Project Fact Sheet

Flywheel Electricity System

What are its Primary Applications?

Flywheel electricity systems can be applied to increase electric utility efficiency and reliability in two areas—electric load leveling and uninterruptible power systems (UPS) applications. As an energy storage device, flywheel systems can transform electric energy into kinetic energy via an electric motor, store the energy in the rotation of the flywheel, and use the rotational kinetic energy to regenerate electricity as needed.

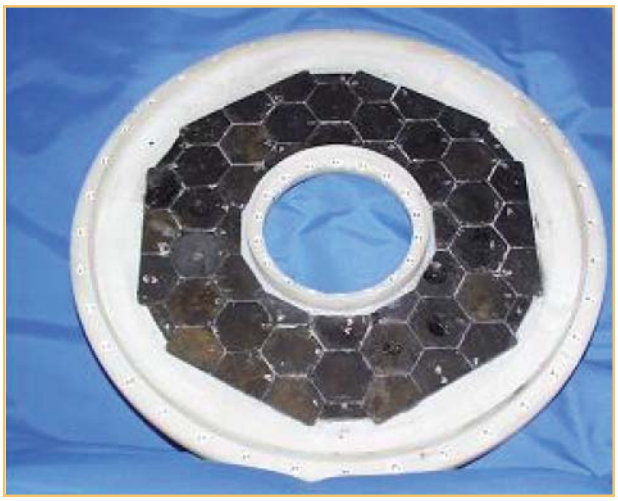
One application of this technology is load leveling. The flywheels can eliminate both momentary voltage and frequency changes and longer-term power interruptions. Flywheels can also be used to "smooth" the fluctuations that result from load following, which allows power plants to operate more efficiently.

Another use of the HTS flywheel electricity system will focus on UPS applications, which provide short-term power in the event of a grid failure. Project efforts toward this downstream application will include developing a more rugged HTS bearing and a high output motor/generator (up to 100 kW) to allow a 5 to 10 minute discharge of stored energy.

This new project will result in a full-scale flywheel system that will allow power users and utilities to better manage both cost and reliability risks through strategic location and use of the systems.

What are the Benefits to Utilities?

Flywheel electricity systems have the potential to provide increased system flexibility and efficiency through load-leveling, maximizing system potential, and reducing electricity waste. Traditional flywheel designs have been prohibitive in all but the most specific applications, because of friction and complex control systems resulting in energy losses of at least 3 to 5% per hour. Compared to traditional rolling contact or conventional electromagnetic bearings, HTS bearings will provide dramatically reduced frictional and parasitic load losses; HTS bearings have demonstrated energy losses of less than 0.1% per hour.



A superconducting bearing, made from bulk high temperature superconductors, on which the flywheel floats.

The UPS applications of the flywheel electricity systems have the potential to save both utilities and consumers millions of dollars in time and work losses. A survey by Pacific Gas & Electric found that 2% of large industrial consumers face losses exceeding $1 million with each interruption of power. These systems have the capability to significantly reduce or eliminate this type of loss by providing consistent, high quality power.

Flywheel electricity systems will prove especially effective at these applications in distributed power systems, meeting high demand at the load center and providing power that is locally non-polluting and efficient.

What is the Market Potential?

Utilities presently spend millions of dollars per year on pumped storage and other power and cost management techniques. Flywheel electricity systems will penetrate a significant portion of this market by offering improved efficiency at a comparable cost.

What is the Status of the Project?

A 10 kWh flywheel electricity system was built and successfully tested in 2003, with energy losses even less than expected. Testing of a 100 kW flywheel electricity system optimized for UPS applications is underway.

Office of Electric Transmission and Distribution, TD-1
U.S. Department of Energy – 1000 Independence Avenue, SW – Washington, DC 20585.

Goal:

To develop and test a 100 kW flywheel electricity system for UPS applications. High-temperature superconducting (HTS) bearings are an enabling technology.

Team:

Boeing Phantom Works (team leader)

Argonne National Laboratory (supporting research)

Ashman Technologies (motor/generators)

Praxair Specialty Ceramics (refrigeration and process engineering)

Southern California Edison (utility end-user)

Period of Performance:

1999 – 2005

Cumulative Project Funding:

Private $5.5 Million (50%)
DOE $5.5 Million (50%)
Total: $11.0 Million

What is it?

Flywheel electricity systems store electric energy as rotational kinetic energy for future restoration to electrical energy, using a motor/generator and a weighted wheel rotating on "frictionless" bearings.

Information Contact:

Michael Strasik
Boeing
425-865-4999
michael.strasik@ boeing.com

The flywheel for the 100 kW HTS Flywheel Electricity System being prepared for assembly and testing.

Large industrial consumers interested in maintaining power quality at reasonable costs represent another huge potential market for flywheel systems. These systems could replace or augment the multi-million dollar standby diesel generator market.

What are the Project Accomplishments to Date?

Boeing, which had independently developed a 2 kWh laboratory flywheel system, teamed with the Department of Energy to develop a 10 kWh flywheel electricity system. The 10 kWh system was tested successfully in 2003, achieving bearing losses that were even less than the goal of 0.1% per hour. However, the 10 kWh flywheel was damaged in a touch-down event during testing. Results of the test failure in the 10kWh test led to a modified design for the hub and spokes of the 100 kW system. All system components for the 100 kW flywheel system have been built and are undergoing testing. An agreement to develop a 30 kWh flywheel electricity system for power risk management is under negotiation and is expected to begin in fiscal year 2005.

Alignment with Administration Priorities:

National Energy Policy: " …expand the Department's research and development on transmission reliability and superconductivity"

National Transmission Grid Study: " … accelerate development and demonstration of its technologies, including high-temperature superconductivity…

Secretary of Energy: "… focuses R&D dollars on long-term, potentially high-payoff activities that require Federal involvement to be both successful and achieve public benefit."

Energy Information Administration: "of [advanced power delivery] technologies, superconductivity holds the most promise for yielding significant efficiency gains."

How Does it Work?

Flywheels have been used to store energy since the invention of the potter's wheel. The less friction in the wheel bearings and the less air resistance on the flywheel, the more efficient its energy storage capability. By attaching a motor/generator to the wheel, electricity can be converted to kinetic energy by the motor, then recovered later by converting the rotation of the flywheel to electricity using a generator. Until the recent development of bulk super- conducting, self-centering HTS bearings, the energy loss associated with both mechanical and electro-mechanical bearings has been prohibitively high. Actively-controlled electromagnetic bearings reduce this problem due to their non-contact nature. Unfortunately, these systems are prohibitively complex and costly. With HTS bearings, losses can be reduced to less than 0.1% per hour while maintaining a stable bearing for the rotating wheel.

The key to maintaining stability is a strong response of the chilled superconductor to changes in the field pattern of a rotating permanent magnet assembly placed above the superconductor. Rotational motion takes place with very little drag, because the magnet assembly provides a circumferentially symmetric field pattern. Only when the rotor moves away from its rotational center are restoring forces generated by the super currents in the stationary HTS ring.

The flywheel is mounted in a vacuum vessel, either fitted with a vacuum pump or hermetically sealed, to reduce frictional losses.