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

WIND AND WATER POWER TECHNOLOGIES OFFICE

U.S. Department of Energy's Wind Program Funding in the United States:

Testing, Manufacturing, and Component Development Projects for Utility-Scale and Distributed Wind Energy

Fiscal Years 2006 - 2013

Introduction

Wind and Water Power Technologies Office

The Wind and Water Power Technologies Office (WWPTO), within the U.S. Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy (EERE), supports the development, deployment, and commercialization of wind and water power technologies. WWPTO works with a variety of stakeholders to identify and support research and development (R&D) efforts that improve technology performance, lower costs, and—ultimately—deploy technologies that efficiently capture the abundant wind and water energy resources in the United States. WWPTO is one office that contains two distinct focus programs: wind and water. The Wind Program and the Water Power Program operate as integrated, but separate entities within WWPTO.

The Wind Program is committed to developing and deploying a portfolio of innovative technologies for clean, domestic power generation to support an ever-growing industry, targeted at producing 20% of our nation's electricity by 2030.

The Wind Program provides R&D funding across six broad areas:

1. Offshore Wind Projects
2. Testing, Manufacturing, and Component Development Projects
3. Integration, Transmission, and Resource Assessment and Characterization Projects
4. Environmental Impacts Projects
5. Market Acceptance Projects
6. Workforce Development Projects.

The breakdown of Wind Program funding is presented in a series of reports that showcase the projects funded in each of the six abovementioned areas.

The Wind Program's research and development (R&D) projects are financed through several primary sources of funding: Congressional appropriations and Congressionally Directed Projects (CDPs). Congressional appropriations determine the operating budgets for each EERE program. Program-funded R&D projects are typically awarded to recipients as grants through competitive Funding Opportunity Announcements (FOAs) that are dedicated to specific topic areas. CDPs are also funded by Congress, but are outside of the annual federal budget process. Frequently, there is a cost-share requirement for recipients of both competitive FOA grants and CDPs. The 2009 American Recovery and Reinvestment Act funds (ARRA) also provided funding directly to some projects, as well as through FOAs.

In addition to these two primary funding sources, the projects may be financed directly through specific legislation passed by Congress. In Fiscal Year (FY) 2009, for example, Congress passed the American Recovery and Reinvestment Act of 2009 (ARRA/Recovery Act). A portion of Recovery Act funding was dedicated to the program's wind R&D projects.

The program also funds research projects at DOE's national laboratories through the laboratories' annual operating plans. This funding is not detailed in this report. However, a national laboratory may be lead or a partner on a competitively awarded project covered in project reports. In this report, national laboratories are partners on several projects. In these instances, they are not explicitly mentioned in the project description; their funding is included in the total DOE share. They are also the project lead on four projects.

The Small Business Innovation Research (SBIR) program in DOE's Office of Science provides competitive awards-based funding for domestic small businesses engaging in R&D of innovative technology. SBIR has funded several projects with relevance to wind technology development; however, these projects are not covered in this report.

Photo from NREL

Photo from NREL

Testing, Manufacturing, and Component Development for Utility-Scale and Distributed Wind Energy

The strong, consistent, and abundant winds within the United States are providing a clean, domestic, and renewable source of power for the nation. As of the end of 2012, the United States had more wind turbine generating capacity installed on land than almost any other country, with an installed capacity of more than 60,000 MW. In 2012, wind energy became the number one source of new U.S. electricity generating capacity for the first time—providing approximately 43% of new generation—and represents the second largest renewable contribution to overall electricity generation in the United States (behind hydropower), providing 3.6% of the nation's electricity. In addition, wind energy costs in areas with good wind resources have been reduced from more than 55 cents (current dollars) per kilowatt-hour (kWh) in 1980 to less than six cents/kWh today. Increasing use of the nation's abundant wind resources for electric power generation will help the nation reduce its emissions of greenhouse gases and other air pollutants, diversify its energy supply, provide cost-competitive electricity to key regions across the country, and reduce water usage for power generation. In addition, wind energy deployment will help revitalize key sectors of the economy by investing in manufacturing and infrastructure and creating long-term, sustainable skilled jobs.

A vital focus of the program is improving the performance, reliability and time-to-market of components through advanced testing, manufacturing, and development initiatives. The program works with U.S. manufacturers to develop advanced component designs, fabrication techniques, and automation processes that will enable wind turbines to capture more energy and help manufacturers increase their component production capabilities. The program's manufacturing research includes work to develop more efficient turbine structures, such as blade designs that fully integrate structure and aerodynamics; adaptive structures, such as passive bend-twist coupling; design details to minimize stress concentrations; and efficient gearbox prototypes.

From 2006 to 2013, DOE's Wind Program announced awards totaling $160,473,011 for 50 projects focused on testing, manufacturing, and component development. Table 1 provides a brief description of each of these projects. There are three sources of funding for wind technology projects covered in this report: competitive Funding Opportunity Announcements (funded by congressional appropriations), Congressionally Directed Projects (CDPs), and the American Recovery and Reinvestment Act of 2009 (ARRA/Recovery Act). See "Types of Funding Sources" on previous page for more information.

Table 1: FY 2006 – FY 2013 Testing, Manufacturing, and Component Development Project Descriptions

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Advanced Magnet Lab	Lightweight, Direct Drive, Fully Superconducting Generator for Large Wind Turbines	$1,951,850	FY11: Next Generation Drivetrain FOA	Florida
Project Description				
Advanced Magnet Lab (AML) is designing and developing an innovative, superconducting direct-drive generator for large wind turbines. AML's generator is lighter, uses lower-cost coils, offers improved scalability and does not require a gearbox, which can be a high-cost component. Subcomponents of the generator are currently in the testing phase before the final generator prototype is constructed.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
AlphaSTAR Corporation	Advanced Composite Wind Turbine Blade Design Based on Durability & Damage Tolerance	$457,007	FY09: American Recovery and Reinvestment Act (part of the 20% Wind by 2030 FOA)	California
Project Description				
AlphaSTAR Corporation created a multi-scale, progressive failure analysis system and applied it to the assessment and certification of wind turbine blades made with lightweight, advanced composite materials. The system combined durability and damage tolerance analysis with virtual design and testing capabilities. The final simulation tool can help manufacturers test and produce durable, lightweight, long-cost, long-lasting wind turbines.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Alstom	Cost of Energy Reduction for Offshore Tension Leg Platform Wind Turbine Systems through Advanced Control Strategies	$3,504,361	FY11: U.S. Offshore Wind: Technology Development FOA	Virginia
Project Description				
Alstom Power is developing an advanced control system that integrates innovative sensors on a floating wind turbine design. This control system will maximize energy production while providing technology for effective monitoring and adjustment to prevent excessive loads on the turbine that reduce power generation.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Analatom	Remote Structural Health Monitoring and Advanced Prognostics of Wind Turbines	$172,000	FY09: American Recovery and Reinvestment Act (part of the 20% Wind by 2030 FOA)	California
Project Description				
Analatom developed a fault detection and diagnostic data collection system that provides early indications of unscheduled emergency shutdown of wind turbine systems. The company determined various ways to measure abnormal behaviors in components and applied it to a system that can provide earlier detection of pitch rate failure, low oil pressure failure, and gearbox gear-tooth failure.				

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Table 1: FY 2006 – FY 2013 Testing, Manufacturing, and Component Development Project Descriptions

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Bayer MaterialScience, LLC	Carbon Nanotube Reinforced Polyurethane Composites for Wind Turbine Blades	$750,000	FY09: American Recovery and Reinvestment Act (part of the 20% Wind by 2030 FOA)	Pennsylvania
Project Description				
Bayer MaterialScience assessed the performance of polyurethane-based composites versus other materials used for wind turbine blades. The team performed additional testing and research on the use of carbon nanotubes to add strength to both polyurethane-based and common non-polyurethane based blades. Their research showed that use of polyurethane-based composite designs resulted in improved performance of wind blades, and will inform future research and testing.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Boulder Wind Power	Boulder Wind Power Advanced Gearless Drivetrain	$214,000	FY11: Next Generation Drivetrain FOA	Colorado
Project Description				
Boulder Wind Power designed and developed an advanced gearless, permanent magnet-based direct-drive generator. The generator is intended for use in offshore and land-based wind turbines and will provide a lower cost of energy through reduced capital investment, reduced maintenance costs, and higher generation yield.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Cascade Engineering, Inc.	Swift Wind Turbine Marketed in North America by Cascade Engineering, Inc.	$100,000	FY09: 20% Wind by 2030 FOA	Colorado
Project Description				
Cascade Engineering performed comprehensive testing of the Swift Wind Turbine at the National Renewable Energy Laboratory's National Wind Technology Center. This testing assessed the Swift Wind Turbine's ability to meet Small Wind Certification Council Standards for performance, duration, and acoustic emissions.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Clear Path Energy, LLC	Buoyancy Stabilized Offshore Wind Turbine	$500,000	FY11: U.S. Offshore Wind: Technology Development FOA	California
Project Description				
Clear Path Energy is creating a conceptual design for offshore wind systems that can be deployed in water deeper than 35 meters using innovative foundation technology.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Clemson University	Large Wind Turbine Drivetrain Testing Facility	$44,555,252	FY09: American Recovery and Reinvestment Act	South Carolina
Project Description				
Clemson University is constructing a large wind turbine drivetrain test facility. The test facility will enhance the performance, durability, and reliability of both land-based and offshore utility-scale wind turbines by enabling the United States to expand its development and testing of large-scale drivetrain systems in the 5-15 megawatt range. As part of a separate project, Clemson will also design and construct a 15 MW Hardware-in-the-Loop (HIL) grid simulator at the facility. When complete, the HIL Grid Simulator will allow wind turbine generator manufacturers to test both mechanical and electrical characteristics of their machines in a controlled, calibrated environment. The funding for the HIL grid simulator is not included in the DOE funding amount listed above.				

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Table 1: FY 2006 – FY 2013 Testing, Manufacturing, and Component Development Project Descriptions

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Cleveland State University	Wind Spires as an Alternative Energy Source	$1,082,400	FY08: CDP	Ohio
Project Description				
Cleveland State University validated the performance of a wind tower system with a kilowatt-level power rating designed for locations with relatively low wind speed, such as urban settings. The focus of this project was testing what effects of the technology shape of wind deflecting structures have on turbine performance, including testing a new spiral structure design.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Clipper Windpower	Novel Low-Cost, High-Reliability Wind Turbine Drivetrain	$398,450	FY11: Next Generation Drivetrain FOA	California
Project Description				
Clipper Windpower developed and tested a novel low-cost, deflection-compliant drivetrain prototype. The prototype uses a modular design, which allows key parts to be removed and replaced without the use of expensive, high-capacity moving equipment.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
DNV Global Energy Concepts, Inc.	Gearbox Durability Study	$399,616	FY09: American Recovery and Reinvestment Act (part of the 20% Wind by 2030 FOA)	Washington
Project Description				
DNV Global Energy Concepts collected and analyzed data from wind turbine gearboxes and additional operational data in order to understand the root causes of wind turbine failures and to advance gearbox design and reliability. DNV's analysis led to the development of guidelines for early detection of malfunctions and failure. Their final report identified several key indicators that should be monitored to maintain gearbox health, and summarized industry recommendations for health management. Connections uncovered in the course of this study – involving operational conditions, gearbox type and lot, maintenance practices, and gearbox health - will be used to build a framework for recommended practices for gearbox health monitoring. DNV plans to further develop this framework into a formal Recommended Practice as part of the ongoing National Renewable Energy Laboratory Gearbox Reliability Collaborative project.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Dominion Virginia Power	Virginia Offshore Wind Technology Advancement Project: Demonstration of an Innovative Offshore Wind System off the Coast of Virginia	$4,000,000	FY12: U.S. Offshore Wind: Advanced Technology Demonstration Projects FOA	Virginia
Project Description				
Dominion, an electric and natural gas utility, plans to design, develop, and install two 6 megawatt direct-drive turbines off the coast of Virginia Beach on innovative "twisted jacket" foundations that offer the strength of traditional jacket or space-frame structures but use substantially less steel.				

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Table 1: FY 2006 – FY 2013 Testing, Manufacturing, and Component Development Project Descriptions

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Dow Corning Corporation	Full Life Wind Turbine Gearbox Lubricating Fluids	$745,189	FY09: American Recovery and Reinvestment Act (part of the 20% Wind by 2030 FOA)	Michigan
Project Description				
Dow Corning Corporation evaluated a new lubricant for wind turbine gearboxes to increase efficiency, extend technology lifespan, and improve overall reliability. The tested lubricant demonstrated an increase in equipment life and great potential to reduce turbine damage resulting from normal operation.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Eaton Corporation	Reliable, Lightweight Transmission for Offshore, Utility-Scale Wind Turbines	$507,951	FY11: Next Generation Drivetrain FOA	Michigan
Project Description				
Eaton Corporation conducted research to reduce the technical risk for a hydrostatic drivetrain for high-power, utility-scale wind turbines. Research included detailed design and cost analysis of key components including the pump, shaft connection, and controls.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
General Electric Global Research	Superconductivity for Large-Scale Wind Turbines	$503,003	FY11: Next Generation Drivetrain FOA	New York
Project Description				
General Electric Global Research designed and demonstrated a direct-drive wind turbine generator that uses low-temperature superconductivity technology at a 10-megawatt power level. The design employs a unique stationary superconducting component design that reduces the risk of cryogenic fluid leakage, which will result in lower drivetrain maintenance costs.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
General Electric	Wind Turbine Manufacturing Process Monitoring	$647,769	FY09: American Recovery and Reinvestment Act (part of the 20% Wind by 2030 FOA)	New York
Project Description				
General Electric developed an advanced inline inspection system using probes that can be combined with automated composite material placement equipment to economically manufacture high performance and reliable wind turbine blade spar caps, which provide structural support to blades. Various inspection probe prototypes, including the optical system prototype and the air-coupled ultrasound array probe, have been designed and tested, and were incorporated into the final production system. Cost-benefit analysis and technical feasibility of the process models and equipment were continually assessed to inform improvements to the process, which will lead to more efficient wind turbine component manufacturing.				

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Table 1: FY 2006 – FY 2013 Testing, Manufacturing, and Component Development Project Descriptions

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Honeywell International	Honeywell Condition Based Maintenance for Wind Farms	$561,786	FY09: 20% Wind by 2030 FOA	Minnesota
Project Description				
Honeywell International developed a Condition Based Maintenance (CBM) system for wind turbines that continuously monitors turbine health. The project applied a dual approach of vibration and performance monitoring.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Illinois Institute of Technology	A World-Class University-Industry Consortium for Wind Energy Research, Education, and Workforce Development	$7,900,000	FY09: American Recovery and Reinvestment Act (part of the Wind University Consortia FOA)	Illinois
Project Description				
A university-industry consortium procured a utility-scale wind turbine at a wind farm and installed a small wind turbine at the Illinois Institute of Technology for academic use. The consortium members use the turbines to perform research on the reliability of the wind turbines and integration of wind into the electric power grid system. Members also collaborate on workforce development efforts—such as enhancing core curricula—for wind energy research, design, and integration.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Massachusetts Clean Energy Center	Massachusetts Wind Technology Testing Center	$24,752,779	FY09: American Recovery and Reinvestment Act	Massachusetts
Project Description				
The Massachusetts Clean Energy Center used project funding to establish the Wind Technology Testing Center, the nation's first facility capable of testing wind turbine blades 90 meters in length. The Center's testing capabilities will accelerate technical innovation in turbine and blade design and speed up deployment of longer turbine blades, which can produce more energy per turbine and help reduce the overall cost of wind energy.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Montana State University	Wind Turbine Development	$1,000,000	FY10: CDP	Montana
Project Description				
Montana State University is performing research in wind turbine systems, with a focus on manufacturing research, outreach, and training for effective construction of wind turbine components, with a goal of creating jobs in the state of Montana. This research involves meetings, workshops, and educational initiatives with wind turbine component manufacturers that have the potential to create jobs in-state, as well as with other universities to establish similar programs.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
National Center of Manufacturing Sciences	Manufacturing Industrial Development for Alternative Energy Systems	$761,200	FY09: CDP	Michigan
Project Description				
The National Center for Manufacturing Sciences is identifying and developing critical manufacturing technology assessments vital to the affordable manufacturing of alternative energy systems. The project's focus is on broad, cross-cutting technologies that enable faster implementation of alternative energy systems. These online tools and guides help users assess and minimize the environmental impacts of products through their entire product lifecycle (design to end-of-life disposal).				

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Table 1: FY 2006 – FY 2013 Testing, Manufacturing, and Component Development Project Descriptions

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
National Renewable Energy Laboratory (operated by Alliance for Sustainable Energy, LLC)	Hurricane Resilient Wind Plant Concept Study	$500,000	FY11: U.S. Offshore Wind: Technology Development FOA	Colorado
Project Description				
The National Renewable Energy Laboratory team is designing and analyzing a 500 megawatt wind plant comprised of 10 megawatt wind turbines, deployed in 25 meter water depths in the western Gulf of Mexico. New technology will be evaluated to overcome the challenges posed by hurricanes while still achieving a low cost of energy.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
National Renewable Energy Laboratory (operated by Alliance for Sustainable Energy, LLC)	U.S.-Sourced, Next Generation Drivetrain for Land-Based and Offshore Wind Turbines	$1,998,626	FY11: Next Generation Drivetrain FOA	Colorado
Project Description				
The National Renewable Energy Laboratory next generation drivetrain project is optimizing and testing a hybrid design that combines the advantages of geared and direct-drive concepts through an improved single-stage gearbox and a medium speed permanent magnet generator that reduces the need for rare earth materials. The technology developed will be scalable to 10 megawatts.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
National Renewable Energy Laboratory (operated by Alliance for Sustainable Energy, LLC)	Wind Turbine Dynamometer Upgrade	$9,950,000	FY09: American Recovery and Reinvestment Act	Colorado
Project Description				
The National Renewable Energy Laboratory used project funds to double the capacity of its existing 2.5 megawatt dynamometer. The project designed, fabricated, constructed, installed, and commissioned the 5 megawatt dynamometer at the laboratory's existing National Wind Technology Center (NWTC). Prior to its upgrade, the NWTC 2.5 megawatt dynamometer was designed to perform long-term fatigue tests and short-term performance verification tests. Nearing completion and opening for industry users, the dynamometer will enable comparable tests on larger wind turbine drivetrains.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Native American Technologies Corporation	Automated Welding, Forming, and Coating for On-Site Fabricated, Self-Erected Utility-Scale Wind Towers	$749,739	FY09: American Recovery and Reinvestment Act (part of the 20% Wind by 2030 FOA)	Colorado
Project Description				
Native American Technologies Corporation developed a comprehensive automated process to efficiently produce the UltraTall Tower for wind turbines. The corporation focused on improving the welding, forming, and costing processes to increase productivity and reduce the time needed to create cost-competitive towers, which will enhance the United States' contribution to global tower manufacturing.				

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Table 1: FY 2006 – FY 2013 Testing, Manufacturing, and Component Development Project Descriptions

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Nautica Windpower, LLC	Advanced Floating Turbine	$500,000	FY11: U.S. Offshore Wind: Technology Development FOA	California
Project Description				
Nautica Windpower is developing a conceptual design for a deep water offshore wind farm using lightweight floating platforms that offer improved access for maintenance.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
New York City Department of Parks and Recreation	Randall's and Ward's Island Wind Project	$990,000	Multi-Year CDP	New York
Project Description				
This project seeks to install a wind, solar, and tidal electric power station on the south shore of Randall's Island, New York. The Randall's Island research team completed system design and component testing of a 200 kW power module that integrates three renewable energy technologies, including wind turbines. In the next phase, solar panels, wind turbines, and tidal turbines will be installed. The electricity generated will be used to support increased power needs from the expansion of recreational facilities on Randall's Island, as well as provide a highly visible demonstration of sustainable energy technologies.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Northern Power Systems, Inc.	Advanced Manufacturing and Supply Chain Automation	$683,204	FY09: American Recovery and Reinvestment Act (part of the 20% Wind by 2030 FOA)	Vermont
Project Description				
Northern Power Systems developed and implemented a comprehensive manufacturing, vendor quality integration, and product warranty support system. This system was tested at one initial assembly facility and will be expanded to additional supply chain manufacturing facilities. The project will significantly improve the company's capacity to deliver its turbines. The support system was shared with the industry to improve the overall commercial viability of wind turbines.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Ohio State University	An Experimental and Theoretical Investigation of Micropitting in Wind Turbine Gears and Bearings	$310,760	FY09: American Recovery and Reinvestment Act (part of the 20% Wind by 2030 FOA)	Ohio
Project Description				
Ohio State University applied a twin-disk type test machine to simulate wind turbine transmission contacts in terms of their kinematics (rolling and sliding speeds), surface roughnesses, material parameters and lubricant conditions. A test matrix that represents the ranges of contact conditions of the wind turbine gear boxes, including both gear and bearing contacts, was defined and executed to bring an empirical understanding to the micropitting problem in terms of key contact parameters and operating conditions. The project developed the first deterministic micro-pitting model based on a mixed elastohydrodynamic lubrication formulations and multi-axial near-surface crack initiation model. This proposed model is suitable for identifying the mechanisms leading to micro-pitting of gear and bearing surfaces of wind turbine gear boxes, including all key material, lubricant and surface engineering aspects of the problem, and providing solutions to these micro-pitting problems.				

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Table 1: FY 2006 – FY 2013 Testing, Manufacturing, and Component Development Project Descriptions

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Pennsylvania State University	A High Performance Computing "Cyber Wind Facility" Incorporating Fully-Coupled Computational Fluid Dynamics and Computational Structural Dynamics for Turbine-Platform-Wake Interactions with the Atmosphere and Ocean	$1,200,000	FY11: U.S. Offshore Wind: Technology Development FOA	Pennsylvania
Project Description				
Pennsylvania State University is developing a computer-modeled "Cyber Wind Facility" to simulate large wind energy array performance for both offshore and land-based wind turbines. The Cyber Wind Facility will model the impacts of complex wind and wave dynamics on wind turbine structures and energy performance, enabling developers to make more informed decisions on array and turbine placements.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
PPG Industries, Inc.	Wind Blade Manufacturing Innovation	$741,754	FY09: American Recovery and Reinvestment Act (part of the 20% Wind by 2030 FOA)	North Carolina
Project Description				
PPG Industries studied, identified, and demonstrated the feasibility of a systems-based application of automated fabrication technology to create wind turbine blades. PPG collaborated with MAG Industrial Automation Systems to create fiberglass composite wind blades that have improved mechanical performance and have lower production costs than PPG's previous blades.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Purdue University	Midwest Consortium for Wind Turbine Reliability and Optimization	$64,133	FY09: Wind University Consortia FOA	Indiana
Project Description				
The Midwest Consortium for Wind Turbine Reliability and Optimization, established and led by Purdue University, designed, fabricated, and characterized the performance of a portable and instrumented 500-watt wind turbine apparatus. The apparatus enables students to learn about wind technology through field experiments and is incorporated as a practice component into existing courses offered at Consortium member institutions.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Purdue University at Calumet	Establishing a Comprehensive Wind Energy Program	$500,000	FY10: CDP	Indiana
Project Description				
Purdue University established a comprehensive wind energy program with both educational and research components. This project developed graduate and undergraduate curricula in energy engineering with an emphasis on wind power; investigated the design and performance of horizontal and vertical axis wind turbines, including novel designs in rural and urban environments; investigated wind farm and urban environment wind and wind turbine aerodynamics; and applied advanced visualization and simulation technologies to develop a wind energy visualization laboratory.				

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Table 1: FY 2006 – FY 2013 Testing, Manufacturing, and Component Development Project Descriptions

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
QM Power, Inc.	Advanced High Power Density Permanent Magnet Wind Generators	$308,005	FY09: American Recovery and Reinvestment Act (part of the 20% Wind by 2030 FOA)	Montana
Project Description				
QM Power designed and tested a scalable direct drive, permanent magnet generator for use in medium- to large-scale (25kW-3MW) direct drive and geared permanent magnet wind generator wind turbine designs. The permanent magnet generator technology will increase reliability and decrease maintenance costs by eliminating the gear-speed increaser, which is susceptible to significant levels of fatigue in wind generators.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Sandia National Laboratories (operated by Lockheed Martin Corporation)	Innovative Offshore Vertical-Axis Wind Turbine Rotors	$4,140,000	FY11: U.S. Offshore Wind: Technology Development FOA	New Mexico
Project Description				
During this five-year project, a collaborative team consisting of members from Sandia National Laboratories, several universities, and a major U.S. wind blade manufacturer are designing, building, and testing advanced vertical-axis wind turbine rotors for deepwater offshore wind energy production on the 10-20 megawatt turbine scale.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Siemens Energy Inc.	Offshore 12 MW Turbine Rotor with Advanced Materials and Passive Design Concepts	$4,701,285	FY11: U.S. Offshore Wind: Technology Development FOA	Colorado
Project Description				
Siemens Energy is investigating the use of a wide range of aerodynamic control technologies that are capable of significantly improving the efficiency and performance of wind turbine blades, resulting in lower energy costs.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
South Jersey Economic Development District	South Jersey Wind Turbines	$500,000	FY10: CDP	New Jersey
Project Description				
The South Jersey Economic Development District is researching, designing, and constructing a wind turbine on the site of an existing sewage treatment plant. The final turbine will be designed with enough capacity to power the connected plant in Penns Grove, NJ. The Development District will evaluate the turbine's performance, and use the findings to assess the feasibility of establishing a similar turbine on the site of a former landfill.				

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Table 1: FY 2006 – FY 2013 Testing, Manufacturing, and Component Development Project Descriptions

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Texas Tech University	Full Scale Testing, Characterization, System Optimization, and Demonstration of Grid Connected Wind Turbines & Wind Powered Water Desalination	$7,356,000	Multi-Year CDP	Texas
Project Description				
Texas Tech University will demonstrate and deploy a 50kW wind turbine, and use it to perform research on the impact of local wind phenomena on turbine efficiency and reliability when construction is complete. The University has expanded its curricula to train engineers and developers to use integrated wind-water desalination systems, which will be incorporated into the deployed turbine.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Texas Tech University	Midsize Wind Turbine Designed and Manufactured in the USA	$850,000	FY10: Midsize Wind Turbine FOA	Texas
Project Description				
Texas Tech University is designing a cost-efficient, mid-sized wind turbine with a rated generating capacity under 1 MW. The turbine will be designed for use at both large and small facilities. Project funds will also be used to assess the design's potential for a demonstration scale up.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
University of Delaware	Wind Turbine Model and Pilot Project for Alternative Energy	$2,427,250	Multi-Year CDP	Delaware
Project Description				
The University of Delaware constructed a shore-side, utility-scale 2.0 megawatt wind turbine for multidisciplinary research. The turbine began generating electricity in June 2010. Additional project funds were used to conduct a post-construction assessment of wildlife impacts.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
University of Houston	National Wind Energy Center	$4,378,750	Multi-Year CDP	Texas
Project Description				
The University of Houston is establishing an advanced testing facility known as the National Wind Energy Center (NWEC), which will research, develop, and test composite materials, components, and manufacturing technologies for larger offshore wind turbines. In the first phase of the project, students and faculty at the university developed test methodologies that will be employed by NWEC. In the second phase, additional research is being performed to develop advanced materials that can be used for blade manufacturing. Blades using these materials will be produced and tested upon completion of construction of the National Wind Energy Center facility.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
University of Maine	DeepCWind - Deepwater Offshore Wind Consortium	$7,100,000	FY09: American Recovery and Reinvestment Act (part of the FY09 Wind University Consortia FOA)	Maine
Project Description				
The University of Maine developed floating offshore wind farm technologies for deepwater development. The project validated computer models for designing and analyzing floating offshore wind turbines and research integrating more durable, lighter, hybrid composite materials into offshore wind floating platforms and towers.				

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Table 1: FY 2006 – FY 2013 Testing, Manufacturing, and Component Development Project Descriptions

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
University of Maine	Feasibility of Thermoplastic Composite Blades	$250,000	FY10: CDP	Maine
Project Description				
The University of Maine researched the potential for using thermoplastic composite materials for wind turbine blades to improve cost-efficiency, blade durability, and environmental sustainability. This project evaluated the performance of thermoplastic composite materials for blade applications and investigated potential manufacturing processes for utility-scale thermoplastic wind turbine blades.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
University of Massachusetts—Lowell	Effect of Manufacturing-Induced Defects on Reliability of Composite Wind Turbine Blades	$401,885	FY09: American Recovery and Reinvestment Act (part of the 20% Wind by 2030 FOA)	Massachusetts
Project Description				
The University of Massachusetts-Lowell designed and demonstrated approaches to minimize manufacturing flaws in the production of wind turbine blades. The University analyzed current critical flaw criteria based on performance assessments, created new methods to enable early detection of flawed blades, and established best practices for quality control.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
University of Minnesota	An Industry/Academic Consortium for Achieving 20% Wind by 2030 Through Cutting-Edge Research and Workforce Training	$7,981,677	FY09: American Recovery and Reinvestment Act (part of the Wind University Consortia FOA)	Minnesota
Project Description				
The University of Minnesota is developing full-scale and laboratory-scale wind energy research facilities that will enable cost-effective development and real-world testing and demonstration of a wide range of wind turbine technologies. The facilities' testing units also collect field-scale data sets for computational models. The Consortium members are establishing new curricula and educational initiatives to train the next generation of wind industry engineering leaders.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
University of Toledo	Advanced Offshore Wind Turbine/ Foundation Concept for the Great Lakes	$750,000	FY09: Wind University Consortia FOA	Ohio
Project Description				
The University of Toledo is developing two models, one for a two-bladed downwind offshore turbine and the other for a gravity based foundation design. The project is also creating curriculum for offshore wind turbine design at the University of Toledo to enhance training opportunities for wind turbine engineers and developers.				

continued >

Table 1: FY 2006 – FY 2013 Testing, Manufacturing, and Component Development Project Descriptions

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Viryd Technologies	Testing the Viryd 8000 to Verify a Lower Cost of Energy	$65,000	FY09: 20% Wind by 2030 FOA	Colorado
Project Description				
Viryd Technologies tested its small wind turbine model—the Viryd 8000—to demonstrate its improved annual energy production capacity, lower system cost, and overall energy efficiency.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Western New England College	Next-Generation Wind Turbine	$1,000,000	FY10: CDP	Massachusetts
Project Description				
Western New England University and FloDesign Wind Turbine are collaborating to develop a novel wind turbine concept that modifies existing FloDesign technology. The project goal is to produce a compact design that generates more electricity than existing small turbines while improving environmental safety.				

Project Recipient	Project Title	DOE Funding Amount	Funding Source	Project Location
Zimitar, Inc.	High Efficiency Structural Flowthrough Rotor With Active Flap Control	$3,998,763	FY11: U.S. Offshore Wind: Technology Development FOA	California
Project Description				
Zimitar is creating two-bladed wind turbine designs that incorporate active aerodynamic controls intended for use on offshore wind farms. This project will result in rotors that are lighter than conventional designs, which will increase energy capture and reduce the cost of energy.				

Photo from NREL

Funding Distribution

DOE has funded 50 testing, manufacturing, and component development projects through the Wind Program from 2006–2013. These projects are categorized in the following sections by topic area, geographic region and division, state, recipient type, and funding source.

Funding by Topic Area

This report covers wind technology development projects which broken down into topic areas: Wind Turbine Testing Facilities; Innovative Offshore Wind Plant System Designs; Advanced Components / High Risk Innovation; Distributed Wind Research, Development, and Testing; and Manufacturing and Supply Chain. Projects in these topic areas reduce the overall cost of wind energy, diminish technical barriers to system development, improve system reliability and performance, and enhance the understanding of various systems and components.

More than half of the Wind Program's funding in testing, manufacturing, and component development projects went to six turbine testing facilities.

Advanced component represents nearly one quarter of funding and a diverse set of innovative projects. Table 2 provides details on the testing, manufacturing, and component development projects within the five topic areas listed above.

Photo from Clemson University

Table 2: FY 2006 – FY 2013 Testing, Manufacturing, and Component Development Projects by Topic Area

Topic Area	Total Funding	Percent of Total
Wind Turbine Testing Facilities	$92,818,458	58%
Advanced Components / High Risk Innovation	$39,735,843	25%
Distributed Wind Research, Development, and Testing	$22,519,783	14%
Manufacturing & Supply Chain	$3,898,927	2%
Innovative Offshore Wind Plant System Design Studies	$1,500,000	1%
Total	$160,473,011	

Photo from NREL

Funding by Geographic Region & Division

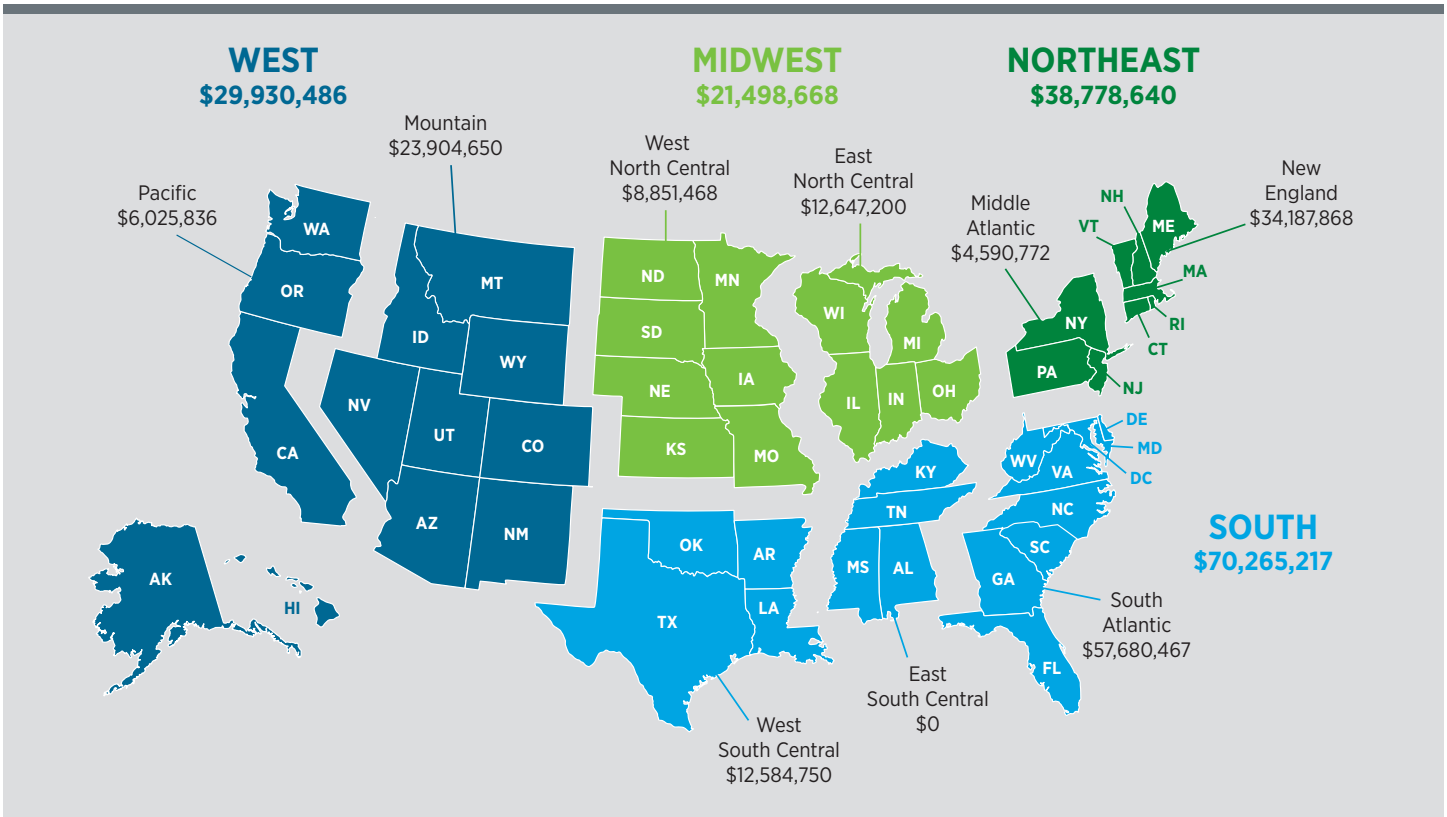
Testing, manufacturing, and component development project funding was awarded in each of the nation's four geographic regions, with the Northeast and South regions receiving the largest share of funding due to FOA and ARRA funding for wind turbine testing facilities in Massachusetts and South Carolina. Remaining funding was distributed to the Midwest and West, with the Midwest receiving a smaller amount. Table 3 provides details on how the Wind Program's funding was distributed within regions and divisions. The geographic regions and divisions used to present the distribution of the Wind Program's funding are based on the U.S. Census Regions and Divisions.[1]

Exhibit 1 provides a map that shows how the Wind Program's funding for these projects was distributed throughout the United States.

Table 3: FY 2006 – FY 2013 Testing, Manufacturing, and Component Development Projects by Geographic Region and Division

Region	Region Total Funding	Division	Division Total Funding
West	$29,930,486	Mountain	$23,904,650
		Pacific	$6,025,836
South	$70,265,217	South Atlantic	$57,680,467
		West South Central	$12,584,750
		East South Central	$0
Northeast	$38,778,640	Middle Atlantic	$4,590,772
		New England	$34,187,868
Midwest	$21,498,668	East North Central	$12,647,200
		West North Central	$8,851,468
		Total	**$160,473,011**

Exhibit 1: 2006–2013 Testing, Manufacturing, and Component Development Projects



Funding by State

Wind Program funding for the 50 testing, manufacturing, and component development projects was broadly distributed to organizations in 24 states. Table 4 outlines funding by state.

Combined, South Carolina, Massachusetts, and Colorado received more than half of the total funding for the projects in this report. All three states had large testing facility projects.

Table 4: FY 2006 – FY 2013 Testing, Manufacturing, and Component Development Projects by State

State	Total Funding
California	$6,126,220
Colorado	$18,764,650
Delaware	$2,427,250
Florida	$1,951,850
Illinois	$7,900,000
Indiana	$564,133
Maine	$7,350,000
Massachusetts	$26,154,664
Michigan	$1,506,389
Minnesota	$8,543,463
Missouri	$308,005
Montana	$1,000,000
New Jersey	$500,000
New Mexico	$4,140,000
New York	$2,140,772
North Carolina	$741,754
Ohio	$2,143,160
Pennsylvania	$1,950,000
South Carolina	$44,555,252
Texas	$12,584,750
Vermont	$683,204
Virginia	$7,504,361
Washington	$399,616
Wisconsin	$533,518
Total	**$160,473,011**

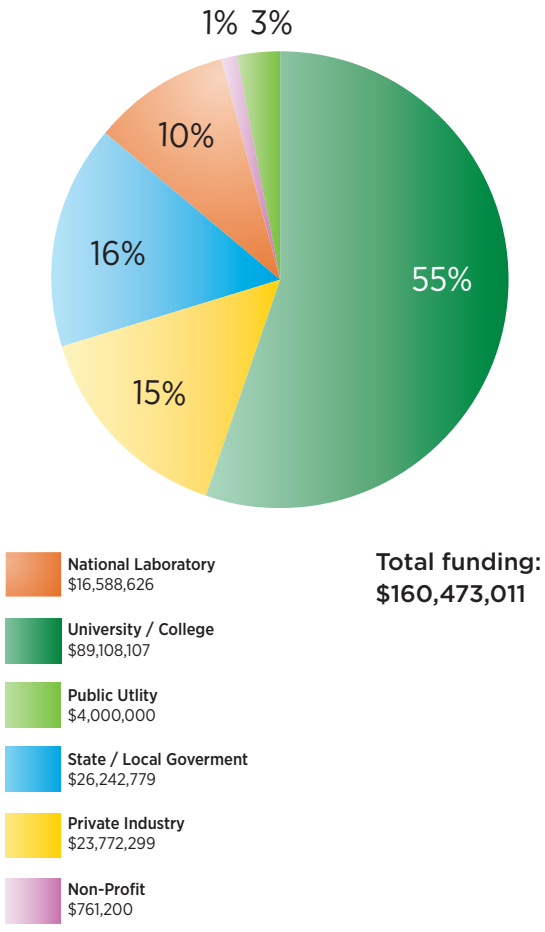
Funding by Recipient Type

DOE provided funding to a variety of recipient types, including private industry, nonprofit organizations, universities and community colleges, investor-owned utilities and public utilities, and local and state governments, as well as DOE national laboratories, other federal agencies, and interstate government agencies.

More than half of the total funding was awarded to universities or colleges. Private industry and state and local governments combined received nearly one third of the total funding. The remaining funds were distributed to public utilities, national laboratories, and non-profits.

Exhibit 2 outlines funding by recipient type.

Exhibit 2: 2006–2013 Testing, Manufacturing, and Component Development Projects by Recipient Type



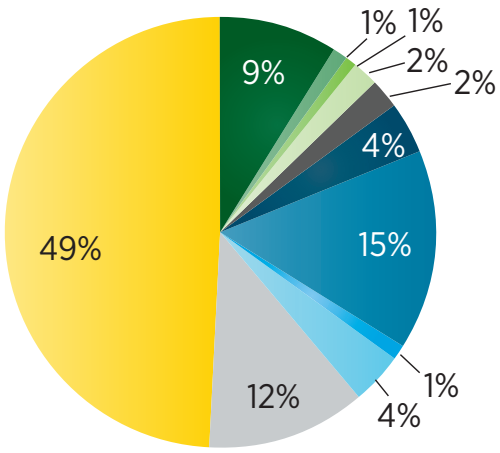
Project funds awarded to universities and colleges dominate the Program's testing, manufacturing, and component development funding portfolio, representing 55%—or more than $89 million—of total funding.

Funding Sources

Exhibit 3 below provides details on the sources of funding for the Wind Program's 50 testing, manufacturing, and component development projects awarded from FY 2006–FY 2013.

From 2006–2013, the Wind Program issued numerous competitive FOAs; five of these FOAs are represented in this report, receiving approximately $160 million of the total funding for 35 projects. An additional $24 million was awarded to 12 projects through Congressionally Directed funds. The American Recovery and Reinvestment Act directly funded three projects totaling approximately $79.3 million. Additional ARRA funds were directed through competitive FOAs. In Exhibit 3, those projects are listed under the corresponding FOA.

Exhibit 3: FY 2006 – FY 2013 Testing, Manufacturing, and Component Development Projects



Total funding: $160,473,011 | Total number of projects: 50

FOA 36%

- **FY09: 20% Wind by 2030 FOA*** $7,093,714 Number of Projects: 15
- **FY09 Wind University Consortia FOA** $23,795,810 Number of Projects: 5
- **FY10: Midsize Wind Turbine FOA** $850,000 Number of Projects: 1
- **FY11: Next Generation Drivetrain FOA** $6,185,447 Number of Projects: 6
- **FFY11: U.S. Offshore Wind: Technology Development FOA** $19,044,409 Number of Projects: 8

CDP 15%

- **CDP: Multi-Year** $15,152,000 Number of Projects: 4
- **CDP: FY08** $1,082,400 Number of Projects: 1
- **CDP: FY09** $761,200 Number of Projects: 1
- **CDP: FY10** $3,250,000 Number of Projects: 5
- **CDP: FY12** $4,000,000 Number of Projects: 1

Recovery Act 49%

- **FY09 American Recovery and Reinvestment Act** $79,258,031 Number of Projects: 3

* Both the FY09: Wind University Consortia FOA and the FY09: 20% Wind by 2030 FOA received partial funds through the American Recovery and Reinvestment Act. In the Wind Consortia FOA, three of five projects were funded by the Recovery Act. In the 20% Wind by 2030 FOA, 12 of 15 projects were funded by the Recovery Act. These totals are reflected in the FOA category in this chart.

Accomplishments

The Wind Program has allocated more than $160 million in funding for 50 testing, manufacturing, and component development projects since FY 2006, with many of the projects operating over multiple years. The Wind Program has already realized significant return on federal investments to date and anticipates significant key accomplishments in years to come.

A few of the program's project accomplishments include the following:

- **Large Wind Turbine Drivetrain Testing Facility:** In November 2009, DOE announced the selection of Clemson University to receive up to $45 million in American Recovery and Reinvestment Act funds for the Clemson Wind Turbine Drivetrain Testing Facility. The fully commissioned testing facility has completed foundations for the 7.5 and 15 megawatt (MW) test stands that are capable of performing highly accelerated endurance testing of drivetrain systems and power grid simulation for land-based and offshore wind turbines. Operation of the 7.5 MW system is scheduled for winter 2013-2014 and the 15 MW by summer of 2014.
- **Massachusetts Large Blade Testing Facility**: In May of 2009, the program awarded Massachusetts $25 million in funding to accelerate development of the state's Wind Technology Testing Center (WTTC), also known as the large blade test facility. Groundbreaking began in Charlestown, Massachusetts in late 2009 and the facility opened in May 2011. Constructed with a combination of funding from DOE (through the American Recovery and Reinvestment Act) and the State of Massachusetts, the WTTC is the first test facility in the world with the ability to test wind turbine blades up to 90 meters in length. The facility's high bay features three test stands and 100 tons of overhead bridge crane capacity, providing industry partners with the latest wind turbine blade testing and prototype development methodologies, blade repair, and workforce training. In October 2011, WTTC completed its first commercial static test applied to a multi-megawatt-size blade manufactured in the United States. In addition, WTTC provides the U.S. wind industry the opportunity to conduct more rigorous testing of blades to improve wind turbine reliability, which will help the industry deploy the next generation of land-based and offshore wind turbine technologies.

- **University of Maine Floating Platform Tank Testing**: In the spring of 2011, the University of Maine-led DeepCwind Consortium tested three different 1:50 scale floating wind turbine concepts at the Maritime Research Institute Netherlands (MARIN). Detailed performance and structural data were collected for a spar buoy, a tension leg platform and a semi-submersible floating turbine model, in response to combined wind and wave loads generated in the testing tank. It was the first time that such extensive scale model tests had been conducted in this field, anywhere in the world. Multiple reports on the testing program have been published and presented at conferences worldwide. The data are being used to validate computer-aided engineering. The university-led team has also constructed and deployed a 65-foot-tall prototype floating wind turbine, VolturnUS. This project will collect data to validate and improve floating wind turbine designs, while helping to address technical barriers to reducing the cost of offshore wind systems while ensuring high performance and efficiency. For example, the floating wind turbine features a unique semi-submersible platform that uses a lower cost concrete foundation in addition to a lighter weight composite tower.
- **Bayer MaterialScience Carbon Nanotube Blade Composites**: In 2009 Bayer MaterialScience was awarded funding to assess the performance of polyurethane-based composites against other traditional materials used for wind turbine blades. Because of the lighter weight, the polyurethane material offers potential to decrease dynamic stress on the blades and increase overall turbine life. During testing, Bayer also assessed the improvements from adding carbon nanotubes to the lighter blades for added support and strength. When combined, the new blades showed improvements in resilience against fractures while still maintaining the polyurethane's lighter weight. Bayer's positive results will inform future research and testing on polyurethane composite blades as a viable, lower cost alternative to existing materials.
- **National Renewable Energy Laboratory Wind Turbine Dynamometer Upgrade**: In 2008 the National Renewable Energy Laboratory was awarded funding to double the capacity of its existing 2.5 megawatt (MW) dynamometer at the laboratory's National Wind Technology Center (NWTC). Funded with American Recovery and Reinvestment Act funds, the upgraded dynamometer will be able to connect wind turbine drivetrains directly to the electricity grid. With one of the largest dynamometers in the world, NWTC's new test facility will be capable of testing the reliability and performance of wind turbine drivetrains with capacity up to 5 MW. These new capabilities will result in a reduction in deployment time, failures, and maintenance or replacement costs.

End Notes

[1] Energy Information Administration, U.S. Census Regions and Divisions. June 14, 2000. http://www.eia.doe.gov/emeu/reps/maps/us_census.html

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