NREL and DONG Energy Collaboration for Grid Simulator Controls and Testing

Cooperative Research and Development Final Report

CRADA Number: CRD-13-527

NREL Technical Contact: Vahan Gevorgian

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

This report is available at no cost from the National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications.

CRADA Report
NREL/TP-5D00-66412
May 2016

Contract No. DE-AC36-08GO28308

NOTICE

This report is available at no cost from the National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications.

Available electronically at SciTech Connect http:/www.osti.gov/scitech

Available for a processing fee to U.S. Department of Energy and its contractors, in paper, from:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
OSTI http://www.osti.gov
Phone: 865.576.8401
Fax: 865.576.5728
Email: reports@osti.gov

Available for sale to the public, in paper, from:

U.S. Department of Commerce
National Technical Information Service
5301 Shawnee Road
Alexandria, VA 22312
NTIS http://www.ntis.gov
Phone: 800.553.6847 or 703.605.6000
Fax: 703.605.6900
Email: orders@ntis.gov

Cover Photos by Dennis Schroeder: (left to right) NREL 26173, NREL 18302, NREL 19758, NREL 29642, NREL 19795.

NREL prints on paper that contains recycled content.

Cooperative Research and Development Final Report

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: Dong Energy Wind Power

CRADA Number: CRD-13-527

CRADA Title: NREL and DONG Energy Collaboration for Grid Simulator Controls and Testing

Joint Work Statement Funding Table Showing DOE Commitment:

Estimated Costs	NREL Shared Resources
Year 1 Year 2 Modification #1	$55,150 .00 $28,834.00 $175,000.00
TOTAL	$258,984.00

Abstract of CRADA Work:

The National Renewable Energy Laboratory (NREL) and DONG Energy are interested in collaborating for the development of control algorithms, modeling, and grid simulator testing of wind turbine generator systems involving NWTC's advanced Controllable Grid Interface (CGI). NREL and DONG Energy will work together to develop control algorithms, models, test methods, and protocols involving NREL's CGI, as well as appropriate data acquisition systems for grid simulation testing. The CRADA also includes work on joint publication of results achieved from modeling and testing efforts. Further, DONG Energy will send staff to NREL on a long-term basis for collaborative work including modeling and testing. NREL will send staff to DONG Energy on a short-term basis to visit wind power sites and participate in meetings relevant to this collaborative effort.

DOE has provided NREL with over 10 years of support in developing custom facilities and capabilities to enable testing of full-scale integrated wind turbine drivetrain systems in accordance with the needs of the US wind industry. NREL currently operates a 2.5MW dynamometer and is in the processes of commissioning a 5MW dynamometer and a grid simulator (referred to as a "Controllable Grid Interface" or CGI). DONG Energy is the market leader in offshore wind power development, with currently over 1 GW of on- and offshore wind power in operation, and 1.3 GW under construction. DONG Energy has on-going R&D projects involving high voltage DC (HVDC) transmission.

Summary of Research Results:

This work produced research results in two topic areas:

1. Harmonic interactions in offshore wind power plants

Converter rich grids such as offshore wind power plants (OWPPs) are prone to become unstable due to control interaction with e.g. the extensive sub-marine cabling. There exists a need to investigate the stability in high voltage direct current (HVDC) grid connected OWPPs, as the electrical characteristics are altered compared to conventional grid connected OWPPs. Previously, the analysis was mainly done in the frequency domain, where the inherent limitation of linearization exists. An evaluation of the frequency domain method is therefore also needed. Under this topic, NREL and DONG Energy investigated the harmonic instability phenomena in HVDC grid connected OWPPs using both frequency and time domain simulations utilizing NREL's 7 MVA power electronic grid simulator and utility scale wind turbine generators. A good correlation at lower frequencies between the two domains was observed in the measured data. However, the frequency domain is insufficient at higher frequencies (i.e. in the vicinity of the switching frequency). A combination of the two techniques is thus recommended in the OWPP design phase. Successful application of active filtering to supress possible instabilities was illustrated during the project as well. Two peer-reviewed joint conference papers were published as a result of this task.

2. Power system oscillation damping by offshore wind power plants

This work represented a unique example of application of a modern test facility consisting of NREL's 7 MVA grid simulator, 5 MW dynamometer, and multi-MW utility-scale wind turbines for experiments regarding the integration of renewable energy in the power system. The capabilities of the test facility were used to validate dynamic simulation models of wind power plants and their controllers. The models were based on standard and generic blocks. The successful validation of events related to the control of active power (control phenomena in the <10 Hz range, including frequency control and power oscillation damping) was performed. There other results include demonstrating the capabilities of the test facility and drawing the track for future work and improvements. One peer-reviewed joint conference paper was published as a result of this task.

Subject Inventions Listing:

N/A

Report Date:

3/18/2016

Responsible Technical Contact at Alliance/NREL:

Vahan Gevorgian

Name and Email Address of POC at Company:

Bo Hesselbæk, BOHES@dongenergy.dk

This document contains NO confidential, protectable, or proprietary information.