Storage, Storage Interfaces, Frequency Regulation, and Beyond

High MW Electronics – Industry Roadmap Meeting Challenges to Growth of Grid Connected Electronics

National Institute of Standards & Technology

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Storage, Grid Applications

Source: ESA
Storage, System Characteristics Comparison

System Ratings
Installed systems as of November 2008 (modified)*

Source: ESA, *modified to include A123 in-service and proposed
Frequency Regulation with Storage (SGSS*)

Standard power plant

Hybridized power plant

SGSS provides power (discharges)
SGSS is charged by power plant/grid

Usage like a hybrid electric vehicle...

* SGSS is A123’s Smart Grid Stabilization System
**Frequency Regulation, What’s Delivered by PCS?**

Per CAISO Tariff, Controlled MW Output Level

**A 1.2.1.2**

The Generating Unit power output response (in MW) to a control signal must meet the minimum performance standards for control and unit response which will be developed and posted by the ISO on its internet “Home Page.” As indicated by the Generating Unit power output (in MW), the Generating Unit must respond immediately, without manual Generating Unit operator intervention, to control signals and must sustain its specified ramp rate, within specified Regulation limits, for each minute of control response (MW/minute);

**A 1.2.2**

**Monitoring:**

The Generating Unit must have a standard ISO direct communication and direct control system to send signals to the ISO EMS to dynamically monitor, at a minimum the following:

**A 1.2.2.2**

High limit, low limit and rate limit values as selected by the Generating Unit operator; and

**A 1.2.2.3**

In-service status indication confirming availability of Regulation service.

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**Star** Point of Delivery Megavars is not required for AGC Regulation Units. However, it may be required in the future if a voltage market is established.
Figure 1 - Timing of Telemetered Data for Generators Providing AGC through the RIG

What happens when tempo goes to 2 seconds? CMU
#1 Driver – Storage F/R Commercially Viable

INDICATIVE COST OF PRODUCTION
- 42 mills CT Production Cost, 12 mills capacity, 30 mills variable cost
- 22 mills Battery Production Cost, 12 mills capacity, 10 mills variable cost

MARKET PRICE
- 10 – 50 mills Frequency Regulation average market clearing price

How can the PCS interface impact the “#1 Driver“ for deploying this solution?
- Lower cost, increase efficiency, and improve reliability
  … and also expand compensable capabilities.
  But, barrier is not technology, it’s lack of investment recovery mechanisms
  See Slide 11

Industry research supports additional potential “drivers”, including emission reduction, renewable integration, system asset efficiency improvement. Once again, barrier is lack of investment recovery mechanism, not technology gaps.
One Implementation
A123’s Smart Grid Stabilization System (SGSS)

- Frequency Regulation
- Spinning Reserves
Grid Deployed SGSS’s, Multi-MW Scale

California

Chile
Grid Interface, Parker-Hannifin

AC890PX Power Entry Types

Four Operating Modes
- Volts/Hertz
- Sensorless vector
- Full flux vector
- Servo (PMAC)

Four Feedback Options
- Incremental encoder
- Sin/Cos encoder
- EnDat absolute encoder
- Resolver

Runs induction, torque motors, or PMAC Servo
AEP’s Vision of Robust Storage Benefits

Locational Value of Energy Storage

PCS Capabilities
For Full Grid Benefit

Steady State W, power transfer

Plus:
Steady State VAR, voltage reg.
Transient W, a/c stall barrier
Transient VAR, sag mitigation
Dynamic W, damping, inertia
Dynamic VAR, voltage stability
Islanding, reliability

Can this be delivered <$3/watt?
First U.S. Retail Rate Case

values are based on studies made for an AEP site
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<th>SCE’s Utility’s Vision of Storage Benefits (FOA 36)</th>
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<td>1. Provide Voltage Support/Grid Stabilization</td>
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<td>2. Reduce Outage Frequency/Duration (islanding)</td>
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<td>3. Reduce Transmission Losses</td>
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<td>6. Transmission Access</td>
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<td>10. Renewable Energy Integration (smoothing)</td>
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B. Chino Battery Energy Source Power System Stabilizer

In 1994 an Energy Source Power System Stabilizer (ESPSS) was designed and built by GE, and added to the Chino Battery and put into operation by SCE.

- loop controlled battery output. Within two days of going into service, dynamic grid-supportive response by the battery was captured, and validated, through project metering.
Wind Challenge: Persistent Cycling Intermittency
PV Challenge: Infrequent Intermittency, Local PQ

Wind Production (Tehachapi)

PV Production (Tucson)

Source: CAISO and TEP
Ideas for Roadmap Development

• Cutting your PCS cost in half and doubling efficiency would be nice, but, wouldn’t be a game changer in terms of accelerating significant commercial uptake of advanced-technology grid stabilizing storage; 4,000 MW UK, 10,000 MW US

• Help me map capabilities to grid performance outcomes relevant to grid-access controlling stakeholders.

• Help me characterize of renewable penetration impacts and solutions. Adamant voices want ‘business as usual’ to 20% penetration. OK, but then what? Stop, or accept higher outage exposure?
BACKUP SLIDES
A123 Core Competencies

Materials science and development expertise

Battery design capabilities

Battery systems engineering and integration expertise

Vertical integration from battery chemistry to battery system design services

Industry-leading partners in focused markets

High-quality, volume manufacturing facilities and proprietary process technologies
A123 Efficiencies for Maximum Value