Beacon Power
20 MW Frequency Regulation Plant

November 3, 2010

Funded in part by the Energy Storage Systems Program of the U.S. Department Of Energy through National Energy Technology Laboratory
Safe Harbor Statement

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Acknowledgments

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Beacon Power Overview

• Spinoff from SatCon 1998
• NASDQ November 2000
• Provider of fast-response flywheel energy storage for grid-scale frequency regulation
• Operating under ISO-NE since Nov 2008
• 60 MW’s under development
  – Stephentown, NY; $43M DOE loan guarantee
  – Hazle, PA; $24M DOE Stimulus Grant, PA budgeted $5M for 20 MW plant
  – Glenville, NY
• $2.25M DOE ARPA-E grant award to develop a flywheel for new applications
Technology

- Composite Rim
- Magnetic Bearing
- Vacuum Chamber
- Hub
- Motor
- Shaft

- 20-year design life
- 125,000 equivalent cycles
- Available à la carte
- Low operating cost
- Zero emissions
Flywheel Product Evolution

- Over 600,000 hours of operation in the field. Units running continuously without service 9 years.
- Technology is product of 10 years of R&D and testing at a cost of $180M.

Gen 1
Telecom
2 kWh / 1 kW

2000

Gen 2
Telecom
5 kWh / 2 kW

2001

Gen 3
Grid
4 kWh / 15 kW

2004

Gen 4
Grid
25 kWh / 100 kW

2006-2007

1 MW Module
10 Gen 4 Flywheels

2008

205-6

(2) 100 kW demo system
(DOE co-sponsored)

20 MW Plant Constructed in Stephentown NY

2010
From Flywheel to 20 MW Plant
Typical “Regulation” Profile

ISO Goal:
Load = Power Generated

Power < Load:
  - Frequency drops under 50/60 Hz.

Power > Load:
  - Frequency rises over 60 Hz.

Short term variation
  - ~ 1% of daily load
  - Managed via regulation
  - Fluctuation is net zero

Video available www.beaconpower.com
Fast Regulation: Speed Matters

A coal-fired power plant poorly following a regulation command signal

A 20 MW flywheel energy storage resource accurately following a signal

Flywheels provide “near instantaneous” response
Gen4 Flywheel Production
Ramping Up Production
1MW / 250 kWh Module

- 10 100kW / 25 kWh flywheels
- Transformers and support equipment
- Electronics and controls inside container
Market Entry Strategy

• Build, own and operate merchant regulation plants
  (Typically 20 MW)
• Sell services essential to the grid (24/7)
• Serve open and well-established markets
• Endorsed by the customer (i.e., grid operators)
• Leverage carbon reduction
U.S. Markets for Regulation Services

- Four open-bid markets accessible now
- California planning new tariff
- ERCOT initial steps under way
DOE Loan Guarantee

• $43M Loan Guarantee closed Aug 5, 2010
• Began construction late in 2009
• 4 MW to be online by the end of 2010.
• Full capacity 1st QTR 2011
Flywheel Energy Storage Plant

- 200 high-speed, high-energy 25 kWh/100 kW flywheels
- +/- 20MW Regulating Range:
- Energy storage capacity: 20 MW for 15 minutes
- Fast response: Achieves full up or down power in less than four seconds after receiving ISO’s control signal
- Quickly and precisely follows moment-by-moment changes in load and generation

Construction of 20 MW plant in Stephentown, NY
Construction Underway
Flywheel Foundations
20 MW Power Transformer
Plant Switchgear Building
View of North Loop Nearly Complete
Flywheels arriving at Stephentown
Flywheel Installation
Control System in Place
Market Rule Best Practice: Create Energy Storage Category

- Storage provides regulation by recycling energy and behaving like a generator and load

Energy Storage should be treated as a separate asset class from Generation and Load
Favorable Market Trends

• Several studies have forecast a sizeable increase in regulation requirements as more wind and solar resources are deployed.

• Pay-for-performance model proven in ISO-NE expected to be used in more markets.

• Establishing a price on carbon expected to increase regulation pricing.
New York ISO Forecast Regulation

Regulation Req. vs. Wind Level

As shown in the graph below, the average regulation requirement increases approximately 9% for every 1,000MW increase between the 4,250MW and 8,000MW wind penetration level.

Requirement increases by 60% with 10% wind
“PJM expects the requirement for regulation to increase from 1,000 MW today to 2,000 MW when we reach 20% wind penetration.”

– Terry Boston, CEO of PJM
Storage Week conference, July 13, 2010

Requirement increases by 200% with 20% wind
# CAISO Forecast Regulation Needs

Expected increase in Regulation capacity (MW) requirements at 20% and 33% RPS (Spring*)

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th>2012</th>
<th>2020</th>
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</thead>
<tbody>
<tr>
<td>Maximum Regulation Up</td>
<td>277</td>
<td>502</td>
<td>1,135</td>
</tr>
<tr>
<td>Requirement (MW)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Regulation</td>
<td>-382</td>
<td>-569</td>
<td>-1,097</td>
</tr>
<tr>
<td>Down Requirement</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>(MW)</td>
<td></td>
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Requirement increases by 300% with 33% wind
Cyclic Content for Storage Based Regulation in ISO-NE Pilot Program

- Typical energy requirement for fast regulation in ISO-NE pilot
- 6300 effective 100% Depth of Discharge cycles / year
- This is the most demanding cyclic grid storage application
ISO-NE Operational Data

Data from 1 MW in ISO-NE Alternative Regulation Pilot
Tyngsboro - May 11th, 2009

Regulation Deployment (in MW from Baseline Power)

-1.0
-0.5
0.0
0.5
1.0


Beacon Power Flywheel Actual Signal Response
Allowable Generator Response in New England
Benefits of Pay-for-Performance

- ISO-NE procures the least amount of regulation as a % of load than any other ISO
- ISO-NE is the only market that has a “pay-for-performance” component in regulation settlement

<table>
<thead>
<tr>
<th>2008 Status</th>
<th>ISO-NE</th>
<th>PJM</th>
<th>NYISO</th>
<th>CAISO</th>
</tr>
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<tbody>
<tr>
<td>“Fast First” Dispatch</td>
<td>✔</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Pay-for-Performance</td>
<td>✔</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Maximum Allowable Response</td>
<td>5 minutes</td>
<td>5 minutes</td>
<td>5 minutes</td>
<td>10 minutes</td>
</tr>
<tr>
<td>Regulation Procurement (as % of Avg. Load)</td>
<td>0.80%</td>
<td>1.11%</td>
<td>1.13%</td>
<td>1.35%</td>
</tr>
<tr>
<td>Procurement vs. New England (as % of baseline)</td>
<td>100%</td>
<td>139%</td>
<td>141%</td>
<td>169%</td>
</tr>
</tbody>
</table>

Fast and accurate regulation reduces the size and overall expense of the regulation market.
• Hazle Township, Pennsylvania or Chicago, IL
• Will apply $24 million smart grid stimulus grant to this plant
• Pennsylvania has earmarked a $5 million grant for PA plant
• Interconnection process initiated in both locations
• Both locations continue to be developed; final decision will be determined by timing and cost
3rd Plant Development: NYISO

- Secured control of industrial site in Glenville NY
- Interconnection process initiated
Smart Grid of the Future?

Does this really make sense?
Smart Grid of the Future

Zero emissions storage-based regulation… is a better performing, more cost-effective resource… a smart grid match for clean wind generation…
Thank You
(Q & A)

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