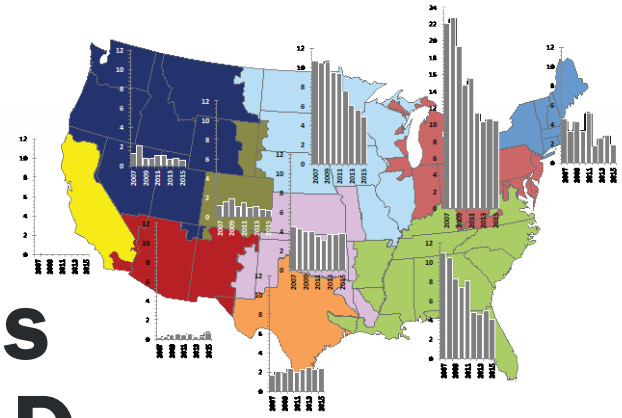
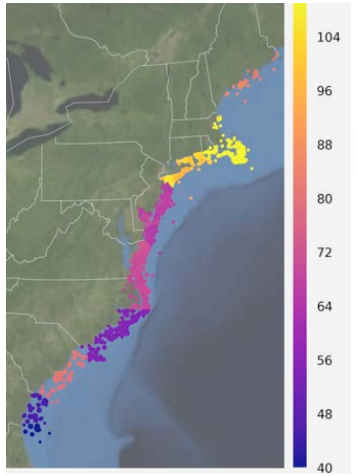
U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY



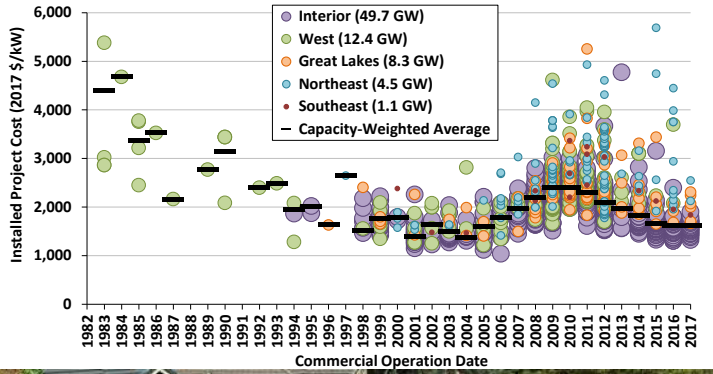


Modeling & Analysis to Inform WETO R&D

Project ID: A3

Ryan Wiser

Lawrence Berkeley National Laboratory



Project Overview

A3: Modeling & Analysis to Inform WETO R&D

Project Summary

Synthesize foundational data, conduct innovative and targeted analysis, and provide analytical support to WETO and its partners. Fill critical knowledge gaps in support of WETO and the wind sector by conducting analysis on the potential cost, performance, value, and barriers to wind power in the United States.

Project Objective & Impact

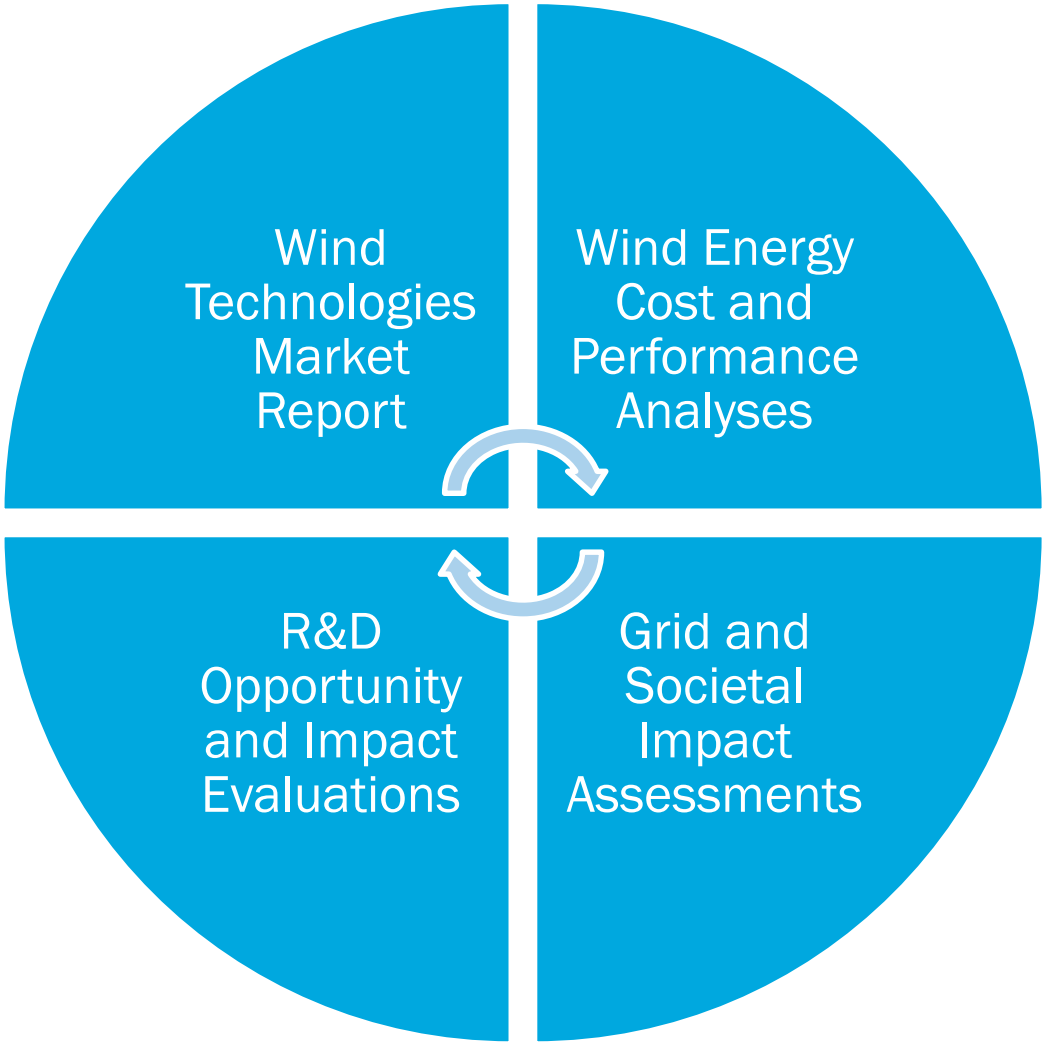
This work informs DOE WETO's R&D planning approaches and investment decisions, and helps WETO prioritize major technology development initiatives. It also provides WETO and other stakeholders with unbiased data on and objective analysis of the potential cost, performance, value, and barriers to wind power in the United States.

Project Attributes

Project Principal Investigator(s)
Ryan Wiser Mark Bolinger
DOE Lead
Patrick Gilman
Project Partners/Subs
National Renewable Energy Lab Exeter Associates, ABB Ventyx IEA Wind Task 26 members Paulos Analysis
Project Duration
2 years: FY17 and FY18

Technical Merit and Relevance

Four Areas of LBNL Engagement



WETO

- Helps WETO understand current market status and serves as empirical foundation for R&D assessments
- Enhances WETO's ability to discern and prioritize future technology improvement options, and assess impacts
- Supports wide range of R&D investment & other decisions with real-time analysis

EXTERNAL

- Provides stakeholders with a trusted source of data on and analysis of potential cost, performance, value, barriers
- Advances understanding of wind's impact, role, and value within electric system

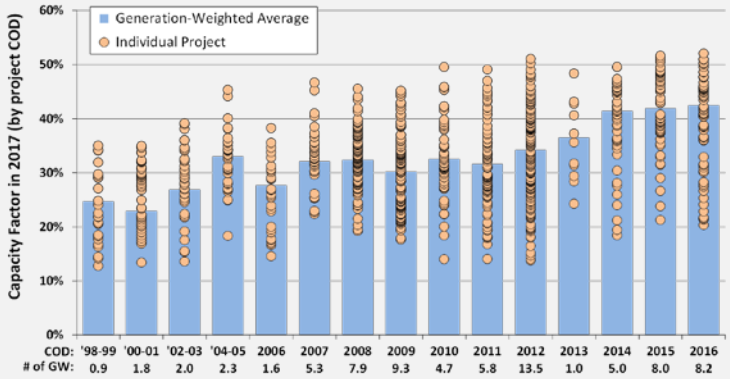
Approach and Methodology

- The **variety of analyses performed** under this overarching "project" leads to diverse methods, including various forms of **statistical, economic, financial, and engineering analysis**
- In all cases, work is designed to **build on existing literature** to give stakeholders greater **confidence in the results**
- As much as possible, analyses are **grounded in actual data from operating wind energy projects** and in experience with wind energy deployment efforts
- Where appropriate, **experts** from other labs, industry, and academia are **used as both advisors and subcontractors**
- A key goal is to **stay nimble** in order to be **responsive to emerging issues** and stakeholder needs in a timely manner
- Key objective is to ensure that work is **used and useful**

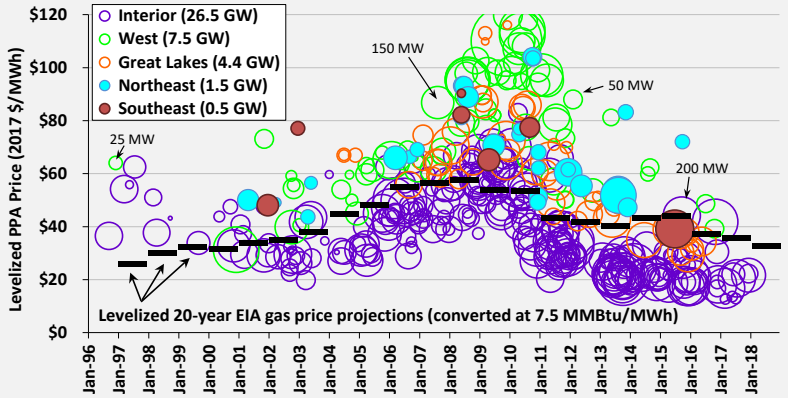
Accomplishments and Progress:
Wind Technologies Market Report

- Goal: Publish annual 'flagship' DOE report that presents data on key trends in the land-based wind market, building on other available data collection efforts; covers installation, manufacturing, technology, performance, cost, and value
- A "go to" guide for diverse stakeholders, and helps DOE benchmark its R&D progress, and provides empirical foundation for other analyses

Dramatic rise in capacity factors…



…enables rock-bottom PPA prices



New and Notable

- U.S. Wind Turbine Database
- Data visualizations and access
- Inter-annual resource index
- Performance degradation assessment
- EIA confidential CapEx data
- Merchant market-value analysis

Accomplishments and Progress:
Wind Energy Cost and Performance Analyses

- **Goal: Conduct analysis of past and possible future wind cost and performance trends and drivers, to inform R&D prioritization and to help illuminate pathways to reduce the levelized cost of wind energy (LCOE)**

Drivers of Wind Turbine Prices

$/kW	2001-08	2008-15
Labor + warranty	+116	-38
Profit margin	+60	-24
Turbine scale	-4	-24
Materials price	+90	-71
Currency	+168-335	-207-308

Wind Performance Uncertainty

Improved financing terms present an LCOE reduction opportunity of up to ~$3/MWh

Impact of Rising Interest Rates

Drop in tax rate to 21% increases price by ~$2/MWh in 2018 → Rising interest rates through 2020 add ~$2/MWh → PTC phase-out post-2020 adds another ~$14/MWh

Need reductions in costs and increases in performance, to compensate

Industry Operational Cost Survey

OpEx has declined from ~$80/kW-yr for projects built in the late 1990s to ~$40/kW-yr for projects in 2018 → 9% OpEx decline for each doubling of wind capacity; ~10% of LCOE reduction could come from OpEx

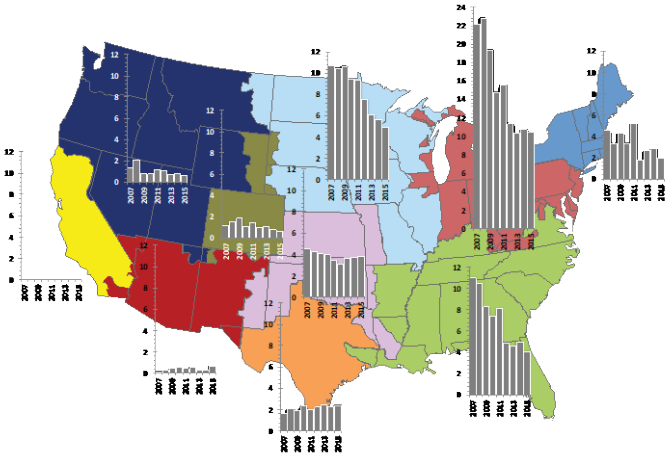
Ongoing: not yet published

Accomplishments and Progress:
Grid and Societal Impact Assessments

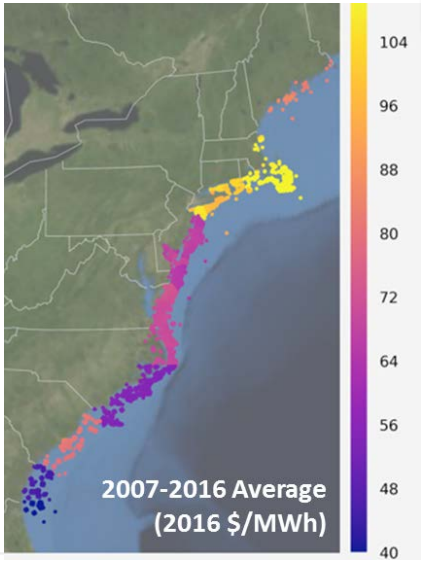
- **Goal: Advance understanding of wind grid integration needs and system value, and ways to boost value. Inform R&D targets & prioritization beyond LCOE; enhance stakeholder understanding of wind's role within electric system**

Societal Value (FY17) → **Grid System Value (FY18)**

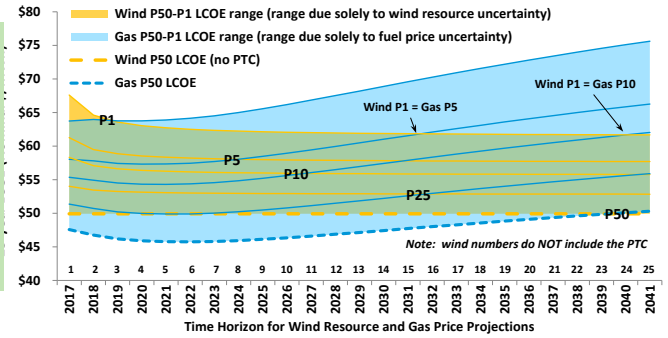
Health Benefits (avoided SO_2)



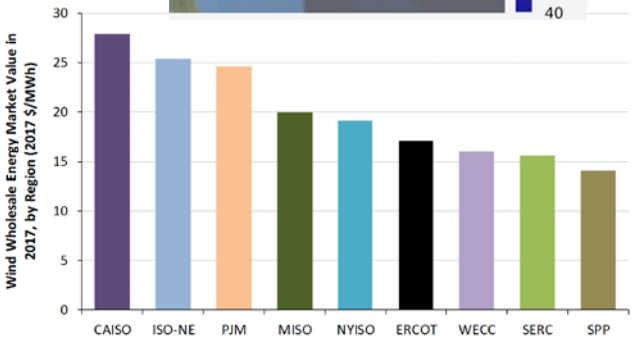
Energy, Capacity and REC Value of Offshore Wind (also considered merit order and natural gas price suppression



Fuel Price Hedge Value

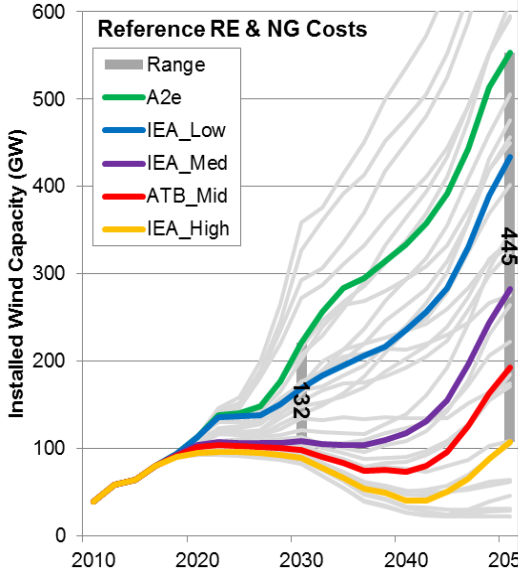


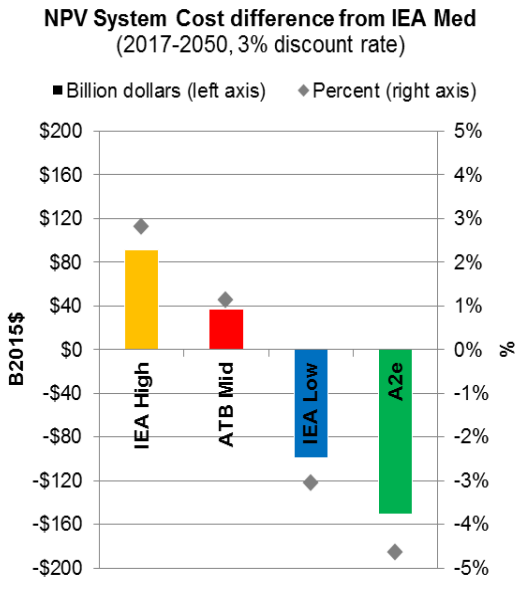
Regional Merchant 'Market Value' of Wind, 2017



Accomplishments and Progress:
R&D Opportunity and Impact Evaluations

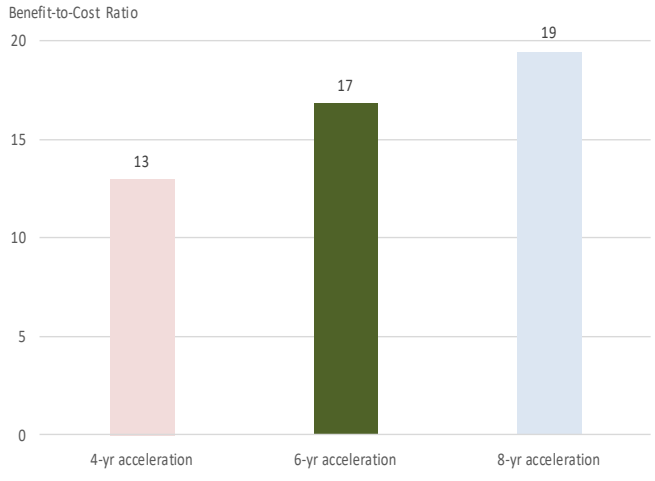
Built on IEA Wind Expert Survey and NREL SMART Wind Plant efforts to understand need for and benefits of R&D (led by NREL)





Wind technology advancement is a core enabler for sustained wind deployment, resulting in lower system costs

Nearing completion of assessment of economic return to WETO's historical R&D investments



Across multiple approaches & sensitivities, sizable net return to WETO's historical R&D

Accomplishments and Progress:
Other Activities and Accomplishments

Impact of wind and solar on wholesale power prices

- ongoing research on the impacts of wind, solar, and other drivers on wholesale prices, to inform electric-system transformation and related impacts on costs, reliability, planning

IEA Wind Task 26 on cost of wind energy

- compare land-based wind technology, cost, and performance data across countries in upcoming report; populate data viewer to enable external access to wind data from participating countries; analysis of the 'system value' of large rotor, high-hub-height turbines

IEA Grand Vision

- participate in an IEA- and NREL-led workshop and subsequent discussions, ultimately leading to submission to *Science* focused on the most critical R&D opportunities for wind energy

Retail rate impacts

- assess degree to which renewables deployment has impacted retail electricity rates

Expert survey on the future cost of wind energy

- disseminate results from earlier survey, including factsheets, press, speaking engagements

Technical assistance

- provided extensive technical assistance to numerous parties, including the DOE, state and federal decision-makers, and a variety of wind and utility stakeholders

Milestones and Schedule: FY17–FY18

- **Formal milestones listed in narrative summary of project—not repeated here**
- **Milestones reflect formal annual operating plans established annually**
- **In practice, additional deliverables completed beyond formal milestones**
- **All milestones met on time or, in a few cases, with minimal delay**
  - Maximum delay for quarterly milestone = 2 months; next highest = 2 weeks
  - One milestone delayed by 5 months, due to 'hold' request from DOE WETO

- **All go/no-go decision points achieved: go/no-go decision points :**
  - FY17: Update stakeholders on trends in cost, performance and deployment of wind energy technologies in the U.S. by publishing annual Wind Technologies Market Report, and completing dissemination activities in accordance with direction from DOE communications staff: Go
  - FY17: Deliver to DOE draft internal analysis in PowerPoint briefing form that identifies the potential LCOE impacts associated with potential interest rate increases, with and without the PTC, to determine how the project finance environment for wind might be affected by interest rate risk: Go
  - FY18: Based on its assessment of the document's value to the program and in light of other budgetary and analysis priorities, the WETO will decide whether or not to direct LBNL to lead the creation of the "2017 Wind Technologies Market Report": Go
  - FY18: Based on the high-level analysis of performance degradation presented within the capacity factor section of the "2017 Wind Technologies Market Report," WETO will decide whether or not to fund LBNL to follow up with a more-detailed and -rigorous degradation analysis, comparable to those recently conducted in Europe, in FY19: Go

Communication, Coordination, Commercialization

12 Lab reports

4 Journal articles

2 Conference posters

[see: https://emp.lbl.gov/publications]

Press uptake	Presentations	Technical assistance
139	44	67+

Tight coordination and collaboration with other Labs (especially NREL), international community via IEA Wind, consultancies, and wind industry

Upcoming Project Activities

Goal: Stay *nimble* to target emerging needs of DOE WETO and the wind industry, but also *strategic* to anticipate DOE and industry longer-term needs

FY19 Current and Ongoing Work

- 2018 edition of annual Wind Technologies Market Report
- Enhanced wind market-value analysis at project level and inclusive of capacity
- Finalize assessment of impacts of wind (and solar) on wholesale market prices
- Finalize industry survey tracking past and recent trends in land-based wind OpEx
- Assess wind project performance as projects age, and underlying drivers
- IEA Wind: update data, finalize cross-country report, prep for possible new survey
- Grand Vision for wind energy, in collaboration with IEA Wind, NREL, others
- DOE WETO program-level cost-benefit analysis of historical R&D investments

Milestones and budget are all on track