

U.S. DEPARTMENT OF ENERGY Energy Efficiency & Renewable Energy

Wind Vision: A New Era for Wind Power in the United States

ATMOSPHERE TO ELECTRONS

BATS

OFFSHORE WINDS

DOE's Wind Energy Agenda
2017 AMS Washington Forum
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U.S. DEPARTMENT OF ENERGY Energy Efficiency & Renewable Energy

U.S. Department of Energy Providing Value to the Nation

DOE Mission
Enhance U.S. security and economic growth through **transformative science, technology innovation, and market solutions** to meet our energy, nuclear security, and environmental challenges

DOE Goal: Science and Energy
Advance foundational science, innovate energy technologies, and inform data driven policies that enhance U.S. economic growth and **job creation, energy security, and environmental quality**

DOE Strategic Objectives: Science and Energy

- Support prudent development, deployment, and efficient use of "all of the above" energy resources that also create new jobs and industries
- Support a more economically competitive, environmentally responsible, **secure and resilient U.S. energy infrastructure**
- Deliver the scientific discoveries and major scientific tools that **transform our understanding** of nature and strengthen the connection between advances in fundamental science and technology innovation

The priorities outlined in DOE's strategic plan are critical to advancing the nation's energy and security goals and strengthening our economy to provide a cleaner energy environment and a more secure and prosperous country for future generations

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Wind Energy Technologies Office (WETO) Overview

Wind Energy Programmatic Goals
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. Program R&D&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. Achieving LCOE goals will support deployment of wind at high penetration levels, sufficient to meet up to 20% of projected U.S. electricity demand in 2030, and up to 35% in 2050, compared to over 5.5% of demand in 2016.

Wind Energy Programmatic Priorities

- Optimize wind plant cost of energy reduction through complex aerodynamics R&D, advanced component development, wind plant reliability improvement and resource characterization
- Establish a competitive U.S. offshore wind industry through offshore system development and demonstration
- Optimize grid integration and transmission for wind systems through integration studies and operational forecasting tool development
- Eliminate and reduce market barriers through accelerated siting and deployment strategies

Wind Energy 2017 Targets Towards Programmatic Goals

- Reduce the unsubsidized market LCOE for utility-scale land wind energy systems from a reference wind cost of \$0.056/kWh in 2015 to \$0.052/kWh by 2020 and \$0.031/kWh by 2030*
- Reduce the unsubsidized market LCOE for offshore wind energy systems from a reference of \$1.81/kWh in 2015 to \$1.149/kWh by 2020 and \$0.95/kWh by 2030*

*For Programmatic purposes, all costs are reported at a 7% discount rate.

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The U.S. Wind Industry: Creating Significant Economic Value & Our Resources are Among the Best in the World

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

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

Robust Industry

- Utility-scale wind power in 41 states and distributed wind power in all 50 states
- 14 states ≥10% wind generation, with four states >25% generation
- U.S. utilities operate high wind penetration without one-to-one backup or storage requirements today through balancing and forecasting management
- Wind power represented 41% of capacity additions in 2015
- 30 MW Block Island (RI) first offshore wind project began producing power in 2016

Domestically Sourced Components and Raw Materials

- Over 80% of towers, 50-70% of blades and hubs, and 85% of nacelle assembly for turbines installed in 2015 were manufactured in the U.S.
- Today's U.S. wind manufacturing capacity is 6-10 GW/year

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Wind Turbine Innovation Matters

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DOE R&D has Contributed in Significant U.S. Wind Industry Innovation and Cost Reduction

National laboratories and federal wind test centers have enabled cost-effective development and validation of high-risk innovative wind technologies for over four decades

Sample DOE R&D Innovations

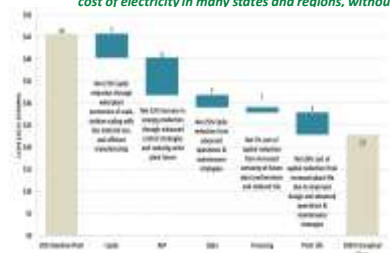
- Over 140 DOE-funded wind patents from 1978 through 2016
- Advanced computer code development and validation have accelerated technology innovation
- Airfoil and blade designs, including **aeroelastic tailoring, flatback airfoils, and carbon fiber design**, have enabled larger rotors with increased energy capture
- Development and demonstration of **MW class machines** and low wind speed turbines enabled cost-competitive utility-scale wind

U.S. Wind Cost and Cumulative Deployment, 1980-2015. The unsubsidized cost of wind energy in good to excellent wind sites dropped 90% from 1980 to 2015 – driven by DOE research and innovation

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America Can Continue to be a World Leader in Wind Power: Wind Plant of the Future

DOE investments in science and research can help industry provide the lowest cost of electricity in many states and regions, without subsidization



Conceptual pathway to 50% LCOE reduction in a hypothetical 2030 wind plant located in an area with excellent (higher speed) wind resources by leveled cost of energy (LCOE) parameter. LCOE parameters are influenced by DOE-funded innovation beyond that which industry would achieve on its own in key technology and/or market areas. Text labels identify primary sources of DOE R&D influence for the cost reduction due to each parameter.



DOE high-performance computing (HPC) capability for high fidelity wind modeling

DOE recognizes resolving wind plant performance as a computational "Grand Challenge"

Science Challenges: Developing the Wind Plant of the Future

Energy Capture & Performance Driven by Multiple Scale Physical Processes

- Planetary Boundary Layer (PBL) is the wind plant energy resource;
- Turbine scale (e.g. rotor, blade) inflow characteristics directly impact production and turbine loading
- Multiple turbine arrays and complex flow modify and alter the inflow, create energy loss, add turbulence and adversely impact turbine & plant performance
 - WPA** (Experimental Planetary Boundary Layer Instrumentation Assessment)—instrument side by side test - Boulder Atmospheric Observatory 300m tower
 - POWER** (Positioning of Offshore Wind Energy Resources)
 - IMPOWER** (Improving the Mapping and Prediction of Offshore Wind Resources) – August 2016 edition of BAMS



Wind Plant Physics Challenge:

- Multiple physics at multiple scales drive wind plant performance
 - Physics resolved through loosely or uncoupled modeling and simulation approaches
 - Quantifying uncertainty is the critical factor to industry in order to quantify risk.
- HPC capability to assess the temporally and spatially complex PBL/wind plant interaction



Closing Thoughts

Wind energy is a national asset that, with additional innovation, can be deployed cost-effectively and unsubsidized across the entire U.S.

- The science and research agenda that brought the industry to over 80 GW of installed capacity and over 5.5% of U.S. electricity generation today is **not the agenda needed** to achieve future potential levels
- DOE is **investing in atmospheric physics for wind plant spatial scale** (750-meter grids) and hourly time scale (and will move to sub-hourly in the future)
- The wind industry needs improved **National Weather Prediction Models** that improve accuracy on diurnal cycles or topography affects
- Comprehensive model improvements are needed:** public, offshore, aviation, fire weather forecasts. **Everybody benefits!**
- Continued innovation in RDD&D is needed** to enable wind in new areas—across the US—through new technologies and understandings



Thank You!

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For more information please see:
wind.energy.gov