T27 - American Wake Experiment (AWAKEN)

Technology RD&T and Resource Characterization – Atmosphere to Electrons (A2e)

Pat Moriarty

NREL

August 4, 2021

FY21 Peer Review - Project Overview

Project Summary:
- **Challenge:** Wake interactions and other wind farm atmosphere interactions are among the least understood physical interactions in wind plants today, leading to unexpected power losses.
- **Approach:** The national laboratories will organize, design and execute a landmark international wake observation and validation campaign. New observation data gathered will be used to further validate wind plant models and lead to both improved layout and more optimal operation of wind farms with greater power production and improved reliability.
- **Project Partners:** National Oceanic and Atmospheric Administration, National Science Foundation, DOE Atmospheric and Radiation Measurement Program, University of Colorado, University of Texas Dallas, Texas Tech University, General Electric, Enel, Engie, and others

Project Objective(s) 2019-2020:
- Organize international AWAKEN consortium including research labs, academia and industry
- Define science goals
- Instrumentation development roadmap and acquisition

Overall Project Objectives (life of project):
The overall objectives are to gather the highest fidelity of wind farm atmosphere interactions to date, use that data to better understand complex wind farm flow phenomena, and validate and improve wind farm modeling tools to use for future improved wind farm performance
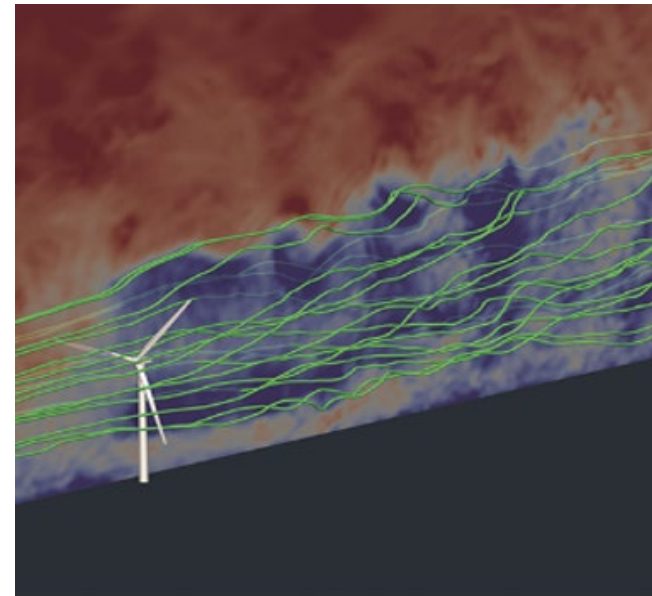
Project Start Year: 2019
Expected Completion Year: FY2024
Total expected duration: 5 years

FY19 - FY20 Budget: $2,283,964

Key Project Personnel: Pat Moriarty, NREL, Sonia Wharton, LLNL, Will Shaw, PNNL, Tommy Herges, SNL

Key DOE Personnel: Ben Hallissy, Michael Derby

Project Impact

Issue

- Typical wind farm will lose 10% annual energy production (AEP) from wakes
- Predictions of wakes and other wind farm atmosphere interactions are highly uncertain ± 2-5% AEP

Approach

- Create a unique data set (100+ instruments) of wind farm atmosphere interactions with industry, research, and academic partners
- Advance state-of-the-art instrumentation
- Validate and improve wind farm modeling tools
- Capstone field validation campaign for A2e conclusion

Result

- Lower uncertainty in preconstruction energy estimates
- Demonstration of advanced wind farm operating techniques
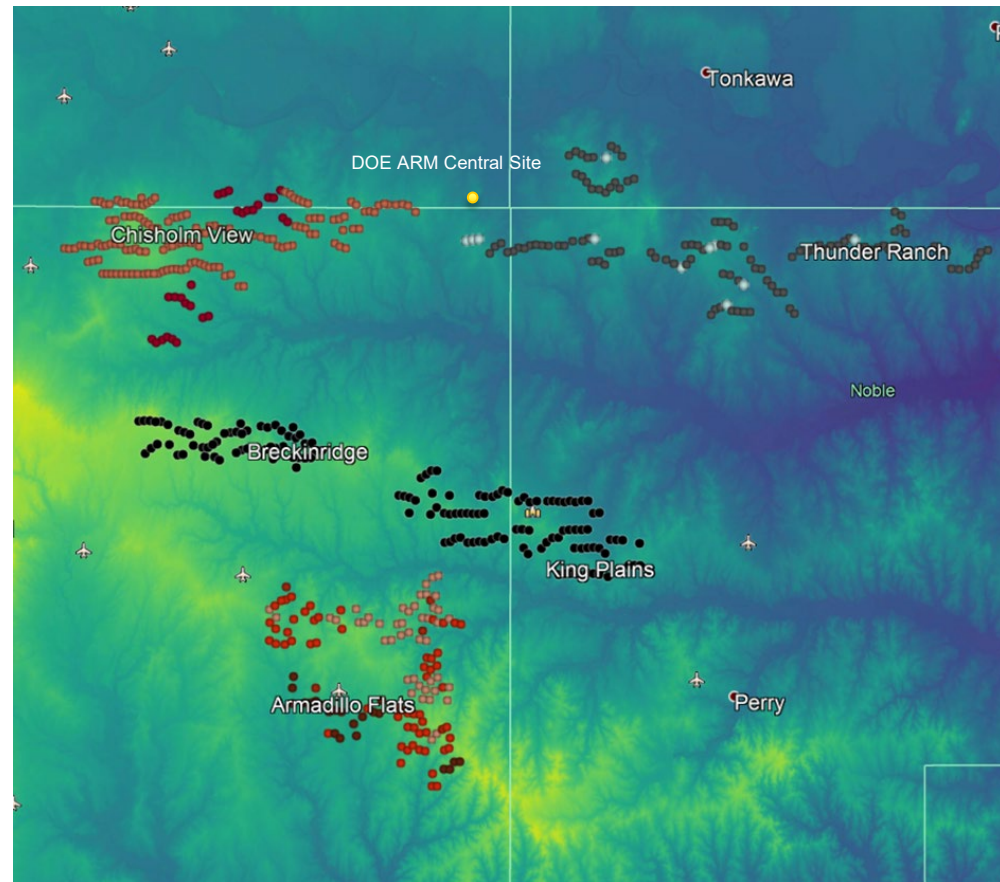- Improved instrumentation capabilities
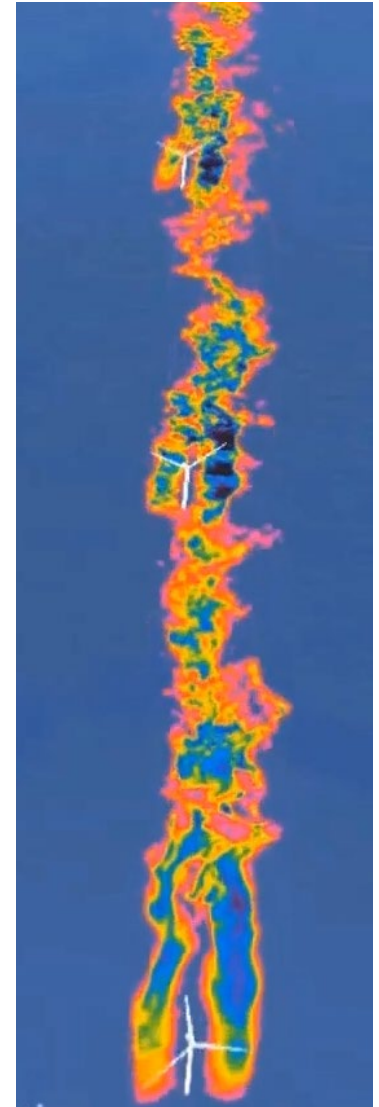
Major tasks FY19-FY20

- Project organization and partnership development

- Seek external leveraged funding

- Define seven science goals

- Identify field campaign locations

- Identify required instrumentation

All completed successfully

Program Performance – Accomplishments & Progress

- DOE
  - Atmospheric Radiation Measurement Program (ARM)
  - Atmospheric System Research Program (ASR)
- National Science Foundation
  - 6 Universities plus National Center for Atmospheric Research (NCAR)
- European Union
  - 6 research institutes led by Danish Technical University (DTU)
- NOAA
  - Earth Systems Research Laboratory and National Severe Storms Laboratory
- Industry
  - GE, Enel, Engie and others
- Partnership opportunities
  - External proposals in summer 2021 ~$10M+
 - Multiple research and data sharing agreements in progress
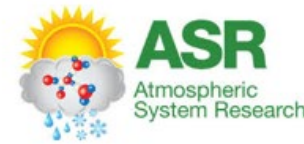
Program Performance – Accomplishments & Progress

- Instrumentation development roadmap

- Instrumentation acquisition

- Science goals defined

- Site selected

- Partnership agreements in development

- Experimental planning started

- External funding proposals submitted

- Supporting simulations
  - Mesoscale wind farm interactions
  - Blockage impacts
  - Wind farm control
  - Optimal instrumentation placement
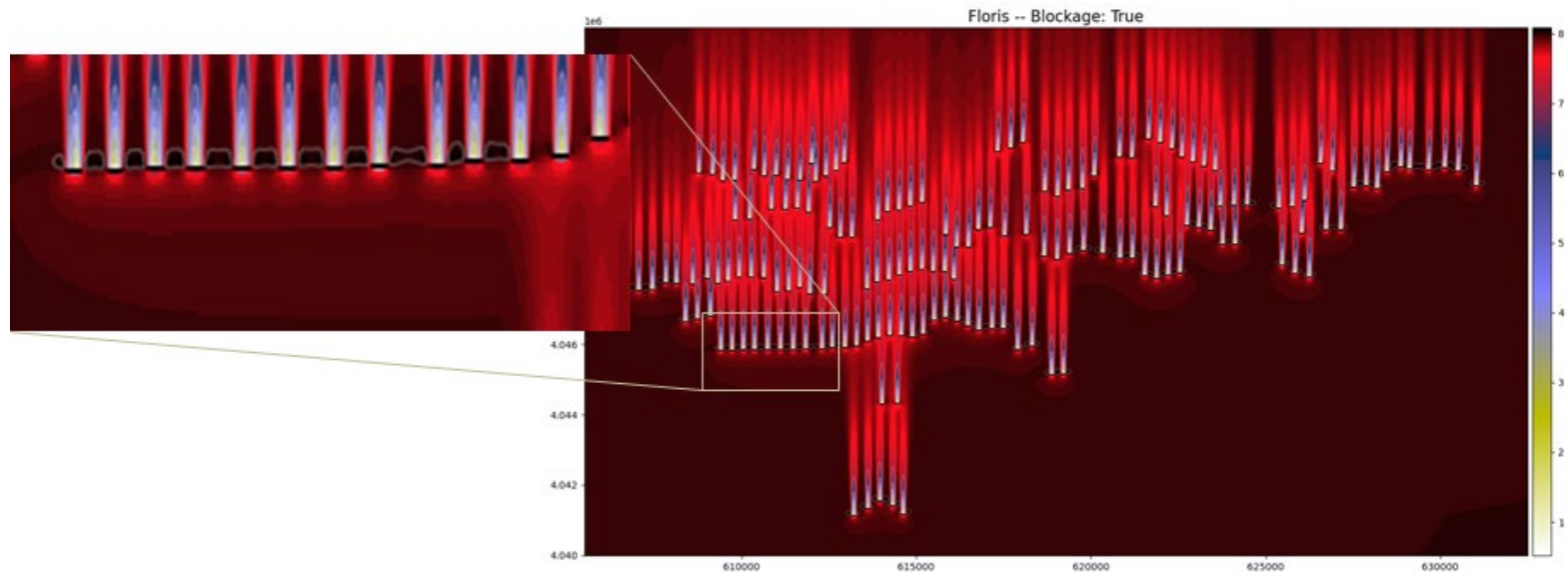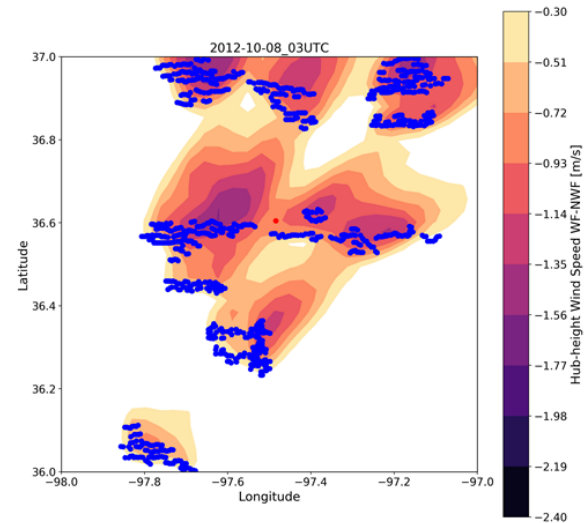
Project Performance - Upcoming Activities

- **2021**
  - Complete critical partnership agreements with wind farm owners, landowners and turbine manufacturers
  - Initial experimental design complete and finalize instrumentation

- **2022**
  - Begin AWAKEN field campaign with long term observational instruments
  - Begin data analysis and model validation efforts

- **2023**
  - Continue data analysis, model validation studies and publications
  - Short term field campaign with high-fidelity observations and AWAKEN field campaign completion

- **2024**
  - International validation benchmarks and final publications
  - All observations, relevant simulations, documentation, and publications archived within the A2e Data Archive and Portal (DAP)
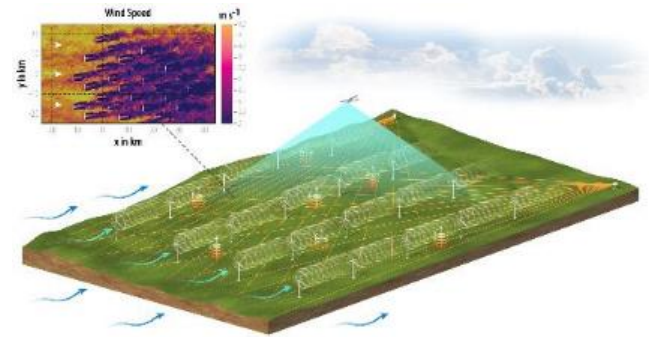
Stakeholder Engagement & Information Sharing

- Open planning process
  - Wiki and open documents
  - Monthly recorded update meetings
- NREL Overview Technical Report
- IEA Wind Task 31 Wakebench
- Presentations
  - American Metrological Society, American Geophysical Union, American Institute of Aeronautics and Astronautics, Wind Energy Science, Cleanpower 2021
- Future
  - One page information sheet
  - Informational video
  - Data available at DOE Data Archive and Portal
  - Numerous publications and presentations – estimate 50+

American WAKE experimeNt
(AWAKEN)

Patrick Moriarty[1], Nicholas Hamilton[1], Mithu Debnath[1], Tommy Herges[2], Brad Isom[3], Julie K. Lundquist[1,4], David Maniaci[2], Brian Naughton[2], Rebecca Pauly[1], Jason Roadman[1], Will Shaw[3], Jeroen van Dam[1], and Sonia Wharton[5]

[1]National Renewable Energy Laboratory
[2]Sandia National Laboratories
[3]Pacific Northwest National Laboratory
[4]University of Colorado Boulder
[5]Lawrence Livermore National Laboratory

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.

Technical Report
2020-03-02

Key Takeaways and Closing Remarks

Project Impact:
- Unique data set of wind farm atmosphere interactions
- Improve prediction of wind farm performance and operations

Project Performance:
- Partnerships in place
- Site selected
- External funding in development
- Instrument development roadmap and acquisition

Stakeholder Engagement:
- Open engagement and planning process
- Numerous industry, research and academic partners
- Many communication channels