ENERGY STORAGE AS AN EMERGING TOOL FOR UTILITIES TO RESOLVE GRID CONSTRAINTS

June 18, 2015

E2Tech Presentation
• Energy storage as a grid solution “high level”

• Specific CEP project examples

• The technology landscape

• Energy storage opportunities in Maine

• Current and future pricing
Energy storage increases utilization of existing infrastructure instead of building more

**WHY ENERGY STORAGE?**

- **Electricity – the world’s largest supply chain – has almost no storage compared with other commodities**
- **Electric infrastructure is sized to exceed projected peak demand, resulting in massive idle capacity**

### World Annual Crude Oil Production
- **World Oil Storage Capacity**: 0.6 Bil m³
- **World Annual Crude Oil Production**: 4.75 Bil m³

### World Electricity Production
- **Electricity Storage Capacity**: 1.3 TWh
- **Electricity Production**: 20,000 TWh

### Electric infrastructure is sized to exceed projected peak demand, resulting in massive idle capacity

- **# in U.S.**
  - 17,350 plants
  - 164,000 miles
  - 3 million miles

<table>
<thead>
<tr>
<th>Utilization</th>
<th>47%</th>
<th>43%</th>
<th>34%</th>
</tr>
</thead>
</table>

- **Storage projects can increase the utilization of existing grid infrastructure with targeted siting and operations**
- **Storage can replace or defer new peak-related infrastructure investments in G/T/D, providing new, lower-cost solutions for utilities without on-site emissions or noise impacts**
- **THEREFORE**: storage projects can increase reliability **AND** lower costs for electric consumers
Targeted deployment of energy storage relieves system constraints

LOCATION MATTERS

Increases Flexibility
• Instantaneous, reliable response / dispatch within load pockets
• Modular design for staged expansion to dynamically respond to load growth

Provides Cascading Relief
• Distribution assets benefit “upstream” feeders, substations and transmission lines
• Buffers grid volatility caused by increasing DG renewables penetration
• Can create additional value in wholesale energy and capacity markets

Reduces Cost
• Avoids costly T&D infrastructure upgrades / reduces ratepayer costs
• Expedites solutions by reducing permitting and construction time
• Extends life / increases utilization of existing infrastructure
Convergent commissioned a 500 kW, 6 hour grid-connected resource to help resolve a sub-transmission constraint in Boothbay, Maine

BOOTHBAY MAINE PROJECT EXAMPLE

“Non-Transmission Alternative” in Boothbay, Maine

- $18M in upgrade deferrals for Central Maine Power (CMP) as part of a 2 MW pilot program administered by GridSolar LLC
- 10 months from contract signing to COD (Interconnection processes had the longest lead times / limiting factors)

<table>
<thead>
<tr>
<th>Project Specs</th>
<th>0.5 MW for 6 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contract Terms</td>
<td>Long term agreement to dispatch with 5 minutes notice in summer</td>
</tr>
<tr>
<td>Technology</td>
<td>Lockheed Martin integration; advanced Pb-Acid batteries</td>
</tr>
</tbody>
</table>
CEP building 12 MWs of projects to address differing grid constraints in Ontario

OTHER PROJECT EXAMPLES

5 MW, 0.5 MWh Flywheel

- **Application**: fast response frequency regulation
- **Technology**: mechanical flywheel with extremely long cycle life
- **Location**: in a fast load growth section of northern Toronto interconnected to the 115 kV transmission system

7 MW, 7 MWh Battery

- **Application**: reactive support and voltage control
- **Technology**: lithium-ion battery integrated by GE
- **Location**: in a 120 MW load pocket on a radial 115 kV transmission line; 60 MWs of PV solar recently added
Primary cost is in the AC-DC system (>75% typically)

### TYPICAL BATTERY PROJECT LAYOUT

#### DC Technology
- Storage medium
- Thermal management
- Monitoring & management system
- Containerization & integration
- DC aggregation in series & parallel
- ~600 V DC

#### AC-DC Conversion
- Inverter / rectifier
- Reactive & real power control
- Communications & software
- Containerization & integration
- 480 V AC

#### Site Work & Interconnection
- Switchgear, breakers / relays / other protection
- Transformation
- AC interconnection
- Civil & electrical work
- Concrete / foundations
Proven storage technologies are available today to address a wide range of applications

## STORAGE TECHNOLOGIES OVERVIEW

<table>
<thead>
<tr>
<th>Description</th>
<th>Key Points</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Value</strong></td>
<td><strong>Key Points</strong></td>
<td><strong>Summary</strong></td>
</tr>
<tr>
<td>Regulated Lead Acid (VRLA)</td>
<td>Proven tech</td>
<td>Low cost / highly financeable</td>
</tr>
<tr>
<td></td>
<td>Used in vast majority of back-up power industry</td>
<td>Proven tech with long track record of safety / performance</td>
</tr>
<tr>
<td>Lithium Ion</td>
<td>Variety of vendors, chemistries, &amp; specs</td>
<td>Growing track record, commercial availability</td>
</tr>
<tr>
<td></td>
<td>High energy density</td>
<td>Pricing dropping ~20% Y-O-Y</td>
</tr>
<tr>
<td>Liquid Metal</td>
<td>High temp operations (~300 C)</td>
<td>Higher price points; manufacturers phasing out</td>
</tr>
<tr>
<td></td>
<td>Large manufacturers</td>
<td></td>
</tr>
<tr>
<td>Flywheels</td>
<td>High RPMs in a vacuum</td>
<td>For power apps only</td>
</tr>
<tr>
<td></td>
<td>Delivers power, not energy</td>
<td></td>
</tr>
</tbody>
</table>

Pricing = AC-integrated cost; no install, site prep, interconnection, financing, etc.
A large group of technology developers are working on next generation energy storage solutions; significant uncertainty but high upside

NEW TECHS & FLOW BATTERIES

**Description**
- Early commercialization
- Promising specs & prices
- Small manufacturers & commercial volumes

**Key Points**
- Inexpensive: $200-$500 / kWh*
- High cycle life: 10-30 years
- Higher energy density (in some cases)

**Summary**
- In pilot / pre-pilot stages
- Promising optionality
- Enticing price points
- Minimal track records
- Early stages of financability

* AC-integrated cost; no install, site prep, interconnection, etc.
4 MWs (and 4 hours) can fit in 0.25 acres using currently available commercial technologies

**EXAMPLE 4 MW, 16 MWH LI-ION SITE SCHEMATIC**

**Key Attributes:**

- Flexible interconnection
- Full install requires ~11,000 SF (0.25 acres) including clearances
- Includes battery degradation to ensure full 4 MW, 4-hour rating over 10 years
Maine requires IOUs to consider NTA solutions first; challenging topography & known infrastructure constraints create storage opportunities

ENERGY STORAGE OPPORTUNITIES IN MAINE

• Omnibus Energy Bill\(^1\) opened ME markets to non-transmission alternatives (“NTA”)
  » 3\(^{rd}\) party analysis of non-transmission alternatives (NTAs) conducted alongside transmission upgrade \(^2\)
  » NTA favored by PUC if less than traditional upgrade
  » Preference given to NTAs with low emissions

• Several Maine areas served by radial lines with growing summer loads
  » CMP has identified ~40 MW of needed NTA resources in mid-coast region

• Larger transmission issues arising from north-south transport of new wind energy

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1. State of Maine Legislature **LD 1559** (HP 1128)
2. Required for transmission upgrades > 69kV or ≤ 69kV with value over $20M
Goal: make energy storage an attractive opportunity for utilities

UTILITY OPPORTUNITY

- Control energy storage asset design, location, interconnection and operations to resolve otherwise expensive or difficult-to-solve constraints
- Expand and optimize capital spend opportunities
- Help define / shape regulatory environment and “utility of the future”
- Vendors (like CEP!) can provide new contracting mechanisms to diversify risk and make storage work for utilities NOW

25 MW, 4 hour ground layout
CEP solutions are competitively priced now and will be even more so in a few years.

### CEP INDICATIVE PRICING

<table>
<thead>
<tr>
<th>Online Date</th>
<th>Asset Size</th>
<th>10-Year Contract Price NPV * from CEP</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>MW</td>
<td>MWh</td>
</tr>
<tr>
<td>May 2016</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>May 2017</td>
<td>5</td>
<td>20</td>
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<td>May 2018</td>
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<td>20</td>
</tr>
<tr>
<td>May 2019</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>May 2020</td>
<td>5</td>
<td>20</td>
</tr>
</tbody>
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**Price Comparables:**

- ConEd (NYC) demand management incentives for ES = $2,100 – $2,340 / kW
- New-build CT gas capacity** = $1,200 – $1,500 / kW
- Residential solar installed cost = $3,500 – $4,000 / kW
- Utility-scale solar = $2,000 – $2,500 / kW

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* 8% discount rate; includes NE market revenues to lower 10-year pricing
** LMS100 GE CT in NE
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