U.S. DOE Wind Program Overview

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

Enabling Wind Power Nationwide

Megan McCluer, Senior Advisor
Wind Power Technologies Program
Energy Efficiency and Renewable Energy
Department of Energy
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DOE Wind Program - Mission

- Lead the Nation's efforts to accelerate widespread deployment of **clean, affordable, reliable and domestic** wind power
- ***Wind Vision*** - Provide 20% of the nation's energy by 2030 (~225 GW) and 35% by 2050 (~400 GW). Today we have 75 GW. ***Enabling Wind Nationwide*** – through Tall Wind.
- Invest in high-risk, high-impact early-stage wind technology **research and innovations** that the private sector cannot adequately address on its own
- Fund research through funding opportunity announcement (**FOA**) awards and direct funding to national labs

Office R&D Research Areas

- **Technology Development**
  - Land-based, offshore, and distributed research advancements
- **Technology Validation and Market Transformation**
  - Demonstrations and commercialization
- **Power to Market**
  - Electric grid access, reliability, and availability; valuing ancillary services
- **Market Barriers**
  - Mitigating barriers to deployment – Wildlife and ecosystem, radar, resource management, recreation

Wind Program Activities

- Tech Development
  - Atmosphere to Electrons (A2e)
  - Turbine Reliability
  - Test Facilities
  - Manufacturing
- Technology Validation and Market
  - Offshore Wind Demo Projects
  - Manufacturing Demonstrations
- Power to Market
  - Grid Integration
  - Distributed Wind Technologies
- Market Barriers
  - Market Acceleration and Deployment
  - Modeling and Analysis

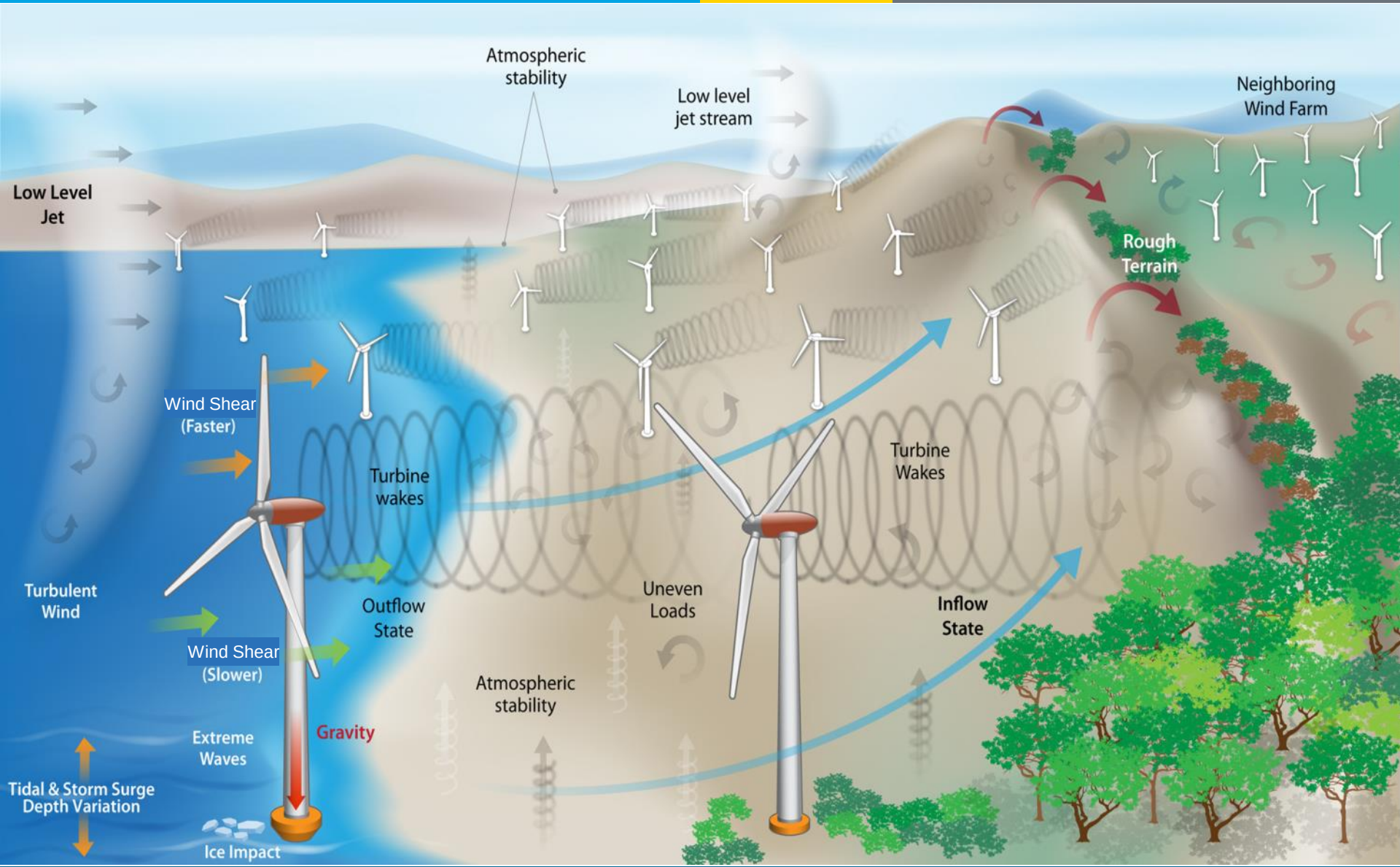
Atmosphere to Electrons (A2e) Initiative

ATMOSPHERE TO ELECTRONS
U.S. DEPARTMENT OF ENERGY

A2e is an initiative focused on **plant optimization** which moves the program from a focus on single turbine R&D to one that emphasizes integrated, interconnected multi-turbine wind power plants.

- **Reduce LCOE through understanding complex wind power plant aerodynamics**, fluid dynamics, and atmospheric physics to improve overall plant capacity factors
- **Enable next-generation wind plants** that target significant reductions in wind plant underperformance (20-30% observed in operational wind plants)
- Evaluate **control strategies for optimizing the energy capture** of wind plants
- **Increase the reliability** of wind energy systems while reducing capital cost

Optimize Wind Plant Performance



A2e Approach:

- **Aerodynamics R&D and Testing Campaigns** will focus on understanding complex flow within the wind plant for efficiency improvements
- **Wind-plant Technology Development** will consider design and innovations at the wind plant level
- **Resource Characterization** accurate characterization and modeling of atmosphere at the meso-scale and wind plant scale

The largest remaining opportunities to reduce LCOE will come from substantial gains in understanding complex wind plant aerodynamics and atmospheric phenomena

Wind Turbine Reliability Activities

Wind Turbine Reliability The reliability of modern wind turbines has improved substantially over the past 10 years but drivetrain and blade failures are still prevalent

❖ Drivetrain Reliability Collaborative

- NREL/ANL led effort to characterize the root cause for the leading gearbox failure, axial bearing cracks, caused by **white etching cracking (WEC)**
- Lab scale WECs have been developed under repeatable conditions at Argonne National Laboratory and a field campaign to understand the loading on the high speed shaft are underway at the NWTC using the DOE/GE 1.5
- NREL is also evaluating **condition monitoring and data analytics** techniques such as compact oil filers to evaluate the amount of particulates in gearbox oils

❖ Blade Reliability Collaborative

- SNL led effort to characterize the **effects of manufacturing defects** in wind turbine blade composites through coupon level testing and modeling
- Evaluates **nondestructive inspection** techniques for factory and in-service blades, and will evaluate the effects of lightning on carbon laminates

White etching cracking is a root cause failure for high speed shaft bearings

DOE Contact: Nick Johnson; Nick.Johnson@ee.doe.gov

Test Infrastructure and User Facilities Activities

DOE develops and supports national test facilities for components, systems, grid integration, and offshore data evaluation networks

- **Blade Test Facilities**
  - National Wind Technology Center (NWTC) – 19m and 50m test stands
  - Massachusetts Wind Technology Testing Center – Large Blade test Facility with 90m test stand
- **Drivetrain Test Facility and Grid Simulation**
  - National Wind Technology Center (NWTC) – 2.5MW and 5.0MW dynamometer drivetrain test facility coupled to a controllable grid interface
  - Clemson University Restoration Institute – 7.5MW and 15.0MW dynamometer drivetrain test facility coupled to a grid simulator
- **Plant Optimization (SWiFT/NWTC)**
  - Scaled Wind Turbine Test Facility (SWiFT) – Turbine to turbine interaction research (Texas Tech University)
  - National Wind Technology Center (NWTC) – Controls Advanced Research Turbines and Utility-scale research turbines

Wind turbine blade testing is a critical factor in maintaining high levels of reliability and evaluating the latest technological developments in airfoils and materials.

NWTC provides field testing, drivetrain testing and grid simulation capabilities

DOE plays a crucial role in providing world class test facilities capability for validating component designs and performing valuable wind energy research

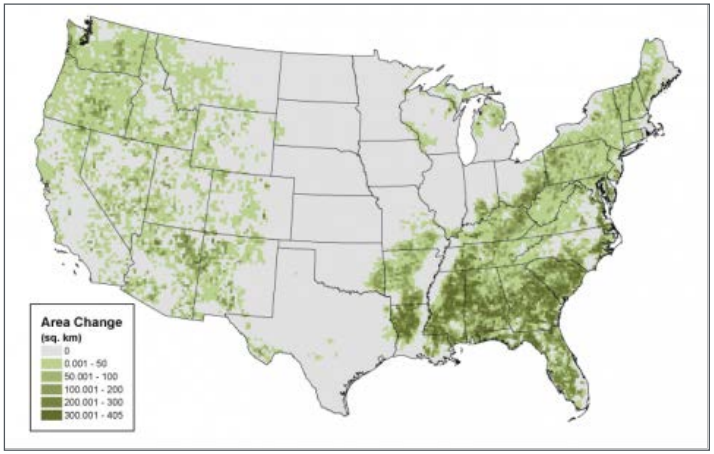
DOE Wind Technology Testing Facilities

DOE –Supported Wind Energy Testing and Validation Facilities			
Facility	**Location**	**Details**	**Status**
225 KW Dynamometer	Boulder, CO (NWTC)	Small wind turbine drive train testing	Operational
2.5 MW Dynamometer	Boulder, CO (NWTC)	Medium-scale wind turbine drive testing; Gearbox reliability collaborative research	Operational
5.0 MW Dynamometer	Boulder, CO (NWTC)	Utility-scale wind turbine drivetrain testing	Operational
7.5 MW Dynamometer	Charleston, SC (Clemson U.)	1st Generation offshore wind turbine drivetrain testing	Operational
15 MW Dynamometer	Charleston, SC (Clemson U.)	2nd Generation offshore wind turbine drivetrain testing	Operational
19m Blade Test Stand #1	Boulder, CO (NWTC)	Scale testing of wind turbine blade innovations; Scaled evaluation of improved blade testing methods	Operational
19m Blade Test Stand #2	Boulder, CO (NWTC)	Small wind turbine blade testing	Operational
50m Blade Test Stand	Boulder, CO (NWTC)	Utility-scale wind turbine blade testing; Full-scale evaluation of improved blade testing methods	Operational
90m Blade Test Facility	Boston, MA (MCEC)	Utility-scale blade testing; 3 test stands sized for anticipated blade lengths of the offshore wind industry	Operational
CART-2/3 Turbines	Boulder, CO (NWTC)	Controls Advanced Research Turbines: Two 600 KW turbines for advanced control algorithm R&D	Operational
1.5 MW Research Turbine	Boulder, CO (NWTC)	GE 1.5MW utility scale wind turbine available to researchers for field testing of innovative technology	Operational
Controllable Grid Interface	Boulder, CO (NWTC)	Simulates electrical grid faults for testing of wind turbine drivetrains	Operational 2013
Grid Simulator	Charleston, SC (Clemson U.)	Research on turbine to turbine interactions in wind plants	Operational 2014
SWiFT Facility	Lubbock, TX (TTU/SNL)	Scaled Wind Farm Test Facility: 3 300kW research turbines for turbine-turbine interaction R&D	Operational
RFORE	Norfolk, VA (CLT)	Reference Facility for Offshore Renewable Energy: R&D & data collection for offshore atmospheric conditions	Operational 2014
Component Testing	TBD	Based on need, new facility targeted at specific component reliability issues	Operational 2016

Manufacturing Competitiveness Activities

Manufacturing Competitiveness: Wind-specific manufacturing R&D funding, complementary to EERE's new Clean Energy Manufacturing Initiative (CEMI), will enable much larger turbines for both land-based and offshore wind markets. This will include the designs, materials, and manufacturing processes to overcome existing transportation barriers and fabricate very large modular or onsite blades, towers, and generators. Specific R&D avenues include new composites applications, resins, automation and onsite assembly techniques.

- **Taller Hub Heights to Access Higher Wind Resources and Lower the Cost of Energy**. This FOA supports the development of technologies that mitigate U.S. transportation and logistics constraints affecting the deployment of taller utility-scale wind turbine systems.
  - Continued turbine up-scaling and design advancements are expected to increase turbine performance and lower costs.
  - Scaling to higher hub heights allows wind turbines to capture less turbulent and often stronger wind resources, thereby improving productivity and economics.
  - Supported projects will develop lifecycle cost-competitive tower solutions that address the challenges of fabricating, transporting, assembling, maintaining, and decommissioning towers for turbine hub heights of at least 120 m.
  - These projects will strengthen U.S. competitiveness in manufacturing wind turbine components, reduce the cost of wind energy, and dramatically expand the geographic range of cost-effective wind power in the United States.

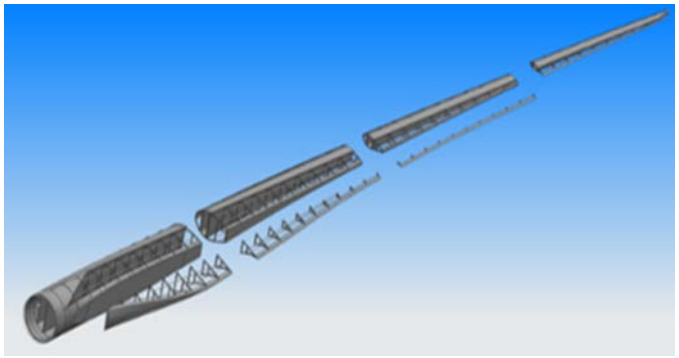


Increasing wind tower hub heights from 96 to 140 meters would unlock an additional 1,800 gigawatts (GW) of wind power resource potential across 237,000 square-miles of the United States, or an area roughly the size of Texas. This increased wind power potential encompasses the northeastern, southeastern, and western United States.

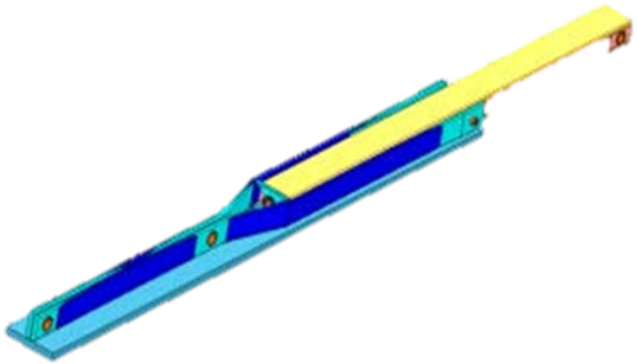
- **Targeted Effects of Manufacturing Defects.** Continued focus on effects of manufacturing defects as part of the blade reliability collaborative (BRC) to result in improve reliability, decreased O&M costs and LCOE reductions.

FOA TITLE: ***U.S. WIND MANUFACTURING: LARGER BLADES TO ACCESS GREATER WIND RESOURCE AND LOWER COSTS***

SELECTIONS: Two jointed-blade proposals were selected:



"a revolutionary approach to engineering and manufacturing of jointed wind turbine rotor blades"



"advancing the state-of-the-art in jointed blade design"

CHALLENGES: THIS IS HARD!

Tall Wind – Taller Towers FOA

FOA TITLE: ***U.S. WIND MANUFACTURING: Taller Hub Heights to Access Higher Wind Resources and Lower Cost of Energy***

Objective is to address transportation logistics through on-site manufacturing and assembly and enable wind deployment throughout U.S.

GREAT PROGRESS!

Advanced Technology Demonstration: This activity provides important evidence to the global market that offshore projects in the U.S. can actually be realized

- In 2012, the Department announced funding for **seven offshore wind energy advanced technology demonstration projects** to validate innovative technologies to lower the cost of energy and address regional challenges and opportunities, expediting development of **the US offshore wind industry**.
- In 2014, a competitive down-select was held and three projects were selected for continued funding.
- In FY 2016, these projects will complete final engineering design, finalize vendors, and begin procurement and fabrication of major project components, such as foundations and turbines.
- In FY 2017, initial construction of the projects will commence with the goal of grid connection in CY 2018.
- **Offshore strategy** with DOI to be released in 2016

DOE Contact: Alana Duerr; Alana.Duerr@ee.doe.gov

Offshore Substructure Types

From left: Monopile, Jacket, Inward Battered Guide Structure (IBGS – also referred to as a "Twisted Jacket"), Semi-submersible, Tension leg platform (TLP), and Spar. Source: NREL, DOE Contact: Alana.Duerr@ee.doe.gov

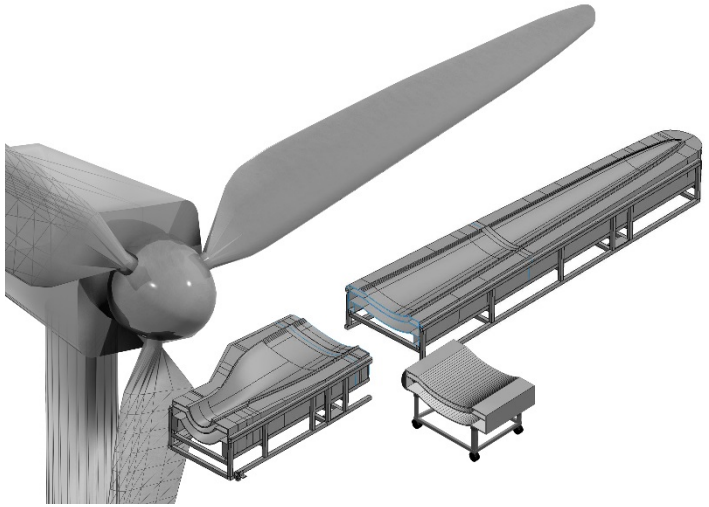
3-D Printing Applied to a Blade Mold

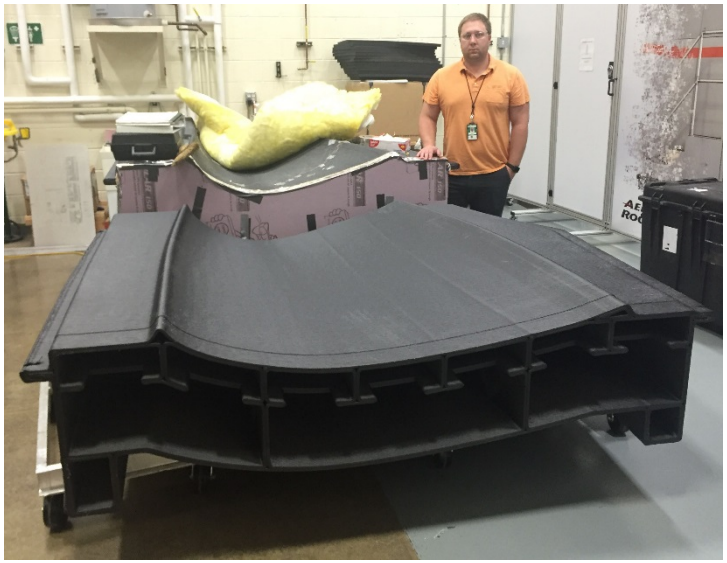
Idea:

- Wind program needed research blades for testing at the SWiFT facility. Idea to 3-D print them would save time, money and leverage and showcase other resources.

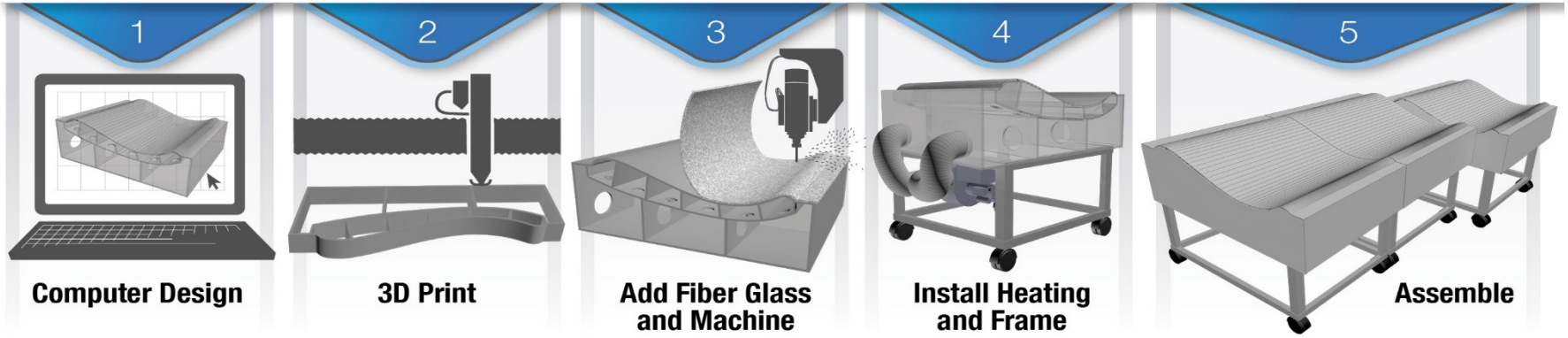
Project Objectives:

- Demonstrate the utility of ORNL's Big Area Additive Manufacturing (BAAM) as a platform technology for clean energy manufacturing.
- Reduce cost and lead time for prototype wind turbine blades through the use of a mold manufactured through 3D printing.
- Use prototype blades to advance wind research objectives, such as the study of rotor wake interactions.
- Sustain U.S. manufacturing competitiveness through innovative applications that advance clean energy technologies.





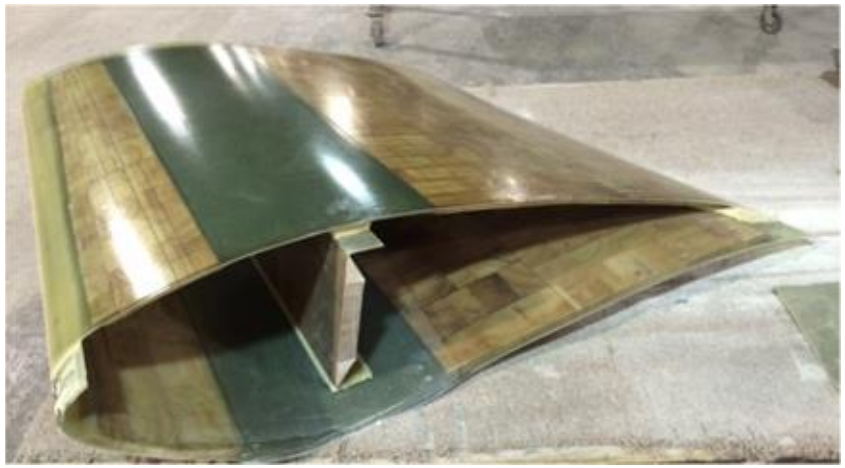
Process for 3D printing wind turbine blade molds



Partners: DOE, ORNL, SNL, NREL, TPI, Wetzel

Status:

- A short mold section and airfoil piece was made for demonstration at AWEA May 2016.
- Actual 13m mold pieces are under construction now.
- Mold complete this summer, blade complete next spring, three blades flying at SWiFT, Summer 2017



Grid Modernization Activities

To achieve high levels of wind energy penetration, grid planning and operations must be adapted to remove wind integration barriers and accelerate deployment

❖ Grid System Planning

- o Support the development and deployment of tools to ensure reliable and economic system operations under high penetration levels of wind generation
- o Conduct integration studies to fully understand effect of wind on the U.S. power system and support the adoption of effective operational practices
- o Support the planning and development of new infrastructure to allow access to high quality wind resources

DOE seeks to enable traditional electricity generation networks to adapt to the variability of renewable resources as well as accommodate distributed energy sources such as distributed wind and solar.

❖ Grid System Operations

- o Evaluate system response to uncertainties and electrical phenomena associated with wind power and develop operations practices for system operator use
- o Improve wind power controls to benefit grid power quality through activities such as voltage ride-through and frequency control
- o Evaluate market structures and signals to develop economic wind deployment solutions

Grid system plans provide access to high wind resource areas while grid systems operations provide cost effective dispatch of wind energy onto the grid

Integration Analysis

Reliably integrate large quantities of wind energy into system operations. To accomplish this, the Wind Program conducts

- **Integration studies and develops models, demonstrations, and assessments** at both the transmission and distribution levels
- The program also analyzes the effect of better wind forecasts, the effect of dynamic line rating

Grid Modernization Initiative

Comprehensive effort across program boundaries to help shape the future of our nation's grid and solve the challenges of

- **Integrating conventional and renewable sources with energy storage and smart buildings**
- Ensuring that the grid is resilient and secure to withstand growing cybersecurity and climate challenges

DOE Contact: Charlton Clark; Charlton.Clark@ee.doe.gov

Distributed Wind Activities

Shifting the Distributed Wind Market Paradigm

- Moving from a small turbine testing and certification focus to one that emphasizes next generation systems which meet operational expectations and streamlined project development processes
- In 2014, U.S. turbines in distributed applications reached a cumulative installed capacity of more than 906 megawatts (MW)–enough to power more than 168,000 average American homes

Provide National Leadership

- Through clearly defined market tracking and analysis, show that all scales of wind technologies are used in distributed applications, not just small wind turbines
- The program continues to support international collaboration though the International Energy Agency's (IEA) research and development and knowledge exchange activities.
- In 2016 and 2017, phase 2 of IEA task 27 collaborative research will better characterize the turbulent wind resources where distributed wind systems are installed and make recommendations for the revision of IEC 61400-2.

Distributed Wind is defined not by size, but by two characteristics of technology application:

- **Proximity to end-use:** wind turbines installed at or near the point of end-use for the purposes of meeting onsite load or supporting the operation of the local (distribution or micro) grid
- **Point of interconnection:** wind turbines connected on the customer side of the meter or directly to the local grid

The Program's Distributed Wind Portfolio represents a significant crosscutting opportunity to reduce LCOE, improve competitiveness, increase stakeholder confidence, and improve grid planning and operation

Distributed Wind

Distributed Wind activities address the performance and reliability challenges associated with small wind turbines and turbines in distributed applications.

DOE has found that there is **potential for balance of system cost reduction**, and data collection and analysis for understanding future market potential.

Competitiveness Improvement Project (CIP) The CIP provides competitively awarded financial and technical assistance for:

- Component and whole system performance optimization
- Advanced manufacturing processes to reduce hardware costs
- Turbine testing for certification

DOE Contact: Bret Barker; Bret.Barker@ee.doe.gov

Reducing market barriers preserves or expands access to quality wind resources. Better understanding of impacts and mitigation solutions will increase the certainty of development outcomes and facilitate increased deployment

DOE addresses a range of market barriers that either preclude, limit, or delay wind power siting, thereby driving up costs and limiting deployment.

❖ Better understand impacts and develop mitigation measures

- Increase siting certainty for wind by evaluating impacts and developing mitigation measures
- Monitor 1st and 2nd generation of offshore wind projects to identify specific impacts
- Demonstrate radar mitigation technology through Interagency Field Tests & Evaluations
- Study barriers and benefits that influence the public and decision-makers

❖ Actively inform the policy and permitting processes

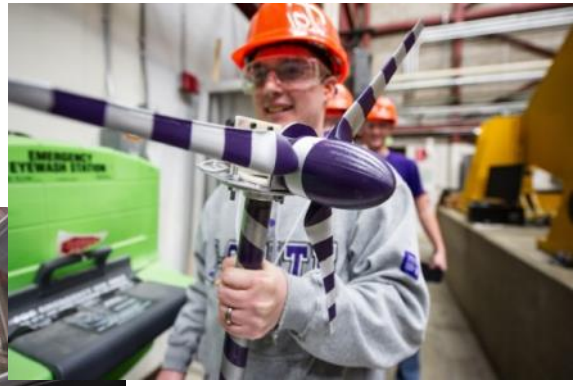
- Provide objective information to decision-makers and the public
- Engage regulators and decision-makers in permitting and policy-making processes
- Develop and maintain policy thought leadership
- Develop regional networks with expertise to address multi-state barriers and stakeholder concerns
- Analyze market and economic impacts and resource assessment tools
- Develop wind educational programs and projects

Providing tools to address market barriers will accelerate deployment by increasing certainty for regulators and developers and lowering LCOE

Collegiate Wind Competition

Challenging Tomorrow's Industry Leaders to Solve Remote Power Needs with Wind Energy, Ingenuity, and Analytics

- **Business Plan:** Develop and deliver a market research-supported business plan that shapes the design and development of the team's technical product into a marketable wind power system.
- **Deployment Strategy:** Prepare a deployment strategy by identifying a project site for the team's power system and developing a plan based on siting constraints and expected challenges.
- **Technology Development:** Design, build, and present a unique, wind-driven power system based on market research and test the wind turbine and corresponding loads in an on-site wind tunnel.



COLLEGIATE WIND COMPETITION
U.S. DEPARTMENT OF ENERGY

Why is this important?

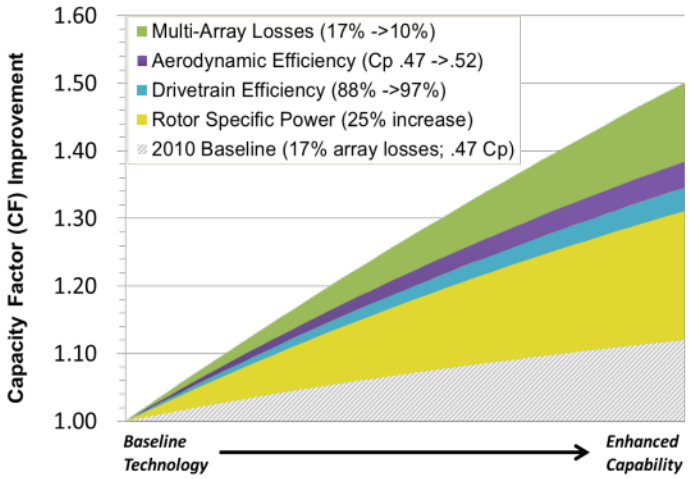
- A robust domestic wind industry requires **a well-qualified and trained workforce** to design, maintain, and install wind energy projects across the country.
- As wind becomes a larger part of the clean energy mix, the need for **skilled** individuals to support this growing industry will increase.
- While the wind industry already employs over 70,000 people across the United States, NREL found in a recent study that at least 70% of industry members surveyed report some difficulty finding qualified applicants for a variety of wind-related positions including **wind technician**, **managers** in manufacturing and construction, **scientists**, **regulators**, **product designers**, **educators**, and **trade workers**.
- Many of these roles require advanced degrees, but the U.S. has **limited programs** in these areas.
- In many cases degrees are not required but **hands-on experience** with technologies is essential.

Modeling and Integrated Systems Economic Analysis

- Focus on wind-specific estimations of electricity production cost, electric sector capacity expansion, national energy-economy modeling, wind technical and economic feasibility analysis, and technology deployment analysis
  - ❖ Develop and release an integrated wind plant system model that integrates cost models with system dynamics models, a major improvement over the existing LCOE model currently in use
  - ❖ Market trends reporting and analysis, including publication of the annual DOE Wind Market Report and annual DOE Distributed Wind Market Report
  - ❖ Wind cost (LCOE) and capacity expansion modeling (GW) modeling and analysis
  - ❖ Impact (cost/benefit) evaluation
  - ❖ Strategic planning, including multiyear wind plan (MYPP), technology roadmaps, and vision reports
  - ❖ Leverage *Wind Vision* modeling and impacts analysis results through interaction with industry, public and policy decision makers

Strategic Planning

- Crosscutting tool development and analysis to support the effective, proactive annual, multi-year and multi-decade planning and project management and assessment required to realize the program's 2020 and 2030 LCOE and GW deployment goals

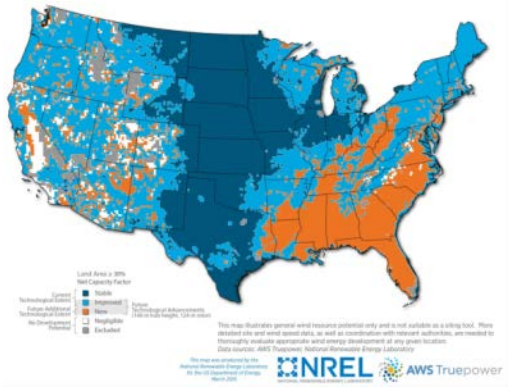


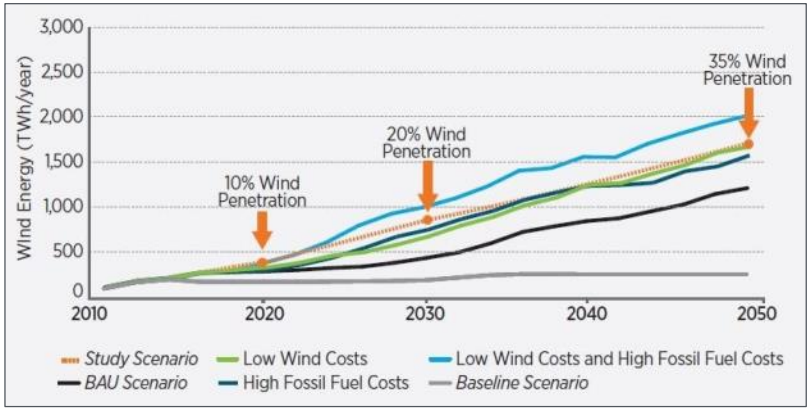
System engineering and reference models are used to identify the best opportunities for cost reduction.

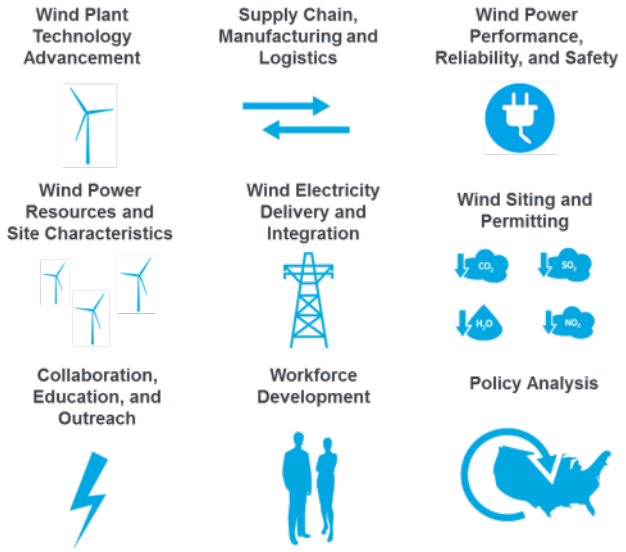
Strategic analysis helps prioritize investment on highest impact program activities

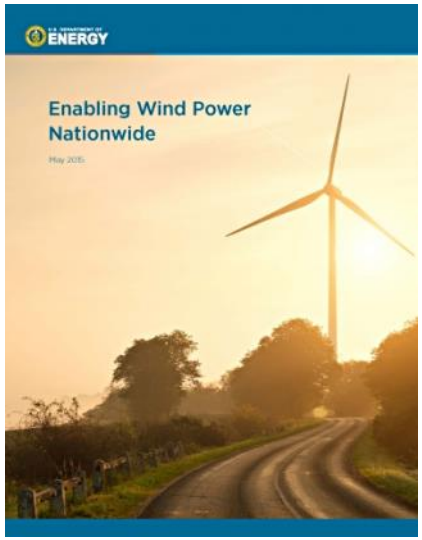
The Wind Vision Report

- ***Wind Vision*** **concludes that 10 % wind by 2020, 20% wind by 2030 and 35% wind by 2050 is technically feasible, generates long-term savings, and brings substantial environmental and local community benefits.**
- ***Wind Vision*** **shows expansion of wind development potential in areas where limited potential was thought to exist.**
- **The *Wind Vision Roadmap* informs ongoing DOE technology research and development initiatives.**









Costs*	Benefits*		*Cumulative 2014-2050
$	GHG	Air Pollution	H_2O
$149 Billion [3%] savings	GHG: 14% less GHG; $400 Billion savings	108 Billion savings; 22,000 lives saved	260 Billion gallons [23%] less consumption

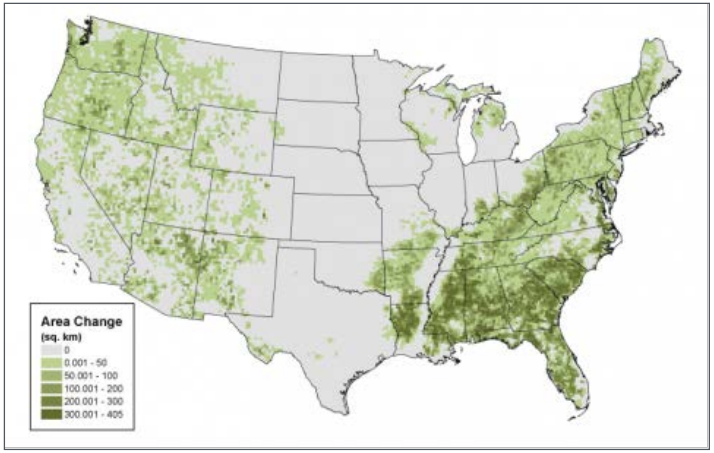
Enabling Wind Power Nationwide

Enabling Wind Power Nationwide Report shows how the US can unlock the vast potential for **wind energy deployment in all 50 states**—through the next-generation of larger wind turbines.

Higher hub heights allows wind turbines to capture less turbulent and often stronger wind resources, thereby improving productivity and economics.

Overcome existing transportation barriers

- **Manufacturing and technologies** to enable much larger turbines for both land-based and offshore wind markets
- New composites applications, resins, automation and onsite assembly techniques
- Fabricating very large modular or onsite blades, towers, and generators



Increasing wind tower hub heights from 96 to 140 meters would unlock an additional 1,800 gigawatts (GW) of wind power resource potential

DOE's Role

- Support research on tower solutions that address the challenges of fabricating, transporting, assembling, maintaining, and decommissioning **towers for turbine hub heights of at least 120 m**
- Support research on methods that reduce transportation constraints for **blades over 60m**

"Tall Wind": Enable domestic manufacturing of larger wind turbine components - enabling cost-effective access to resources throughout all 50 states (~140 meters).

Questions?

http://energy.gov/eere/wind/wind-program

Megan McCluer, Senior Advisor
U.S. Department of Energy
Wind Program
megan.mccluer@ee.doe.gov

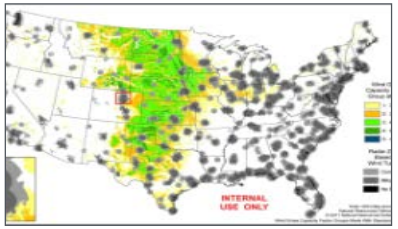
Back up Slides

Wind Energy Major Programmatic Goals and Endpoint Targets

The Wind Energy Program 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 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. 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 **4.8% of demand in 2015**.

Wind Energy Programmatic Impact

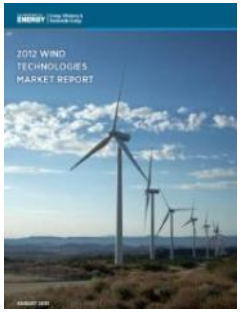
- **Optimize wind plant cost of energy reduction** through complex aerodynamics R&D, advanced component development, wind plant reliability improvement and resource characterization
- **Establish a competitive U.S. offshore wind industry** through offshore system development and demonstration
- **Optimize 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 $.074/kWh in 2012 to $.057/kWh by 2020 and $.042/kWh by 2030*
- Reduce the unsubsidized market LCOE for **offshore fixed-bottom wind** energy systems from a reference of $.20/kWh in 2010 to $.167/kWh by 2020 and $.136/kWh by 2030*

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



Importance of EERE Wind Program's Unique Role

- The program has unique roles in the RDD&D of wind systems that are not being undertaken by the U.S. wind industry due to real or perceived cost, risk, or their need to focus on near-term investment returns.
- The program conducts R&D that addresses high risk, transformational technological innovations that are essential for the advancement of U.S. wind systems that individual industry participants typically do not pursue due to the proprietary and competitive nature of their business.
- Federal projects can also address different time-scales and/or engage comprehensive competencies that industry alone cannot tackle, such as the National Wind Testing Center at NREL.
- The program also addresses inter- and intra-governmental agency issues related to wind energy and leverages development of solutions that also engage the Department of Defense, Department of Health and Human Services, Department of Transportation, Department of Interior, and other agencies.

Interagency government coordination to accelerate deployment
- Collaboration on permitting barriers with BOEM, FWS, DHS/DOD/FAA, others
- Collaboration on transmission planning and integration with FERC and OE

Funding to benefit Industry 'commons'
- National Testing Facility infrastructure
- Certification and standards for small wind
- Publicly available national datasets for wind resource data

DOE Wind Industry Role

Perceived High Risk/Long-term R&D Projects
- Offshore Demonstration project
- Next Generation drive-train
- Next Generation wind plants

Accelerate Administration priorities
- Investments in Manufacturing Innovation/U.S. Competitiveness
- R&D targeted on addressing renewables integration and transmission planning challenges

Focused on DOE unique role in high impact areas with evidence based metrics

Wind Energy - *Recent Accomplishments (presented to White House)*

- In FY 2015, A2e conducted **complex aerodynamics R&D and experimental testing campaigns** to determine the effect of wakes on plant performance. Followed in FY 2016 by joint computational-experimental campaigns using high fidelity simulations of atmospheric physics and scaled experiments to study turbulent inflow and near-wake development (**NREL** and other labs).
- In FY 2015, FOA awards were made for a **manufacturing initiative to address transportation and logistics barriers** associated with very large turbine blades. FOA work will be conducted in FY 2015 and FY 2016. The FOA will further LCOE reductions thorough economies of scale and allow access to new U.S. geographic areas to wind turbine deployment.

- Both awardees of the FY 2014 **Taller Towers FOA** successfully completed tower design and testing tasks in FY 2015 and will be performing experimental validation and LCOE analyses in FY 2016.
- The third round of the **Distributed Wind Competitiveness Improvement Project (CIP)** was completed in FY 2015, supporting both existing and emerging small and medium-sized wind turbine manufacturing companies, and assisting them in improving component designs, improving manufacturing competitiveness, and system certification. The fourth round of CIP is planned to continue in FY 2016. The **Annual Distributed Wind Market Report** was published in FY 2015. (**NREL)**
- The **Wind Forecasting Improvement Project Phase 2** (WFIP-2) began analysis of data gathered in FY 2015 and will continue in FY 2016. This three year project targeted at better understanding atmospheric phenomenon in complex terrain.
- In FY 2015, began work under the **Bat Impact Minimization Technologies and Field Testing Opportunities** FOA. Five awardees will: (1) conduct reliability tests and full-scale validation of the effectiveness of an electronic deterrent device at a wind plant; (2) develop and test an ultrasonic acoustic deterrent system; (3) develop a turbine-integrated, air-powered deterrent device; (4) develop and test coatings that alter the surface texture of wind turbines; and (5) develop a blade-mounted ultrasonic whistle.
- Released stakeholder supported (Industry, Academia, Researchers and NGO's) ***Wind Vision*** **report**, outlining a credible robust wind energy future by 2020, 2030 and 2050, inclusive of multi-stakeholder actions (Roadmap)