into active materials has become cheaper in the United States than any other comparable jurisdiction.[4] Despite having the raw materials, Australia is left at a cost disadvantage. To capture more value from its critical mineral wealth, and leverage its abundant renewable energy to decarbonise the battery supply chain, government intervention will be required.

Enabling Policies:

1a. Introduce a 10% production tax credit (PTC) for the refining of lithium. An additional credit should be offered to refiners utilising novel green technologies to accelerate decarbonisation.

A 10% PTC will bridge the gap between Australia and the United States’ incentives under the IRA. A 10% PTC would cost approximately $140M over the forward estimates, but will drive significant investment. To compete with the IRA, the proposed PTC will run up until 2035, but with the policy ramping down from 2030.

Benefits to business:

- A PTC is a clear signal to business that Australia is a profitable jurisdiction - companies looking to establish manufacturing facilities are likely to be incumbent raw material miners and are less likely to be incentivised by debt financing models as they already have ample access to capital. What drives investment is the certainty that production will be profitable.

Benefits to government:

- A PTC does not pick winners. A credit is only paid out after a product is produced, and incurs lower upfront costs than grants or direct capex subsidies.
- Production tax credits will generate additionality, offsetting costs to the government through increased tax revenue from new facilities.

The government can support green refining

Lithium refining is a carbon intensive process - a 50ktpa facility will produce more than 100,000 tCO2-e in scope 1 emissions, which is in excess of the limits of the safeguard mechanism.[59] It is possible to significantly reduce emissions resulting from this process through the application of novel technologies, such as Calix’s pilot plant, which uses an electric kiln rather than a gas fired-kiln in the refining process[60]. Accelerating the testing and

adoption of novel technologies will be critical in fast tracking emission reductions. The government could consider increasing the size of the PTC for facilities deploying green refining technology to incentivise low carbon operations in this emerging industry. This will supplement the Industrial Decarbonisation Stream and encourage low emission operations from the outset.

N.B. BZE analysis was performed on the lithium supply chain. The IRA extends to the full breadth of battery minerals. To capture the full value of Australia's resources, a similar treatment should be given to other materials, in particular nickel, graphite and other key battery minerals.

1b. Introduce a 10% PTC for processing of active materials.

Active materials include chemical precursors in the production for cathodes and anodes, which in turn are used in the production of battery cells.

There is approximately a 10% difference in production costs between Australia and the United States since the introduction of the IRA.[4] To move further along the value chain, a PTC of 10% for the production of active battery materials is required. This will support the growth of onshore capability alongside the development of regional supply chain partnerships outlined in Recommendation 4**.**

Recommendation 2: Establish cell manufacturing capacity and support non-cell technologies to capture optimum value in the supply chain

With a number of onshore manufacturers active in the assembly of batteries, stepping up the value chain is a logical step that has gained support from first movers including Energy Renaissance and 3ME Technology. Capability in cell manufacturing will provide a key input for existing battery assembly enterprises while growing demand for local production of active materials and refined battery minerals. **Developing onshore capability in cell manufacturing is the key to unlocking the full battery supply chain.** It will catalyse the development and growth of a strong onshore battery manufacturing industry to service both domestic and export demand. As such, battery cell manufacturing should be considered a priority investment for the Australian economy. Australia's leading position in stationary energy deployment also positions it to support manufacturing of non-cell technology.

To establish onshore cell manufacturing capability and generate community value, BZE recommends both equity investment and the incentivisation of production.

Enabling Policies:

2a. Introduce a 28% PTC for cell manufacturing.

The generous subsidies of the US IRA make incentivising cell manufacturing particularly expensive. Whilst Australia has many advantages afforded to it, with stable governance, strong ESGs, and abundant renewable energy, the $35USD p/kWh subsidy is difficult to compete with. This has been evidenced recently with up to two thirds of planned investments in Europe being cancelled or delayed in part as a result of the appealing North American subsidies.[60] To ensure that cell manufacturers are incentivised to set up in Australia rather than other jurisdictions, a production tax credit of approximately 28% would be required to compete.[4]

BZE modelling shows that a 45GWh advanced cell manufacturing facility would be sufficient to unlock the scales of economy to be export competitive. Establishment of up to five 45GWh advanced cell manufacturing gigafactories would service domestic requirements for stationary storage (Short and medium) and CEV needs, and set Australia up to be an export competitive nation across the whole battery supply chain.

A PTC of 28% for up to five gigafactories would cost up to $1.1B AUD over the forward estimates, taking into account a three year construction period[11a]. The high cost of production and the high energy intensity of the cell manufacturing facilities make a strong case for facilities to be built in existing industrial regions where ready access to renewable energy zones can reduce costs and operational emissions.

2b. Introduce a 15 % PTC for non-cell battery technology.

The USA also offers a $45 p/kWh subsidy to batteries that do not have a cell. This amounts to approximately 15% difference between Australia and US manufacturing of, for example, Vanadium Redox Flow (VRFB) batteries.[4] Given the need to diversify energy storage supply chains, there is a significant case for supporting non-cell battery manufacturing to reach commercialisation and scale. Early commercial industries including VRFB, are likely to see a significant decrease in cost as they move toward economies of scale comparable to lithium-ion. Without government support, this will not happen at the speed required to see this industry mature to meet increased demand for energy storage.

A corresponding PTC of 15% alongside the demand incentives of Recommendation 3 will drive investment and help the technology achieve commercial maturity in Australia. The lower PTC reflects the higher per kWh cost of non-cell battery storage systems.

[11a] See appendix B

2c. Deploy $2B of equity funding in cell facilities and non-cell battery technology to unlock the full supply chain.

Australia currently has no onshore cell manufacturing facilities, however has capability in the assembly of completed batteries and manufacture of non-cell battery technology. The Government has an opportunity to support and scale existing players or new entrants with the deployment of $2B equity funding. Government equity investment provides the government, and therefore the Australian community, with a stake in a globally significant supply chain. Government equity investment should be commensurate with the opportunity. Government should make available $2B of equity for Australian manufacturers of cells and non-cell batteries to establish and scale up their production to gigawatt scale. As the highest value supply chain component, Australia would miss a significant opportunity to step into this market and establish a presence while market share is still available. End to end supply chain capability will guarantee that Australia has access to the components required to meet its energy storage objectives in the context of increasingly constrained global supply chains.

Recommendation 3: Stimulate demand for Australian-made batteries, through the expansion of the Capacity Investment Scheme (CIS), and inclusion of batteries in the SRES

Coordinated demand signalling offers certainty to investors that there will be sufficient offtake for their product and can further incentivise onshore battery manufacturing. Australia is at a disadvantage here given its smaller population when compared to similar jurisdictions such as the EU or the USA. BZE research has shown that significant demand can be created through developing Australia's CEV sector to scale the industry (BZE's CEV paper forthcoming), while strategic regional partnerships (recommendation 4) can scale demand for export markets. Demand signalling can be demonstrated by low cost modifications to existing policy frameworks.

Enabling Policies:

3a. Expand the Capacity Investment Scheme's (CIS) 6GW target to 12GW by 2030 and extend the scheme to 24GW by 2035 and include preferential treatment for Australian-manufactured batteries.

The Capacity Investment Scheme (CIS) is designed to ensure grid stability by underwriting 6GW of dispatchable capacity until 2030.[61] This is in line with AEMO's step change scenario. With some modifications, this scheme can also be used to help drive Australian

manufacturing of battery technologies.

To strengthen the demand signal, it is recommended that the CIS **set its target based on AEMO's more ambitious Hydrogen Superpower model, to 12GW by 2030.**[32]

BZE further recommends that **the CIS be extended to 24GW of dispatchable capacity by 2035** - to provide enough capacity to replace gas peakers and thereby driving energy costs down[12a].

Additionally, the CIS should be modified to **significantly weight projects using Australian-made batteries** (in Stage A of the project assessment tender evaluation) with **generous underwriting given to projects with Australian-made batteries. BZE also supports the inclusion of duration considerations in the CIS process**. This can stimulate onshore manufacturing with little additional cost to the government.

3b. Include battery storage systems in the Small-Scale Renewable Energy Scheme (SRES).

The Small Scale Renewable Energy Scheme (SRES) was the driving policy that has seen Australia lead the world in rooftop solar deployment. The government can replicate this success story with batteries. The scheme awards Small-Scale Technology Certificates (STCs) to purchases of renewable energy technology at the household scale and are sold to liable entities, effectively subsidising the cost of the system for the end user.[62]

BZE recommends the inclusion of household batteries in the SRES to drive demand for household battery storage, and signal that Australia is a suitable location for battery manufacturing. Importantly, this will lower deployment costs for households at a time when states have withdrawn state-based subsidies. The Northern Territory, who still have an active scheme in the Home and Business Battery Scheme will benefit the most with the territory scheme providing grants of up to $5000 ($400 per kWh), cutting the average cost of an 8kWh household battery down from $10,000 to $5,800.

The Parliamentary Budget Office calculates that this will cost the taxpayer around $7M by 2030. To ensure that the inclusion of batteries in the SRES supports Australian manufacturing, **additional certificates should be awarded to batteries made domestically**.[63]

Recommendation 4: Secure supply chain inputs through strategic partnerships to fill supply chain gaps and grow regional capability

[12a] BZE modelling

Australia is a small player in global markets, and while offering a large contribution in terms of raw inputs, **it risks being unable to secure what it needs to grow industry to export scale**. Its size leaves it at a disadvantage too, when competing with larger nations to access the finished products it needs to decarbonise its economy. Australia can leverage its privileged position in the battery supply chain to develop partnerships and grow its supply chain capabilities.

Enabling Policies:

4a. Develop international partnerships to ensure that key trading partners have the inputs they need and to pool demand for Australian batteries.

The Australian government has initiated a series of international clean energy partnerships to increase collaboration in innovation across net-zero production systems, including the Singapore Australia Green Economy Agreement and the Australia - United States Climate, Critical Minerals and Clean Energy Transformation compact. A few of these partnerships incorporate energy storage supply chains; however it is not a dominant theme. Given the maturity and diversity of energy storage systems available globally and their key role in enabling renewable energy deployment, it is **recommended that energy storage be included as a priority in these and future partnerships.**

The development of additional partnerships across Southeast Asia, in particular with South Korea, the second largest battery manufacturer in the world, can assist in securing the supply chain components that Australia cannot manufacture onshore in the short term and leveraging expertise across the energy storage supply chain to the benefit of the region.[64] The development of partnerships with a targeted focus on energy storage will accelerate decarbonisation, bringing new technologies to commercialisation more rapidly and diversifying global energy storage supply chains. What is critical to Australia, is that these partnerships can grow demand for Australian supply chain offerings, building the economies of scale required for export markets, and enable access to the skills needed to develop its own capabilities.

Key characteristics that partnerships should seek to ensure:

- Parties increase their access to the supply chain elements they need
- Australian innovations can be tested and commercialised more rapidly
- Regional capability can be developed across the supply chain
- Skills exchange to fill in gaps in technical capabilities
- Environmental, Social, and Governance (ESG) credentials can be harmonised across the supply chain.

4b. Implement pre-emptive rights for domestic business to further incentivise onshoring.

Pre-emptive rights for domestic battery projects is a novel way of leveraging future mineral supply shortages to incentivise onshoring. They provide surety to onshore manufacturing by guaranteeing supply of critical manufacturing inputs, without the distortionary effects of other domestic reservation policies.

Under pre-emptive rights legislation the government can mandate that producers in the battery supply chain offer their offtake to domestic purchasers first. Doing so will encourage forward thinking manufacturers to establish Australian operations to ensure that future supply shortages do not impact their production capacity further downstream. Battery minerals are essential to the future energy security of Australia. Other key players in the battery supply chain have enacted more heavy-handed protectionist policies to ensure the development of sovereign capability. To secure Australia's energy security, and share of the battery supply chain, **BZE recommends mandating pre-emptive rights for domestic battery projects**. As batteries are essential to Australia's energy security and decarbonisation efforts, this policy would be compliant with the General Agreement on Tariffs and Trade (GATT) under Section XI 2(a).

Recommendation 5: Coordinate supply chains and onshore manufacturing in Renewable Energy Industrial Precincts (REIPs) to lower lead times through streamlined permitting, lower energy costs, and unlock benefits of clustering

Proposed REIP locations, such as Kwinana and the Hunter, are a logical place to locate battery hubs, the former from an upstream perspective (mining and processing) and the latter from an downstream perspective. REIP locations have ready access to key enabling infrastructure such as transport networks and ports, energy infrastructure including proximity to low cost renewable energy via Renewable Energy Zones and offshore wind, as well as access to labour. These considerations are also key in determining suitable locations for battery projects.

Enabling Policy:

5. Identify and pre-approve appropriate locations for battery supply chain operations within REIP locations.

Finding the appropriate site location can be a significant barrier in establishing new battery operations. Ensuring the supply of water, energy and labour, as well as lengthy permitting

and approvals processes can delay or cancel projects. Coordinating battery hubs in REIP locations will make private investment more attractive by ensuring shorter lead times and access to existing logistics infrastructure, industrial capabilities, and skills. Site selection and pre-approvals in REIPs will lower both the administrative burden and the lead times for prospective entrants. Co-location of battery manufacturing and recycling further reduces transportation costs and facilitates knowledge transfer and coordination.

Recommendation 6: Ensure that Australia is well placed to meet the circular economy opportunity

At the end of a battery's useful life (taking into account second life opportunities for battery reuse) the battery is dismantled and shredded. This shredded material is further processed into what is known as black mass. This material contains the critical minerals of the particular battery chemistry (lithium, manganese, cobalt and nickel for example), which can be extracted and used in the battery manufacturing process in place of virgin mined materials.

The economic incentive to recycle black mass is well established due to its inherent value and projected future battery mineral shortages.[65] Additionally, recovering this material has been shown to reduce the lifecycle emissions from the battery manufacturing process.

The challenge of establishing the circular economy is that there will be a delayed but exponential growth in feedstock. As the first wave of EVs and household batteries reach retirement, it will be followed by a rapid influx of end of life batteries that follow the trajectory of today's deployment.

If Australia is to participate in the development of the circular economy for batteries, it has to make this commitment today rather than scramble for an opportunity for which it has no established infrastructure in ten years' time.

Enabling Policies:

6a. Include black mass under the Hazardous Waste Act (1989) to retain feedstock for domestic recyclers.

The first step will be to establish a clear commitment to recycle our own battery material by sending a clear signal to industry that resource recovery will happen onshore. The approach taken to address this challenge by the EU is legislating black mass as hazardous waste, limiting its export.[66] A similar solution is available for Australia. **BZE recommends that the government consider classifying black mass under the Hazardous Waste Act (1989)**, to limit export to only volumes beyond what domestic industry has the capacity to process.[67] This is a simple, effective way of ensuring that valuable feedstock for Australia's recycling operations stays onshore and that the recycling industry can be guaranteed a

ready feedstock for domestic recycling.

6b. Map and plan the end of life logistics for batteries, including appropriate aggregation and recycling locations.

The second critical step in establishing onshore recycling will be to minimise costs and streamline collection to make sure that batteries do not languish in landfill. BZE recommends that the government undertakes logistics planning to map the appropriate sites and pathways for battery collection, aggregation, processing and recycling that is proximate to planned and existing manufacturing facilities.

Appendix A: Supporting Information

A1: Global battery supply chain

Over 75% of global battery manufacturing is done in China. China is:

- the largest refiner of raw materials with 89% of the market,
- 64% of active material production,
- 50% of cell manufacturing and
- 45% of recycling.[4,7]

Despite the rest of the world (namely South Korea, USA and Europe) beginning to grow its battery manufacturing capabilities, China is set to continue as the world leader in battery manufacturing.

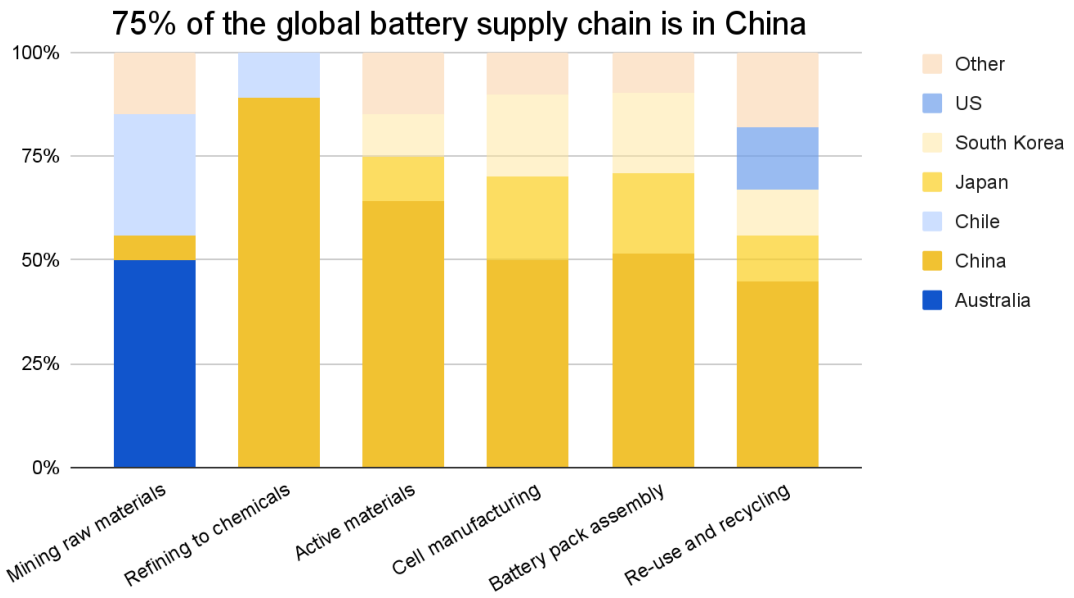


Figure 1: *Current country market share across battery value chain segments (Reproduced from FBICRC, Charging Ahead.)*[4]

The good news is the world is growing manufacturing capacity at 22 gigafactories per year to 2030 (planned projects). Planned battery manufacturing projects are set to grow battery manufacturing 4-fold by 2030 to a total of 6.1 TWh.[7] Benchmark Minerals forecasts the capacity growth to be even higher, reaching 9.1TWh by 2030 with over 400 planned gigafactories in the pipeline.[3]

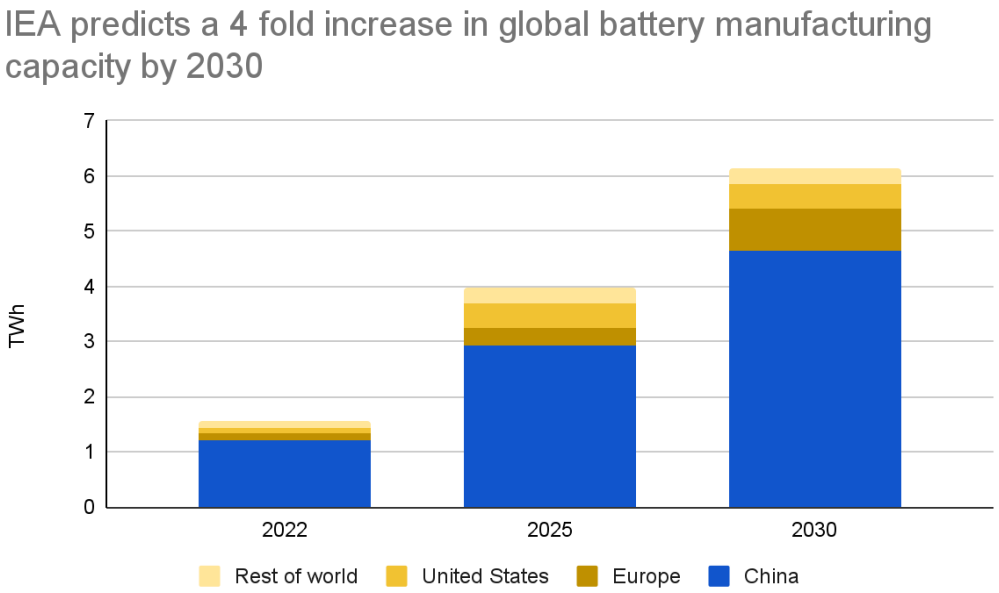


Figure 8: Announced battery manufacturing capacity by region to 2030.[2]

A2: Critical mineral demand

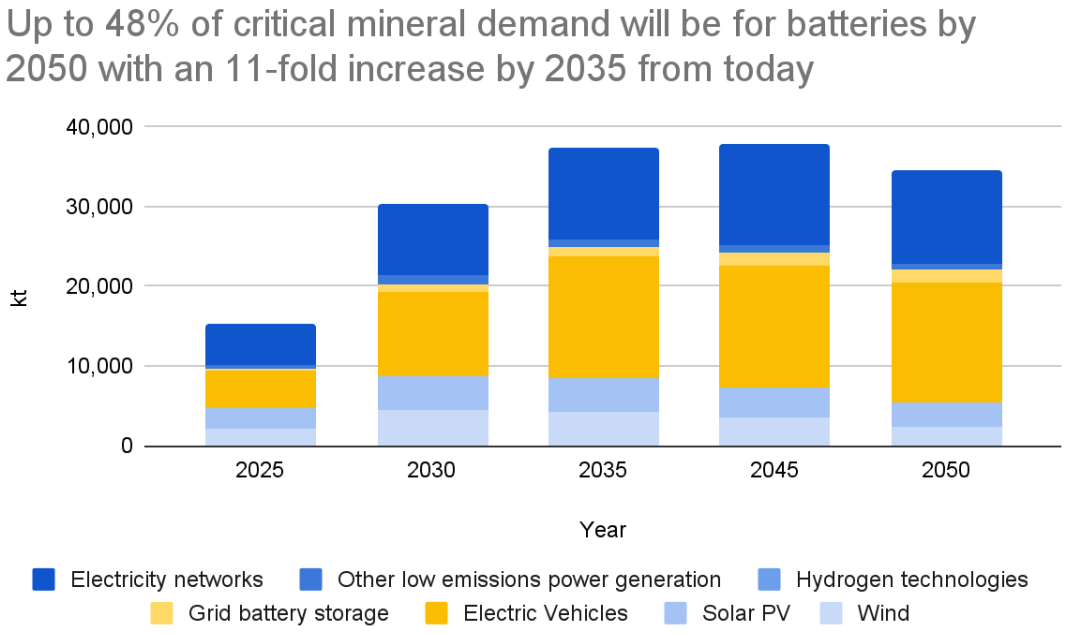


Figure 9: IEA Net Zero by 2050 modelled aggregate critical mineral demand by technology in kt.[69]

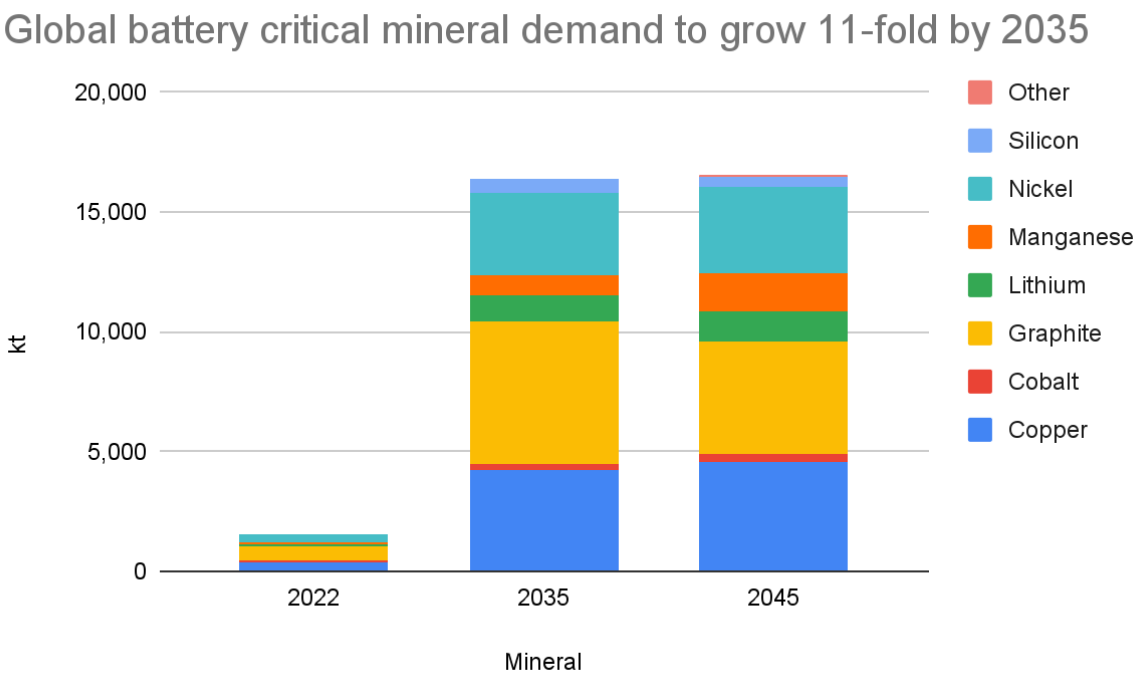


Figure 10. IEA Net Zero by 2050 aggregate critical mineral demand by mineral type in kt.[69]

Critical mineral production falling short of demand forecasts

Global supply of lithium is expected to fall short of demand as soon as 2028 and by 2035, to fall short of global demand by almost 1Mt.[4,70] The gap will be larger if full production capacity is realised. Similarly, supply shortfalls are expected across the array of critical minerals needed for batteries including cobalt, nickel and graphite.[4] Demand for nickel, for example, is expected to grow 25 times by 2040; it is already in short supply and by 2040 will be 2Mt short of demand.[4,71]

A3: Battery supply chain emissions

The embodied energy and emissions of battery production are considerable. An average 70kWh EV battery produces 5.1 tonnes CO2-e in embodied emissions from mining to assembly while an average 3000kWh stationary energy storage unit produces 219 tonnes CO2-e (BZE analysis). For every kWh of energy storage produced, 318kWh of energy is required. The largest sources of energy demand are for precursor, cathode and cell production, which amount up to 55% of embodied energy requirements. Across the supply chain, transportation accounts for 4-5%.[15]

Zero-carbon global battery supply chains are a critical priority to manage as the world targets rapid emissions reductions supported by battery deployment. Batteries are the largest source of emissions in the production of EVs accounting for up to 60% of EV production emissions.[72]

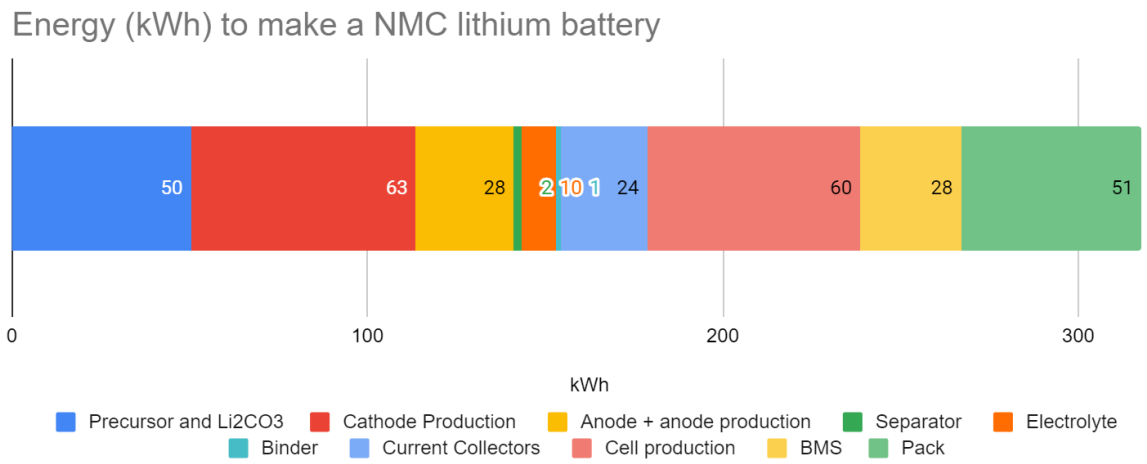


Figure 11. Energy to make one kWh battery for a nickel-managanese-cobalt (NMC) battery (the most common battery type).[73]

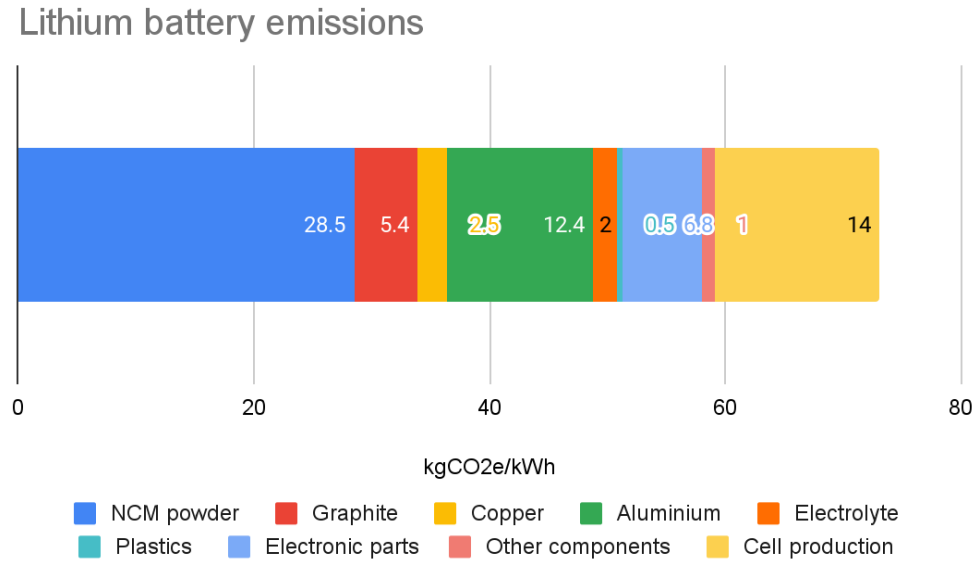


Figure 12. Energy to make one kWh battery for a nickel-managanese-cobalt battery (the most common battery type).[73]

A4: Battery energy storage - coal closures and gas peaker upgrades

Timely closure of coal power

Deployment of batteries will play a key role in enabling the closure of Australia's coal-fired power stations. AEMO's latest *Electricity Statement of Opportunities* states that if all planned battery projects are delivered on time, Eraring power station can be closed in 2025.[74] Big battery deployment is critical to meeting the stated closure timeline of Australia's coal-fired power plants.

Battery peakers are better than gas peakers

Australia can cut 5% of domestic emissions by replacing gas peakers with batteries.[75] Batteries have reached commercial maturity to outcompete gas in Australia's electricity market. Comparing the levelised cost of energy, 2 and 4-hour batteries are between

16-33% cheaper than open-cycle gas peakers.[76] As the cost of electricity is generally set by gas peakers, battery-powered peaking can reduce electricity prices.[77] Replacing gas peakers with batteries can decouple Australia's exposure to commodity price volatility serving to insulate Australian businesses and households from bill price shock as experienced in 2022.[26]

Appendix B: Modelling

Economic analysis and method available on request.

Global battery demand modelling

- Based on IEA Net Zero by 2050 Datasets, chapter 2.[7]
- Critical mineral demand.[69]

Australia battery demand modelling

- Based on BZE's Deploy modelling to 2030 and extrapolated out to 2035
- Deployment assumes rapid emissions reduction pathway

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