THE MOST ADVANCED WIND-ENERGY TESTING CENTER COMING TO SOUTH CAROLINA

In a one-of-a-kind testing facility under construction at the Clemson University Restoration Institute, offshore wind turbine manufacturers will have the tools to evaluate products in simulated real-world conditions

NORTH CHARLESTON, S.C. — New technology requires advanced testing capability. By next year, one of the world's most important wind energy testing sites will open in South Carolina.

In November 2009, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) awarded Clemson University the largest grant in the university's history to build and operate a facility to test next-generation wind turbine drivetrain technology.

The facility will be like no other, with testing capacity three-times greater than any other currently in operation. Weighing more than a new wide-body jet airliner filled with fuel, passengers, and luggage, specifications for the facility's 15 MW test rig are so large that many of its components have never before been designed.

The Energy Department's goal of generating 20 percent of the total U.S. electricity supply from wind power by 2030 will require significant innovation. Wind energy production in the U.S. will need to increase from the current 35 GW level to more than 300 GW.

To reach this ambitious target, land-based wind energy units must be supplemented by units located off the coast, which typically require an investment about twice that of land-based systems.

Within the 300 GW total, the Energy Department estimates that 54 GW will be required from offshore wind to feed the large coastal demand centers.

New technology is needed to reduce the cost of energy delivered in order for offshore wind power to meet its full potential. Considering the large investment, the economic viability of offshore wind power plants depends implicitly on their expected service life.

To address the increasing worldwide demand for offshore wind power, many turbine manufacturers are developing machines in the 6 to 7 MW range. To date, the reliability and daily functionality of these large machines could only be tested in full operating mode in the field, as there were no test facilities available for systems of this magnitude. Soon, that will no longer be the case.

RENK LABECO Test Systems, the U.S. subsidiary of RENK Test System GmbH, is supplying two test stands to Clemson University for the purpose of testing next-generation large drivetrains and generators.

These test rigs — one capable of testing wind turbine drivetrains up to 7.5 MW, the other up to 15 MW — are at the heart of a new testing facility that the university is building at the Clemson University Restoration Institute (CURI) location in North Charleston, South Carolina.

The CURI Wind Turbine Drivetrain Testing Facility will offer turbine manufacturers the opportunity to validate their designs and save time and money in the development of new offshore wind systems. In addition, the facility will offer opportunities for workforce development, research and education as these new technologies are tested.

15 MW TEST STAND

The larger of the two test stands is a flexible unit that accommodates complete wind turbine nacelles up to 15 MW, in addition to large turbine gearboxes and generators. This test stand handles wind turbine equipment rated at what is projected to be the upper limit for wind generation.

The test rig drive unit consists of two 8,700-kW, asynchronous, water-cooled motors and an adaptation gearbox. Each motor is controlled by its own variable frequency drive and is capable of producing a nominal torque of 68 kNm at 1,200 rpm, with a maximum speed of 2,000 rpm. The motors can handle a current overload of 30 percent for up to 5 minutes.

For testing of complete nacelles, the two drive motors are connected in parallel to an adaptation gearbox with a ratio of approximately 120:1. Each input shaft is rated for a maximum torque of 68 kNm and a maximum speed of 2,000 rpm.

The gearbox's single output shaft can handle a maximum output torque of 16,000 kNm and a maximum output speed of 17 rpm. The gearbox, with its external lubrication system, is equipped for monitoring oil and critical bearing temperatures as well as vibrations. The gearbox's lubrication oil is water cooled.

The adaptation gearbox is uniquely designed to handle drivetrain movements caused by specimen distortions. This feature reduces tensile and compressive stresses in the drivetrain shafts, thereby extending the working lives of the shafts and the flexible coupling — the next component in the drivetrain.

Power from the adaptation gearbox is transmitted into an enclosed, hydraulic load application system. This system consists of a load disk mounted on the test stand's central shaft. Seventy-two hydraulic actuators apply radial and axial loads on the disk to simulate forces and bending moments acting in three axes on the test specimen.

An integrated measurement system gathers data about the forces and moments generated by the load-application system, and inputs these data to the test-stand control system, which monitors conditions and provides control signals to the system actuators.

The basic load-application system is capable of a maximum axial load of ± 4,000 kN; a maximum radial load of ± 8,000 kN; a maximum rotational moment of ± 50,000 kNm; and a maximum load-application frequency of 1 Hz.

Using various load frequencies and magnitudes, simulation of static and dynamic loads is possible in a range from normal, cyclical conditions to the extreme, erratic forces caused by violent winds.

Additionally, future system upgrades are possible that could increase the maximum bending moment capability to 70,000 kNm and/or allow a full 6 DOF specimen test.

A rigid adapter shaft connects the test stand's central shaft to the test specimen, which is mounted on a specimen support, which in turn is mounted on the test stand base frame.

The 35 x 12 m base frame is designed with the flexibility to accommodate test specimens and specimen supports in a range of sizes and configurations, ensuring that practically any nacelle, gearbox or generator can be tested on the CURI test stand.

All components are mounted so that the centerline of the shafts has a vertical angle of 6°. This reflects the typical axis angle when the nacelle is installed on its tower. Electrical power generated during nacelle or generator testing is fed back into the drive system via switchgear included with the test stand.

7.5 MW TEST STAND

The "smaller" test stand is a flexible unit designed to handle gearboxes and nacelles for wind turbines up to 7.5 MW.

The drive unit of the 7.5 MW test stand consists of one 8,700-kW, asynchronous, water-cooled motor. Specifications for this motor are identical to those used on the big test stand: It has its own variable frequency drive, is capable of producing a nominal torque of 68 kNm at 1,200 rpm with a maximum speed of 2,000 rpm, and can handle a current overload of 30 percent for up to 5 minutes.

The drive motor connects to an adaptation gearbox with a ratio of approximately 100:1, rated at the input side for a maximum torque of 68 kNm and a maximum speed of 2,000 rpm, and at the output side for a maximum torque of 6,000 kNm and a maximum speed of 20 rpm.

The gearbox has an external lubrication system with water cooling, and is equipped for monitoring oil and critical bearing temperatures as well as vibrations. Like the adaptation gearbox on the 15 MW test stand, this gearbox is also designed to accommodate drivetrain movements, which reduces stress in the drivetrain shafts and flexible coupling.

Power from the adaptation gearbox travels into an enclosed, hydraulic load-application system that is a smaller version of the unit on the larger test stand. Capable of applying radial and axial loads via 24 hydraulic actuators, this load-application system has a maximum axial load of ± 2,000 kN; a maximum radial load of ± 2,000 kN; and a maximum rotational moment of ± 10,000 kNm.

The special measurement system gathers data about the forces and moments generated by the load applicator, and sends this information to the test stand control system.

The specimen under test is connected to the test stand's central shaft via a rigid adapter shaft and is mounted on its own specimen support, which is mounted on the test stand base frame. The base frame is designed to accommodate test specimen supports of varying sizes so that a wide range of equipment from various manufacturers can be tested.

The commissioning process for the 7.5 MW test stand is scheduled to begin in April 2012, followed by the commissioning of the larger 15 MW stand scheduled to start in January 2013. Wind industry manufacturers interested in scheduling time on either test stand are encouraged to contact the CURI facility directly.

DOWNTIME IS EXPENSIVE: The importance of pre-installation testing

In the case of offshore wind energy, failure-free operation is even more critical than for land-based systems. Problems in offshore systems that cannot be repaired remotely can take days or weeks to fix.

Stationary turbines generate no profits, so wind farm operators increasingly expect trouble-free operation that can be assured via validation tests prior to installation. Such tests have previously been performed on individual components. Now, that same level of validation for the complete nacelle will be possible using the CURI Wind Turbine Drivetrain Testing Facility.

The CURI test stands will be capable of simulating operational stress and will allow manufacturers to conduct accelerated, long-term tests in a Highly Accelerated Life Test (HALT) environment.

The HALT process is a method of subjecting products to accelerated wear environments to swiftly confirm design and component integrity. This means the wear and tear of many years in the field can be replicated in just a few months on the test stand.

The new facility will not only be capable of mechanical testing of the new drivetrains, but grid compatibility testing, also.

The project will include capability for Low Voltage Ride Through Testing (LVRT) and Zero Voltage Ride Through Testing (ZVRT) to ensure the response of wind turbine generators to transmission system faults.

Clemson University plans to leverage the planned electrical infrastructure of the drivetrain testing facility to build a 15 MW grid simulator with Hardware-in-the-Loop (HIL) capability, not only to test next-generation wind turbines for grid compatibility, but to serve as a platform for testing and certifying new technology that supports the country's smart grid and renewable energy goals.

While there are numerous locations that can model and perform grid simulation, the combination of actual electrical hardware and grid simulation with HIL capability is rare.

The proposed facility will focus on transmission and distribution system technology. Having HIL capability allows testing of current and new high voltage technology, generation of models to duplicate actual performance, and a means of certifying new technology to accelerate its introduction into the market.

The planned testing capability also can be used to evaluate problems with existing wind power systems, so that improvements can be implemented proactively.

Peter Hull (*Clemson University Restoration Institute*)
Sam Bedwell *(RENK LABECO Test Systems Corporation)*