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**Wind Energy Program Technology Portfolio**



**Wind Partnerships for Advanced Component Technology: WindPACT Advanced Wind Turbine Drivetrain Designs**

**Northern Power Systems, Inc.**

**Project Description:** The WindPACT drivetrain studies explored a range of configurations that appear to offer opportunities for reducing overall wind turbine capital cost and improving drivetrain efficiencies. Two studies were conducted, one by Global Energy Concepts and one by Northern Power Systems. Each team looked at several common configurations and proposed some special ones. They completed preliminary designs and produced detailed cost and performance estimates to determine the relative cost of energy between competing designs. After these alternative designs were thoroughly explored, each subcontractor produced a report that detailed the findings. Three configurations—direct drive, single-stage drive with medium-speed generator, and distributed drive with multiple generators were identified. All appeared to offer a significant likelihood of improvement over the baseline design (a three-stage planetary drive with a doubly fed induction generator). Each design assumed the use of a rare earth (neodymium-iron-boron), liquid-cooled permanent magnet generator. Several factors contributed to the estimated improvements in these designs. The alternative gearbox designs significantly reduced the number of gear stages and bearings. The permanent magnet generators reduced mass and size by eliminating copper in the generator rotors. The additional flexibility in the generator design allowed overall improvements in generator efficiencies. Because of unknowns in technical details and differences in cost estimates, no single clear winner was identified. Therefore, each subcontractor was directed to proceed with one target design. Clipper Windpower selected the multidrive path, multiple generator design for development under a Low Wind Speed Turbine Phase I project. Global Energy Concepts chose the single-stage drive, medium-speed generator.

Under its subcontract, Northern Power Systems developed a direct-drive (no gearbox) permanent magnet generator because the Phase I study showed that this configuration had the greatest potential to decrease the cost of energy. Permanent magnets provided increased efficiency and allowed this 1.5-MW generator, with a rotational speed of just 19.65 rpm, to be no larger than 4.0 m in diameter. The generator design was based on design concepts developed by General Dynamics Electric Boat Division for ship propulsion systems. Additional details of these designs can be found in the Northern Power Systems WindPACT Drivetrain Alternative Design Study Report. This design is awaiting a test slot in the National Wind Technology Center dynamometer. As part of this program, Northern Power also designed and fabricated a full-power converter that will allow variable-speed operation of the WindPACT drivetrain. The converter features state-of-the-art controls and can address the ride-through requirements of the EON Specification. Northern Power is now developing a next-generation advanced power converter under a Low Wind Speed Technology Phase I project.

**Total Project Budget:** \$5,858,435  
**Industry Cost Share:** \$0  
**DOE Cost Share:** \$5,858,435  
**Planned Project Duration:** April 2001–December 2005

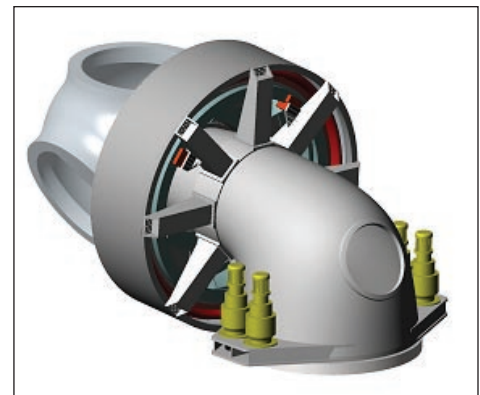
**Current Status:** Project Complete—Northern Power Systems, *WindPACT Drivetrain Alternative Design Study Report*  
[www.nrel.gov/docs/fy05osti/35524.pdf](http://www.nrel.gov/docs/fy05osti/35524.pdf)  
 1.5-MW Drivetrain Fabricated and Waiting for Testing in NWTC Dynamometer

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Concept illustration of advanced drivetrains.



Concept illustration of an NPS direct-drive permanent-magnet generation.

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