U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

2021 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
WIND ENERGY TECHNOLOGIES OFFICE

E11 - North American Energy Resilience Model (NAERM)

Mitigate Market Barriers – Grid Integration

Jessica Lau

NREL

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FY21 Peer Review - Project Overview

Project Summary:

- Design and develop modeling and analytical capability for wind technology within the NAERM program
- Provide situational awareness and operational planning capability
- Develop modeling and analysis of wind in extreme cold event
- Develop contiguous U.S. wind forecasting capability
- Collaborate with 7 labs to develop capability for DOE (ANL, INL, LANL, LLNL, PNNL, ORNL, and SNL)
- Support DOE Offices: WETO, Office of Electricity, Solar Energy Technologies Office, and Water Power Technologies Office

Project Start Year: 2019
Expected Completion Year: FY 2020
Total expected duration: 1.5 years

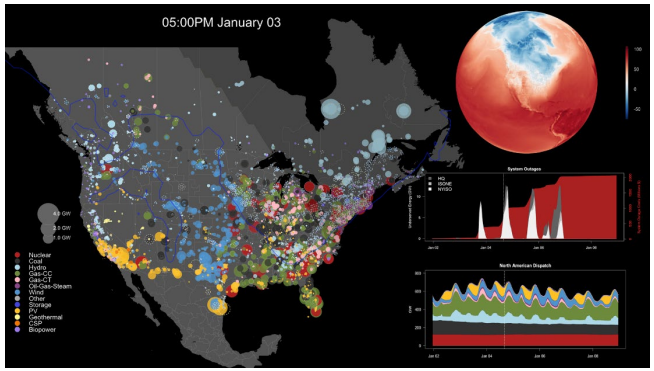
FY19 - FY20 Budget: $2,249,586

Key Project Personnel: Jessica Lau, Greg Brinkman, Kenny Gruchalla, Daniel Levie, Jiazi Zhang, Surya Dhulipala, Matt Irish

Key DOE Personnel: Jian Fu

Project Objective(s) 2019-2020:

- Design, develop, and conduct modeling scenarios and sensitivities of a Polar Vortex use case
- Create and develop a nationwide day-ahead forecast for each wind turbine in the U.S.



Overall Project Objectives (life of project):

- Provide rigorous and quantitative assessment, prediction, and improvement of national-scale energy planning and real-time situational awareness capabilities.

Project Impact

Goal: Improve modeling of extreme events and their impacts on the grid

Today's modeling tools are limited in capturing extreme events' complex impacts:

- Wind turbines can cut out due to **cold-weather cut-off limits**
- Cold weather **increases uncertainty** for load forecasting
- Thermal generators experience **increased failures** from equipment failures and supply shortages
- Cold weather triggers natural **gas supply interruptions**

Project Impact

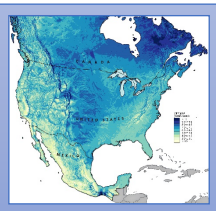
Objectives

1. **Design, develop, and conduct modeling scenarios and sensitivities of a Polar Vortex use case**
   a. Improved modeling of wind turbines under cold temperature and icing impacts
   b. Lessons learned led to improved temperature corelated impacts of other technology types
   c. Applied method to other projects with DOE and Xcel Energy
2. **Create and develop a nationwide day-ahead forecast for each wind plant in the contiguous U.S.**
   a. Created a new capability for DOE for situational awareness
   b. Provided post-event analysis capability, like supporting Feb 2021 Deep Freeze event in the U.S. Southern area

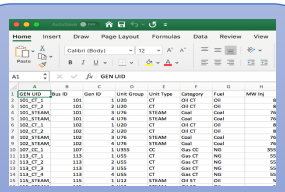
Program Performance

– All milestones and deliverables were met.

Program Performance – Analyst Workflow



Meteorological Data

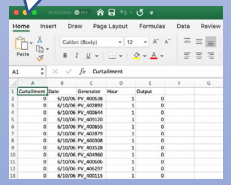


Power System Data

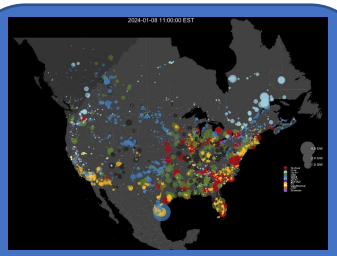
Threat and Impact Characterization

Mitigation Strategies (Operations or Investments)

Resilient Operations Simulation (PLEXOS) Simulation Engine



Time series outputs



Comprehensive Visualization

A. Created state-of-the-art and imperfect forecast of wind turbine icing and low temperature impacts

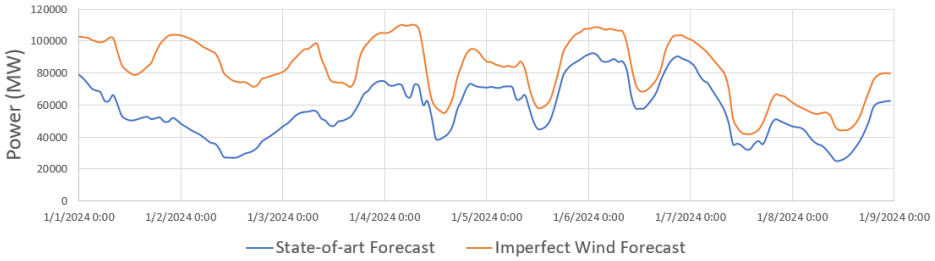
B. Implemented full Day-Ahead and Real-Time nodal model and simulation of North America. Continuing efforts for automating case-building.

C. Standardized outputs and analytical methods to help enable integration with other models

D. Created visualization to communicate grid simulation and metrics for impact

Program Performance – Grid Modeling for Polar Vortex Events

- **Creating and improving wind forecasts to reflect uncertainty in extreme cold**
  - Developed cold temperature and icing outage impacts to wind turbines in reV and SAM
  - Cold weather package installation sensitivities
- **Grid simulations and analysis of a polar vortex event**
  - Recreated 2014 polar vortex event in PLEXOS for benchmark across the Western Interconnect, Eastern Interconnect, and Texas
  - Analysis and visualization of modeling outputs



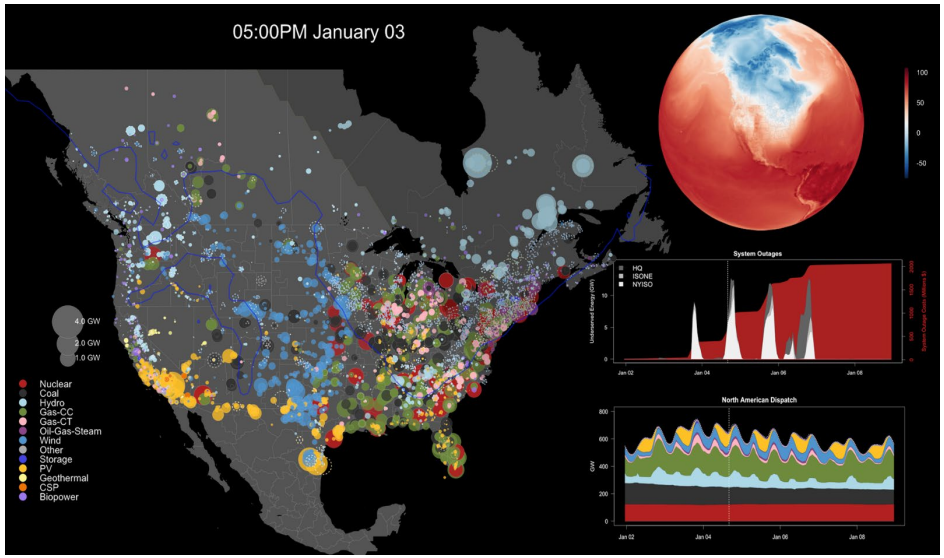
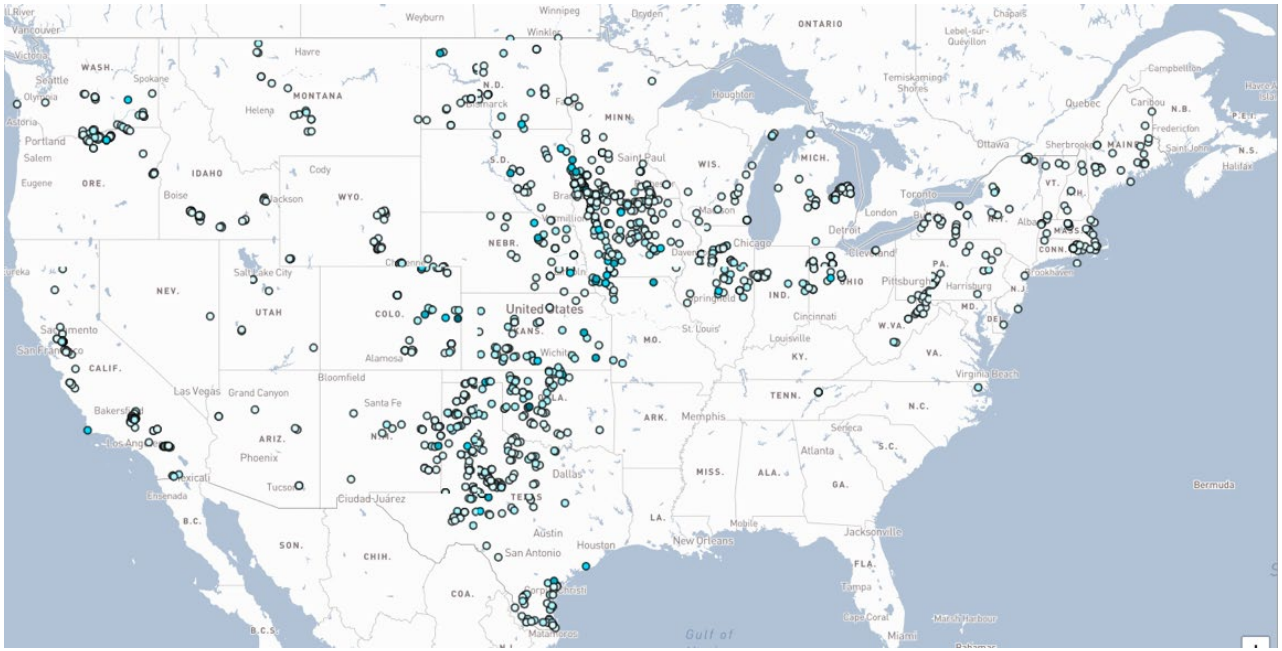


Figure top: Sample data from developed wind energy forecasting with and without cold weather impacts
Figure bottom: Snapshot of visualization video developed for polar vortex simulation

Program Performance – Forecasting Wind across U.S. 48

Create and develop a nationwide day-ahead forecast for each wind plant in the contiguous U.S.

- Using wind plant metadata, Numerical Weather Predictions, and wind turbine power conversion
- Automated daily process creates a situational awareness and analytical capability for DOE



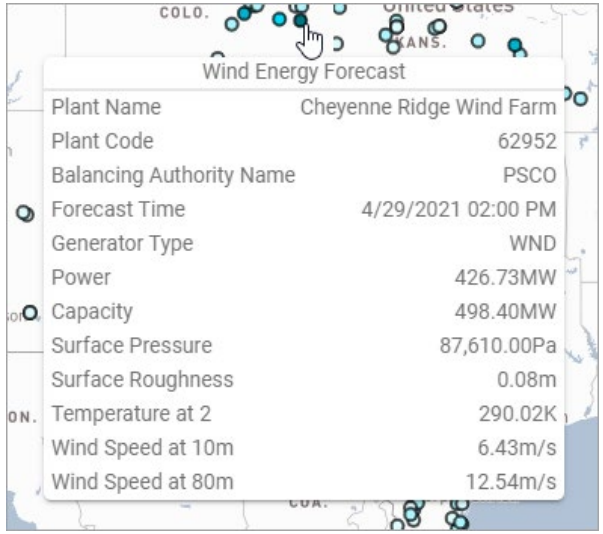


Figure left: Map of the forecasted wind plant sites in the contiguous U.S.
Figure right: An example forecast data point for a specific wind plant

Stakeholder Engagement & Information Sharing

- On 3/3/20, the polar vortex visualization was presented to the House Energy & Water Appropriations Committee
- Wind modeling technique has been used by Xcel Energy.
- Modeling lessons learned and techniques have been shared with Austin Energy and over 30 state energy planners.