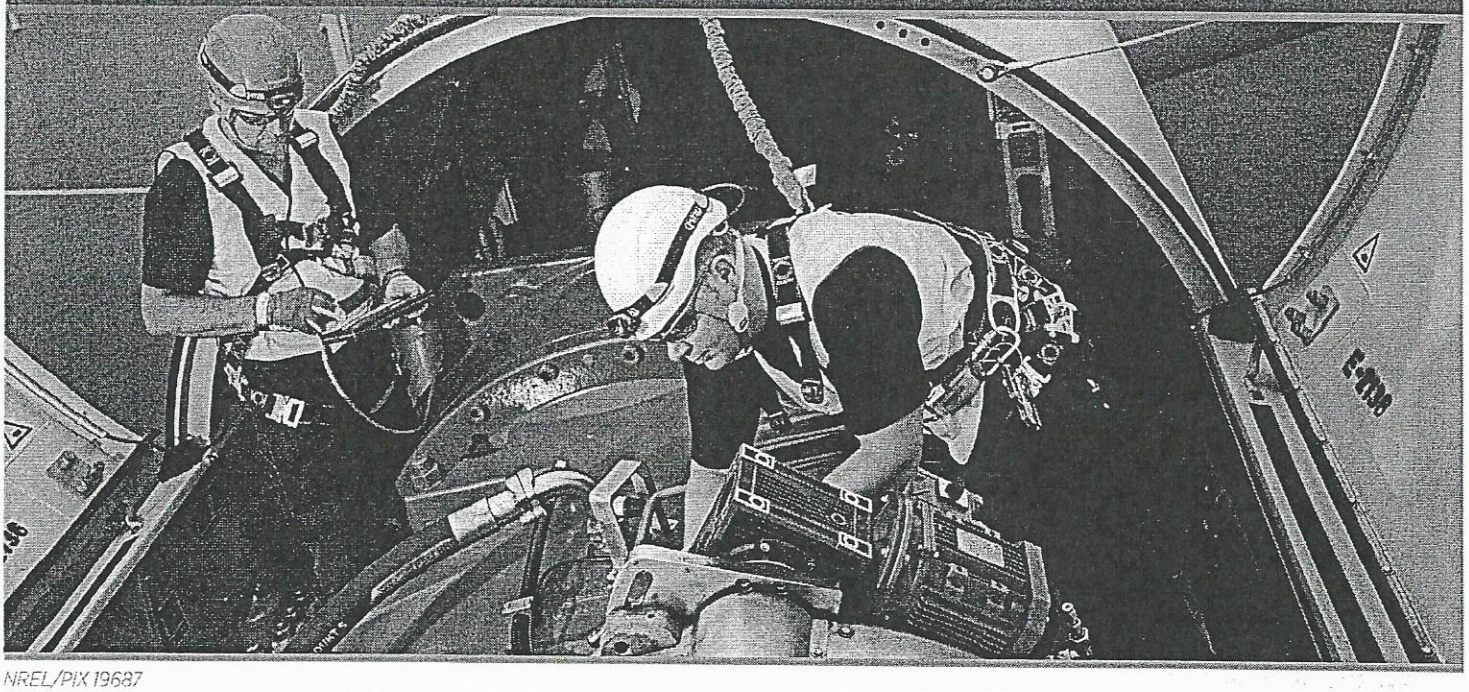
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

WIND PROGRAM ACCOMPLISHMENTS



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U.S. Department of Energy's Wind Program—Lasting Impressions

State of the Industry

1980–Today

Wind power has the potential to provide 20% of all electricity for the nation by 2030. By August 2012, the U.S. wind industry totaled more than 50,000 MW installed power capacity, over 16% of the 300,000 MW needed to achieve 20% by 2030. Wind power is expanding across the United States and is deployed in 31 states and territories. Texas alone has more installed wind power than all but five countries around the world.

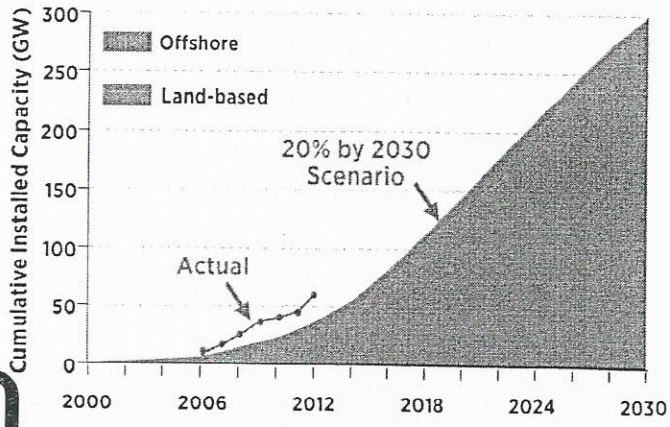
Over the past 4 years, the U.S. wind industry represented 35% of all new installed generation capacity. Wind energy will continue to be a fundamental component of the next era of energy projects to connect to the electricity grid. Interest in wind power continues to grow, with the proposed number of wind projects surpassing that of all other forms of generation.

The U.S. wind industry isn't just generating clean electricity for American homes. It employs more than 75,000 professionals nationwide. These jobs span more than 400 manufacturing facilities across the United States, including dedicated wind facilities in every region that manufacture turbine components such as towers, blades, and assembled nacelles.

What if the U.S. Generated 20% of Electricity from Wind by 2030? Fast Facts

- 300,000 MW total installed capacity in 2030
- 409,200,000 tons coal consumption offset per year
- $13,200,000,000 social cost of carbon offset per year
- 450,000,000,000 gallons water use offset per year
- $8,760,000,000 reduced health costs per year
- 626,700,000 metric tons CO_2 emissions offset per year
- 6,360,000,000 standard cubic feet of natural gas consumption offset per year
- 2,880,000 direct job-years in manufacturing, construction and operations and maintenance

Installed Wind Capacity by Year



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The Wind Program's Role in Innovation—Moving the Nation's Power Dial

Plugging into the nation's abundant wind resources for electric power generation will stabilize energy costs, help secure energy independence, and improve our environment. The U.S. Department of Energy (DOE) Wind Program recognizes that wind is a clean, domestic, renewable, and plentiful energy resource. Over the last three decades, the Wind Program has led the nation's efforts to improve performance, lower costs, and accelerate deployment of wind technologies on land and offshore. The cost of energy from wind power, in areas with good wind resources, has decreased from over $0.55/kWh in 1980 (current dollars) to under $0.06/kWh today. The program partners with national laboratories, industry, universities, and other federal agencies to conduct research and development activities efforts to achieve 20% of the nation's electricity from wind resources by 2030. As creative and scientific minds gather, DOE is there to invest in technology breakthroughs by following through on long-term commercialization strategies that evolve to meet growing market demand.

Simulation Codes and Design Tools

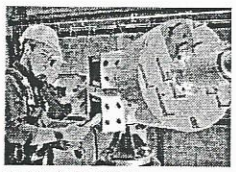
The Wind Program developed turbine simulation codes to streamline design development and reduce costs of technology commercialization. These codes allow designers to build virtual models of blades and full systems to predict performance in different environments before prototypes are even constructed.

- Publicly available codes such as FAST and AeroDyn are now widely used by university, government agencies, and industry.
- The NuMaD blade software tool significantly reduces development time compared to conventional tools; a blade model previously requiring 15 hours to complete can now be completed in less than an hour.

Next Generation Component Design and Fabrication

The Wind Program facilitates the development of next generation wind turbine components such as rotor blades, drivetrains, generators, power electronics, and towers. Research and development in this area includes advanced design studies, design competitions, industry collaboratives, and materials characterization studies. Many of these innovations have been incorporated by industry into modern commercial wind turbines.

- Advanced airfoils led to new turbine blade designs that produced 30% more energy than previous designs, and are now the industry standard.
- Researchers fabricated a 1.5 MW single-drive, permanent-magnet drivetrain, which reduced the total cost of production by 12.8%. A planetary gearbox and a medium-speed (190 rpm), permanent-magnet generator reduce tower-head weight and total drivetrain costs.



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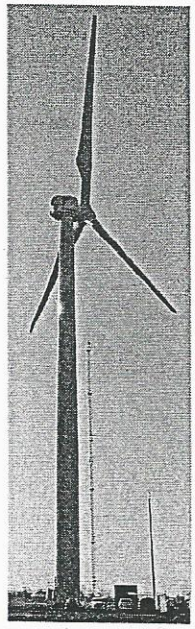
- The sweep twist adaptive rotor (STAR) blade, specially designed to take maximum advantage of a wider range of wind speeds, sets the stage for next generation blade design. The STAR design was developed for a 750-kW turbine, and received the 2005 DOE "Outstanding Research and Development Partnership Award."

Turbines

Modern wind turbines are increasingly cost effective and more reliable, and have scaled up in size to multi-megawatt power ratings. Since 1999, the average turbine generating capacity has increased by 43% to 1.79 MW. Wind Program research has helped facilitate this transition, through the development of longer, lighter rotor blades, more reliable drivetrains, and performance-optimizing control systems. Furthermore, improved turbine performance has led to a more robust domestic wind industry that saw wind turbine technology exports grow from $15 million in 2001 to $142 million in 2010.



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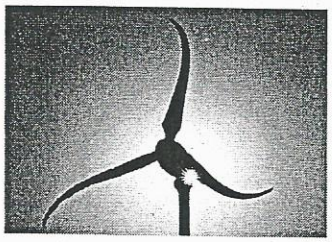
- Wind turbine initiatives, including *WindPact* and *Low Wind Speed Turbine*, supported innovative prototypes and early commercial growth of turbines that reach higher wind classes and capture much more energy.
- Wind Program researchers worked with GE to design and test components such as blades, generators, and control systems that resulted in GE's 1.5 MW commercial wind turbine. The GE 1.5 constitutes approximately half of the nation's installed commercial wind energy fleet, and is a major competitor in global markets.
- The first "plug and play" wind turbine, Southwest Wind Power's 1.8 kW Skystream turbine, features an integrated inverter and controls and low noise fiberglass blades and is easier to install, operate, and maintain than comparable turbines. The Skystream 3.7 wind generator, developed in collaboration with the DOE National Renewable Energy Laboratory, received Popular Science's 2006 Best of What's New Award and was recognized as one of the best inventions of 2006 by Time Magazine.



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Simulation Codes and Design Tools | Next Generation Component Design and Fabrication | Turbines

1990: Turbine research and development realizes new materials for components

1991: Advanced blade designs produce 30% more energy

1995-2006: First-in-industry wind turbine systems demonstrated

1996: National Wind Technology Center opens

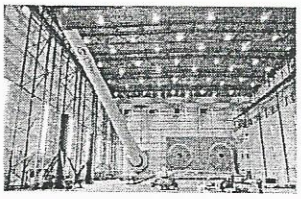
1999: Wind Powering America kicks off nationwide efforts

1990 2000

Testing and Demonstration

The Wind Program supports testing centers across the nation that enable researchers and industry partners to conduct a wide range of system, component, and field tests to identify and resolve technical design issues.

- The Utility-Industry Wind Turbine Verification Program tested and evaluated prototype utility-scale wind turbines prior to deployment. This program expanded the market for wind power by introducing the benefits of wind to several electric utilities that today are key wind players.
- DOE's National Wind Technology Center in Colorado employs field, drivetrain, and blade test facilities to test next generation turbine designs and components.
- The Wind Technology Testing Center in Boston, Massachusetts is the nation's first large wind blade test facility, with the capability to test blades up to 90 meters in length and suitable for wind turbines up to 15 MW, as anticipated for offshore installations.



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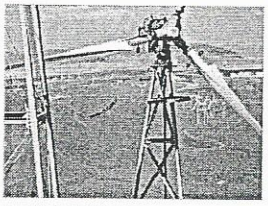
Market Acceleration and Barrier Reduction Activities

In the 1990s, wind development had largely occurred at a few sites in California and had not established a foothold elsewhere in the country. DOE-funded market acceleration and environmental initiatives, such as Wind Powering America and the National Wind Coordinating Collaborative, were critical in enabling wind to break out of California and develop in markets across the country.

- Wind Powering America has provided state and local policymakers with objective information and tools such as the Jobs and Economic Development Impact (JEDI) model to promote sound decision making about wind energy policy and deployment in their jurisdictions.



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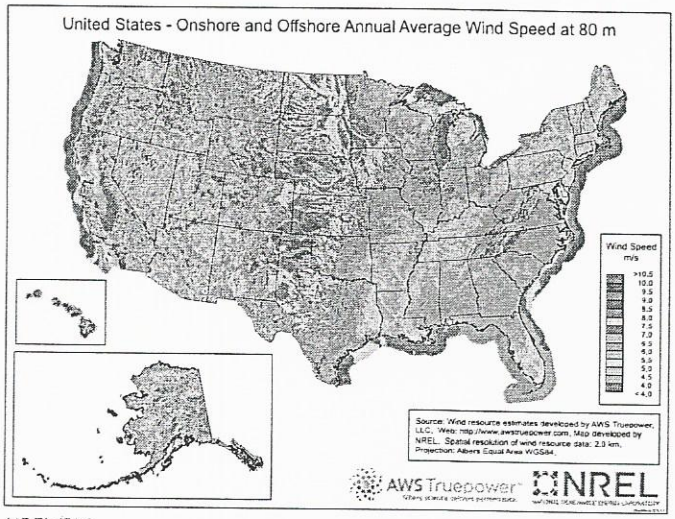
- The National Wind Coordinating Collaborative has built public-private partnerships to show that wind can be integrated cost-effectively, and along with offshoot efforts such as the Bats and Wind Energy Cooperative has built a scientific basis for how to site and operate wind farms that is reducing substantially the impact of wind deployment on sensitive wildlife like birds and bats.

Resource Characterization and Integration

DOE Wind Program efforts in resource characterization have given energy planners and understanding of the resource potential, allowed manufacturers to design more cost-effective and reliable turbines, and helped grid operators to integrate electricity from the nation's wind resource.

- The TurbSim code provides designers with realistic wind inflow for turbine simulation models, yielding higher confidence in performance and reliability of new turbine systems.
- Utility power system simulations using high resolution time-synchronized wind data have become the world standard for conducting wind and solar integration studies.
- The WindSENSE project increases awareness of wind conditions and energy forecasts so grid operators can make informed scheduling decisions, especially during extreme events such as wind ramps. By working closely with Western utilities and system operators, WindSENSE improves integration of wind generation into the grid while maintaining grid reliability.
- Wind resource maps help developers and policy makers identify areas of significant resource for wind farm planning. The web-based maps attract over 20,000 page views each month.



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Wins in Wind: 1990–Today

Testing & Demonstration | Resource Characterization & Integration | Market Acceleration & Barrier Reduction Activities

2003: NuMAD software introduced

2004: 1.5 MW permanent magnet drivetrain reduces cost of production 12.8%

2005: STAR curved blade tips debuts

2007:
First plug and play 1.8 kW Skystream
GE 1.5 MW commercialized
Wind resource maps available

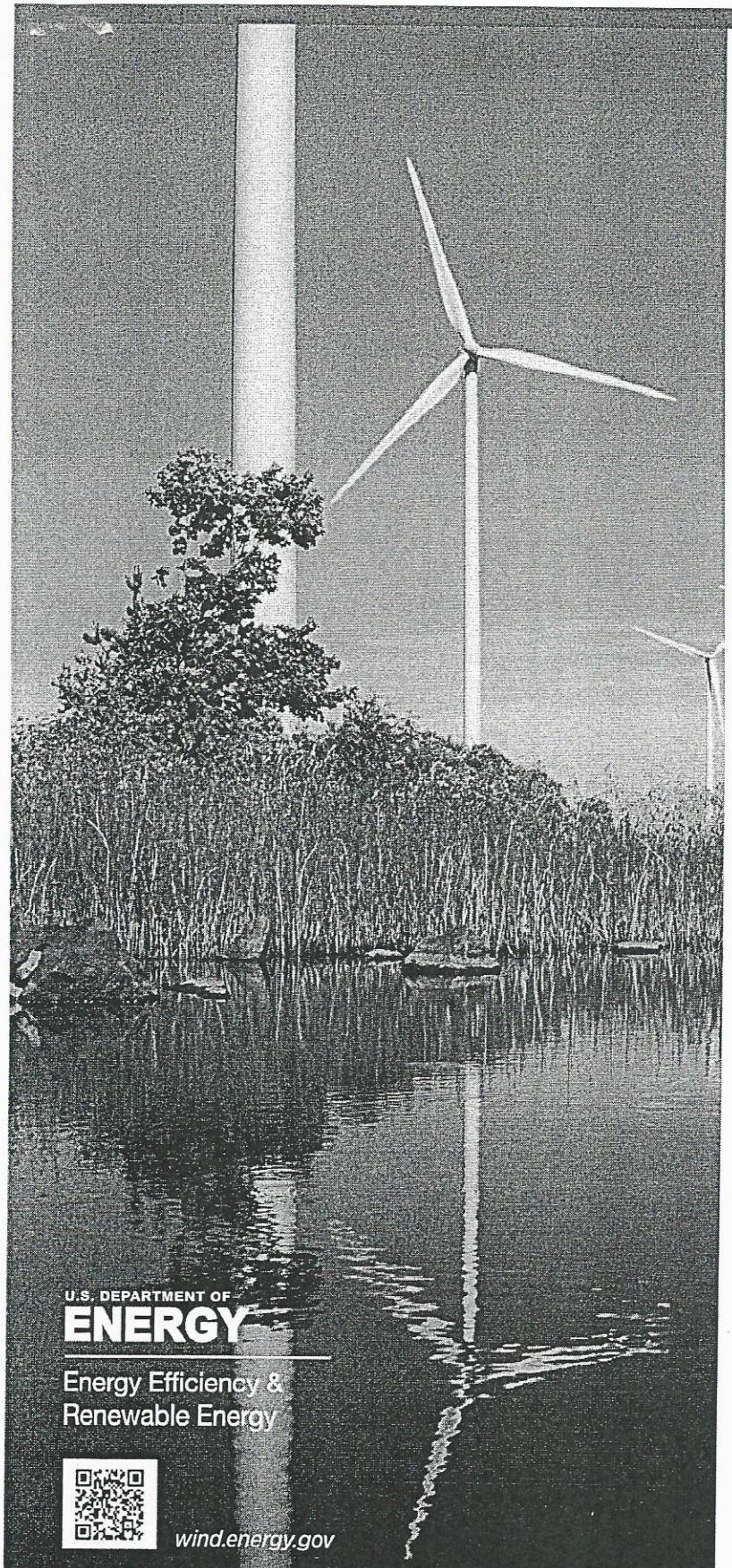
2008: *20% Wind Energy by 2030* report is released

2010

2011: Nation's first large blade test facility opens

Today

2011: *National Offshore Wind Strategy* report is released



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DOE/EE-0726 • September 2012

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Where the Wind is Blowing—DOE is Going

Developing our nation's vast energy resources is an important part of President Obama's blueprint for an American economy that makes the most of America's energy resources. DOE's Wind Program is dedicated to driving down the cost of wind energy with more efficient, more reliable, and more predictable wind energy systems. The Wind Program is leading the nation's path towards capturing more wind than ever before through the installation of innovative offshore wind turbines and systems in U.S. waters, complex flow characterization of air movement in a wind energy system, and market acceleration and deployment activities. The Wind Program is mobilizing efforts across the nation to ensure the United States remains competitive in this growing global industry.

- **Advanced Technology Demonstration** will catalyze development of offshore wind resources through the installation of optimized turbines and systems in U.S. waters in the most rapid and responsible manner possible. As part of the *National Offshore Wind Strategy*, DOE supports collaborative partnerships between government and innovators to design and demonstrate next generation wind energy technologies.

- **Complex Flow Characterization** will play a major role in the future optimization of wind plant systems that produce more power. DOE is partnering with government, academia, and industry to improve reliability of next generation wind turbines and wind plant systems that address complex dynamics of winds created by turbulent weather, variable terrain, and wakes.

- **Market Acceleration and Deployment** efforts will continue to address wind power market and deployment barriers, centering on activities that reduce cost of energy in environmental assessment and permitting, operations, installations, and maintenance over the full lifecycle of a wind system.