U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

2021 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
WIND ENERGY TECHNOLOGIES OFFICE

A05 – Energy System Modeling and Impacts Analysis

NREL Transforming ENERGY

Modeling & Analysis – Modeling & Analysis

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FY21 Peer Review - Project Overview

Project Summary:
This project applies:

- State-of-the-art models to identify the potential for future wind deployment and interactions between wind with (1) other grid technologies, (2) social and ecological systems, (3) and clean energy policies.
- Rigorous but accessible analysis of current and future grid needs, and wind's potential role.
- Key project partners: *Lawrence Berkeley National Laboratory (LBNL), Energy Information Administration, International Energy Agency, Environmental Protection Agency, Electric Power Research Institute, NREL and EERE researchers and staff*

Project Objectives:
The project is designed to provide:

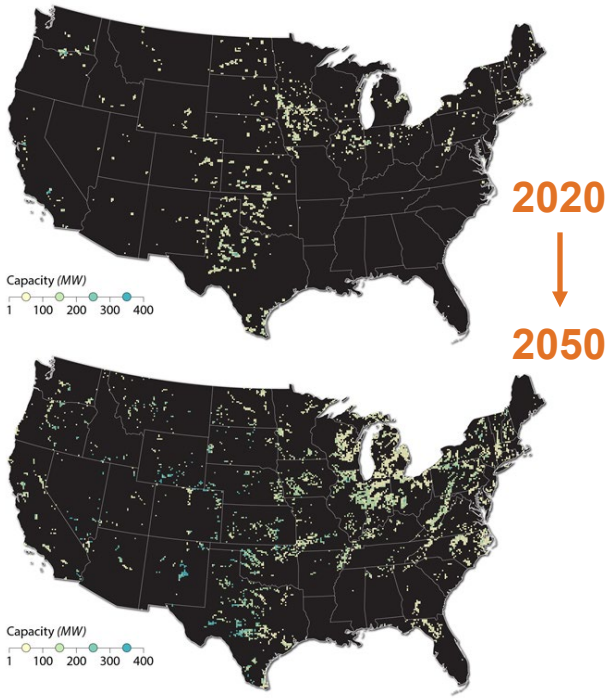
- The analytic tools for WETO to evaluate impact of R&D decisions and targets
- Insights and improved understanding for WETO and other stakeholders about grid system needs and the economic and technical capabilities for wind to provide such needs
- Targeted analysis for WETO, DOE, or policy priorities
- Visionary scenarios for the future of wind—and identification of barriers to cost-effective wind deployment

Project Start Year: FY2019
Expected Completion Year: FY22
Total expected duration: 4 years

FY19 - FY20 Budget: $2,559,529 total
($1,968,875 actual spend)

Key Project Personnel: Trieu Mai (PI), Paul Denholm, Jennie Jorgenson, Anthony Lopez, Wesley Cole, Philipp Beiter, Matthew Mowers

Key DOE Personnel: Patrick Gilman



Project Impact

DOE-WETO

- Informs WETO decisions with analysis of the impacts of R&D investments
- Enhances WETO's understanding of the future grid
- Provides a nexus for WETO and other DOE offices for cross-EERE studies and initiatives

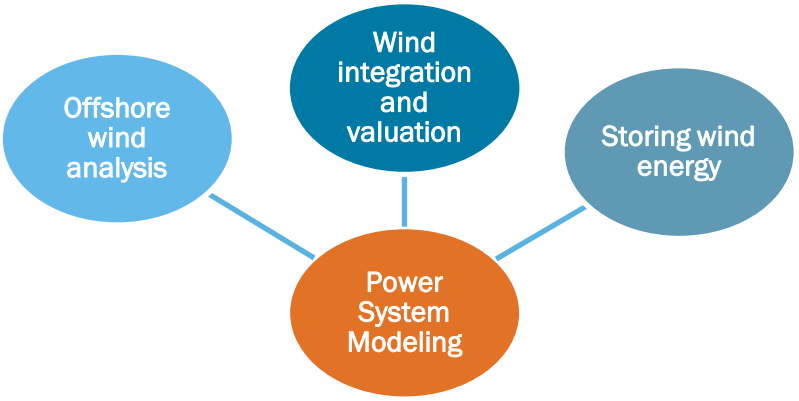
External

- Develops data and tools for improved assessment of wind
- Provides decisionmakers with accessible insights of how wind interacts with the grid
- Highlights what is possible—and what are key barriers—for future wind energy expansion

By assessing the interactions between wind and the rest of the energy system, the insights and tools from this project are applied for major cross-cutting DOE analyses and scenarios studies of power system transformation.

Examples: Standard Scenarios, Electrification Futures Study, transmission planning and decarbonization studies

Project Performance Scope, Schedule, Execution



- All milestones have been met or are on track to be met. Budgets are on track.
- Specific products during FY19-FY20 are summarized in the following slides

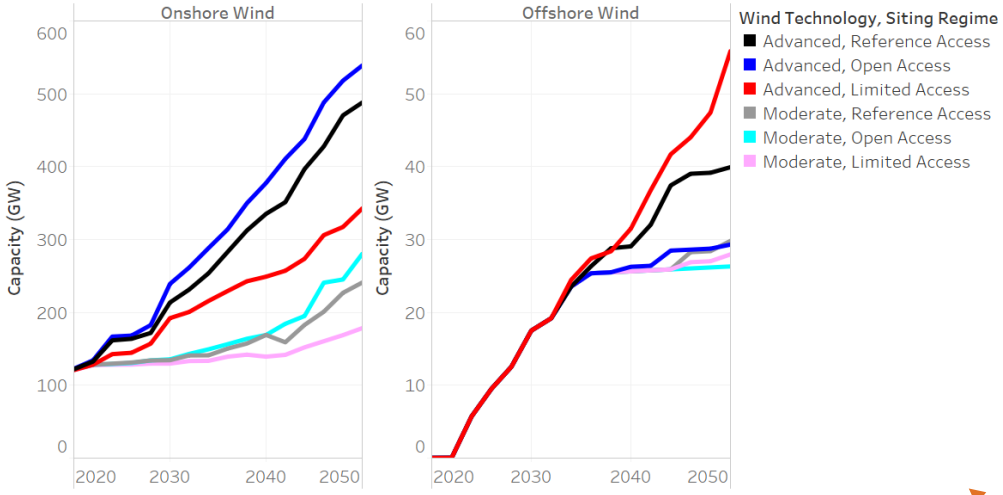
Area	FY19	FY20	FY21	Beyond
Power system modeling	• Deriving cost and value metrics	• Advanced land-based supply curve • Advancing resource adequacy models	• Individual site representation • Transmission modeling	• Site-optimized technology and plant design
Wind integration and valuation	• Intro to grid services • Conceptual framework of system value	• Inertia explainer • Relative value framework • Marginal capacity credit (West)	• System strength explainer • Marginal capacity credit (East, Texas)	• Changing wind value and cost over time • Wind capacity credit at higher penetrations
Offshore Wind analysis	• NE case study • Cost targets	• Current procurement	• Updated supply curves • Drivers of offshore	• Offshore wind in a low-carbon energy system
Storing wind energy	• Storage timescales screening	• Diurnal storage modeling	• Seasonal storage modeling	• Dedicated wind for hydrogen production

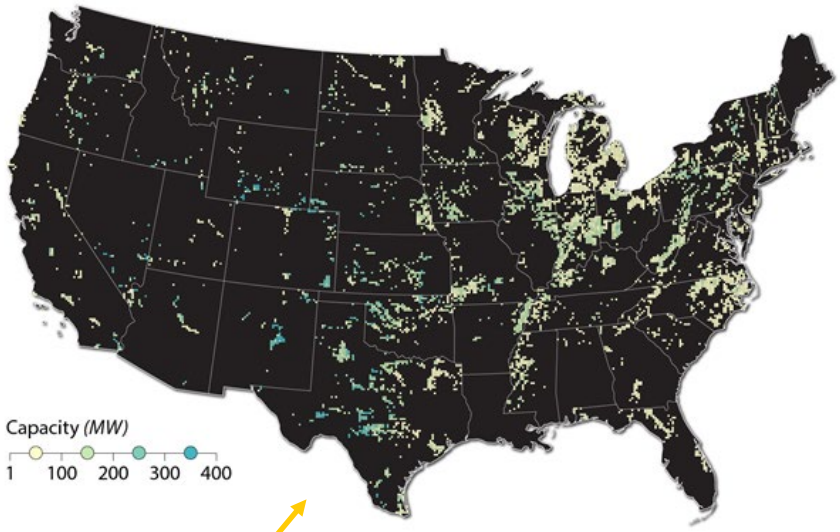
Project Performance, Accomplishments and Impacts:

Power system modeling

Objective: Advance and share state-of-the-art methods to represent wind—and other clean energy—technologies in power system planning models

Tools: Regional Energy Deployment System (ReEDS) capacity expansion model, Probabilistic Resource Adequacy Suite, and production cost models—tools used by EERE and external users





High-fidelity modeling to understand drivers behind the magnitude and location of future wind deployment

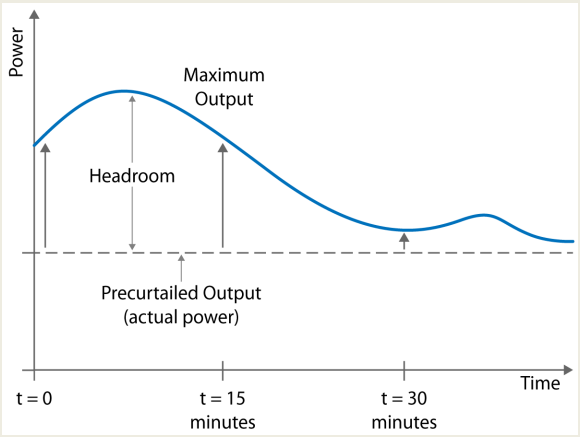
- Suite of tools used to inform R&D impacts, low-carbon scenario studies, policy analysis, and transmission and grid integration studies across DOE—including co-funding across EERE
- ReEDS is now publicly available with 600 users from other national labs, federal agencies, universities, and other organizations

R&D 100 AWARDS

Project Performance, Accomplishments and Impacts:
Wind integration and valuation

Objective: Synthesize data on current and future grid needs and wind's capability to provide those needs; assess future wind cost and economic value—and their drivers; and improve understanding to enable stakeholders to go 'beyond LCOE'

Intro to Grid Services…and Provision from Wind

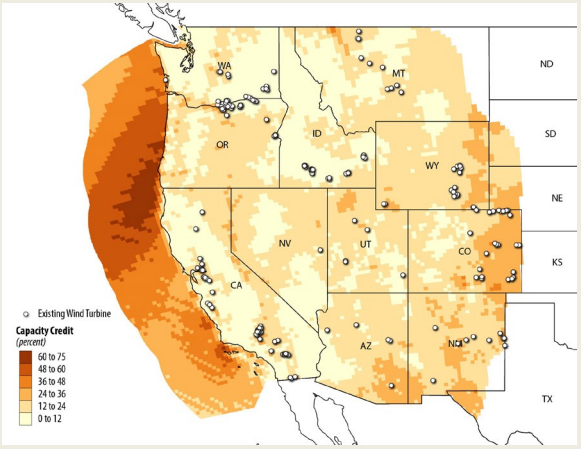


- Operating reserves are important but are shallow markets
- Wind can provide many of these services but requires pre-curtailment and forecasting

Reduction in system inertia is unlikely to be a barrier to wind growth in most interconnections especially with fast frequency response and grid-forming inverter solutions

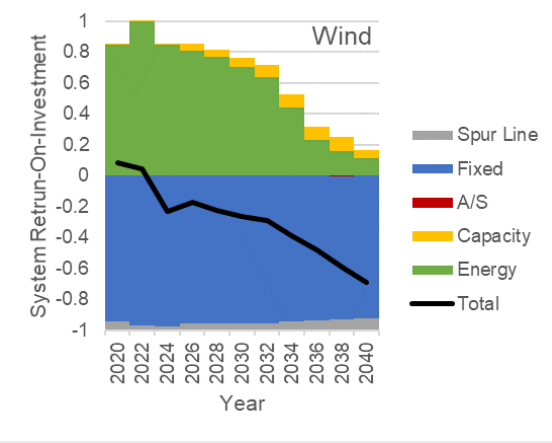
Wind Capacity Credit

- Wind can support system resource adequacy but its capacity credit varies significantly by region
- High offshore wind capacity credit highlights it potential value especially under a low-carbon grid



Competitiveness Metrics

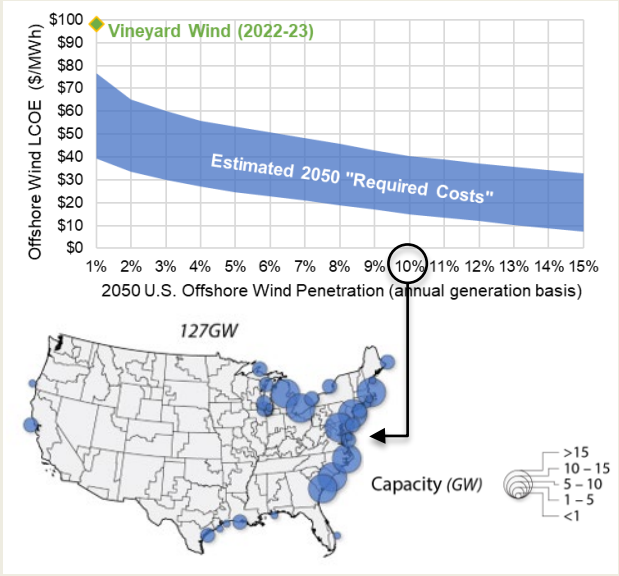
- Competitiveness metrics can help advance understanding beyond LCOE and 'integration costs'
- Improved modeling enables robust estimates of future costs and value of wind



Project Performance, Accomplishments and Impacts:
Offshore wind analysis

Objective: Inform R&D planning and ambition by estimating offshore wind cost targets required to reach long-term deployment levels; identify impacts of offshore wind integration in the near-term; and assess current offshore wind procurement mechanisms and their implications for revenue.

Setting Offshore Wind Cost Targets



- Developed a new method to estimate the levelized cost that needs to be reached to a specified deployment target
- The 'required cost' for offshore wind is estimated to range from ~$15-40/MWh to achieve 10% offshore wind generation

Northeast Offshore Wind Grid Study

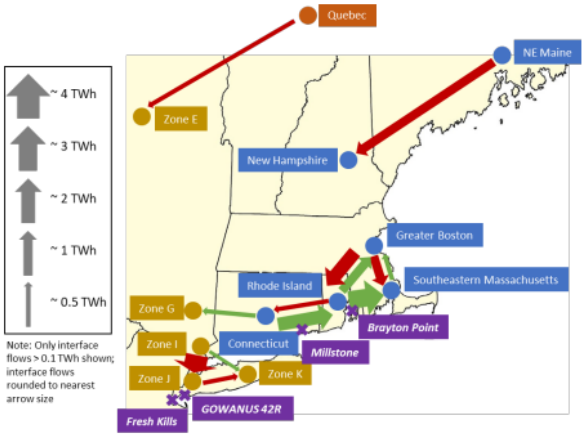
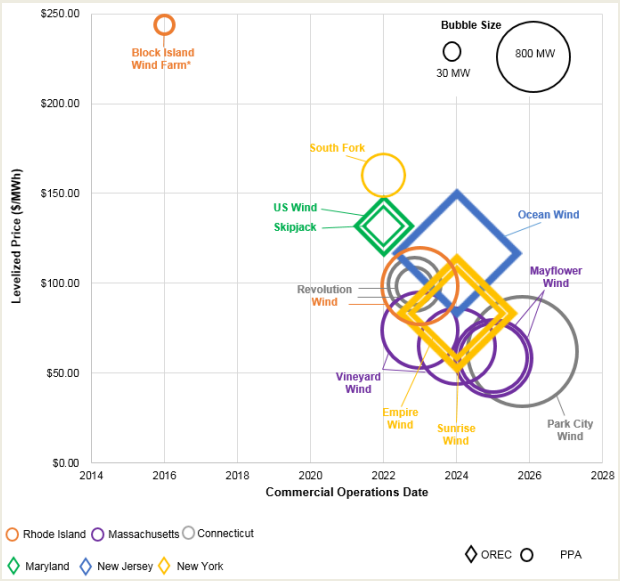


Figure 13. Difference in interface flows in U.S. Northeast between the 2024 7-GW and 0-GW (base) scenarios

- Integrating up to 7 GW of offshore wind in the existing northeast grid is possible with modest curtailment and an increase in thermal plant cycling
- Offshore wind can help lower production costs and contribute to regional adequacy needs

Offshore Wind Procurement and Revenue Sources



- Systematic analysis of offshore wind support regimes in U.S. states
- Enables comparison of different long-term contracts and bottom-up cost and revenue estimates

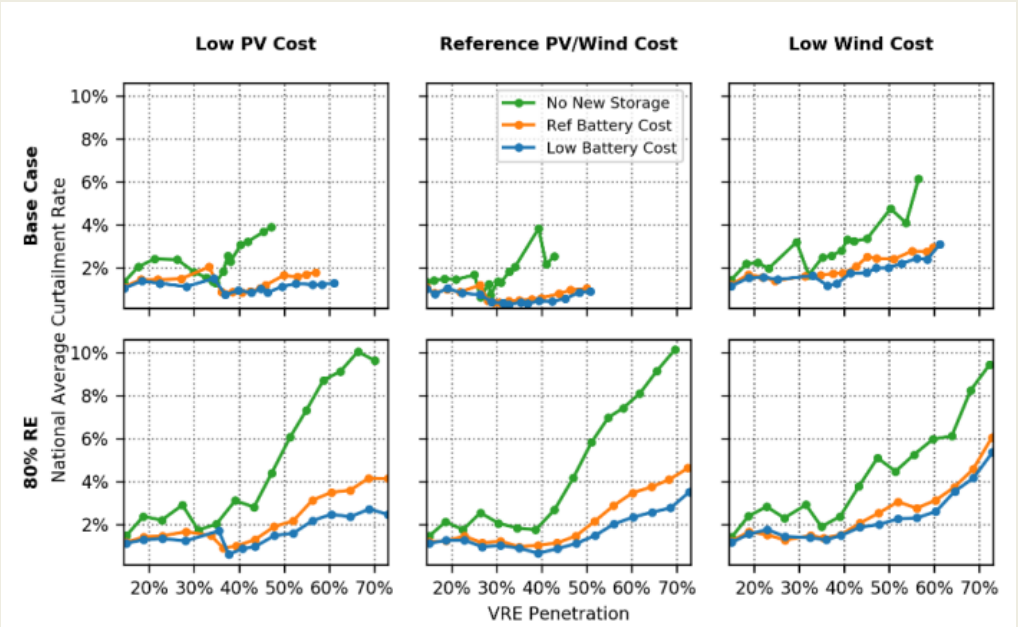
Project Performance, Accomplishments and Impacts:

Storing wind energy

Objective: Assess the relationship and interactions between wind and energy storage; and innovate and disseminate new capabilities in models to reflect the complexities of storage

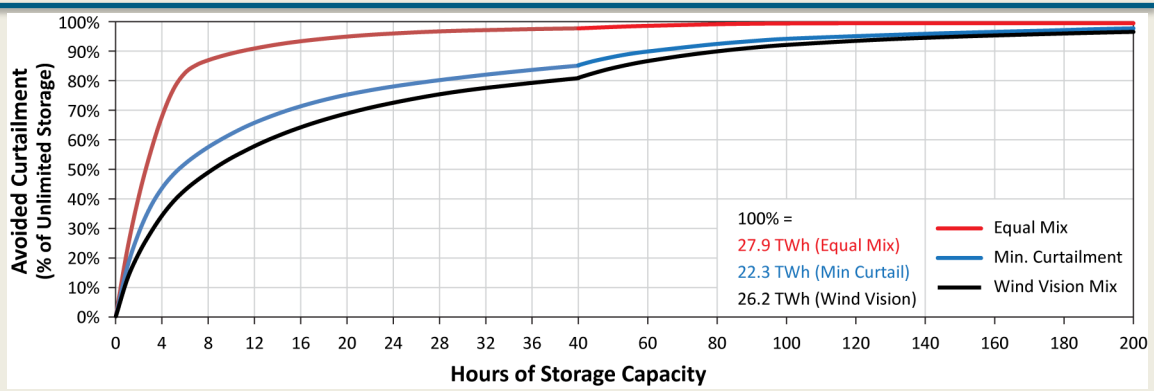
Modeling the interactions between wind and diurnal energy storage

- Collaboration between leading modeling teams to improve model representations
- A large potential exists for battery storage as a peaking capacity resource; such pathways may be critical for the success of high wind / low-carbon power systems
- Greater synergies exist between solar and battery storage, but storage also mitigates wind curtailment



Beyond batteries: timescales for energy storage

- Seasonal mismatch in renewable energy and demand motivates research in very long-duration storage options
- Most of the value is provided by the first ~8 hours thus highlighting the challenge for seasonal storage technologies

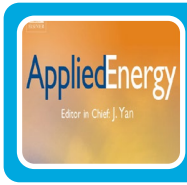


Publications, Stakeholder Engagement, Information Sharing

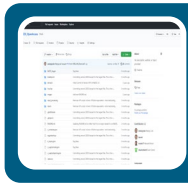
The project, as a whole, is designed to engage and inform a diverse set of stakeholders through multiple forums and products, including reports, presentations, multi-media, social media, press releases, and NREL Analysis (2,631) and Wind lists (+WETO). Direct collaborations further enhance engagement.

- *32k technical report downloads*
- *75 citations*
- *4 news stories with 13k views*

7 technical reports



8 journal papers
(+1 under review)



1 model release
(600 external users)

1 explainer video
(3 industry awards)

20+ presentations and engagements

Stakeholders engaged:

- ✓ WETO and DOE Offices
  - Multi-office co-funding
  - Data sharing with LBNL
- ✓ Energy modelers and analysts
  - International organizations
  - Collaborations with leading energy modeling teams
  - ReEDS user group meeting (70 attendees)
- ✓ External decision-makers
  - State governments and regulators
  - Utility planners and industry
  - Wind industry

List includes products released primarily during FY19-20 or based on work conducted during that period. Some products are co-funded.

Project Performance - Upcoming Activities

Ongoing FY21 planned activities and project vision

- **Offshore wind 'vision':** new supply curves and scenario study
- **Transmission modeling:** macrogrid design, high-voltage direct current, updated costs and options (e.g., existing and new corridors, undergrounding, reconductoring)
- **High-fidelity wind modeling:** individual wind 'sites,' economies of scale, (>FY21) site-optimized plant and turbine design
- **Capacity credit:** visualization, national scope, methodological comparison, high wind analysis
- **Explainer video:** short circuit strength
- **Nexus for WETO and other DOE Offices** for new studies focused on energy system decarbonization and the future U.S. grid