Energy Storage on the Grid Edge

Energy Storage Workshop for Southwest Utility Regulators
Sandia National Laboratories, Albuquerque, NM

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(505) 280-0997
The Grid Edge

Generating Station

Generating Step Up Transformer

Transmission Customer 138kV or 230kV

Transmission lines 765, 500, 345, 230, and 138 kV

Substation Step Down Transformer

Subtransmission Customer 26kV and 69kV

Primary Customer 13kV and 4kV

Secondary Customer 120V and 240V

Color Key:
Black: Generation
Blue: Transmission
Green: Distribution

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## What Does Storage Do at the Grid Edge?

<table>
<thead>
<tr>
<th>STORAGE APPLICATION</th>
<th>TRANSMISSION</th>
<th>DISTRIBUTION</th>
<th>CUSTOMER SITED</th>
</tr>
</thead>
<tbody>
<tr>
<td>T&amp;D Deferral</td>
<td>YES</td>
<td>YES</td>
<td>X</td>
</tr>
<tr>
<td>Ancillary Services</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Load Leveling</td>
<td>YES</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Demand Response</td>
<td>X</td>
<td>X</td>
<td>YES</td>
</tr>
<tr>
<td>Peak Shaving</td>
<td>X</td>
<td>X</td>
<td>YES</td>
</tr>
<tr>
<td>Distr. Ren. Integration</td>
<td>X</td>
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# Regulatory Framework to Monetize Value

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<tbody>
<tr>
<td>T&amp;D Deferral</td>
<td>Exists</td>
<td>Partial</td>
<td>Needed (P)</td>
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<tr>
<td>Ancillary Services</td>
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<td>Exists</td>
<td>Needed</td>
</tr>
<tr>
<td>Load Leveling</td>
<td>Exists</td>
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</tr>
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<td>Needed</td>
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<tbody>
<tr>
<td>T&amp;D Deferral - Movable</td>
<td>Needed</td>
<td>Needed</td>
<td>Needed</td>
</tr>
<tr>
<td>Ancillary Services***</td>
<td>??</td>
<td>-</td>
<td>Needed</td>
</tr>
<tr>
<td>Demand Response***</td>
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*** SHARED OWNERSHIP of the storage system
What is needed?

- Regulatory framework that allows monetization of distributed storage in the distribution system, with option for “shared” ownership

- An “Aggregator”: Combine the outputs of “clustered” distributed storage systems into a “single” source

- Responds to “grid” needs at a significant scale

- Control hardware/software that allows the coordinated management of “clustered” storage systems
# Technology Match for Grid Edge Applications

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<tr>
<td>T&amp;D Deferral</td>
<td>Flow/CAES</td>
<td>Flow/Li</td>
<td>Li</td>
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<tr>
<td>Ancillary Services</td>
<td>Flow/Li/Fly</td>
<td>Flow/Li/Fly</td>
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<td>Li/Flow</td>
<td>Li</td>
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*** SHARED OWNERSHIP of the storage system
Industry Stakeholders and Drivers

Tesla home energy storage

- Most visible presence, collaboration with Solar City
- “…will sell 116 MWh of storage systems to SolarCity in 2016.”
- Powerwall: 6.4 kWh,


Swell Energy partnership with Verengo Solar for residential storage

One Japanese auto manufacturer developing residential storage system
Industry Drivers

Residential photovoltaic energy storage

Microgrid component of energy storage: projected growth in microgrid installed capacity

Second-use of EV batteries

Change in electric utility T&D practice
Customer-side Storage Deployment - 2015

- 2015 U.S. behind-the-meter storage deployments: 71.4
- 2015 Tesla sales to SolarCity: 25.8
- 2016 Tesla expected sales to SolarCity: 168.5
- KIUC project: 52.0
- 2016 Tesla expected sales to SolarCity (Excluding KIUC): 116.5

Source: GTM Research Based on Recognized Revenues Disclosed by Tesla Motors
U.S. Microgrid Capacity Forecast To 2020

Source: GTM Research/ABB
Tesla Storage Products - Powerwall

Technology
Wall mounted, rechargeable lithium ion battery with liquid thermal control.

Model
6.4 kWh
For daily cycle applications

Warranty
Ten years

Efficiency
92.5% round-trip DC efficiency

Power
3.3 kW

Depth of Discharge
100%

Voltage
350 – 450 volts

Current
9.5 amperes
Tesla Storage Products - Powerpack

Peak Power
- 50 kW

Energy Capacity
- 95 kWh (AC)
- 100 kWh (DC)

Weight
- 1,720 kg (3,800 lbs)

Dimensions
- L x W x H: 1,321 mm (52") x 966 mm (38") x 2,185 mm (86")
### S&C Community Energy Storage - PureWave

<table>
<thead>
<tr>
<th>Ratings, Dimensions, and Weight</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Active and Reactive Power</td>
<td>25 kVA</td>
</tr>
<tr>
<td>Energy</td>
<td>25 - 75 kWh</td>
</tr>
<tr>
<td>Secondary Voltage</td>
<td>240 / 120V</td>
</tr>
<tr>
<td>Battery</td>
<td>Li-Ion</td>
</tr>
<tr>
<td>Round-Trip AC Energy Efficiency</td>
<td>&gt; 85%</td>
</tr>
<tr>
<td>Dimensions (CES only)</td>
<td>50 inches L x 34 inches W x 31 inches H</td>
</tr>
<tr>
<td>Weight (CES only)</td>
<td>Approx. 750 lbs.</td>
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</table>
What Started it All

Power: 200 kW
Energy: 167 kWh

First-ever:
• Containerized battery storage for utility applications
• Factory-assembled, ac-ac aggregation of modules
• Transportable
What Started it All

8 modules: includes batteries and power conversion electronics
25 kW; 20 kWh
What Started it All
Questions?