# 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***

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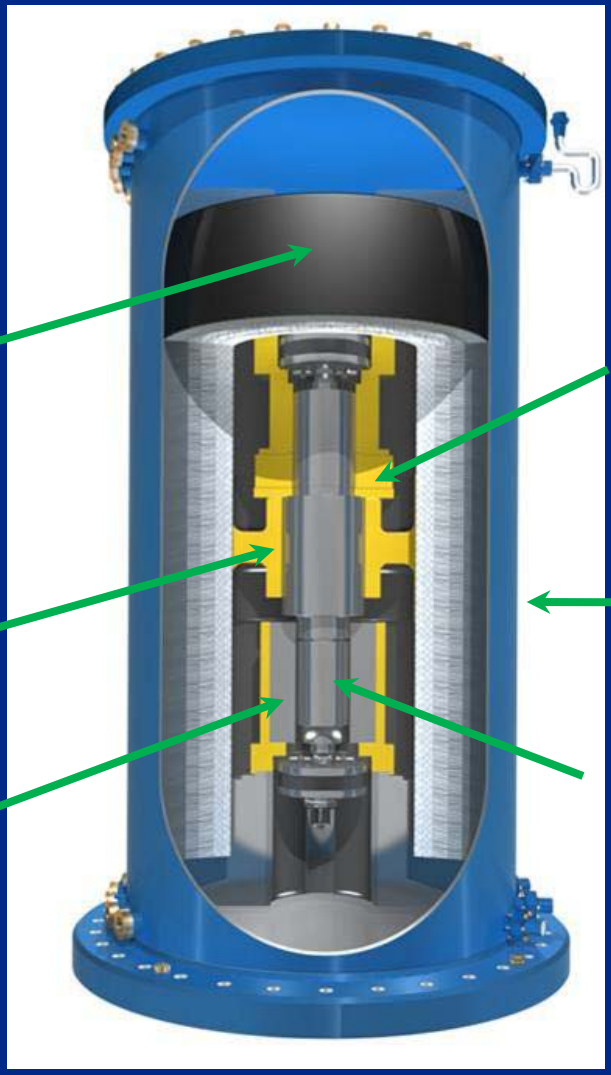
# Acknowledgments


- DOE- Imre Gyuk
- Sandia - Georgianne Huff – Garth Corey – Dan Borneo
- NYSERDA – Joe Sayer
- CEC – Promod Kulkarni – Mike Gravely

# 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




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

# Flywheel Product Evolution

**2000**

**Gen 1**
**Telecom**
**2 kWh / 1 kW**

**2001**

**Gen 2**
**Telecom**
**5 kWh / 2 kW**

**2004**

**Gen 3**
**Grid**
**4 kWh / 15 kW**

**2005-6**

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

**2006-2007**

**Gen 4**
**Grid**
**25 kWh / 100 kW**

**2008**

**1 MW Module**
**10 Gen 4 Flywheels**

**2010**

20 MW Plant Constructed in
Stephentown NY

- 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

# From Flywheel to 20 MW Plant

# Typical “Regulation” Profile

**ISO Goal:**

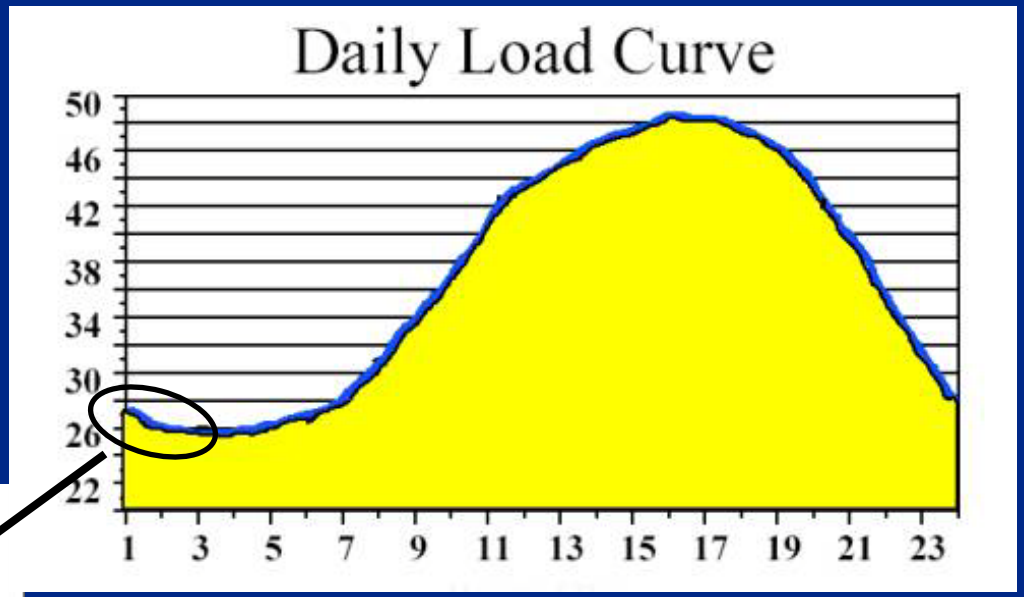
**Load = Power Generated**

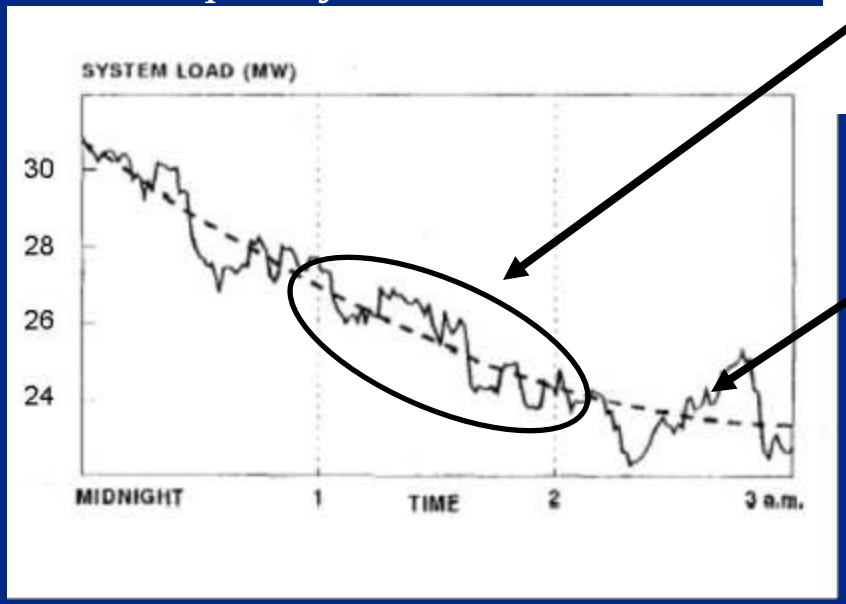
**Power < Load:**

– Frequency drops under 50/60 Hz.

**Power > Load:**

– Frequency rises over 60 Hz.



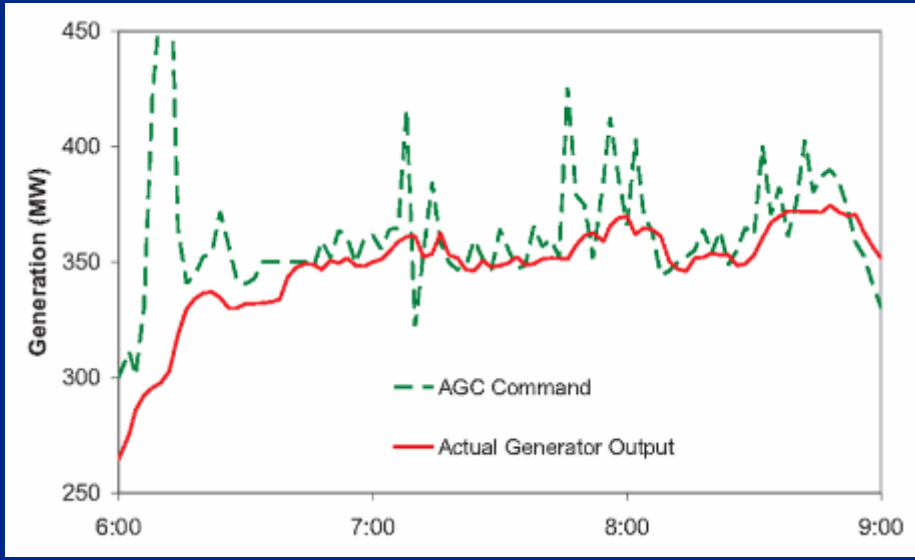




Short term variation

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

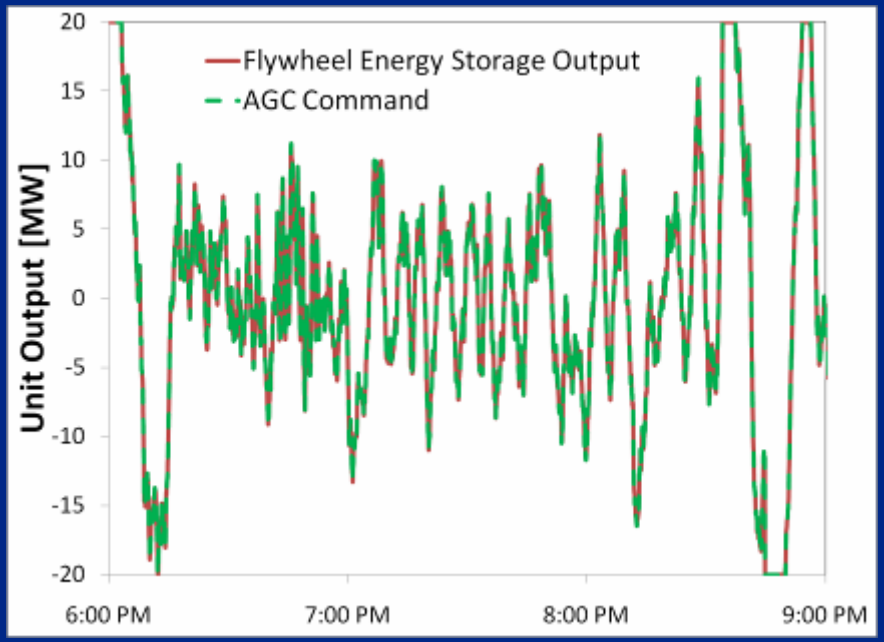
Video available www.beaconpower.com

# 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

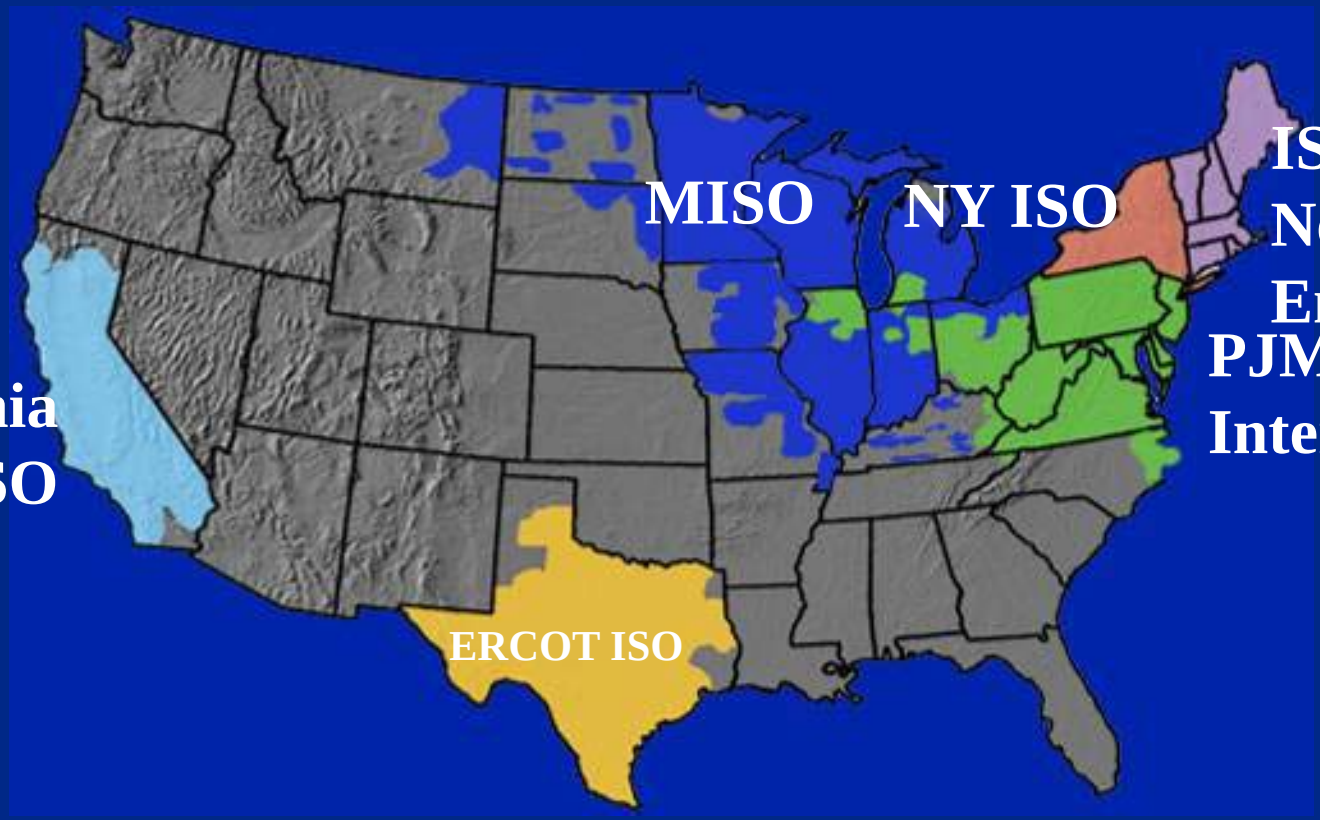
- 10 100kW / 25 kWh flywheels
- Transformers and support equipment
- Electronics  and controls inside container

# 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

# Electronics Module Placement

# 20 MW Power Transformer

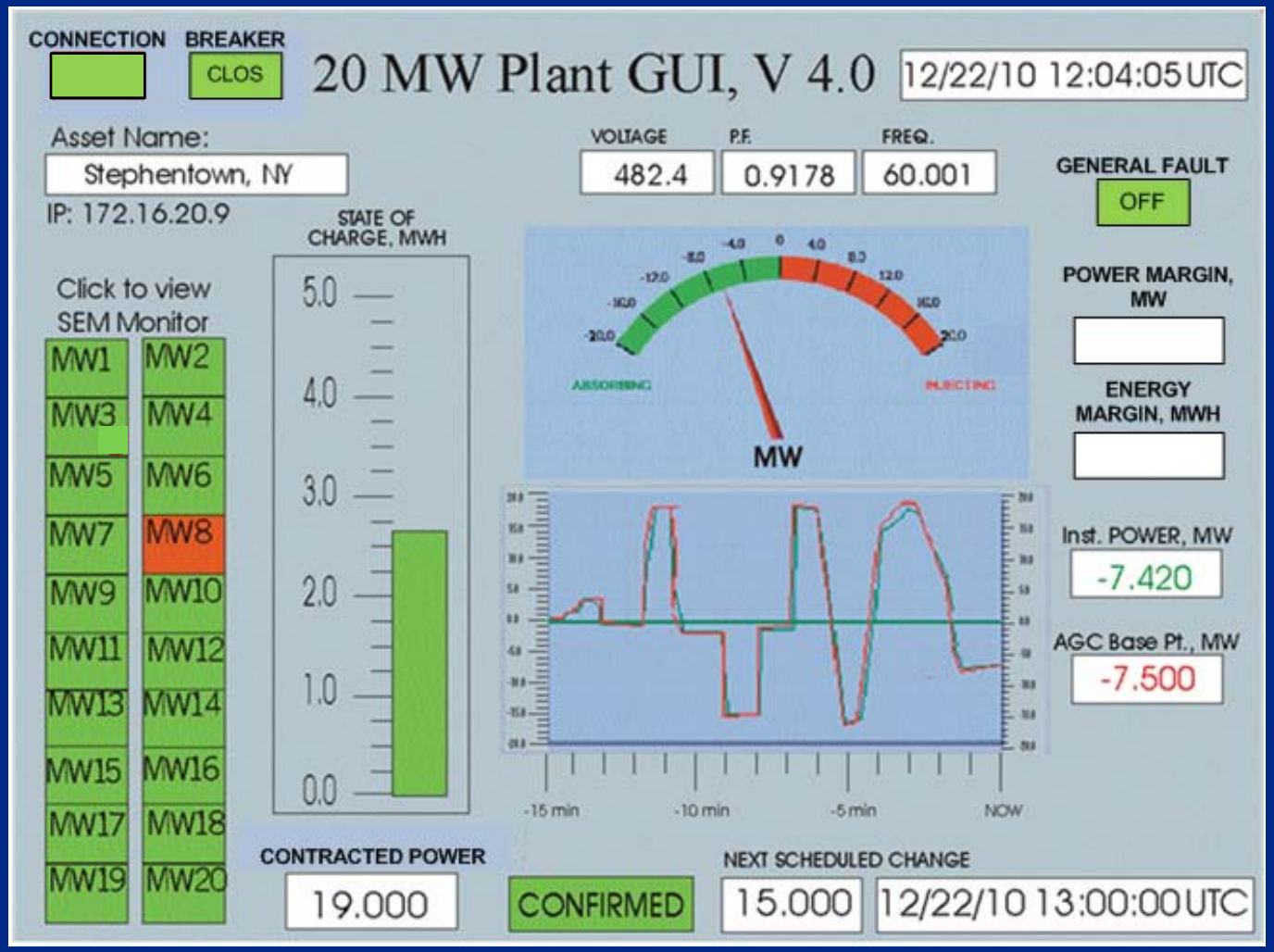
# Plant Switchgear Building

# View of North Loop Nearly Complete

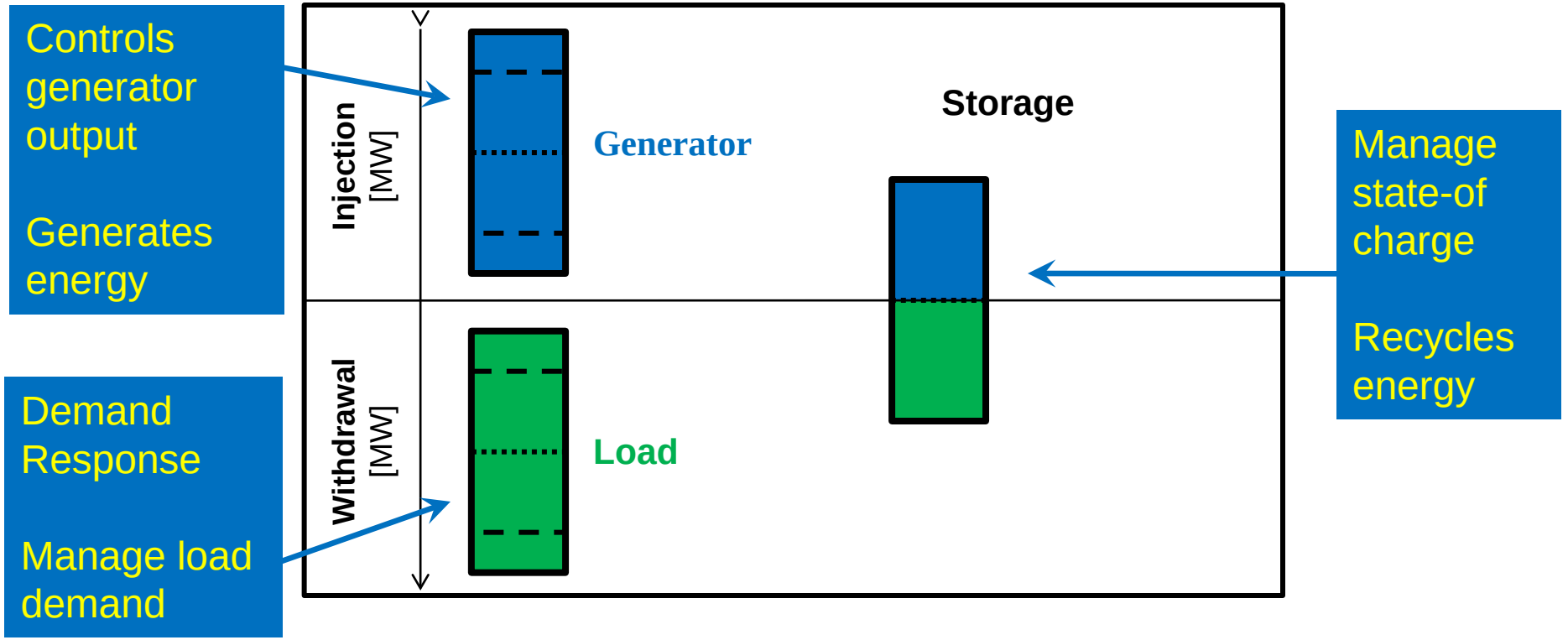
# Flywheels arriving at Stephentown

# 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***

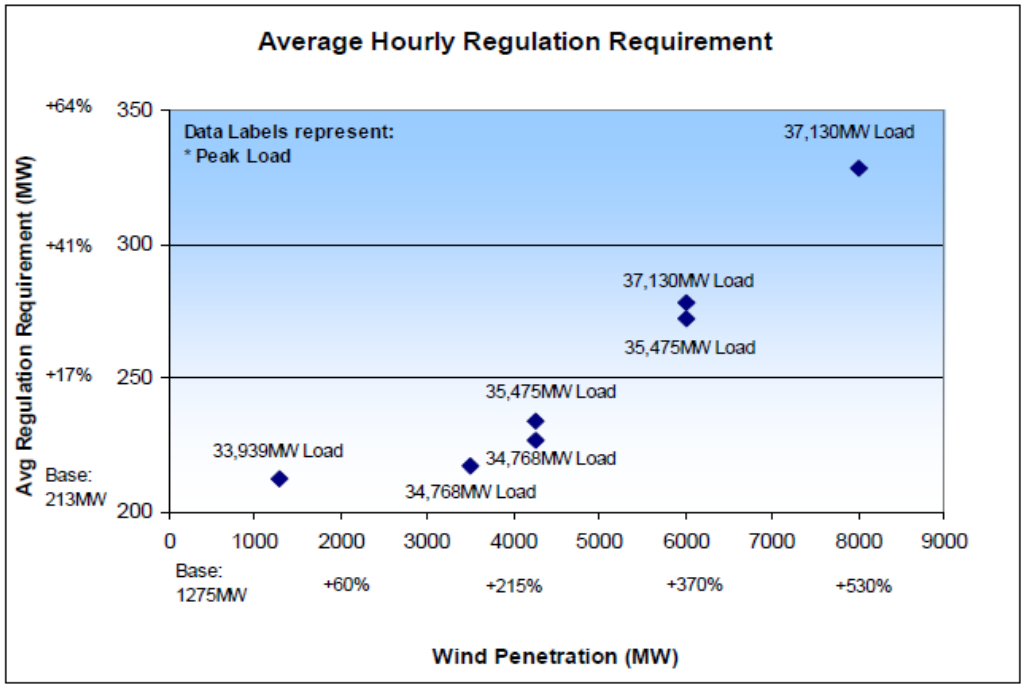
# Favorable Market Trends

- 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 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 Forecast Regulation Needs

*"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

Beacon POWER

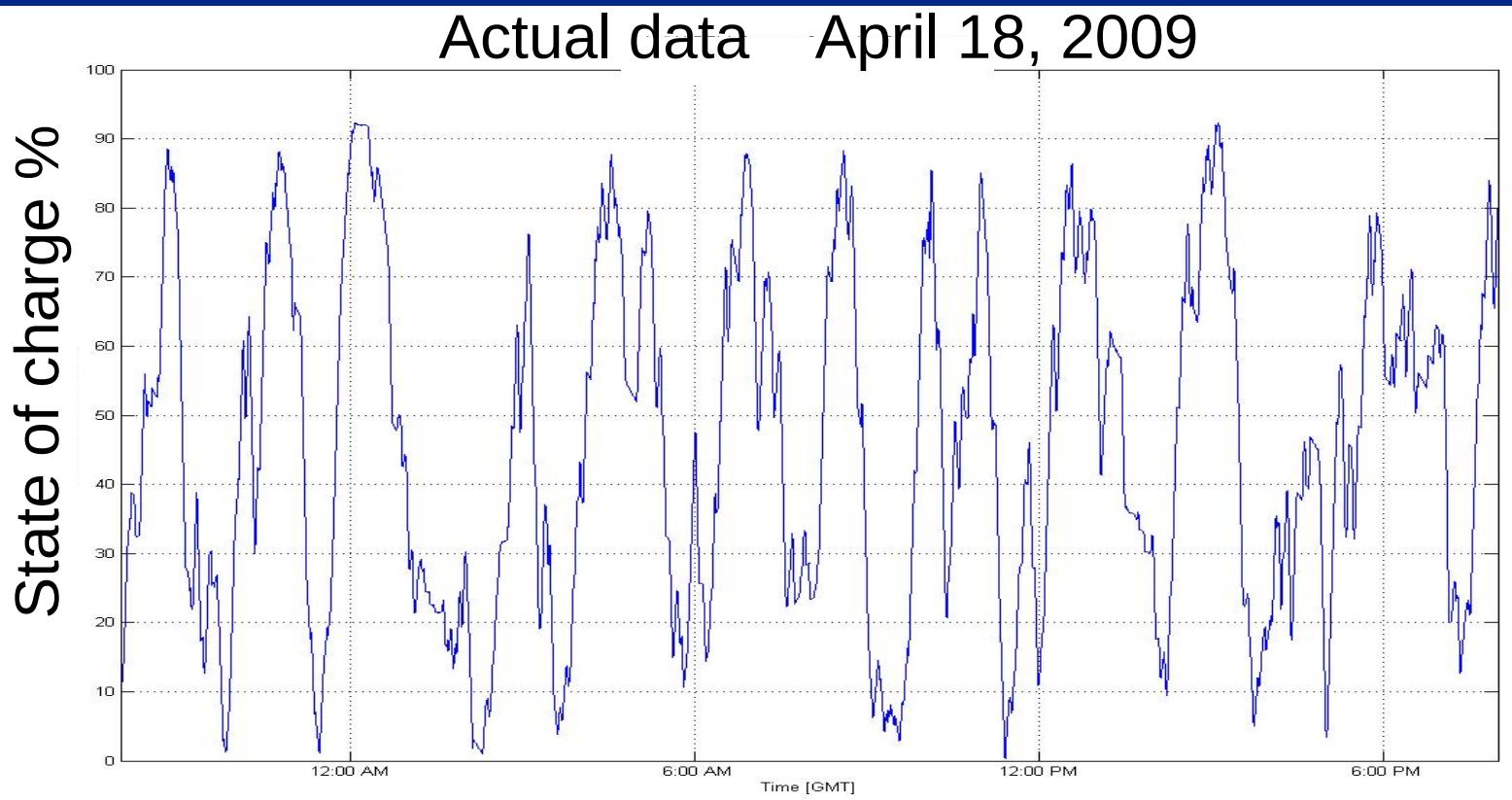
## Expected increase in Regulation capacity (MW) requirements at 20% and 33% RPS (Spring*)

| | 2006 | 2012 | 2020 |
|---|---|---|---|
| Maximum Regulation Up Requirement (MW) | 277 | 502 | 1,135 |
| Maximum Regulation Down Requirement (MW) | -382 | -569 | -1,097 |

California ISO
Your Link to Power

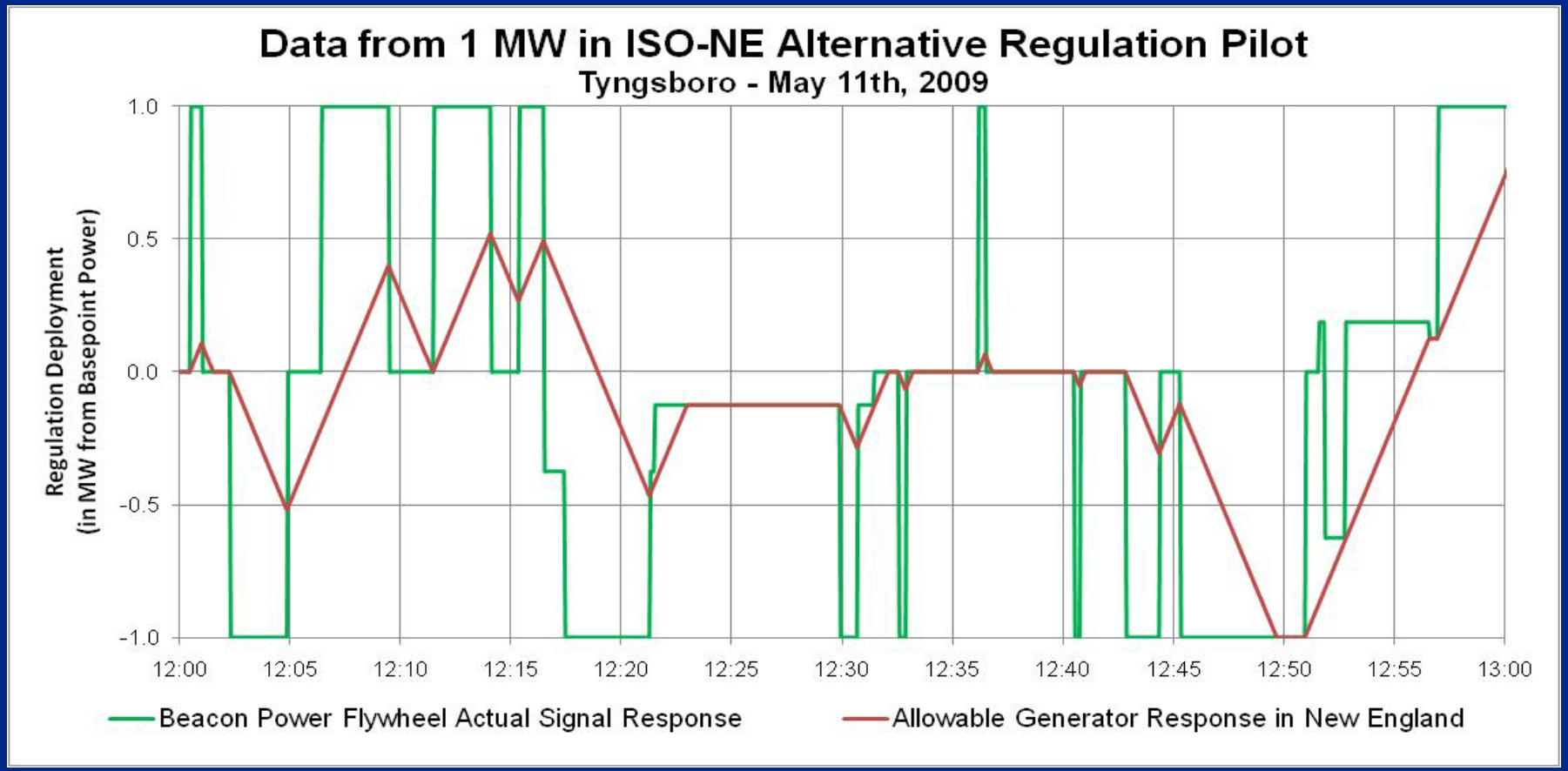
Requirement increases by 300% with 33% wind

# 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



# Benefits of Pay-for-Performance

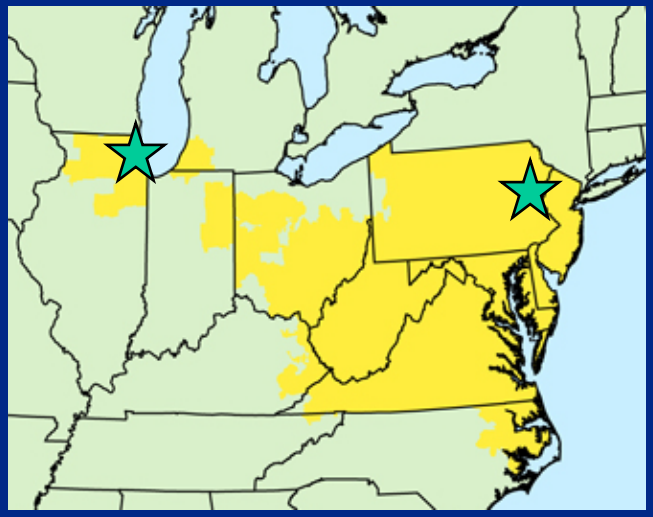
- ISO-NE procures the least amount of regulation as a % of load than any other ISO
- ISO-NE is the only market that has a “pay-for-performance” component in regulation settlement

| 2008 Status | ISO-NE | PJM | NYISO | CAISO |
|---|---|---|---|---|
| “Fast First” Dispatch | ✓ | N | N | N |
| Pay-for-Performance | ✓ | N | N | N |
| Maximum Allowable Response | 5 minutes | 5 minutes | 5 minutes | 10 minutes |
| Regulation Procurement (as % of Avg. Load) | 0.80% | 1.11% | 1.13% | 1.35% |
| Procurement vs. New England | 100% (baseline) | 139% | 141% | 169% |

Fast and accurate regulation reduces the size and overall expense of the regulation market

# 2nd Plant Development: PJM

- 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)*

**Jim Arseneaux**
**arseneaux@beaconpower.com**

**978-661-2097**