Increased Generator Flexibility through Distributed Software and Storage Assets

FERC Software Technical Conference
June 30, 2011
A123 Systems Global Locations

- 2,000+ employees in locations worldwide
- >1,000,000 square feet of manufacturing facilities in United States, China and Korea

**Corporate Headquarters, Research and Development**
- Waltham, Massachusetts

**Systems Design and Manufacturing**
- Boston Area (Grid Hardware Systems)
- Livonia & Ann Arbor, Michigan (Automotive Systems and Cells)
- St. Louis, Missouri (Grid Software Systems)

**European Sales and Engineering**
- Stuttgart, Germany

**Battery Components and Cells**
- Michigan, USA
- Korea
- China

*HQ: Waltham, MA*
### Core Markets

**Enabling New Products through Advanced Energy Storage**

#### Transportation
- Passenger Hybrids, PHEVs and EVs
- Commercial Hybrids, PHEVs and EVs

#### Electric Grid
- Regulation, Grid Reliability
- Renewable Integration, Congestion Relief

#### Commercial
- IT & Telecomm
- Medical Systems
- Material Handling
- Industrial Controls

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**Drivers**

- Fuel economy
- Reduced emissions
- Energy independence
- Lighter-weight components
- Increase grid reliability
- Enable Wind and Solar
- Increase plant efficiency/utilization
- Improve performance
- Lighter weight
- Lower total cost of ownership over lead acid

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Building Block

Rack Management Controller

Intelligent Battery Rack
System Overview

System consists of 4 major subsystems

- Power Conversion System (2MW)
- Battery System (2MW 500kWh)
- Customer MV 4-35 kVAC
- Intelligent Battery Modules
- Cooling
- 960VDC
- Control System
Scalable Architecture from 100kW to 100’s of MW
Building-Based Wind Integration

+ 8MW, 4hr Storage
+ Dynamic 4-Quadrant PCS/Grid Interface
A123 Smart Grid Controls

Redundancy

- Measurement
  - Voltage
  - Current
  - Harmonics
  - Frequency

- Inverter
  - Chiller
  - Zone Control
    - PLC #1
    - Rack #1 BMS
    - Rack #2 BMS
    - Rack #n-1 BMS
    - Rack #n BMS

- Zone Control
  - PLC #2
  - Rack #1 BMS
  - Rack #2 BMS
  - Rack #n-1 BMS
  - Rack #n BMS

- Zone Control
  - PLC #3
  - Rack #1 BMS
  - Rack #2 BMS
  - Rack #n-1 BMS
  - Rack #n BMS

- Zone Control
  - PLC #n
  - Rack #1 BMS
  - Rack #2 BMS
  - Rack #n-1 BMS
  - Rack #n BMS

- Fiber Ethernet x2
- A123 SmartGrid Domain Controller Realtime Linux-based
- Clustered Standby (Hot Spare)

- User Interface Display
  - Customer Programmatic Interface
  - DNP3/L2
  - XML
  - SSL

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Smart Grid Domain Controller Dashboard

Smart Grid Stabilization System

Group Status

- **M1**: Spinning Reserve
  - ESC01
  - ESC02
  - ESC03
  - ESC04
  - ESC05
  - ESC06
  - ESC07
  - ESC08
  - ESC09
  - ESC10
  - ESC11
  - ESC12

- **M2**: Manual
  - ESC13
  - ESC14
  - ESC15
  - ESC16

**Group M2 Details**

- **Group Health**: 
- **Group Mode**: Manual
- **Grid Connection**: 

**Power**

- **Real Power (kW)**: 3500
- **Actual Power (kW)**: 3500
- **Avg State Of Charge (%)**: 69.2%

**Energy**

- **Energy Available (kWh)**: 1385
- **Charge Capability (kW)**: 8000
- **Discharge Capacity (kW)**: 8000

**Assets Online**

- **Number of Zones**: 4 / 4
- **Number of Inverters**: 2 / 4

**M2 Group Response**

- **Power / Frequency vs Time**

- **Average SOC**

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Application Review
Spinning Reserve: Chile

The Problem:

• Fragile power system increases risk of loss of production for area mines, driving high generation reserve requirement

The Solution:

• 12 MW storage in eight packaged systems replaced unpaid generating reserve, freeing up this generating capacity for paid energy service.

• In commercial service with < 3 year payback
AES Chile 2009: 12 MW Grid Stabilization & Generation Capacity Release

Photo courtesy of AES
Autonomous Response to Loss of Generation

CDEC-SING Fault Report No. 2777, June 3, 2011
Response to Loss of Transmission (Load)

CDEC-SING Fault Report No. 2580, October 22, 2010
Operational Results

Faster, more consistent fault response through software

- High Reliability and Performance
  - Responded to all generator assisted fault recoveries since Jan. 2010
  - 209 reported faults in 2010
  - Only unit to respond this consistently
  - Response speed consistently higher than other units

- Improved thermal generator efficiency
  - Power previously required to be held in reserve can now be sold
  - Increase power generation by 4 percent

- Highly Configurable
  - Speed and shape of response are programmable via SGDC
Application Review
Wind Ramp Management: Denmark
The Problem:
Renewable Output is Highly Volatile

Definition of Ramp Rate: The speed at which the output of a resource changes.

Wind farm output with Ramps as high as 75% of full range.
Magnitude of the Ramp Rate Problem

Ramp Rate Distribution for Each Minute

Distribution of Ramps for typical wind farm

- 27% violations on downward ramp
- 46% within ramp rate requirement
- 27% violations on upward ramp
- 2MW/Minute Ramp Rate Requirement

• Utilities are requiring renewable developers to limit ramp rates
• FERC has issued a Notice of Proposed Rulemaking (NOPR) to create a new service for allocating the cost of managing renewable variability
Battery System Performance

Battery Power Volatility

- Wind Power
- Grid Power
- Battery Power

Time (hours)

Power (MW)
Application Review
Wind Ramp Management

The Problem: the Intermittent output from Wind and PV plants challenges the utility’s ability to balance supply and demand. Interconnect approval requires ramp management.
The Problem

Renewable Output is Unpredictable

Output vs. Forecast for a Wind Farm

• Forecast is > 85% accurate, but not enough
• Insufficient to maintain stability on the grid
• Utilities will impose restrictions on output variability
Using Storage to “Firm” the Wind Farm Output

Output vs. Forecast for a Wind Farm

Curtailment even with ‘guard bands’
Using Storage to “Firm” the Wind Farm Output

Storage Charging and Discharging to “Firm” Output

Storage Charges during overproduction and Discharges during underproduction to be compliant with Forecast

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Resulting Grid Output is Firm

Storage Charging and Discharging to “Firm” Output
Conclusion

• A123’s SGDC has proven the value of end point software through 18 months of ultra-fast spinning reserve calls

• End point control systems and software optimize storage asset and generation utilization based on local measurements

• Efficiency gains can be realized from software at grid end points in conjunction with central dispatch
Summary of Efficiency Gains

Examples of gains that can be achieved by Grid Storage:

- Make renewable resources more predictable to improve their value on the grid
- Reduce the ramp rate of renewable resources to limit negative impact on the grid
- Increase output of traditional generators by freeing up reserve capacity
- Improve efficiency of traditional generators by offloading variability of demand to a fast response storage resource
Why autonomous distributed resources

• Dramatically improve response time by placing storage resource at the point of potential grid disturbance to permit sub second response
  + Proximity reduces the lag time of response and results in more accurate compensation for grid events. As a result, one can achieve more compensation with fewer resources.

• Reduce overall system complexity by distributing the problem into discrete components/chunks

• Distributing fast response resources results in more predictable grid participants at points where resources are placed, making central dispatch for macro grid events less complicated.
Thank You!
Questions?

For more information, please contact:

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