NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Wind Farm Monitoring at Lake Benton II Wind Power Project – Equipment Only

Cooperative Research and Development Final Report

CRADA Number: CRD-08-275

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-5D00-62193
June 2014

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 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
phone: 865.576.8401
fax: 865.576.5728
email: mailto:reports@adonis.osti.gov

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

U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
phone: 800.553.6847
fax: 703.605.6900
email: orders@ntis.fedworld.gov
online ordering: http://www.ntis.gov/help/ordermethods.aspx

Cover Photos: (left to right) photo by Pat Corkery, NREL 16416, photo from SunEdison, NREL 17423, photo by Pat Corkery, NREL 16560, photo by Dennis Schroeder, NREL 17613, photo by Dean Armstrong, NREL 17436, photo by Pat Corkery, NREL 17721.

Printed on paper containing at least 50% wastepaper, including 10% post consumer waste.

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.

CRADA Number: CRD-08-275

CRADA Title: Wind Farm Monitoring at Lake Benton II Wind Power Project - Equipment Only

Parties to the Agreement: Lake Benton Power Partners

Joint Work Statement Funding Table Showing DOE Commitment:

Estimated Costs	NREL Shared Resources
Year 1	$ 20,130.00
Year 2	$ 00.00
Year 3	$ 00.00
TOTALS	$ 20,130.00

Abstract of CRADA Work:

Long-term, high-resolution wind turbine and wind power plant output data are important to assess the impact of wind power on grid operations and to derive meaningful statistics for better understanding of the variability nature of wind power. These data are used for many research and analyses activities consistent with the Wind Program mission: Establish a database of long-term wind power similar to other long-term renewable energy resource databases (e.g. solar irradiance and hydrology); produce meaningful statistics about long-term variation of wind power, spatial and temporal diversity of wind power, and the correlation of wind power, other renewable energy resources, and utility load; provide high quality, realistic wind power output data for system operations impact studies and wind plant and forecasting model validation.

Data acquired under this agreement becomes the property of NREL. In order for this project to fulfill program objectives, the Wind Program intends to report overall data statistics and publish sample data series and results of analyses of these data sets. The data will also be used for the purpose of advancing the knowledge of the wind power variation, its spatial and temporal diversity, and its correlation with output from other wind power plants by NREL and other researchers. However, NREL recognizes the sensitivity of facilities' operating data and also recognizes the need to maintain the proprietary nature of such data. Therefore, when making the data available to other researchers, the identity of the project will not be revealed.

Summary of Research Results:

The results of this research are described in the NREL report, *Long-Term Wind Power Variability*, which can be found at www.nrel.gov/docs/fy12osti/53637.pdf.

The resulting data have been used to analyze wind power fluctuations, frequency distribution of changes, the effects of spatial diversity, and wind power ancillary services. This report uses multi-year wind power data to examine long-term and shorter-term wind power variability, and provide an overview of the results.

The wind power data from WPPs in different parts of the country suggest that one can expect relatively large inter-annual changes. The climate and regional weather pattern are the driving forces behind wind and wind plant outputs. Changes in climate and weather patterns will be reflected in the longer-term performance of WPPs. In this respect, wind power is similar to hydropower, especially the run-of-the-river type, in that there are high energy production (wet) years and low energy production (dry) years. The available data show that during the highest production year, total wind energy from the same WPP can be almost 40% higher than the annual production of the lowest production year. The available data do not appear to be enough to establish a long-term pattern or trend.

However, shorter-term variations of wind power appear to be less than longer-term variations. The data show that distinctive seasonal and diurnal patterns are persistent over the years independent of the overall annual wind energy production.

For even shorter-term variations, such as power level from one hour to the next, changes of wind power levels become a stochastic process with a very narrow range of standard deviation values around the respective mean. The magnitudes of these mean and standard deviation values are functions of the size of the WPP. Larger WPPs have bigger changes, but the relationship with size is not linear because the spatial diversity of wind speeds within a large WPP will reduce the variability of the plant output relative to a single wind turbine or a small WPP with fewer wind turbines. However, when those mean and standard deviation values are expressed in terms of the installed capacity of the WPPs, they are almost constant on an annual basis. It can be concluded that short-term wind power fluctuations do not exhibit year-to-year variability.

Subject Inventions Listing:

N/A

Report Date:

January 13, 2014

Responsible Technical Contact at Alliance/NREL:

Vahan Gevorgian

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