Energy Storage – Applications, Business Models and Policy Considerations

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RES Americas
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## RES at a Glance

### QUICK FACTS

| Founded: | 1997 |
| Technologies: | Wind, Solar, Transmission, Energy Storage |
| Services: | Development, Engineering, Construction, Operations |
| Locations: | Broomfield, CO (HQ); Austin, TX; Minneapolis, MN |
| Employees: | >300 |

### EXPERIENCE

| Wind & Solar: | 7,500+ MW renewable energy construction portfolio, of which we’ve developed over 3,500 MW. |
| Transmission: | 600+ miles of overhead & transmission lines (up to 345kV) built. |
| Energy Storage: | 8 MW (16 MW range) constructed, 67 MW under construction, & 200+ MW in development. |
| Projects: | 80+ projects in the U.S., Canada, & the Caribbean. |
## RES Energy Storage Projects

<table>
<thead>
<tr>
<th>Function</th>
<th>Owner</th>
<th>MW / MWh</th>
<th>Revenue Model</th>
<th>Jurisdiction</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR</td>
<td>RES</td>
<td>4.0 / 2.6</td>
<td>Owner Merchant</td>
<td>PJM</td>
</tr>
<tr>
<td>FR</td>
<td>RES</td>
<td>4.0 / 2.6</td>
<td>Owner PPA</td>
<td>IESO</td>
</tr>
<tr>
<td>FR</td>
<td>JV (RES + Financial)</td>
<td>19.8 / 7.9</td>
<td>Financial Instrument</td>
<td>PJM</td>
</tr>
<tr>
<td>FR</td>
<td>JV (RES + Financial)</td>
<td>19.8 / 7.9</td>
<td>Financial Instrument</td>
<td>PJM</td>
</tr>
<tr>
<td>Deferral &amp; Micro-grid</td>
<td>Utility</td>
<td>2.0 / 4.4</td>
<td>EPC</td>
<td>WECC</td>
</tr>
<tr>
<td>FR</td>
<td>Financial Investor</td>
<td>6.0 / 2.0</td>
<td>DEV &amp; BOP</td>
<td>PJM</td>
</tr>
<tr>
<td>FR</td>
<td>IPP</td>
<td>19.8 / 7.9</td>
<td>EPC</td>
<td>PJM</td>
</tr>
<tr>
<td>Deferral</td>
<td>Utility</td>
<td>2.0 / 12.0</td>
<td>EPC</td>
<td>NYISO</td>
</tr>
<tr>
<td>Multiple</td>
<td>R&amp;D Center</td>
<td>0.15 / 0.3</td>
<td>EPC</td>
<td>Hydro Quebec</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>77.6 / 47.5</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 9 Projects
- 4 different functions (at least)
- 6 different ownership models
- 5 different revenue models
- 5 different jurisdictions
- 3 different battery vendors

4MW/2.6 MWh “Amphora” Project
Energy Storage Overview
Grid integrated energy storage is the only technology that allows utilities to accomplish all of the following:

- Improve reliability by providing backup power during short-term outages
- Defer transmission and distribution investment through extending grid element life and optimization of system
- More efficiently and flexibly use existing power resources
- Improve voltage regulation
- Address renewable integration and grid stability
Opportunities for Energy Storage in Texas

Factors for Energy Storage in Texas:

• Nation leading wind power sector

• Growing Power Needs

• Growing Solar Power Sector

• Infrastructure Upgrade Needs

• Competitive Market Structure

Source: ERCOT (September 2014 GIS report, 2014 Summer SARA report, December 2014 CDR)
Defining & modeling the value of storage is a challenging, multi-stage journey

• How is storage classified (generator, T&D infrastructure, load)?

• ERCOT conducting cost-benefit analysis on market redesign - Is there a mechanism for compensating the superior performance of storage?

• Legislation - depending on how storage is classified, certain services may be ‘off-limits’ for utilities

“I think you should be more explicit here in step two.”
Applications
Use Cases & Applications

- Energy Storage has values that are both local & global.
- Most ES projects must capture both local & global values to be cost effective.

<table>
<thead>
<tr>
<th>Local ES Values / Services</th>
<th>Global ES Values / Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution Deferral</td>
<td>Frequency Regulation</td>
</tr>
<tr>
<td>Voltage Regulation</td>
<td>Frequency Response (FFR)</td>
</tr>
<tr>
<td>Solar Ramp Control</td>
<td>Spinning Reserve / Synthetic Inertia</td>
</tr>
<tr>
<td>Power factor control</td>
<td>Avoiding balancing charges in PV/Wind dispatch</td>
</tr>
<tr>
<td>Motor Start Mitigation / Fault Events</td>
<td>Arbitrage</td>
</tr>
<tr>
<td>Microgrid / Outage Mitigation</td>
<td>Grid Blackstart</td>
</tr>
<tr>
<td>Demand Management (local)</td>
<td>Demand Management (transmission charges)</td>
</tr>
<tr>
<td>Peaking Energy (in load pocket)</td>
<td>Peaking Energy (transmission level)</td>
</tr>
<tr>
<td>Flicker Control</td>
<td></td>
</tr>
<tr>
<td>Electric Vehicle Charging Stations</td>
<td></td>
</tr>
</tbody>
</table>

- Utilities are generally the only entities that can combine local & global values.
Use Cases & Applications - Lots of Options!

Flywheels

Thermal ES

CAES (Compressed Air ES)

Aqueous Sodium

Super Capacitors

Liquid Metal

High Temperature Sodium

Zinc Air

Flow Batteries
But...Need to Prove the Business Model

NPV cost vs. savings over 20-year time horizon
- Typically, need to ‘stack’ use-cases to realize full financial benefit

NPV Over Project Life

Cost Benefit

- Outage Mitigation
- Ancillary Services
- Electric Supply Capacity
- Substation Deferral
- Operating Expenditure
- Capital Expenditure
ES Applications: Renewable Integration

Mitigation of PV DG Variability on Distribution (voltage fluctuations)
Ramp control for large grid PV projects

Much faster than available carbon based balancing
Improve power quality
Eliminate upstream current flows

Webberville 30MW PV on a Partially Cloudy Day
Rooftop PV causing Voltage Fluctuations on local Distribution. SDG&E Rate Case 2012
ES Applications: Distribution & Transmission Deferral

Values
- Reduce cost of infrastructure upgrades

Benefits
- Reduces risk of upgrade
- Modular ES may be moved easily
- Reduces visual, environmental, and community impacts

Storage can be used to control flow on congested elements.

Storage can supply voltage support at the end of long distribution lines.

Short duration overloads can be economically mitigated with storage.
Energy Storage Applications: Frequency Regulation

Market Models

- **Merchant, FFR**
- Utilities can provide this service less expensively & return value to ratepayer

Benefits

- Faster and more efficient than gas or coal generation with far less emissions
ES Applications: Microgrid - Outage Mitigation

Values

- Reduces outage cost to customers
- Increases grid resiliency, reduces risk of storm or terroristic actions

Benefits

- Additional value on top of distribution deferral
- Storm Mitigation
- Can support critical facilities
Energy Storage Applications: More Energy Storage Services

- Additional revenue streams or benefits from energy storage
  - Spinning reserve
  - Wind integration fee mitigation
  - Reducing resource adequacy requirements
  - Volt/VAR power quality services
  - Replace dynamic VAR in renewable energy plant
  - Demand management
  - Power factor control
  - Phase balancing
  - Mobile locations / seasonal load relief
Case Study
Energy Storage with PV:
- Combined energy storage and PV inverter
- Combined control system
- Higher performing PV asset that can perform multiple functions.
## Introduction - Energy Storage Solutions

<table>
<thead>
<tr>
<th>Use Case</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Renewable Integration</strong></td>
<td>ESS is used to provide dynamic voltage regulation, ramp rate control, and voltage flicker mitigation caused by distributed variable PV</td>
</tr>
<tr>
<td><strong>Substation Deferral</strong></td>
<td>ESS is used to “peak shave” high load periods to avoid an expensive upgrade, for a period of time. Economic value is the time value of money for the achieved timeframe of deferral.</td>
</tr>
<tr>
<td><strong>Arbitrage</strong></td>
<td>System is used to storage energy when energy prices are low, and discharge when energy prices are high.</td>
</tr>
<tr>
<td><strong>Ancillary Services</strong></td>
<td>ESS may be able to participate in the ancillary services market during periods where it’s not needed for distribution peak shaving.</td>
</tr>
<tr>
<td><strong>Outage Mitigation</strong></td>
<td>ESS can provide backup power to the distribution system for a limited time during some outages.</td>
</tr>
</tbody>
</table>

Note: Terminology and definitions for grid services that storage may provide are not yet uniform. Definitions herein strive for consistency with the 2013 U.S. Department of Energy DOE/EPRI Electricity Storage Handbook.
Use Case: Substation Upgrade Deferral

Seasonal Peaks' Daily Profile - Overage

<table>
<thead>
<tr>
<th>Load Growth</th>
<th>MW</th>
<th>MWh</th>
<th>Duration (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5%</td>
<td>0.35</td>
<td>0.42</td>
<td>1.2</td>
</tr>
<tr>
<td>10%</td>
<td>0.81</td>
<td>1.76</td>
<td>2.2</td>
</tr>
<tr>
<td>15%</td>
<td>1.27</td>
<td>3.52</td>
<td>2.8</td>
</tr>
</tbody>
</table>
Use Case Example:

- To better align with load profile, PV production is stored and discharged during peak period.

- Result is better utilization of PV asset and elimination of ‘duck curve’.

- Thermal resources are able to operate more efficiently and don’t have to ‘ramp up’ as extensively as without storage.
Use Case Example:

- 1 MW, 2 hour energy storage system
- Using ERCOT AS market prices, ESS would be used for either regulation (regulation up AND regulation down), or emergency response services
- Potential for future fast frequency response product

<table>
<thead>
<tr>
<th>Ancillary Service Participation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulation Up Average Clearing Price</td>
<td>$9.10</td>
</tr>
<tr>
<td>Regulation Down Average Clearing Price</td>
<td>$5.31</td>
</tr>
<tr>
<td>Combined Reg Up/Down Revenues</td>
<td>$14.42</td>
</tr>
<tr>
<td>Annual Regulation Service Revenue</td>
<td>$107,346.50</td>
</tr>
<tr>
<td>Emergency Response Service Payments</td>
<td>$70,157.24</td>
</tr>
</tbody>
</table>
Final word
Grid integrated energy storage is the only technology that allows utilities to accomplish all of the following:

- Improve reliability by providing backup power during short-term outages
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Source: The Utility Perspective: Energy Storage
Bill Muston at Texas Energy Storage Summit Austin December 5, 2014
Thank you!

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