A123 Systems’ Energy Storage Projects & Applications Overview

California Energy Commission, Lead Commissioner Workshop on Renewable Integration Costs, Requirements, and Technologies

June 11, 2012
Storage for Renewable Integration

- Technology is not a barrier
  - Track record of using storage for grid benefit, 20,000 MW of P.S.
  - Unique attributes of new *Fast, Modular, Flexible, and Accurate Advanced* Energy Storage introduce new solution options and value-add opportunities

- Cost is not a barrier
  - But, does limit opportunities right now

- Regulatory Rules for Storage, needs work
  - G or T or D - who invests and mechanisms for investment recovery?
  - Operating experience will support policy effort focus & investment
  - Modeling in CAISO and CA IOU and Muni utility transmission and resource planning studies will expand consideration and incorporation of effective storage alternatives
    - Load Flow and Dynamic Stability
    - Production Simulation
>90 MW of A123 Advanced Battery Systems Performing Grid Applications

Completed installations:
- Nov 2008 – 2MVA/500kWh, California (to PJM ‘12)
- Nov 2009 – 12MVA/4MWh, Atacama, Chile
- Oct 2010 – 400kVA/100kWh, Denmark
- Jan 2011 – 20MVA/5MWh, New York
- Sep 2011 – 32MVA/8MWh, W. VA/PJM
- Oct 2011 – 4MVA/1MWh, California
- Nov 2011 – 20MVA/5MWh at Angamos, Chile

A/S, and release generation for energy
Frequency Regulation
Frequency Regulation
A/S, and Renewable Integration
Smart Grid Resource (Multi-T&D Services)
A/S, and release generation for energy

Under construction:
- Aug 2012 – 500kVA/125kWh, China
- Jun 2012 – 2MVA/500kWh, Massachusetts
- Aug 2012 – 8MVA/32MWh, Tehachapi California
- Sep 2012 – 500kVA/250kWh, Detroit
- Oct 2012 – 11MW/4.4MWh Maui
- Nov 2012 – 1MVA/3MWh, Europe
- Dec 2012 – 1MVA/1MWh, Maui
- Dec 2012 – (1) 5MWh & (5) 100KWh systems, U.K.

Renewable Integration Demo
Frequency Regulation
Grid-Side Wind Integration Demo
PV Integration Demo
Wind Ramp Rate Control
T&D Support, Load Shifting & Voltage Reg.
T&D Support, Load Shifting & Voltage Reg.
T&D Support, Load Shifting & Voltage Reg.

Traditional Storage is a vital grid resource today at 20 GW of Pumped Storage

Advanced Storage is growing. 170 MW per DoE, http://www.energystorageexchange.org/
Frequency Regulation & Wind Integration:
32 MW, PJM, commercial operation 2011

Photo courtesy of AES Storage
Frequency Regulation (F/R): Sample Output

Faster and more accurate response = better grid system performance, and lower total cost for meeting F/R Ancillary Service requirement
Spinning Reserve for Generation Capacity Release: Chile, 12 MW 2012, 20 MW 2011
Chile System, A123 Response to Grid Outage

CDEC-SING Fault Report No. 2777, June 3, 2011

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Renewable Integration Pilot – Denmark 2011
Ramp Rate Management demo system

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Storage for Meeting Ramp Rate Control Req’t

Net power delivered to grid meets performance requirements.

ESS power centered around zero results in battery Target SOC being maintained.

10-sec. time steps
Extending Advanced Storage App’s to Bulk Transmission And Regional Support

PMU-equipped Storage Systems
Detect and Damp Inter-area Oscillations.

*Higher Dynamic Stability Limit = More Useable Transmission & Import Capacity*

*(GE) ES-PSS, In Action, 1994*

Source, SCE, EPRI

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BACKUP SLIDES

Applying Energy Storage to Electric Grids
Multiple Applications for Grid Storage

**High Power Applications:**

- Regulation
- Spinning Reserve
- Renewable Integration
  - Ramp Management
- **Requirements:**
  - Very high Charge/Discharge Rates
  - Short Duration (<1hr)
  - Many cycles (100s per day)
  - Continuous use

**High Energy Applications:**

- Peak Load Shifting
- Renewable Integration
  - Firming, Shifting & Curtailment Recovery
- Energy Arbitrage
- T&D Asset Support
- **Requirements:**
  - Minimum Size (1+ hrs of energy)
A123’s Expanding System Options

High Power Applications

GBS-C-53
0.5 MWh

High Energy Applications

GBS-P-53
4 MWh

• Frequency Regulation
• Reserve
• Renewable Ramping
  + Enabling Access to Full Energy Value

• Peak Shifting and Arbitrage
• Renewable Integration
• Firming, Shifting & Curtailment Recovery
• T&D Support & Investment

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## Spec’s for Standard GBS-P and GBS-C Systems

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Long-Duration (LD) Grid Battery Systems</th>
<th>High-Rate (HR) Grid Battery System</th>
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</thead>
<tbody>
<tr>
<td>GBS-C53-LD40</td>
<td>4 MWh (nominal at C/2 rate)</td>
<td></td>
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<tr>
<td>GBS-C40-LD28</td>
<td>2.8 MWh (nominal at C/2 rate)</td>
<td></td>
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<tr>
<td>GBS-C20-LD12</td>
<td>1.2 MWh (nominal at C/2 rate)</td>
<td></td>
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<tr>
<td>GBS-C53-HR20</td>
<td>700kWh (nominal at 1C rate)</td>
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<thead>
<tr>
<th>Energy Storage</th>
<th>4 MW</th>
<th>2.8 MW</th>
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<tbody>
<tr>
<td></td>
<td>1.2 MW</td>
<td>2 MW</td>
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<tr>
<th>Power Rating</th>
<th>4 MW</th>
<th>2.8 MW</th>
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<tbody>
<tr>
<td></td>
<td>1.2 MW</td>
<td>2 MW</td>
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<tr>
<th>Dimensions (LxWxH)</th>
<th>53’ x 8.5’ x 9.5’ (16.2m x 2.6m x 2.9m)</th>
<th>40’ x 8.5’ x 9.5’ (12.2m x 2.6m x 2.9m)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>20’ x 8.5’ x 9.5’ (6.1m x 2.6m x 2.9m)</td>
<td>53’ x 8.5’ x 9.5’ (16.2m x 2.6m x 2.9m)</td>
</tr>
</tbody>
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| Mass                 | 141,000 lbs                            | 103,000 lbs                        | 49,000 lbs                        | 64,000 lbs                        |

| DC Efficiency*       | 97% (C/2 rate)                         | 96% (1C rate)                      |

| DC Voltage           | 944V nominal (750V – 1050V DC operating range) | 960V nominal (750V – 1050V DC operating range) |

<table>
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<tr>
<th>Ambient Operating Temperature Range</th>
<th>-30°C to + 50°C</th>
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</table>

| Enclosure details                  | Containerized, ISO 1496-1 certified, IMO CSC-compliant, designed to IP56 per IEC60529 |

* Inclusive of battery management electronics; excluding auxiliary power consumption by thermal management systems. Long-Duration GBS efficiency measured at full depth of discharge. High-Rate GBS efficiency measured at partial depth of discharge near mid state-of-charge.

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