The Role of Energy Storage In Pushing Toward 100% Renewable Energy

Alison Mason, January 2017
Spirae’s Wave® software platform provides a scalable architecture for integrating and managing high levels of renewable and distributed energy resources (DER) at the edge of the grid.
I will cover...

- Flexibility
- Market Trends in Energy Storage
- What Energy Storage Can Do
- Why Energy Storage is Not the Holy Grail
- Cool Energy Storage Projects
What Are We Solving?

- Down Ramp
- Storage or Curtailment
- Up Ramp

DGPV
Utility Solar
Thermal Generation
Reserves
Pmin
Figure 1: Net load on the CAISO system

Net Load – March 31

Ramp needs
~13,000 MW in three hours

Potential over-generation

Source: CAISO
How California utility regulators are turning electric vehicles into grid resources
Remove Pumped Hydro...
## What Kinds of Energy Storage?

<table>
<thead>
<tr>
<th>Grid Scale Battery</th>
<th>Pumped Hydro</th>
<th>Flywheel</th>
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</thead>
<tbody>
<tr>
<td><img src="image1" alt="Grid Scale Battery" /></td>
<td><img src="image2" alt="Pumped Hydro" /></td>
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<tr>
<td>Ice Bear</td>
<td>Molten Salt</td>
<td>Hot Water</td>
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<tr>
<td><img src="image4" alt="Ice Bear" /></td>
<td><img src="image5" alt="Molten Salt" /></td>
<td><img src="image6" alt="Hot Water" /></td>
</tr>
</tbody>
</table>
Molten Salt (Crescent Dunes)
Grid Scale Batteries
Residential Battery Systems

- Sonnen
- Sunverge
- Tesla
- Mercedes
What is Energy Storage Doing?

- **Electric Energy Timeshift**
- **Electric Bill Management**
- **Renewables Capacity Firming**
Reverse Power Flow

Figure 10: Storage Can Avoid Reverse Power Flows with Solar PV

Massachusetts State of Charge Report, 2016

Can also do this with controllable loads (commonly thermal storage)
Trends Driving Energy Storage

Battery Cost

Prediction: Cost will fall by 70% over next 15 years.

Battery Manufacturing Scale

EV Adoption
Energy storage: Good, Bad, Ugly

The Good
Can solve many of the grid’s problems
load leveling | frequency regulation | contingency reserves | firm capacity

The Bad
Expensive
Adds Nothing

The Ugly
Carbon Intensive (Manufacture | round trip efficiency<1)
Dangerous
A high flexibility grid can achieve the same renewable energy penetration with half the energy storage as a low flexibility grid. 

Source: Denholm et al. [2016]

1. Reduced minimum generation levels
2. Increased export capacity
3. Expanded demand Flexibility, and
4. Optimized charging of electric vehicles

Source:
Energy Storage Requirements for Achieving 50% Solar Photovoltaic Energy Penetration in California
Paul Denholm and Robert Margolis
National Renewable Energy Laboratory (NREL)
August, 2016
Relative Economics of Integration Options [Cochran et al., 2014]
Stacked Value of Energy Storage

Value Stream Examples
- Frequency Regulation
- Demand Response
- Demand Charge Management
<table>
<thead>
<tr>
<th>Customer</th>
<th>Location</th>
<th>Assets</th>
<th>Delivery</th>
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<tr>
<td>Green Mountain Power</td>
<td>Vermont</td>
<td>Dynapower Battery Energy Storage (2 MW/1 MWh Li Ion; 2 MW/1.2 MWh Lead Acid) SolarEdge/Tesla – Behind the Meter</td>
<td>2016-2017</td>
<td>Peak Management</td>
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<td>Investor Owned Utility</td>
<td>California</td>
<td>Grid-scale ABB/Saft (x2) 1 MW/3 MWh Parker/Saft 0.5 MW/1.5 MWh Greensmith/ABB/Samsung Greensmith/Satcon/Winston S&amp;C/Dow Kokam Community Storage S&amp;C 25 kW/75 kWh</td>
<td>2016</td>
<td>Resilience Microgrid</td>
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<td>Avista Utility</td>
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<td>UET flow battery 1 MW/4 MW</td>
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<td>800 Electric Water Heaters, Aclara Communications</td>
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<td>Peak Management</td>
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<td>OEM</td>
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<td>DEIF AGC-4 (genset control) EMCP 4.4 (genset control) ISO Switchgear (genset switchgear) SMA Tripower 24000TL-US (PV inverter) BDP-250 (ESS inverter)</td>
<td>2016</td>
<td>Remote Microgrid</td>
</tr>
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NY REV

ConEdison
300 homes in Brooklyn and Queens
Virtual Power Plant
Leased solar panels and lithium ion batteries
Peak shaving and frequency regulation

Aliso Canyon

Southern California Edison
San Diego Gas and Electric
60 MW utility scale storage
SCE – 20 MW (80 MWh)
SDG&E – 37.5 MW (150 MWh)
Fast – 6 months or less

FERC

PJM
Front of the meter
Interim cap – Regulation D
2017 – 100 MW
Frequency Regulation

De-Carbonization
Grid Modernization

Loss of resource – natural gas supply
Market Demand
Infrastructure Deferral

New York (Con Ed)
- $1.2B substation upgrade needed
- Energy efficiency
- Distributed generation
- Demand response
- Energy storage

$1 Billion Saved AND can integrate more renewables
Grid Flexibility for a Tiny Grid

Ta’u, Samoa – 14 MW Solar – 6 M Wh Energy Storage – 100% Renewable
Good Policy Wanted

FERC seeks comment on new rules for energy storage in wholesale power markets
To Those Who Have Inspired, Encouraged, Assisted, Supported, Coached, and just plain beat things into my head...

My Parents
Dr. Franz Brotzen
Dr. Few
Dr. Jane Davidson
Jeff Miller
Sue Reilly
Dr. Maury Albertson

Peggy Plate
Dr. Byron Winn
Judy Dorsey
Jim Welch
Dan Bihn
Randy Udall
Chris Cook

Jigar Shah
Randy Gee
Kelly Beninga
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Bill Becker
My Daughters

Thank You!

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