NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Dynamometer Testing of Samsung 2.5MW Drivetrain

Cooperative Research and Development Final Report

CRADA Number: CRD-08-311

NREL Technical Contact: Robb Wallen

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Cooperative Research and Development Final Report

In accordance with Requirements set forth in Article XI.A(3) of the CRADA document, this document is the final CRADA report, including a list of Subject Inventions to be forwarded to the Office of Science and Technical Information as part of the commitment to the public to demonstrate results of federally funded research.

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CRADA Title: Dynamometer Testing of Samsung 2.5MW Drivetrain

Parties to the Agreement: Samsung Heavy Industries (SHI) and NREL

Joint Work Statement Funding Table showing DOE commitment:

Estimated Costs	**NREL** Shared Resources
Year 1	$ 00.00
Year 2	$ 00.00
Year 3	$ 00.00
TOTALS	$ 00.00

Abstract of CRADA work:

In order to minimize risk associated with the introduction of their new wind turbine, the participant (SHI) requested testing support from the National Renewable Energy Laboratory (NREL). This testing support was intended to verify function and performance of the turbine's drivetrain using NREL's 2.5 MW dynamometer test bed at the National Wind Technology Center (NWTC).

Summary of Research Results:

SHI's prototype 2.5 MW wind turbine drivetrain was tested at the NWTC 2.5 MW dynamometer test facility over the course of 4 months between December 2009 and March 2010. This successful testing campaign allowed SHI to validate performance, safety, control tuning, and reliability in a controlled environment before moving to full-scale field testing and subsequent introduction of a commercial product into the American market. In addition to providing valuable data and feedback to SHI's design and engineering teams, the CRADA benefitted NREL and tax payers through the opportunity to develop and verify the procedures and methodologies required to conduct dynamometer testing on large scale drivetrains. This information has proven invaluable to the development of the NWTC 5 MW dynamometer upgrade.

Three primary testing modes were chosen by SHI to validate the prototype design: steady state, turbulent wind, and endurance. In the steady state mode, a series of points along the turbine's power curve and a selection of "extreme" cases outside the normal operating range were imposed on the test article by the dynamometer to verify anticipated generator and power electronic performance. During the turbulent wind mode, a sophisticated "model-in-the-loop" technique was employed to simulate the turbine rotor and tower allowing the evaluation of drivetrain and control system response to IEC design load cases. The final stage of testing involved 24/7 unattended operation of the drivetrain at single load case to capture thermal saturation on mechanical elements. In each testing mode the prototype performed acceptably, minor issues were resolved, and performance data was collected and reviewed by SHI.

The work performed under CRD-08-311 represents the largest and most sophisticated test of a prototype drivetrain at the NWTC to date and resulted in the refinement of numerous techniques and tools required to test the next generation of drivetrains. Turbulent wind simulation, a central focus of the testing effort, allowed the prototype turbine's control system to be verified and tuned in a controlled, low risk environment. In this configuration, a third party simulation tool interfaced to the test article and dynamometer calculated the turbine's main shaft torque in real time in response to a virtual wind input profile. The calculated shaft torque was fed to the dynamometer control system, converted to mechanical torque, and imposed on the test article. The turbine's response, in the form of shaft speed, was fed back into simulation software and turbine control system completing the loop. Successful implementation of this "model-in-the-loop" system, a first for the NWTC, required a detailed characterization of the coupled and uncoupled torque response of the test article and dynamometer setup. In addition, the dynamometer control software and drive communication were completely redesigned to support real-time, deterministic operation required by the turbulent wind simulation. The final products of this effort includes a better understanding of dynamometer response and flexible control platform for current and futures dynamometer testing at the NWTC.

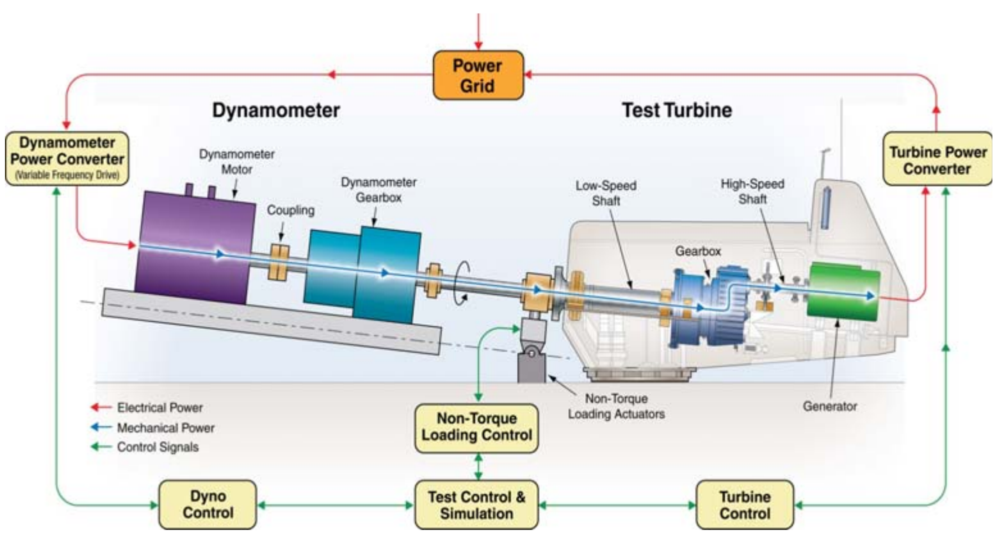

Figure 1. Test configuration for SHI 2.5 MW turbine (note: non-torque loading was not utilized)

While the testing campaign was successful in meeting SHI's testing requirements, a number of deficiencies in current 2.5MW dynamometer configuration were identified. Unloading the drivetrain from the 200 foot, 19 axle transport rig, and installing it into the dynamometer facility, required a 400-ton all-terrain mobile crane, an improvised rail system, and a complicated two crane lift over the course of two working days. The situation has been addressed in the 5 MW dynamometer upgrade through increased crane capacity and vastly improved facility layout. Testing a 2.5 MW turbine with a 2.5 MW dynamometer obviously leaves no margin for the evaluation of long term overload conditions. However, a 10-20% short term overload capacity was assumed by SHI of which the dynamometer should be capable of providing. Upon reviewing the mechanical connection between the dynamometer torque transducer and coupling shaft, it was found that operation above rated torque would reduce the safety factor below acceptable levels.

Subsequently, rated torque was not exceeded during the test campaign and the opportunity to exercise a number of load points was lost. The current connection is being reviewed for possible retrofits to enhance the overload capacity. The 5 MW upgrade facility will be designed with an adequate level of overload capacity. Finally, characterization of the dynamometer revealed an approximate 1-2 Hz. torque response bandwidth. While this response time has proven adequate for numerous steady state tests during the operation of the facility, it is problematic for conducting turbulent wind simulations due to the lack of fidelity and likelihood of artificially exciting resonances in the 1.5-2 Hz. range. Torque bandwidth in the 50-100Hz range, along with regenerative braking capability is considered imperative for future facilities and upgrades to the existing 2.5 MW drive system.

Subject Inventions listing: None

Report Date: 7/07/2010 Responsible Technical Contact at Alliance/NREL: Wallen, Robb

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