SolarTAC Tour for NCSL

August 24, 2016
About Xcel Energy

The Vision
To be the preferred and trusted provider of the energy our customers need

The Mission
We provide our customers the safe, clean, reliable energy services they want and value at a competitive price

The Stats
- 3.4M electric customers
- 1.9M natural gas customers
- 11,400 employees
- $11.7B in revenues
- 17,000 MW owned generation
- >6.5 GW of wind

Xcel Energy®
Our business is changing

TOMORROW’S GRID

Enable two-way flow of energy + variable resources + storage + demand response
Optimize performance
Increase reliability & resiliency
Enable energy services
SolarTAC - Technology Acceleration Center

AURORA COLORADO

74 ACRES
1900 TOTAL

300+ DAYS

W·I·D·E TEMP RANGE
SolarTAC Battery Projects

- 1.5MW, 1MWh Solar to Battery (S2B)
  - Feeder/substation -level
  - Advanced lead acid (1200 cells)
  - 780kW concentrated PV

- 25kW, 50kWh Community Energy Storage (CES)
  - Neighborhood-level
  - Sodium nickel chloride
  - 4 simulated homes: 4-7kW solar + 10-21kW load banks
Can Batteries Integrate Solar?

<table>
<thead>
<tr>
<th>Battery Function / Characteristic</th>
<th>Solar To Battery</th>
<th>Community Energy Storage</th>
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</thead>
<tbody>
<tr>
<td>Smoothing (manage small power fluctuations)</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Ramp Rate Limiting (manage larger power spikes)</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Time Shifting (shifting peak PV production)</td>
<td>YES – performance was limited due to degradation</td>
<td>YES</td>
</tr>
<tr>
<td>Voltage Regulation (maintain/improve grid reliability)</td>
<td>YES – observed but not analyzed due to degradation</td>
<td>YES – 1st gen algorithm prioritized smoothing and time shifting over voltage regulation</td>
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</tbody>
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Solar to Battery Pilot
Solar to Battery Pilot
Community Energy Storage Pilot
Community Energy Storage Pilot
Demonstration

- Utility-scale battery systems are still not yet ‘turn-key’ integrations
- The battery chemistry matters and the field is changing rapidly
- Reliable, robust communications and control is paramount to a battery’s operation

Research

- Stacking battery capabilities could improve battery economics today; each battery & location has its own values
- Today’s changing policies are driving battery markets, e.g. PJM (frequency regulation), CAISO (capacity)
- Utility battery installed costs range from ~$600-1300/kWh; research firms project 20-40% reduction per year
Home Battery Pilot:

- 10kWh (usable) LiFePO4 Iron Edison battery
- 9kW solar PV
- Testing:
  - “Nanogrid” concept
  - Charging/discharging characteristics with various residential scenarios
  - Behavioral adaptations to minimize power and energy
Thank you!

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