Advanced Management and Protection of Energy storage Devices (AMPED)
Annual Meeting 2015

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Focused Programs

- Transportation Energy Technologies
  - AMPED
  - HEATS
  - REACT
  - SBIR/STTR

- Stationary Energy Technologies
  - METALS
  - SWITCHES

- Remote Range MOVE
  - PETRO
  - Electrofuels
  - RANGE
  - REMOTE

- ADEPT
  - Solar

- GRIDS
  - IMPACCT
  - BEETIT
  - GENI
  - FOCUS
BMS: Not a lot of info, but a lot to worry about

Given I,V,T, (and t), you must protect against:

- Circuit faults
- Electrolyte oxidation
- Electrolyte reduction
- Dendrite growth
- Cracking
- Graphite exfoliation
- Changes in porosity
- Solvent co-intercalation
- Lithium plating (Dendrites)
- Internal cell defects
- Current collector corrosion
- Overcharge
- Over discharge
- Voltage imbalance
- Separator shutdown
- Current-collector dissolution
- Gas evolution
- Binder decomposition
- Thermal runaway
- SEI dissolution
- Lithium loss
- Active material islanding
- Solid phase transformations/disordering
- Power fade
- Spurious corrosive side reactions

(Note: partial list)
AMPED: Achieving more with today’s battery chemistries

AMPED Objectives:

- Safety & Reliability
- Performance
- Prognostics

Areas of interest:

1. Online sensing
2. Characterization for fast monitoring and prediction
3. Active cell control
4. Integration of dissimilar devices
5. New control capabilities
AMPED Portfolio

1. Direct Sensing
   - Internal cell temperature
   - Intercalation strain
   - Optical sensing
   - Gas signatures

2. Modeling & controls
   - Real-time physical state estimation
   - Adaptive degradation models

3. Flexible Power Systems
   - Cost effective cell-level power management
   - Flexible power architectures
   - Wireless communications
   - Intra-cell thermal management

4. Diagnostics & prognostics
   - High-precision columbic efficiency
   - Real-time load prediction
Staying connected w/o accruing mass

Increasing the number of sensors yields critical information

- System cost: standard solutions incur complexity, weight, expense, and safety penalties

AMPED teams have devised multiple paths to increasing pack information while minimizing penalties
AMPED: Increasing real-time pack information

Wireless Communication

Power Line Communication

Optical Communication

Modeled Observer
Valuing certainty of state information

The identified value of enhanced system awareness:

- Increased capacity utilization
- Ability to right size
- **End-of-Life prediction**

Both downsizing potential and utilization are application dependent.

Better **EOL prediction** impacts all use scenarios:

- Product lifecycle expense
- Warranty and Insurance
- System integration expenses
AMPED: Design and control for lifetime

Real-Time Battery Utilization

Model Defined Operation

Detection of Operational Hazards

Enabling optimal use of energy storage assets from design to end of life.
Back to the FOA for a bit…

“The ease with which the proposed solution, if successful, may be adapted to provide benefits to other state-of-the-art or advanced battery systems and chemistries.”

‣ No AMPED solution is cell specific, but every AMPED solution requires knowledge of the cell.

‣ Challenge: How can we expedite the process?

Can we get from an “unknown” cell to an integrated system in a rapid and routine manner?
AMPED: Expediting cell characterization

High Precision Measurements

Differential Diagnostics
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Next steps for AMPED

- Teams entering validation testing in Year 3 of program. Questions to be answered:
  - What is limit of pack downsize for xEV?
  - How far can we push fast charge capabilities?
  - How much can sophisticated models and new control parameters improve the operation and SOX estimates?
What challenges face today’s battery systems:

1. System Cost,
2. SOH/Life time expectations,
3. SOC/Utilization,
4. Safety/Reliability,
5. Power availability
# AMPED Annual Meeting Day #1

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<thead>
<tr>
<th>Time</th>
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| 11:00-1:00 | Registration  
**Poster Set-up Will Take Place in 4th Floor Prefunction Area** | 4th Floor Prefunction Area  |
| 1:00-1:30 | Welcome and Introduction  
Patrick McGrath, ARPA-E, AMPED Program Director  
Eric Rohlfing, ARPA-E, Deputy Director of Technology | Gold Coast Ballroom          |
| 1:30-2:00 | DoD Challenges in BMS and a Update of HESM Program  
Don Hoffman, ONR  
John Heinzel, NAVSEA  
Ed House, NAVSEA  
Jack Taylor Mitre/OSD  
Sean McNeal, AFRL  
Andrew Corbishdale, OASD(R&E) | Gold Coast Ballroom          |
| 2:00-2:30 | Electrochemical energy storage research at Argonne and highlight of potential BMS challenges originating from advanced materials  
Kevin Gallagher, Argonne National Lab | Gold Coast Ballroom          |
| 2:30-3:00 | Battery Management System Benchmark and Standardization  
Robert Ratz, Ricardo Inc. | Gold Coast Ballroom          |
| 3:00-5:30 | Poster Session/Networking Session | 4th Floor Prefunction Area  |