Array Effects in Large Wind Farms

Cooperative Research and Development Final Report

CRADA Number: CRD-15-590

NREL Technical Contact: Patrick Moriarty

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
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Contract No. DE-AC36-08GO28308

Technical Report
NREL/TP-5000-73292
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Suggested Citation
Moriarty, Patrick. 2019. *Array Effects in Large Wind Farms: Cooperative Research and Development Final Report, CRADA Number CRD-15-590*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-73292. https://www.nrel.gov/docs/fy19osti/73292.pdf.

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This work was authored by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Wind Energy Technologies Office. The views expressed herein do not necessarily represent the views of the DOE or the U.S. Government.

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Cooperative Research and Development Final Report

Report Date: December 17, 2018

In accordance with requirements set forth in the terms of the CRADA agreement, this document is the final CRADA report, including a list of subject inventions, to be forwarded to the DOE 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: Sibley School of Mechanical and Aerospace Engineering, Cornell University

CRADA Number: CRD-15-590

CRADA Title: Array Effects in Large Wind Farms

Joint Work Statement Funding Table showing DOE commitment:

Estimated Costs	NREL Shared Resources a/k/a Government In-Kind
Year 1	$ 10,000.00
Year 2	$ 10,000.00
Year 3	$ 10,000.00
TOTALS	$ 30,000.00

Abstract of CRADA Work:

The effects of wind turbine wakes within operating wind farms has a substantial impact on the overall energy production from the farm. The current generation of models drastically underpredicts the impact of these wakes offshore leading to non-conservative estimates of energy capture and financial losses to wind farm operators and developers. To improve these models, detailed research of operating wind farms is necessary. Cornell University is a world leader of wind farm wakes effects and would like to partner with NREL to help improve wind farm modeling (by gathering additional wind farm data), develop better models and increase collaboration with European researchers working in the same area.

Summary of Research Results:

The work accomplished under this agreement included advanced observations of wakes in full scale operating wind farms and a comparison to simulations using NREL-developed, large eddy simulation tools. The comparisons allowed researchers to quantify the uncertainty introduced

through observational campaigns—more specifically, lidar scanning patterns. Based on these uncertainty estimates, researchers recommend higher frequency and spatial fidelity scans to improve future wake measurement campaigns. The observations and large eddy simulation results were used to develop a new wind turbine wake model that was not dependent on axisymmetry to better capture the intermittent behavior of wake dynamics.

Under this agreement, researchers examined a series of lidar measurements from an offshore wind farm to determine if the data were of sufficient quality for wake model validation. The data were deemed too coarse and further examination with new complimentary data channels were deemed necessary. Additional analysis is being pursued as follow-on work.

Also under this agreement, researchers across institutes discussed needs for new future utility scale wake observational campaigns. Researchers hosted an international workshop of wake experts, refined science goals and shared lessons learned from previous wake field campaigns. Planning for future wake field campaigns continues.

The results from this work were presented at international conferences focused on wind energy and atmospheric science and published in the journals *Wind Energy* and *Remote Sensing*. Links to the journals are below.

Doubrawa, P., Barthelmie, R.J., Wang, H., Churchfield, M.J., 2017. A stochastic wind turbine wake model based on new metrics for wake characterization. *Wind Energy* 20, 449–463. https://doi.org/10.1002/we.2015

Doubrawa, P., Barthelmie, R.J., Wang, H., Pryor, S.C., Churchfield, M.J., 2016. Wind Turbine Wake Characterization from Temporally Disjunct 3-D Measurements. *Remote Sensing* 8, 939. https://doi.org/10.3390/rs8110939

Subject Inventions Listing:

None

ROI #:

None

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DOE Program Office:

Office of Energy Efficiency and Renewable Energy Wind Energy Technologies Office

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