CHAPTER 23

UNITED STATES

1.0 INTRODUCTION

Total net generation of electric power in the United States was 3,953 TWh in 2004. Of that generation, 49.8% was coal-fired, 19.9% was nuclear, 18.0% was natural gas-fired, 6.5% was hydroelectric, and 3.0% was by petroleum-fired. The remaining 2.8% was generated by renewable resources such as wind, solar, biomass, and geothermal, and wind generated the majority at 0.5% (Figure 1).

The United States added 359 MW to its wind energy capacity in 2004, bringing the total national capacity to 6,740 MW. Wind industry experts predict that, with the renewal of the federal production tax credit in October 2004, the U.S. installations for 2005 will exceed 2,000 MW (Figure 2). The federal production tax credit, or PTC, provides a tax credit of 0.018 U.S. dollars (USD) per kilowatt-hour (adjusted for inflation) to the producer of electricity from wind energy.

This report describes the current status of the U.S. wind energy industry and any changes that occurred to installed capacity, advancements in research and development, new market incentives, economics, and national policies during 2004.

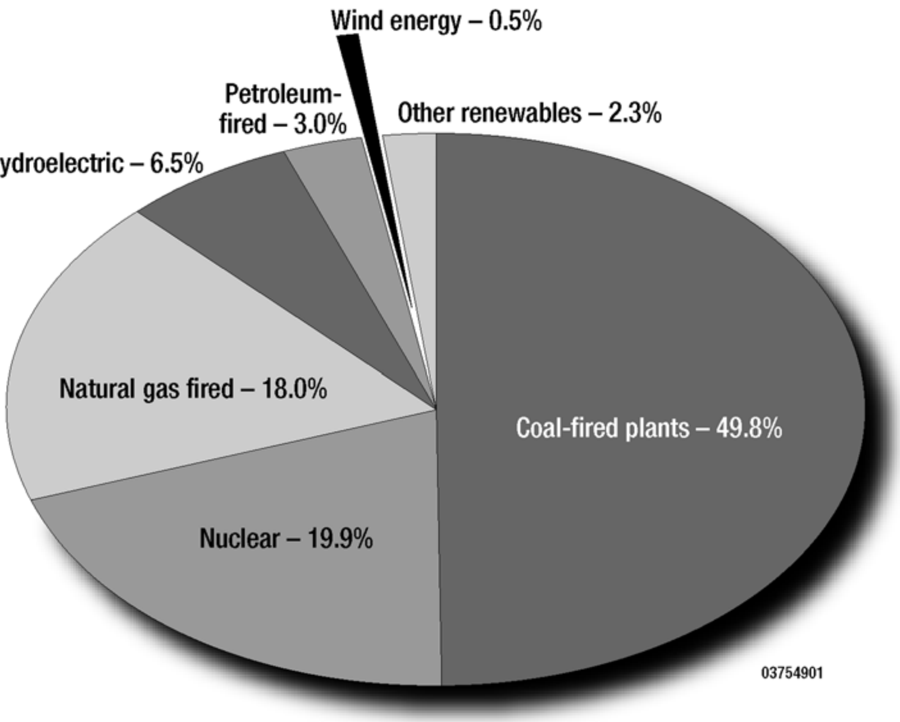

Figure 1 U.S. electricity generation by source as of November 2004.

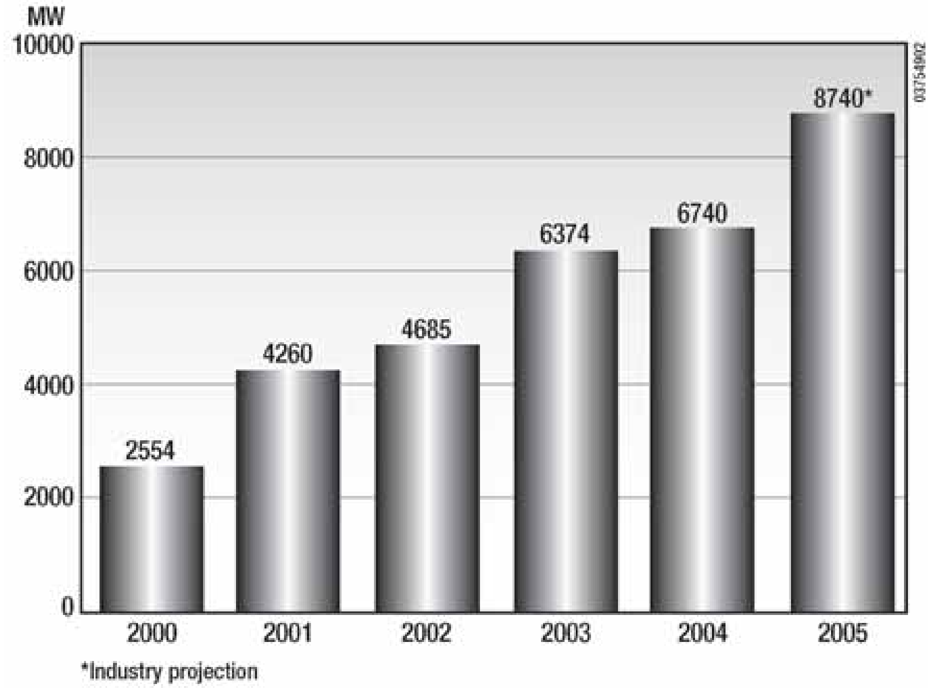

Figure 2 U.S. wind energy capacities 2000 – 2005.

2.0 NATIONAL POLICY

One objective of the U.S. National Energy Policy is to "Increase the viability and deployment of renewable energy technologies, by improving performance and reducing costs, and by facilitating market adoption of renewable technologies." The U.S. Department of Energy (DOE) leads the nation's effort to develop renewable energy technologies, and wind energy is at the forefront of this effort. The DOE Wind Program supports the national energy policy to increase the viability and deployment of renewable energy by working to improve wind energy technologies through public/private partnerships and by coordinating with stakeholders on activities that address barriers to use of wind energy. The Program's goals are as follows:

- By 2012, reduce the cost of electricity from large wind systems in Class 4 winds (average wind speeds of 5.8 m/s at 10-m height) to 0.03 USD/kWh for onshore systems and 0.05 USD/kWh for offshore systems
- By 2007, reduce the cost of electricity from distributed wind systems to between 0.10 and 0.15 USD/kWh in 2007 in Class 3 wind resources (average wind speeds of 5.3 m/s at 10-m height), the same level that is currently achievable in Class 5 winds (average wind speeds of 6.2 m/s at 10-m height)
- By 2012, complete program activities addressing electric power market rules, interconnection impacts, operating strategies, and system planning needed for wind energy to compete without disadvantage to serve the Nation's energy needs
- By 2010, facilitate the installation of at least 100 MW of wind energy in 30 states.

To achieve these goals, the Program is focusing its efforts in two areas; technology viability and deployment.

To increase technology viability, the Program is working with industry to lower the cost of energy produced by utility-scale wind systems that can be deployed in less energetic, Class 4 wind regimes (average wind speeds of 5.8 m/s at 10-m height) and to develop cost-effective, small distributed wind systems. The Program's strategy is to reduce the cost of wind energy incrementally by analyzing each component of the wind system to characterize and capitalize on technology improvement opportunities. Examples of technology improvement opportunities include: advanced control systems to improve performance and reduce loads; advanced drivetrains that incorporate rare-earth permanent magnets; advanced power electronics to allow variable-speed operation, and taller, self-erecting towers constructed on site using advanced materials.

To increase the deployment of wind energy in the emerging marketplace, the Program is working to resolve many non-technical barriers and to facilitate the installation of wind systems by providing supporting research in power systems integration, technology acceptance, systems engineering, communication, and analytical support.

By including near-term and long-term research in both viability and deployment areas, the Program provides a balance between the need to work with industry to solve pressing short-term technological issues and the need to maintain U.S. industry momentum as a technological innovator.

3.0 MARKET DEVELOPMENT AND STIMULATION

Industry experts predict that 2005 will be a record-breaking year for new wind power installations in the United States as a result of the extension of the Federal Production Tax Credit (PTC) in October 2004. The PTC, enacted in 1992 and extended through December 31, 2005, provides a 0.018 USD/kWh credit (adjusted periodically for inflation) for electricity produced from a wind farm during the first 10 years of its operation.

As part of an effort to increase development of renewable energy on Federal lands, the Bureau of Land Management released its draft Programmatic Environmental Impact Statement designed to ease the permitting of wind projects. The statement aims to speed up the environmental reviews needed to develop a wind project on Federal land.

In addition to the Federal incentives, there are several incentive programs on the state level. State programs that support utility-scale wind energy development include renewable energy purchase mandates, renewable energy funds, green power markets, tax incentives and utility resource planning. Of all the state incentives, renewable energy purchase mandates will likely have the largest impact on wind development.

Renewable Energy Purchase Mandates – Renewable energy purchase mandates include traditional set-asides directed at individual utilities in a regulated setting and renewables portfolio standards (RPS) that require all retail suppliers to serve a minimum portion of their load with eligible renewable energy. Set-asides and RPS policies are attractive in some states, because they create a strong demand for wind-generated electricity, offer incentives for wind power cost minimization through a competitive process, and can be used in regulated and restructured market settings. In 2004, five states added RPS policies, bringing the total number of states with RPS or mandates to 18. Approximately 2,000 MW of wind power has been supported by these policies to date, and far greater additions are expected in the coming years.

Renewable Energy Funds – Most often funded through system-benefits charges (a small surcharge on electricity rates), state renewable energy funds provide significant support for utility-scale wind development. Present in 15 states, these funds are expected to generate approximately 4 billion USD for the development of renewables from 1998 through 2012. Production incentives (USD/kWh supplemental financial payments) are the most common form of incentive employed by renewable energy funds in support of utility-scale wind power, although up-front grants, forgivable loans, and subordinated debt have also been used. By the end of 2004, 1,871 MW in capacity had been obligated with funds under these programs; of those projects, 568 MW have been installed by the close of 2004.

Green Power Markets – Voluntary purchases of renewable energy by end-use customers can provide a supplemental revenue stream to support the development of utility-scale wind energy facilities. In

2003, approximately 1.3 billion kWh of green power was sold to retail customers and, by the end of 2004, about 15% of the utilities offered green power to customers in 34 states. Green power programs in the United States had supported the installation of more than 1,500 MW of new wind projects.

Tax Incentives – In addition to Federal tax incentives, some states offer supplemental state tax advantages to wind projects. These efforts provide an additional, typically modest, stimulus for wind development.

Utility Resource Planning – With the Federal PTC in place, wind is often found to be one of the least-cost resources in some states. As a result, utilities are increasingly turning to wind as a cost-effective resource in their planning efforts. Twelve major utilities in the western United States, for example, are planning over 3,000 MW of wind additions by 2014 on the basis of cost effectiveness.

Many states also have policies and incentives for small wind electric systems. These incentives include net metering, investment incentives, tax incentives, and low-interest loan funds. Investment incentives and net metering are considered the most important programs.

Investment Incentives – Often administered by renewable energy funds, more than 10 states offer direct rebates or grants to small wind electric systems, sometimes covering over half of the installed cost of the systems. Not surprisingly, much of the activity by small wind installers is in those states with aggressive incentives of this type, including California and New York.

Net Metering – Net metering is an easily administered mechanism for encouraging direct customer investment in renewable energy. Under this policy, electric customers installing their own grid-connected wind turbines would be allowed to interconnect their turbines on a reverse-the-meter basis with a periodic load offset. The customer is billed only for the net electricity consumed over the entire billing period. In most states with net metering, excess generation beyond what the customer uses to offset consumption during the billing period is sold to the utility at avoided cost or granted back to the utility without payment to the customer. As of September 2004, 41 of the 52 states offered some form of net metering policy.

4.0 DEPLOYMENT

In 2004, U.S. wind energy capacity increased by 359 MW bringing the total U.S. net capacity to 6,740 MW. In all, 389 MW were installed, 30 MW were decommissioned for a total net generation of 359 MW. The rate of growth for 2004 was considerably lower than for previous years due to a delay in the extension of the Federal PTC. Although wind energy growth slowed in 2004, with the extension of the PTC in October 2004, industry experts are predicting that 2005 will be a record-breaking year for new wind energy installations.

Twenty-five new wind projects and 326 turbines were commissioned in 2004. The new capacity was constructed in 9 states: 161 MW in Iowa, 92 MW in California, 60 MW in New Mexico, 39 MW in Minnesota, 27 MW in Tennessee, 6 MW in Colorado, 4 MW in Ohio, and 1 MW in Illinois. The average size of the turbines was 1.2 MW.

The state of California still held the record for total capacity with 2,096 MW and the state of Texas was second with 1,293 MW. Iowa took third place with 632 MW and Minnesota was fourth with 615 MW (Figure 3). Nine states had over 200 MW and 12 had over 100 MW.

The annual wind energy production for 2004, assuming a capacity factor of 35%, was 19.6 TWh – an increase of 1.2 TWh over 2003. Electricity produced by wind provided about 0.5% of the national electricity supply. Industry members believe that with advancing technologies and policy development, as much as 6% of this nation's electricity requirements could be met by wind energy by 2020.

5.0 DEPLOYMENT AND CONSTRAINTS

The deployment of wind energy has increased substantially in the United States during the last

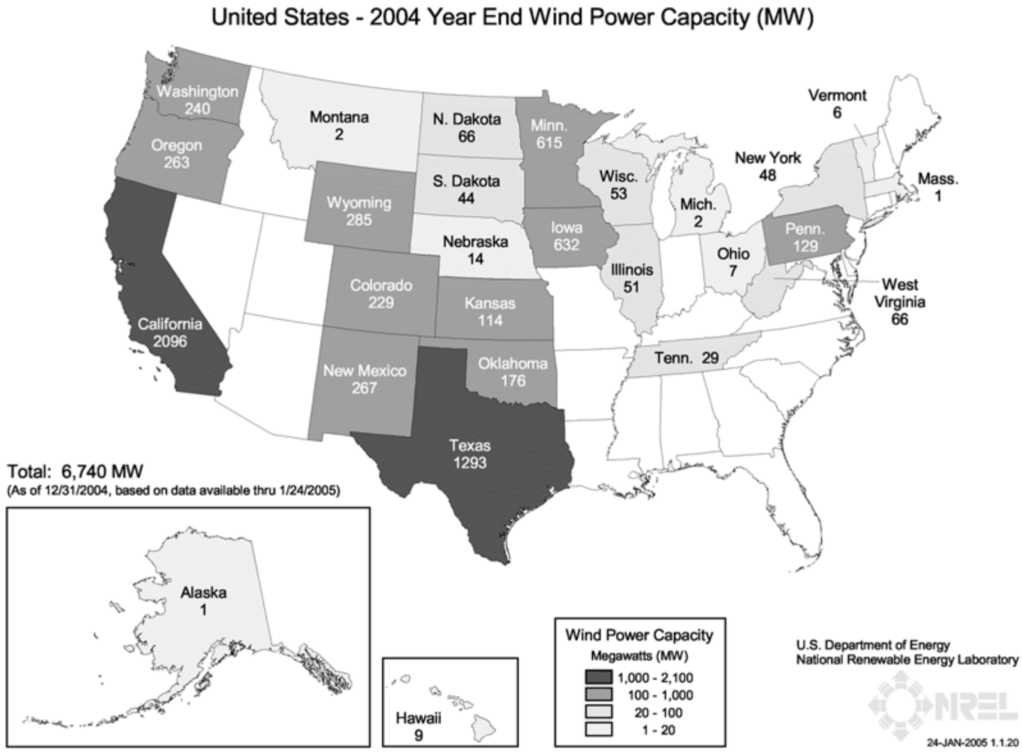

Figure 3 United States 2004 year-end wind power capacity.

decade. Nevertheless, transmission constraints, operational policies, and a lack of understanding of the impacts of wind energy on utility grids are three of the toughest barriers facing future deployment. DOE is working to remove these barriers and furthering the deployment of wind energy by working with utilities and utility groups like the American Public Power Association, the National Rural Electric Cooperative Association, power marketing authorities, the National Wind Coordinating Committee's (NWCC) Transmission Working Group, and the Utility Wind Interest Group to identify grid integration issues and analyze transmission constraints.

Lack of sufficient transmission to meet market demand for wind energy is one of the most significant barriers facing wind energy development today. In some cases, high-quality wind resources are located far from load centers. Existing transmission is controlled by owners of competing generation resources, usually utilities or government agencies. Because the existing transmission was built for current generation and load levels, very little excess transmission capacity is available to serve the development of wind resources.

Since the Energy Policy Act of 1992 was enacted, open access to transmission has been an issue before the Federal Energy Regulatory Commission (FERC). The open access tariffs that transmission providers have filed at FERC limit services available to wind, maintain high costs for transmission services, and include penalties that adversely affect wind economics and require unrealistic controls. These limits on service, high rate levels, and penalties can make the cost of transmission services prohibitive. FERC is working on a standard set of rules for interconnections between generators and the transmission system. Although interconnection agreements can consume substantial time and effort, FERC is seeking to streamline the process. In December 2004, FERC hosted a conference in Denver, Colorado, titled the State of the Wind Energy in Wholesale Electric Markets. The focus of the conference was short- and long-term measures that can be taken to ensure that wind energy technology receives nondiscriminatory treatment in electric power markers.

As the wind industry continues to grow, siting issues, including interactions with wildlife, permitting processes, aesthetics, noise, and communications interference, can also present a barrier to deployment and must be addressed. In an effort to support continued wind energy industry growth in concert with wildlife preservation, DOE is working with the U.S. Fish and Wildlife Service, American Wind Energy Association (AWEA), and Bat Conservation International to address problems associated with bats and wind turbines. A two-day workshop held in Juno, Florida, in May, drew more than 20 participants including several of the world's leading bat scientists. The workshop's objectives included discussions on state-of-the-art methods and technologies for understanding bat behaviors to prevent future interaction between wind turbines and bats. In October 2004, AWEA held a Wind Power Project Siting Workshop in Portland, Oregon, to address emerging issues and ways to build local support for wind power projects, and in November, the NWCC held a workshop to assess wind turbine/bird/bat interactions and the impacts of wind energy development on wildlife habitats and land.

To assist developers in evaluating future projects, the NWCC produced a guidebook to siting issues, *Permitting of Wind Energy Facilities: A Handbook*. The guidebook is available online at http://www.nationalwind.org/publications/siting.htm

6.0 ECONOMICS

Trends in Investment

Investment trends in 2004 changed very little from 2003. While strategic investors, like Florida Power and Light, American Electric Power, Pacific Power Marketing, and Shell remained the principal source of capital for the industry in 2004, passive institutional investors continued to show interest in wind energy investments and there is an increasing interest in community-owned wind projects.

Passive institutional investors are not interested in being active participants in the industry. They are motivated by tax benefits and overall return and are experienced in other energy tax credit regimes. They are investing in projects developed by other companies. Examples include traditional leveraged lease investors and purchasers of tax credits, regional banks, industrial finance subsidiaries, utility finance subsidiaries, and insurance companies.

Community-owned projects provide greater economic benefits to local communities because all or a significant portion of the projects are owned by community members.

In one successful community project in Minnesota, a group of farmers formed two limited liability companies as a vehicle to pursue farmer-owned commercial wind turbines. Sixty-six investors purchased all available shares. Eighty-five percent of the shares were owned by local farmers, and the remaining 15% were made available to local townspeople. The investors had enough capital to purchase four 950-kW turbines, and the farmers signed a 15-year contract with an energy holding company.

Trends in Unit Costs of Energy and Buy-Back Prices

Since 1980, the cost of electricity from wind systems without subsidies at excellent wind sites has been reduced from 0.80 USD/kWh (in year 2000 dollars) to between 0.04 and 0.06 USD/kWh (Figure 4). In the best wind areas, some project bids are running as low as 0.02 USD/kWh, including available tax credits. Although costs have decreased significantly, researchers believe that additional improvements could further reduce costs. The goal of the Wind Program is to decrease the current cost of electricity from large wind systems in lower wind speed areas

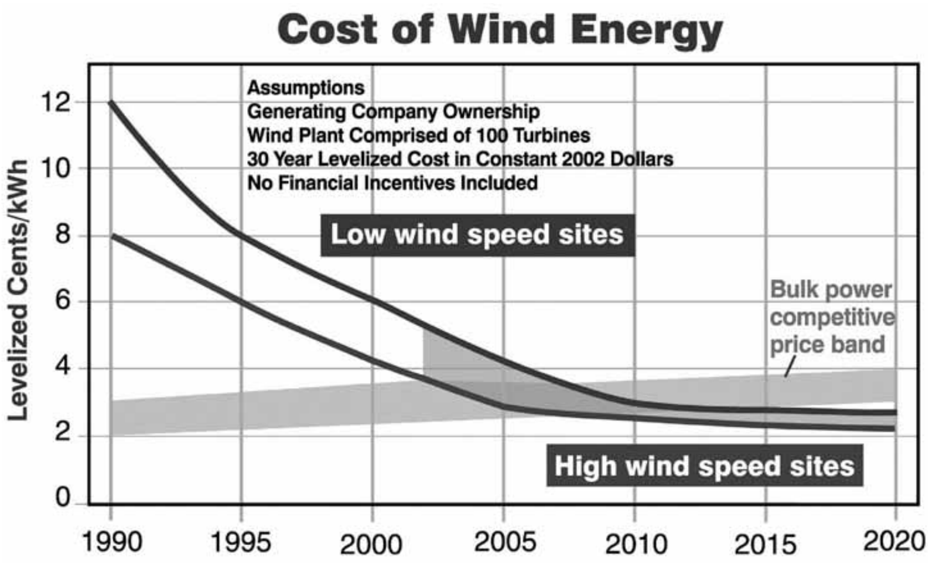

Figure 4 Cost of wind energy in the United States, 1990 to 2020.

(average wind speeds of 5.8 m/s at 10-m height) to 0.03 USD/kWh for onshore and to 0.05 USD/kWh for offshore applications by 2012. The current cost of electricity produced by small, distributed wind systems is between 0.10 and 0.15 USD/kWh in good wind resources. The program goal is to maintain that cost while increasing efficiencies so that small turbines can produce electricity cost-effectively in lower wind speed areas.

7.0 INDUSTRY

Several U.S. companies are currently manufacturing wind turbines, and numerous businesses are building components, developing projects, and providing engineering services and related equipment. Two companies are building wind turbines larger than 100 kW and several are building smaller turbines. Information about U.S. firms is available on the AWEA web site at www.awea.org.

For the last couple of years, the U.S. wind turbine market has been dominated by GE Energy's 1.5-MW machine. Of the 389 MW installed in 2004, GE Energy provided 171 MW, Mitsubishi provided 120 MW, and Vestas provided 97 MW. One installation of an Atlantic Orient turbine and remanufactured turbines account for the remaining 1 MW of installed capacity in 2004. Most wind energy project developers only completed one project in 2004, so their rankings depend on the size of their project. Clipper Wind was responsible for the largest project built in 2004, the 159-MW Intrepid Wind Energy project. Cielo Wind Power and enXco each developed a 60-MW project, in New Mexico and California respectively. Invenergy entered the wind energy development market with the installation of the 27-MW Buffalo Mountain project for Tennessee Valley Authority. FPL Energy installed a 20-MW repower project in California.

While the component manufacturers and supporting industries are too numerous to list, there were several significant developments in 2004. Second Wind, Inc. introduced satellite connectivity for its Nomad 2 wind resource data logger. Nomad 2 loggers can provide customers with convenient, cost-effective access to wind data from remote locations without connection to cellular or landline phone systems. The wind measurement system can be installed literally anywhere in the world and still be able to transmit the data from the site back to the office on a daily basis.

Global Energy Systems, a new company headquartered in Stevens Point, Wisconsin, announced plans to build and operate North America's first fully automated facility for manufacturing utility-scale wind turbine components, including towers. The company plans to produce more than 200 towers per year that range from 64 to 91 meters in height.

Spanish-based wind energy company Gamesa Corporation announced its plans to open an advanced technology manufacturing facility for wind turbine blades in Pennsylvania. The company also negotiated 400 MW of new power purchase agreements with Pennsylvania utilities for projects that it is developing in the state. As many as 1,000 jobs are expected to be created that will be directly related to Gamesa's activities over the next 5 years.

Chicago Bridge & Iron's steel-fabrication plant in Provo, Utah, announced that it would be adding 60 workers and investing more than one million USD in expanding its capacity to fill a contract for 150 80-m towers for 1.5-MW wind turbines.

Zoltek Companies, Inc. announced an agreement to supply Vestas Wind Systems of Denmark with carbon fiber and carbon fiber materials worth between 80 to 100 million USD over a period of three years for the manufacture of rotor blades for wind turbine generators. To meet the demand for carbon fibers for wind energy and other commercial applications, Zoltek is planning to expand its facilities in Abilene, Texas, and in Hungary.

8.0 GOVERNMENT-SPONSORED R,D&D

The bulk of U.S. wind energy research and development is conducted by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. The total funding dedicated to wind energy research in fiscal year 2004 was 39.8 million USD. The Wind Program focuses its research in two areas: technology viability and deployment.

Under technology viability, researchers work with industry to increase efficiencies and reduce the cost of energy for both utility-scale and small, distributed wind systems for low wind speed regions. Industry partnerships are formed through the award of cost-shared technology development subcontracts. These subcontracts concentrate on three technical areas: (1) concept design studies, (2) component development and testing, and (3) full turbine prototype development and testing. The funding provided by the program enables industry to develop high-risk, advanced wind technology that they would not be able to fund on their own and explore the effects of increased turbine size on performance and cost.

Under technology deployment, researchers are assisting industry partners with a number of projects to increase utilities' understanding of grid-integration issues and to help them gain confidence in the reliability of new wind turbine products. Information from the projects is distributed through a national outreach effort to investor-owned utilities, electric cooperatives, public power organizations, and energy regulators to encourage the inclusion of wind power in generation portfolios and ensure the continued growth of the wind energy industry.

Technology Viability

TURBINE PROTOTYPE RD&D

In 2004, DOE researchers continued to work with two companies to increase the viability of utility-scale technologies through turbine prototype development and testing; GE Wind Energy and Clipper Windpower.

Clipper Windpower completed the fabrication of most of the components for its 2.5-MW Liberty prototype turbine. The prototype incorporates a distributed drivetrain, advanced blades with truncated root section airfoils, and advanced controls. The National Renewable Energy Laboratory (NREL) completed dynamometer testing on the new drivetrain and the company will begin construction on a site for its new turbine in Wyoming in 2005. Clipper plans to begin field tests on the prototype in 2005, including a full suite of certification tests. A Clipper 45-m blade for this turbine will also undergo fatigue testing at the National Wind Technology Center (NWTC).

GE Wind Energy completed a design conceptualization for a 3- to 5-MW prototype turbine that includes advanced controls and diagnostic systems, an innovative drivetrain, blades that incorporate advanced materials and load alleviation, and a taller tower.

DOE also worked with several companies to develop more efficient distributed wind prototypes. Bergey Windpower has developed a 50-kW turbine, Northern Power Systems is developing a 100-kW turbine, and Southwest Windpower completed the design and fabrication of a 1.8-kW prototype.

Northern Power Systems began work on redesigning its 100-kW cold weather turbine for agricultural applications. The company's goal is to reduce the cost of energy from its new design from 0.12 USD/kWh to 0.08 USD/kWh at low wind speed sites by increasing energy capture, reducing initial capital costs, increasing reliability, and lowering maintenance costs. The design will incorporate a larger 20-m rotor, a direct-drive, variable-speed drivetrain, and its controller and power converter will be located in its nacelle.

Figure 5 The Southwest Windpower Storm prototype turbine was installed at NREL in December 2004 for field-testing.

Southwest Windpower completed the fabrication of its 1.8-kW Storm prototype turbine in 2004 (Figure 5). The goals for this project included reducing the cost of energy to 0.10 USD/kWh at sites with 5.4 m/s average annual wind speeds, and reducing the installation cost to 3,500 USD. Initial findings indicate that the project will meet or exceed its goals. The new system was installed at NREL in December 2004 and will be tested to IEC standards for acoustics, power, duration, and safety in 2005.

Abundant Renewable Energy and Wetzel Engineering are both working on preliminary design concepts for small wind turbine systems. Abundant's goal is to develop a design for a 10-kW turbine that will produce 100 kWh per day on average for 0.11 USD/kWh at a site with moderate wind resources. The company completed its conceptual design in June 2004 and expects to have its preliminary design ready for review by April 2005. The goal of the Wetzel Engineering project is to design a 6-kW turbine that can produce electricity for 0.08 USD/kWh at a Class 3 wind site (average wind speeds of 5.8 m/s at 10-m height). The company is working to have its preliminary design ready for review by March 2005.

ADVANCED COMPONENT DEVELOPMENTS

To increase technical viability, DOE also worked with several companies in 2004 to develop more efficient, advanced components for both utility-scale and distributed wind systems. These include new lighter weight, high-efficiency drivetrains, power converters, and rotors.

Three of the companies working under the Wind Program are developing new lower cost utility-scale drivetrains that have either completed or will undergo testing at NREL's dynamometer test facility. NREL's 2.5-MW dynamometer conducts specialized tests such as gear tooth contact pattern tests, system endurance/fatigue tests, component efficiency tests, generator/power system characterization, advanced lubrication and wear studies, load mitigation testing, wind turbine control simulations, and transient operation. Dynamometer testing services are provided

Figure 6 Robert Thresher, director of the National Wind Technology Center at NREL, and the Clipper Windpower 2.5-MW drivetrain at the facility's dynamometer test stand.

at the request of industry partners and are an integral part of the Program's low wind speed development activities.

NREL completed the testing on a 1.5-MW, eight-generator, variable-speed drivetrain for Clipper Windpower. Clipper's goal is to produce a drivetrain that is 30% lighter weight and potentially more efficient than conventional drivetrains. (Figure 6)

One of the systems to be tested at NREL in 2005 was constructed by Northern Power Systems. The company completed the design, fabrication, and factory testing of a new 1.5-MW direct-drive permanent-magnet generator with a novel power converter to allow variable-speed operation in 2004. The goal of this drivetrain project is a 2% reduction in the cost of energy. Another system to be tested at NREL, constructed by Global Energy Concepts (GEC), is a 1.5-MW, single-stage drive, permanent-magnet drivetrain. The goal of this project is to reduce the cost of production by 12.8%. GEC completed the design, fabrication, and testing of its drivetrain in 2004.

Wind Program researchers are also conducting research that will lead to improved energy capture by wind turbine blades and to lower the cost of blade manufacturing. In 2004, DOE worked with GE Wind to produce a glass-carbon hybrid demonstration blade that will be tested at NREL's upgraded blade test facility in 2005. The 34-m blade is constructed of advanced, lighter weight glass/carbon hybrid materials. Researchers at the DOE Sandia National Laboratories have been working in cooperation with U.S. universities for several years to develop the hybrid lighter-weight materials, aeroelastic designs, and innovative manufacturing processes needed to produce the longer stiffer blades for the larger wind turbines.

While Sandia is developing the materials needed to manufacture the longer blades, NREL is developing ways to test them. In 2004, NREL tested the longest blade in the facility's history for TPI Composites. The 45-m blade (Figure 7) was 13 feet longer than the facility was designed to handle. To meet the needs of the longer blades, NREL plans to build a 50-m blade test stand in 2005.

The Wind Program is also working with several companies to develop more efficient components for small wind systems. GEC is working on a concept study to develop a blade flap coupling software tool to control loads. Another company, TIAX, LLC, is working on a concept for an axial-flow, permanent-magnet alternator, and Alaska Applied Sciences is designing a 14-m blade to replace worn blades on some of the older turbines on wind farms in California. Another firm, Windward Engineering, is designing a unique over-speed control system. Although most small wind systems manufactured today have passive controls that allow the turbines to shut themselves down in adverse conditions, the systems do not provide consumers with manual stopping capabilities. Windward's active control system will allow the owner/operator to shut the system down under all conditions. The company also plans to build a wind turbine on which to test the new control system in 2005.

Technology Deployment

In an effort to increase deployment, DOE researchers are working with project operators, utilities, and rural electric cooperatives to collect high-speed power data from a number of operating wind power plants with a total capacity of almost 950 MW. The power measurements are needed to characterize the actual performance of wind farms, evaluate the interconnection and grid operational impacts of existing and proposed wind farms, and develop and validate wind generator and wind farm electrical models used for interconnection studies. In May, a Wind Integration and Interconnection Workshop provided detailed information on analysis methods used in operating impact studies, capacity credit valuations, interconnection issues, and worldwide grid code efforts to more than 160 participants.

DOE is also collaborating with five states to measure wind resources at levels above normal measurements (50 meters above ground level) under its Tall Towers Research Project. Researchers will collect taller tower data to validate meso-scale weather modeling and examine interaction of the "nocturnal jet" and high-hub wind turbines.

Figure 7 NREL receives a 45-m blade sent by TPI Composites for testing.

DOE's Wind Powering America (WPA) activity continues to promote the use of wind energy technologies, increase rural economic development, protect the environment, and enhance the nation's energy security. WPA provides technical support and educational outreach materials about utility-scale development and small wind electric systems to utilities, rural cooperatives, federal property managers, rural landowners, Native Americans, and the general public throughout the country.

New RD&D Efforts

While the wind industry has experienced constant annual growth during the past decade, to achieve program and industry goals and enable the technology to achieve its full potential, researchers at NREL are exploring innovative applications. These innovations include exploring development offshore in deep water, the use of wind power to clean and move water, and development of new technologies that will enable wind energy to work in synergy with other energy technologies such as hydropower and hydrogen.

OFFSHORE DEVELOPMENT

Higher quality wind resources (reduced turbulence and increased wind speed), proximity to loads (many demand centers are near the coast), increased transmission options, potential for reducing land use and aesthetic concerns, and ease of transportation and installation are a few of the advantages drawing attention to offshore wind energy development. In the U.S. onshore markets, where electric transmission capacity is limited, the development of offshore wind would reduce the burden of supplying electricity to coastal cities from the inland transmission system.

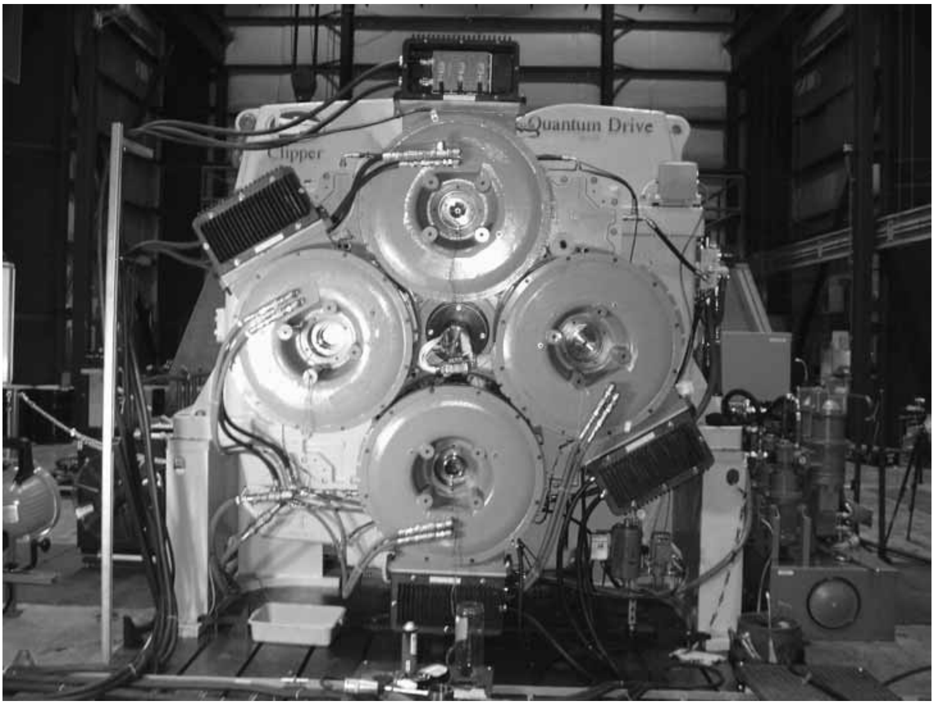

Figure 8 Clipper Windpower's new 2.5-MW turbine incorporates an innovative distributed drivetrain.

Although the United States currently has no offshore wind installations, interest is increasing and there are several proposed applications for offshore projects along the East Coast. One project proposal for a wind farm off the coast of Massachusetts released its environmental impact statement in November 2004 and is currently receiving public comments.

To develop offshore wind resources, especially in deep water areas, U.S. researchers are turning their attention to developing technologies such as the use of floating platforms cabled to the ocean floor as well as technologies that will overcome the challenges facing offshore development (Figure 9). These challenges include: higher investment and development costs, severe environmental conditions, more complicated offshore construction, and higher maintenance costs.

As part of an effort to address the challenges, in March 2004, the IEA Executive Committee approved a proposal for an offshore wind energy annex. The purpose of Annex XXIII – Offshore Wind Energy Technology Development is to provide its participants with an overview of the technical and environmental challenges encountered in offshore applications and to help them understand the need for additional research. The Annex was divided into two subtasks; Subtask 1: Offshore Wind – Experience with Critical Deployment Issues, and Subtask 2: Offshore Wind – Technical Research. Subtask 1, to be led by Risø National Laboratory in Denmark, will address critical deployment issues for developments closer to shore. Subtask 2, to be led by NREL in the United States, will address the research needs for deepwater development.

The Offshore Wind Energy Technology Development annex held its first meeting in October 2004 in Washington, D.C. Meeting participants included the United States, the United Kingdom, Japan, and Norway and the collaborative research topic discussed was Coupled Turbine/Substructure Dynamic Modeling.

WIND AND HYDROPOWER

The United States is also conducting research into the potential benefits of combining wind and hydropower to provide a stable supply of electricity to the grid. As part of that effort, the U.S. participated in the formation of the IEA RD&D Wind Annex XXIV - Integration of Wind and Hydropower Systems. The two purposes of this annex are to conduct cooperative research concerning the generation, transmission, and economics of integrating wind and hydropower systems and to provide a forum for information exchange. The first meeting of this annex will take place in Nevada in February 2005.

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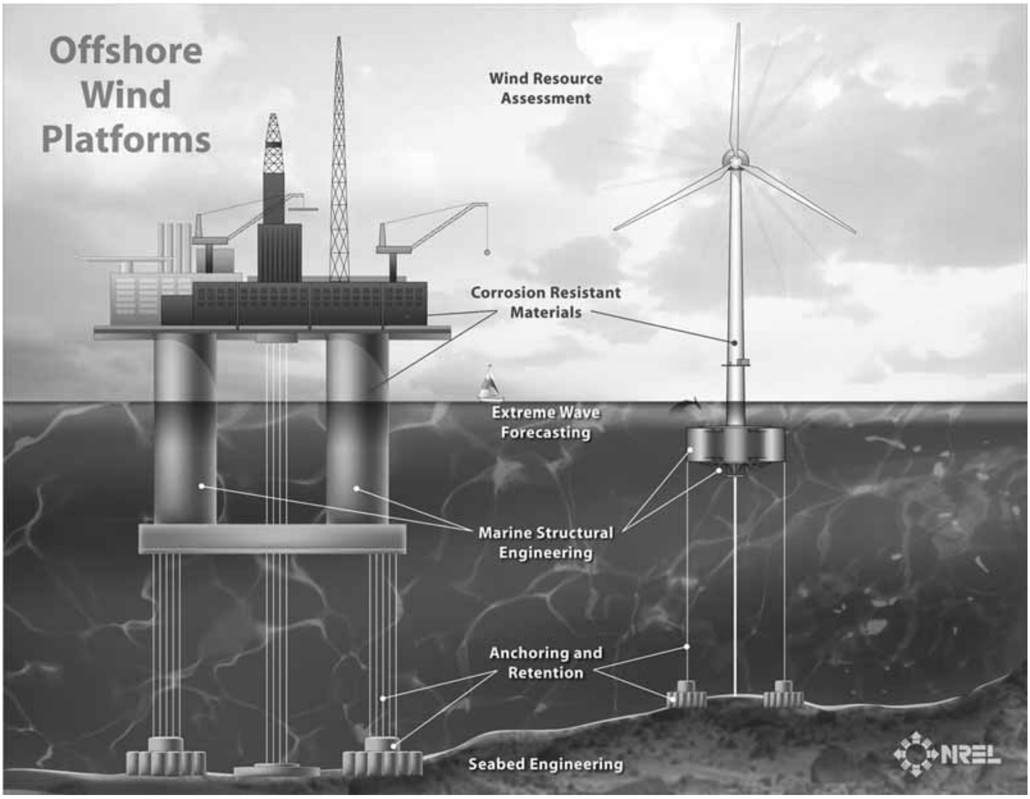

Figure 9 Researchers at NREL are turning their attention to developing technologies such as the use of floating platforms.