**Quad Tech Network** QTN Series

# A QUAD PARTNERSHIP TO SECURE BATTERY VALUE CHAINS

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# About the Quad Tech Network Series

The Quad Tech Network (QTN) is an Australian Government initiative to promote Track 2 research and public dialogue on cyber and critical technology issues relevant to the Indo-Pacific region.

As part of the initiative, research institutions in Australia (the National Security College at The Australian National University), India (the Observer Research Foundation), Japan (the National Graduate Institute for Policy Studies) and the United States (Center for a New American Security) have commissioned papers on key issues facing the region.

These papers – together, the QTN series – offer analysis and recommendations on shared challenges facing Australia and Indo-Pacific partners in the cyber and technology environment.

The QTN is managed by the National Security College at The Australian National University, with the support of the Australian Department of Foreign Affairs and Trade.

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# About the Author

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# Executive Summary


- **Batteries are a critical technology to support the energy transition necessary for adapting to climate change.** The deployment of grid-scale renewables, and the electrification of transport networks, will require a tenfold increase in battery supply in the next decade. Without a stable, secure and rapidly expanding supply of batteries, there can be no renewable energy transition.
- **The global value chains that produce batteries are insecure.** At several points in the value chain, near-monopolies present choke points that could be used to strategically disrupt supply. China's control of several of these choke points is a particular concern, given its deteriorating political relationships internationally and its demonstrated willingness to use geoeconomics for strategic ends.
- **The Quad governments – Australia, Japan, India and the US – all recognise the need for secure battery value chains but have yet to align their battery strategies.** Each has classified batteries and their components as a critical material, and sought to develop more secure supplies. However, they do not have mechanisms to coordinate battery policy development, and commercial partnerships between their economies remain embryonic. Such mechanisms are essential to realise the opportunities to develop new Quad-led value chains.
- **A Quad battery partnership should be developed in order to secure this critical twenty-first century technology.** This process should begin by establishing a formal batteries agreement, within the remit of the Quad's 2021 commitment to collaborate on critical technologies. The Quad governments should further develop and align their national strategies to better complement each other, and develop "intra-Quad" battery value chains that provide a more secure foundation for their clean energy transitions.


# Batteries are a Critical Technology for the Twenty-first Century

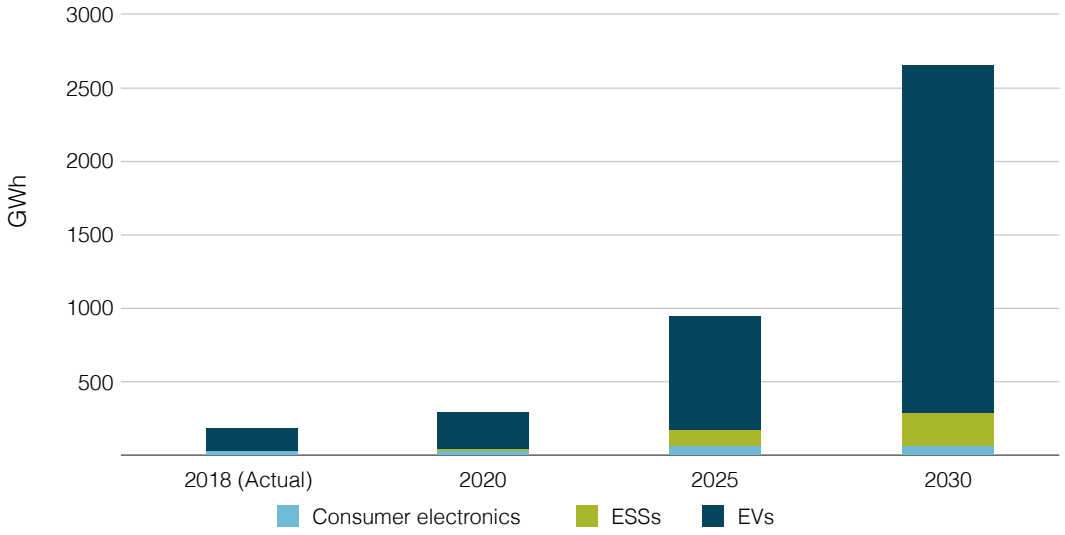
The importance of batteries to the technological ecosystem of the twenty-first century is often under-appreciated. The battery was invented over two centuries ago, and the presently-dominant technology – the lithium-ion battery – was first commercialised in 1991. Batteries are already ubiquitous in society, particularly in consumer electronics and industrial applications, and are increasingly appearing in new applications such as electric vehicles (EVs) and energy storage systems (ESSs). In the last decade the cost of lithium-ion batteries has fallen by almost 90 percent[1], and they are now cheaply and readily available for all industrial users.

It may seem strange to label a mature and commodified product as a "critical technology" worthy of special attention. However, the economic and technological importance of batteries is rapidly increasing. Batteries are an essential enabling technology for the transition from hydrocarbons to renewables in the global energy system. Batteries will play two critical roles for the energy transition as a storage medium. First, they enable the electrification of transport systems, through the adoption of EVs that can be powered by renewable sources[2]. Second, they enable the deployment of renewable energy generation, where ESS technologies will allow households and network operators to balance intermittent renewables supply with user demand[3]. Batteries are therefore essential for adaptation to climate change.

**Without a secure supply of batteries, there can be no renewable energy transition.**

This new role in renewable energy systems will demand a rapid transformation in the global battery industry. Battery demand is expected to increase dramatically in coming years, as a greater share of renewables in the energy mix requires significant build-out of supporting battery infrastructure. The World Economic Forum forecasts that global battery demand will increase ten-fold in the decade to 2030, to 2600 gigawatt hours of batteries required per year (Figure 1). The bulk of this new demand is due to the expansion of the global EV fleet which, based on current policy settings, will grow from 7.6 to 138.3 million vehicles by 2030[4]. The uptake of ESS systems by energy utilities and households will also make a significant contribution. Consumer electronics, hitherto the main use of batteries, will by contrast become a marginal application. To meet these needs, an extraordinarily rapid expansion of global battery production will need to occur – averaging 26 percent growth per year for a decade.

Figure 1: Forecast global battery demand by application, 2020-2030

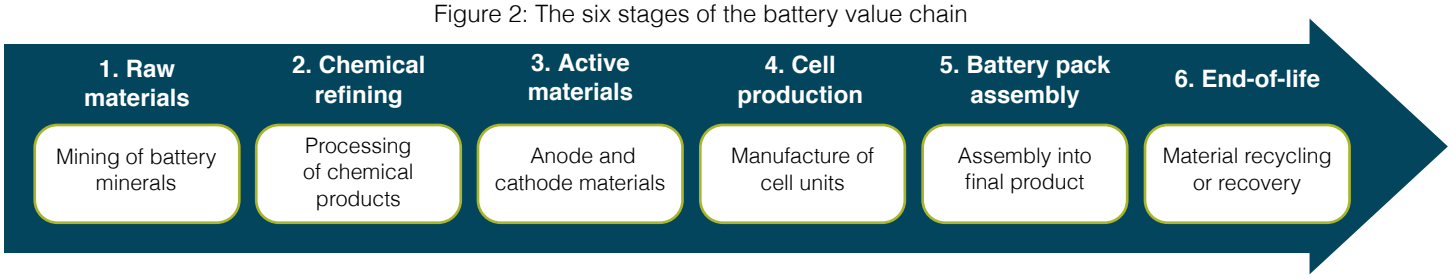



*Source:* World Economic Forum[5]

**Whether the battery industry is capable of this transformation remains an open question.**

Batteries are currently produced in complex global value chains, which transform raw materials into finished products (Figure 2). Importantly, different countries specialise in different stages of the value chain. At the upstream stage, resource-rich countries such as Australia and Chile supply the six battery minerals (cobalt, graphite, lithium, nickel, rare earths and vanadium) required for different types of batteries. In a midstream stage, Chinese industry performs chemical refining and the production of "active materials" from these minerals. A downstream stage, dominated by Japan and Korea, then manufactures final battery products. Materials are also recovered and recycled from used batteries, and reinserted into the midstream stage of the value chain. This industrial geography means batteries are a genuinely global industry, and no single country is capable of producing batteries on its own.

Figure 2: The six stages of the battery value chain




For this reason, batteries are a classic example of what economists label "critical materials" – a special type of commodity of outsized importance. The commonly-used definition of critical materials has two features[6]. First, they have very high *economic importance,* as there are few or no economically- and technically-viable substitutes for their use. This criterion applies to batteries, as they are an essential enabling technology for the deployment of renewable energy. Second, critical materials are subject to high levels of *supply insecurity*, which can interrupt their physical availability and/or affordability for end-users. While supply insecurity has yet to affect the battery industry, the complexity of global value chains, and emerging political and strategic threats to their integrity, means that governments and companies are increasingly concerned by supply chain risks. This combination of economic importance and supply insecurity means governments globally attribute higher policy priority to critical materials than other economic sectors.

**Many governments now recognise that batteries are a critical material.**

The European Union was the first to recognise batteries as a critical material, including battery minerals and their processed products in its *Raw Materials Initiative* of 2008[7]. Japan followed a year later, including these products in its *Strategy for Ensuring Stable Supplies of Rare Metals*[8]. A decade later in 2019, both the Australian[9] and Indian[10] governments launched dedicated battery strategies, which aim to establish national capabilities at the midstream and downstream stages of the value chain respectively. In June 2021, the Biden Administration included batteries as one of four sectors targeted in a critical supply chain resilience initiative, alongside semiconductors, critical minerals and pharmaceuticals[11]. Importantly, this means that all four countries of the Quad – Australia, Japan, India and the US – are actively pursuing strategies to secure battery supply chains. To explain this emerging Quad alignment requires an understanding of the emerging security risks facing battery value chains.

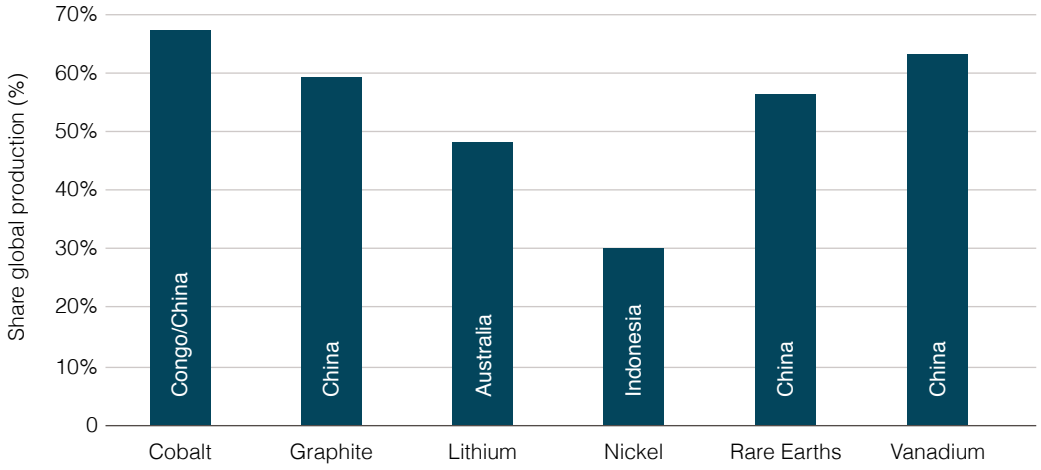
# Security Challenges in the Battery Value Chain

Despite the ubiquity of batteries in modern society, the global value chains which produce battery products suffer from a number of supply security risks. These stem from the concentrated nature of the battery industry, which is dependent on a small number of players that occupy critical choke points in the value chain. They have also been compounded by the complex politics of critical materials, particularly in terms of China's perceived reliability as an economic partner. These risks mean that current battery value chains lack the diversity or reliability required to guarantee a secure source of supply in future years.

The global battery industry is subject to a high degree of concentration at multiple points in the value chain. At the upstream end, only a narrow range of countries supply the minerals required to produce batteries. As Figure 3 shows, most battery minerals markets are characterised by near-monopolies, where a single dominant supplier accounts for the majority of global production. Moreover, China has an outsized role in these markets. It is the near-monopolist in three of the six battery minerals (graphite, vanadium and rare earths), and also processes Congolese ores into refined cobalt. These patterns of monopoly are not due to natural endowments, as many countries have presently un- or under-utilised reserves of battery minerals[12].

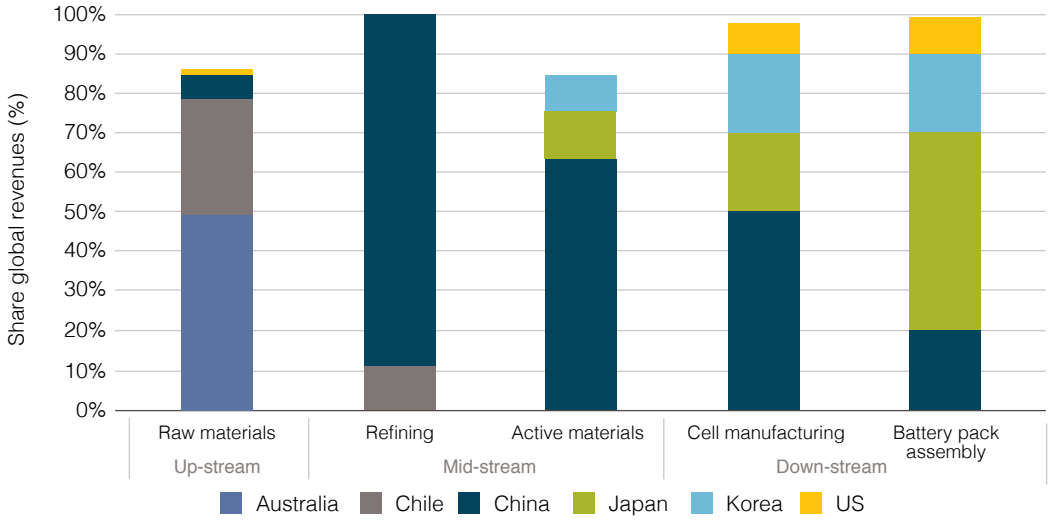
A similar pattern occurs in the midstream stages of the battery value chain (Figure 4). At the refining stage, China has considerable market dominance, accounting for 89 percent of the global market by revenues. This reflects the cost competitiveness of Chinese producers, owing to its large scale of production and significant government and private investment in the sector relative to other countries. It also accounts for 64 percent of active materials production, and 50 percent of cell manufacture. It is only at the final stage of the value chain – battery pack assembly – that China's dominance disappears, where it is replaced by Japan and Korea as the leading producers. As a result, China's market power in the global battery industry is significantly greater than that suggested by its 20 percent share of final product sales. While battery minerals are sourced from Australia and Chile, and finished batteries are produced in Japan and Korea, China occupies a strategic choke point in the midstream of the value chain.

Figure 3: Dominant suppliers in battery minerals markets, 2020




*Source:* Authors' calculations, from United States Geological Survey[13]

Figure 4: Share of battery value chain by stage and country, 2020



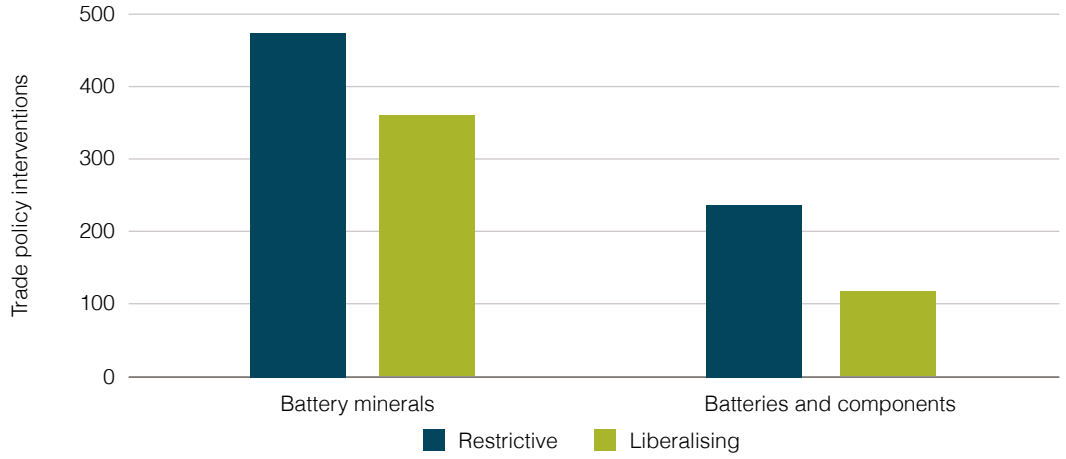

*Source:* Accenture 2021[14]

These choke points mean the battery industry is subject to very high levels of potential supply risk. With near monopolies occurring at many points in the value chain, there is a heightened risk that adverse events will cause interruptions to international trade. Some of these risks are common to many globalised industries: such as trade interruptions caused by social problems in key suppliers, industrial accidents and extreme weather events, and more recently the effects of the COVID pandemic on international connectivity. However, there are also an additional set of political risks affecting the battery industry, wherein dominant suppliers may deliberately intervene in the normal operations of the market for political or economic gain.

**Political risks currently threaten the global battery industry.**

The first political risk is trade protectionism. In the battery sector, the majority of value-adding occurs in the mid- and downstream stages of the value chain[15]. This creates an incentive for governments to capture a greater share of economic rents by imposing distortive policies that mandate additional local processing and manufacturing. These distortive policies can take a variety of forms, including export prohibitions, taxes, and other licensing and performance requirements. In practice, protectionist trends are accelerating. As Figure 5 shows, governments have made almost 1,200 trade policy interventions over batteries or battery minerals, with the balance being towards restrictive rather than liberalising policy changes. Particularly significant are those in the mid- and downstream categories, where governments have restricted trade twice as often as it is liberalised. These protectionist policies undermine value chain integrity by distorting the operation or market mechanisms, and exposing other players to the risk of arbitrary supply constraints.

Figure 5: Trade policy interventions in battery value chains, 2009-2020




*Source:* Author's calculations, from Global Trade Alert Database[16]

The second risk arises from the use of the so-called "resource weapon". This is a type of economic sanction where a government withholds (or threatens to withhold) supply of a critical material during a diplomatic dispute. The resource weapon can be an effective tool for diplomatic sanctions in situations where a consumer is dependent on a particular supplier. The resource weapon has been widely used in international diplomacy, with famous examples including the Organisation of Arab Petroleum Exporting Countries (OAPEC) oil embargo of 1973[17], and Russian threats to withhold gas to Eastern Europe during the 2010s[18]. As the battery value chain features many monopolised choke points, it is at particular risk of politically-induced disruptions.

**The resource weapon has been deployed in the battery value chain before.**

In 2010, China withheld supply of rare earths to Japan during a diplomatic dispute over the Senkaku/Diaoyu Islands[19]. While Japanese supply was interrupted for only two months, the dispute had a dramatic effect on global markets, causing world prices to dramatically increase for over a year. The Japanese government responded by sponsoring new suppliers to enter the market and lessen its reliance on China, with Australia's Lynas Corp emerging as the world's only non-Chinese rare earths producer. In the more recent US-China trade war, Chinese authorities have made similar threats that the "rare earths weapon" will be deployed if a negotiated settlement cannot be reached[20]. While this threat has yet to be executed, its effects on global markets would be equally dramatic. China's monopoly position in several battery minerals, and its control over the midstream stages of the value chain, mean it controls several choke points that could be weaponised in a future political dispute.

Third, tensions in China's foreign relations also cast a cloud over battery value chain security. In recent years, growing rivalry between the US and China has seen the major powers use economic means to pursue geopolitical ends. The US-China trade war, and China's use of economic sanctions against many countries, have raised questions regarding the security of value chains that rely on nodes based in China. These concerns are especially pronounced for critical materials such as batteries, given the

security risks associated with monopolised choke points and the significant economic impacts if value chains were interrupted. While an across the board "economic decoupling" with China is highly unlikely, the US and other countries with deteriorating China relationships are seeking to diversify value chains to reduce reliance for specific critical products and technologies. Such efforts have already begun in semiconductors, next generation telecommunications (such as 5G) and medical products. Given the geopolitical risks associated with China's dominance in battery value chains, there is a strong case for considering similar strategies for batteries as well.

# Quad Efforts to Secure Battery Value Chains

The security risks facing the global battery industry have catalysed efforts to develop more diversified value chains. While battery supply has yet to be interrupted, the presence of Chinese near-monopolies at critical points in the up- and midstream of the value chain means emerging political tensions could credibly do so in the future. The critical importance of battery technologies to the energy transition, and need for battery supply to increase ten-fold in the next decade, means any such interruptions will carry significant negative economic effects. Governments and and businesses have recognised there is a need to build new and more diverse battery value chains, which feature a broader range of participants to reduce the dependence on Chinese nearmonopoly choke points.

**Importantly, all four of the Quad countries have adopted policies to secure battery value chains.**

The Quad countries' interest in securing battery value chains reflects three common factors among them: an interest in ensuring more secure supplies of critical battery products, the capacity for their industrial capabilities to play a greater role in the value chain, and increasingly difficult economic and/or strategic relationships with China. The battery-related policies Quad countries have adopted in recent years include:

- **Australia's** *Critical Minerals Strategy*[21] of 2019 outlined the first integrated national policy to develop opportunities in the battery industry. It aims to build on Australia's established presence as a mineral supplier to the industry to move forward along the battery value-chain from up- to midstream activities.
- **India's** 2016 *Critical Non-Fuel Mineral Resources for India's Manufacturing Sector: A Vision for 2030*[22] sought to build national capabilities in critical minerals. It was complemented by the *National Mission on Transformative Mobility and Battery Storage*[23] of 2019, which sought to establish downstream battery manufacturing capability.
- **Japan's** *Strategy for Ensuring Stable Supplies of Rare Metals*[24] of 2009. To reduce the risks of overdependence on single producers, the strategy aimed to diversify import sources of critical materials, promote recycling and the use of substitutes, and build international partnerships with new suppliers.
- **The US** issued a *Critical Materials Strategy*[25] in 2010, focused on research and development for critical materials required for the energy sector. In 2019 it was complemented by the *Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals*[26] that added efforts to develop both up- and midstream domestic capabilities. In June 2021, the White House launched a supply chain resilience initiative that specifically targeted developing new and more secure supplies of high-capacity batteries[27].

These policies all aim to promote international partnerships. Recognising the inherently globalised nature of the battery value chain, the strategies prioritise developing international trade and investment connections. In Japan, these efforts are led by Japan Oil Gas and Metals Exploration Corporation (JOGMEC), a government-owned bank tasked with providing financial and technical support to companies developing critical material projects abroad[28]. The Australian Trade and Investment Commission (Austrade) has programs specifically aimed at attracting inward investment and developing new technological capabilities in the battery sector[29]. In 2019, the Indian Government established Khanij Bidesh India, a state-owned enterprise designed to develop critical material supplies abroad[30]. While the US government does not have a dedicated agency for international engagement on critical materials, its strategy similarly recognises the importance of "accessing and developing critical minerals through investment and trade with our allies and partners"[31].

While each of the Quad countries has policies targeting battery value chain security, they have yet to develop cooperative mechanisms to link their efforts. At present, there are only two relevant intergovernmental mechanisms – bilateral Memoranda of Understanding (MoUs) – for critical minerals cooperation between Australia and the US[32] and India[33] respectively – neither of which specifically target the battery sector. A trilateral "Supply Chain Resilience Initiative" involving Australia, Japan and India was also launched in April 2021[34], but has yet to undertake any activities focused on the battery sector. This lack of international mechanisms is a missed opportunity to capitalise on synergies between the Quad countries' national battery strategies.

**Economic synergies mean there is much to be gained through Quad battery collaboration.**

Each of the four countries bring complementary capabilities at different stages in the value chain. Australia is already an established mineral supplier to the industry, and now seeks to leverage its resource endowments and capabilities to move "along the value chain" from mining into midstream (refining and active materials) stages. India's strategy exploits its low-cost manufacturing capabilities to establish a presence in the downstream (cell and pack) stages. Japan and the US are focused on research to develop new processing technologies, and using foreign investment to sponsor new and more reliable partners into the battery value chain. There is natural complementarity between the Quad countries' respective battery strengths and much to be gained through cooperation that allows a division of labour to be unlocked.

Indeed, private companies have already recognised the opportunities for Quad partnerships in batteries. In Australia, joint ventures have been launched in the battery or battery minerals sectors with partners from each of the Quad countries:

- **Australia-Japan: Rare earths.** Lynas Corporation is an Australian producer of semi-processed rare earth oxides, with a focus on Neodymium-Praseodymium (NdPr) used in permanent magnets for EVs. Lynas' entry into the global market is supported by investment and offtake agreements from its Japanese partners, Sojitz and JOGMEC. Lynas is currently the only commercial-scale rare earths manufacturer outside China[35].
- **Australia-US: Lithium hydroxide.** Albemarle, a US speciality chemical company, is constructing a lithium hydroxide refinery at Kemerton, Western Australia. At completion, the project will have the capacity to convert one million tonnes of spodumene (hard rock lithium) into 50, 000 tonnes of lithium hydroxide required for the production of battery cathodes[36]. The Kemerton project will enable further processing of Australian raw materials, and bring a new supplier into the refining stage of the value chain.
- **Australia-India: Lithium hydroxide.** Neometals, an Australian advanced materials company, is exploring options to develop lithium refineries in India. In 2019 it established a partnership with Manikaran Power, an Indian energy trading and renewables firm, to jointly develop a lithium hydroxide project to support the development of the local battery manufacturing industry. If executed, the Neometals-Manikaran project would establish India's first lithium refinery[37].

These commercial projects demonstrate the potential for battery collaborations between the Quad countries, leveraging their complementary strengths in resources, chemical processing, manufacturing and technology. They are also testament to the potential for new battery value chains to achieve cost competitiveness with existing networks. While global cost comparisons are not presently available, recent research by Accenture on Australia's role in the industry indicate that with targeted specialisation it could competitively move into midstream chemical processing activities presently dominated by China[38]. However, while the Quad governments' battery strategies remain national in scope, exploiting these opportunities remain the preserve of the private sector. Forging linkages between their national strategies would unlock "across-the-value-chain" synergies that will prove critical in diversifying and securing this critical industry.

# Policy Options for a Quad Battery Partnership

There is a strong case for establishing a Quad battery partnership. Batteries are critical technology for the realising the energy transition, but existing global value chains face monopoly choke points that undermine their reliability. If these choke points were interrupted as a result of increasing geopolitical tensions involving China, it would derail global efforts towards the clean energy transition and climate mitigation. The Quad countries could, by acting collectively, make a meaningful contribution to diversifying and securing this economically and environmentally important sector. Economically, each brings distinct and complementary capabilities that when combined cover all required steps in the value chain. All four Quad governments have recognised the battery challenge, and already have national policies in place to grow their presence in the industry. Established relationships of trust and cooperation, fostered through the development of the Quad summit processes since 2018, also provide the political foundation for Quad cooperation in batteries.

**The alignment of capabilities and interests makes battery cooperation a natural evolution for the Quad.**

The next step is to align the existing national policies of the Quad governments. Batteries are an inherently globalised industry, in which no one country can alone perform all the required steps in the value chain. Rather than the four governments pursuing battery strategies individually, coordinated efforts would streamline efforts and deliver more cost-effective results. These should target the creation of value chains between the Quad partners, in which each partner specialises in the stage of production where they have competitive advantages. The Quad's recent move to add economic issues to its agenda – telegraphed by commitments for cyber, critical technologies, infrastructure and vaccines cooperation at the 2021 Quad Leaders' Summit[39] – provides a platform to foster battery cooperation.

How can Quad collaboration on batteries be achieved? Three strategies provide a potential way forward:

- **Establish a formal Quad batteries agreement.** To identify and realise joint battery opportunities, the Quad governments need a mechanism for aligning their national policy efforts. A formal batteries agreement, potentially delivered through a memorandum of understanding, would serve two purposes. First it would signal high-level political intent to cooperate, ensuring that bureaucratic resources prioritise within-Quad initiatives. Second, it would create formal dialogue structures between the relevant agencies of the four governments, enabling information sharing and joint planning of battery industry initiatives. A formal batteries agreement could be established pursuant to the 2021 Quad Leaders' Summit commitment to cooperate on critical technologies.
- **Align national battery and critical mineral policies towards Quad partners**. All of the Quad battery policies contain an international engagement component; and the Australian, Indian and Japanese governments have dedicated agencies to promote trade and investment opportunities. But with the exception of Australian MoUs with the US and India, these agencies' work has yet to be targeted specifically towards other Quad partners**.** Given the scope for Quad battery cooperation, these policies and agencies would benefit from specific targeting towards other Quad partners, and should be allocated financial and bureaucratic resources commensurate with a Quad focus. Beyond the Quad, Korea's leading position in the global batteries industry would make it an ideal "plus one" to incorporate in these efforts.
- **Explore opportunities for multilateral, rather than bilateral, battery value chains**. Hitherto, the intergovernmental MoUs and commercial partnerships within the Quad have been developed on a bilateral basis (and all involve Australia as one partner). However, there are clear opportunities for multilateral value chains involving multiple Quad partners. A potential division of labour would involve Australia at the up- and midstream stages, India at the downstream end, with Japanese and US partners supplying capital, technology and final markets. Such an approach would allow the development of secure battery value chains predominantly contained within the Quad grouping. While these value chains are by nature private-sector led, the high degree of coordination required will benefit from governmental efforts to align regulatory frameworks and broker commercial partnerships.

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