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Low-Cost, High Safety Fast Charge Automotive Cells

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Project ID#: BAT494

Overview

Timeline
- Project Start Date: Jan 2020
- Project End Date: Jan 2023
- Percent Complete: 35%

Budget
- TOTAL: 4.5M / 3 years
- FED: 2.25M

Barriers Addressed
- Li-ion Battery Cost
- Li-ion Battery Performance
- Li-ion Battery Sustainability

Collaborations
- USABC – Vijay Saharan
- Idaho National Laboratory

Relevance

Objective:
- Develop and integrate low cost, high performance materials for fast charge Li-ion batteries
- Prototype a Li-ion battery that is safe, costs 75 $/kWh at scale, and can be charged in 15-minutes

Potential Impact:
- Improve Li-ion battery sustainability by greatly reducing, or potentially eliminating, the use of cobalt in the cathode electrode
  - Lowers costs & addresses energy security questions regarding cobalt
- Improve the accessibility of electric vehicle ownership
  - Fast charge to address range concerns
  - Lower cost to make more affordable

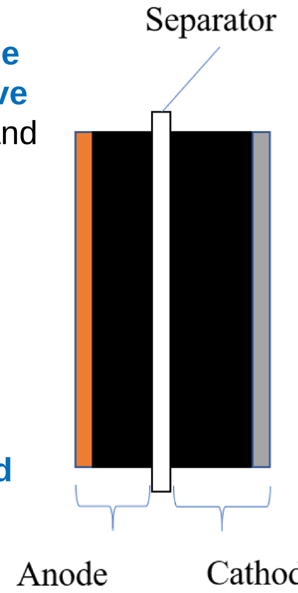
Timeline w/ Key Deliverables

	Status	2020 Q1	Q2	Q3	Q4	2021 Q1	Q2	Q3	Q4	2022 Q1	Q2	Q3	Q4	Q1
Task 1 - Low Co Cathode Development	Complete													
Task 2 - Scale-up Electrolyte Additive	Complete													
Task 3 - Pre-A Cell Studies	Cell Testing In Progress													
Deliverable: PreA cells to National Labs	Delivered 26 35Ah Cells													
Go/No-Go: Proceed to Sample A	Approved													
Task 4 - Impedance Reduction Technologies	In Progress													
Task 5 - LCFC 310 Wh/kg Cell "A Sample"	In Progress													
Mid-Review (End USABC BP6)	Not Started													
Deliverable 5A: A Sample Progress Report and Gap Analysis	Not Started													
Go/No-Go: Proceed to B Sample	Not Started													
Deliverable 5B: 15 Cells for Cycle Testing to National Lab	Not Started													
Task 6 - LCFC 310 Wh/kg Cell "B Sample"	Not Started													
Final Deliverable 6A: 45 Cells to National Lab	Not Started													
Final Deliverable 6B: Final Report Complete	Not Started													

Technical Approach

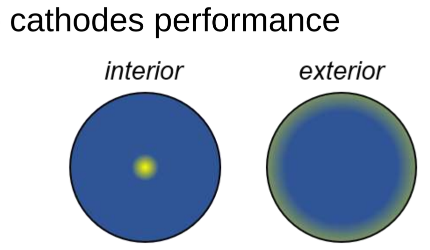
Low-Cost Process for Desirable Fast Charge Electrolyte Additive
- Avoid expensive purification and separation steps thru revised synthetic approach
- Additive effects SEI and CEI
- Combine additive into formulations to balance cost, performance and safety

Graphite / Si Based Alloy Blend
- Increase cell energy density
- Alters electrode thickness for fast charge improvements



Microvast's Aramid Separator
- Tailorable thickness and pore size

Low Cobalt (< 2wt%) Full Concentration Gradient (FCG)
- Lowers cathode cost (cobalt is most expense cathode atom)
- FCG concept allows cobalt to be targeted for maximum effectiveness to cathodes performance

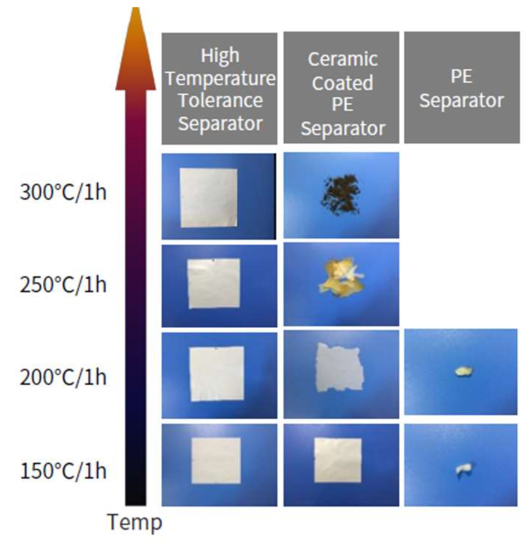


Example of targeting Co location in FCG particle

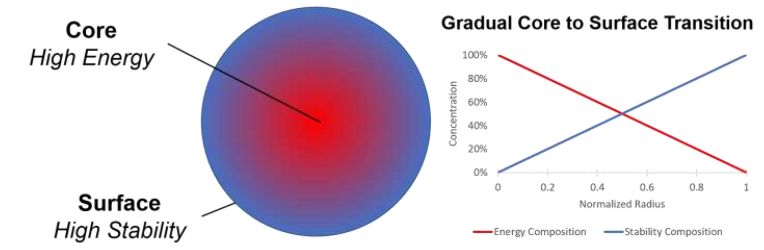
Impedance Reduction Technologies
- Electrode additives and active material coatings to lessen impedance of cell
- Low weight % minimizes impact to cell cost

Advanced Materials Improve Li-Ion Cell

Microvast Separator



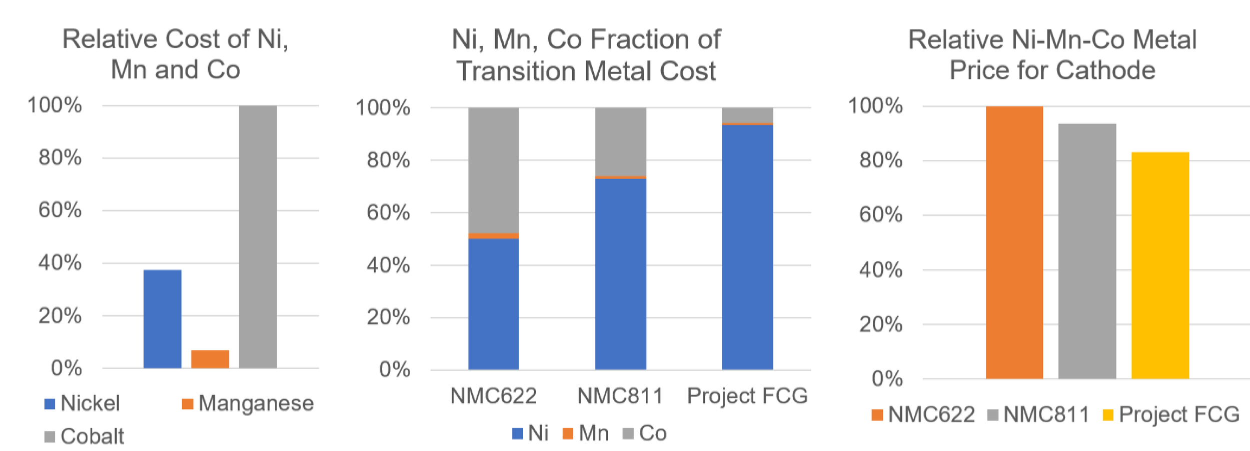
Full Concentration Gradient (FCG) Cathode



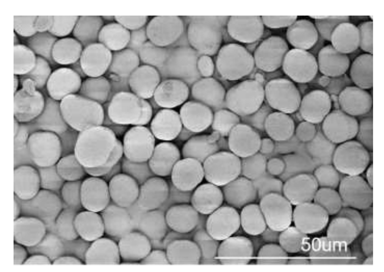
- FCG cathodes known to have delayed thermal decomposition temperatures, delaying exothermic heat release from material decomposition [1]
- Separator keeps structure beyond the temperature when a charged cathode decomposes / de-energizes

Technical Progress

Low Co Cathode Development

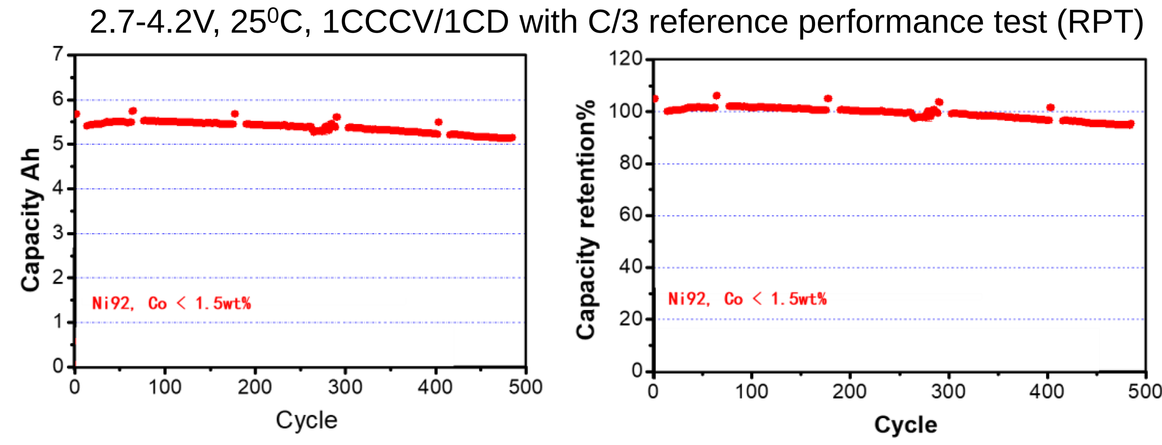


- Reduced cobalt content in cathode to < 2 wt.%
- Lowering cobalt reduces cathode Ni, Mn, Co metal cost ~10%



Technical Accomplishment:
- Successfully prepared 2+ kg of low Co cathode complete
- High capacity of developed low Co FCG provides high energy, resulting in lower $/kWh for cell

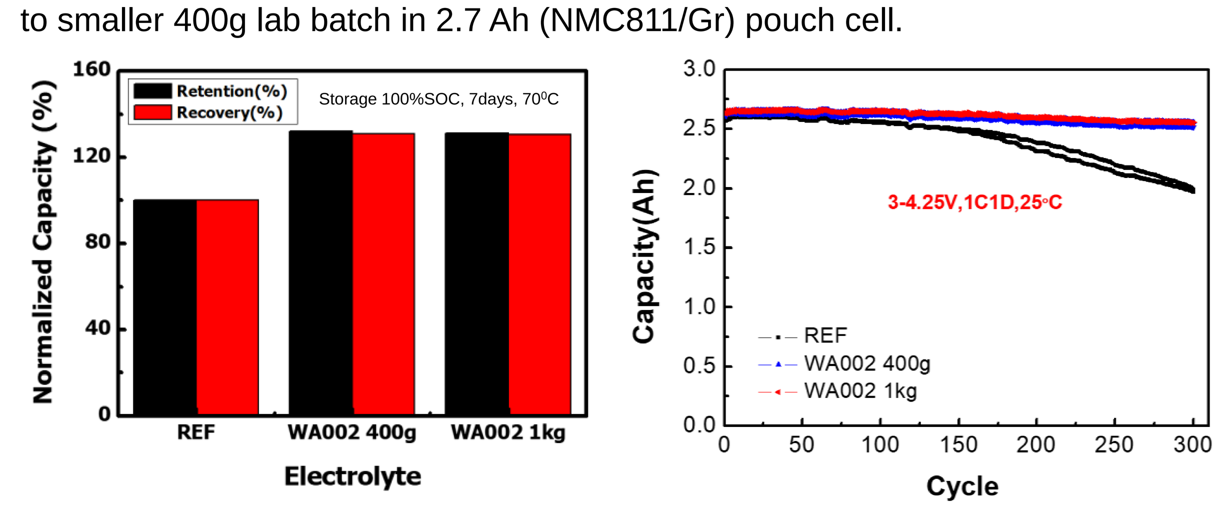
2.7-4.2V, 25⁰C, 1CCCV/1CD with C/3 reference performance test (RPT)



>95% capacity retention thru 500 cycles in pouch cell low Co FCG trail

Electrolyte Additive Scale-Up

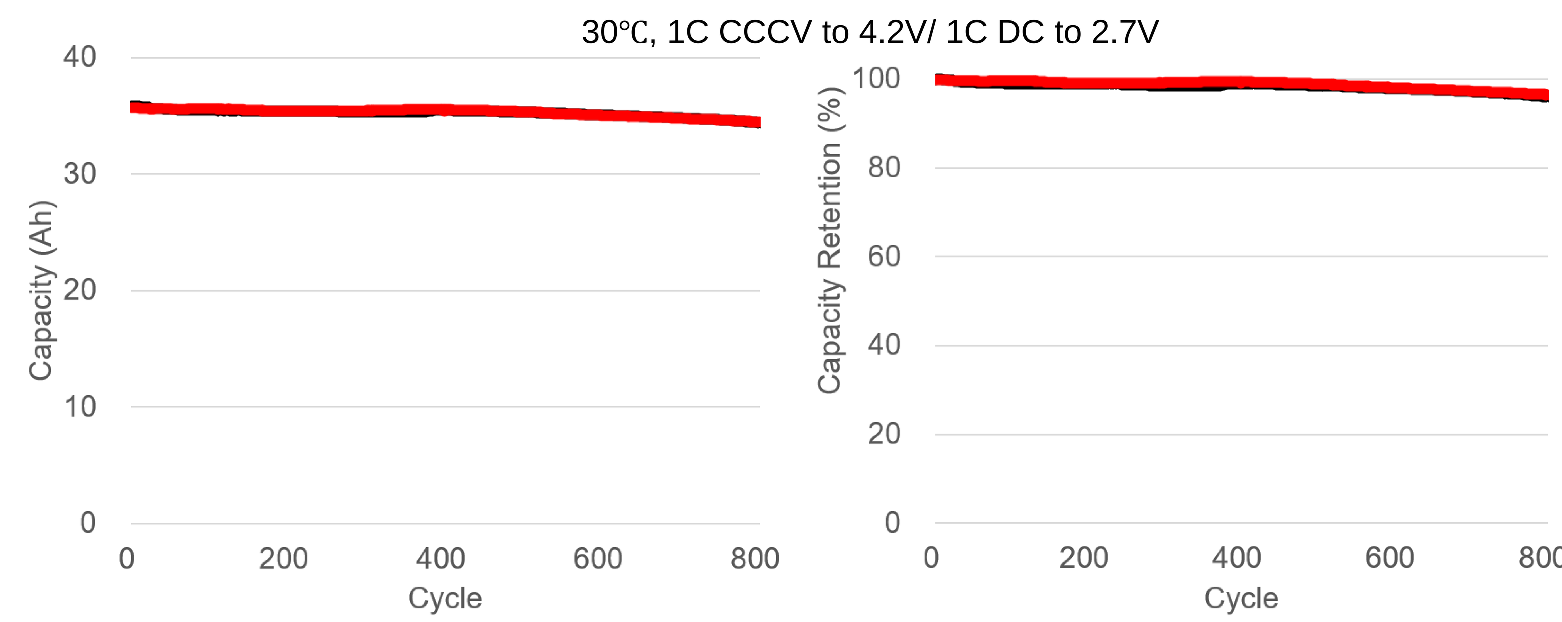
Technical Accomplishment:
Synthesize >1kg of targeted electrolyte additive (WA002) and verified performance to smaller 400g lab batch in 2.7 Ah (NMC811/Gr) pouch cell.



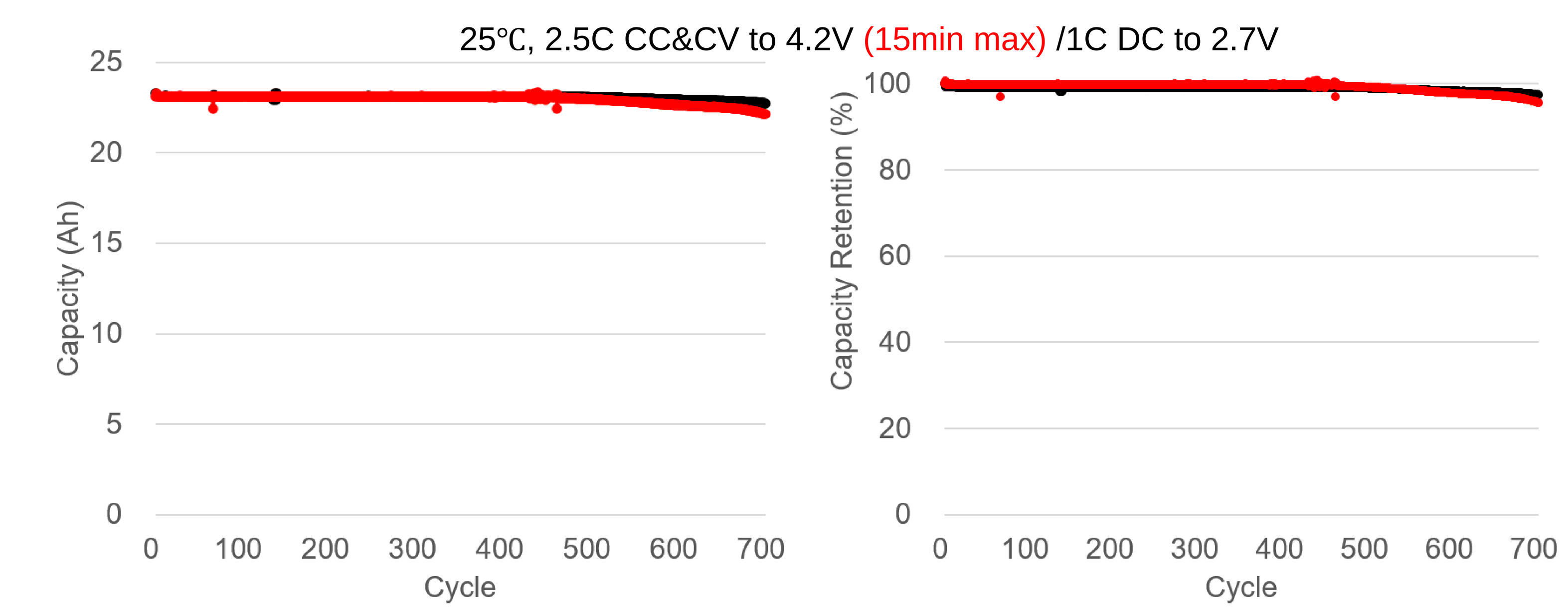
Year 1 Deliverable Cell

Criteria To Meet (Deliverable 1 Go/No-Go)	
Energy density	260 Wh/kg (BOL)
Cycle life (1C, 30⁰C)	>800 cycles
Self-Discharge	<2%
Fast Charge (15 min, Δ60% SOC)	>300 cycles

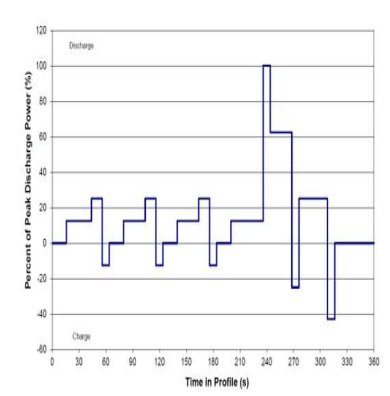
Twenty-six 260 Wh/kg pouch cells were delivered to Idaho National Laboratory for independent testing in Feb. 2021



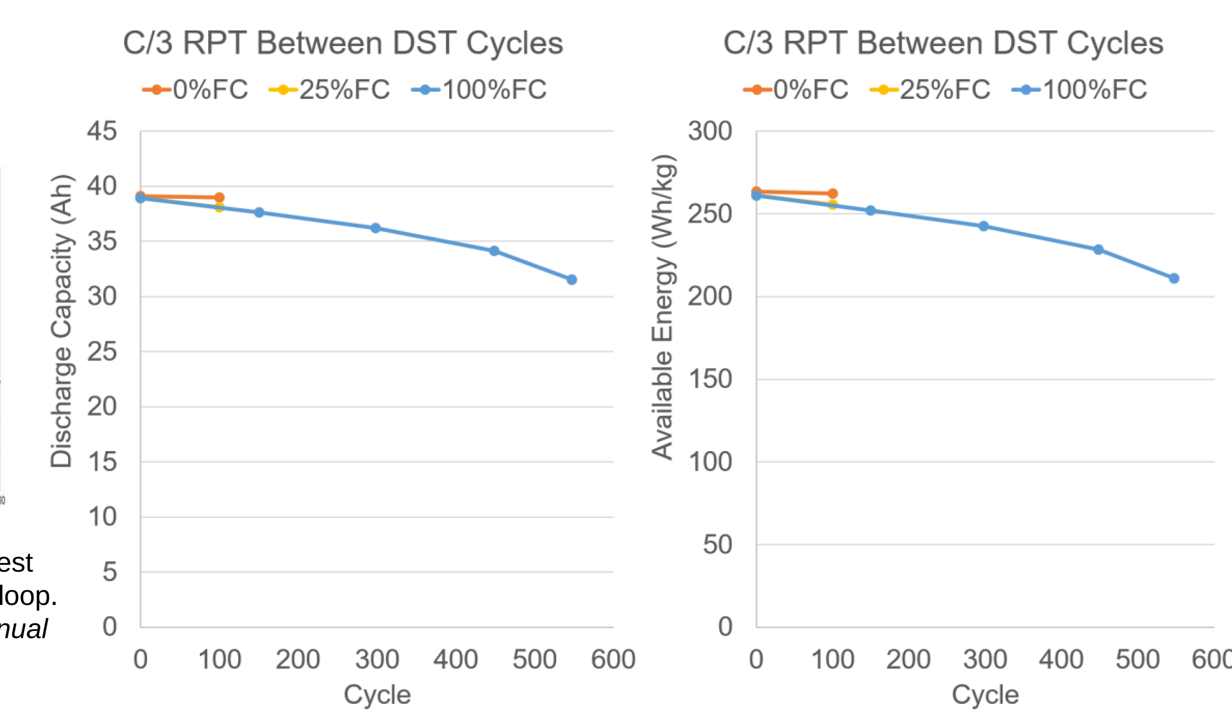
After 800 1CCCV/1CD cycles the 260 Wh/kg pouch cells have > 95% capacity retention



At 2.5C (15-min max) charge the 260 Wh/kg pouch cells both completed 700 cycles with > 60%SOC



Example of dynamic stress test (DST) discharge drive cycle loop. *From USABC Rev3 Test Manual*



100% fast charge (FC) in under 15-minutes has demonstrated over 500 cycles. 25% and 0%FC testing in progress

Prior Reviewer Comments

- This is first year project is reviewed

[1] Nature Materials 11 (2012), 942-947

Collaboration and Coordination

USABC – A project manager receives and provides monthly feedback. Every quarter USABC workgroup comprising GM, Ford, FCA, INL, and DOE representatives is updated on progress and provides feedback and recommendations on projects direction.

Idaho National Laboratory – Testing institution for project deliverable cells. Has provided valuable training and review on correct implementation of USABC testing protocols.

Remaining Challenges & Barriers

Improve Cell Energy Density: The electrode capacity must increase for the anode and/or cathode, and/or the cells first cycle efficiency must be improved.
Improve Cell Fast Charge ΔSOC: Need to increase 15-minute storage capacity further. Minimizing electrical, kinetic, and diffusion-based voltage losses is critical to facilitate fast charge in high energy Li-ion cells.
Lower Cell Cost: The developed electrolyte additive and low cobalt cathode from year 1 need to be integrated into the high energy fast charge cell.

Proposed Future Work

For FY2022
- Iterate cell design using Gr/silicon alloy-based anode and FCG cathode to achieve >300 Wh/kg
  - The low cobalt cathode developed in year 1 will help reduce the cells material cost
- Once energy density is reached, study the use of electrode modifiers to improve the ΔSOC during a 15-minute fast charge. Electrode modifiers that boost the conductivity of the electrode or of particular interest.
- Further develop the electrolyte formulation that incorporates the lower cost electrolyte additive worked on in year 1

Any proposed future work is subject to change based on funding levels

Summary

- Over 500 cycles have been demonstrated when doing 100%DST fast charge cycles
- Low-cost cathode and electrolyte additive have been prepared for integration in into low cost, fast charge cell development in year 2.

End of Life Characteristics @ 30⁰C	Units	Program Goals	After Year 1
Peak Discharge Power Density, 30s Pulse	W/L	1400	1400
Peak Specific Discharge Power, 30s Pulse	W/kg	700	700
Peak Specific Regen Power, 10s Pulse	W/kg	300	300
Available Energy Density @ C/3 Discharge Rate	Wh/L	>500	>530 (BOL)
Available Specific Energy @ C/3 Discharge Rate	Wh/kg	>240	>260 (BOL)
Calendar Life	Years	10	TBD
Cost	$/kWh	75	Est. <105
Operating Environment	⁰C	-20 to +45	-20 to +45
Fast High Rate Charge	Minutes	70% SOC, 15 minutes	60%SOC, 15 minutes
Minimum Operating Voltage	V	>0.55 Vmax	> 0.55Vmax
Unassisted Operating at Low Temperature	%	>70% Useable Energy @ C/3 discharge rate – 20⁰C	>78% Useable Energy @ C/3 discharge rate, -20⁰C
Survival Temperature Range, 24hr	⁰C	-40 to +66	TBD
Maximum Self-discharge	%/month	< 1	<1