APS Solar Partner Program (SPP)  
Phase II – Lessons Learned  

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Overview

• APS/EPRI SPP Phase II
  – Utility voltage control
  – Battery storage system (2MW/2MWh)
  – Voltage, power factor, grid operations
  – High penetration PV
### APS SPP Phase II - Lessons Learned

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<th><strong>BATTERY</strong></th>
<th><strong>GRID OPS</strong></th>
<th><strong>HUMAN INTERFACE</strong></th>
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<td>Measurement based battery dispatch preferred over scheduled</td>
<td>Low VAR flow, not power factor, should be the goal</td>
<td>Need to simplify battery-grid operator interface</td>
<td>Clear requirements RFP test reports and extensive FAT are necessary</td>
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<td>BESS downstream of feeder constraint offers most value (even smaller sizes)</td>
<td>Clearly set voltage control priorities to eliminate potential conflict</td>
<td>Extensive operator training / change management are necessary</td>
<td>Battery inverters will need to follow IEEE 1547 advanced functionality</td>
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<tr>
<td>Direct communication path with low latency for effective response</td>
<td>Utility devices for large voltage change, then inverter for smoothing</td>
<td>Standardize MW and VAR flow reference directions</td>
<td>Routine operations, daily dispatch and optimization should be automated</td>
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<td>Draw losses from the grid-side to preserve battery capacity</td>
<td>Only load transfer can resolve voltage issues when BESS and VVO cannot</td>
<td>Alarm prioritization and management with mitigation is recommended</td>
<td>Engineering time series study prior to implementation (charge / discharge)</td>
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Battery Operation

• Measurement Based vs Scheduled Dispatch
  – Measurement based preferred
  – Consistent peak reduction
  – Highest energy deferral
  – Requires reasonable load shape forecast assumption

• Use direct measurement communication path
  – Low latency and response time
  – Direct more robust in various operating scenarios
  – Lower comm loss probability
Battery Operation

• Locate battery downstream of feeder constraints
  – If ahead, no deferral possible
  – Distributed closer to loads

• Draw inverter losses from the grid (not the battery)
  – When idle, energy is lost
  – Affects desired objectives
Grid Operation & Impacts

- Manage feeder VAR flow, not power factor
  - BESS inverter managing VARS / PF hold to min targets
  - Utility voltage control managing voltage / VARS / PF hold close to 1
Grid Operation & Impacts

- Utilize utility voltage control for large changes
- Clearly set voltage priorities to eliminate conflict

Less variability – closer to 1.0
Grid Operation & Impacts

- Battery only doing voltage control
  - Less variability than baseline

- Utility capacitors and regulators doing voltage and PF control
  - Less variability than baseline, higher overall system voltage profile

- Battery, capacitors and regulators doing voltage and PF control
  - Minimum variability with best voltage profile
Human-Machine Interface

• Data intensive application
  – Simplify battery interface for operators
  – Automate dispatch decisions
  – Ease of operation important
  – Complex technology with many functions

• Batteries operate as both load and generation
  – Convention (lingo) must be standard
  – Injecting or absorbing both MW and MVAR
  – ... also performs voltage control
Human-Machine Interface

- Extensive training is required
  - New technology, not extension of existing
  - Capabilities that do not exist elsewhere

- Alarms can be overwhelming
  - Especially during disturbance, operators need guidance on what to do, not just system states
Other Lessons Learned

• Clear requirements and expectations up front
  – Alignment on expected operating conditions
  – Alignment on technology capabilities
  – Test and verify system details prior to installation
• Battery inverters will need to align to IEEE 1547
  – They may or may not today
  – Outlines Volt/VAR, voltage and frequency ride-thru
  – Communication and control parameters
• Automate routine and simple functions
• Time series studies to understand daily dispatch
Intermediate Feeder Energy Storage

• Delivered scope
  – 1 x 380 kW
  – 2 x 507 kW
  – Total capacity 1.39 MW

• Use cases
  – Thermal load management
    • Charge from PV
    • Shave peak
  – Voltage management
    • Not intended to replace capacitor (1200 kVAr)
    • Feeder capacitors retrofit with 1-phase controls
    • Inverter / capacitor inter-operability and fine-tune voltage control
Peak Day
Batteries operating at full and ½ capacity

Reduces summer peak
Minimum Load Day (Max PV Output)

Batteries operating at full and $\frac{1}{2}$ capacity

- Base
- W/ IFES 1C
- W/ IFES 0.5C

- Reduces spring peak (small benefit)
- Increases feeder minimum load
QUESTIONS?
Other Examples with SPP

- Solar Partner Program BESS
  - Feeder peak demand shaving
  - Demand profile shaping
    - High PV penetration circuits
  - Feeder voltage control and VVO integration
  - VVO interoperability
    - Capacitors and regulators
    - Advanced inverters
    - BESS inverters
7 MW limit is arbitrary (for testing only)

- Missing the peak (left)
- Charging right after peak (right)