Energy Storage

Kev Adjemian, INL

April 21, 2016

Energy Storage: Three-Prong Approach to meet Cost Targets

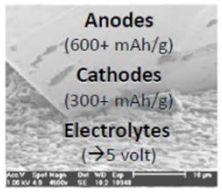
VTO Battery R&D Activities and Target Metrics

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Advanced Battery Materials Research
- ✓ New materials discovery
- ✓ Structure –activity exploration at materials level

Applied Battery Research
- ✓ Cell chemistry optimization
- ✓ Advanced processing technologies
- ✓ Life Improvement

Advanced Battery Development
- ✓ Performance Optimization
- ✓ Cost Reduction



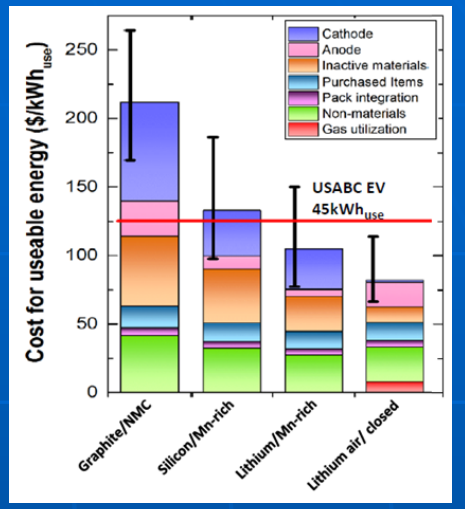
Cell Targets
350 Wh/kg
750 Wh/l
1,000 C/3 cycles

Pack Targets
$125/kWh
250 Wh/kg ; 400 Wh/l
2,000 W/kg

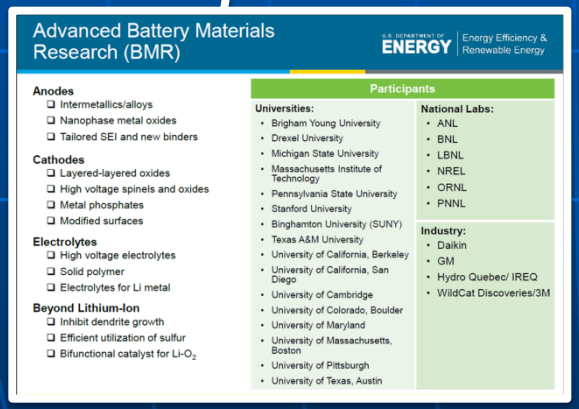
materials characterization
in operando spectrocopy
½ cell data
10 - 100 mAh full cells

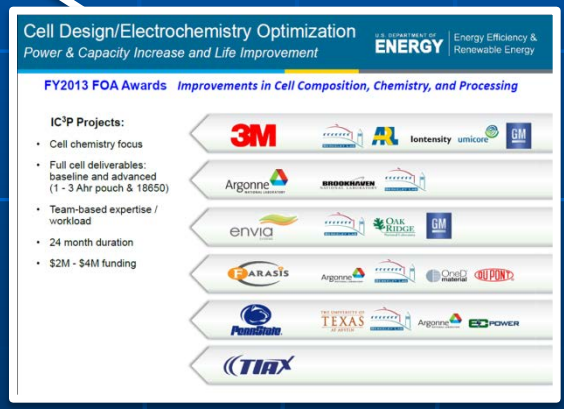
component characterization
processing R&D
½ cell data
0.5 - 1.0 Ah full cells

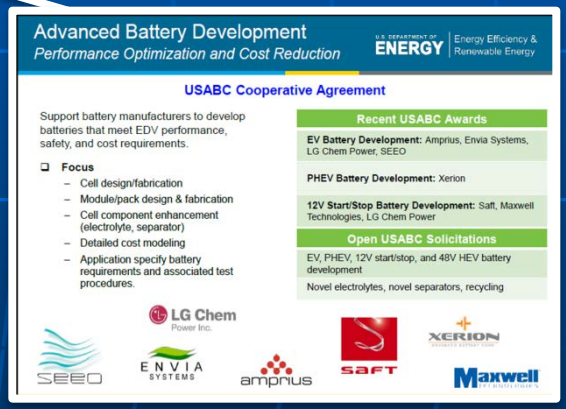
5 - 40+ Ah full cells
performance testing
modules
packs



Cost
Targets, Projections, Chemistries







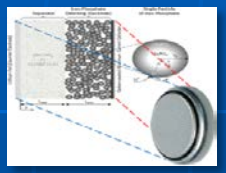
Presented by Peter Faguy at 2015 DOE-EERE-VTO Annual Merit Review

Testing and Analysis at Scale for Deeper Insight

Correlating the lab data to data collected in the field for "real-world" validation

Vehicle

Pack



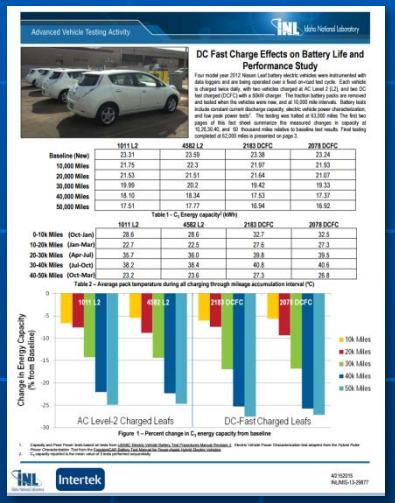
Half-Cell / Coin

Pouch / Cell

Understanding basic performance and durability characteristics in state of the art laboratories

Performance Science: Testing and Analysis @ Scale

- Independent testing and validation of various energy storage devices
- Systems analysis from half-cell to vehicle and back – connecting the lab to the real-world
- Durability, Performance and Lifetime Modeling



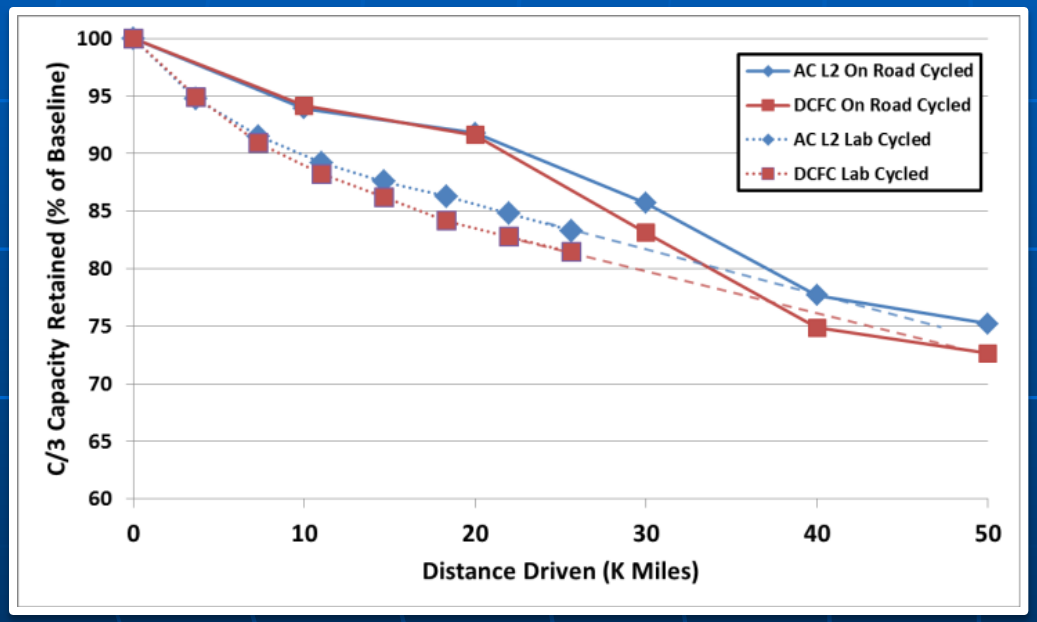
Improving performance and durability of energy storage devices while reducing cost and complexity

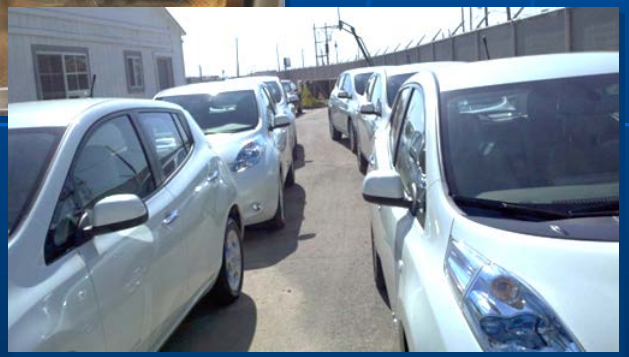
Battery Degradation Testing and Analysis

Pre-conceived notions that DC Fast Charging (480V) would be extremely detrimental for battery durability relative to Level II (240V)

After 50,000 miles (80,000 km):

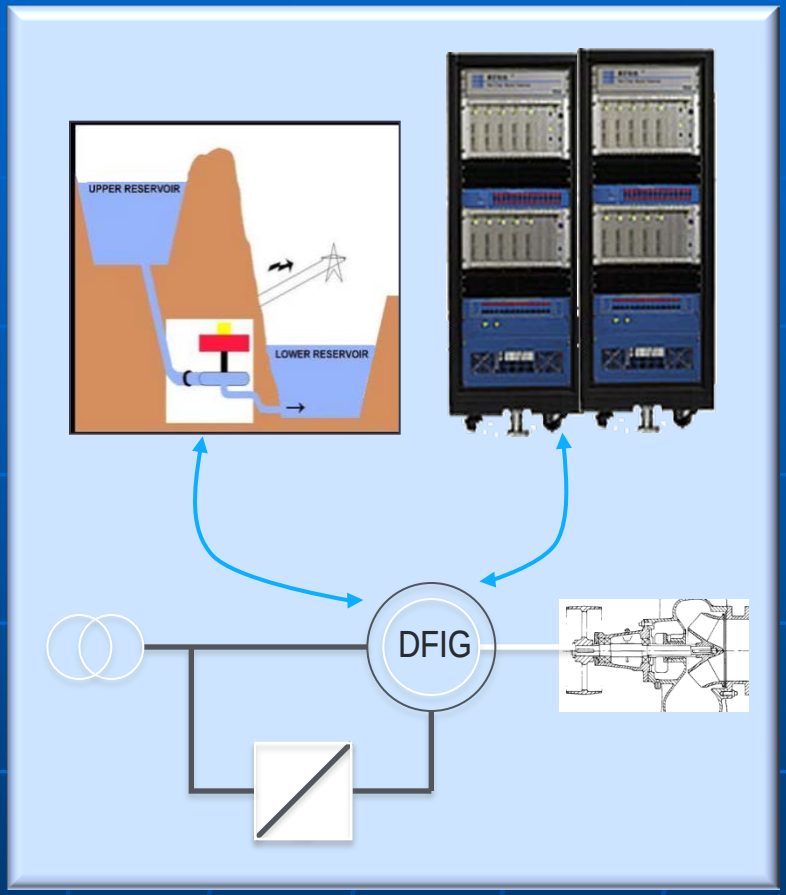
- ✓ No appreciable difference in capacity loss (~2%) between Level II and DC Fast Charging
- ✓ On-Road cycled packs subjected to varying temperatures each period
- ✓ In-lab cycled packs cycled in constant ambient temp (30°C)
- ✓ Capacity loss rate approaches steady state in constant temperature testing





Adjustable Speed Pumped Storage Hydropower (A-PSH) Transient Simulation Modeling

- Develop transient A-PSH models in small time steps (5 - 50 ms) to better understand the dynamic interactions between electromagnetics and hydrodynamics
- Study the hydrodynamic behaviors such as water hammering and flywheel effects due to sudden load and fault conditions
- Conduct System level testing and analysis on the Real Time Digital Simulator
- Provide a greater understanding of variable renewable interactions and the value of energy storage



Co-simulation of the electromagnetic & hydrodynamic transients

Clean Energy and Advanced Transportation

Leveraging Advancing Technologies

- **Holistic approach to develop next generation Advanced Transportation technologies to integrate and flow with next generation Power & Energy Systems**