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Trends in Battery Technology Forum

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ESTABLISHING AUSTRALIA'S BATTERY INDUSTRY SUPPLY CHAIN

By

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The Centre for Clean Energy Technologies and Practices
Queensland University of Technology, Australia

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ABSTRACT

Australia is rich in battery mineral resources. However, it has not developed a sovereign lithium-ion battery manufacturing capability. A major limiting factor for establishing this industry is the lack of a local material and component supply chain to support cell manufacturing.

The Future Batteries Industries Cooperative Research Centre (FBI CRC) has been recently established to assist in the development of Australia's battery industries. One of the FBI CRC's initial objectives has been to provide an audit of existing capability and future requirements necessary to complete the battery supply chain. This work includes initial reports of the current "State of Play" in Australia's Battery industry and the viability of producing downstream products by value adding to mineral resources to produce cathode, anode and electrolyte materials for our developing industry.

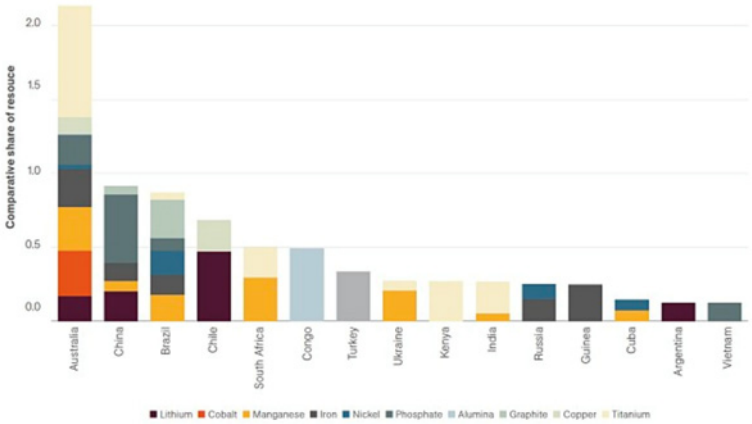
Federal and state governments, research institutions including universities, CSIRO and DSTG and over 60 local and international companies have come together through the FBI CRC to establish flagship projects to establish the local manufacture of the complete battery supply chain.

These advanced materials-based projects are supported by the National Battery Testing Centre and the Cell Fabrication and Electrochemical Testing projects. They will provide essential electrochemical testing of the advanced materials at both the cell level and at the complete battery systems level for safety, performance and compliance with Australian and International standards.

The commercially accepted method of validation of battery materials is to combine all components of a lithium-ion battery cell into a standard cell format and perform electrochemical testing of capacity, cycle life and safety. This extensive testing is necessary because during initial cell charging and discharging cycles, an essential solid-electrolyte-interface (SEI) is formed between the electrodes and the electrolyte. The SEI is optimised to achieve the best performance of cells. With this in mind, the FBI CRC has designed major projects to be interactive with outcomes of each of the material-based projects, such as an advanced cathode, anode or electrolyte formulation project to combine their products into standard cell formats. The final cooperatively produced cell then undergoes the requisite testing and in doing so, individual participants are able to both cooperatively demonstrate the performance of their cell component in a commercial form suitable for marketing to international suppliers and establish a supply chain for Australia's developing battery industry.

Australia is Rich in Battery Mineral Resources

- Australia currently produces nine of the 10 mineral elements required to produce lithium-ion battery anodes and cathodes, and has commercial reserves of graphite – the remaining element.



Australia is abundant in mineral resource reserves relevant to manufacturing lithium-ion batteries.

Small Caps *December 12, 2018*

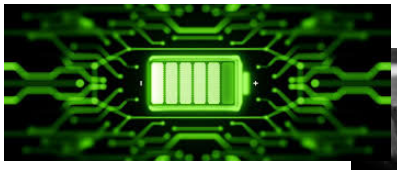
The Growing Battery Market

Growing an Australian Battery Industry

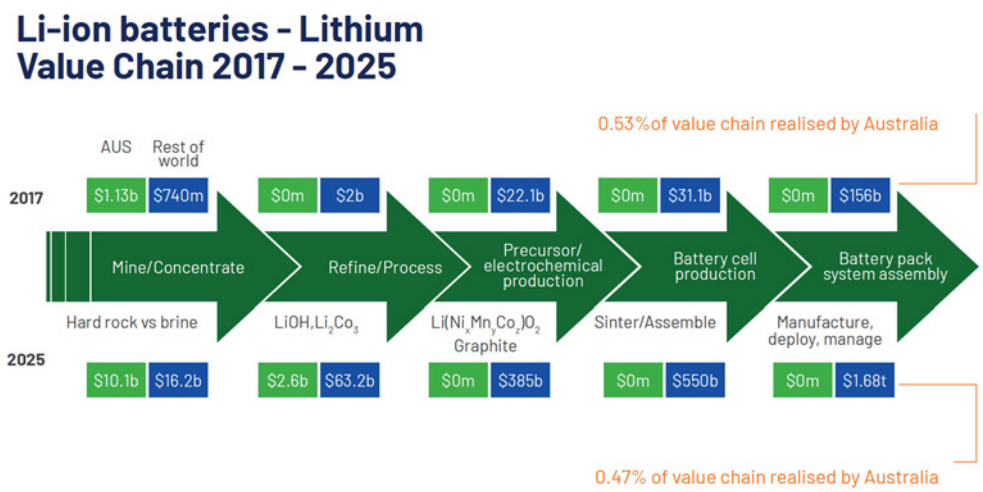
Business

The Global Automotive Lithium-ion Battery Market is Projected to Reach USD 95.3 Billion by 2030, Growing at an Annualized rate

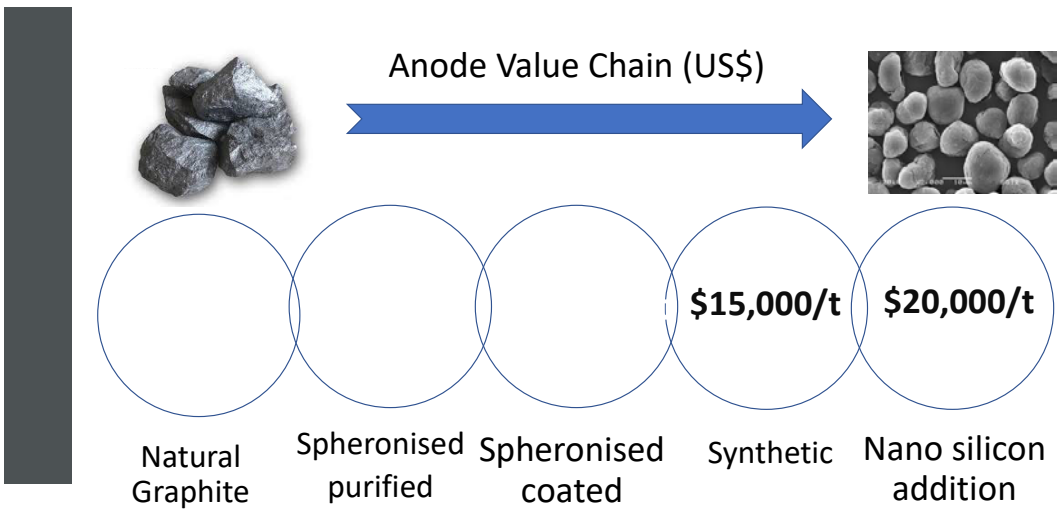
21 November 2019, 2:45 am AEST



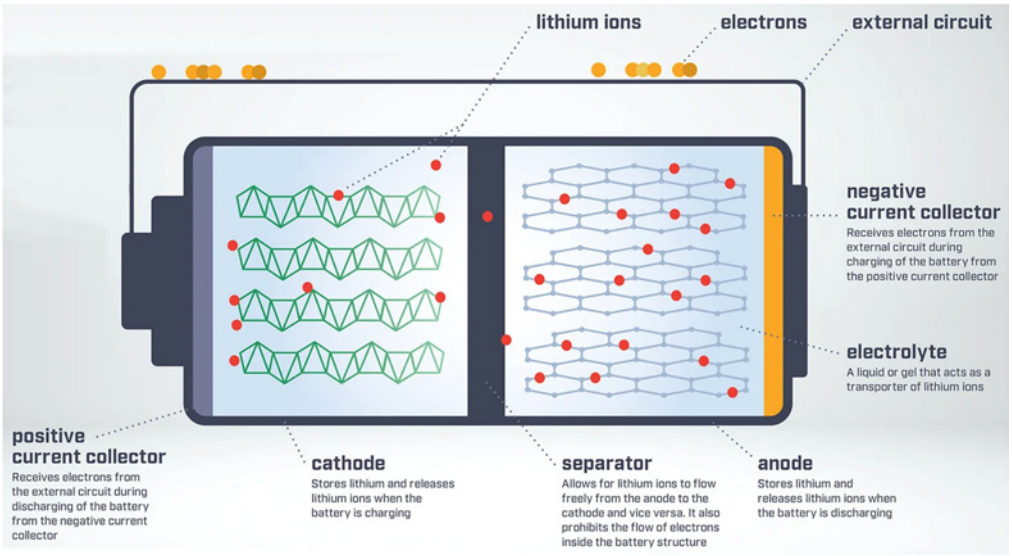
Minerals Processing Value Chain- Lithium



Minerals Processing Value Chain- Graphite

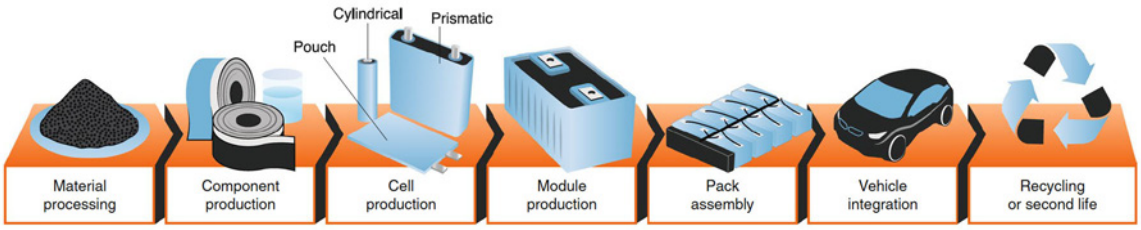


How does a lithium-ion battery work?

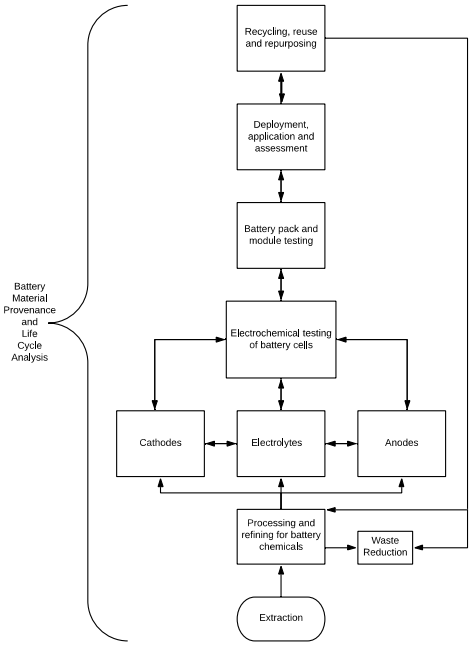


Establishing the Battery Value Chain

Stages of the Lithium-ion Battery Value Chain

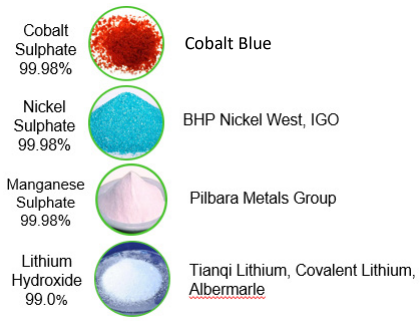


FBI CRC Projects supporting the growth of the Lithium-ion value chain

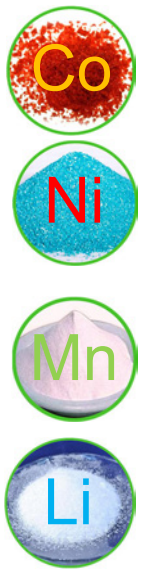


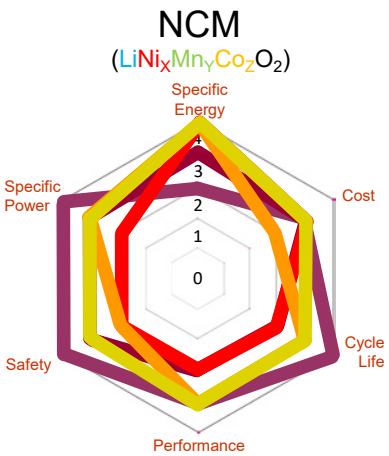
CATHODE MANUFACTURE

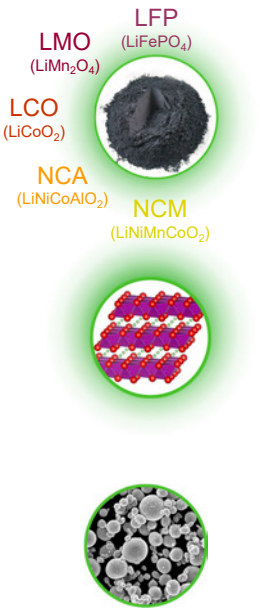
- A state-of-the-art technical assessment on the process to establish precursor manufacture in WA.
- It confirms its technical and commercial feasibility as a foundation for laboratory and pilot scale testing.
- A number of groups are already advancing from raw materials to battery grade chemicals – these are the source materials for precursor chemistries.
- The reward is a 10 fold increase in value (Austrade).



Cathode choice







NMC Cathode Precursors

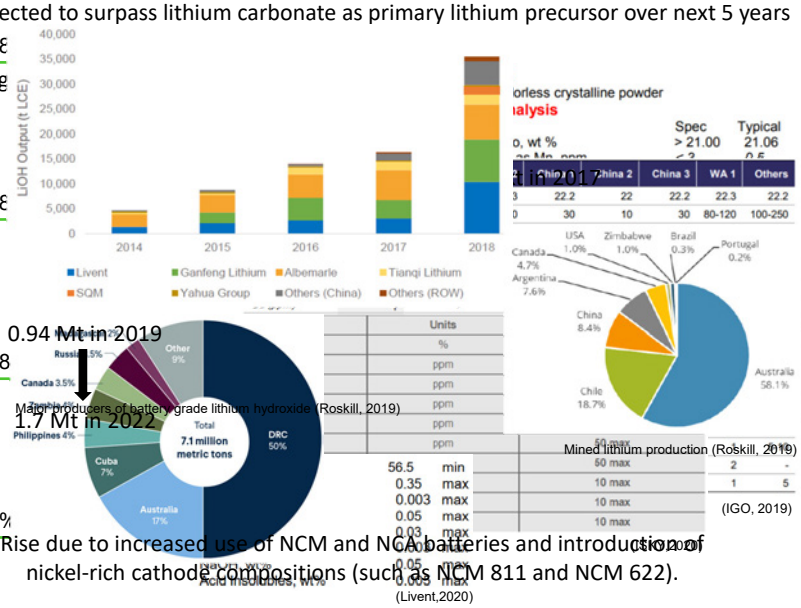
Expected to surpass lithium carbonate as primary lithium precursor over next 5 years

Cobalt Sulphate 99.98%

Nickel Sulphate 99.98%

Manganese Sulphate 99.98%

Lithium Hydroxide 99.0%



0.94 Mt in 2019

1.7 Mt in 2022

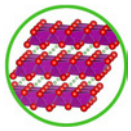
Major producers of battery-grade lithium hydroxide (Roskill, 2019)

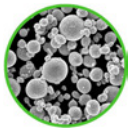
Mined lithium production (Roskill, 2019)

(IGO, 2019)

Rise due to increased use of NCM and NCA batteries and introduction of nickel-rich cathode compositions (such as NCM 811 and NCM 622).

(Livent,2020)





Cathode active material manufacture (co-precipitation)

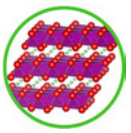
Cobalt Sulphate 99.98%

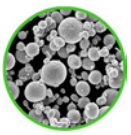
Nickel Sulphate 99.98%

Manganese Sulphate 99.98%

Lithium Hydroxide 99.0%

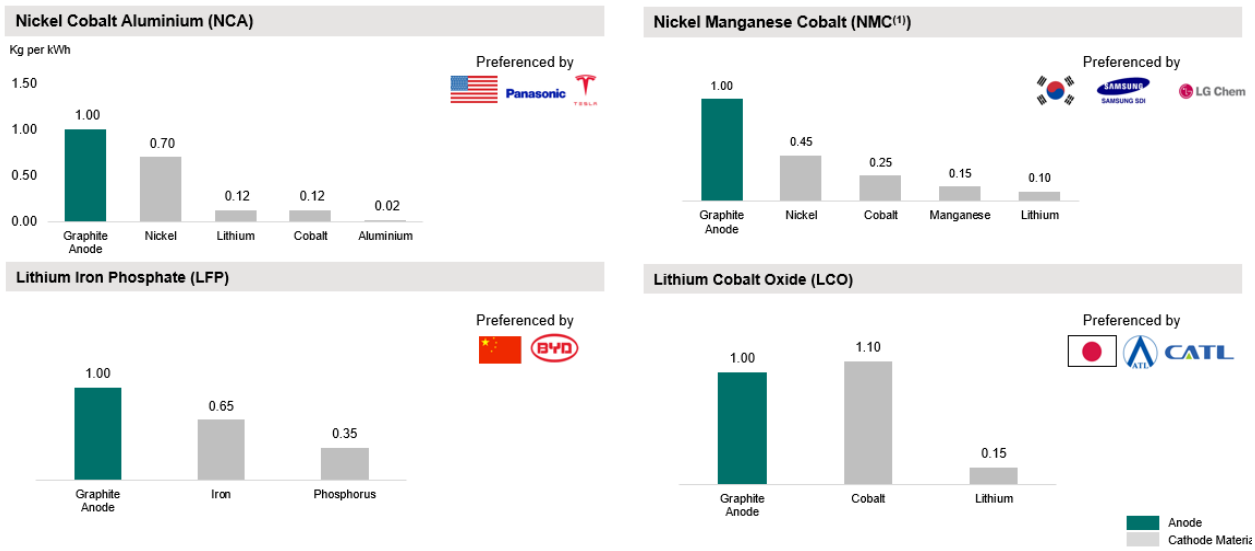
Chemical mixing → Co-precipitation → Dry solids recovery → Lithiation Doping → Calcination/ Coating



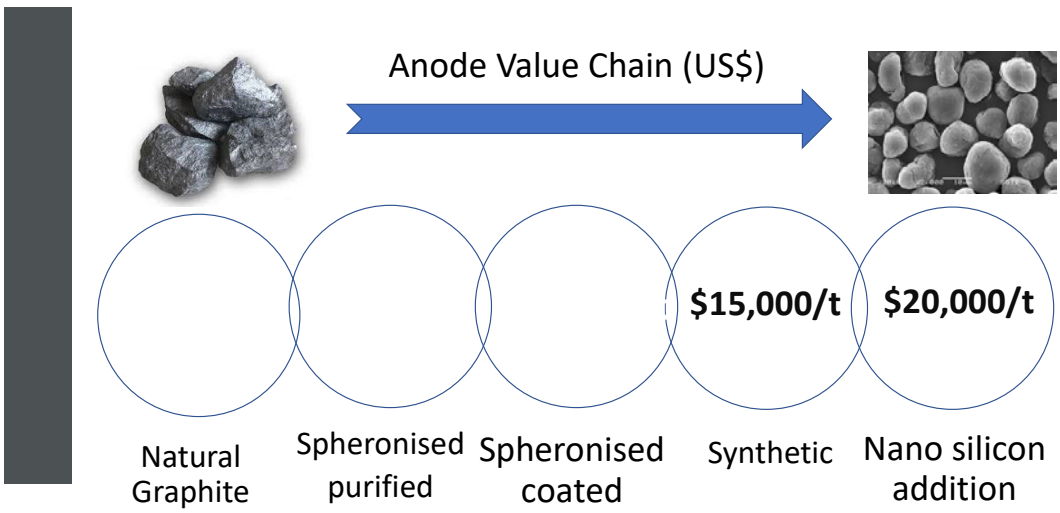


Anode Manufacture

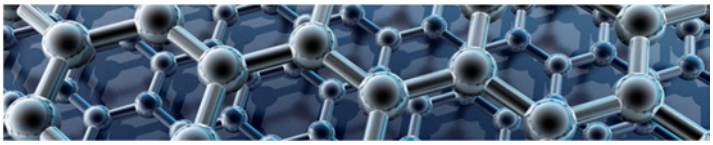
Graphite is the main component in a Lithium-ion Battery



Minerals Processing Value Chain- Graphite



Anode Research Team



- The Department of Chemical Engineering
- Manufacturing Division
- Lithium-ion battery Pilot Plant

The Resource Team – All Australian

- The worlds largest graphite resource and mine
- Europe's largest and purest graphite resource
- Graphite Purifying and Processing plant planned in Australia

Industry Technical Support

Calix

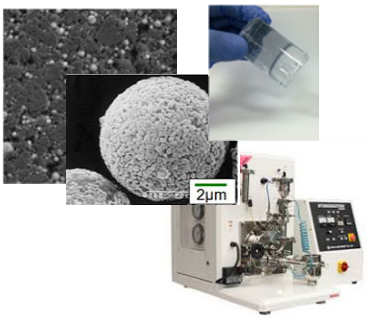
- Novel, large scale thermal processing

anteo diagnostics

- Nano silicon to graphite binders

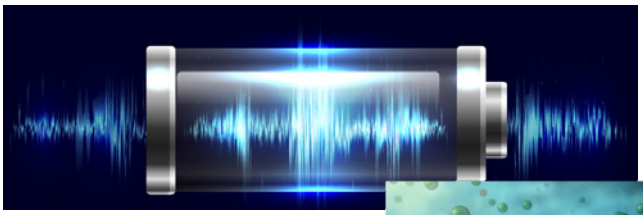
NARA

- Spheronising equipment



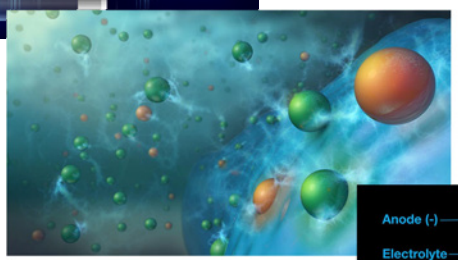
Safe, High Temperature Electrolytes

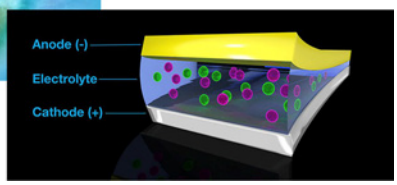
Future Electrolyte Systems Project



- Deakin University
- University of Technology Sydney
- Queensland University of Technology
- CSIRO

- Solvionics
- Boron Molecular
- Calix
- Talga

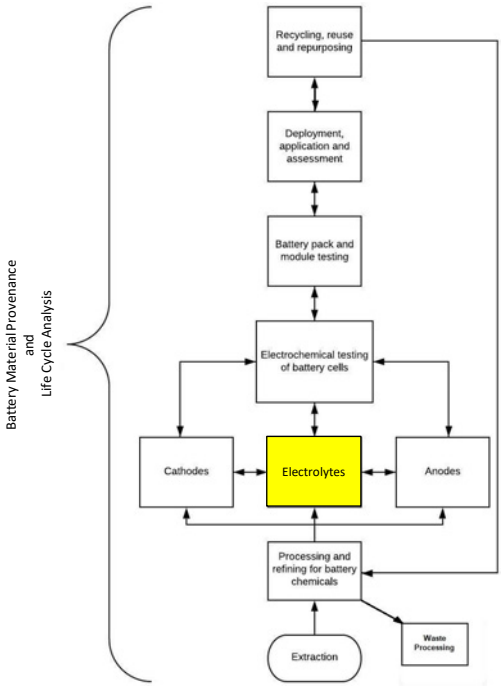




Project Context

Electrolyte at the Centre of the Value Chain

- Link with
  - **Super Anode** and
  - **Cathode Precursor Production Pilot Plant**
  - **Electrochemical Testing** of Li-ion Battery Materials in Standard Cell Formats and
  - **Recycling, Reuse and Repurposing** of Spent Batteries projects to extend capabilities



Future Electrolytes

Materials Characterisation and Benchmarking

- Electrolyte formulations *(Deakin)*
- Separators *(Deakin)*
- Binders for advanced electrodes *(QUT)*

Future Electrolytes

Enhancing cell performance

- Electrolyte Systems Development *(Deakin)*
- SEI Design and Characterisation *(Deakin)*
- Cell formation optimisation *(Deakin)*

Materials Validation- Electrochemical Testing

Electrochemical Testing and Cell Fabrication

Existing Baseline Facilities and Experience

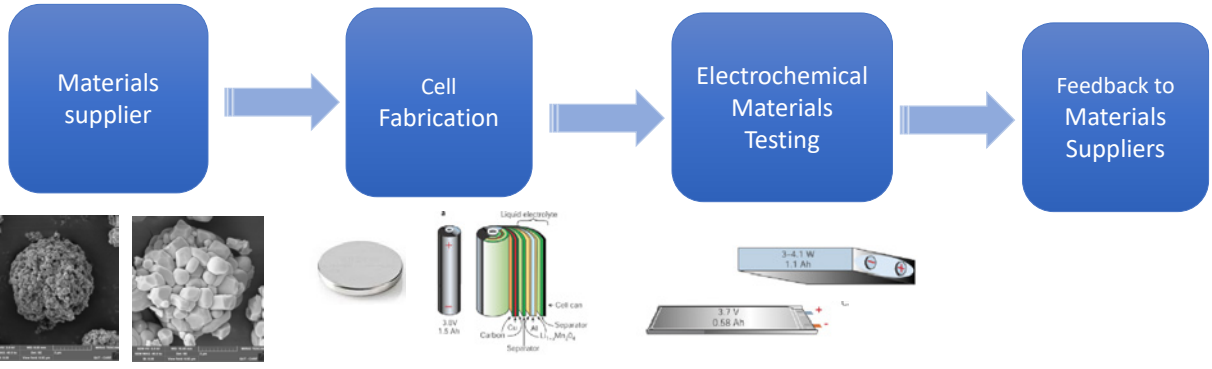
The Electrochemical Testing Facility (ETF);

- Test the electrochemical performance of cathode, anode and electrolytes in standard cell formats.
- Test advanced separator materials
- Establish a database of test parameters and outcomes for feedback to materials producers
- Provide an essential database link between other key projects

Building on Existing Infrastucture?

- Will build on existing dry rooms and Li-ion cell fabrication facility (Capital costs to date > **$8M**).
- Will build on existing Li-ion cell fabrication know-how
- Will add to the current database of materials specification and performance in battery cells.

Cell Fabrication and Electrochemical Materials Testing



Powder characteristics

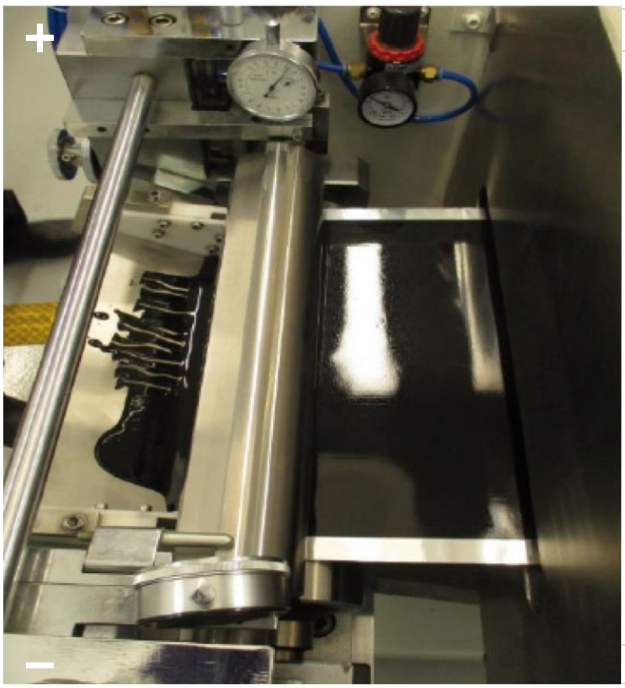
- Composition
- Purity
- Primary particle diameter
- Agglomerate diameter
- Density
- Porosity

Cell characteristics

- Cell format choice
- Half /full cell fabrication
- Electrode ink formulation
- Electrode coating
- Coating density/porosity
- Cell construction
- Coating quality/thickness

Electrochemical characteristics

- Half cell electrode testing
- Full cell formation cycling
- SEI formation
- Conductivity and Impedance Capacity
- Cycling over temperature range
- Cyclability life



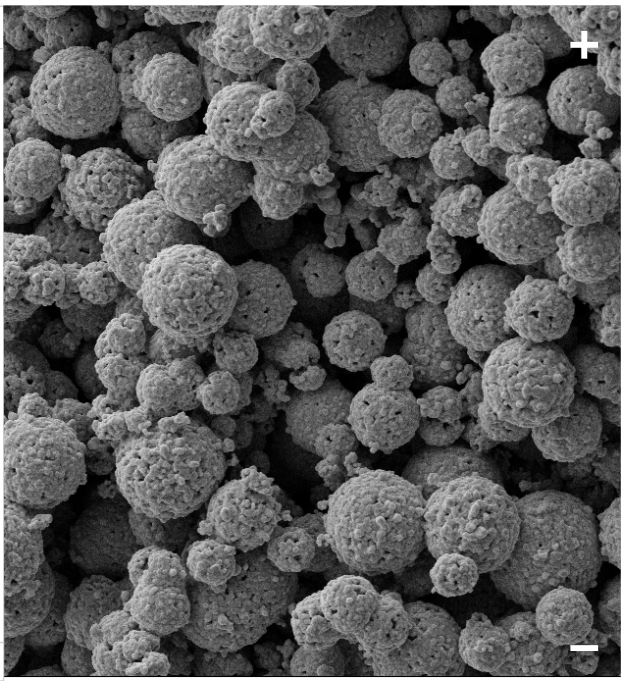
Fabricate Standard Cells

- Fabricate cells using commercial LFP, NCM 622 and NCM-811
- Bench mark against existing commercial cells

Cell Fabrication

Electrochemical Testing

- Produce and test cells using Australian NCM cathode material.



Materials Validation

Materials Validation and Certification

- Validate Australian NCM and additional components.
- External validation/certification

National Battery Testing Centre

- **Professor Peter Talbot – QUT**
- **Program Lead, FBI CRC**

FUTURE BATTERY INDUSTRIES CRC

March 11, 2020

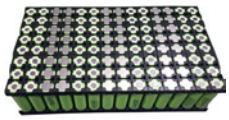
Clean Energy Plug and Play Microgrid

- Battery Testing Centre
- ARENA Hydrogen Project
- Solar CPV Arrays
- System Microgrid Integration
- 60Ha site

QUT ife Institute for Future Environments

National Battery Testing Centre

Battery Module assembly/ Testing → Battery system integration testing → Pack Testing → Safety Testing and Standards



Module

- Module Assembly
- Abuse conditions
- Safety
- Thermal propagation/runaway
- Mechanical construction

Systems

- BMS
- Module balancing
- Module cycling
- Over/under voltage protection
- Environmental testing
- Abuse conditions
- Safety
- Thermal runaway tests

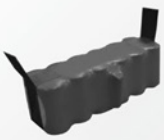
Pack

- Pack Cycling
- Capacity and performance testing
- Over/under voltage protection
- Humidity/temperature environment
- Flow Battery testing
- Microgrid testing
- Standards and Certification testing

Battery Testing – Cells, Modules and Packs

BATTERY: CELL TESTING
Up to 10V

BATTERY: MODULE TESTING
Up to 60V



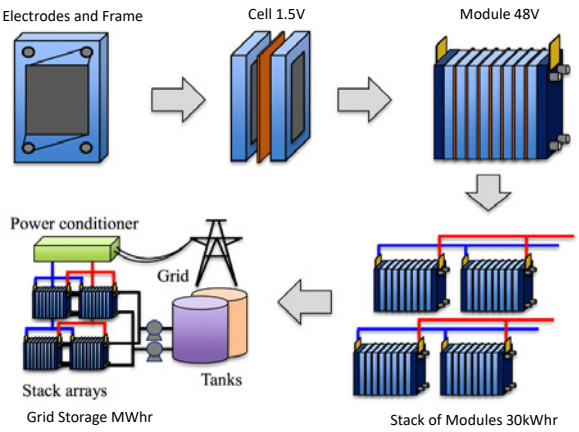
BATTERY: PACK TESTING
Up to 1000V

Module Testing

Battery Voltage 60V to 100V
Battery Current up to 2500A

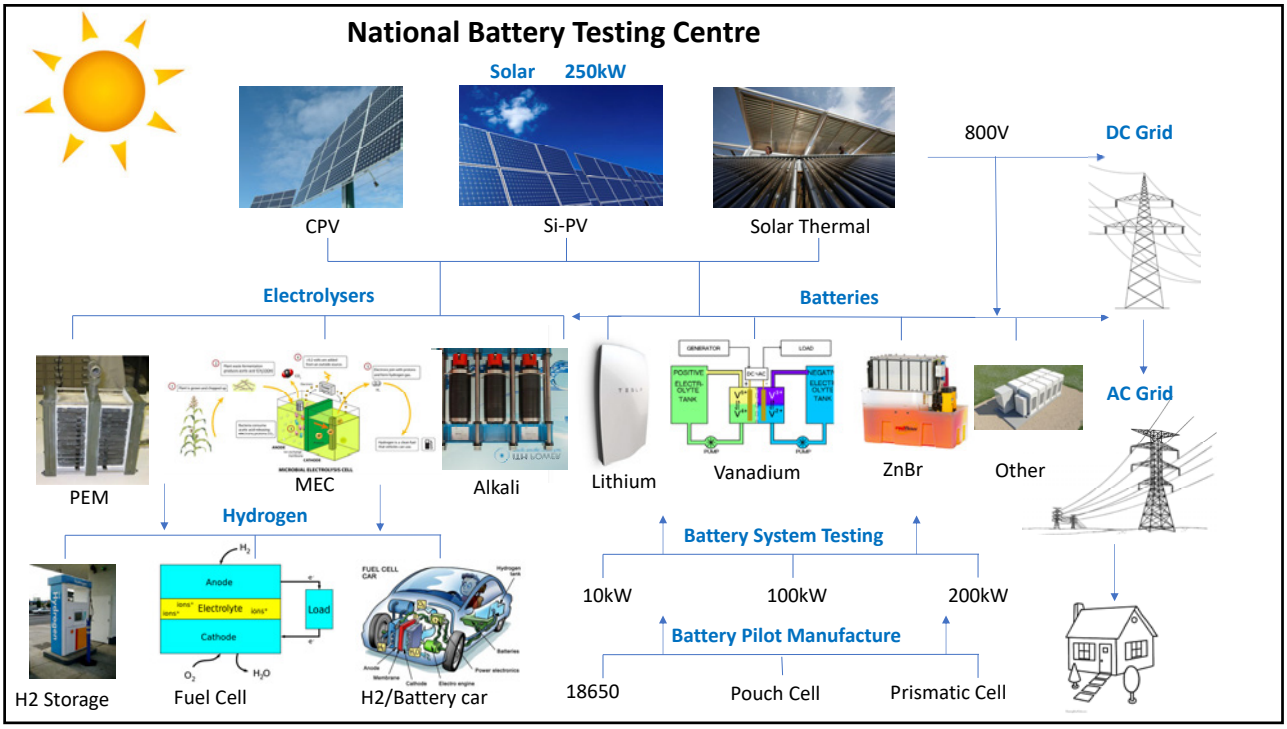
- Life Cycle Testing
- Simulation of advanced real-world test profiles
- R&D of batteries for electric vehicle and grid storage applications
- Validate internal battery management system (BMS)
- Test Smart Battery modules

Vanadium Redox Flow Batteries



Battery Testing Equipment

Up to 1000V



Acknowledgements

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