Chapter 6. Wind Power Markets

Wind power suppliers and consumers span a broad range. Currently, wind power serves primarily large-scale utility markets, and smaller scale community-based projects are playing an increasing role in some regions. In addition, the eastern and Gulf Coast states are considering offshore proposals.

If 20% wind energy by 2030 were to be reached, supply and demand markets would need to expand to deliver wind energy to end-use customers throughout the United States. This chapter presents a brief overview of U.S. electricity markets, major wind power supply chain segments, market drivers, and their potential impacts on U.S. wind power expansion.

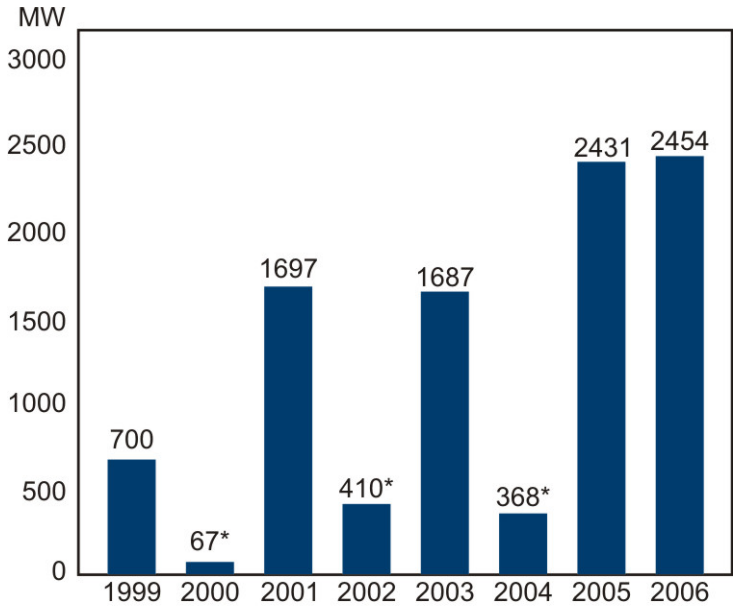
6.1 U.S. Market Evolution Background

The U.S. Department of Energy (DOE) projects U.S. electricity demand to increase by 39% from 2005 to 2030 (EIA 2007). Taking into account projected plant retirements and the implementation of energy efficiency and demand reduction programs, meeting this increased demand could require new electricity generation to increase by more than 50% over that period. Wind power is a viable option for meeting a substantial portion of this growing demand for electricity.

During the past seven years, the total number of wind installations worldwide has grown at an average annual rate of 27%. Recent growth of the wind power market in the United States has been driven by a dramatic reduction in the cost of wind energy, public interest in renewable energy, state renewable energy standards, federal production tax credits (PTCs), and volatile natural gas prices. Historically, however, periodic expiration and subsequent extensions of federal PTCs have resulted in intervals of no growth followed by explosive growth, as shown in Figure 6-1.

The U.S. wind power industry has experienced two major transformations in its history. In 1940, more than 100,000 wind turbines—many of them Jacobs Windmasters—were in operation across the Midwest, producing electricity for isolated farms and ranches. Their use declined, however, as electrification connected rural U.S. regions to electricity grids in the 1940s and 1950s. The oil price shocks of the 1970s stimulated new interest in renewable energy and led to the establishment of the Public Utility Regulatory Policies Act (PURPA) of 1978. By requiring utility companies to buy electricity from independent power producers (including wind companies), PURPA provided the foundation for the emergence of a second wind energy market in a few states in the 1980s. A key catalyst for wind's further development was California's investment tax credit and supportive state policies that jump started the bulk power wind industry in the early 1980s. The addition of federal tax credits also contributed to industry expansion. Several firms pioneered

Figure 6-1. U.S. wind energy capacity growth (shown in megawatts [MW]) slowed during years when the PTC expired



*Years without Federal production tax credit (2000, 2002, 2004)

modern wind turbine technology during this period, and by 1990 more than 6,000 turbines were operating in the state.

The significantly broader and larger wind electricity supply today originated in the late 1990s. This most recent expansion resulted from a technical revolution that is influencing electricity markets in dozens of countries around the globe. Public and private research and technological innovation have rapidly improved wind resource assessment and siting, wind turbine aerodynamics and component design, and power electronics. Turbine sizes have increased steadily, leading to improvements in wind generation economics. Wind plant reliability has also improved—today, manufacturers routinely guarantee the availability of their turbines at 97% or higher. Although the wind resource is variable, wind turbines are highly reliable and operate whenever winds are sufficient to generate electricity. The current U.S. wind energy market is robust and expanding at unexpected rates.

6.2 U.S. Electricity Market

Electricity in the United States is supplied mainly by the more than 3,000 utilities across the country, some of which are owned by shareholders, others by the customers they serve. State public utility commissions and the Federal Energy Regulatory Commission (FERC) oversee these utilities and specific electricity markets. Utilities and commissions work within a regulatory framework based on federal and state legislation and jurisdiction-specific regulations that vary throughout the country. As a result of these regulatory differences, the roles of utilities and commissions also differ, creating a variety of market structures at the local and regional levels. To bring wind energy to customers nationwide, wind project developers must accommodate these local and regional market features.

6.2.1 Electric Utilities

Approximately 200 investor-owned utilities (IOUs), 70 large municipal and federal or state systems, and 50 rural generation and transmission cooperatives supply power for more than 3,000 local distribution companies across the country. The largest of these utilities typically own power plants and generate much of the power they supply. They purchase the rest of the electricity needed to serve their customers from other utilities or from nonutility generators through power purchase agreements (PPAs).

Utilities serve a variety of customers with differing needs and priorities, both retail and wholesale. Retail customers are divided into three categories: residential, commercial, and industrial. Residential customers use energy in a single dwelling for personal service. Commercial customers often have multiple dwellings, offices, or business enterprises located in a multifunction building. Industrial customers are typically large manufacturing or assembly plants that have hundreds of workers and multiple electricity applications. Special forms of commercial and industrial customers include the federal, state, and local public sectors.

Retail electricity service to end-use customers is regulated by state commissions in many states and jurisdictions. Some states have implemented restructuring or deregulation of their electricity markets, increasing competition among electricity providers and retailers. In states where competitive entities are vying to supply electric generation and to serve retail customers, wind developers have the opportunity to build projects and deliver energy directly to customers. In states that have not restructured, wind developers can sell into wholesale markets or sell to the incumbent utilities under a PPA. Some utilities are pursuing options for owning and operating their own wind projects.

At the national level, FERC policies have been implemented to foster competitive wholesale electricity markets and spur innovation and efficiency improvements. FERC continues to review and modify, as appropriate, its policies concerning competition in wholesale power markets. FERC policies cover transmission lines, treated as a common carrier, meaning that it requires transmission providers to allow nondiscriminatory access to their wires. The large wholesale markets enable a more effective exchange of services and compensation for all electricity generators, including wind power generators, helping them compete for larger shares of generation markets.

To regulate their utilities, roughly half of states in the country have integrated resource planning (IRP) policies in place. An IRP policy requires utilities to evaluate opportunities to serve loads through energy efficiency and demand reduction programs on the same basis they use to plan new generation. In addition, utilities must compare supply alternatives—including fossil and non-fossil resources—on a risk-adjusted basis. Some decisions made under the IRP process consider local customer preference, which can influence decisions made by commissions in selecting generation options. As a result, the IRP process has been an important factor in establishing wind power markets.

6.2.2 Federal Agencies

In aggregate, the federal government is the largest single consumer of electricity in the world. Federal agency electricity consumption in 2005 was more than 55,000

gigawatt-hours (GWh), which would equate to approximately 18 gigawatts (GW) of wind capacity at a 35% capacity factor.
Federal agencies were encouraged to meet an executive order goal of 2.5% of site electricity from new renewable energy sources by the end of 2005. Agencies exceeded the goal with a final tally of about 3,800 GWh (6.9%) of electricity consumed coming from renewable sources (DOE 2006). There was a dramatic increase in 2004 and 2005, largely because of renewable energy certificate (REC) purchases by the Air Force, the General Services Administration, and the Environmental Protection Agency (EPA). Overall, 96% of federal renewable energy—outside the Department of Defense—was purchased with RECs.

The Energy Policy Act (EPAct) of 2005 also guides federal agency energy use. It requires the agencies to incorporate renewable energy into their electricity supply mix at an escalating rate beginning at 3.0% in 2007 and increasing up to 7.5% by 2013, to the extent economically feasible and technically practicable. Wind energy could play a significant role in meeting this goal, particularly through projects sited on federal lands, and both EPAct 2005 and the executive order goal will help advance wind power use across federal facilities.

6.2.3 Power Marketing Administrations

Starting in the 1930s, the federal government created Power Marketing Administrations (PMAs) to market electricity generated by government-owned hydropower projects. The PMAs include the Bonneville Power Administration (BPA), the Western Area Power Administration (Western), the Southwestern Power Administration (SWPA), and the Southeastern Power Administration (SEPA). Though not technically a PMA, the Tennessee Valley Authority (TVA) has a similar purpose. Each of these entities operates as a utility, supplies power to other utilities, and often owns extensive transmission networks that are important to generators, including the wind industry. Western and BPA, in particular, have extensive transmission grids in regions with significant wind potential. Generally, the PMAs and the TVA are mandated by Congress to set rates at the lowest possible levels consistent with sound business principles. The PMAs provide access to available transmission capacity on their systems under FERC-approved transmission tariffs.

6.2.4 Compliance, Voluntary, and Emissions Markets

Under a scenario of significant wind energy expansion, multiple revenue streams and diverse markets for wind generation output will be increasingly important. Compliance and voluntary markets, which have the potential to create separate and complementary revenue streams for supporting wind energy generation, can reduce risks. Emerging emissions reduction markets might also provide revenue streams.

Policy-Driven Markets

Compliance markets, or markets where there are standards for renewable energy contributions, play an important role in supporting the development of wind energy resources. Today, 25 states plus the District of Columbia have established renewable portfolio standards (RPS) requirements, which proscribe the amount of renewable energy that must be produced within the state. These compliance markets have been growing rapidly in recent years and hold the potential to substantially expand wind energy capacity. Current state RPS policies call for about 55 GW of new renewable energy capacity by 2020, and a number of states are considering increasing their targets.

Voluntary or Green Power Markets

Voluntary markets for renewable energy also play a key role in supporting new wind energy development. Today, more than 500,000 electricity customers across the nation are purchasing green power products through regulated utility companies, from green power marketers in a competitive market setting, or in the form of RECs.

These voluntary purchasers support about 2 GW of new renewable energy capacity, mostly wind. Sales have recently grown at annual rates exceeding 60%. Large nonresidential customers—including businesses; universities; and federal, state, and local governments—are driving much of the growth, and this trend is likely to continue.

Voluntary REC markets can also be important because they might be able to support wind energy projects in regions that have good wind regimes but no compliance markets (e.g., RPS). Because RECs are sold separately from commodity electricity, they can be used to support wind energy facilities in regions with the best resources. Some factors do limit the effectiveness of RECs, though, including the lack of a national REC tracking system, the lack of a national REC trading system, and the difficulty of using RECs in project financing.

Air Quality Markets

Throughout the past several decades, approaches for controlling pollution from fossil-based power generators have moved from traditional command and control strategies to market-oriented trading regimes that allow the most cost-effective emission reduction techniques to be applied first. Sulfur dioxide (SO_2) emissions were the first to be controlled with cap and trade programs, and now nitrogen oxides (NO_x) and mercury (Hg) programs have been added. Others, such as carbon dioxide (CO_2) programs, are currently under serious consideration. Markets must have accurate price information to operate efficiently, and these programs help to incorporate the external costs of pollutants from carbon-based fuels into power prices.

6.3 Wind Power Applications

There are four basic wind applications:

- Utility-scale wind power plants, both land-based and offshore
- Community-owned projects, which often produce power for local consumption and sell bulk power under contracts
- Institutional and business applications

- Off-grid home installations and behind-the-meter farm/ranch/home systems.

The size and number of turbines vary in each of these applications. Utility-scale wind power plants typically use turbines larger than 1,000 kW to produce large amounts of wholesale power, accounting for more than 90% of all wind power generated in the United States. A 1,000 kW turbine can supply electricity for about 300 homes. Off-grid and behind-the-meter projects usually employ turbines smaller than 100 kilowatts (kW).

Wind projects range from less than 400 watts (W) to more than 400 megawatts (MW), with much larger projects expected in the future. The utility-scale technology that started in California in the early 1980s revolved around 50- to 100 kW machines, while the standard size of today's more efficient and reliable turbines ranges from 1,500 kW to 2,500 kW.

6.3.1 Large-Scale Wind Power Plants

Wind power plants consist of a number of individual wind turbines that are generally operated through a common control center. The number can range from a few, to dozens, to hundreds of energy-producing turbines.

Wind projects that are 2,000 megawatts or larger have been proposed. Such large-scale wind projects will bring about new challenges and benefits, requiring (and large enough to justify) dedicated large-scale transmission infrastructure to carry power long distances on land or shorter distances offshore to urban demand centers.

Accelerated growth of wind power in the United States would almost certainly require developing a number of very large-scale projects, considering:

- **Siting constraints on traditional projects:** Installing large numbers of turbines in remote regions minimizes landowner objections to dense turbine siting in populated areas.
- **Geographic distribution of the wind resource:** Most high-quality land-based wind resources in the nation are in mountain and plains states. The 20% Wind Scenario would require significant amounts of these resources to be captured.
- **Development pace and scale of development:** A few very large projects can add as much wind generation capacity as hundreds of traditional 100 MW projects and can be developed and built much more quickly.
- **Restrictions on land-based deployment:** Some energy-constrained coastal areas will depend on offshore wind resources that will require large-scale project development to reduce overall infrastructure costs.

6.3.2 Offshore Wind

Coastal areas, especially in California and the northeastern United States, pay higher than average prices for electricity, so offshore wind developers have an added incentive—in the form of high market prices—to enter these markets. There are uncertainties with permitting requirements in federal waters. However, the Minerals Management Service (MMS) is in the process of developing proposed rules, along with a programmatic environmental impacts statement. The MMS program is

expected to be in place toward the end of 2008. Still, technical, market and policy uncertainties are limiting the deployment of offshore wind turbines alone (see chapters 3 and 5 for more discussion of offshore wind).

In addition, the cost of offshore wind projects is higher than land-based turbines by about 40%, according to a study conducted by Black & Veatch, an engineering company based in Overland, Kansas (Black & Veatch, 2007). This higher cost can be attributed to the added complexity of siting wind turbines in a marine (and potentially harsher) environment, higher foundation and infrastructure costs, and higher operations and maintenance (O&M) costs because of accessibility issues and O&M associated with offshore locations and the marine environment.

In the next 10 years, the U.S. offshore wind market could play a more significant role in bringing new power generation online in selected regions of the country where electricity prices are higher than average, population density restricts power plant installations, shallow water sites are available, state governments have passed aggressive RPS requirements, and coastal communities support this energy option.

6.3.3 Community Wind

Community stakeholders have started to evaluate wind development as a way to diversify and revitalize rural economies. Schools, universities, farmers, Native American tribes, small businesses, rural electric cooperatives, municipal utilities, and religious centers have installed their own wind projects. Although community wind projects can be of any size, they are usually commercial in scale, with capacities greater than 500 kW, and are connected on either side of the meter. Community wind includes both on-site wind turbines used to offset customer's loads and wholesale wind generation sold to a third party.

Community wind is likely to advance wind power market growth because it has the following advantages:

- **Strengthens communities:** Locally-owned and -controlled wind development substantially broadens local tax bases and generates new income for farmers, landowners, and entire communities.
- **Galvanizes support:** Local ownership and increased local impacts broaden support for wind energy, engage rural and economic development interests, and build a larger constituency with a direct stake in the industry's success. Local investments and local impacts produce local advocates.

6.3.4 Small Wind

Small wind (sometimes called "distributed wind energy") refers to wind turbines that are generally smaller than 100 kW. Residences or businesses can install small wind turbines on-site to meet their local electricity demands, often selling excess electricity sold back to the grid on distribution lines. On-grid behind-the-meter applications, where turbines are connected to distribution lines and supply electricity to partially meet local loads, comprise the primary market for small wind. On-grid installations are currently supported by a variety of state and utility financial incentives, which reduce up-front capital costs to the consumer. Small wind can also include small units for off-grid applications, such as remote homes and livestock watering facilities as well as wind–diesel hybrid systems that are deployed in remote village settings, such as, Alaska.

Small wind has lower wind speed requirements, so more locations can accommodate and harvest wind. The U.S. small wind manufacturing industry dominates today's world markets, and deploying distributed wind energy in rural or remote parts of the United States can help to build acceptance of future wind power plants. As markets continue to expand and manufacturers increase their volume, the result will be lower cost turbines. An additional benefit, although small wind systems have higher per-kilowatt costs than utility-scale systems, they compete with retail instead of wholesale electricity rates, which are also higher.

Community Wind in Minnesota

Minnesota took major steps to encourage the development of renewables by requiring the state's largest utility, Xcel Energy, to acquire a growing amount of wind energy. The target was 425 MW in 1994, 825 MW by 1999, and 1,125 MW by 2003. This created a reliable wind energy market in the state which, in turn, helped wind energy find its way into many areas of Minnesota's economy, including construction, O&M, and engineering. It also forged the path for development of permitting rules that other states and counties use as models for writing their own regulations.

Community wind began in the United States in Minnesota in 1997, when local advocates worked with the legislature to create the Minnesota Renewable Energy Production Incentive (REPI). Local ownership was a priority for those who created this incentive, which paid $0.01 to $0.015/kWh for the first 10 years of production for projects smaller than 2 MW. In the beginning, local wind developers had to individually negotiate with utilities for interconnection and PPAs. It was not until a special community wind tariff—establishing a set power purchase rate of $0.033/kWh and standard procedures for interconnection for wind projects below 2 MW—was created in 2001 as part of Xcel Energy's merger settlement, that community wind projects really became feasible. The initial Minnesota REPI allocation was then quickly subscribed, and a second round was fully subscribed within 6 months. Pairing of these complementary policies allowed the community wind market to really take off.

Small wind energy market challenges include turbine availability (product gaps exist for 5-, 15-, and greater than 100 kW turbines); economics and lack of financial incentives across all market segments; turbine reliability; utility interconnections; and zoning and permitting.

6.3.5 Native American Wind Projects

Native American reservations constitute a special community with emerging interests in wind power development. Wind-generating potential on tribal lands, which is conservatively estimated at more than 1.5 GW, could make an important contribution toward the 20% Wind Scenario. At least 39 Native American reservations with significant wind power potential (Class 4 and higher) are located in remote areas that could support development. Self-governed Native American tribes also have a unique legal relationship with the U.S. federal government and are afforded increased opportunities under EPAct 2005.

6.4 Stakeholder Involvement and Public Engagement

As wind energy development proceeds in the United States, site selection and development will require well-designed and effective stakeholder engagement. The preceding sections outlined the markets and supply segments that can contribute to the 20% Wind Scenario. The types of stakeholders and their perceptions of wind energy are likely to vary markedly from one location to another. An important part of any stakeholder initiative is to identify the full range of interested parties and decision makers, such as public utility commissions and their staffers, utilities and regional transportation organizations and their customers, state and federal legislators, and financiers. Understanding

stakeholder interests and how to effectively communicate with these various groups is central to the pursuit of 20% wind energy by 2030.

Experience with past wind and other energy facility development in the United States has brought home the critical importance of stakeholder involvement. The energy community now generally recognizes that effectively engaging stakeholders in siting-related decisions requires attention to a number of key factors:

- State and local siting guidelines and procedures are needed to establish a known and deliberate siting process in which local concerns and siting issues are fully considered. Developers must also be able to plan for and manage a predetermined and predictable process.
- The developer, state and local officials, and the host communities should collaborate on designing stakeholder outreach
- A comprehensive list of stakeholders—including those who will be targeted in the engagement efforts—should be compiled early in the process.
- Concerns and requirements of various stakeholders should be assessed. Needs should be identified and defined through interviews with stakeholders.
- The stakeholder-engagement process should begin before the site is assessed and selected so that baseline information can be established. Stakeholders should continue to be actively engaged throughout facility development and operation, with an emphasis on two-way communications.
- A neutral third party should carefully evaluate effectiveness of the engagement process along the way, to ensure that any initiatives incorporate new stakeholders that might appear and new concerns that might arise. This will also allow deficiencies in engagement and communications to be forthrightly addressed.

Finally, no element in an engagement and communications effort is more important than building trust among the developers, state and local officials, and members of the host community. Although this is a much more difficult task than is generally understood, experience has shown that openness, serious consideration of local concerns, and a participatory process all contribute substantially to successful outcomes.

6.5 CONCLUSIONS

Within the 20% Wind Scenario, multiple revenue streams and multiple markets for wind generation output would be increasingly important. Standards for renewable energy contributions as well as voluntary markets have the potential to create separate and complementary revenue streams for supporting wind energy generation while reducing risks. Today, 25 states have established RPS requirements. Compliance markets, which have been growing rapidly in recent years, can make substantial contributions to the expansion of wind energy capacity. Emerging emissions markets can also be a source of revenue streams.

To create the catalyst necessary to support aggressive wind energy growth, many different market drivers must converge; and if the significant increase in wind power development under the 20% Wind Scenario is to be realized, many stakeholders will need to embrace a robust wind future. Stakeholder interests are as diverse as stakeholder types; a long-term commitment to understanding and working with stakeholders will be critical for deploying significant levels of wind power. All segments of the market must be taken into account when planning for the wide adoption of wind-generated electricity. Market forces need to be targeted and utilized efficiently to leverage stakeholder interests if 20% of U.S. electricity from wind is to be realized.

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