The Spectrum of Clean Energy Innovation

Fundamental Science
Market-Relevant Research
Systems Integration
Testing and Validation
Commercialization
Deployment

Unique Dynamometer Enables Rapid Advancement of Industry Leader

In the past decade, the National Renewable Energy Laboratory (NREL) and newly formed wind turbine builder, Clipper Windpower Inc., forged a partnership based on rapid innovation. Over a four-year span, Clipper developed its Liberty Turbine using NREL's unique wind turbine dynamometer, the only such facility in the world. It might seem surprising that Clipper, begun in 2001, could move so quickly to viability, but Clipper's roots go deep into NREL's soil. Even so, the project didn't unfold without challenges.

Two decades before launching Clipper, its founder, James Dehlsen, had started Zond, a pioneering U.S. wind power firm. Zond worked closely with NREL, and once it was acquired by another firm in the late 1990s, Dehlsen was free to pursue his latest wind turbine innovations. His new idea was the Distributed Generation Drivetrain (DGD), which Dehlsen patented. The DGD concept offered to lower the cost and weight of the wind turbine nacelle by employing a radical departure from the standard turbine gearboxes. In part, weight savings came from reduced component bulk, accomplished by eliminating much of the heavy copper that would typically be required for windings in the rotor.

The 2.5-MW Clipper Liberty wind turbine features a new lightweight, enlarged rotor that increases power production, a revolutionary generator design that improves reliability, and reduced gearbox weight and size. PIX 16150

The NREL-Clipper collaboration also allowed exploration of the turbine's variable-speed design. Beginning in 2002, Clipper was able to build a proof-of-concept DGD that had eight output shafts and eight independent permanent magnet generators. The company then tested the model at NREL's dynamometer site, a unique facility that can demonstrate decades of wear in a matter of months by loading turbine drivetrains and gearboxes at various speeds with low or high torque. The one-of-a-kind tool has a powerful 3,350-horsepower electric motor coupled to a 2.5-megawatt (MW), three-stage epicyclic gearbox that can produce variable speeds from 0 to 146 revolutions per minute and run at torque levels up to 9.6 million inch-pounds to simulate the effects of various wind conditions. This process uncovered what one researcher described as irresoluble problems with the controller as it was trying to synchronize and properly load the individual

Through deep technical expertise and an unmatched breadth of capabilities, NREL leads an integrated approach across the spectrum of renewable energy innovation. From scientific discovery to accelerating market deployment, NREL works in partnership with private industry to drive the transformation of our nation's energy systems.

This case study illustrates NREL's contributions in Market-Relevant Research through Deployment.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

generators. Using these results from both NREL's and its own design review teams, Clipper streamlined its design to a less complex system using only four output shafts. This proved highly successful and enabled the Clipper turbine to operate at variable speed. As the rotor speeds up and slows down with the wind speed, the whole drive train—including the fixed-ratio gearbox and the generators—speeds up and slows down. The electricity coming out of the generators varies before the wind turbine's power electronics changes the power to a fixed 60 hertz frequency to feed the power grid.

All of this makes the Clipper drive train significantly lighter than comparable machines with more conventional drive trains. Also, a Clipper generator can be changed using the crane that's built into the nacelle, thereby eliminating the need for having an expensive crane to service the machine. Finally, the machine can be operated with one or more generators out of service.

Production of Clipper wind turbine rotor parts. PIX 14932

Simultaneously, NREL began structural testing and verification of the new Clipper 45-meter (147.6 feet) rotor blade for the Liberty prototype rotor. This, too, proved advantageous, boosting efficiency.

In 2005, NREL worked with Clipper to assist in rigorous testing of the fully assembled commercial prototype of the first Liberty 2.5-MW machine in the harsh environment of Medicine Bow in southeast Wyoming. Because of NREL's extensive design expertise and experience, the concept flourished. Today, that wind turbine powers some 700 households in Fort Collins and Estes Park, Colorado. NREL's teamwork with the California-based supplier earned DOE's 2007 Outstanding Research and Development Partnership Award, two years after Clipper's Liberty 1 turbine swung into operation.

Clipper Windpower of Carpinteria, California, installed a prototype of its new wind turbine near Medicine Bow, Wyoming. The new machine incorporates four permanent-magnet generators, advanced variable-speed controls, and an advanced blade design. PIX 14928

Clipper Expands from Concept to a Wind Power Success

When Clipper began in 2001, it was launched with a prototype development project budget of $19 million, split evenly between industry and the U.S. Department of Energy. Backing for the start-up, coupled with use of NREL's unique dynamometer, proved worthwhile.

Today, Clipper maintains a 6,500-MW portfolio of wind resource rights for the development of projects utilizing Clipper wind turbines. And that portfolio is expanding. In September 2009, the British government awarded a $7 million grant to contribute towards costs associated with the development of blades for the Britannia Project, a 10-MW offshore wind turbine prototype under development by Clipper in late 2011.

The California-based company has grown rapidly from a handful of employees in 2002 to more than 600 employees, including those in the Cedar Rapids, Iowa, turbine works. Clipper's 2.5-MW turbine today features a lightweight enlarged rotor that increases power production, a revolutionary generator design that improves reliability, and a gearbox of reduced weight and size. Because the drivetrain is lighter, it costs less to produce and is easier to maintain than similar machines. Researchers believe this advanced design will become a benchmark for future turbine design in the United States and Europe.

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