



# Spinning a Solution to Momentary Electric Grid Disturbances

## Successes from Hazle Spindle’s Smart Grid Demonstration Project

### Introduction

The Hazle Spindle flywheel grid frequency regulation project, part of the [Smart Grid Demonstration Program](#) (SGDP), is making the grid more reliable at its Humboldt Industrial Park plant in Hazle Township, Pa.

With its \$52.4-million cooperative research agreement under the U.S. Department of Energy’s Smart Grid Demonstration Program, which provided \$24.1 million, the recipient, originally named Beacon Power, was to design, build and operate a utility-scale 20 MW flywheel plant, where power from the electric grid can accelerate the flywheel, which can then return the power to the grid when needed, with few losses. The Beacon Gen4 flywheel is designed to provide 100 kW of output and store 25 kWh of energy. Two hundred flywheels were connected in parallel to provide 20 MW in capacity, spanning a 40 MW range of frequency

“[Flywheels] can deliver at least twice as much frequency regulation from each megawatt of capacity as a typical natural-gas-fired power plant while cutting carbon emissions in half.”



Figure 1. A flywheel

regulation. The system can fully respond to a grid imbalance in less than four seconds, allowing it to correct short-term unpredictable imbalances in electricity supply and demand. Because the system is mechanical, it can repeatedly operate at 75% depth of discharge with 85% round-trip efficiency, and is sturdy enough so there is virtually no energy degradation over time. The flywheels are built to last at least 20 years, or 100,000 cycles at full rated depth of discharge<sup>1</sup>.

Virtually no maintenance is required in the mechanical portion of the flywheel system.

Flywheels occupy a special niche in the grid ecosystem because of their rapid response time, their energy density is less than most other energy sources, however, like batteries they can respond to grid disturbances within milliseconds, correcting imbalances in electricity supply and demand<sup>2</sup> more efficiently than traditional generators

<sup>1</sup>Flywheel Energy Storage System, Beacon Power specification sheet, [http://www.mytopschool.net/mysti2d/activites/poly nesie2/ETT/C011/21/StockageEnergie/files/Documents/FESS\\_Tech\\_Data\\_Sheet.pdf](http://www.mytopschool.net/mysti2d/activites/poly nesie2/ETT/C011/21/StockageEnergie/files/Documents/FESS_Tech_Data_Sheet.pdf), accessed 2/9/15

<sup>2</sup>MarketWired, Beacon Power Installs First Flywheels at Pennsylvania Energy Storage Plant, <http://www.marketwired.com/press-release/beacon-power-installs-first-flywheels-at-pennsylvania-energy-storage-plant-1804470.htm>, June 21, 2013, accessed 1/20/15

while not consuming additional fuel or producing new emissions. They also use no hazardous materials or water.

The Hazle Spindle project deployed flywheels supplying fast frequency regulation service to the grid in the PJM Interconnection market. Currently, the complete 20 MW storage plant is operational. "PJM continues to welcome new technologies that provide diversity to the asset mix in PJM, as well as an opportunity to provide frequency regulation service," said Terry Boston, CEO and president of PJM Interconnection. "This will be the first flywheel technology placed into our regulation market."<sup>3</sup>



Figure 2. Courtesy of Hazle Spindle

## Performance

A final milestone to full operations was met when Hazle Spindle passed its 20 MW PJM regulation qualification test in September 2014. Operating currently at full capacity, the flywheel plant has delivered a cumulative 11,655 MWh of energy as of December 31, 2014.

## The new plant complements the Stephentown, NY plant

The Beacon power Gen4 flywheel technology consists of "1150-kilogram magnetically levitated flywheel motor-generators<sup>4</sup>." By adjusting their

rate of spin, these machines balance electrical supply and demand, regulating grid frequency near 60 hertz.

According to David Hawkins of KEMA, due to the quick response capabilities of flywheels, they "can deliver at least twice as much frequency regulation from each megawatt of capacity as a typical natural-gas-fired power plant while cutting carbon emissions in half.<sup>5</sup>" This is because flywheels are more specialized in their response to grid disturbances than gas generators, absorbing and releasing energy without reference to heat rates. Fast response resources such as flywheels and batteries do so rapidly enough to participate in ancillary service markets for frequency regulation<sup>6</sup>.

<sup>3</sup> Beacon Power press release to MarketWire, Beacon Power Installs First Flywheels at Pennsylvania Energy Storage Plant, June 21, 2013, <http://www.marketwired.com/press-release/beacon-power-installs-first-flywheels-at-pennsylvania-energy-storage-plant-1804470.htm>, accessed 2/4/2015

<sup>4</sup> IEEE Spectrum, Flywheels Keep the Grid in Tune, 6/27/11, [http://spectrum.ieee.org/energy/the-](http://spectrum.ieee.org/energy/the-smarter-grid/flywheels-keep-the-grid-in-tune)

[smarter-grid/flywheels-keep-the-grid-in-tune](http://spectrum.ieee.org/energy/the-smarter-grid/flywheels-keep-the-grid-in-tune), accessed 11/7/14

<sup>5</sup> IEEE, Flywheels keep the grid in tune, <http://spectrum.ieee.org/energy/the-smarter-grid/flywheels-keep-the-grid-in-tune>, 6/27/2011, accessed 2/9/15

<sup>6</sup> PJM, Ancillary Services, <http://www.pjm.com/markets-and-operations/ancillary-services.aspx>, accessed 1/9/2015

## Navigating tough waters: Emerging from bankruptcy

The Hazle Spindle project was originally managed by Beacon Power, which went bankrupt in 2012.

Rockland Capital acquired Beacon's assets, and is successfully operating the Stephentown, NY and the Hazle Township, PA plants. The market rules are not initially as progressive as hoped, but slowly the regulatory and policy environment are moving to favor fast responding resources through implementation of FERC Orders 745, 755 and 784. These orders are summarized as:

Order 745: Demand Response Compensation in Organized Wholesale Energy Markets, recognizes value of "capacity" made available by demand response.

Order 755: Pay for Performance, so that underperforming plants are penalized.

Order 784: Third party reporting for New Electric Storage Technologies, supporting energy storage activity in ancillary markets, by monitoring speed and accuracy<sup>7</sup> of regulation resources.

## Next Steps

Now that Hazle Spindle is delivering a range of 40 MW of regulation in PJM, it is evident that flywheel plants can play an important role in the

fast-response frequency regulation markets that play a critical role in accommodating higher penetration of renewables with variable power, such as solar and wind, on the electric grid.

## Further Reading

For more information about the Hazle Spindle demonstration project, read its [project description](#), published on the [SmartGrid.gov](#) website. A more detailed description of [SGDP](#) can also be found at [SmartGrid.gov](#).

"PJM continues to welcome new technologies that provide diversity to the asset mix in PJM, as well as an opportunity to provide frequency regulation service," said Terry Boston, CEO and president of PJM Interconnection. "This will be the first flywheel technology placed into our regulation market."

Under the American Recovery and Reinvestment Act of 2009, the U.S. Department of Energy and the electricity industry have jointly invested over \$1.5 billion in 32 cost-shared Smart Grid Demonstration Program projects to modernize the electric grid, strengthen cybersecurity, demonstrate energy storage, improve interoperability, and collect an unprecedented level of data on smart transmission, distribution operations, and customer behavior.

<sup>7</sup> FERC Order 784, <http://www.ferc.gov/whats-new/comm-meet/2013/071813/E-22.pdf>, accessed 1/23/15