NWTC Dynamometer and Controllable Grid Interface Commissioning and Testing of General Electric Wind Turbine Drivetrain

Cooperative Research and Development Final Report

CRADA Number: CRD-14-551

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NOTICE

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In accordance with Requirements set forth in Article XI. Reports and Abstracts A.(3), of the CRADA agreement, 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.

Parties to the Agreement: General Electric Company – GE Power & Water

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CRADA Title: NWTC Dynamometer and Controllable Grid Interface Commissioning and Testing of General Electric Wind Turbine Drivetrain

Joint Work Statement Funding Table Showing DOE Commitment:

Estimated Costs	NREL Shared Resources
Year 1	$ 100,000 .00
Year 2	$ 300,000.00
Modification #1	$ 400,000.00
TOTAL	$ 800,000.00

Abstract of CRADA Work:

This CRADA (1) facilitates commissioning of the new NWTC 5MW dynamometer facility while testing a General Electric (Participant) 2.75MW wind turbine drivetrain under loaded conditions, (2) facilitates commissioning of the new NWTC the Controllable Grid Interface (CGI) as part of testing the GE 2.75MW drivetrain, (3) facilitates further wind turbine drivetrain testing utilizing the commissioned dynamometer and CGI test facilities.

Summary of Research Results:

In 2013 the Department of Energy (DOE) and the National Renewable Energy Laboratory finished construction of a new wind turbine test facility at the National Wind Technology Center (NWTC) south of Boulder, Colorado. This facility augmented the NWTC's capability for dynamometer testing embodied in the 2.5 MW dynamometer.

The new facility enables testing wind turbine drivetrains up to 5 MW – the largest size expected to be deployed on land. DOE also provided support for the construction of a Controllable Grid Interface (CGI) that is used in conjunction with dynamometer testing. The CGI enables engineers to control electrical characteristics of the grid as seen by a drivetrain in the dynamometer.

Commissioning of the equipment in the 5 MW dynamometer occurred in two stages: a no-load commissioning test and a second "loaded" commissioning test that included commissioning of the CGI. To test the dynamometer drivetrain under load, it is necessary to connect it to a wind turbine drivetrain. This test configuration has been named Integrated System Test (IST).

NREL completed commissioning test planning and interface equipment design to connect the GE drivetrain to the 5MW dynamometer and CGI. This work is documented in "NWTC 5 MW Dynamometer & Controllable Grid Interface Commissioning Test Plan". GE confirmed that the test conditions during NREL facility commissioning were acceptable operating conditions for the drivetrain. GE prepared a test plan that described drivetrain tests to be conducted during the period of GE testing. NREL reviewed the desired test conditions to verify that the 5 MW dynamometer and CGI had the needed capability. NREL also designed and fabricated hardware needed to connect the GE drivetrain to the 5MW dynamometer and provided a 3 MVA transformer.

In September of 2013, NREL finished the installation of the 2.75 MW drivetrain in the 5 MW dynamometer with GE technical support.

NREL commissioning tests intended to verify safety, instrumentation, control, and loading capabilities of the dynamometer and CGI were conducted according to the test plan. Verification of safety includes: Emergency Power Off capability to isolate the dynamometer, CGI, and GE drivetrain electrically; Emergency Shut Down capability to quickly stop rotation of the dynamometer due to fault conditions; and prevention of overspeed, overtorque, overloading in thrust, lateral shear, vertical shear, pitch moment, and yaw moment. Verification of instrumentation included measurements of low speed shaft speed, torque, thrust, lateral shear, vertical shear, pitch moment, and yaw moment; power into the dynamometer VFD and out of the GE drivetrain; voltage, frequency, current, phase angle, harmonic distortion of the CGI. Verification of control included: operation of the dynamometer motor in both speed and torque control; operation of the non-torque loading device in both force and displacement control in each of its five degrees of freedom; and operation of the CGI at voltages and frequencies above and below nominal. Verification of loads includes: application of torque and non-torque loads to approximately 50% of dynamometer ratings as limited by GE specification of acceptable loads on the GE drivetrain.

Following completion of GE testing, NREL prepared a report and produced other related documents describing the configuration and results of commissioning tests of the 5 MW dynamometer and CGI. The publishing of "Phase 1 Integrated Systems Test and Characterization Report for the 5-Megawatt Dynamometer and Controllable Grid Interface" made this information available to the public (available at https://www.nrel.gov/docs/fy18osti/63073.pdf). Specific findings encountered with the GE drivetrain or other sensitive GE information are considered proprietary information and have not be publicly reported.

Additional investigations of the dynamometer performance were published in papers titled, "Theoretical and experimental study on gear-coupling contact and loads considering misalignment, torque, and friction influences" (available at: https://www.sciencedirect.com/science/article/pii/S0094114X15002748?via%3Dihub) and "Characterizing the Influence of Abstraction in Full-Scale Wind Turbine Nacelle Testing" (available at: https://www.nrel.gov/docs/fy16osti/66302.pdf)

Subject Inventions Listing:

None

ROI#:

None

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June 18, 2018

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DOE Program:

Office of Energy Efficiency and Renewable Energy Wind and Water Technologies Office

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