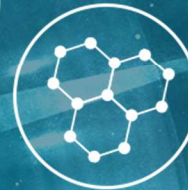


Liquefied Gas Electrolytes for Next-Generation Batteries for Extreme Cold Temperature Operations



Space Power Workshop

April 25, Energy Storage III – Advanced Energy Storage Topics

Ryo Tamaki, Ph.D. | rtamaki@south8.com

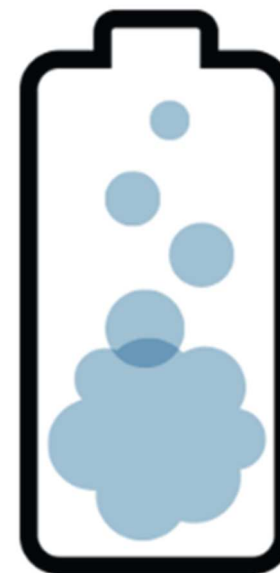
Vice President of Product | South 8 Technologies, Inc.

 **SOUTH 8
TECHNOLOGIES**

South 8 unique electrolyte technology: Liquefied Gas Electrolyte (LiGas®)



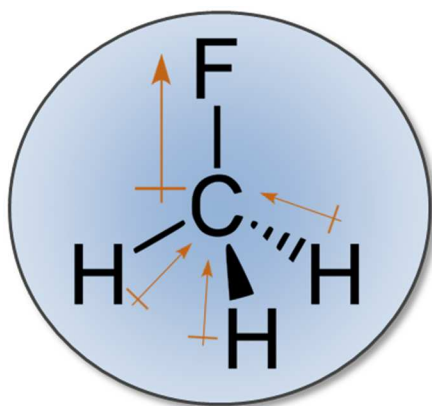
**Conventional
Liquid Electrolyte**



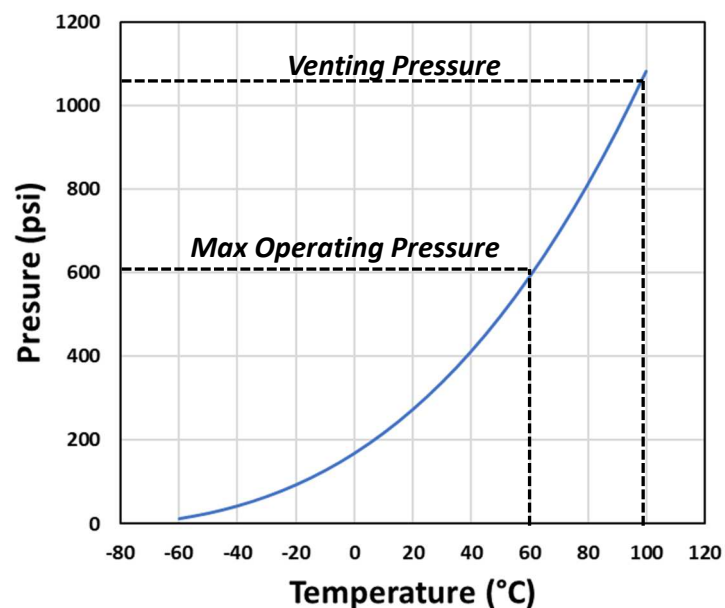
**Liquefied Gas Electrolyte
(LiGas®)**

LiGas[®] is made of commercially available low molecular weight gases

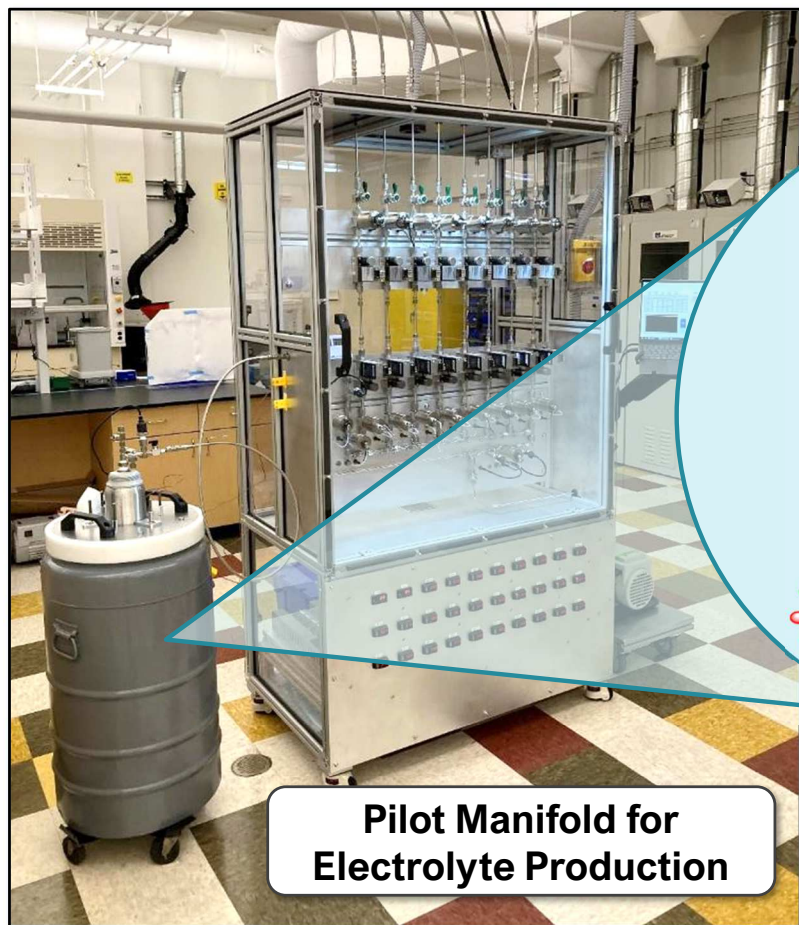
- ❖ Low Viscosity
- ❖ Low Melting Points
- ❖ Non-Ozone-Depleting
- ❖ Non-Toxic, Non-Corrosive
- ❖ Low Global Warming Potential
- ❖ Excellent Electrochemical Stability
- ❖ Compatible With All Common Battery Materials
- ❖ Low Cost, Commercially Available in High Purity, No Supply Chain Concern



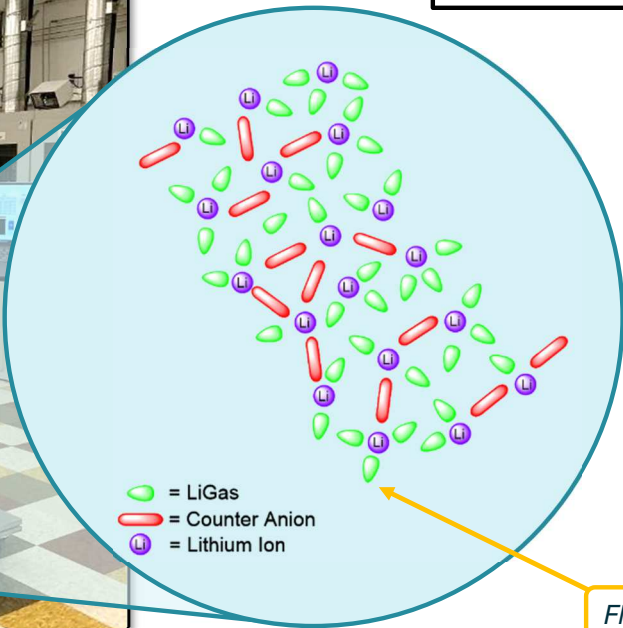
Typical Vapor Pressure Curve for LiGas Cell



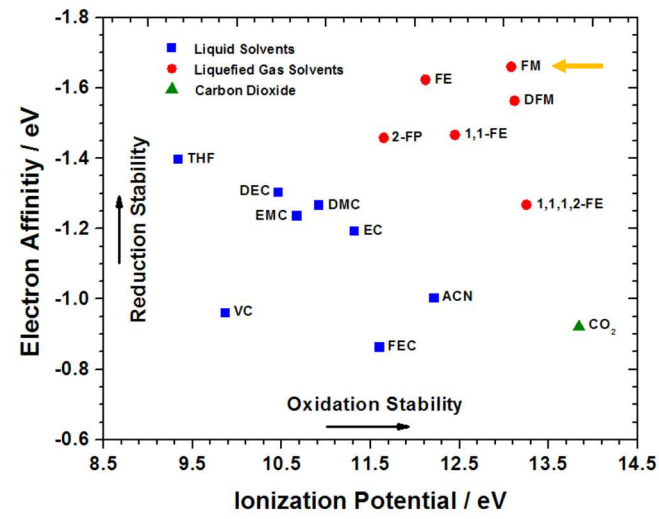
Liquefied Gas Solvent Electrolytes



Pilot Manifold for Electrolyte Production



Calculated via DFT at B3LYP/6-31+g(d,p) level of theory.



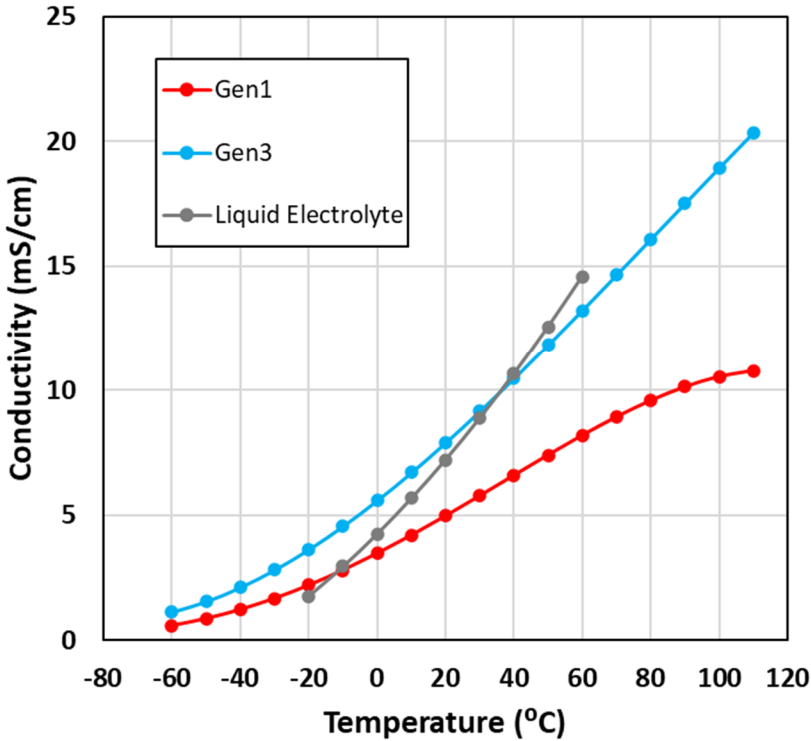
Rustomji et al., Science 356, 1351 (2017)

Fluoromethane: the only publicly disclosed LiGas component

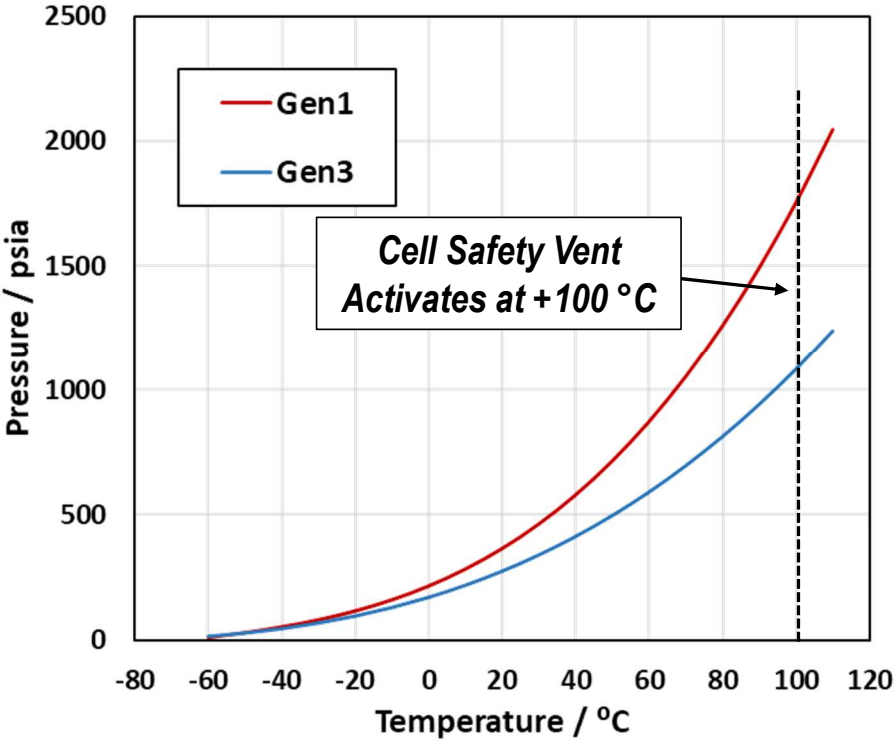
- **Liquefied gas blends form electrolyte solutions analogous to traditional formulations**
- **Excellent electrochemical stability windows**

Gen 3 LiGas properties

Higher conductivity

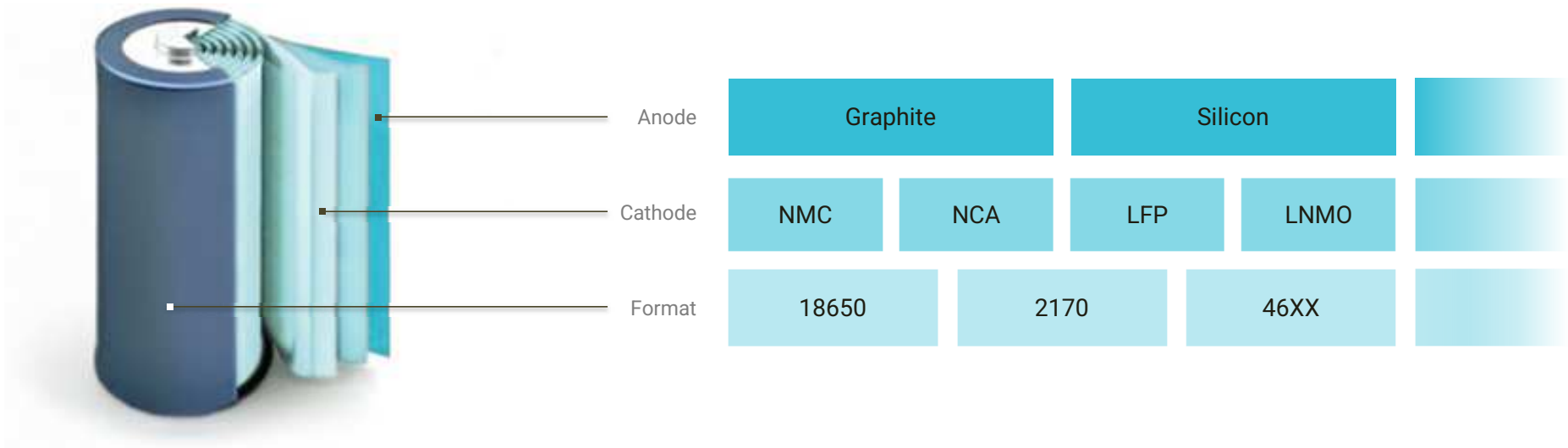


40% reduction in vent pressure



LiGas is a platform solution

Compatible with all conventional cathode, anode, and separator materials

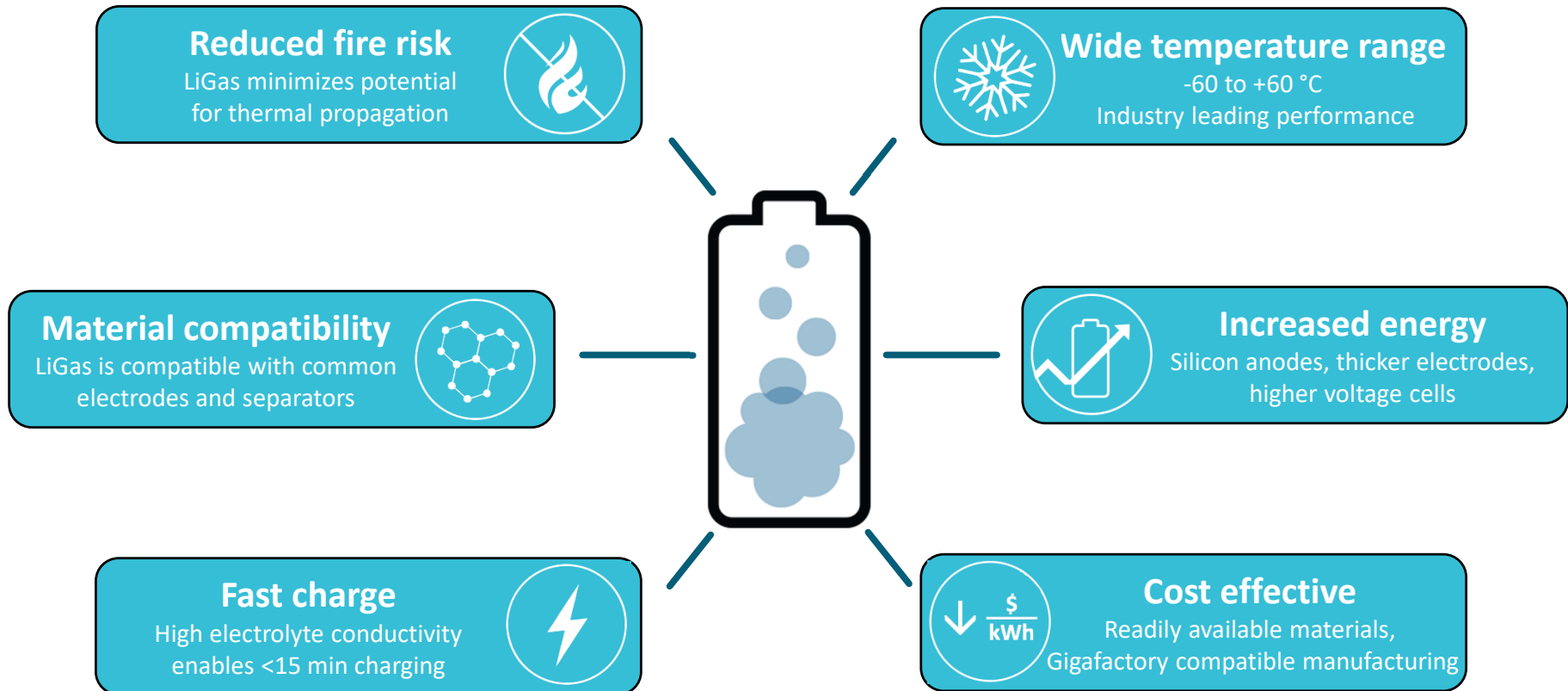


Cylindrical LiGas Cell Product Offering

South 8's LiGas technology works with any cylindrical formats

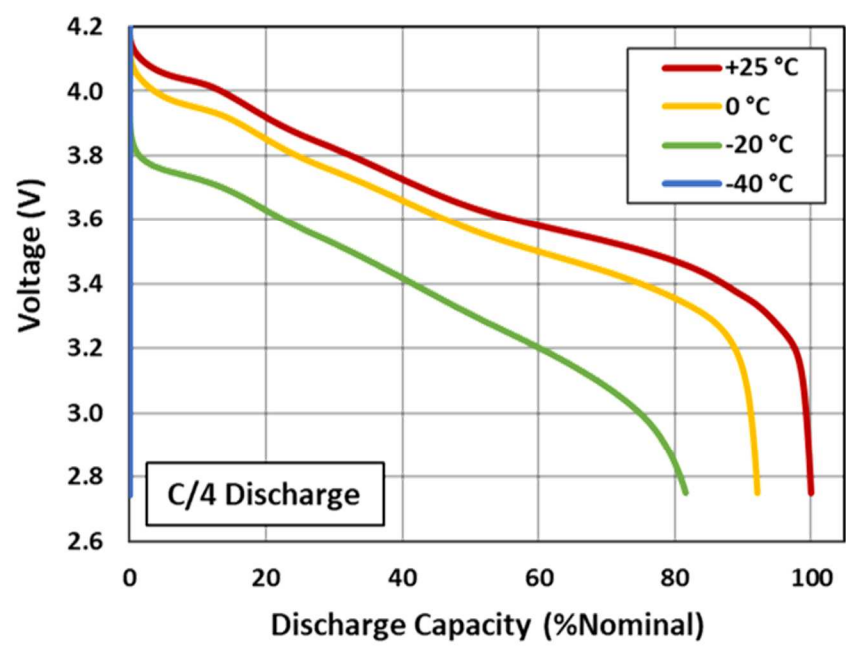


LiGas advantages

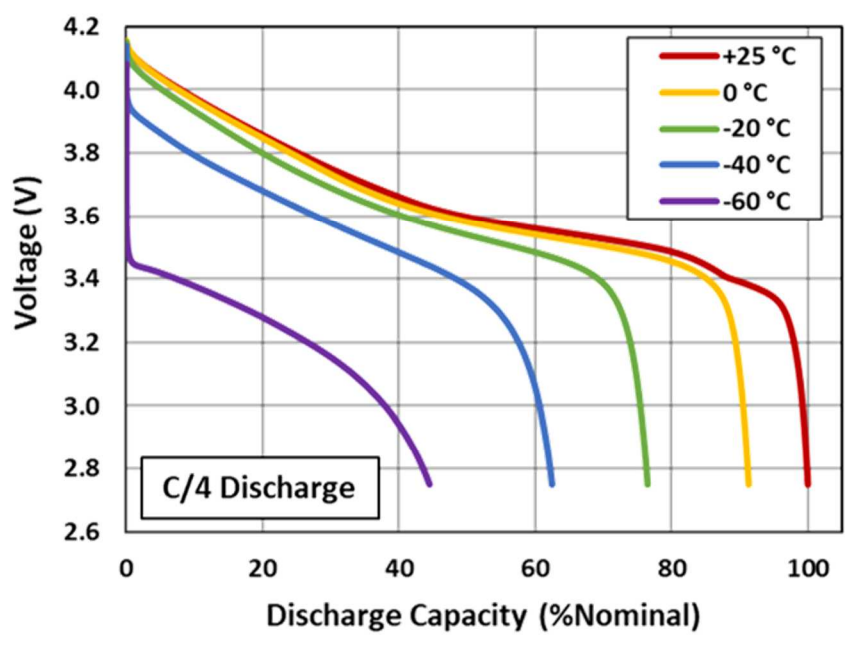


Industry leading low temperature performance

 **Wide temperature range**
-60 to +60 °C
Industry leading performance



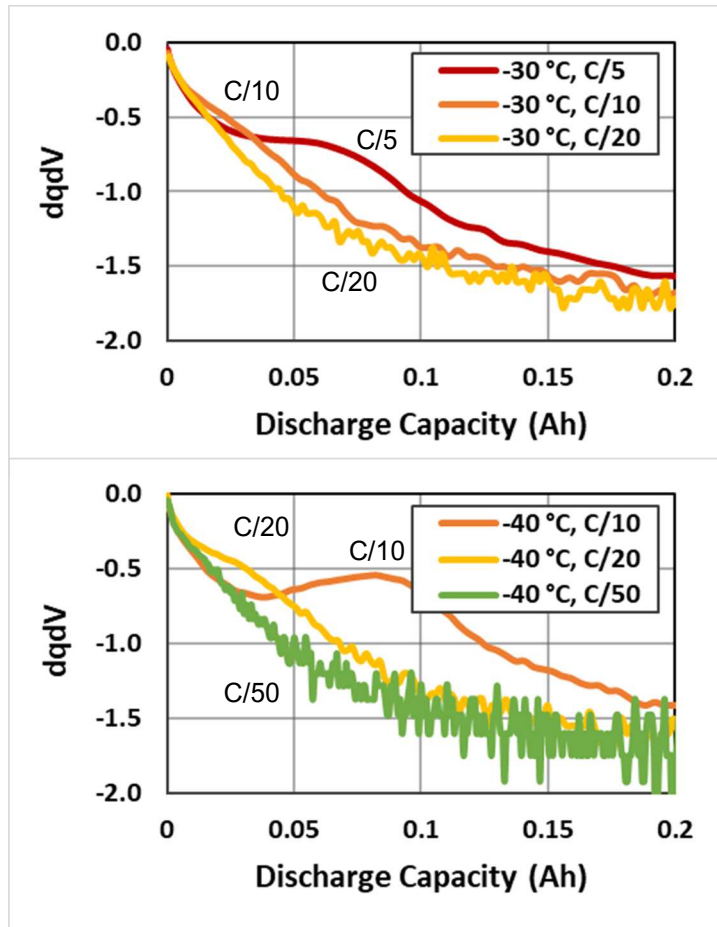
Liquid Electrolyte
2.85 Ah 18650 Cell



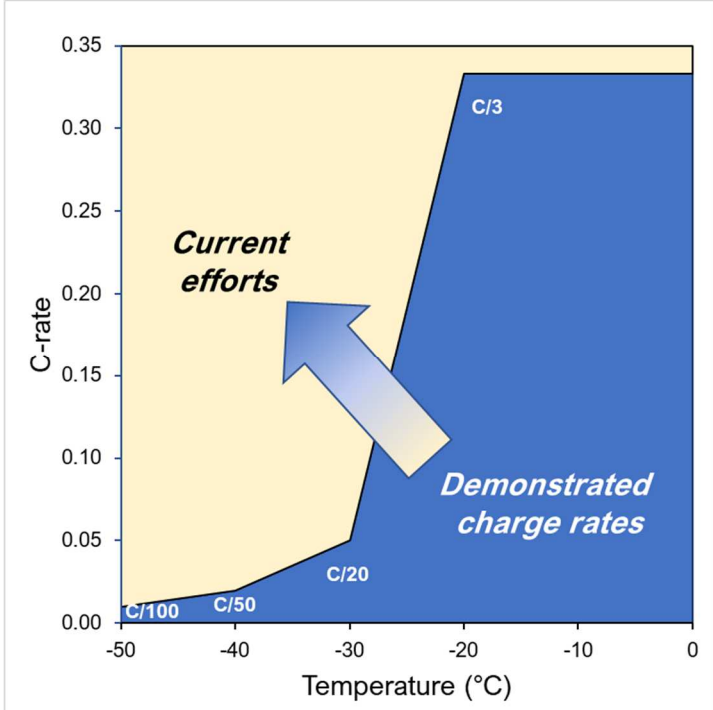
LiGas Electrolyte
2.85 Ah 18650 Cell

Low temperature charging

 **Wide temperature range**
-60 to +60 °C
Industry leading performance



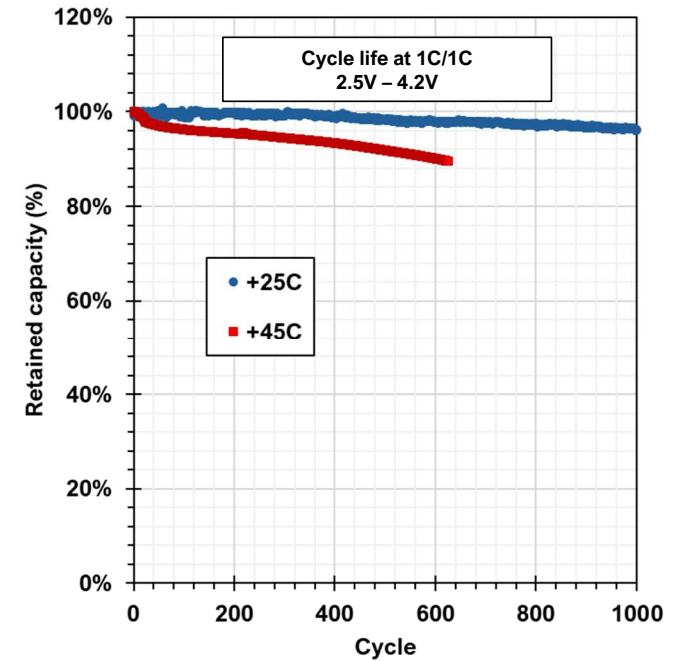
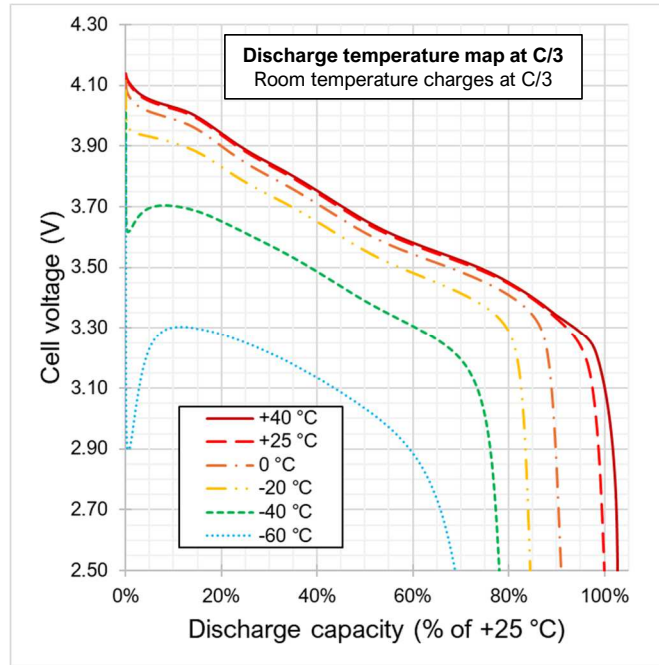
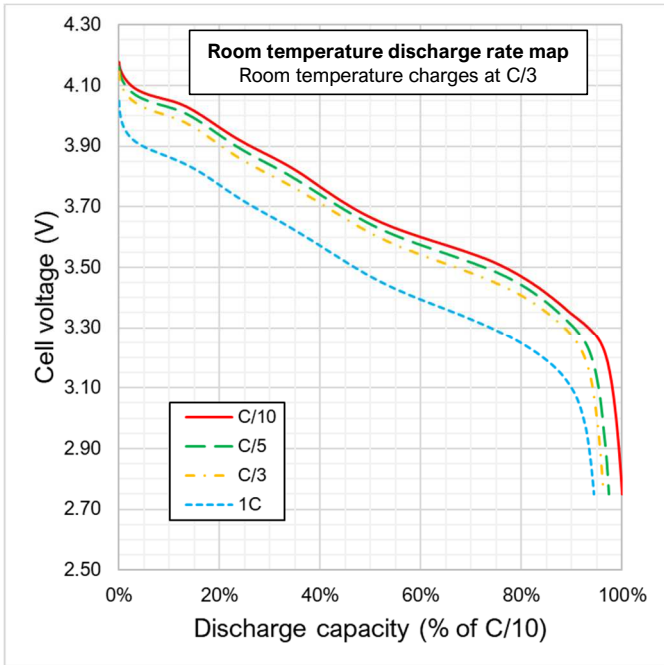
Demonstrated low-temperature charging without Li plating:



2.7Ah 18650, Graphite-NMC811

Excellent power, low/high temperature performance, high cycle life

Material compatibility
LiGas is compatible with common electrodes and separators

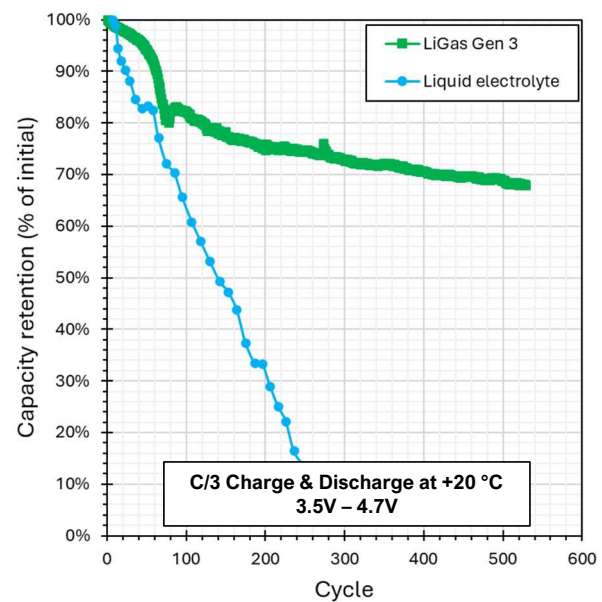
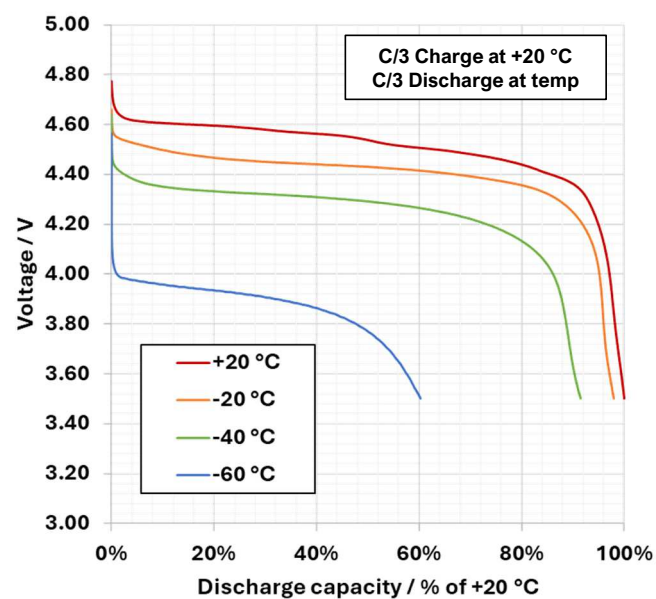
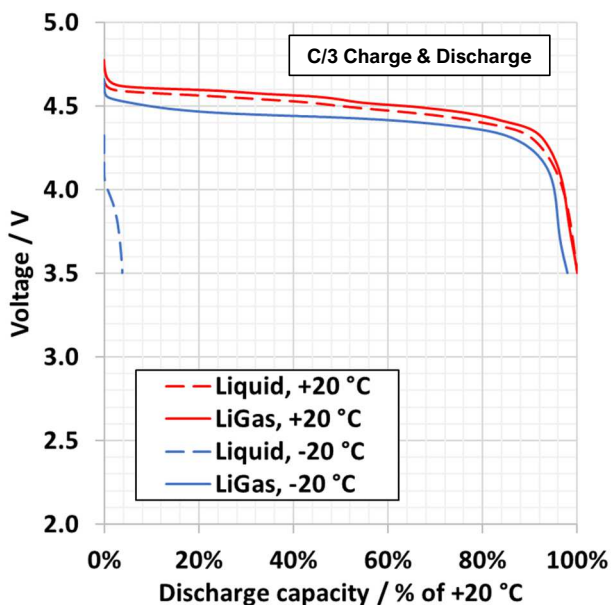


1.5Ah 18650 cells, Graphite/LNMO

Excellent low temperature performance.

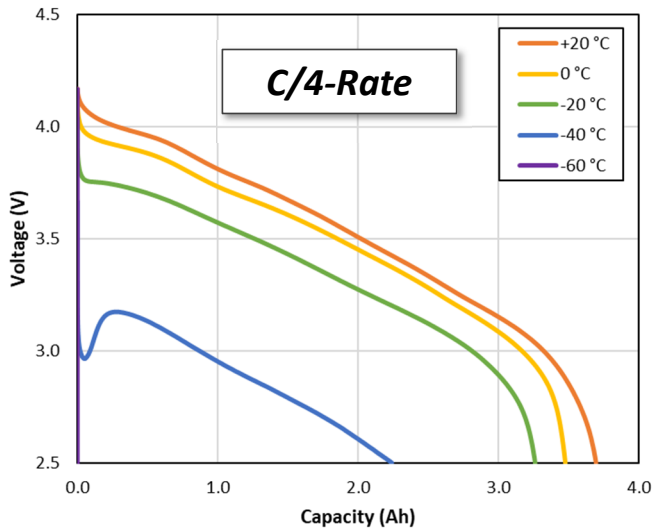
Superior cycle life to liquid electrolyte, further improvements pending.

Material compatibility
LiGas is compatible with common electrodes and separators

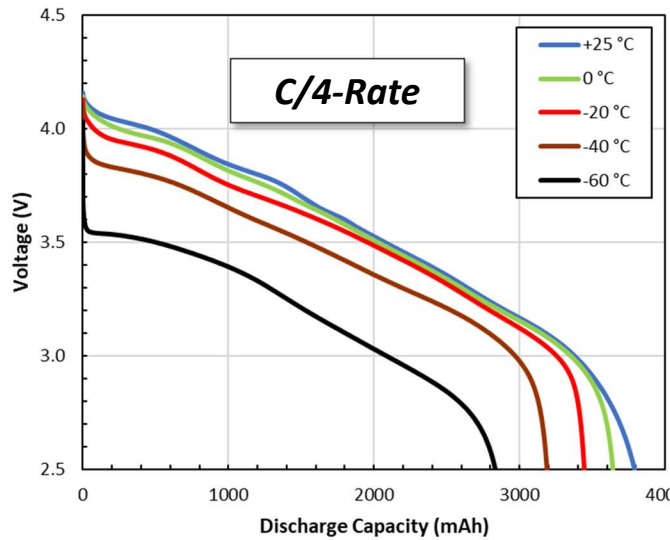


3.8Ah 18650 cells, Graphite+Si/NCA
Excellent power and temperature capability
Cycle life results pending

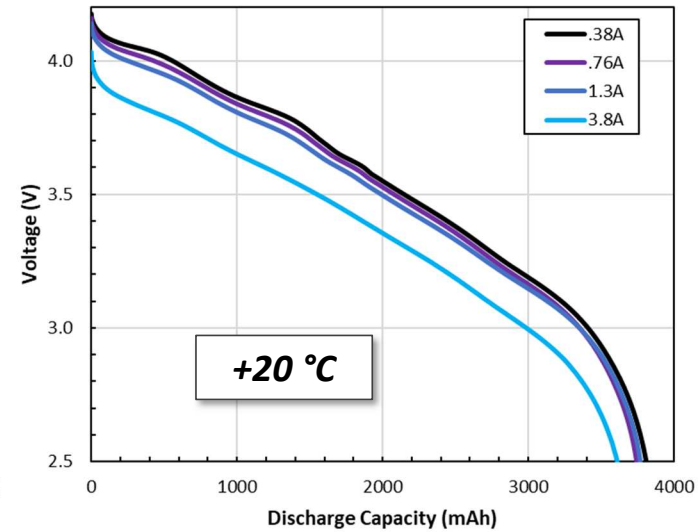
Material compatibility
 LiGas is compatible with common electrodes and separators

Liquid Electrolyte

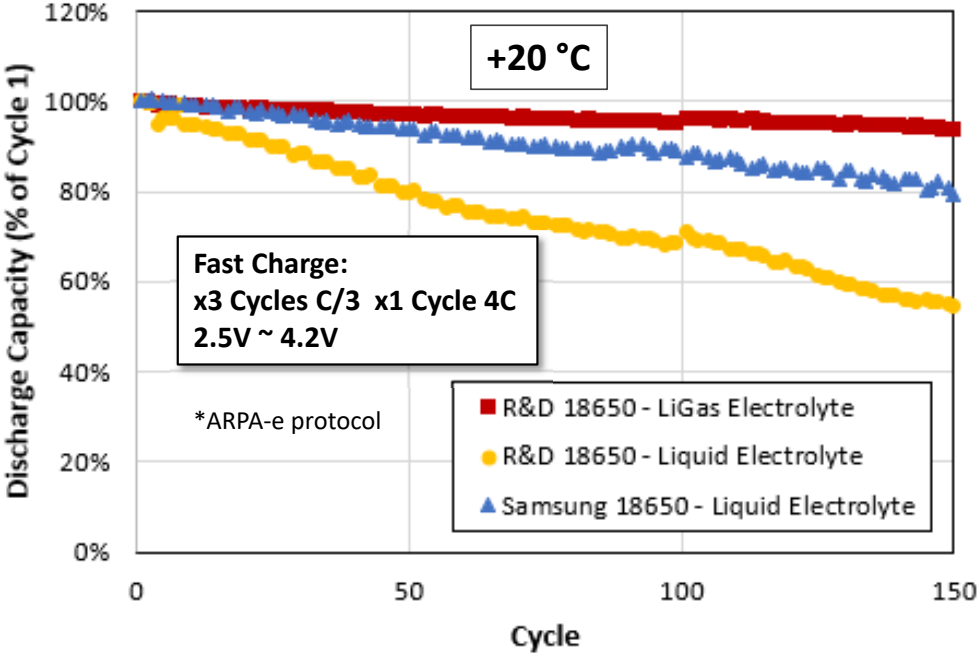
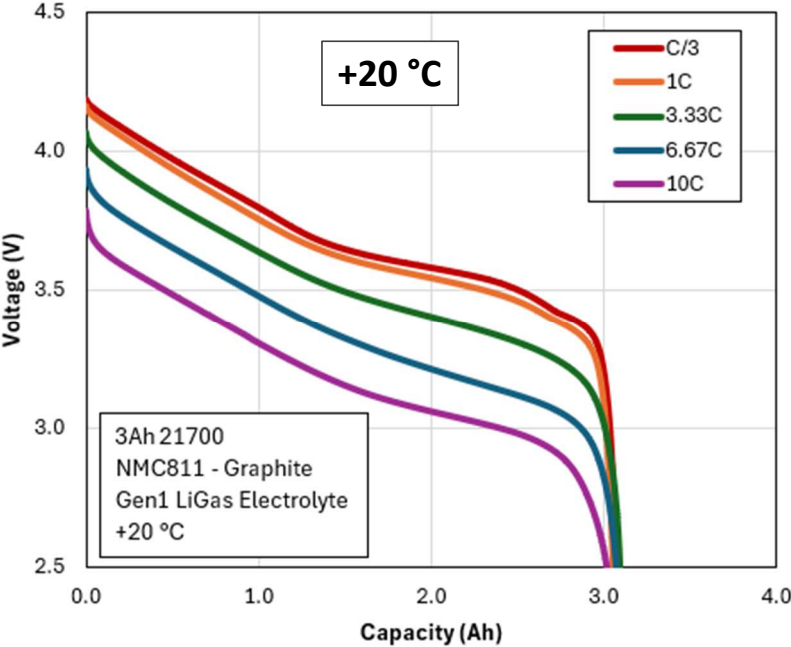


LiGas Electrolyte



High Power Capability & Superior Fast Charge Capability

Fast charge
 High electrolyte conductivity
 enables <15 min charging

Reduced thermal propagation risk

LiGas has a shorter burn, lower temperature and faster cooling.

(Silicon – NMC811, 3.8Ah 18650 cell at 100% SOC)

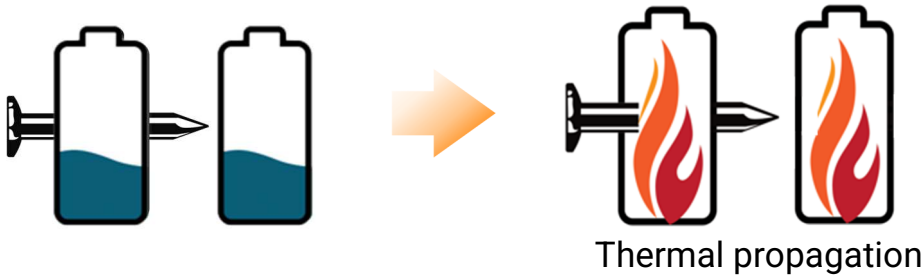
Reduced fire risk

LiGas minimizes potential for thermal propagation

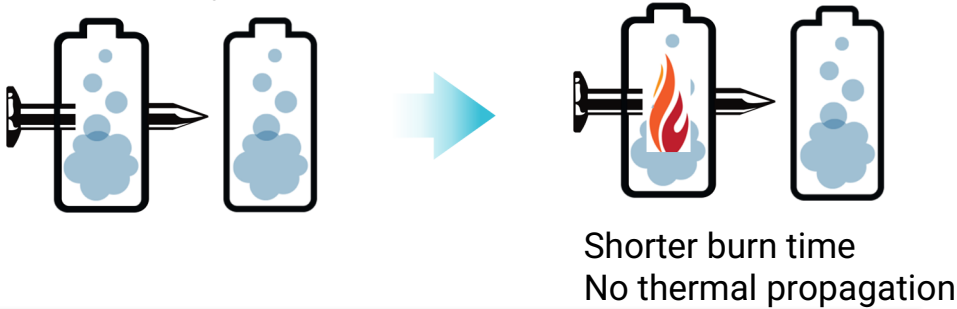


Bullet penetration test

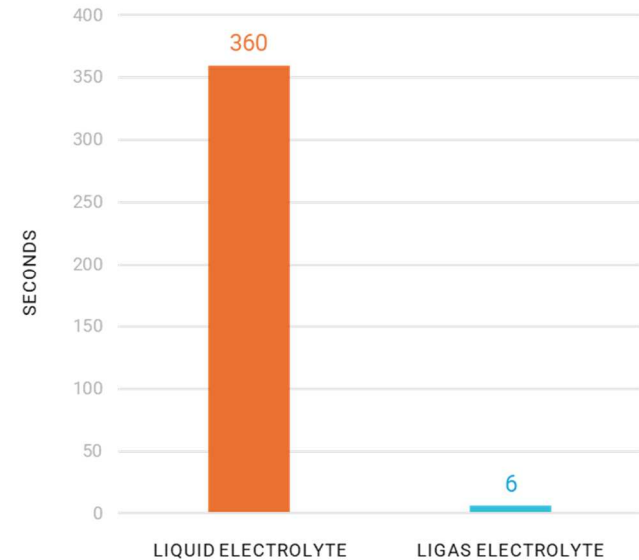
Liquid electrolyte



LiGas electrolyte



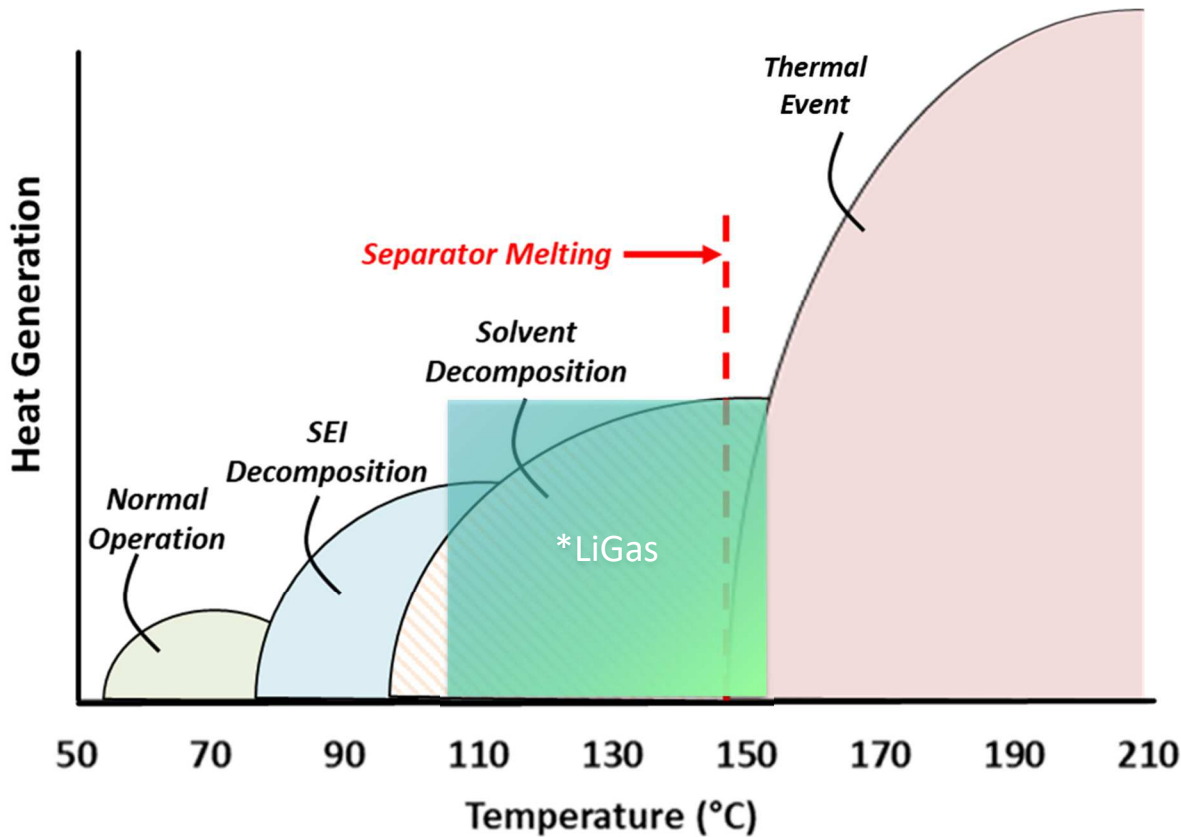
Burn time after bullet penetration



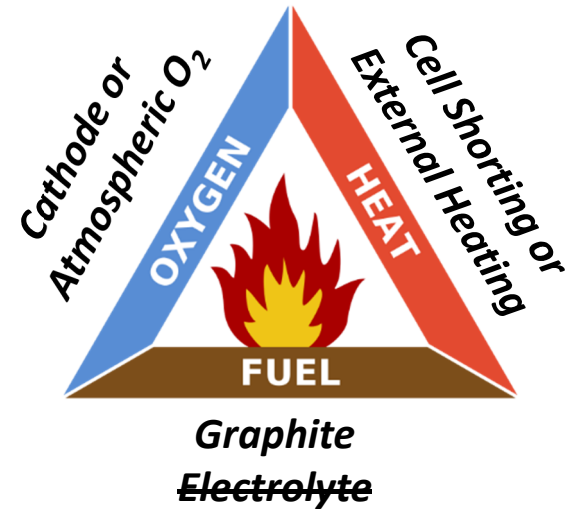
Venting Electrolyte Reduces Fuel

LiGas could potentially prevent cascading thermal events.

Reduced fire risk
 LiGas minimizes potential for thermal propagation

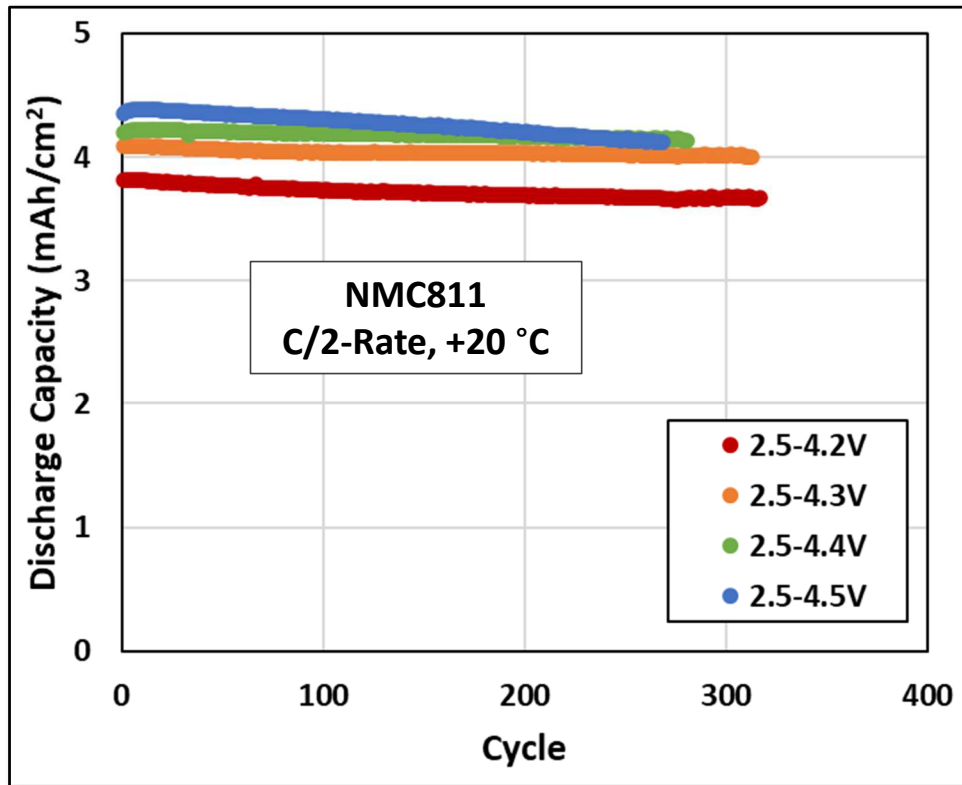
**As soon as the can is breached, LiGas immediately vaporize and vacate the cell and reduces fuel to burn.*



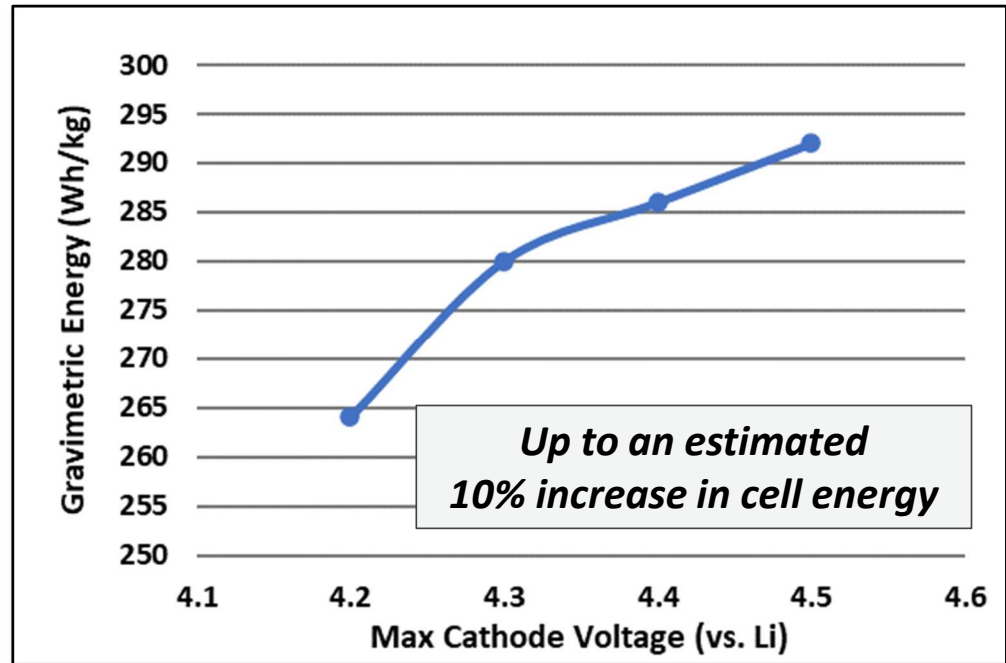
Less Fuel = Safer Cell

High Voltage - energy and cost improvements

 **Increased energy**
Silicon anodes, thicker electrodes,
higher voltage cells

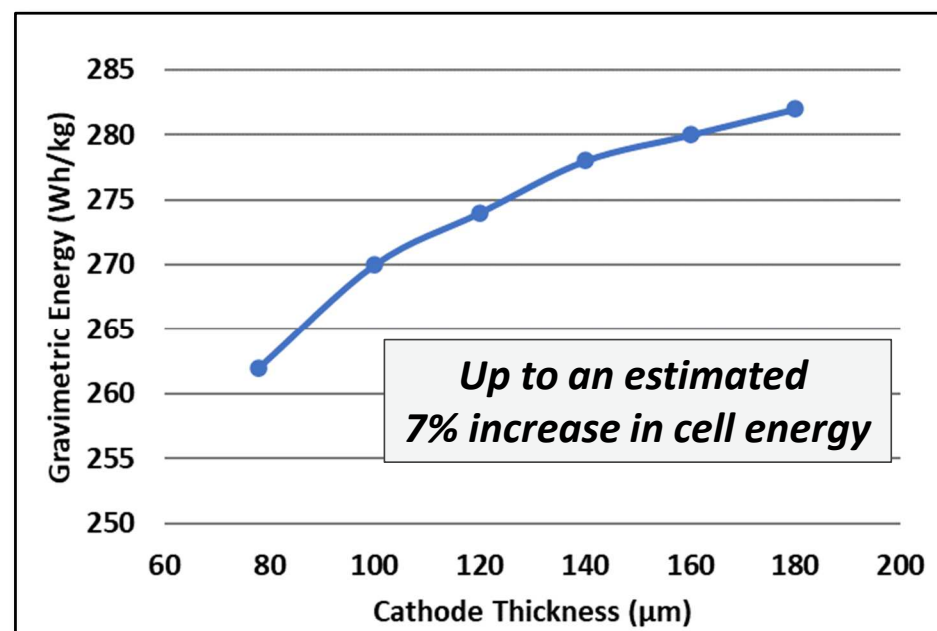
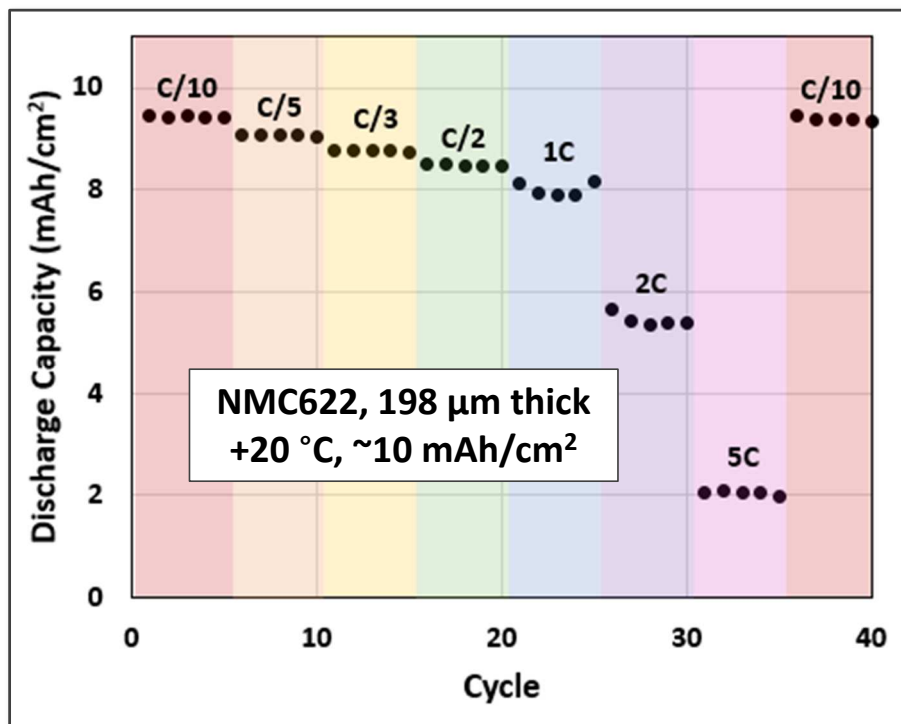


Significant \$/kWh Savings with High Voltage NMC

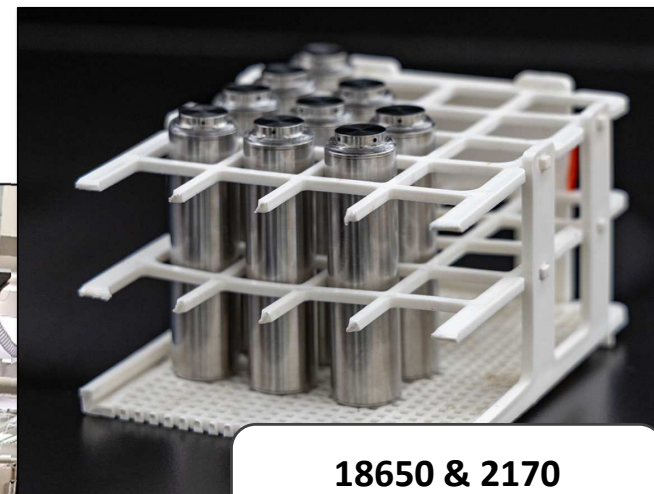
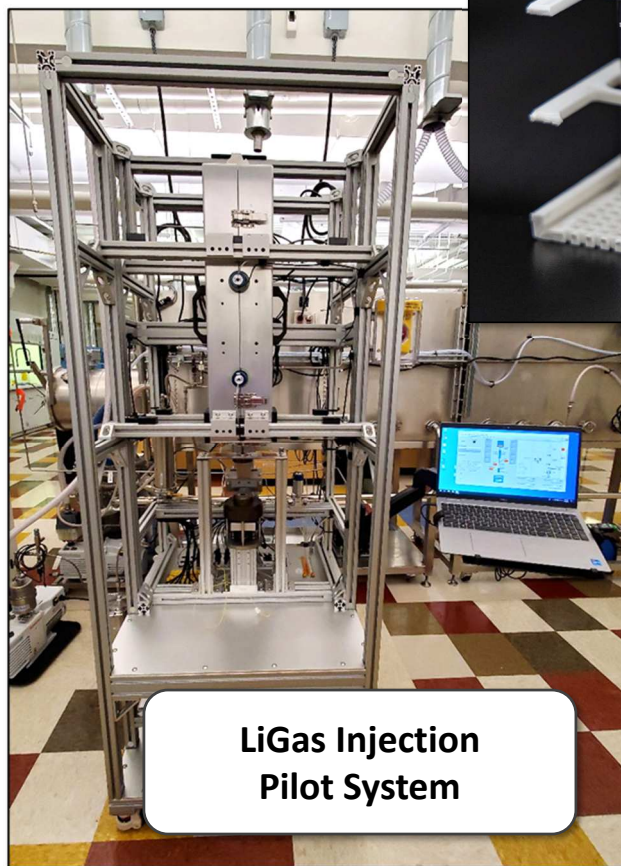


Energy and cost improvements – thick electrode

Increased energy
Silicon anodes, thicker electrodes,
higher voltage cells



South 8 pilot LiGas system



**18650 & 2170
Capability Today**



Thank you!

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