Queensland University of Technology
response to the
National Battery Strategy consultation

QUT welcomes the opportunity to contribute to the refinement of the new Australian Government National Battery Strategy being developed through the Department of Industry, Science and Resources and applauds the strategic and forward-looking spirit of the exercise.

The University strongly supports development of the Strategy including its linkages with other Government priorities including National Reconstruction Fund (NRF), Powering Australia plan (including the National Electric Vehicle Strategy and Australia's emissions reduction target), A Future Made in Australia, and the Critical Minerals Strategy.

The challenges to support a battery industry across the full value chain will require new skills and technology linked to existing research and development capabilities from critical minerals processing to advanced manufacturing. The following submission addresses each of the themes outlined in the consultation paper.

Theme 1: Moving up the value chain

There are currently limited centres of battery manufacturing, testing and validation within Australia. The Queensland-based National Battery Testing Centre (NBTC), funded in part by the Future Battery Industries – Cooperative Research Centre (FBICRC) and co-located at the QUT Banyo Pilot Plant Precinct with the QUT Advanced Battery Facility (ABF), provides nation-leading services in battery and battery active material testing, qualification and translational research and development (R&D) support. The ABF was established six years ago through funding from the Automotive Australia CRC and combined, these facilities constitute more than $40 million of co-investment from government, university and industry. The FBICRC was established in 2019 to facilitate the growth of battery industries in Australia, with >70 participants across 15 projects and a value of >$120M.

QUT's industry collaboration model facilitates cross-training and expertise sharing of skilled workers across multiple interrelated projects and disciplines enabling real-world research, development and deployment (RD&D) solutions for Australia's energy storage requirements. This work is actively supporting and contributing to Australian standards development to promote and advance best practices in lithium-ion safety and currently participates in multiple working groups under Australian Standards EL-005: Secondary Batteries. Through its diverse suite of projects and capabilities in the energy storage sector, QUT strives to work with industry and research organisations to generate high quality data to inform and generate best practice and standards to support safe and efficient deployment of energy storage solutions to meet Australia's clean energy targets.

Existing Advantages

The following advantages exist or are emerging in Queensland across the battery value chain that Australia can capitalise on to uplift our battery industries.

1) FBICRC National Battery Testing Centre

The NBTC is the emerging national facility that Australia will require for standardised and application-based testing, validation and certification of battery energy storage systems (BESS). The facility contributes to Australian battery standards development and assists in advancing the technology readiness level (TRL) of developing battery technologies for deployment of functional BESS solutions within Australia. The NBTC actively supports and enables Australian battery industries through commercially relevant, results-driven collaborations co-located with industry partners and centred around the generation of high-quality data for practical outcomes. The current core capabilities of the NBTC include:

- A battery cell/module/pack and systems testing facility for validation and non-destructive safety testing of all types of energy storage devices such as lithium-ion batteries (LIB) and vanadium/iron redox flow batteries (RFB). Consisting of dedicated battery testing units, specialised test fixtures, environmental chambers and advanced testing protocols, this facility enables Australian manufacturers to rapidly develop safe and reduced-cost market-ready BESS products.
- A renewable energy Battery Testing Microgrid (BTM) powered by a 100kW roof-top solar PV array. The BTM provides testing, validation and standards compliance services for a diverse range of large-scale BESS under real-world operational conditions, enabling deployment of these systems to meet Australia's rapidly growing large-scale energy storage requirements.

2) Advanced Battery Facility (QUT)

The ABF is a pilot-scale facility for standard format LIB cell fabrication. It is the only public industry accessible facility capable of fabricating commercial-grade cylindrical-format LIB cells in Australia. The Facility enables battery-grade materials validation through material incorporation in standard, commercially representative cell formats, accelerating the transition of early-stage research and development to industrial pilot-scale and large volume manufacturing. The ABF also enables performance validation and benchmarking of LIB materials manufactured in Australia, testing of componentry and prototyping of a diverse range of LIB cell formats and configurations. The Facility's current core capabilities include:

- The ability to manufacture prototype and standardised cell formats at pilot-scale. This includes test cells (coin cells, single-layer pouch cells) for fundamental property analysis, to industry-representative cell formats (multi-layered pouch cells, cylindrical cells) in humidity controlled, clean room environments.
- A battery materials and components testing laboratory. This laboratory provides testing and qualification services based on the most advanced industry aligned protocols. The laboratory enables Australian miners, refiners, mid-stream processors and LIB active material manufacturers to enter local and international battery supply chains as well as fundamental research and development in novel LIB materials.
- A training facility for LIB cell assembly, testing and manufacture. The ABF was designed to enable training in LIB cell building, qualification testing and LIB manufacturing processes. QUT is working to create dedicated training spaces and programs to up-skill scientists and engineers for work in the energy storage sector in Australia.
- A curated test results database for battery materials and components performance under standardised conditions (software modelling and machine-learning ready).

3) Advanced Robotics for Manufacturing (ARM)

Advanced manufacturing will also be a major component of any Australian battery manufacturing industry. In an Australian first, the ARM Hub was established in 2020 as a collaborative facility for the manufacturing sector, led by the Queensland Government and delivered in partnership with QUT and Urban Art Projects (UAP).

ARM Hub provides the skills and resources needed to scale-up and prove-out high value manufacturing technologies.

Emerging Advantages

1) The Queensland Energy Storage Technology Hub (QUT and the Queensland Government)

Through support from the Queensland Government, Queensland universities and local industry partners, QUT will establish the Queensland Energy Storage Technology Hub (QUEST Hub) which aims to achieve growth and support of battery industries through targeted research, development, testing and practical deployment of high TRL large-scale energy storage technologies to enable the manufacture and installation of these systems in Australia. This includes iron and vanadium redox flow batteries (RFBs), sodium sulphur (NAS) batteries as well as lithium-ion batteries (LIBs) incorporating advanced safety features.

Key pathways to linking these technologies and unlocking industry collaboration in generating value-added products and battery solutions are research, development and manufacturing of:

- Valued-added energy storage materials derived from Australian vanadium resources such as vanadium RFB electrolyte and lithium-vanadium-phosphate (LVP) LIB cathode.
- Separator membranes used in RFB and LIB cells, including the addition of high-purity alumina (HPA) for increased LIB safety performance.
- Advanced LIB cells and systems for niche and high-performance specialist applications such as space, defence, mining, harsh conditions etc.
- A diverse range of large-scale, long-duration BESS and associated components such as iron and vanadium RFB cell stacks and systems and NAS batteries.
- Power conversion systems required for connection of large-scale BESS to electricity grids.

QUEST Hub will focus on enabling the production of these components and systems through the growth of existing QUT capabilities, including support for the National Battery Testing Centre in the development of accredited certification services to enable market entry for Australian products. QUEST Hub will create dedicated prototyping and pilot-scale demonstration facilities for industry partners supported by skilled battery technologists and engineers. These ‘industry incubator’ spaces will unlock the collaboration potential between industry partners and foster the development of advanced energy storage technologies for the generation of world-leading products. QUEST Hub will support and enable battery component and system manufacturing, supplying a diverse range of domestic and international battery supply chains and markets. Demonstration scale deployment of diverse stationary storage systems is made possible in Queensland, in part, due to the State ownership of generation and distribution assets, and recent announcements of nation building investments in transmission in strategic sections of the Queensland segments of the east coast Australia grid.

2) Lava Blue Ltd – Centre for Predictive Research into Specialty Materials (Lava Blue & QUT)

Lava Blue, in collaboration with QUT, has developed a research, development and demonstration facility at QUT’s Redlands research precinct known as the Centre for Predictive Research into Specialty Materials (PRISM).

The first specialty material that Lava Blue is focused on is the production of battery and glass grades of High Purity Alumina (HPA) from a variety of aluminium sources, particularly from the aluminium rich waste streams of other mineral processing facilities. Lava Blue have demonstrated manufacture of +4N HPA for a number of mineral project developers and has two licensees in place with a total planned capacity of 6,000 tpa of production and with plans to advance a further two licensees with similar production targets.

PRISM is a unique facility in Australia, combining laboratory grade quality control and small batch scale processing capacity. Staffed by a team of QUT post-doctoral researchers, PRISM fills an essential gap in commercialisation of scaling up laboratory processes to a demonstration scale from which vital engineering data can be captured.

Lava Blue has been working closely with QUT for the past five years and has assembled a world class team of researchers in HPA manufacturing. The capabilities at PRISM will be continually enhanced to establish a data rich, machine learning driven demonstration scale mineral processing facility utilising advanced extraction and refining techniques. Ultimately, this will build a foundation in machine learning capabilities capable of modelling new processes and materials using AI techniques and deliver a research and training capacity for a new cohort seeking to enter the advanced minerals manufacturing industry addressing a critical skills need for the Nation.

3) A Battery Industrialisation Centre

QUT is actively supporting the creation of a Battery Industrialisation Centre (BIC) in Queensland in line with recommendations made by the Queensland Government's *Battery industry opportunities for Queensland* issues paper and the Federal Government's commitments to support and enable battery industry growth with the local manufacturing of battery components, cells and systems.

The Queensland BIC will bring together training organisations, industry, government and research organisations nationwide to leverage and scale existing capabilities and investments across the battery value chain.

Theme 2: Turning our innovative ideas into opportunity

For Australia to become a major player in the battery global supply chain, a number of opportunities exist while acknowledging potential barriers.

1) Raw mineral mining

Elements/minerals critical to battery technologies include but are not limited to: lithium, vanadium, iron, nickel, manganese, cobalt, aluminium, copper, zinc, graphite, phosphorous, sodium, sulphur and rare earths.

2) Refining to chemicals

Iron and vanadium flow battery electrolytes: Queensland is rich in vanadium and iron deposits and there exists an opportunity to value add to these raw minerals to manufacture vanadium and iron-based flow battery electrolytes for domestic and export markets.

Potential barriers:

- Further R&D support for pilot-scale service provision of bespoke refining equipment will be required with a focus on vertical integration with processes to value-add. The Queensland Government's $75 million commitment to the Townsville critical minerals demonstration facility will provide support for Northern Australia.

- More work is needed on testing and qualification services to assist with iterative R&D to develop high-quality and/or advanced performance battery precursors. QUT's ABF as well as QUEST Hub are developing standardised testing and qualification laboratories to provide this service to industry which will also support refiners/manufactures with third party performance validation to enable entry into the battery supply chain locally and internationally.

Rare Earth Elements (REE): Development of sustainable electrochemical processing technologies, which are much less energy-intensive than traditional processes used overseas.

Potential barriers:

- REE demand is being driven by the requirement of wind turbines, electric vehicles & electronics.
- China maintains its pre-eminence in rare earths, owing to state subsidisation of the companies that mine and process them.
- REE deposits require unique R&D for optimal mid-stream processing.
- The nature of the minerals in which the REE are contained varies significantly within the ore and across different ores.
- The cost of energy to conduct the mid-stream processing of REE is significant and a critical ESG requirement in light of reforms such as EU's new mandatory sustainability laws.

Lithium: With the lithium demand being driven by the growing Li-ion battery market, realising the value of lithium from our spodumene deposits through the development of new technology, with vastly reduced energy inputs compared to conventional processing with improved overall extraction would be of significant value to our critical minerals industry.

Potential barriers:

- The majority of Australia's lithium deposits are in the form of spodumene, where convention extraction is in a rotary kiln & involves very high temperatures (>1000°C).
- The traditional method of extracting lithium is highly energy intensive with a large portion of lithium remaining in the ore post processing.
- There is a strong demand for lithium and lack of projects at the construction and ramp-up stage.

Nickel laterites: Development of sustainable processes for nickel extraction from laterite deposits that meet Environmental, Social and Governance (ESG) requirements.

Potential barriers

- There are minimal skills in laterite processing technology in Western countries due to environmental concerns.
- Current technologies used to process nickel laterites are not environmentally friendly resulting in expensive waste treatment and disposal of chemicals used in the extraction process.
- Many years of nickel sulphide exploitation have depleted these ore bodies and/or made them more expensive to mine.
- Companies are increasingly interested in nickel production from nickel laterites. More than half of Australia's nickel reserves are nickel laterites, however, the nickel (and cobalt) grade is low and the mineralogy is complex.

3) Cell manufacturing

High TRL lithium-ion batteries cells with enhanced safety: Australia needs a secure supply of high-quality lithium-ion batteries (LIBs) to meet the demand created by the need for efficient and on-demand electricity distribution utilising renewable energy generation sources to meet our clean energy targets. Cells manufactured in Australia should focus on proven, high TRL LIB cell formats with enhanced safety for large-scale grid support and domestic use. Existing domestic capability in this sector (i.e. existing cell manufactures such as Feline Pty Ltd) should be supported to grow further and increase manufacturing throughput, enabling organic growth of Australian technology and companies to better support training and the creation of local jobs.

Potential barriers:

- Lack of domestic accredited certification services to certify cells to Australian transport and use standards. The National Battery Testing Centre is currently developing this service.

Flow battery cell stacks: Australia needs a secure supply of Battery Energy Storage Systems (BESS) with long-duration storage capability (LIBs not ideal for long-duration applications). Flow batteries are currently one of the only high TRL long-duration BESS solutions available commercially. To enable domestic manufacturing of vanadium and iron flow BESS, manufacturing of flow battery cell stacks must also be enabled.

Potential barriers:

Further R&D support will be required with a focus on translation to industry 4.0 manufacturing of commercial products. Initiatives such as QUEST Hub will support such endeavours through provision of ‘industry incubator’ spaces to bridge the gap between lab and pilot-scale manufacturing and support IP and technology translation to real-world outcomes.

4) Battery pack/system assembly

Iron and vanadium for large-scale BESS: Australia is rich in vanadium and iron deposits and an opportunity exists to move further downstream towards manufacturing of complete flow battery systems. Apart from the flow cell stack, flow battery systems comprise of common, simple components which allows for local manufacturing of these systems.

Potential barriers:

Further R&D support will be required with focus on translation to industry 4.0 manufacturing of commercial products. Initiatives such as QUEST Hub will support such endeavours through provision of ‘industry incubator’ spaces to bridge the gap between lab and pilot-scale manufacturing and support IP and technology translation to real-world outcomes.

Assembly of lithium-ion battery packs and modules: There is a large and increasing local demand for LIB BESS in supporting residential and community energy storage and distribution. Currently local manufacturers must import LIBs to manufacture LIB BESS. Once domestic LIB cell manufacturing increases in volume, this has the potential to supply to local pack manufactures with mature BESS products.

Potential barriers:

- Lack of domestic accredited certification services to certify LIB modules and packs to Australian transport and use standards. This requires local manufactures to export systems overseas for certification which is costly and time consuming. The National Battery Testing Centre is currently developing this service to enable local manufactures to get products to market quicker.

5) Integration, service and maintenance

Technology demonstration to allow grid connection and training with large-scale BESS: To enable uptake of large-scale BESS in Australia, technology demonstration is crucial. This includes identification of and integration with appropriate (Australian compliant) power conversion systems for grid connection. Both Government and privately owned energy generation and supply companies are hesitant to procure/install new energy storage technologies (non-lithium) without having first seen domestic third-party testing and validation.

Potential barriers:

- Limited facilities capable of testing/demonstration of large-scale BESS. QUT is developing a Battery Testing Microgrid capable of testing up to 250 kW BESS in an off-grid configuration. Grid connected testing capability is required.
- Government and privately owned energy companies need to build collaborations in testing/demonstration endeavours across a wide range of energy storage technologies. A collaborative testbed for grid connection of large-scale BESS would significantly reduce the cost of demonstration and testing and facilitate rapid uptake of systems. The testbed would minimise duplication of efforts, expedite testing campaigns and assist with standardising and best practice generation for grid connection. Through QUEST Hub, QUT will be working with multiple Government and privately owned energy corporations and BESS suppliers to develop this capability. This large-scale BESS demonstration testbed will also serve as a training ground to upskill skilled workers to support Australia's clean energy transition.

Standards and best practice generation: Urgent updating and generation of best practice and Australian standards is required to enable safe and efficient implementation of BESS in Australia. Currently, standards pertaining to BESS utilisation are not keeping pace with the speed of consumer uptake in Australia, and significant work needs to be done to accelerate this, particularly in regard to the safety of LIBs and other emerging intercalation storage technologies (such as sodium-ion) as well as emerging technologies such as flow batteries and sodium sulphur liquid metal (NAS).

Potential barriers:

- More testing and validation facilities will be required to generate the data needed to inform standards development. The National Battery Testing Centre, is currently providing this service through testing of a wide range of energy storage technologies to generate high-quality data and best practice for BESS utilisation to inform standards generation. Such endeavours should be supported and grown to meet demand.
- Lack of expertise in the field of battery energy storage on the EL-005: Secondary Batteries Standards Australia committee. QUT as a registered nominating organisation with Standards Australia is currently requesting representation on EL-005 to provide access to their experts in supporting the acceleration of improved safety standards generation in energy storage.

6) Recycling & reuse

- A national plan for battery recycling will be required as part of any broader National Battery Strategy. Initiatives including a recycling guarantee for batteries manufactured in Australia for domestic use should be considered.

Theme 3: Encouraging investment to grow our battery industries

Both innovation and investment opportunities could be harnessed by building the battery manufacturing ecosystem throughout Australia, and especially in regions which have strong foundations in advanced manufacturing, critical minerals processing and existing research and development capacity.

The existing capacity that exists in the Australian Battery Facility and NBTC as outlined offers a path for investors and battery innovators – across the full battery value chain.

A focus on domestic manufacturing on large-scale, recyclable, enhanced safety energy storage solutions would give Australia an advantage due the global demand for energy storage solutions to support integration of renewable energy generators into electricity transmission grids. Currently globally there is a shortage of large-scale, long-duration energy storage solutions with enhanced safety features. Focusing on these products would create a strong export market for Australia.

QUT believes the following functions delivered by the Powering Australia Industry Growth Centre would support the growth Australian battery industries:

1) Funding

   - To support R&D, product development and commercialisation of new products & technologies.

2) Market intelligence

   - To share latest & emerging global battery industry trends, technology & policy developments.

3) Collaboration

   - Facilitate partnerships and collaborations between industry, government and research and training providers across the battery value chain.

4) Policy advocacy

   - Productive dialogue between battery industry stakeholders and government decision makers to create proposals and recommendations that will support the growth of the industry.

QUT also believes that the establishment of standardised testing and qualification processes for battery materials, cells and systems as well as accredited certification to Australian and international standards will enable entry into the supply chain and provide confidence that Australian product safety risks are effectively understood, mitigated and managed.

To address this, QUT has existing capabilities and investments across the battery value chain, with more than $40M in the Advanced Battery Facility (ABF) and Future Battery Industry CRC (FBI-CRC) National Battery Testing Centre. Additionally, there is a $15M commitment by the Queensland Government to establish the Queensland Energy Storage and Technology Hub (QUEST Hub) to scale up support in growing the battery industry with focus on enhanced safety.

1) QUT FBI-CRC Projects

Electrochemical Testing

- Establish fabrication facility for standard form Li-ion cells in Australia
- Development, testing and validation of Li-ion battery materials and cell componentry
- Creation of interactive database correlating materials and processing parameters to supportive iterative cycle of continuous improvement of cell materials and components

National Battery Testing Centre

- Testing and validation of battery systems: cell, module and pack
- Development, testing and validation of battery control systems
- 'Plug and Play' integration of battery systems with renewable energy microgrids for application-based testing and validation
- Prove-in and pre-commercial demonstration of energy storage technologies for Australian deployment

2) QUEST Hub

Sub-Project: BESS validation, certification and deployment

Expansion of validation and certification services will enable industry partners to manufacture market-ready LIB cells and systems within Queensland. Expansion of battery testing microgrid and BESS deployment programs will provide performance data on a diverse range of large-scale long-duration BESS alternatives (vanadium/iron RFB, NAS) informing optimum deployment options for supporting Queensland's rapidly growing renewable energy generation infrastructure. Work streams include:

- Standards development
- Large-scale long-duration BESS validation, deployment and optimised grid integration
- Certification and safety validation of cells/modules/packs/large-scale BESS to Australian Standards via accredited processes through support for the National Battery Testing Centre
- Technical and economic optimisations through co-location of renewable generation and energy storage via DC/DC coupling

Sub-Project: Development of the QUEST Hub/Queensland Fire and Emergency Services (QFES) Destructive Testing Facility

The ability to destructively test LIB systems under safe and controlled conditions – to purposely initiating thermal runaway resulting in fire – will allow project partners to observe the severity of hazardous conditions presented by a LIB thermal runaway. This capability is not only critical to informing robust emergency response procedures, but is also in high demand from LIB cell/system manufactures and consumers.

A key requirement from LIB system manufacturers is to understand the failure mechanisms and severity of thermal runaway events of procured cells and developed battery systems to inform increased safety in their products. There is a large demand from commercial partners to verify the safety of LIB systems before committing to purchasing or committing to off-take agreements.

The establishment of the QUEST HUB/QFES destructive testing facility at the Whyte Island Live Fire facility will enable local manufacturing of LIB cells and systems with demonstrated advancements in safety, which is currently in high demand by industry and end-users. Destructive cell testing capability is also key to enabling the commercialisation of safety-additive technology such as HPA/separator hybrids. Work streams include:

- Standards development
- LIB emergency response procedure generation for Queensland emergency services
- Destructive testing capability for LIB cell/modules/packs

Theme 4: Creating the enabling environment for industry growth

The Battery Stewardship Council (BSC) is an industry-led, not-for-profit organisation that aims to promote responsible management of batteries throughout their lifecycle in Australia. QUT supports its efforts to promote sustainable battery management. Notwithstanding this, we believe that government and industry can take the following steps to ensure that circular economy principles are incorporated into the life cycles of batteries made and used in Australia:

Design for circularity: regulated battery design requirements that aim to maximise circularity, durability & reusability across the entire battery lifecycle.

Infrastructure: investment into appropriate battery recycling infrastructure that will enable valuable materials such as lithium, cobalt and nickel to be safely recovered and used to make new batteries.

Policy: that requires battery manufacturers (domestic and international) to take responsibility for the end-of-life management of their battery products, such as setting targets for collection and recycling of batteries.

Research and Development: Collaboration across the battery industry, government and research organisations to develop and commercialise new battery technologies & recycling processes that focus on delivering circular economy solutions.

Conclusion

The National Battery Strategy presents a unique opportunity for collaboration between industry and academia. The development and implementation of this strategy will require a multi-disciplinary approach, drawing on expertise from fields such as materials science, engineering, and sustainability.

Universities are well-positioned to contribute to the National Battery Strategy, by conducting research and development on new battery technologies, training the next generation of skilled workers in the industry, and fostering collaboration with industry partners. This collaboration can take the form of joint research projects, student placements and internships, and the co-development of commercial opportunities.

Through the implementation of the National Battery Strategy, universities can play a key role in driving innovation and growth in the battery industry, while also contributing to Australia's broader economic, social and net-zero goals. Implementation of the strategy offers the potential to seed not only battery manufacturing, but also related innovation industries where batteries could be used in a range of products for our energy transition including electrified transport. This manufacturing renaissance across Australia will create the jobs of the future, and offer opportunities to transition skilled workers into higher paying clean energy roles.

By working together, industry, academia and governments can capitalise on Australia's existing strengths in mining, research and development, and renewable energy, and position the country as a leader in the development and production of battery technologies.

Ends

Dr Joshua Watts
Project Lead | National Battery Testing Centre
School of Chemistry and Physics
Faculty of Science
Queensland University of Technology
Phone: +61 7 3138 7408
Mobile: +61 4 39 790 189
Email: joshua.watts@qut.edu.au