U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Technology Development & Scientific Research 2017 - 2018

2019 Wind Program Peer Review

Mike Derby

April 30 – May 2, 2019

Wind Energy Technologies Office

Overview

Wind Office Vision

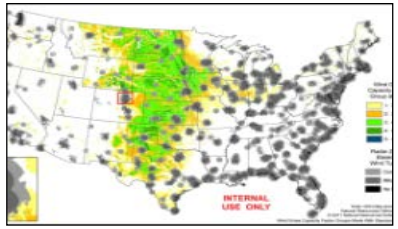
Clean, low cost wind energy as an option nationwide

Wind Office Scope

The Wind Energy Technologies Office aims to accelerate widespread U.S. deployment of clean, affordable, reliable, and domestic wind power to promote national security, economic growth, and environmental quality. Office RDD&D activities are applicable to **utility-scale land** and **offshore wind** markets, as well as **distributed** turbines—typically interconnected on the distribution grid at or near the point of end-use.

Wind Office Programmatic Priorities

- **Reduce the cost of wind energy technology**—targeting near-zero costs with no cost fuel —and increase wind value to the economy in all sectors – land-based, offshore, and distributed; contributing to lower, stable electricity rates, with increased domestic manufacturing, and increased domestic investment
- **Improve wind energy grid integration and increase grid resilience and reliability**; with diverse locations providing value to address extreme weather events and cyber-attacks
- **Reduce market barriers and associated costs** to increase options for responsible deployment in markets where wind is cost competitive; with improvements for local communities through lower pollution and minimized impacts to wildlife and the environment



Wind Office Goals

Enabling Wind Options Nationwide

FY 2017–18 LCOE Targets

- The Office exceeded its Government Performance Reporting Act (GPRA) levelized cost of energy (LCOE) end of year targets for both land-based and offshore wind in Both FY 2017 and FY 2018.

FY 17-18 GPRA Targets

Land-Based Wind: Reduce the unsubsidized market LCOE for utility-scale land wind energy systems from a reference wind cost of $.074/kWh in 2012 to $.057/kWh by 2020 and $.042/kWh by 2030.

Offshore Wind: Reduce the unsubsidized market LCOE for offshore fixed-bottom wind energy systems from a reference of $.18/kWh in 2015 to $.15/kWh by 2020 and $.096/kWh by 2030.

Future Goals

- **LCOE targets:** The office works to achieve breakthroughs in reducing the LCOE for land-based wind by 50% from today's LCOE, to $.023/kWh without subsidies by 2030, and achieving a 50% reduction in offshore wind and distributed wind by 2030 from a 2015 benchmark.

- **Additional non-LCOE targets are under development by the office**

Wind Office Strategic Priorities

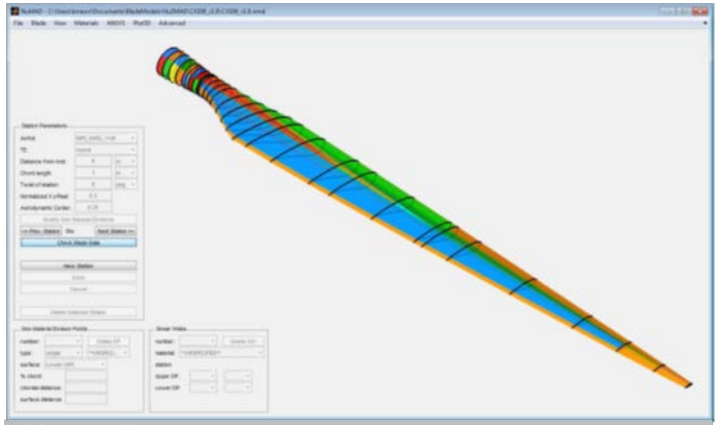
Clean, low-cost wind energy options nationwide

	Land-Based Wind	Offshore Wind	Distributed Wind
Technology Development & Scientific Research	Atmospheric Science & Wind Plant Systems Engineering	Atmospheric Science & Wind Plant Systems Engineering	Atmospheric Science
	Standards and Certification	Standards and Certification	Standards and Certification
	Technology Innovation	Technology Innovation	Technology Innovation
	World Class Testing Facilities	World Class Testing Facilities	
	Tech to Market Commercialization	Tech to Market Commercialization	
	Integrated Systems Design	Integrated Systems Design	
		Offshore Specific R&D	
		Advanced Technology Demo Projects	
Market Acceleration & Deployment	Advanced Grid Integration	Advanced Grid Integration	Advanced Grid Integration
	Workforce and Education Development	Workforce and Education Development	Workforce and Education Development
	Stakeholder Engagement	Stakeholder Engagement	Stakeholder Engagement
	Environmental Research	Environmental Research	
	Siting & Wind Radar Mitigation	Siting & Wind Radar Mitigation	
Analysis & Modeling	Evaluate and Prioritize R&D	Evaluate and Prioritize R&D	Evaluate and Prioritize R&D
	Model Development and Maintenance	Model Development and Maintenance	Model Development and Maintenance
	Techno-economic Analysis	Techno-economic Analysis	Techno-economic Analysis
	Electricity Sector Modeling	Electricity Sector Modeling	Electricity Sector Modeling

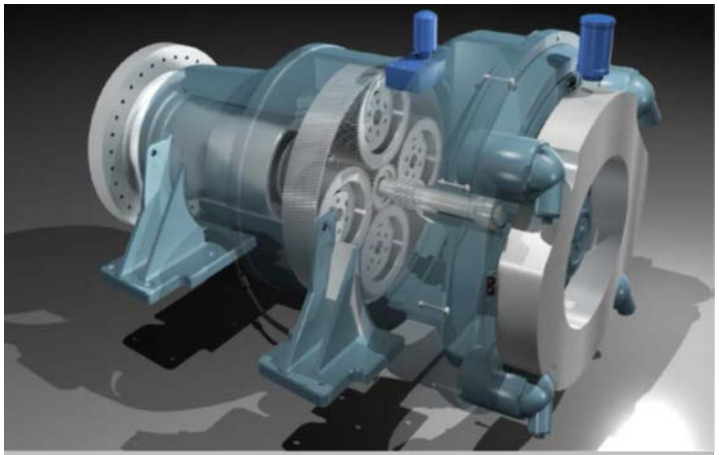
How We Do Business

DOE wind energy research, development, demonstration and deployment (RDD&D) projects:

- Invest in **high risk, transformational** technological innovations that are essential for the advancement of all U.S. wind systems
- Focus on novel research **not being undertaken by the U.S. wind industry due to real or perceived cost & risk**
- Wind Office initiatives and projects leverage **DOE and National Lab unique skills, facilities, and capabilities, and are non-duplicative with Industry & Academia.** Each R&D project is independently Merit Reviewed
- Invest in **emerging market opportunities, such as offshore wind, and work through public-private partnerships to develop wind systems addressing domestic opportunities and challenges**
- Engage in **key industrial partnerships** through use of federally-funded national test facilities



Model of next generation blade design

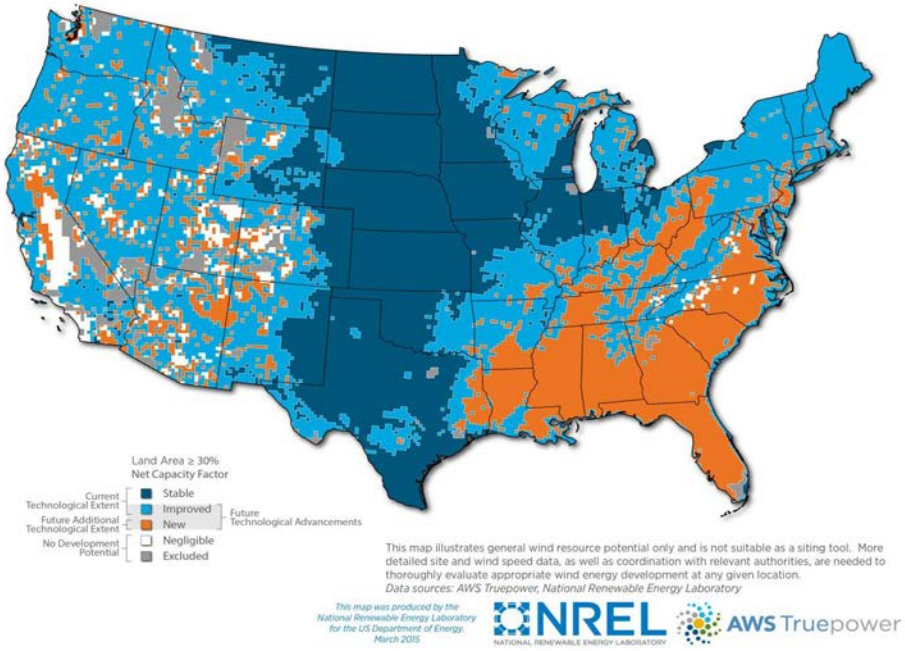


Next generation drivetrain design

R&D Motivation: Enabling Wind Nationwide

The combined land-based and offshore domestic wind resource potential is more than 10 times greater than the total U.S. electricity demand

- Untapped Wind Market Potential in All 50 States: Land-based utility-scale wind (LBW), Offshore wind (OSW) and Land-based distributed-scale wind
- Barriers: Wind Turbine Design, Reliability, Wind plant optimization, Cost reduction, Grid integration, and Mitigation of environmental impacts and human use impacts such as radar interference.



Land area achieving a minimum 30% net capacity factor, based on current technology, increased rotor diameter and a 140-m hub height. Areas of expanded access to wind power are highlighted in orange.

How We Organize Our Work

Wind Plant Optimization

Atmosphere to Electrons (A2e) initiative

- *Atmospheric Science*
- *Wind plant physics*
- *Wind Plant Systems Engineering*
- *Risk and uncertainty analysis*

Technology Innovation

Crosscuts land-based, offshore, and distributed wind

- *Advanced Components*
- *Manufacturing*
- *Reliability*
- *Materials science*

Offshore Wind (OSW) R&D

Specific to offshore wind technologies and systems

- *R&D and analysis*
- *Resource characterization*
- *Floating and fixed systems*
- *Demonstration projects*

Distributed Wind (DWT) R&D

Specific to small and medium sized wind technologies

- *Market and cost analysis*
- *Resource and performance*
- *Turbine testing*
- *Component/System R&D*

How We Organize Our Work- Continued

Technology to Market Activities

Crosscuts land-based, offshore, and distributed wind

- *Small Business Vouchers*
- *Energy I-Corps*
- *Technology Commercialization Fund*

Standards Support and International Engagement

Crosscuts land-based, offshore, and distributed wind

- *International Electrotechnical Commission (IEC)*
- *American National Standards Institute (ANSI)*

Testing Infrastructure

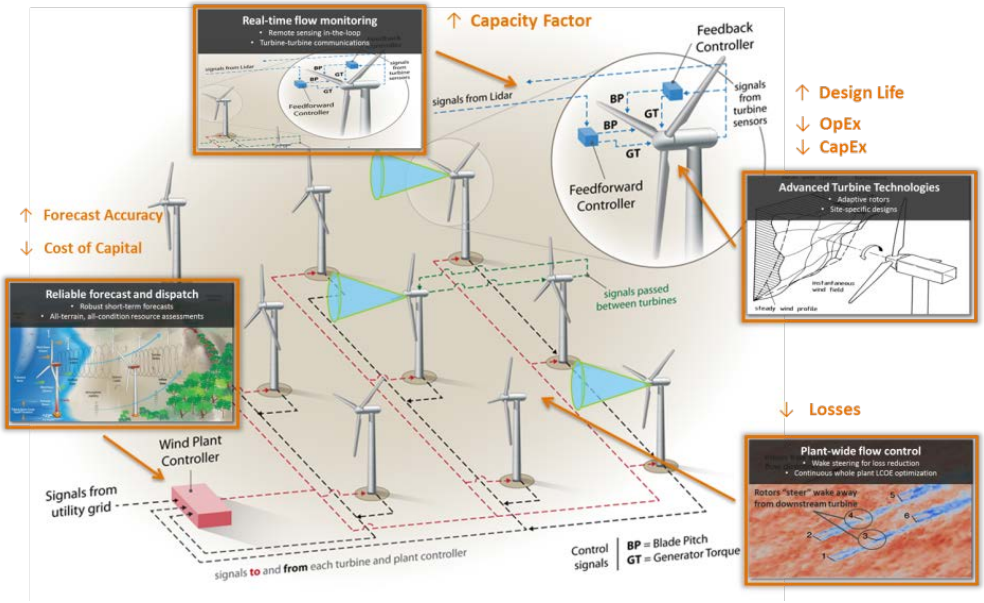
Crosscuts land-based, offshore, and distributed wind

- *Field Testing*
- *Dynamometers*
- *Structural Testing*
- *Grid Integration*
- *Offshore resource assessment*

Atmospheric Science & Wind Plant Systems Engineering

Motivation: Provide a better physical understanding of the atmospheric boundary layer interaction with wind plants and develop new SMART plant technologies that maximize energy capture and optimize cost performance

SMART = System Management of Atmospheric Resources through Technology

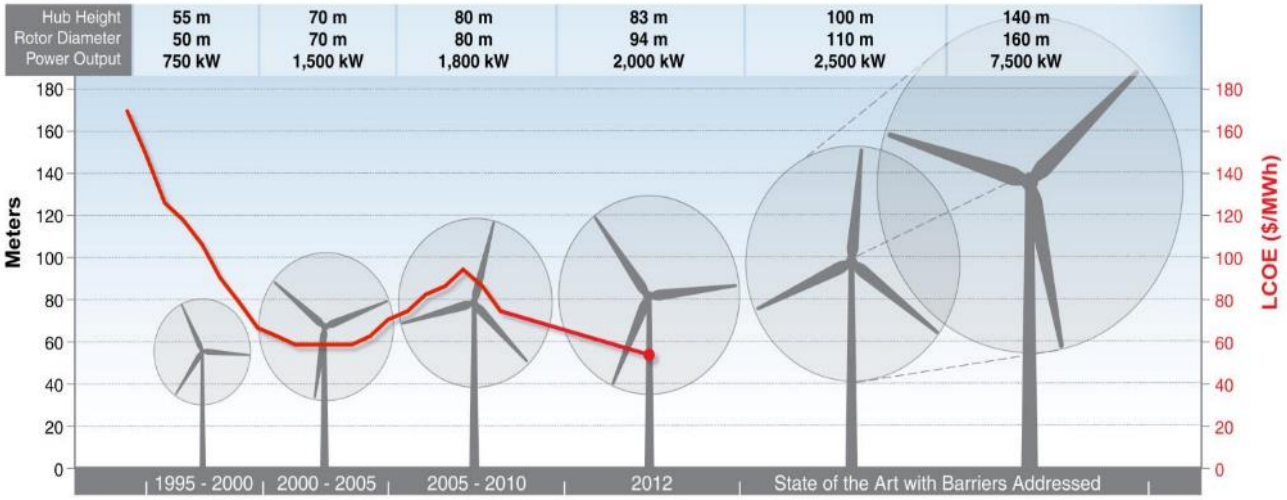


- ***Significantly improve industry's predictive capability of wind plant flow;***
- ***Enable next-generation wind plants and turbines that target dramatically improve in cost and performance;***
- ***Extend operational life and improve wind plant reliability over 30-35 year lifetime;***
- ***Demonstrate real-time, plant flow control strategies capable of increased energy capture and loads mitigation in both existing and next-generation wind plants.***
- ***Achieve $23 MWh by 2030***

Technology Innovation

Motivation: Innovation in material science and engineering R&D to develop next generation technologies that maximize energy capture and decrease LCOE:

- *Larger turbines that access better wind resource*
- *Overcome logistics and transportation barriers for scaling of turbines*
- *Strengthen US manufacturing & economic value*
- *Improve wind turbine reliability- decrease O&M costs*

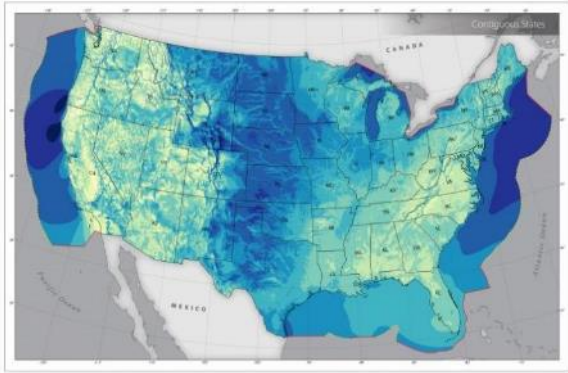


Increasing hub heights from 86 to 140 meters would expand technical potential by 67% and unlock an additional 1/5th of U.S. land area of wind power resource potential in the U.S. (~1800 GW)

Offshore Wind

Motivation: 2,058 GW of technically accessible resource potential, with options for every coastal region of the nation, including the Great Lakes

- Projected to provide 18.6 GW of cost-effective power in seven states on the Atlantic Seaboard by 2030 based on state commitments to date
- Represents a nearly $70 billion CAPEX revenue opportunity to businesses in the offshore wind power supply chain over the course of the next decade
- Global bid prices are dropping dramatically
- To lower U.S costs and build U.S. supply chain, DOE is supporting technology development focused on:
  - adapting European solutions to the unique conditions of the U.S.
  - development of new solutions by U.S. companies and research organizations
- Specific long term focus: 60% of the U.S. offshore wind resource is in deep water requiring floating platforms



Continental United States—Land-Based and Offshore Annual Average Wind Speed at 100 Meters above the ground

Block Island, RI

Distributed Wind

Motivation: Enable wind technology as a key player in a growing market for Distributed Energy Resources by reducing LCOE and increasing reliability.

Wind turbine technologies of all sizes deployed as a distributed energy asset, connected directly to the electric distribution grid or at an off-grid location to support local loads and grid operations.

2017- 2018 Objectives

- Support innovative R&D and testing of wind technologies designed for distributed energy applications through the Competitiveness Improvement Project request for proposals
- Research, analysis, and stakeholder engagement to develop a fundamental understanding of the installed costs, market potential, and R&D challenges limiting market development

Technology-to-Market
Small Business Vouchers

Technology to Market

Motivation: Focus on strengthening the innovation ecosystem by eliminating common barriers that prevent market exploration of new energy technologies.

- Technology Commercialization Fund (TCF) is designed to increase the number of energy technologies developed at DOE's national labs that graduate to commercial development and achieve commercial impact
- Energy I-Corps aims to accelerate the deployment of energy technologies by granting DOE laboratory scientists and engineers access to direct market feedback on their technology offerings

Small Business Vouchers

Motivation: Provide U.S. small businesses with unparalleled access to the expertise and facilities of the national labs for technology development and commercialization

- Small businesses receive targeted development, validation, and demonstration assistance from National Laboratories

Wind Standards

Motivation: Internationally recognized standards are needed to assure minimum levels of safety, remove market barriers, and provide high quality reproducible test results

- Objective design criteria based on industry experience
- Open markets (global design requirements)
- Assist with removal of deployment barriers
- Standard products – volume manufacturing
- Feedback from field performance to design requirements

- Standards provide clear expectations for all industry stakeholders, reduce risk and uncertainty, and create a level paying field for U.S. industry.
- Standards provide a quick path to industry and real-world applications for the knowledge developed in other parts of the U.S. Department of Energy Wind Program

Wind Program Stewardship Testing Infrastructure

Motivation: Support research facilities across the nation that offer unique assets and capabilities for conducting wind energy R&D

- Field Research Facilities
  - SWiFT
  - DOE 1.5 MW
  - CART 2 / 3
  - Instrumented meteorological research towers
- Dynamometer Research Facilities
  - 225 kW
  - 2.5 MW
  - 5.0 MW
- Controllable Grid Interface
  - 7MVA
- Structural Research Facilities
  - Structural Test Laboratory
  - Building 251 and A-60
- Offshore resource assessment
  - AXYS WindSentinel lidar buoys

AXYS WindSentinel

SWiFT

National Wind Testing Infrastructure

National facilities providing cross-cutting support for wind energy research, development and testing that offer unique facility assets and capabilities for conducting wind energy R&D

- **Argonne National Laboratory- Illinois**
- **Oak Ridge National Laboratory- Tennessee**
  - Manufacturing Demonstration Facility (MDF) and Carbon Fiber Test Facility (CFTF)
- **National Renewable Energy Laboratory- Colorado**
  - Composites Manufacturing Education and Technology (CoMET) facility
- **Sandia National Lab- New Mexico**
- **Idaho National Laboratory- Idaho**
- **Pacific Northwest National Laboratory- Washington**
- **Lawrence Livermore National Lab- California**
- **Mass CEC Wind Technology Testing Center**
- **Clemson University- South Carolina**
- **Montana State University- Montana**