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SOLID-STATE ELECTROLYTE PROGRESS DE-RISKS INTEGRATED BATTERY EVALUATION PROGRAM

Amorphous Solid-State Electrolyte (ASE) interface stability sustained over 1,200 hours at room-temperature, confirming electrochemical durability and addressing key solid-state battery chemistry challenges.

- **Solid-State Electrolyte (ASE) demonstrates durable performance:** Stable operation over 1,200 hours at room temperature, confirming strong electrochemical stability and addressing a key technical challenge in solid-state battery development.
- **Integrated solid-state battery evaluation advanced:** ASE program validation complements Critical Resources' Dry Supersonic Deposition (DSD) program, reinforcing an integrated strategic approach to reduce both materials and manufacturing risk.
- **Key early-stage solid-state battery failure mode materially de-risked:** Laboratory validation of ASE program confirms a lithium-metal-compatible solid-state electrolyte, materially reducing one of the most persistent early-stage technical barriers to solid-state battery development.
- **Room-temperature performance achieved:** Ionic conductivity of 3.2 mS cm^{-1}, with low activation energy (0.27 eV) confirming efficient lithium-ion transport under ambient laboratory conditions — a foundational requirement for practical solid-state battery operation.
- **Performance demonstrated beyond materials-only validation:** Functional electrochemical performance confirmed within a full solid-state cell architecture, demonstrating amorphous electrolyte operation beyond isolated or component-level laboratory testing.
- **Measured technical risk reduction delivered under CEPS framework:** Results generated within the U.S. Centre for Solid-State Electric Power Storage (CEPS) evaluation program move the ASE workstream from theoretical feasibility to laboratory-validated performance.

Critical Resources Limited ('**Critical Resources**' or the '**Company**', **ASX**: CRR) is pleased to report laboratory validation results from its Amorphous Solid-State Electrolyte (**ASE**) program, delivered in collaboration with the South Dakota School of Mines & Technology within the American National Science Foundation (**NSF**) supported Centre for Solid-State Electric Power Storage (**CEPS**) evaluation framework.

Solid-state batteries are widely recognised as a next-generation energy storage solution; however, electrolyte instability remains a key barrier to commercialisation. This phase of the Amorphous Solid-State Electrolyte (ASE) program was designed to assess lithium-metal interface stability under controlled laboratory conditions, a primary early-stage technical risk in solid-state battery development. The results provide early-stage laboratory validation of electrolyte material performance and lithium-metal interface behaviour, systematically reducing known solid-state battery failure modes prior to progression into later-stage cell-level evaluation.

The results demonstrate that CRR's amorphous solid-state electrolyte achieves room-temperature ionic conductivity, sustained lithium-metal interface stability over extended testing, and functional performance within a full solid-state cell configuration. Collectively, these outcomes address several of the most persistent technical failure modes that have constrained solid-state battery development, particularly electrolyte instability and interface degradation.

Importantly, the ASE program forms a core component of CRR's integrated battery strategy. It complements the Company's Dry Supersonic Deposition (DSD) solvent-free cathode manufacturing evaluation program, with both workstreams designed to systematically reduce materials and manufacturing risk while maintaining a disciplined, laboratory-stage evaluation approach.

> **Critical Resources Managing Director, Tim Wither, commented:** *'This first step in our lithium-ion solid-state electrolyte (ASE) validation program advances our integrated battery strategy by addressing several of the key technical failure modes from chemical design that have constrained solid-state battery development.*
>
> *'Demonstrating room-temperature electrolyte performance alongside sustained lithium-metal interface stability for more than 1,200 hours under controlled laboratory conditions materially reduces early-stage interface-related risk — one of the most challenging aspects of solid-state battery development. Importantly, this work complements our solvent-free Dry Supersonic Deposition program, reinforcing an integrated approach that addresses both materials performance and manufacturing complexity.*
>
> *'While this work remains at an early laboratory stage, the results indicate the program is progressing in the right direction and strengthen the technical foundation of our battery strategy.'*

ASE PROGRAM CONTEXT – WHY ELECTROLYTE STABILITY MATTERS

In solid-state batteries, the electrolyte replaces the flammable liquid electrolyte used in conventional lithium-ion systems. For lithium-ion solid-state batteries to operate reliably, the electrolyte must:

- conduct lithium ions efficiently at room temperature.
- remain chemically and mechanically stable when in contact with lithium metal.
- maintain cathode/electrolyte interface integrity over extended operating periods.

Electrolyte instability — particularly at the lithium-metal interface — is one of the primary technical barriers to solid-state battery viability. Interface degradation can lead to increased resistance (**performance risk**), short-circuit risk (**safety risk**), and premature cell failure (**real-world durability risk**).

The ASE program has been designed to assess whether an amorphous non-sulphide solid-state electrolyte system can address these challenges under controlled laboratory conditions, with a focus on electrochemical stability, durability, and compatibility with lithium metal. Under the ASE program, a new amorphous lithium electrolyte was synthesised by a high-energy ball-milling process under inert room-temperature conditions.

X-Ray Diffraction (**XRD**) analysis conducted at multiple stages during electrolyte synthesis confirmed the progressive breakdown of the original crystalline structure and the formation of a fully amorphous phase following extended milling (**Figure 1**). The ASE chemical composition was systematically evaluated across a range of parameters to disrupt the rigid crystalline framework and optimise lithium-ion transport and interfacial behaviour under laboratory solid-state battery conditions.

WHY AMORPHOUS MATTERS. In a solid-state battery, the electrolyte functions as the primary pathway for lithium-ion transport between electrodes. Crystalline electrolytes behave like rigid transport networks with fixed junctions, where bottlenecks and localised stress points can restrict ion flow and degrade performance over time. By contrast, an amorphous electrolyte provides a more continuous, multi-lane transport pathway, improving lithium-ion mobility, reducing internal stress, and maintaining more uniform contact at the lithium-metal interface. This combination supports both **improved electrochemical performance** and **greater interface stability** during repeated cycling.

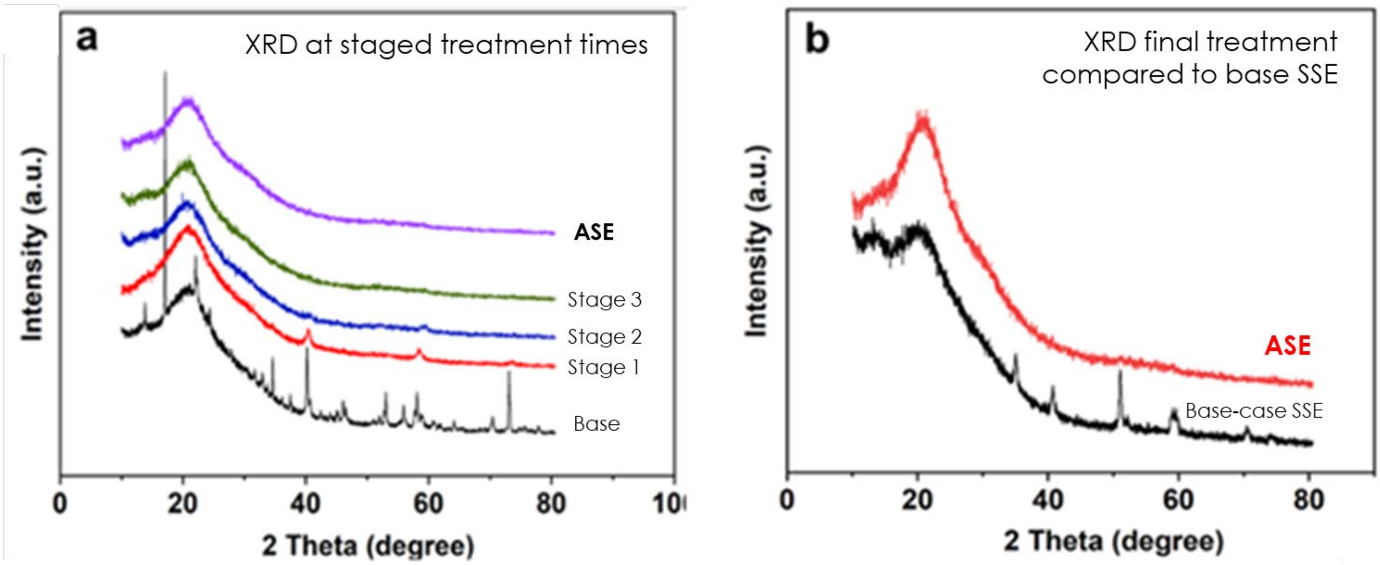


Figure 1 *- X-ray diffraction (XRD) analysis conducted at multiple stages (a) during electrolyte synthesis, confirming the progressive loss of long-range crystalline order and (b) the formation of a fully amorphous solid-state electrolyte (ASE) following treatment.*

FULL SOLID-STATE CELL PERFORMANCE

To validate performance beyond isolated material testing, the amorphous, non-sulphide solid-state electrolyte was integrated into full solid-state cell assemblies incorporating an NMC811 cathode and a Li–In alloy anode (a standard laboratory configuration for early solid-state evaluation).

Testing confirmed functional electrochemical performance within a complete solid-state cell architecture during short-duration laboratory cycling. Post-cycling analysis using X-ray diffraction (**XRD**) and X-ray photoelectron spectroscopy (**XPS**) identified no new phase changes or new chemical species at either electrode interface under the applied test conditions.

IONIC CONDUCTIVITY AND ROOM-TEMPERATURE PERFORMANCE

The ionic conductivity of the amorphous electrolytes was evaluated using electrochemical impedance spectroscopy (EIS). Testing demonstrated:

- low activation energy of 0.27 eV, derived from temperature-dependent impedance measurements.
- effective ionic conductivity of 3.2 mS cm^{-1} at room temperature.
- optimised performance governed by electrolyte composition.

WHY IONIC CONDUCTIVITY MATTERS: These results confirm that the ASE electrolyte supports efficient lithium-ion transport under ambient laboratory conditions — a foundational requirement for solid-state battery operation and an initial step forward in the Company's solid-state battery evaluation program.

Ionic conductivity and activation energy values were derived from Electrochemical Impedance Spectroscopy (**EIS**). Nyquist plot analysis (**Figure 2**) shows that the modified amorphous electrolytes support efficient lithium-ion transport at room temperature. Measurements were conducted on cold-pressed electrolyte pellets across a temperature range of 20–70 °C.

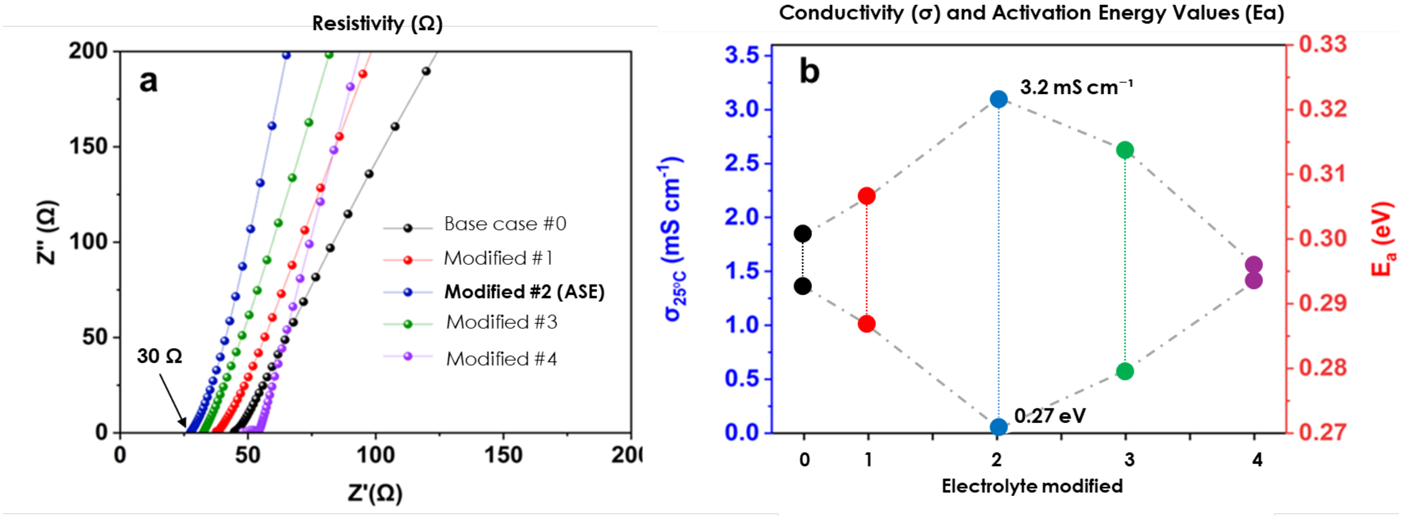


Figure 2 – *(a) Nyquist impedance plots for modified amorphous electrolytes measured at 25 °C (b) Calculated values of lithium-ion conductivity and the corresponding values of activation energy at room temperature for amorphous electrolytes in a temperature range of 20–70 °C.*

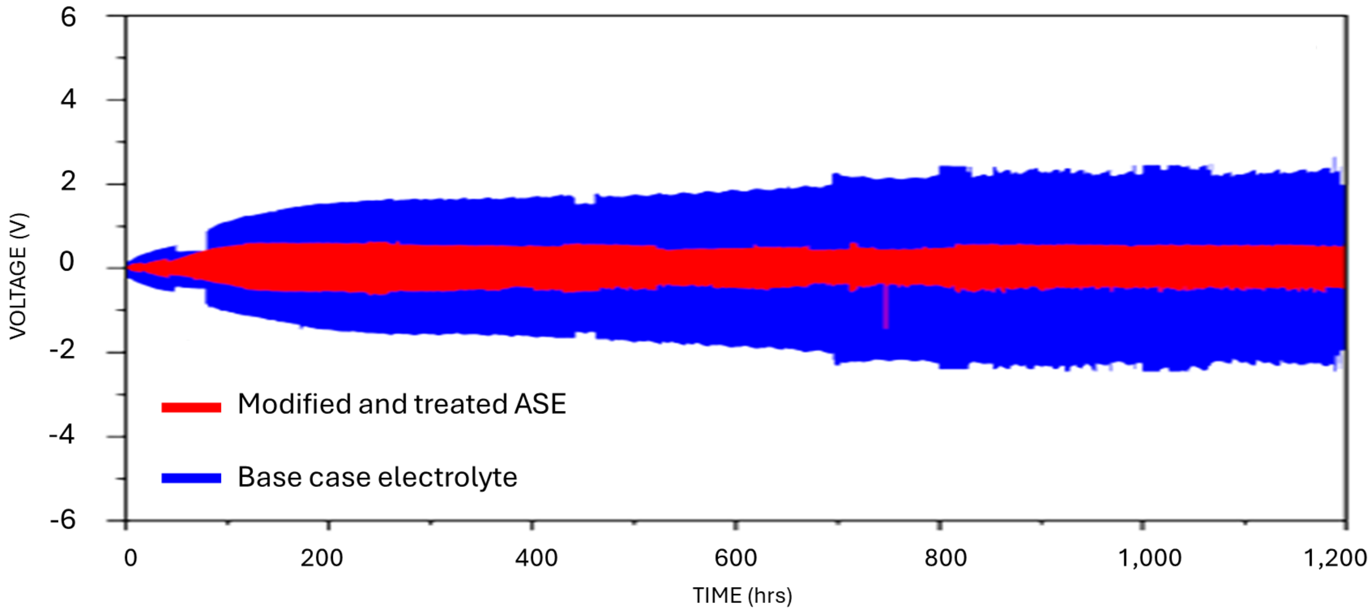


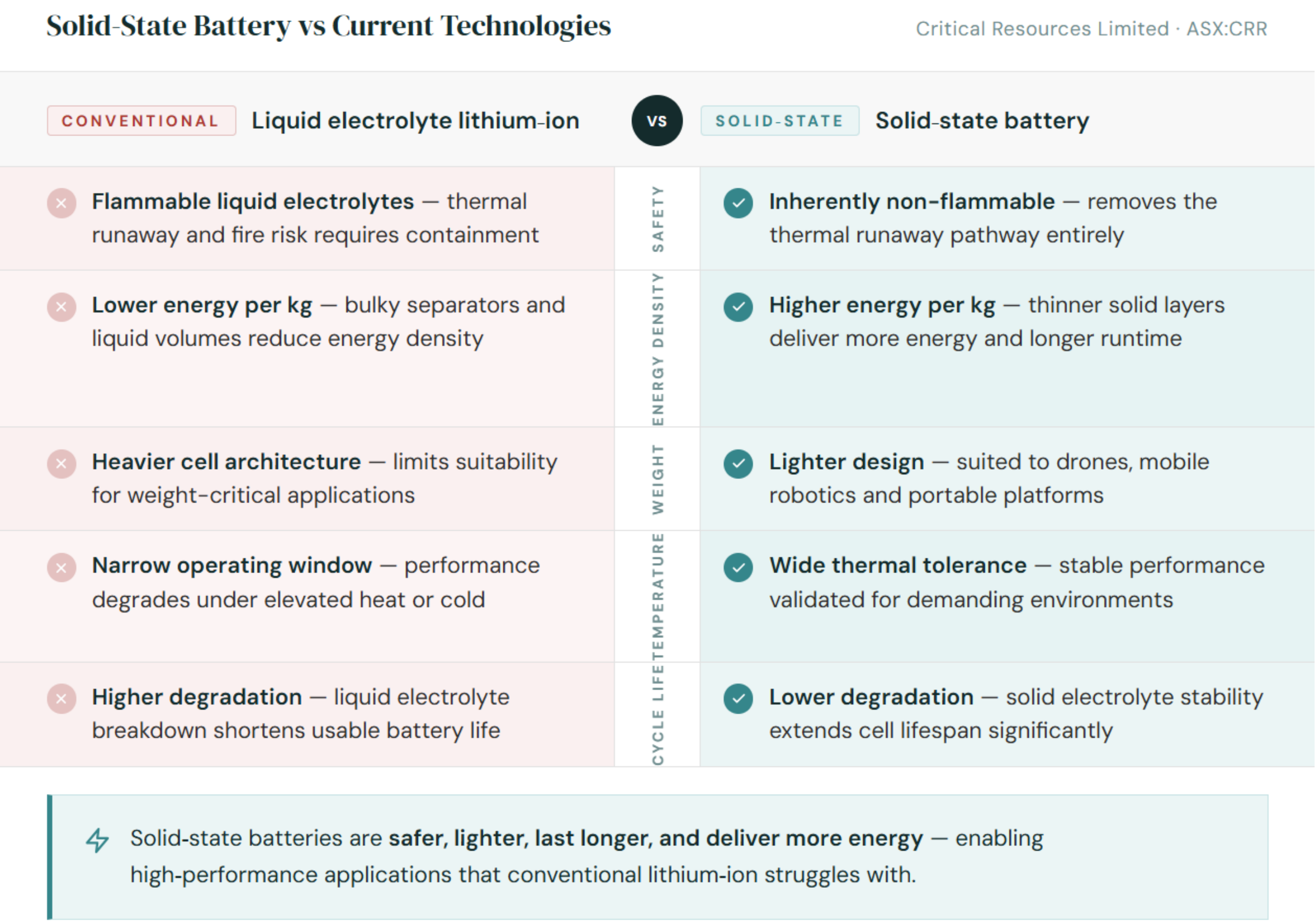
Figure 3 *– Galvanostatic charge/discharge cycling performance of the modified ASE (red) and untreated electrolyte (blue), demonstrating stable interfacial behaviour of the ASE over 1,200 hours at a current density of 0.1 mA cm* $^{-2}$ *under controlled laboratory conditions.*

LITHIUM-METAL INTERFACE STABILITY

To assess compatibility with lithium metal, symmetric lithium–electrolyte–lithium cells were assembled and cycled under controlled laboratory conditions (**Figure 3**). Testing demonstrated:

- Stable operation for over 1,200 hours at a current density of 0.1 mA cm^{-2}.
- Low initial voltage drop (~0.08 V) and stable voltage profile during charge/discharge cycling.
- Formation of a stable, protective interphase at the lithium–electrolyte interface.

WHY INTERFACE STABILITY MATTERS: Instability at the lithium-metal interface is a leading cause of degradation and short-circuit failure in solid-state batteries. Sustained interface stability over extended testing indicates a material reduction in interface-related risk under the applied test conditions.



Solid-State Battery vs Current Technologies

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CONVENTIONAL Liquid electrolyte lithium-ion	VS	SOLID-STATE Solid-state battery
✕ **Flammable liquid electrolytes** — thermal runaway and fire risk requires containment	SAFETY	✓ **Inherently non-flammable** — removes the thermal runaway pathway entirely
✕ **Lower energy per kg** — bulky separators and liquid volumes reduce energy density	ENERGY DENSITY	✓ **Higher energy per kg** — thinner solid layers deliver more energy and longer runtime
✕ **Heavier cell architecture** — limits suitability for weight-critical applications	WEIGHT	✓ **Lighter design** — suited to drones, mobile robotics and portable platforms
✕ **Narrow operating window** — performance degrades under elevated heat or cold	TEMPERATURE	✓ **Wide thermal tolerance** — stable performance validated for demanding environments
✕ **Higher degradation** — liquid electrolyte breakdown shortens usable battery life	CYCLE LIFE	✓ **Lower degradation** — solid electrolyte stability extends cell lifespan significantly

Solid-state batteries are **safer, lighter, last longer, and deliver more energy** — enabling high-performance applications that conventional lithium-ion struggles with.

Figure 4 *– Solid-state battery design delivers measurable safety, energy density, and longevity advantages over conventional liquid electrolyte lithium-ion technology.*

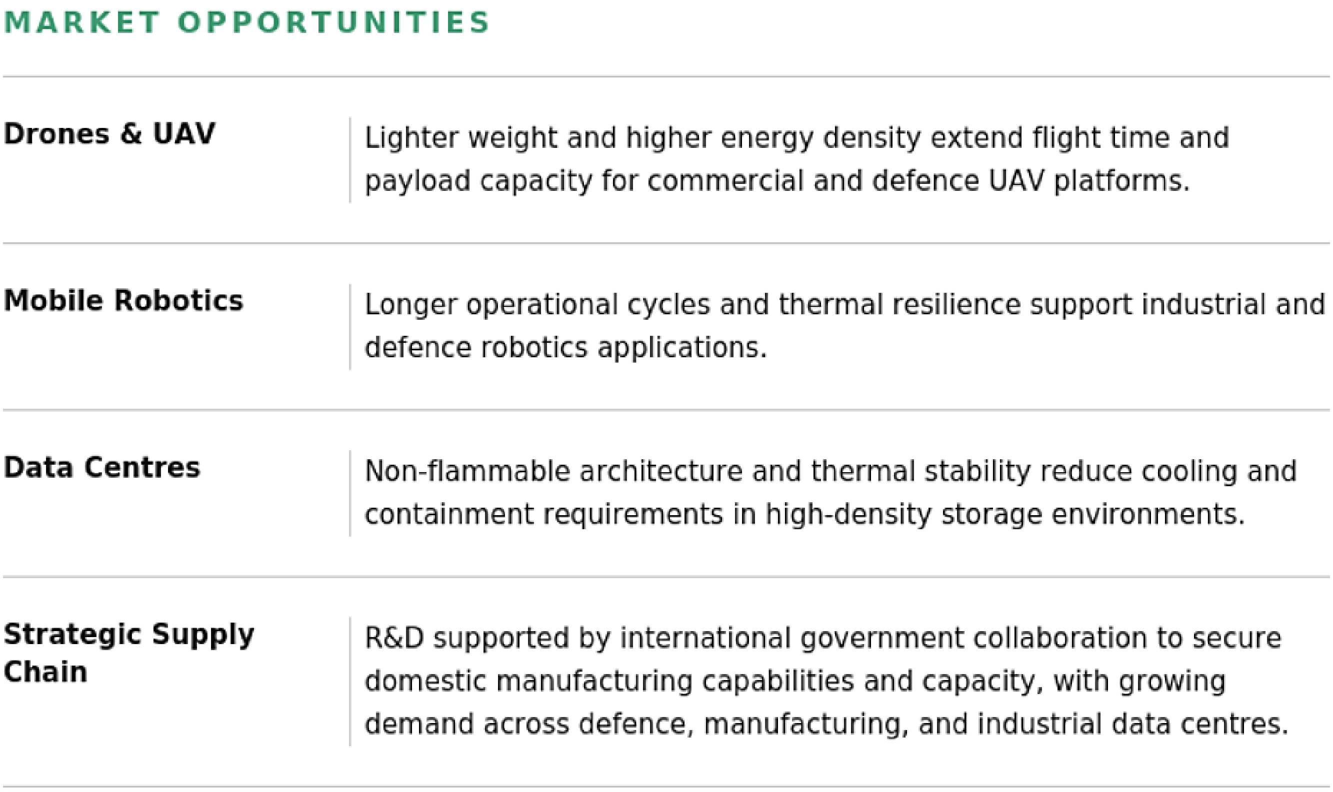
STRATEGIC ALIGNMENT WITH CRR'S INTEGRATED BATTERY STRATEGY

The Company's lithium-ion solid-state battery evaluation strategy is focused on systematically reducing the key **materials and manufacturing risks** associated with solid-state batteries, while maintaining a **capital-light, staged pathway** under the CEPS framework with the South Dakota School of Mines. The programs include:

- **Amorphous Solid-State Electrolyte (ASE) program:** Addresses electrolyte performance, lithium-metal interface stability, and electrochemical durability — key early-stage technical material risks in solid-state battery systems.

- **Dry Supersonic Deposition (DSD) program:** Targets solvent-free cathode manufacturing, reducing process complexity, energy intensity, and permitting challenges associated with conventional slurry-based processes.

Together, these programs support an integrated approach to solid-state battery development that prioritises **safety, durability, and manufacturability**, while preserving **strategic optionality** as the technology matures.



MARKET OPPORTUNITIES

Drones & UAV	Lighter weight and higher energy density extend flight time and payload capacity for commercial and defence UAV platforms.
Mobile Robotics	Longer operational cycles and thermal resilience support industrial and defence robotics applications.
Data Centres	Non-flammable architecture and thermal stability reduce cooling and containment requirements in high-density storage environments.
Strategic Supply Chain	R&D supported by international government collaboration to secure domestic manufacturing capabilities and capacity, with growing demand across defence, manufacturing, and industrial data centres.

***Figure 5** – Solid-state battery market opportunities, delivering performance and safety advantages over conventional lithium-ion technology.*

NEXT STEPS

Critical Resources will continue advancing the ASE program under the structured six-month evaluation framework with CEPS and SDM, building on these initial results toward later-stage cell-level validation. These activities are designed to strengthen the technical foundation of the Company's solid-state battery strategy without implying commercial manufacturing at this stage.

Key next steps include:

- **Electrolyte composition optimisation:** Refine amorphous electrolyte formulations to further enhance ionic conductivity, interface stability, and temperature performance — targeting improved consistency across a broader operating range.

- **Expanded interfacial validation:** Continue post-cycling electrochemical and XRD/XPS testing across broader conditions — building the dataset required to model interface behaviour and degradation over time.

- **Compression pathway assessment:** Evaluate cell performance under conventional uniaxial pressing and Warm Isostatic Pressing (WIP) — an emerging densification technique applying uniform pressure across complex geometries to improve interface contact and reduce resistance to improve performance and potential scalable manufacturing pathways.

- **Progressive full-cell evaluation:** Integrate optimised electrolyte and cathode formulations into increasingly representative solid-state cell assemblies — the critical bridge between materials validation and cell-level performance metrics.

- **DSD integration trials:** Commence controlled cathode–electrolyte interface trials aligned with DSD-fabricated cathode architectures — connecting the ASE and DSD workstreams into a unified solid-state cell evaluation pathway during the evaluation period with SDM.

This announcement has been approved for release by the Board of Directors of Critical Resources.

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ABOUT CRITICAL RESOURCES LIMITED

Critical Resources Limited (ASX:CRR) is an Australian mining and technology company focused on the discovery and development of critical metals and next-generation battery technologies essential to a sustainable future. The Company holds a diversified portfolio including the Mavis Lake Lithium Project in Ontario, Canada, the Halls Peak Base Metals Project in New South Wales, and a growing gold portfolio in New Zealand.

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