

20 MW Flywheel Energy Storage Plant



Hazle Spindle – Hazle Township, PA



Acknowledgements

Thanks to the following who supported this project

- DOE's Office of Electricity and Dr. Imre Gyuk, Program Manager of the Electrical Energy Storage Program
- NETL – Ron Staubly, Project Manager
- Pennsylvania PUC
- PPL
- PJM



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Purpose of Hazle Project

- Develop additional experience in performing frequency regulation in different locations.
- Speed the deployment of fast response flywheel-based frequency regulation
- Build on experience of 20 MW plant in NYISO
- Validate modifications in FESS design from Stephentown
- Obtain experience interconnecting into a different Utility and ISO
- Gain experience in PJM Fast Response Regulation Market
- Continue to explore additional applications and revenue streams

Third Plant in Commercial Operation

Over 40 MW & 7 Million Hours In Commercial Operation



Tyngsboro, MA
0.5 MW
Operating since 2008



Stephentown, NY
20 MW Facility
Operating since Q1 2011



Hazle, PA
20 MW Facility
Operations from Sep 2013
Full COD July 2014



Beacon Power – fourth largest deployed ES capacity in 3Q 2013*

*excluding traditional pumped storage, CAES and solar thermal, Navigant Research “Stationary Storage in Utility Applications”, May 2014



Changes from Stephentown to Hazle

- Design Improvements
 - Hub material improvement
 - Improvements to rotor lock to prevent bearing damage
 - Simplified cooling system
 - Vendor process improvements
 - Software updates
- Interconnection to PPL transmission system at 69 kV
- Participating in PJM Fast Response Regulation Market

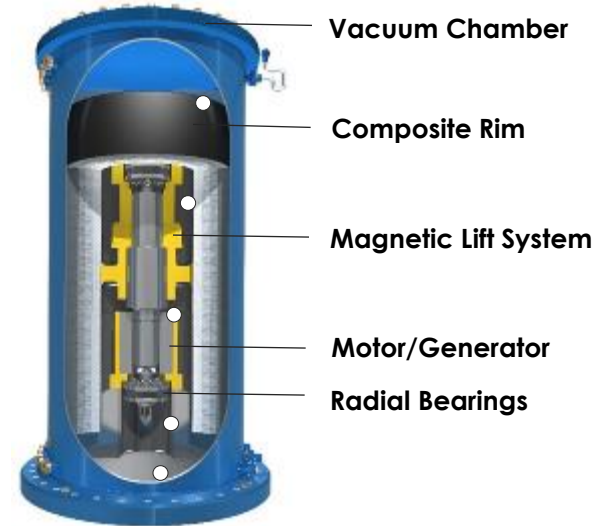


Hazle Project Milestones

- Groundbreaking – Spring 2013
- Began operation at 4 MW – Sept 2013
- Major site work complete– April 2014
- Last flywheel delivered – July 2014
- Full commercial operation at 20 MW
July 2014

Beacon BP- 400 Flywheel

- ~7' tall, 3' in diameter
- 2,500 pound rotor mass
- Spins up to 15,500 rpm
- Max power rating **100** kW, **25** KWh charge and discharge
- Lifetime throughput is over 4,375 MWh
- Capable of charging or discharging at full rated power without restriction
- Beacon flywheel technology is protected by over 60 patents



BP - 400 Flywheel in Production



Hazle Plant Construction

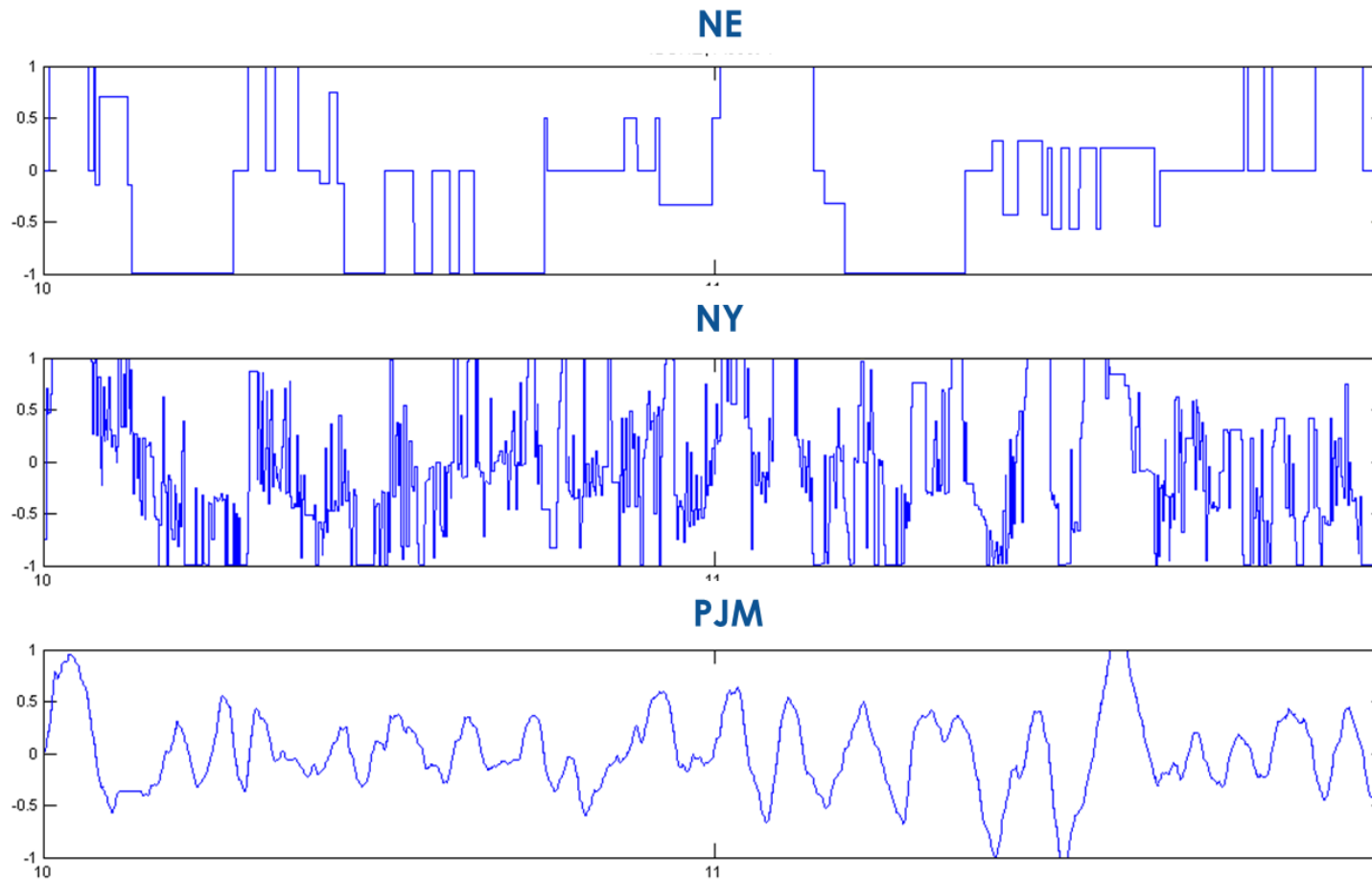


Plant Performance



System online 24/7 with >98% Availability and >97 % Accuracy

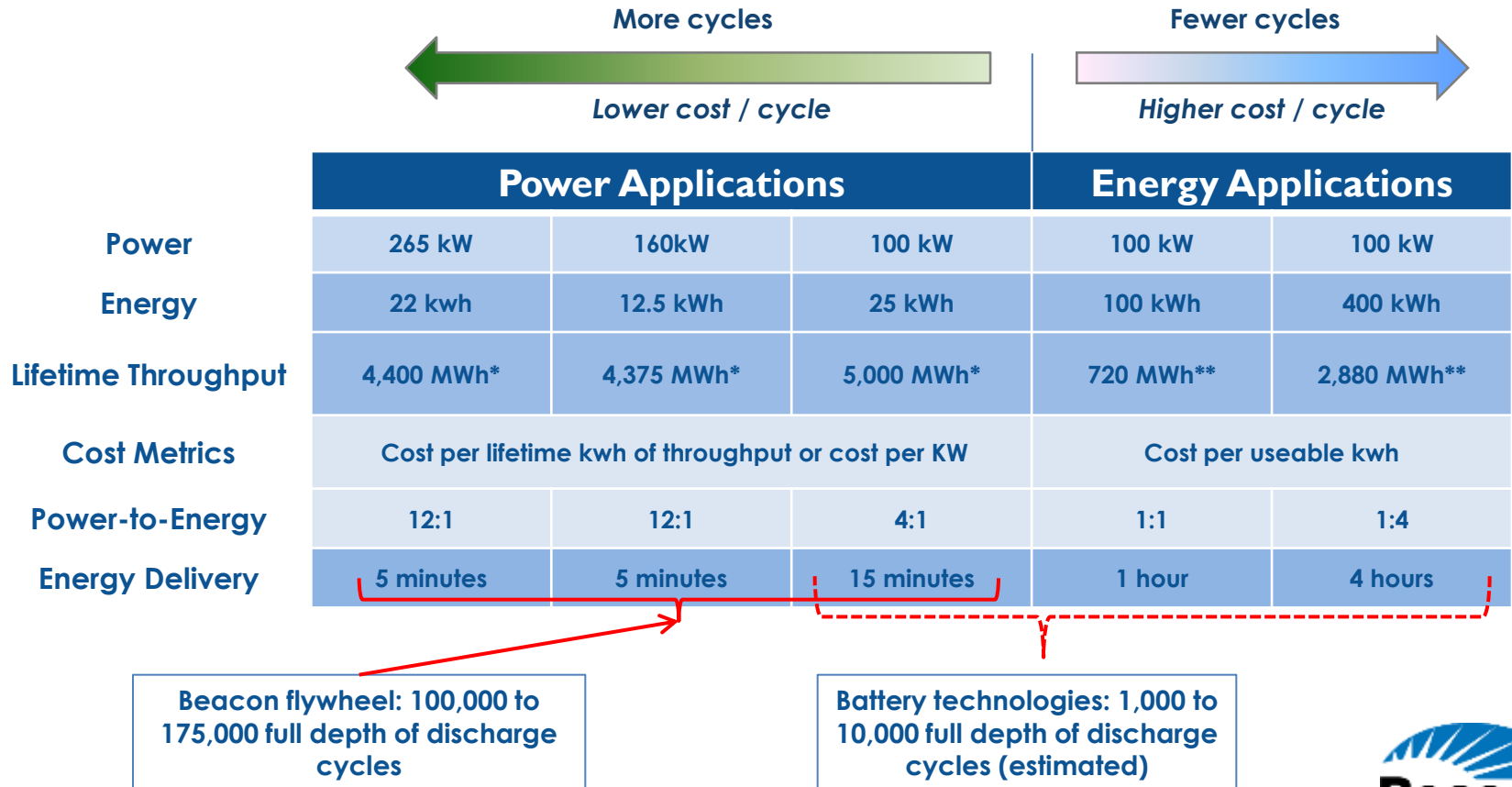
Flywheel Regulation – ISO Market Experience



- Actual data from plant operations normalized to +/- 1 MW
- 2 hour plot

Substantial differences in how ISOs dispatch fast resources currently. Markets are still developing on how to best fully utilize these plants.

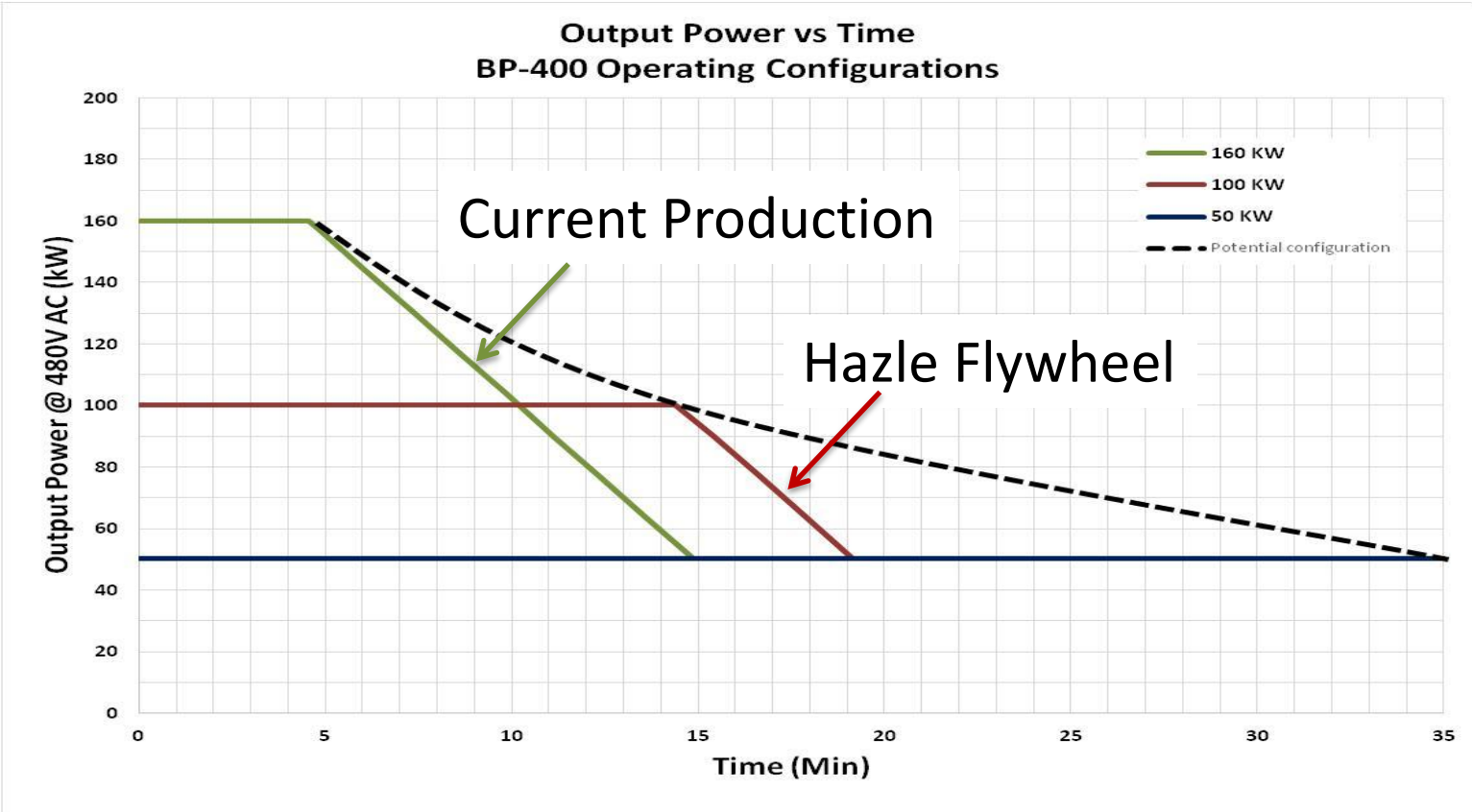
Flywheel vs. Battery Comparison



(*Beacon throughput. **Assumes 5,000 cycles , 80% useable SOC, 10% avg. lifetime degradation)



Beacon BP-400 Flywheel: Power & Energy



Same flywheel with more power now available

Current Production Modular Design

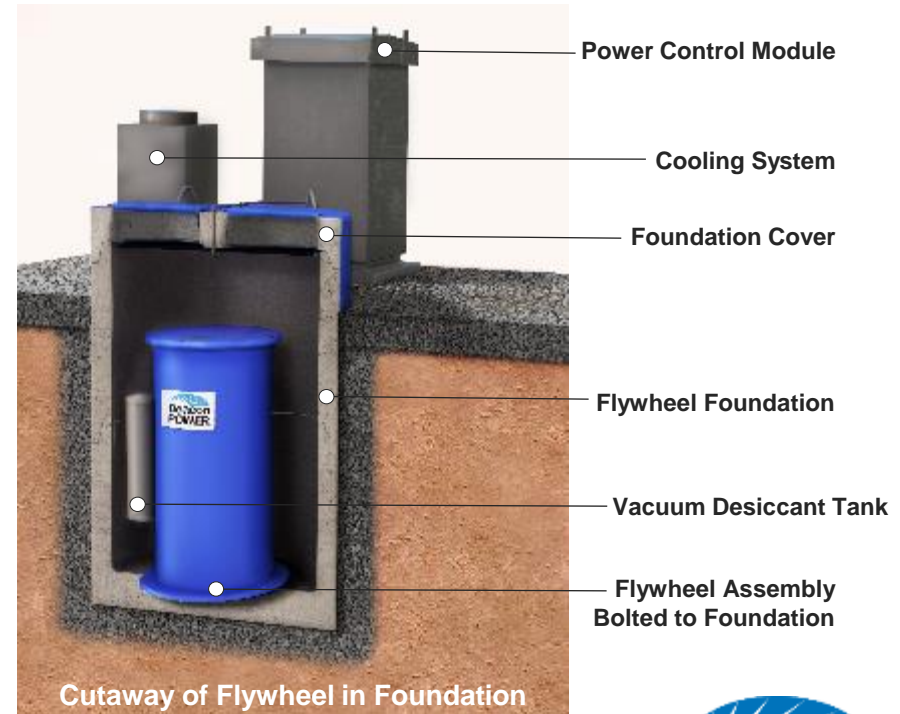
Lower Cost

- Eliminates containers
- Less on site construction
- Higher power means less flywheels per plant

Easy Installation

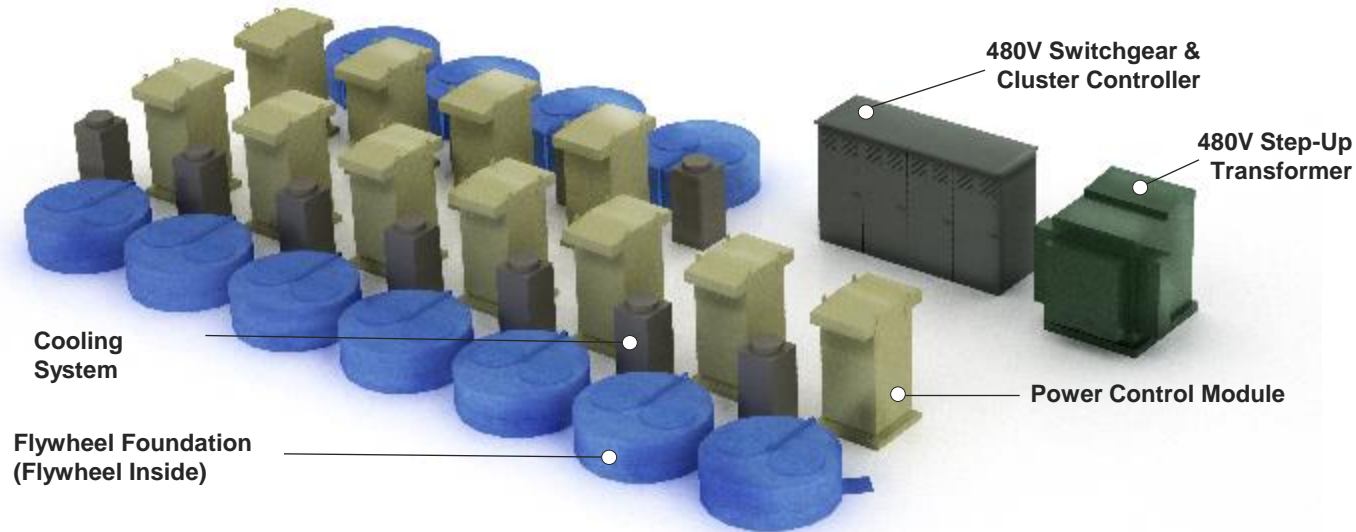
- Smaller components
- Moderates climate conditions
- Allows service access

Less Land Required / Smaller footprint



Representative Flywheel Energy Storage Systems

2 MW Configuration



- Fully distributed architecture facilitates permitting & siting
- System operation at any size from 100 kW to multi-MW power blocks

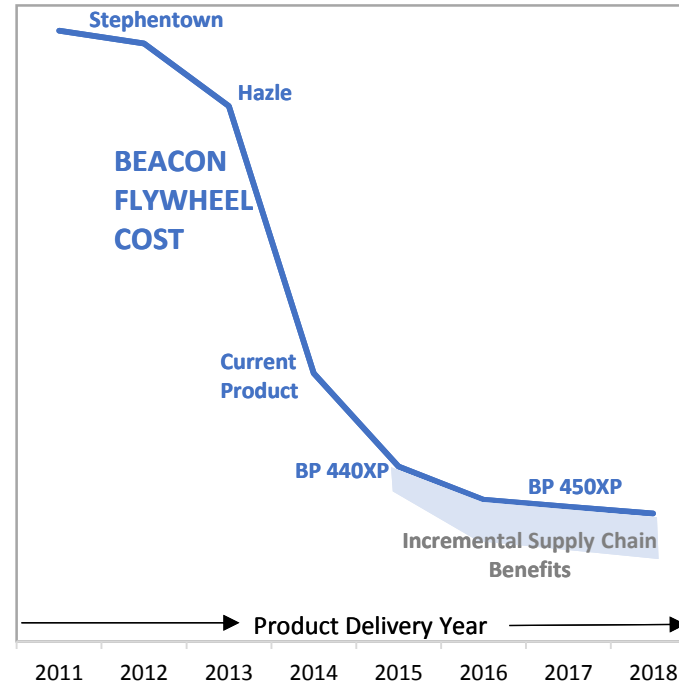
Next 20 MW Plant Site Layout



Product Development Road Map

- ▶ Beacon flywheel capital cost decreasing rapidly
- ▶ Learning from existing operations and market discussions
- ▶ Improvements in
 - ▶ storage device
 - ▶ system controls and
 - ▶ balance of plant
- ▶ Incremental supply chain and manufacturing potential

\$/kW Cost Reduction Roadmap
PJM Interconnect Type Installation



Cost decreasing rapidly with each project

Summary

- Hazle Township construction complete
- Plant online at 20 MW
- Changes from Stephentown to Hazle being validated and resulting in lower maintenance cost.
- Performance of plant continues to meet expectations
 - Availability >98%
 - Accuracy >97%
- Lessons on market needs being reflected in next generation products.

Thank you.



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