



# WIND-TO-BATTERY PROJECT

As the nation's number one wind power provider, Xcel Energy wants to harness renewable energy to the greatest extent possible. With that focus, we have launched a groundbreaking project to test cutting-edge technology for storing wind energy in batteries. Our project marks the first use of direct wind energy storage technology in the United States.

Energy storage is key to expanding the use of renewable energy. Integrating variable wind and solar energy production to the needs of the power grid is an ongoing issue for the utility industry and will become even more important as the penetration of both of these renewable resources increases. The technology we're testing has the potential to reduce the impact caused by the variability and limited predictability of wind and solar generation.

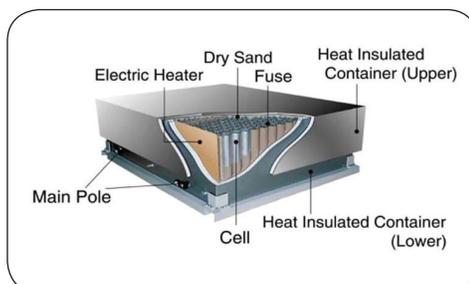
Xcel Energy is testing emerging technologies and energy storage devices as part of our overall Smart Grid strategy, which aims to modernize and upgrade the grid to allow for easier integration of renewable energy sources.

## Project Summary

Xcel Energy will test a one-megawatt wind energy battery-storage system, using sodium-sulfur (NaS) battery technology. The test will demonstrate the system's ability to store wind energy and move it to the electricity grid when needed, and to validate energy storage in supporting greater wind penetration on the Xcel Energy system. NaS technology has been selected for this project because of its high storage capacity; its ability to handle a large number of charge-recharge cycles as would be incurred with an intermittent renewable energy resource; its large scale and potential for even larger scalability; its dynamic response to system changes; and its demonstrated commercial performance and availability.

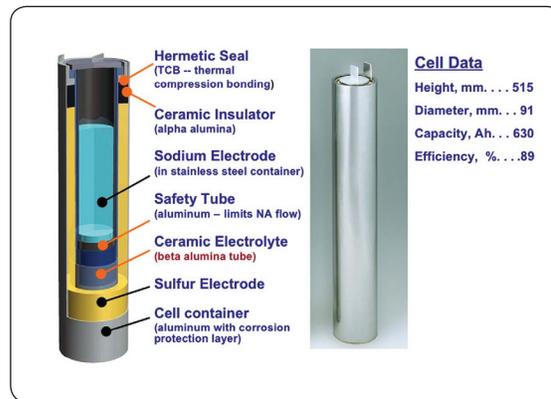
We've purchased the battery from NGK Insulators Ltd., a Japanese firm involved in the manufacture and sale of power-related equipment. Versions of this technology are already being used in Japan and in a few U.S. applications, but this is the first domestic application of the battery as a direct wind energy storage device.

*Right: A cross section of battery components*



*Lifting a battery module into place  
Photo courtesy of S&C Electric Company*

The battery is made up of twenty 50-kilowatt modules. It is roughly the size of two semi trailers and weighs approximately 80 tons. The battery is able to store about 7.2 megawatt-hours of electricity, with a charge/discharge capacity of one megawatt. When the wind blows, the batteries are charged. When the wind calms down, the batteries supplement the power flow. Fully charged, the battery could power 500 homes for over 7 hours.



*A schematic of a single battery cell*

The entire Distributed Energy Storage System (DESS) includes the battery; the power conversion system (PCS); the wind farm and grid interfaces; backup power for emergency battery temperature regulation; and equipment for local and remote performance monitoring, data collection, system control and other communications. We've contracted with S&C Electric, a Chicago-based company that provides equipment and services for electric power systems, to design and build the PCS and to provide turnkey installation services for the DESS.

GridPoint Inc., a leading innovator in smart grid technology, is providing the communications and control system for system integration, remote control and data access. This system will allow the battery system to be the first of its kind to act like a power plant, including selling power into the MISO market and responding to Automatic Generation Control signals.

**In-service date** First quarter 2009

**Location** Luverne, Minn., about 30 miles east of Sioux Falls, S.D., connected to a nearby 11-megawatt wind farm owned by Minwind Energy, LLC.

**Project partners**

University of Minnesota                      National Renewable Energy Laboratory  
 Great Plains Institute                      Minwind Energy, LLC.

The project has been selected to receive a \$1 million grant from Minnesota's Renewable Development Fund.

**Project Objectives**

Areas of testing that Xcel Energy will perform during the demonstration period include:

- Evaluation of the ability of large-scale battery-storage technology to effectively 'firm' wind energy, enabling a shift of wind-generated energy from off-peak to on-peak availability.
- Evaluation of the ability of battery-storage technology to reduce the need to compensate for the variability and limited predictability of wind generation resources.
- Evaluation of the optimal ratio of energy storage to total wind capacity that would allow the wind energy storage system to be a viable peak-load resource.
- Evaluation of whether or not the battery is responsive enough to meet the qualifications of spinning reserve, and evaluate any special relay requirements for a spinning reserve frequency response characteristic.
- Evaluation of the potential for battery-storage technology to support the transmission and distribution grid system and therefore allow the system to more effectively integrate wind into system operations. This includes the ability of the battery discharge and recharge process to be used to buffer and/or smooth the wind generation output ramp rates; the optimal mix of battery uses between demand shaping, generator leveling and contingency reserve response; the ability to provide reactive load support and frequency support.
- Assessment of cold weather effects on the performance and integrity of the NaS Battery system.



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