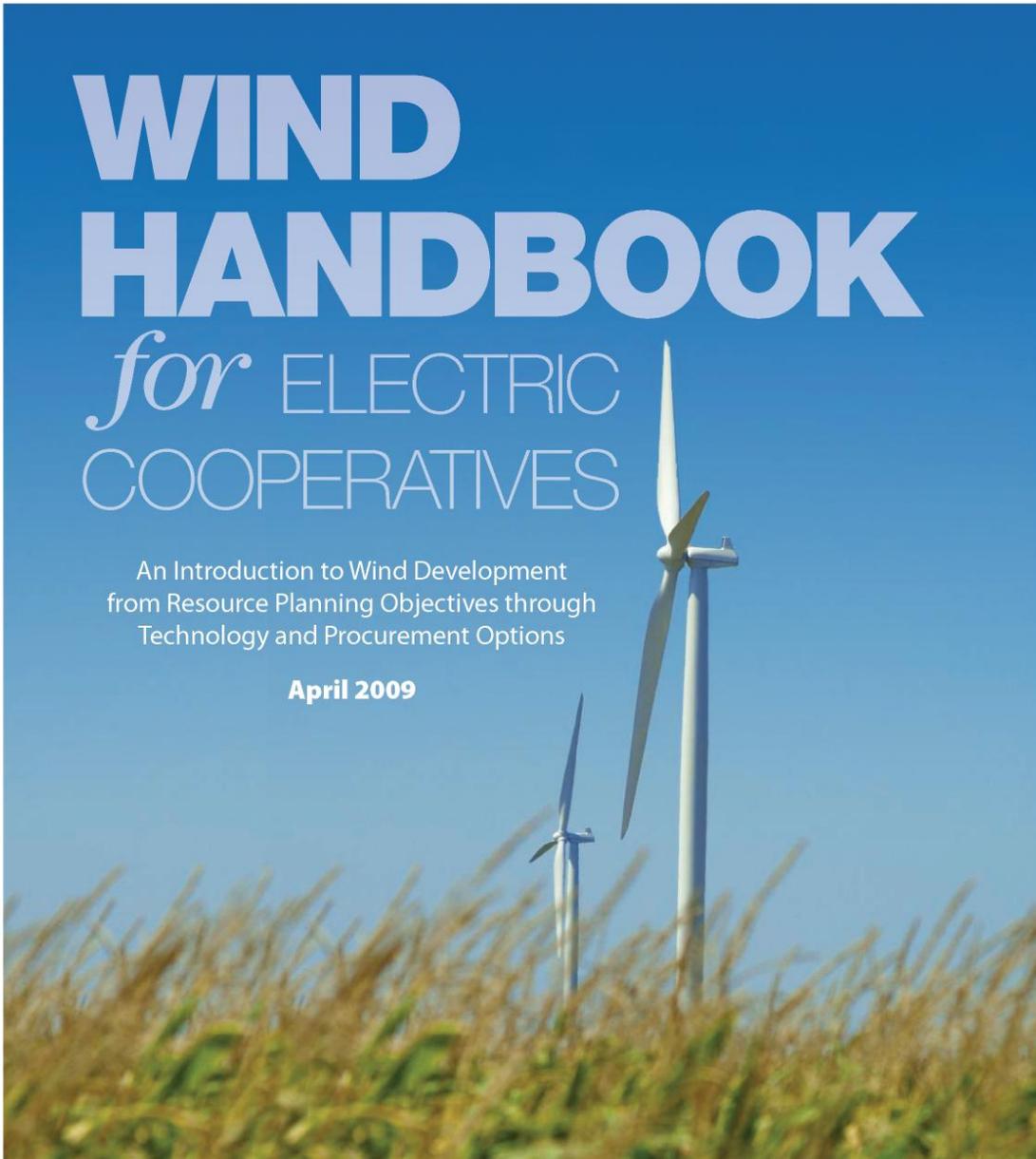


# WIND HANDBOOK

*for* ELECTRIC  
COOPERATIVES

An Introduction to Wind Development  
from Resource Planning Objectives through  
Technology and Procurement Options

April 2009



Supported by a grant from U.S. Department of Energy Wind and Hydropower Technologies Program, Wind Powering America and Western Area Power Administration for the National Rural Electric Cooperative Association

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# SECTION ONE

## The Co-op Wind Decision

### 1.0 Overview

In less than a decade, the role of wind in electric co-ops' resource portfolios has changed dramatically. Where once a few generation and transmission (G&T) cooperatives field-tested wind technologies, by 2007, some 150 G&T and distribution co-ops either owned their own wind projects or were supplied with wind energy through power purchase agreements. The co-op sector accounts for more than 600 MW of wind power development nationwide. Wind energy can help electric co-ops meet strategic planning goals, offset fuel costs and support local economic development.

While independent power producers own the largest share of the nation's wind power, now in excess of 20,000 MW in nameplate capacity, electric co-ops have been pioneers in utility ownership. They own wind projects ranging in size from less than one MW to projects surpassing 100 MW. They also are leaders in green power marketing. In 2007, the U.S. Department of Energy recognized four electric co-ops among the top green power programs nationwide, and three of these focus on wind. Wind plays an important part in the co-op family's overall commitment to the responsible development and use of all cost-effective renewable resources—a commitment that was formalized in a 2005 National Rural Electric Cooperative Association (NRECA) member resolution and through NRECA's endorsement of the broad-based "25 by 25" initiative for renewable energy development in agricultural communities nationwide.

It is easy to see the trends that signal growing interest in wind, but the decision to develop or purchase wind energy is unique to each co-op that considers it. This section reviews the most common drivers of the co-op wind decision. Once a co-op has made the decision to pursue wind-related opportunities, the development process can begin.

### 1.1 Direct Utility Benefits

Interviews with top managers at utilities that have wind programs suggest that in every case, a set of drivers besides sheer economics has played a role. Often these drivers include commitments to capture both direct utility benefits and external, community-based benefits.

Direct utility drivers, discussed below, include

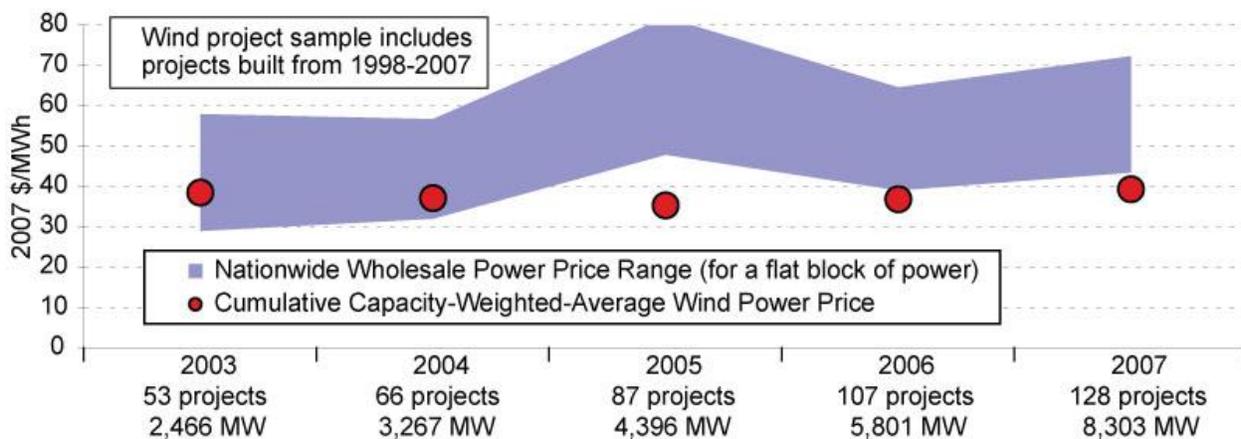
- Competitive resource cost,
- Portfolio diversification value,
- Environmental benefits, and
- Member satisfaction.

#### 1.1.1 Competitive Resource Cost

An early survey of renewable energy development by rural electric co-ops sent one message loud and clear: the economics have to work before co-op wind acquisitions—either by power purchase agreement or direct project development—can move forward. Today, wind energy is

increasingly competitive with other utility resource options, but electric co-op decision-makers still must be sure that each resource under consideration meets unique performance needs.

The U.S. Department of Energy's (DOE) *Annual Report on U.S. Wind Power Installation, Cost, and Performance Trends: 2007* compared the capacity-weighted price of wind energy from projects built since 1998 to nationwide average wholesale power prices (Figure 1.1). It found that the capacity-weighted price of wind power since 2003 consistently averaged near or below the low end of the wholesale power price range. In some regions, low-end wind prices have been half the price of comparable wholesale power. This study did not go into detail on transmission integration issues and costs. But its findings support a conclusion that wind energy can be competitive today in some good wind resource regions of the country.

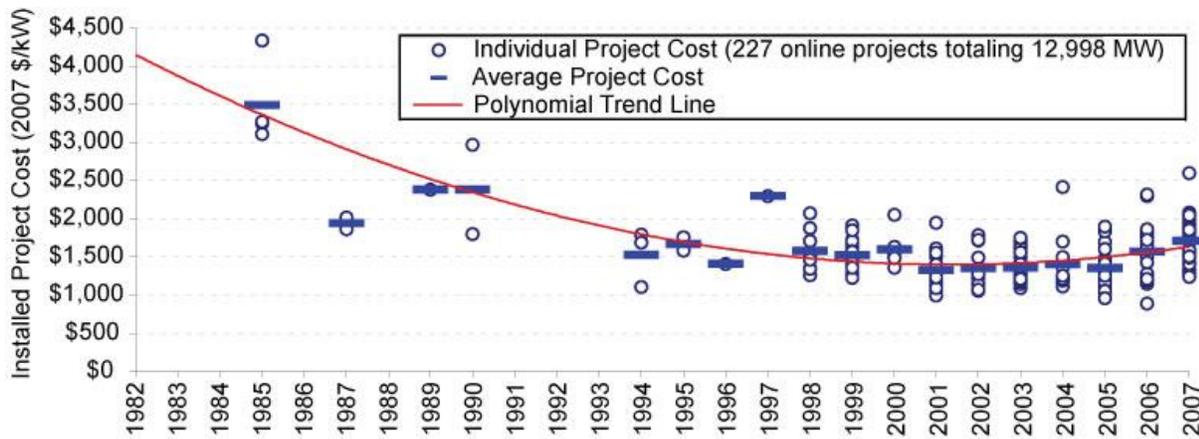


Source: FERC 2006 and 2004 "State of the Market" reports, Berkeley Lab database, Ventyx.

Figure 1.1. Average Cumulative Capacity-Weighted Wind and Wholesale Power Prices Over Time.

Source: U.S. DOE *Annual Report on U.S. Wind Power Installation, Cost, and Performance Trends: 2007*

Co-op decision-makers know that wind project development costs have increased in the last few years, and this is true. Rising demand for wind equipment has temporarily outpaced supply. At the same time, the price of steel and other raw materials, as well as equipment transportation costs, have gone up. Figure 1.2 tracks installed wind project costs over time, from the early years of wind development through 2007. The steady decline in project costs over 20 years remains striking, but the recent upturn in installed project costs raises new concerns. Available data shows a range of project costs in 2007 from \$1,240 per installed kW to \$2,600 per installed kW. The average cost of \$1,710 per kW is up 9%, or \$140 per kW from the previous year, and up roughly \$370 per kW, or 27% from the average cost of projects installed from 2001 through 2003. Indications from pending wind projects suggest that average costs will continue to rise, at least in the short-term, possibly to \$1,920 per kW by the end of 2008. According to DOE market research, this cost increase is mostly centered on the costs of turbines, towers, and turbine construction.



Source: Berkeley Lab database (some data points suppressed to protect confidentiality).

Figure 1.2. Installed Wind Project Costs Over Time.

Source: U.S. DOE Annual Report on U.S. Wind Power Installation, Cost, and Performance Trends: 2007

Rising project costs have slowed some types of U.S. wind development. Co-ops that plan relatively small projects in remote locations may experience long delays and other frustrations (procuring turbines for example), while the big project developers cut in line. Strategic project design and finance (discussed later in this handbook) and the selection of high-performing wind technologies can lower effective project costs. Figure 1.3 shows comparative costs for new energy resources for Puget Sound Energy in 2004 and 2006. The 20-year levelized cost of natural gas and coal-fired generation are also up dramatically in recent years, partly due to capital costs and partly due to projected fuel costs and environmental compliance costs. Co-ops will continue to need a mix of base load, intermediate, and peaking resources in their portfolios, but this mix may well include wind.

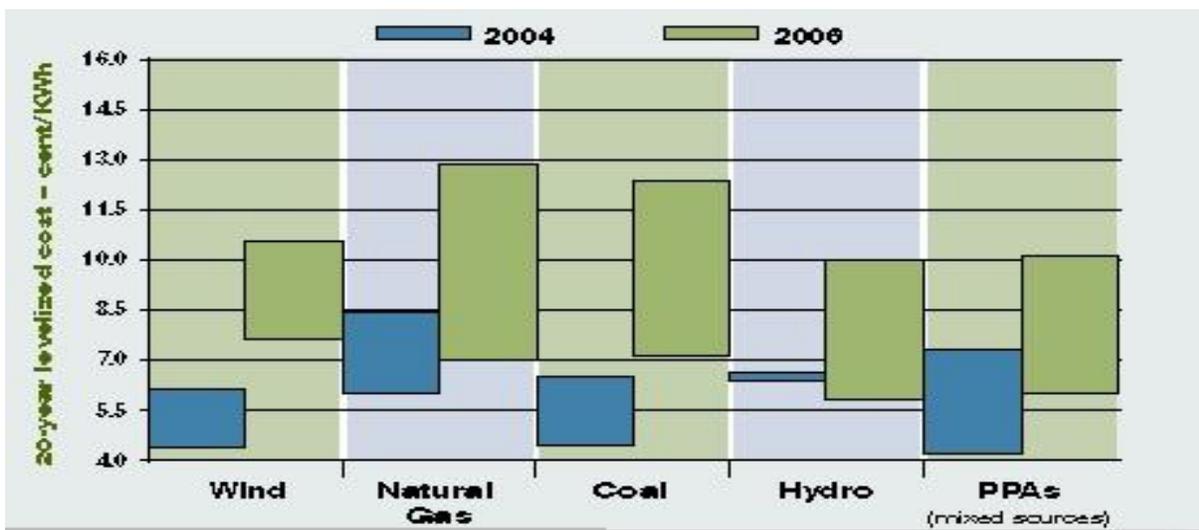


Figure 1.3. Resource Costs for Puget Sound Energy Show Widespread Increases.

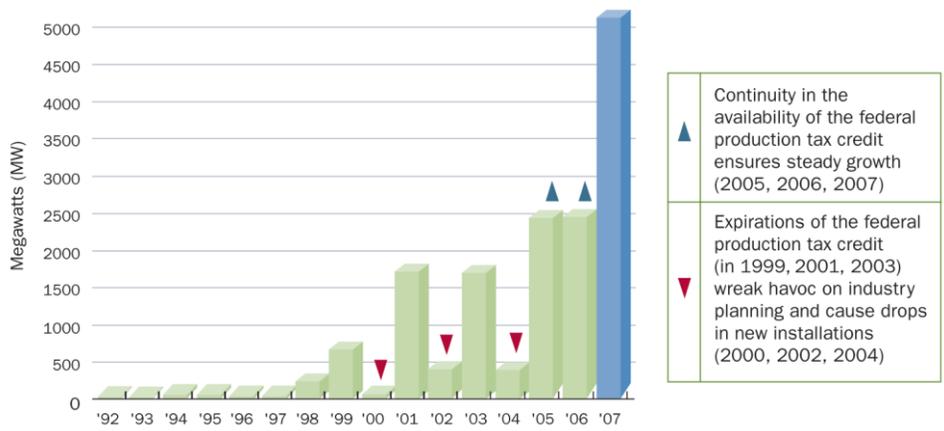
Source: Puget Sound Energy and AWEA.

Subsequent sections of this handbook will discuss specific technical, regulatory, and project-design factors that affect the levelized cost per MWh for a given wind project. Major co-op wind projects may involve a range of consulting specialists to support that analysis. But most co-ops can move into the early stages of project development with limited up-front cost.

## Wind Development Sets Records in the U.S. and Worldwide

According to the American Wind Energy Association (AWEA), which represents the U.S. wind industry, wind capacity nationwide accounted for about 30% of all new nameplate generating capacity added in 2007 and 42% in 2008. In 2008, 8,358 MW of new nameplate capacity was installed, shattering the record previously set in 2007. In recent years, wind power has consistently ranked second among new sources of generation in terms of nameplate capacity added to the grid, behind natural gas.

The year-on-year growth of wind power in the U.S. through 2007 is reflected in Figure 1.4. Off years coincided with the expiration of the federal production tax credit, a central policy driver for the wind industry. No one can predict energy policies with certainty; however, so long as the wind production tax credit remains in place, the industry's record-setting growth is likely to continue.



**Figure 1.4.** Annual Installed U.S. Wind Energy Capacity.  
*Source:* AWEA Wind Power Outlook 2008.

The U.S. took first place in annual wind development worldwide in 2008 followed by China. Its leadership position may or may not continue, as countries around the world are fast-developing their own wind industries. According to the Global Wind Energy Council (GWEC), worldwide wind capacity will double within the next three and a half years! Among the leading countries in terms of cumulative wind capacity today are the U.S., Germany, Spain, India, China, and Denmark. Following early leadership from the West, countries like India and China are turning to wind as part of a low-pollution solution to meet their booming energy needs.

Leading wind states jockey for position every year, but front running states have consistently included Texas and California, followed by a second tier, including Minnesota, Iowa, Washington, Colorado, Oregon, Illinois, Oklahoma, and New Mexico. Table 1.1 shows cumulative wind generation in terms of installed nameplate capacity in leading wind states as of December 2007. Co-op territories are strongly represented in the national drive for wind resource development.

Table 1.1  
Leading States for Wind Power Cumulative Capacity  
December 2007. (MW)

State	MW
Texas	4,356
California	2,439
Minnesota	1,299
Iowa	1,273
Washington	1,163
Colorado	1,067
Oregon	885
Illinois	699
Oklahoma	689
New Mexico	496

*Source: AWEA Wind Power Outlook 2008.*

### 1.1.2 Portfolio Diversification

Besides assessing cost figures, co-op planners today must consider the full value of diversifying their resource portfolios. Most electric co-ops already use several energy resources and power-purchase instruments. Still, the resource portfolios of all kinds of utilities (investor-owned, public power and co-op) tend to lean heavily on just a few conventional resources. In recent years, the risks of this approach have increased. Also in recent years, communications and information technologies have greatly improved, supporting a shift to more diverse portfolios.

The Energy Policy Act of 2005 (EPAct 2005) underscored the emerging importance of portfolio diversification. It requires state utility regulators to consider adopting a standard that would require each electric utility to put forward a plan to minimize dependence on one fuel source and to ensure that the electric energy it sells to consumers is generated using a diverse range of fuels and technologies, including renewable technologies. State regulators are not obligated however to accept any of the EPAct 2005 proposed standards.

Likewise, Renewable Portfolio Standard (RPS) policies, passed in at least 24 states, variously affect co-ops nationwide. Figure 1.5 shows state RPS policies current to fall 2007. Note that new state RPS policies pass every year, and 15 states have already raised or accelerated their previous RPS targets.

A national RPS bill, requiring all states to meet a 15 percent minimum RPS standard, passed the House in 2007 but was rejected in the Senate (co-ops were exempt from the bill's provisions). Whether or not a national RPS becomes law in the near future, this Congressional action suggests that it may be wise for utilities to begin now to reassess the best mix of wind and other renewables for their supply portfolios.

## Renewables Portfolio Standards

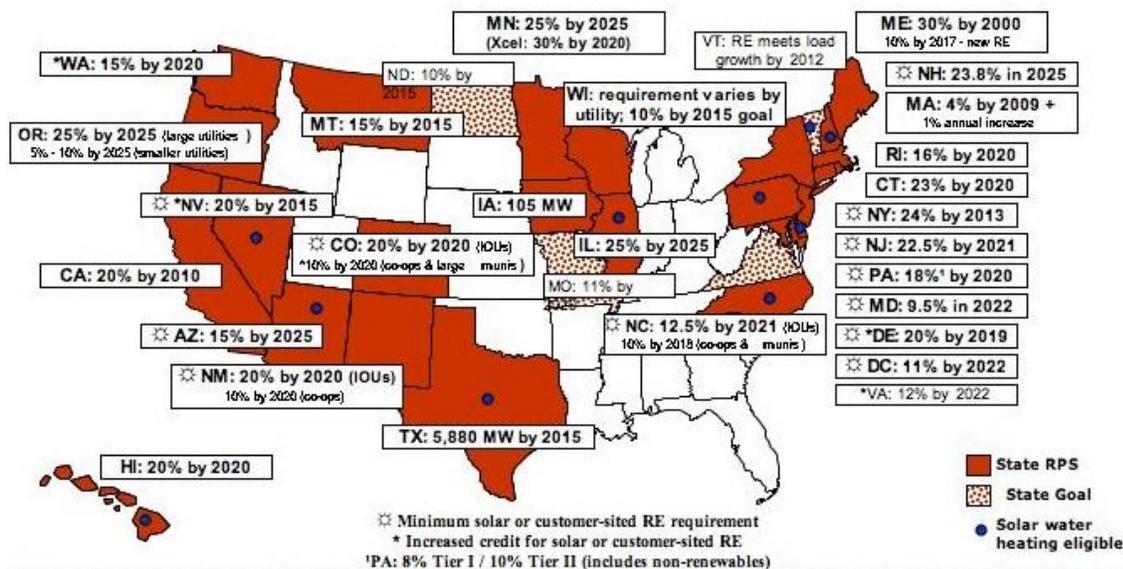


Figure 1.5. State RPS Policies in Fall 2007.

Source: Interstate Renewable Energy Council, <http://www.dsireusa.org>.

According to the National Regulatory Research Institute (NRRRI), a think tank for utility regulators and planners, five areas of risk drive utility portfolio diversification:

1. **Market conditions.** Can the utility respond quickly and cost-effectively to different scenarios for load growth, load shapes, and market prices for power?
2. **Fuel prices.** How will volatile or rising prices for fuel (natural gas, coal, etc.) impact the utility in the short or long term? Natural gas price volatility has been an important driver for renewable energy development. Wind generation requires some continuing investment in operations and maintenance, but it is free of fuel costs.
3. **Fuel supply.** Sometimes generating fuels are hard to find at any price. For example, fuel supplies were jeopardized by Hurricane Katrina in 2005. Other risks include disruptions of coal deliveries due to strikes or transportation fuel disruptions or natural gas pipeline disruptions. Similar, non-fuel risks include droughts that can impact hydropower or generating-plant cooling requirements.
4. **National policies.** A national RPS, discussed above, would have significant impact on utility resource portfolios. Limits or costs on emissions, such as mercury emissions or greenhouse gas emissions, could significantly increase costs for utilities that rely heavily on conventional coal plants. While co-ops and other utilities may be working to create favorable policy alternatives, policy risks remain.
5. **Unforeseen circumstances.** Unforeseen events can disrupt the best-laid plans. Can the utility respond to unforeseen construction delays and cost overruns? Has it correctly anticipated the impact of technological change, such as advances in wind, solar, and related communications and information technologies?

To find the best balance of conventional and renewable resources for any G&T or local distribution co-op, decision-makers should ask how resources work alone and in combination. In practical terms, NRRI encourages utility planners to consider how each resource (a conventional coal plant, a combined cycle natural gas plant, or a wind plant) would score on nine risk-related criteria:

- Load-service function
- Time to construct
- Cost to construct
- Operational life
- Fuel costs
- Fuel dependability
- Operations and maintenance cost
- Maturity of the technology
- Externalities, such as environmental impacts

Electric co-ops should consider other criteria, too, notably those related to member-impacts and community or customer benefits. It is beyond the scope of this handbook to detail the process of utility resource portfolio planning, but references are included in the Appendix.

This handbook focuses on the potential for wind in the resource portfolio. Wind scores very well as a hedge against volatile or rising fuel costs or supply disruptions. Some analyses have incorporated a value, up to a half-cent per kWh, for wind's avoided fuel cost risk, compared to volatile natural gas prices.

Wind plants are relatively quick to develop and construct. The U.S. DOE Energy Information Administration (EIA) estimates the time to develop and construct a 50-MW wind project at three years. Wind projects can keep the utility moving forward while other projects, such as new coal-fired plants, work their way through a longer development processes. The planning recommendations in this handbook should help planners to prepare for or avoid costly delays in the wind development process.

The key to understanding utility resource portfolio planning lies in understanding that no single resource offers a silver-bullet solution for the utility's future energy needs. Yet wind "plays well" with many other resources. And a utility portfolio that is diversified may be stronger overall.

### **1.1.3 Environmental Benefits**

Many utilities consider environmental benefits to be a major reason for wind development. This includes emissions reductions of all kinds and water conservation.

Of course, utilities have reduced the pollution impacts of conventional resources and will continue to do so. Using industry averages from 2007, AWEA estimates that the nation's aggregate wind generating capacity of nearly 17,000 MW at the end of 2007 displaced approximately 28 million tons of carbon dioxide emissions, or 1,650 tons of carbon dioxide per MW generated.

Some emissions reductions translate directly into utility regulatory cost savings. In regions of the country where water is a concern, wind plants can save tens of millions of gallons of water, which would be required for fossil or nuclear plant cooling and is lost through evaporation in hydro plant operation.

## **1.2 Community-Based Benefits**

Whether a co-op is planning to build its own wind plant or to acquire wind power through a power purchase agreement, it is likely to win majority support from the local wind community in which the project is located. Renewable energy development has been called the new crop for rural America. It is popular in rural communities for many reasons. Community-based benefits of wind power include:

- Landowner revenues,
- Tax revenues,
- Jobs, and
- Local revitalization.

### **1.2.1 Landowner Revenues**

Rural farms and ranches have some of the best wind resources in the country. To secure these resources, wind developers typically lease wind rights from landowners. Although leasing arrangements vary widely, lease rates are typically \$2,000 to more than \$4,000 per year per utility-scale turbine. Another rule-of-thumb formula estimates lease payments at two to three percent of the project's gross revenues. This is a good, steady revenue stream and a hedge against a bad year for corn, beans, wheat, or beef. Moreover, the amount of land needed per turbine is small. Farmers can continue to plant crops or graze livestock right up to the base of the turbines.

### **1.2.2 Tax Revenues**

Wind power also provides significant tax revenues to support a range of local community needs such as education, road construction and maintenance, healthcare, corrections, fire protection, and general fund operations. Property tax rates vary, but typically range from one to three percent of the wind project's value. Since the installed cost of wind is more than \$1.5 million per MW, county governments realize tens—or even hundreds—of thousands of dollars per year in property tax revenue from wind farm construction. Wind projects generate other tax revenues as well, including sales taxes and income taxes.

While wind projects may get tax breaks from enthusiastic local and state governments, many such breaks are discounts not full exemptions, or they expire long before the life expectancy of the wind project. This is true of all kinds of energy development projects. The dispersed nature of wind projects however, gives more local communities the opportunity to potentially realize additional tax revenue from wind plant construction and operation compared to a single centrally-located power plant of similar size using conventional generation technologies.

### **1.2.3 Jobs Creation**

As the wind industry grows by 25 to 30 percent each year, it creates more and more jobs. AWEA estimates that the U.S. wind industry, from manufacturing and transporting wind equipment, through site preparation and construction, to plant operations and maintenance, adds up to an employment base of about 75,000 jobs. In 2006 alone, leading wind turbine manufacturers opened plants in Iowa, Minnesota, Texas, and Pennsylvania. A new Gamesa turbine manufacturing plant in Pennsylvania, located on the site of an abandoned steel mill, by itself employs more than 300 workers.

One rule of thumb, based on the Danish wind industry experience, estimates that 22 direct and indirect jobs are created for every MW of installed wind capacity. That includes five jobs per MW for installing the turbines and 17 jobs per MW related to manufacturing. In addition, wind development creates skilled operations and maintenance jobs, on the order of one job per 10 MW of installed capacity. The DOE Wind Powering America program has estimated that wind development to meet five percent of the nation's electricity needs would create a total of 80,000 new jobs.

The majority of jobs in the wind industry are construction jobs, and this creates a local economic boom effect. The downside of this is that booms do not last. However, wind projects tend to be dispersed across a region over a longer period of time, compared to conventional power plant construction. There is also anecdotal evidence that wind projects jumpstart other kinds of economic development in some rural communities as well, such as tourism.

### **1.2.4 Local Revitalization**

Communities that have experienced wind development report a strong and lasting boost in sustained economic activity. A 50 MW wind project in Atchinson County, Missouri—one of several new wind projects that serve Associated Electric Cooperative—has become the centerpiece of a rural energy development initiative for the region. Talk about the flight of young people away from Atchinson County has been replaced by talk of job opportunities in wind, biomass, and related technical businesses.

Community revitalization through wind development is in evidence across the country. This trend can also benefit electric co-ops that are concerned about potential opposition to local wind farms.

#### **Atchinson County Welcomes Wind Power**

Atchinson County, Missouri lost almost 14 percent of its population between 1990 and 2000, including lots of young people who graduated from high school and moved away. The region was known mostly for its struggling corn and bean farmers, its beautiful scenery along the Missouri River, and a small group of determined local leaders who loved their agricultural roots and small town lifestyles. Despite the fact that national wind maps did not show a strong wind resource here, these leaders believed they had some extraordinary geographic niches that were suited to wind development. They worked hard to explore the wind resource and to find excellent development partners, including the St. Louis-based Wind Capital Group, John Deere, and their regional and statewide G&T cooperatives, N.W. Electric and Associated Electric Cooperative, Inc.

The result was a 50 MW wind plant, called Cow Branch, on a windy Atchinson County ridge. It includes 24 Suzlon 2.1 MW turbines, with transmission from N.W. to serve the Associated Electric system. It was developed as part of a larger complex, including two other nearby wind projects for a total nameplate capacity of 156 MW. Associated Electric has a power purchase agreement for the output of the entire project. For its pivotal role in this project, Associated Electric won the Wind Co-op of the Year Award in 2007 from U.S. DOE's Wind Powering America program.

Locals say the real news about this project is the boost that it has given to the local economy. Landowners have received wind lease payments, even as they farm nearly up to the base of the new turbines. Construction for the wind plant filled local motels and restaurants. Even an influx of tourists has been stopping at local businesses on their way to see the wind site. Some permanent jobs have developed directly out of the wind project, and perhaps more important, the community was inspired to focus on rural energy industries as the new center of its economic development planning. A nearby ethanol plant is expanding. A biodiesel plant is in the works. An abandoned college is coming back with a focus on energy-related vocations.

The region is proving a viable location for even more wind development. The Wind Capital Group has suggested that northwest Missouri and similar areas in neighboring states that were considered a "dead zone" for wind development actually could support up to 100 MW per year of wind development for the next decade or more. The municipal utility of Rock Port in Atchinson County recently completed a four-turbine, 5 MW wind project within the city limits, designed as a distributed generation project to serve local needs. The municipal utility is still served by the Missouri Joint Municipal Utility System, but Rockport has become the first city in America that can meet its energy needs on an annual basis entirely with wind power.



**Figure 1.6.** Associated Electric has purchased the wind output of three new wind plants in Missouri.

*Source:* Wind Capital Group.

## SECTION TWO

# Siting: Wind Resources, Environmental Concerns, and Grid Access

### 2.0 Overview

A later section of this guide outlines the wind development process. Within that process, siting is a first step in project design. Yet siting, including assessing wind resources, environmental concerns, and grid access is so fundamental that it is discussed separately here. Co-op decision-makers need a basic understanding of siting issues whether they wish to become project developers or whether they need to assess third-party proposals. The following discussion is a starting point in either case.

### 2.1 Wind Resources

As wind developers in many communities have found, it may be useful simply to pay attention to local folks, who can tell where the wind blows the hardest and most often. But more sophisticated tools, including wind resource maps and wind monitoring equipment, are necessary to verify and fine-tune intuitive assessments.

#### 2.1.1 Wind Maps

Electric co-op territories include many of the best wind resources in the nation. National and even international companies are also engaged in wind development and have been wind prospecting—putting up wind monitoring equipment and securing leases for future wind projects.

Wind resource maps give a first clue about where the strongest sustained winds blow. State-level maps are easy to find on the DOE Wind Powering America Web site, <http://www.windpoweringamerica.gov>. These maps show wind resources from Class 1 (low) to Class 7. As a rule of thumb, a utility-scale wind project requires wind resources of Class 3 or above.

The latest revised maps, which benefit from new wind detection and Geographic Information System (GIS) technologies, show more specific opportunities for wind development than the earlier maps did (Figure 2.1). Still, local investigation and site-specific monitoring can spot windy locations that state maps miss. For example, state wind maps for Missouri suggested dismal prospects for utility-scale wind, but development partners working with Associated Electric Cooperative have proved them wrong. Wind resource specialists look for strong wind microclimates in locations such as

- Gaps, passes, and gorges
- Long valleys extending down from mountains
- High-elevation plains and plateaus
- Exposed ridges and mountain summits
- Coastlines and immediate inland strips with a minimum of relief and vegetation
- Upwind and crosswind corners of islands

- Areas with low vegetation and an absence of wind breaks.

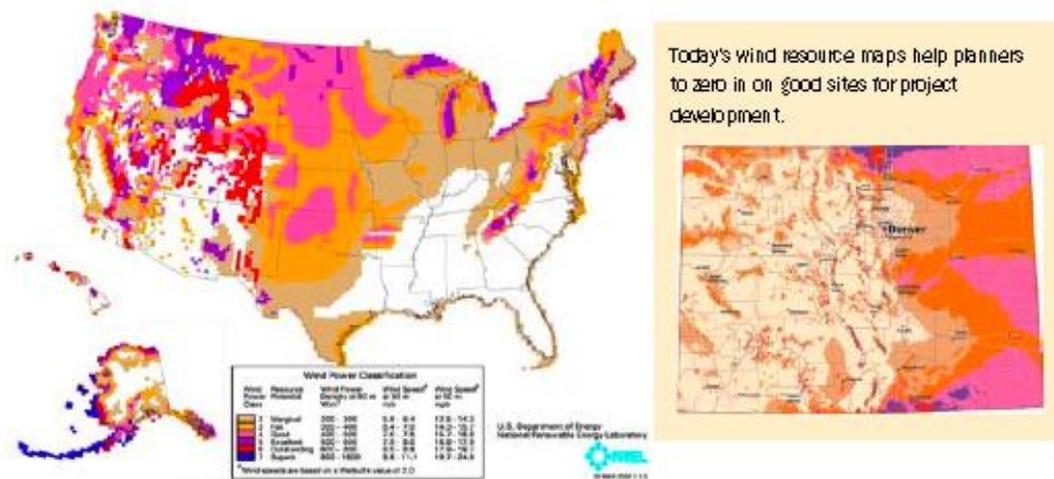


Figure 2.1. U.S. DOE wind maps offer guidance and fairly detailed assessments of state wind resources. *Source:* National Renewable Energy Laboratory (NREL).

### 2.1.2 Wind Monitoring

Using the best available wind maps at the time, a small municipal utility in Bowling Green, Ohio targeted a Class 2 wind site for development, despite its marginal economics. Fortunately, on-site monitoring revealed that a taller tower could reach a pocket of Class 3 wind. Finding the best available wind resource is critical because the energy in the wind is related to the *cube* of its speed. A site with a 12 mile-per-hour average annual wind speed could produce 70 percent more energy than a site with a 10 mile-per-hour average annual wind speed.

Wind monitoring installations, called meteorological—or met-towers, provide useful time-series data on the wind resource in specific locations for a year or more. Met towers typically house

- Anemometers to measure wind speeds at different heights,
- Wind vanes for directional data,
- Thermometers, and
- Barometers to track changing air pressure.

Monitoring is part of the early stage of wind development called validation. Validation includes setting up met towers, but it also includes careful analysis of available data from local meteorologists and landowners. This data is best assessed by experienced wind resource specialists.

## 2.2 Environmental Concerns

Some wind projects may present environmental concerns including:

- Visual impacts,
- Noise impacts,
- Bird and bat impacts, and
- Other issues (e.g., erosion, wildlife impacts).

These concerns are typically addressed in permitting processes, but some jurisdictions have more stringent regulations than others do. It pays to anticipate any stakeholders' concerns early on, avoiding or addressing problems before they become costly showstoppers.

### **2.2.1 Visual Impacts**

The visual impacts of wind power are literally “in the eye of the beholder.” In some cases, aesthetic issues have resulted in long wind project delays. Some controversial projects have been abandoned. Suggesting the subjective nature of aesthetic complaints, the community of Hull, Massachusetts on Boston Harbor near Martha’s Vineyard, has enjoyed strong community support for two successive wind projects already, and it plans to develop a four-turbine offshore project soon. The Hull example is instructive because local leaders say that public support was not a given. Local project sponsors, including the municipal utility, informed residents of wind development plans early on, and they worked hard to build local support.

Public dialog is the best tool for assessing and addressing concerns about visual impacts. At the earliest possible date, utilities and developers should share detailed information about potential wind sites with stakeholders. The following tools are useful:

- A viewshed map showing all the places from which the project would be seen. The map should depict all relevant boundaries and historical or cultural sites.
- Visual simulations that illustrate what the project would look like from different sites of significance or concern to the community.
- A line-of-site profile providing a measurable way to show how much of a particular tower would be visible from sites of significance or concern.

One utility wind developer suggested that visual simulations should be as large as possible, for example on poster boards, to help stakeholders prepare for what the actual project will look like. Developers also suggest presenting a process to local officials, whereby the local government will sign off on a project plan once serious considerations are addressed. This provides some closure to the process, minimizing the likelihood that visual impact issues will not come up again.

Besides its overall visual presence, a wind project may present specific visual problems. The Federal Aviation Administration (FAA) requires that structures more than 200 feet tall must be lit for nighttime air safety. The National Wind Coordinating Collaborative (NWCC) and other wind interest groups have negotiated with the FAA to minimize the amount of lighting that is required, in order to balance concerns for air safety with visual concerns and avian protection, as birds tend to fly toward lights at night. Project developers should be sure to consider the latest minimum lighting standards, available through NWCC’s Web site, [www.nationalwind.org](http://www.nationalwind.org).

Another specific visual problem called shadow flicker is seldom an issue with today’s utility-scale wind projects and can be mitigated by observing appropriate setbacks from sensitive receptors such as individual residences. In rare cases, the rotating blades of a turbine might cast a moving shadow on nearby residences, depending on the time of the year and time of day. Project designers can calculate precisely whether a flickering shadow would fall on a given location, and how many hours in a year it will do so.

If a wind site seemed likely to present troubling visual impacts, the project designer could take any of a number of measures to mitigate the problem. A sampling of these includes:

- Relocating one or more turbines. In some cases a suitable alternative wind site is available.
- Screening. Sometimes the line of sight is such that a bank of fast-growing trees can disguise a wind project from a particular visual angle.

## 2.2.2 Noise Impacts

New utility-scale wind turbine designs tend to reduce noise impacts. This is largely because large turbines are designed to rotate much slower than small turbines (defined as rated at 100 kW or less) are. Large turbines also tend to have insulation in the nacelle (the enclosure at the top of the tower on which the blades are mounted that contains the drive train, generator, etc.). Another factor is whether the turbine is designed to be upwind or downwind. Downwind turbines, where the wind strikes the tower before it strikes the blades, tend to be relatively noisier. Today, most utility-scale wind turbines are upwind designs.

All kinds of turbines still emit tonal sounds from moving gears and whooshing sounds from the wind against the turning blades. The question is whether those sounds are significant to nearby residents or visitors. Studies from the Scottish Office of Environmental Planning and others suggest that at a distance of 1,000 feet most wind turbines are as quiet as a typical house (Figure 2.2).

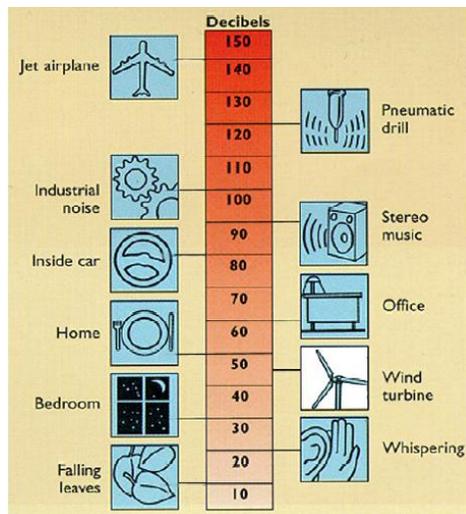


Figure 2.2. Wind Turbine Noise Compared to Noise in Typical Settings  
 Source: <http://www.awea.org/pubs/factsheets/MythsvsFacts-FactSheet.pdf>

Successful wind developers suggest providing accurate information to stakeholders before issues such as potential noise impacts come up. Most wind turbine designers also can estimate the noise impacts of specific designs.

## 2.2.3 Bird and Bat Impacts

Bird kills are primarily associated with older wind turbine designs that featured fast-turning blades and latticed towers that attracted nesting birds. Some early California wind projects, most notably in Altamont Pass east of San Francisco, raised concerns which linger today about killing raptors. In fact, bird mortality rates for wind projects outside California have historically been about three birds per MW per year, and the most recent reports are even more encouraging.

Extensive research by DOE’s National Renewable Energy Laboratory and others suggests that bird issues are not a serious issue for most wind development today, and represent a significantly lower risk of mortality than many other sources as shown in Figure 2.3. New turbine designs minimize avian impacts, and new assessment and simulation tools help to identify critical zones, such as migratory paths for endangered birds or bats, where wind development should be avoided.

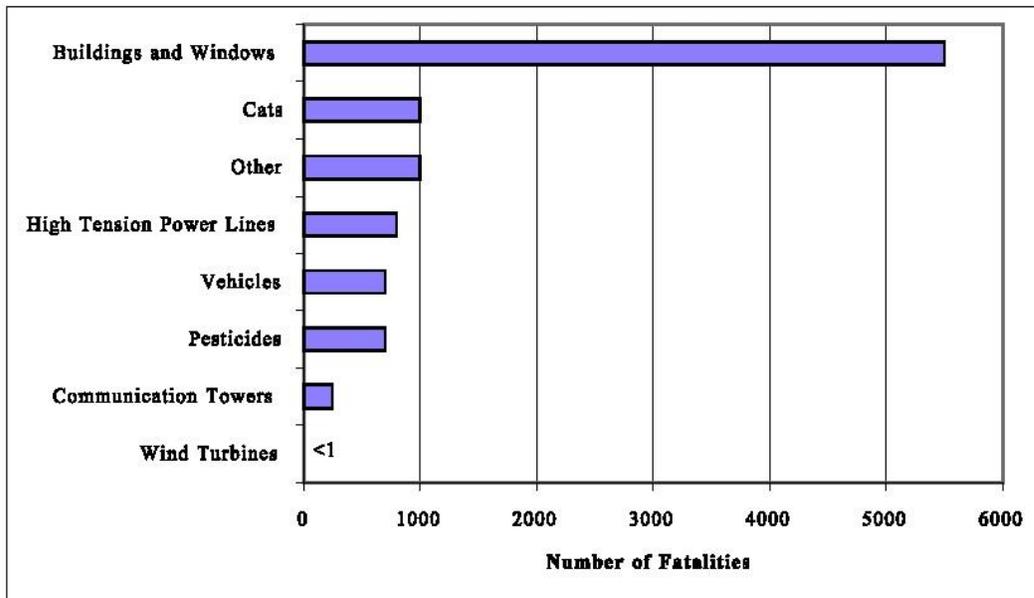


Figure 2.3. Sources of Fatalities per Sample of 10,000 Bird Fatalities.  
 Source: National Wind Coordinating Collaborative.

In its energy policy statement, the American Bird Conservancy (<http://www.abc.org/policy>) supports wind development, stating that the overall avian impacts of wind development are small relative to the environmental benefits of wind power. Most conservation groups generally favor wind development.

Still the goals of wind project developers sometimes conflict with avian protection goals. Recent research indicates that bat mortality may in some cases be a more serious problem for wind projects than bird mortality. Bat mortality from wind development has been estimated at 4.6 per MW per year on average, but figures from some Eastern wind projects have been strikingly higher. The wind industry and wildlife groups are now working collaboratively to identify locations at high risk for bat mortality and to mitigate impacts.

Wind project developers and utilities that plan to work with them should be aware of avian impact mitigation strategies and regulations before proceeding with any wind development project. The NWCC (<http://www.nationalwind.org>) recently published an avian impact *Mitigation Toolbox*, which it plans to update regularly, to address these issues. The *Toolbox* lists regulations and preventative mitigation strategies, with links to specific resources.

Mitigation strategies typically include strategies for each stage of wind project development and implementation.

#### Examples of Design-Stage Mitigation:

- General siting studies that include review of regional bird and bat habitat and migration data,
- Development of buffer zones around critical areas, where wind development should not take place,
- Micro-siting studies, including positioning of multiple turbines or adjusting turbine heights to accommodate flight patterns,
- Avoidance of hazardous design features, such as latticed towers, nacelles that provide nesting sites, etc., and
- Early-stage communication with agencies and organizations that would subsequently be involved in regulatory processes.

#### Examples of Construction- and Operations-Stage Mitigation:

- Planning for most construction when the landscape is frozen or least vulnerable and when breeding activities can be avoided,
- Undergrounding wires and cables as much as possible,
- Avoidance of revegetation plants that could attract specific roosting birds or bats,
- Use of motion-sensor lighting instead of floodlighting construction sites after hours,
- Negotiations for no-net-loss restoration of similar habitats if necessary, and
- Monitoring to report and address problems as they arise.

Some actions designed to decrease avian impacts could increase other environmental impacts. For example, painting the leading edge of turbine blades can increase visibility, which is helpful to birds but may upset area residents. Responsible wind developers maintain a dialog with researchers and the various regulatory agencies so they can take appropriate actions as new environmental protection protocols become available.

#### **2.2.4 Other Issues**

Siting issues include those that are strictly environmental, and some that are more stakeholder-specific. For example, ice-throws refer to the unexpected shedding of ice buildup from turbine blades. It poses little environmental risk or danger, unless buildings or heavily traveled roads are located nearby, and then it can be mitigated by the observance of appropriate setback distances. New turbine designs also include sensor technology that helps to mitigate heavy icing.

Stakeholders from the military, airlines, and/or communications industries may raise concerns about wind turbines possibly interfering with radar or radio signals or creating hazards in certain flight paths. There is some basis for these concerns. Radar and communications equipment sometimes may be modified to address the problem, or the parties can work together on solutions. The Federal Aviation Administration is involved in the permitting of many wind projects—especially if turbine heights exceed 200 feet. Wind development near sensitive military sites is sometimes forbidden, but the military itself is committed to promoting renewable energy development whenever it can. NWCC is a good source for information on these and other relatively rare siting issues. AWEA recently published a *Wind Energy Siting Handbook*, which also provides excellent resources.

## 2.3 Grid Access

A more detailed discussion of interconnection and integration of wind resources is included later in this handbook. Yet grid access should be an early concern for project planners. Project siting is often a compromise between selecting the site with the greatest wind resource and selecting the site with the best grid access.

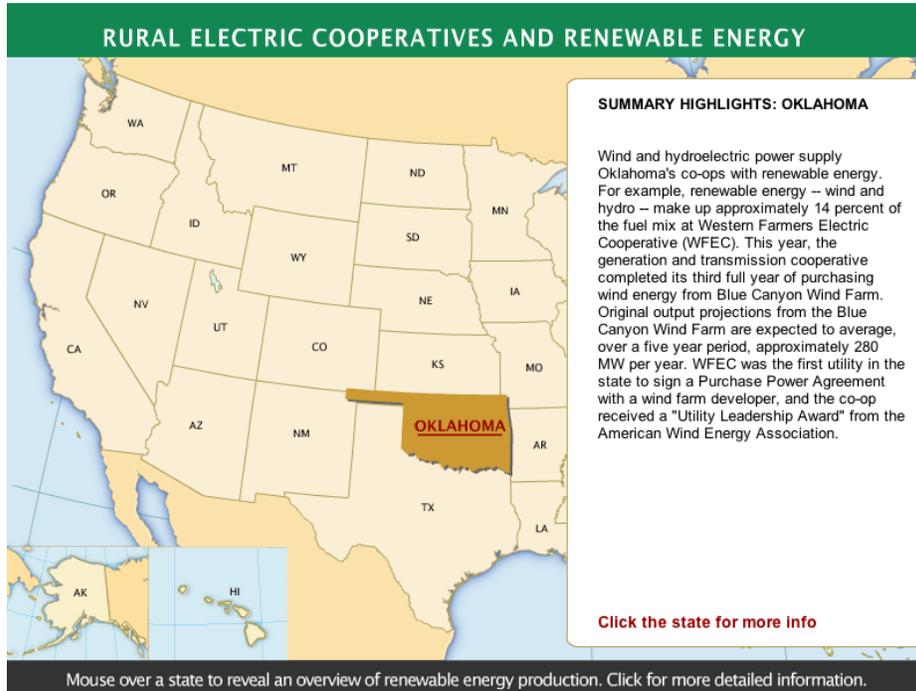
Early-stage questions about wind integration are different for smaller wind plants than they are for large plants. For smaller plants, the first question is whether turbines might be connected directly to the distribution co-op grid. This configuration has worked for wind turbines owned by distribution co-ops, such as Illinois Rural Electric Cooperative's 1.65-MW project and by G&Ts, such as East River and Basin Electric, who worked with distribution members to bring on two 1.3-MW turbines. Municipal utilities have sponsored projects of more than 3 MW that still do not require regional transmission. New lines, upgrades, and/or substation modifications may be required, but the overall cost and administrative burden is much less than the burden of interconnecting at the transmission system level. Siting should then take into consideration options that require the minimum of new construction to achieve a safe, reliable interconnection. The Utility Wind Integration Group ([www.uwig.org](http://www.uwig.org)) is a good source of detailed information on this option. Turbine selection is necessary before the utility performs an interconnection study.

Larger multi-MW wind projects must have reasonable transmission access—though the class of the wind resource, the scope of the proposed project, and specific construction challenges will help to define what is “reasonable” access. If a G&T project partner owns the transmission, so much the better. Often, the G&T will not be the project owner, but will arrange a power purchase agreement with the developer. As part of that agreement, the G&T may build and own the interconnection facilities, including new transmission line(s), substation, transformers, protection, control equipment, and any associated/required network upgrades. Even if the developer initially builds the interconnection facilities, ownership is typically transferred to the interconnecting utility.

Interconnection planning and wind integration are discussed in more detail in Section 4. These topics are specialized and complex, usually requiring consulting expertise. At the earliest stage of planning, the co-op's focus should be on considering interconnection requirements in general, making a realistic estimate of costs, and comparing the overall benefits of different sites or different interconnection approaches, in order to set a successful course for subsequent project development.

## Got Wind?

Today, more than 150 electric cooperatives, including G&Ts and distribution co-ops, include wind energy in their resource portfolios. A new Web site, <http://www.nreca.coop/renewablemap/index.html>, tracks electric co-op renewable energy developments, including wind developments, state-by-state. A review of this Web site suggests the variety of wind projects and how these projects fit in with other renewable resources in the co-ops' energy supply portfolios.



**Figure 2.4.** Interactive map of renewable co-op energy projects.

Source: <http://www.nreca.coop/renewablemap/index.html>.

## SECTION THREE

### Wind Technology

#### 3.0 Overview

The headline news about wind technology is that, in the words of one GE Energy executive, “Wind development is not a science project, anymore.” Today’s wind machines are far advanced from legendary Dutch windmills and ranchland water pumping machines. They are vastly improved from generating wind turbines of just ten to fifteen years ago. This chapter reviews:

- The basic principles behind wind equipment design,
- The innovations that the wind industry has recently introduced, and
- The range of today’s wind industry partners.

#### 3.1 Wind Equipment Basics

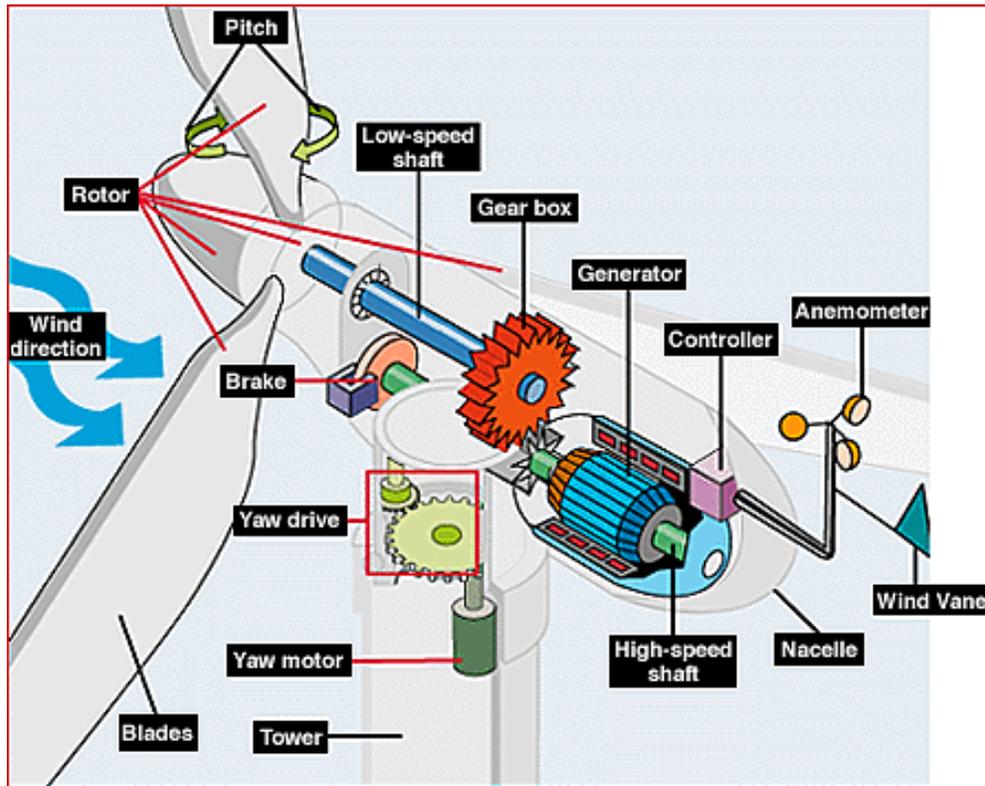
Simply stated, a wind turbine works the opposite of a fan. Instead of using electricity to make wind, as a fan does, a wind turbine uses wind to make electricity. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity

Nearly all utility-scale wind turbines today are horizontal-axis machines, with blades that spin like propeller blades on a tall, slightly tapered pole. The enclosure on top of the tower on which the hub and blades are mounted is called the nacelle, and it contains the drive train, gearbox (if needed) and generator. While not readily apparent, a variety of electronic equipment, including controls, cables, ground support equipment, and interconnection infrastructure is part of a wind turbine installation.

One indicator of wind technology evolution is the size of viable utility-scale wind machines. In the early 1980s, utility-scale wind machines had a capacity rating of less than 200 kW. Less than a decade ago, when pioneering electric co-ops began testing wind technologies, utility-scale turbines were typically rated at 750 kW. Today, most utilities consider a 1.0 MW turbine to be the minimum size for most utility-scale applications. The trend, however, is toward larger, more powerful turbines (1.5–3 MW).

The configuration of multiple wind turbines operating together constitutes a wind project, or wind plant. There is no physical limitation on how many wind machines may be coupled together in a single plant. Often, wind developers and their utility partners will begin with a relatively small plant. Later they might build out the site to its full resource capacity. The variable operation of a single wind turbine is somewhat mitigated by operating multiple, dispersed wind turbines. Output variability is further reduced when operators have multiple wind projects in their portfolio spread across the control area.

## Wind Technology Lexicon



**Anemometer** - A device that measures the wind speed and transmits wind speed data to the controller.

**Blades** - Most turbines have either two or three blades. Wind blowing over the blades causes the blades to "lift" and rotate.

**Brake** - A disc brake component, which can be applied mechanically, electrically, or hydraulically to stop the rotor in emergencies.

**Controller** - The controller starts up the machine at wind speeds of about 8 to 16 miles per hour (mph) and shuts off the machine at about 55 mph. Turbines do not operate at wind speeds above about 55 mph because they might be damaged by the high winds.

**Gearbox** - Gears connect the low-speed shaft to the high-speed shaft and increase the rotational speeds from about 30 to 60 rotations per minute (rpm) to about 1000 to 1800 rpm, the rotational speed required by most generators to produce electricity. The gearbox is a costly (and heavy) part of the wind turbine and engineers are exploring "direct-drive" generators that operate at lower rotational speeds and don't need gearboxes.

**Generator** - Usually an off-the-shelf induction generator that produces 60-cycle AC electricity.

**High-speed shaft** - An axle that drives the generator.

**Low-speed shaft** - The rotor (blades and hub together) turns this axle at a low speed—about 30 to 60 rotations per minute.

**Nacelle** - The enclosure that sits atop the tower and contains the gearbox, low- and high-speed shafts, generator, controller, and brake. Some nacelles are large enough for a helicopter to land on.

**Pitch** - The angle to which blades are turned out of the wind to control the rotor speed and to keep the rotor from turning when winds would not be productive.

**Rotor** - The blades and the hub together are called the rotor.

**Tower** - The pole, typically made from tubular steel that holds the nacelle. Because wind speed increases with height, taller towers enable turbines to capture more energy and generate more electricity.

**Wind direction** - This is an “upwind” turbine, so-called because it operates facing into the wind. Other turbines are designed to run downwind, facing away from the wind.

**Wind vane** - Measures wind direction and communicates with the yaw drive to orient the turbine properly with respect to the wind.

**Yaw drive** - Upwind turbines face into the wind; the yaw drive is used to keep the rotor facing into the wind as the wind direction changes. Downwind turbines don't require a yaw drive, the wind blows the rotor downwind.

**Yaw motor** - Powers the yaw drive.

### 3.1.1 Wind Energy Production

Generally speaking, the output of a wind turbine depends on the turbine's size and the wind speed through the rotor. Wind speed has a lot to do with the output of a wind turbine because the power available in the wind is proportional to the cube of its speed. Thus, doubling the wind speed would increase available wind generation (kWh) by a factor of eight. A turbine operating at a site with an average wind speed of 12 mph could in theory generate about 33 percent more electricity than one at an 11 mph site, because the cube of 12 (1,768) is 33 percent larger than the cube of 11 (1,331). This principal underscores the importance of good wind project siting. Many innovations in wind system design and operation help to achieve greater output from lower wind speed sites, but this basic principle still applies.

Another serious concern for utilities is the capacity factor for the wind system. This is determined by the constancy of the wind resource and by the sensitivity of a particular wind technology to run under varying (low or high) wind conditions.

$$\text{Capacity Factor} = \frac{\text{Actual power produced over time}}{\text{Power ideally produced through continuous operation}}$$

Although modern utility-scale wind turbines typically run 65 to 90 percent of the time, they usually run at less than full nameplate capacity. An average capacity factor of 25 to 40 percent is common.

It is important to note that, in contrast to conventional power plants, the capacity factor of a wind system is usually related to the wind itself and not to the reliability of the equipment. Wind turbines are technically available about 95 percent of the time, but if the wind dies, then the turbine will produce little or no electricity.

Capacity factor as it impacts utility system integration is discussed in a later chapter of this handbook.

### 3.1.2 Wind Technology Innovation

Wind is a mature technology, and yet it continues to evolve. In the 1990s, the wind industry achieved system reliability and availability factors of more than 95 percent, within the constraints of wind resource availability. Today, the industry meets rigorous testing and certification standards, demonstrating up to 98-percent availability at some operating projects.

In recent years, the U.S. government and the wind industry formed a collaborative, aimed at looking at what the U.S. wind market would have to look like in order to greatly increase wind penetration. In 2007, the collaborative defined the technical and market requirements for that goal, assuming a mix of 88-percent land-based wind and 12-percent offshore wind. Those requirements are summarized below:

Land-based wind technology improvements:

- Increasing average size of utility-scale turbines,
- Design improvements to increase average capacity factor by 15 percent,
- Design improvements to reduce O&M costs by 38 percent, and
- Design and manufacturing improvements to reduce capital cost by 10 percent.

Offshore wind technology improvements:

- Increasing average size of turbines from 3 MW today to 10 MW by 2030,
- Design improvements to increase average capacity factor by 14 percent,
- Design improvements to reduce O&M costs by 48 percent, and
- Design and manufacturing improvements to reduce capital costs by 12 percent.

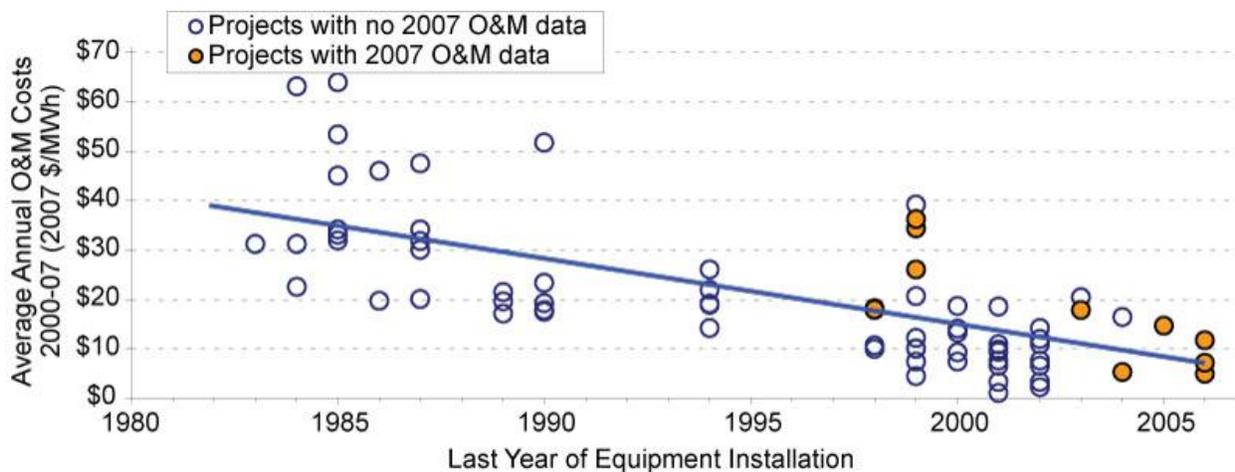
Integration improvements:

- Forecasting methodologies and software to improve scheduling, penetration, and integrated system performance,
- Further improving fault tolerance and ride-through capabilities,
- Modest ramping capabilities, using advanced controls,
- Other improvements using advance information and control technologies, and
- Integration with hydro, compressed air, and other storage strategies.

Already, today's blade designs are far stronger under heavy wind conditions than those of a decade ago; wind machines operate in winds up to 55 mph and can survive wind speeds in excess of 125 mph. Controls on blade pitch and other operational parameters can further improve overall system performance.

Current research and development efforts include the design of more sensitive and lightweight machines that will operate cost-effectively at lower wind speeds. The wind industry is also addressing remaining environmental challenges, so the industry can develop more sites that are closer to load centers and therefore easier to serve.

Future wind projects also will benefit from research and development to ease operating and maintenance (O&M) requirements. For example, gearbox improvements are aimed at eliminating bearing breakdown. Better remote monitoring and diagnostics are expected to help operators solve problems before they turn into costly breakdowns. Figure 9 shows the steady decline in project O&M costs, documented in a recent U.S. DOE study. This data does not pinpoint O&M costs that a new project developer might expect, but it confirms an encouraging trend.



Source: Berkeley Lab database; five data points suppressed to protect confidentiality.

Figure 3.2. Average O&M Costs Over Time.

Source: U.S. DOE *Annual Report on U.S. Wind Power Installation, Cost, and Performance Trends: 2007*

Most expected land-based wind technology improvements would advance technologies that are already performing fairly well. At this time, designers and engineers are turning their attention to ways to make wind even more attractive and cost-competitive than it already is.

Offshore wind, by contrast, represents a newer set of technologies. Offshore systems, installed in relatively shallow water, account for about 900 MW of wind capacity worldwide today. Average capacity factors of around 40 percent for offshore wind are readily achievable. However, technical and management approaches to O&M for offshore wind are not well developed. Wind manufacturing for offshore also suffers from a lack of economy of scale. This will change as new turbine designs and new approaches for securing projects, especially in deep-water locations, are developed.

One other set of wind developments to watch is centered on the smaller, distributed wind technologies. Small wind systems are usually rated in kilowatts (kW) of generating capacity, and range in size from less than 1 kW to 100 kW. Wind machines ranging in size from 1 to 10 kW are performing well for less than \$6000 per kW installed. Machines in the 50 to 100 kW range are performing well in the price range from \$3,000 to \$4,000 per kW installed. Industry watchers expect advances, especially in the mid-sized range, supporting distributed generation in a utility smart-grid strategy.

Two reference books that focus on small wind systems are:

“Wind Power: Renewable Energy for Home, Farm, and Business” ([http://www.wind-works.org/books/wind\\_power2004\\_home.html](http://www.wind-works.org/books/wind_power2004_home.html)) and “Wind Energy Basics: A Guide to Small and Micro Wind Systems” ([http://www.wind-works.org/books/wind\\_energy\\_basics.html](http://www.wind-works.org/books/wind_energy_basics.html)).

Other sources of information on small wind systems include:

- The U.S. Department of Energy’s (DOE’s) “Small Wind Electric Systems: A U.S. Consumers Guide” (<http://www.windustry.org/small-wind-electric-systems-a-us-consumers-guide>)
- The DOE’s Office of Energy Efficiency and Renewable Energy (EERE) ([http://www.eere.energy.gov/windandhydro/windpoweringamerica/small\\_wind.asp](http://www.eere.energy.gov/windandhydro/windpoweringamerica/small_wind.asp)), and
- *Home Power Magazine*’s article “Wind-Electric Systems Simplified” (<http://www.homepower.com/files/beginner/WindPowerBasics.pdf>)

Electric cooperatives that are members of NRECA can also order or download a copy of the “Cooperative Small Wind Guide” produced in 2008 by NRECA’S Cooperative Research Network (CRN). The guide provides a range of technical, market status, cost and benefit, and utility interconnection information to benefit electric co-op staff as they assist members with inquiries about small wind. Among the features of the guide are a consumer information packet featuring a “frequently asked questions” section that members can refer to when discussing small wind options with a vendor, a set of case studies of electric co-op and member experiences in interconnecting small wind turbines to the distribution system, and a small wind cost calculator to help estimate a return on investment.

The Small Wind Guide is one of CRN’s most popular products, evidence of the strong interest in rural America in the potential of small wind. Electric cooperative members of NRECA can receive more information on the Small Wind Guide by going to [www.cooperative.com](http://www.cooperative.com) and clicking on the CRN icon.

### **3.2 Wind Industry Partners**

Leading wind turbine manufacturers worldwide, and their home countries, are listed below in Table 3.1. In 2006, the six leading manufacturers were responsible for about 90 percent of the market. At the same time, new manufacturers, including those in the U.S., China, and India, are growing fast. GE Wind, the third largest manufacturer in the world, dominates the U.S. market, but a number of new U.S. turbine manufacturers are doing well in the U.S. (e.g., Clipper Windpower).

**Table 3.1**  
**Leading Wind Turbine Manufacturers**  
**Worldwide (2006)**

<b>Manufacturer</b>	<b>Market Share (%)</b>
Vestas (DK)	28.2
Gamesa (ES)	15.6
GE Wind (US)	15.5
Enercon (GE)	15.4
Suzlon (Ind)	7.7
Siemens (DK)	7.3
Nordex (GE)	3.4
REpower (GE)	3.2
Acciona (ES)	2.8
Goldwind (PRC)	2.8
Others	4.6
<b>Total</b>	107%
	(inc. some inventory)

*Source:* U.S. DOE and Black and Veatch.

Remember that the turbine is only one element of a successful wind project. There are scores of other wind technology providers, project engineering and construction consultants, and construction support businesses working in the wind industry today.

Many co-ops that wish to invest in wind or acquire wind resources may work with wind developers rather than directly with turbine manufacturers. Wind developers, project engineering and construction consultants, and construction support businesses offer services in project design, technology specification and selection, financing, and project construction. Some companies recently have become very large through acquisitions and mergers. A partial list of strong players today includes AES, Shell, BP, John Deere, FPL Energy, PPM Energy, Iberdrola, Babcock & Brown, Airtricity, RES, UPC Wind, Invenergy, Edison Mission, enXco, Clipper, Acciona, Xcel, NRG Energy, Gamesa, Cielo, Noble Environmental Power, Exenergy, U.S. Wind Force, Wind Capital Group, Foresight, Western Wind, and Midwest Wind Energy. Sometimes smaller companies, not listed here, may be good partners for a co-op wind project. Co-ops should do their homework before choosing a wind developer, just as they would act carefully in choosing any capital project developer. Networking with other utilities, attending wind energy trade shows, and reviewing information from the wind industry trade group, the American Wind Energy Association, are good starting points. Other useful resources on wind technology and project development are listed in the appendix.

## SECTION FOUR

### Wind Integration

#### 4.0 Overview

Wind power accounted for about one-third of all new generating capacity added nationwide in 2007—a one-year leap in wind capacity of 45 percent. Until recently, U.S. electric grid operators would not have imagined this much wind generation coming on line. But today, grid operators are beginning to plan for an energy mix that could include increasingly higher levels of wind penetration.

This does not suggest that wind integration is simple or cost-free. Wind integration is a challenge, but progress is being made. Improvements in wind equipment and in communications and control technology have helped. A number of utility-sponsored wind integration studies completed since 2003 have found that the cost of wind integration (e.g., regulation, load following, unit commitment) is about \$5 per MWh.

It is beyond the scope of this handbook to provide detailed guidance on wind integration. An industry collaborative called the Utility Wind Integration Group (<http://www.uwig.org>) serves as a center for fostering and tracking the development of wind integration expertise. The IEEE Power Engineering Society Wind Power Coordinating Committee (<http://www.ieee.org>) is another center of professional leadership and collaboration in this field. The Planning Committee of the North American Electric Reliability Corporation (NERC) has also established an Integration of Variable Generation Task Force (IVGTF) (<http://www.nerc.com/filez/ivgtf.html>) responsible for the preparation of a concepts document to include the philosophical and technical considerations for integrating variable resources and specific recommendations for practices and requirements including reliability standards for real-time operating timeframes.

In addition, NRECA along with the American Public Power Association, American Wind Energy Association, Utility Wind Integration Group (UWIG), Western Area Power Administration (WAPA), and the U.S. Department of Energy's Wind and Hydropower Technologies Program will be sponsoring a distributed wind interconnection workshop January 20-22, 2010 at WAPA's Electric Power Training Center (EPTC) in Golden, Colo. This workshop, which is conducted on an annual basis, focuses on the interconnection of wind turbines to electric cooperative and public power distribution systems. The workshop begins with an overview of wind energy technology, markets, distributed wind applications, economics, and development issues and opportunities. Following this overview, participants are instructed in the use of internet tools developed by the UWIG to assess the impact of wind generation on distribution systems. Training includes an introduction to the theory behind the use of each tool and practical examples of their use using actual cooperative feeder data. The workshop concludes with a demonstration of the EPTC's miniature power system, which includes a Wind Farm Simulator developed in partnership with the National Renewable Energy Laboratory (NREL) and the Wind Powering America Program, and an optional tour of the NREL's National Wind Technology Center. For more information, and to register, go to <http://windworkshop.govtools.us/>.

The following discussion provides an introduction to wind integration issues and approaches, which co-op decision-makers should consider in the earliest stages of project development. Key considerations include

- Wind resource variability
- Capacity requirements
- Integration strategies
- Integration studies
- Transmission access
- Alternatives if access is limited.

## 4.1 Wind Resource Variability

One indication of changing thinking about wind integration is a shift in language. Utility planners used to describe wind resources as *intermittent*, to differentiate them from highly available, dispatchable generating resources. But this characterization of intermittency implies that wind is a highly unpredictable, unreliable resource. As wind experts have become better at adapting weather forecasting tools and as wind technologies have improved, this characterization has changed. Today, wind is more often referred to as a *variable* resource. The output of wind plants varies very little in the time frame of seconds (0.1 percent), somewhat in the time frame of minutes (3 percent), and more in the timeframe of hours (10 percent). Seasonally, it tends to vary a great deal, but generally in keeping with predictable patterns. As wind experts understand the resource better, they have developed models to help electric system operators to make the best possible use of wind resources, in concert with other resources and loads on the grid.

## 4.2 Capacity Requirements

Utility planners recognize that wind is primarily an energy resource. However, a wind plant does have some capacity value. A wind plant's nameplate capacity does not go into the equation for meeting regional generation capacity needs. Neither does the wind plant's average capacity factor necessarily represent its capacity value to utility planners; that value may be greater or less, depending on the coincidence of wind resource availability with peak system demand. To date, no conventional generation has been built in the U.S. specifically to compensate for wind's variability due to the regulation margin built into the existing system. At very high levels of wind penetration however (e.g., 10 to 20 percent), additional regulation capacity may be required.

AWEA offers the following clarifications:

**Capacity factor** is the ratio between the average amount of electricity that a power plant produces and its peak power output. Capacity factors vary depending on the type of power plant and its purpose. Natural gas peaking plants may run only part of the time, for example, resulting in capacity factors of 10 to 20 percent. Other power plants may run most of the time, unless idled by equipment problems or for maintenance. A capacity factor of 40 to 90 percent is typical for conventional intermediate and base load plants.

For wind plants, capacity factor depends mostly on the average wind speed at the site. Since wind speed varies, wind plants *on average* operate at about 25 to 40 percent of their peak power. That is their capacity factor. Note that wind plants generally operate at some level of output up to

their nameplate rating over two-thirds of the time throughout the year. Capacity factor is simply the measure of their performance on average throughout the year.

**Capacity value** is the expected amount of capacity that a wind plant can contribute to meeting annual system peak loads. Wind capacity value depends on the statistical probability that wind generation will coincide with peak customer demand and other system characteristics. As wind technology improves and more production data becomes available, utility planners have started to become more comfortable giving wind generation some capacity value.

The measure for this value is called effective load-carrying capacity (ELCC). It is calculated by determining the increase in load that can be met by an additional generator—in this case, a wind plant—based on meeting the same reliability expectations that would be expected of any generating resource. Using available planning and system operating tools, studies estimate that wind can provide an ELCC of 10 to 40 percent of nameplate capacity (but typically on the lower end of this range). Thus, wind does not make a great contribution to system capacity, but it can contribute to overall grid reliability.

## Wind Energy Storage

A number of technologies are available that can store wind energy, resolving many of the operating issues surrounding wind's short-term variability. For example, capacitors smooth power on the scale of a few seconds; flywheels may store power for a minute or two; flow batteries, though still expensive, may store wind energy in the timeframe of an hour or so. Still, energy storage over a longer time frame could support wind markets where the resource is abundant off-peak or during the "shoulder seasons" of the year.

Compressed Air Energy Storage (CAES) could become popular for longer-term storage of wind energy, if a test project in Iowa proves successful. The project, called the Iowa Stored Energy Park, is cosponsored by about 100 municipal utilities in Iowa, Minnesota, and the Dakotas, with additional funding from the U.S. DOE and the state of Iowa. It has an estimated price tag of \$200 million and is currently in advanced planning stages.

The cost would pay off if the fuel-free technology proves viable. A multi-turbine wind plant will be constructed, and the off-peak wind energy it produces will be used to compress air and pump it into a geologically stable cavern underground. The 3,000 foot deep cavern will store the compressed air until it is needed, when it will be released to run generating turbines, with a capacity up to 260 MW. Similar CAES plants already operate in Germany and in Alabama. However, this would be the first CAES plant to run on wind power. Construction is expected by 2011. Once operating, the plant will provide power generated by wind, "on demand" for most of the year. See <http://www.isepa.com> for details.

In the Northwest, the Bonneville Power Administration has tested using off-peak wind to increase hydropower storage. Basin Electric Cooperative in North Dakota is pursuing the research and development of hydrogen fuels, which could be made with wind power for use in the transportation sector. These and other technologies on the near horizon could change the market for wind and for other renewable energy resources.

## 4.3 Integration Strategies

Utility-scale wind projects usually interconnect with the transmission grid. Thus, the Federal Energy Regulatory Commission (FERC) has regulatory authority over many wind integration issues. Recent FERC orders—notably Order 661 & 661-A—have affected wind integration in important areas, including:

- Low voltage ride-through,
- Voltage support and dynamic reactive capability,
- New transmission planning,
- Transmission reservation,
- Scheduling and imbalance, and
- The role of the North American Electric Reliability Corporation (NERC).

In the area of low voltage ride-through, wind generating plants are now required to remain in service during three-phase faults with normal clearing and single line-to-ground faults with delayed clearing. They are expected to return to pre-fault voltage unless clearing the fault effectively disconnects the generator from the system. Specific aspects of the standard include time parameters. Wind plants interconnected to the grid through a radial line may not be required to ride through a fault on that radial line, but they must meet high standards for recovery. Past practices, whereby a wind plant might simply drop off the grid during a low-voltage event, had

little impact when the amount of installed wind capacity was not significant, but as wind penetration increases, wind plant performance must be comparable to that of other generators.

The industry is also working to meet new standards for dynamic reactive capability. Here the problem stems from the fact that most wind turbines use induction motors and require an electrical field provided by the grid. This consumes reactive power, measured in VARs. Generator designs may be improved to control reactive power with a range of plus or minus 0.95. If the interconnection study shows a need for improved reactive capability in order to protect the grid, then Order 661 would require it. While this protection could be a costly retrofit on older wind turbines, many new designs provide this capability directly from the power electronics that control real power operations.

Likewise, new standards for Supervisory Control and Data Acquisition (SCADA) capabilities are familiar to today's wind plant operators. The ability to use sophisticated electronic communications and controls enhances grid reliability and—in the long run—wind plant cost effectiveness. Co-ops that are engaged in wind development need to anticipate not only the need for up-to-date SCADA equipment, but also the need for the necessary staff training.

According to a summary of interconnection policies and progress provided in the *IEEE Power and Energy Magazine* (November/December 2007), the wind industry is responding well to these new requirements.

#### **4.4 Integration Studies**

Detailed guidance on developing wind integration studies may be found with the Utility Wind Integration Group (<http://www.uwig.org>) and summarized in the professional literature, such as the integration issue of the *IEEE Power and Energy Magazine* (November/December 2007) and its references. The discussion here provides a brief introduction.

There are two distinct purposes for wind integration studies, and study methodologies will differ depending on their purpose. The most common wind integration studies are focused on technical requirements to bring a project from planning to successful commissioning. These studies focus on modeling grid performance including the proposed wind plant, to determine specific line and substation upgrades and communications and control equipment needed in the wind development process. These studies may also look at integration costs related to wind plant operation, but from the perspective of what is specifically required and at what cost to the developer and its wholesale customer(s).

A different perspective would be broader, resulting in integration studies that focus more on regional electricity markets and operations. These integration studies ask “what if” questions about current and expected market conditions. They provide information not only for wind developers, but also for regional transmission operators and regulators. Such studies are especially useful for regional transmission- and resource - development planning.

Regional electricity market and system operations integration studies usually require modeling a “no wind” case from benchmark data and then modeling the variability and uncertainty that a given wind plant would impose on the system. Modeling is typically repeated for three different time frames:

1. Under one minute, to determine needs for frequency regulation by automatic controls;
2. Minutes to hours, to determine load following needs, typically handled by economic dispatch and operator actions, based on short-term load and generation forecasts and daily schedules for generating unit commitments;
3. Hours to days, to determine unit commitment, based on wind forecast information and information about expected loads and generating units.

Marked improvements in wind forecasting have resulted in lower wind integration risks and lower associated costs. The ability to model the behavior of specific wind turbines in a large wind plant is also useful; resource diversity—even at one site—diminishes the risk of sudden, dramatic changes in wind resource availability.

The table below summarizes the findings of recent wind integration studies. While these studies are not perfectly comparable, they provide an order-of-magnitude estimate of the associated costs of integrating wind generation at various levels of capacity penetration in various utility systems.

**Table 4.1**  
Key Results from Recent Wind Integration Studies

Date	Study	Wind Capacity Penetration	Cost (\$/MWh)				TOTAL
			Regulation	Load Following	Unit Commitment	Gas Supply	
2003	Xcel-UWIG	3.5%	0	0.41	1.44	na	1.85
2003	We Energies	29%	1.02	0.15	1.75	na	2.92
2004	Xcel-MNDOC	15%	0.23	na	4.37	na	4.60
2005	PacifiCorp	20%	0	1.60	3.00	na	4.60
2006	CA RPS (multi-year)*	4%	0.45	trace	trace	na	0.45
2006	Xcel-PSCo	15%	0.20	na	3.32	1.45	4.97
2006	MN-MISO**	31%	na	na	na	na	4.41
2007	Puget Sound Energy	10%	na	na	na	na	5.50
2007	Arizona Public Service	15%	0.37	2.65	1.06	na	4.08
2007	Avista Utilities***	30%	1.43	4.40	3.00	na	8.84
2007	Idaho Power	20%	na	na	na	na	7.92

\* regulation costs represent 3-year average

\*\* highest over 3-year evaluation period

\*\*\* unit commitment includes cost of wind forecast error

Source: Berkeley Lab based, in part, on data from NREL.

Source: U.S. DOE *Annual Report on U.S. Wind Power Installation, Cost, and Performance Trends: 2007*.

Recent integration studies have highlighted the importance of looking at the performance of the electrical system as a whole rather than trying to isolate the wind plant and balance it in isolation. Wind engineers sometimes compare a wind plant’s performance to the variability of customer-driven system load. Grid operators have successfully dealt with swings in load—without necessarily controlling it—for decades, and they can adapt that understanding to dealing with the variability of wind resources.

A longer list of suggested wind integration strategies, generally supported by the wind industry, is listed below. This list does not reflect NRECA's specific positions on developing regulatory policies, but NRECA is engaged with all the stakeholders in this changing utility landscape.

### **Technical and Operational Strategies to Improve Wind Plant Integration**

Wind proponents cite the following as strategies to improve wind plant integration.

- Incorporation of wind forecasts into standard utility operations planning tools
- Increases in geographic diversity
- Coordination with generating capacity that has good ramping and load-following capability
- Assignment of real-time control of wind generators to larger control areas
- More use of customer load-management technology and markets for price-responsive loads
- Turbine advances, such as low-speed wind turbines that extend resource availability
- Electricity storage, including pumped hydropower and compressed air energystorage

## **4.5 Transmission Access and Alternative Solutions**

Like all generating facilities, wind plants require transmission access. But wind plants present two major concerns that most other generating facilities do not:

1. Wind resources are often greatest in remote places, which may not have good transmission service;
2. Because wind is variable throughout the year, it may be difficult or costly to reserve transmission capacity, in competition with conventional resources, even where transmission exists.

These problems have challenged the wind industry and the utility industry at large.

FERC has set forth interconnection rules, generally directed by Order 2003A on Large Generator Interconnection Agreements and Procedures. FERC Order 661 and 661-A provide updated guidance to help wind developers bring their plants online in an orderly fashion. Yet a tremendous amount of work remains in this area, especially where the need for entirely new transmission lines is at issue.

The DOE *Annual Report on U.S. Wind Power Installation, Cost and Performance Trends for 2007* cited several recent developments that indicate progress at removing transmission barriers. Section 216(a) of the Federal Power Act (created by section 1221(a) of the Energy Policy Act of 2005) directs DOE to identify transmission congestion and constraint problems. In addition, section 216(a) authorizes the Secretary, in his discretion, to designate geographic areas where transmission congestion or constraints adversely affect consumers as National Interest Electric Transmission Corridors (NIETC). The first two designated NIETCs are the Mid-Atlantic Area National Corridor (Docket No. 2007-OE-01) and the Southwest Area National Corridor (Docket No. 2007-OE-02). The affected states are: Delaware, Washington DC, Maryland, New Jersey, New York, Ohio, Pennsylvania, Virginia, and West Virginia.

A National Corridor designation itself does not preempt state authority or any state actions. The designation does not constitute a determination that transmission must, or even should, be built;

it is not a proposal to build a transmission facility and it does not direct anyone to make a proposal to build additional transmission facilities. Furthermore, a National Corridor is not a siting decision, nor does it dictate the route of a proposed transmission project. The National Corridor designation serves to spotlight the congestion or constraint problems adversely affecting consumers in the area and under certain circumstances could provide FERC with limited siting authority pursuant to FPA 216(b).

These designations serve as an important indication by the federal government that, at a regional level, a significant transmission constraint or congestion problem exists – one that is adversely affecting consumers and that has advanced to the point where we have a national interest in alleviating it. In other words, the federal government is not dictating how the states, regions, transmission providers or electric utilities should meet their energy challenges. It is a way of focusing attention on the areas of the country that are most congested – and whose consumers stand to benefit most from alleviation of it.

On a more specific level, the designation of a National Corridor is a necessary first step in providing the federal government – through the Federal Energy Regulatory Commission – siting authority that supplements existing state authority. The Energy Policy Act of 2005 provides a potential siting venue at FERC for transmission facility proposals within a National Corridor. In practice, this will mean that if an applicant does not receive approval from a state to site a proposed new transmission facility within a National Corridor, the applicant may then apply to FERC for a permit and authorization to construct the facility. If FERC accepts the application, before it would issue a permit, it would conduct a full National Environmental Policy Act review and consider alternatives. Such a federal permit would empower the project developer to exercise the right of eminent domain to acquire necessary property rights to build the facilities. However, that authority could only be exercised if the developer could not acquire the property by negotiation, and even then would not apply to property owned by the United States or a state, such as a national or state park.

The first two designated NIETCs are the Mid-Atlantic Area National Corridor (Docket No. 2007-OE-01) and the Southwest Area National Corridor (Docket No. 2007-OE-02). The National Corridor’s boundaries coincide with county boundaries. The states affected by the Mid-Atlantic Area National Corridor designation are Delaware, Washington DC, Maryland, New Jersey, New York, Ohio, Pennsylvania, Virginia, and West Virginia. The counties included in this National Corridor, by state, are:

#### DELAWARE

Kent County  
New Castle County  
Sussex County

#### WASHINGTON, DC

#### MARYLAND

Allegany County  
Anne Arundel County  
Baltimore City  
Baltimore County

Calvert County  
Caroline County  
Carroll County  
Cecil County  
Charles County  
Dorchester County  
Frederick County  
Garrett County  
Harford County  
Howard County  
Kent County  
Montgomery County  
Prince George's County  
Queen Anne's County  
St. Mary's County  
Talbot County  
Washington County  
Wicomico County  
Worcester County

#### NEW JERSEY

Atlantic County  
Bergen County  
Burlington County  
Camden County  
Cape May County  
Cumberland County  
Essex County  
Gloucester County  
Hudson County  
Hunterdon County  
Mercer County  
Middlesex County  
Monmouth County  
Morris County  
Ocean County  
Passaic County  
Salem County  
Somerset County  
Sussex County  
Union County  
Warren County

#### NEW YORK

Alba County  
Bronx County

Broome County  
Cayuga County  
Chenango County  
Clinton County  
Columbia County  
Delaware County  
Dutchess County  
Erie County  
Franklin County  
Fulton County  
Genesee County  
Greene County  
Herkimer County  
Jefferson County  
Kings County  
Lewis County  
Livingston County  
Madison County  
Monroe County  
Montgomery County  
Nassau County  
New York County  
Niagara County  
Oneida County  
Onondaga County  
Ontario County  
Orange County  
Orleans County  
Otsego County  
Putnam County  
Queens County  
Rensselaer County  
Richmond County  
Rockland County  
St. Lawrence County  
Saratoga County  
Schenectady County  
Schoharie County  
Seneca County  
Suffolk County  
Sullivan County  
Ulster County  
Wayne County  
Westchester County  
Wyoming County

## OHIO

Belmont County  
Carroll County  
Columbiana County  
Harrison County  
Jefferson County  
Monroe County  
Stark County

## PENNSYLVANIA

Adams County  
Allegheny County  
Armstrong County  
Beaver County  
Bedford County  
Berks County  
Blair County  
Bradford County  
Bucks County  
Butler County  
Cambria County  
Carbon County  
Centre County  
Chester County  
Clearfield County  
Clinton County  
Columbia County  
Cumberland County  
Dauphin County  
Delaware County  
Fayette County  
Franklin County  
Fulton County  
Greene County  
Huntingdon County  
Indiana County  
Jefferson County  
Juniata County  
Lackawanna County  
Lancaster County  
Lebanon County  
Lehigh County  
Luzerne County  
Mifflin County  
Monroe County  
Montgomery County

Montour County  
Northampton County  
Northumberland County  
Perry County  
Philadelphia County  
Pike County  
Schuylkill County  
Snyder County  
Somerset County  
Susquehanna County  
Union County  
Wayne County  
Washington County  
Westmoreland County  
Wyoming County  
York County

#### VIRGINIA

Arlington County  
Clarke County  
Culpeper County  
Fairfax County  
Fauquier County  
Frederick County  
Loudon County  
Madison County  
Page County  
Prince William County  
Rappahannock County  
Rockingham County  
Shenandoah County  
Stafford County  
Warren County  
City of Alexandria  
City of Harrisonburg  
City of Fairfax  
City of Falls Church  
City of Manassas  
City of Manassas Park  
City of Winchester

#### WEST VIRGINIA

Barbour County  
Berkeley County  
Boone County  
Braxton County

Brooke County  
Calhoun County  
Clay County  
Doddridge County  
Gilmer County  
Grant County  
Hampshire County  
Hancock County  
Hardy County  
Harrison County  
Jackson County  
Jefferson County  
Kanawha County  
Lewis County  
Marion County  
Marshall County  
Mason County  
Mineral County  
Monongalia County  
Morgan County  
Nicholas County  
Ohio County  
Pendleton County  
Pleasants County  
Pocahontas County  
Preston County  
Putnam County  
Randolph County  
Ritchie County  
Roane County  
Taylor County  
Tucker County  
Tyler County  
Upshur County  
Webster County  
Wetzel County  
Wirt County  
Wood County

The states affected by the Southwest Area National Corridor designation are Arizona and California. The counties included in this National Corridor, by state, are:

ARIZONA  
La Paz County  
Maricopa County  
Yuma County

## CALIFORNIA

Imperial County

Kern County

Los Angeles County

Orange County

Riverside County

San Bernardino County

San Diego County

On March 6, 2008, the Department of Energy issued an order denying all applications for rehearing and requests for stay of the Department's National Electric Transmission Congestion Report and Order (72 FR 56992 10-5-07). This final agency action was effective upon publication in the Federal Register. Since then, several entities have filed suits protesting these decisions.

In the meantime, DOE began the work required by Congress to conduct the 2009 congestion study, including a series of public workshops to gather information about what data to collect and how to collect and analyze it. For more information, visit the DOE Office of Electric Delivery and Energy Reliability Web site at <http://nietc.anl.gov>.

Several state and regional transmission policy projects have also emerged. A full summary, compiled by Exeter Associates for the NREL Wind Technology Center, is referenced in the Appendix of this handbook. The policy projects covered include:

- California ISO Location Constrained Resource Interconnection
- Texas Competitive Renewable Energy Zones
- Colorado Energy Resource Zones
- Bonneville Power Administration Commercial Infrastructure Policy
- MISO Regionally Planned Generator Interconnection Project
- California PUC Transmission Back Stop.

In addition, AWEA tracks new transmission projects nationwide, at [http://www.awea.org/policy/regulatory\\_policy/transmissionexpansion.html](http://www.awea.org/policy/regulatory_policy/transmissionexpansion.html).

In the West, the Western Governors Association (WGA) has called for 30,000 MW of new clean energy, including wind, by 2015. This policy has led to interstate collaboration on developing new transmission and to development of new transmission "products." For example, the WGA project has called for a classification of transmission service called conditional firm. Wind resources that have conditional firm service would have firm transmission on the grid except during times of peak demand, when their service could be curtailed. This can be an affordable solution for wind projects that are focused more on energy- than capacity-resource economics.

Transmission expansion is almost always a difficult undertaking, since transmission corridors cut through many jurisdictions and across land owned or controlled by numerous individuals and agencies. In some cases, wind proponents can become good allies in developing transmission projects that are actually needed for a variety of reasons. Industry experts sometimes encourage

utilities to look at more distributed wind generating options—for example a series of smaller wind plants installed near the loads—which may not require regional transmission service at all.

In 2008, the wind industry and U.S. DOE completed a collaborative effort to look at the costs and benefits of a 20% nationwide market penetration for wind. Assessing the need for new transmission was part of that effort. The map in Figure 4.1 shows the location of the nation’s greatest wind resources against existing and proposed transmission service.

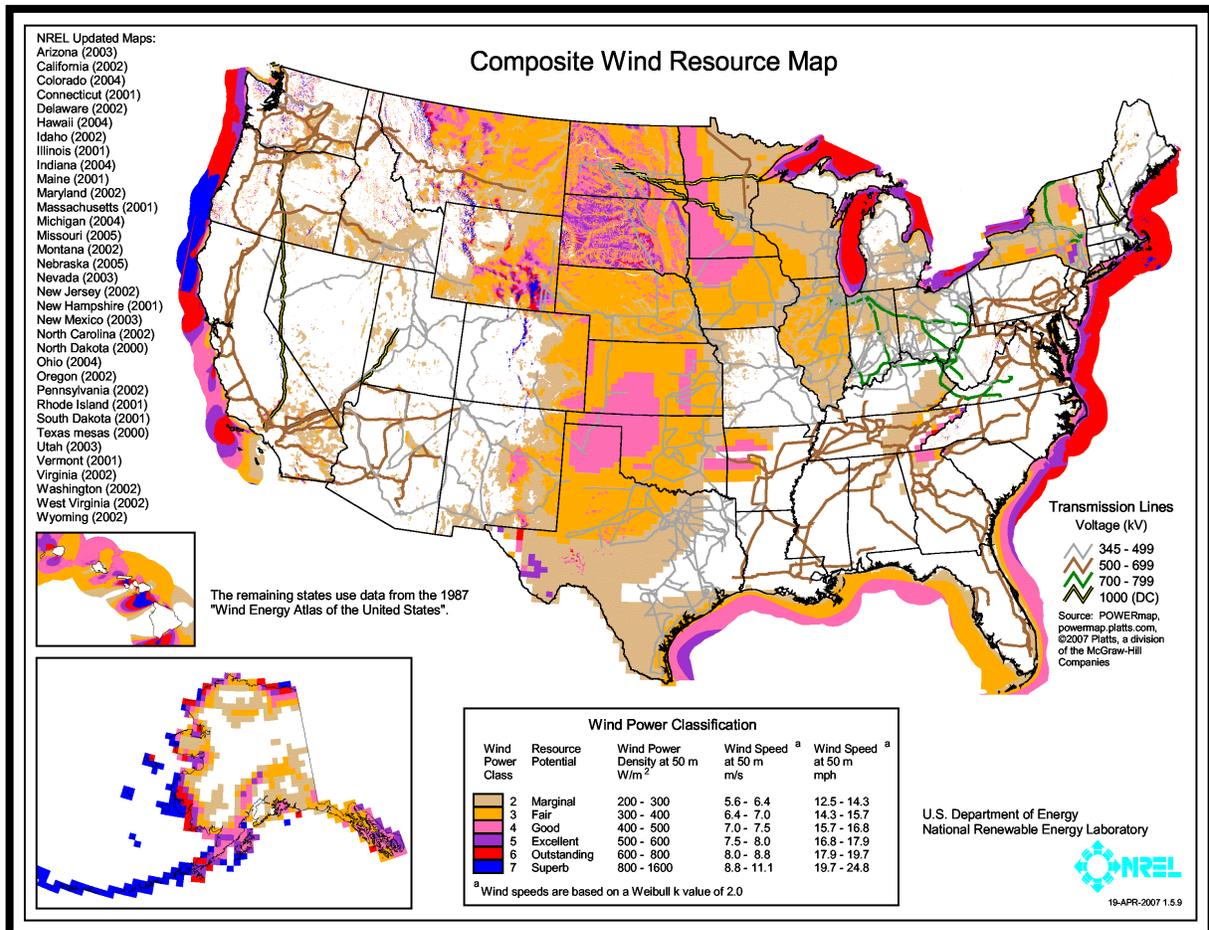


Figure 4.1. A Vision of Transmission Needs for 20% Wind Penetration Nationwide  
 Source: AEP and U.S. DOE 20% Wind Collaborative, 2007.

## SECTION FIVE

### The Wind Development Process

#### 5.0 Overview

The preceding discussion of wind resource and siting considerations is a prelude to the wind development process. This is a five-step process (Figure 5.1), which could be initiated by the co-op or by a developer who subsequently approaches the co-op to become a wind buyer. These steps include:

- Technical assessment,
- Project design and specification,
- Economic/business planning,
- Regulatory assessment, and
- Procurement, construction, and commissioning.

None of these steps is strictly defined; *they all overlap and interact to some degree*. For example, the project design could be adjusted during the economic modeling and business planning step. Economic modeling and business planning could be affected by outcomes of the regulatory assessment, and so on. Still it is useful to think of the wind development process in steps, each of which is necessary to bring a project to completion.

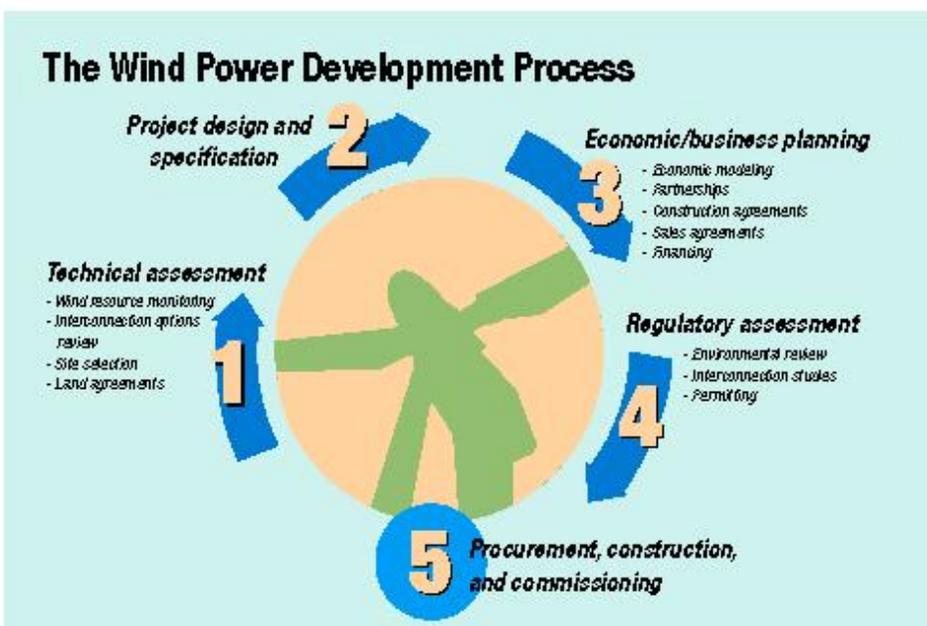


Figure 5.1. Wind Power Project Development.  
Source: Wind Powering America.

Co-ops that plan to use a purchase contract to acquire wind should focus mostly on economic modeling and business planning. However, smart business planning includes making sure wind suppliers are credit-worthy and have a solid technical plan.

## **Project Development Milestones**

In practice, any wind development process will be marked by a number of milestones. The exact sequence and definition of these steps will differ based on the project. Typically, the process takes place over two to three years.

1. Establishment of the co-op role;
2. First overview of the process, including technical, economic, and regulatory steps;
3. Feasibility study, including interconnection modeling and review of financing options;
4. Design decisions: ownership, interconnection, power sales, financing, procurement;
5. Investment grade feasibility study;
6. Agreements and contracts;
7. Completion of regulatory steps;
8. Completion of construction specifications; bid process and contracts;
9. Construction; and
10. Commissioning.

### **5.1 At the Outset: Establishing the Co-op Role**

Case study experience with wind development by electric co-ops and municipal utilities suggests that the utility might not want to define its ultimate role as project owner, co-owner, or wind buyer at the outset. A co-op may use the early steps in wind development to decide exactly how to design the project. Sometimes, the relationships established during the technical assessment step leads to strong development partnerships.

At the outset, it is important for the co-op to:

- Establish a high-level commitment and timeframe for decision-making,
- Set the tone for positive relations with the communities and customers who will be affected, and
- Get expert help, as needed, to answer technical and economic questions.

Engineering consultants, wind technology suppliers, and wind developers all have expertise to offer, though there may be strings attached. Networking through co-op organizations and wind-industry networks and consulting with government-sponsored programs, such as Wind Powering America, can be very helpful.

### **5.2 Step 1: Technical Assessment**

Some aspects of the technical assessment have been introduced in the sections above. The goals of the technical assessment typically include:

- To assess the feasibility of wind sites in terms of wind output, grid interconnection, and land-use agreements,
- To estimate project output and cost-effectiveness, and
- To suggest challenges and solutions for better project design and development.

In short, this phase of project development tells project sponsors and investors if it is worth moving forward and in which general direction—before the costs of wind development begin to add up.

### **5.2.1 Site Considerations**

The technical assessment begins with identification of one or more feasible wind sites. Co-ops should pursue wind resource monitoring, as described in Section 2 of this handbook. It will take time to collect and analyze wind data if it is not already available. The co-op then must match wind resource information with possible sites for grid interconnection. A wind project engineer can give a preliminary assessment of interconnection requirements and costs. If the co-op does not own the prospective wind sites, it must find out if wind developers already hold wind leases with landowners or if public (county, state, or federal) lands in the area are available for development.

It is important for the potential wind developer to look into zoning and permitting requirements before finalizing a lease. Sometimes it is quick and easy to obtain all needed permissions. In general, private agricultural or non-zoned properties are easiest to convert to use for wind development. However, if the co-op or wind developer has a good relationship with local government, then township or county land might be a good choice. Several small wind projects have been developed on public landfill sites, and at least one large wind project, near Sacramento, California, is located on city-owned land. Permitting for federal- and state-controlled land has been difficult in the past, but new policies encourage wind development on public lands. A 2003 publication from NREL and the Department of Interior, *Assessing the Potential for Wind Development on Public Lands*, opened the door for quicker wind development, especially in Western states (see [http://www.eere.energy.gov/windandhydro/windpoweringamerica/public\\_lands.asp](http://www.eere.energy.gov/windandhydro/windpoweringamerica/public_lands.asp)).

A complete regulatory assessment will come later in the wind development process, but land use and permitting requirements should get a good review early on, before the parties sign a wind development lease.

A private land lease agreement should include a) right of access to and across the property for project construction, operation, and maintenance, b) right to transmit electricity off the property, and c) a term at least as long as the expected life of the project (at least 20 to 30 years). The lease may include some limitations on the construction project and some provisions for site restoration at the end of the term. The cost of the lease is usually paid as a royalty. This could be a fixed fee per kW produced or a percentage of the gross revenue of the project. Some landowners prefer the percentage of gross revenue as a way to share in the increasing value of wind resources in the future.

### **5.2.2 Overview of Technical Issues**

The technical assessment includes an overview of technical issues. Detailed project design and specifications are separate steps. This overview of technical issues relates directly to the site and situation. For example, what kind of turbine is best suited to the wind resource at this site? How much construction will be required to make the interconnection? Does the co-op have more than one option for interconnection that is worth considering?

Co-ops may want to investigate equipment availability at this stage, too. For example, if the wind project will be relatively small, it may have to wait for access to turbines. Some cooperatives have some projects may want to combine their order for turbines with others to get better deliveries and prices. This can be a win-win situation. If the co-op wishes to finance the project using Clean Renewable Energy Bonds (CREBs), it must be able to secure turbines on a schedule that meets requirements for CREBs awards and expenditures.

### 5.2.3 Economic Feasibility

A project funded by the Minnesota state legislature for the Minnesota Municipal Utilities Association (MMUA) outlines a process for wind development that is fairly compatible with the one presented here. *A Practical Guide to Wind Energy Development*, by MMUA and the Center for Energy and Environment, July 1999, suggests that the initial technical assessment should conclude with a quick estimation of project output and cost effectiveness, from the utility's point of view. This may be a complicated exercise and MMUA suggests consulting an expert. A detailed utility economic feasibility analysis will be needed for project financing, so this exercise is good preparation. See <http://www.awea.com> for a listing of useful texts and for suggestions of how to find a wind consultant.

#### **Intermediate Assessment of Wind Project Economic Feasibility: A Sample Approach Suggested by the Minnesota Municipal Utilities Association**

1. Obtain wind data.
2. Correct the wind data for relevant local conditions.
  - a. Wind speed at hub height
  - b. Air density
3. Compute the annual wind energy density, based on local distribution of wind speeds.
4. Estimate the total amount of electricity that can be produced from the wind resource.
5. Estimate the annual output of each proposed turbine, using textbook methodologies.
6. Verify your estimate by comparing it to the nameplate rating of the turbine.
7. Estimate the capital cost of the wind turbine.
8. Estimate operation and maintenance costs (see Wind Integration section of this handbook).
9. Estimate the total net costs per kWh.
  - a. Consider federal incentives.
  - b. Consider state incentives.
  - c. Verify the status of incentive programs.
10. Estimate the reductions in transmission and distribution losses, if the project is local.
11. Calculate avoided wholesale energy charges.
12. Calculate the total costs avoided by wind power.
13. Estimate likely offset from voluntary green power subscriptions, if applicable.
14. Estimate the incremental cost of wind energy to your utility relative to current costs.

### 5.3 Step 2: Project Design and Specification

As co-op decision-makers review results of the technical assessment, they will be prepared to authorize project design. If the co-op wants to be directly involved as an owner or project partner, then this step will be very different than if the co-op decides to purchase wind power from a third-party developer. In the latter case, it may develop a request for bids to acquire wind resources from a third-party developer, using a Power Purchase Agreement (PPA). Basin Electric Power Cooperative, Great River Energy, Western Farmers Generating and Transmission Cooperative, and others may be possible sources for template documents. Depending on the size of the acquisition, consulting and legal expertise is suggested, too.

If the co-op decides to own or co-own a wind project, then it will be more deeply involved in the design and specification of the project. It may work with consulting engineers who specialize in wind development. The design team must begin design and specification early, but it cannot complete this step until the economic modeling is completed and business agreements are sealed. In turn, the economic modeling will require a fairly detailed assessment of the technologies and costs for the project (suggested in Table 5.1, Wind Project Cost Categories). This is an interactive process, which generally requires the help of skilled consultants.

**Table 5.1**  
Wind Project Cost Categories

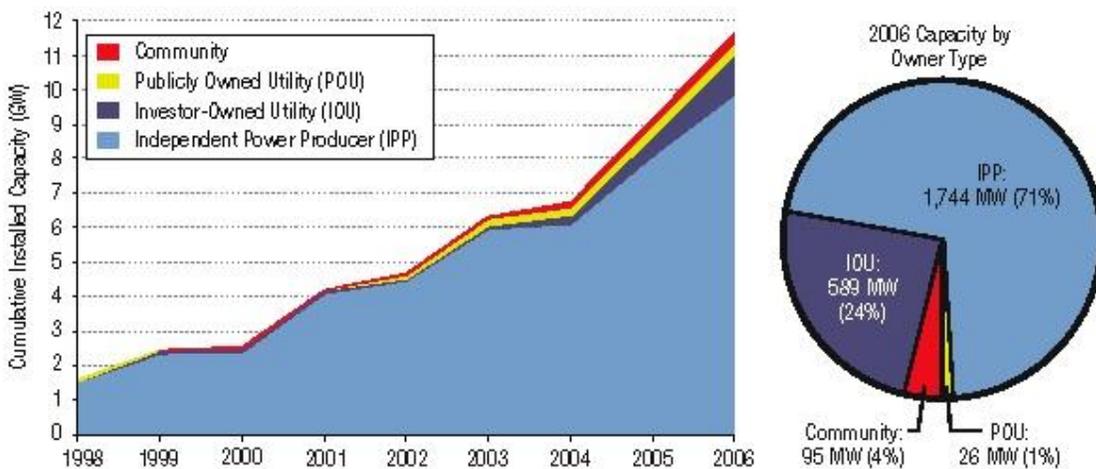
<b>Wind Equipment</b>	<b>Construction-Related</b>
Towers	Pre-approval maps, studies, and permits
Turbines	Site access and preparation
Blades	Foundation assembly
Electronics	Concrete
Interconnection infrastructure	Cabling
Warranties	Tower assembly and erection
	Turbine installation
	Interconnection to the utility
	Commissioning
	Overall project management

### 5.4 Step 3: Economic/Business Planning

This step in project development results in an investment-grade feasibility study, which subsequently results in power sales or purchase agreements, project financing, procurement, and construction.

Economic modeling takes into account the costs and benefits of every aspect of wind development over the life of the investment, which is usually 30 years. Typically this includes wind equipment costs, construction-related costs, O&M estimates, integration costs, system output, costs offset (including utility costs for a utility-owned project, such as environmental compliance, fuel savings, etc.), taxes, incentives, depreciation, equity rate of return, debt (interest rates and terms), debt to equity ratio, and other measures.

Project finance greatly impacts economic feasibility. For this reason, wind project finance—especially as it relates to the distribution of costs and benefits in multi-partner projects—has become a specialized field.



Source: Berkeley Lab estimates based on AWEA/GEC wind project database.

**Figure 5.2.** Almost all wind capacity built to date is owned by independent power producers. However, new incentives and financing structures make co-op wind ownership (here included in “public ownership”) increasingly attractive.

The four basic business models for electric co-op wind acquisitions are discussed below.

### 5.4.1 Utility Ownership Model

Some co-ops opt to invest directly and drive wind development from project design and financing through construction, commissioning, and the use or sale of wind power. Advantages to this approach include potentially lower costs and greater flexibility in balancing wind’s role in the resource portfolio. In the past, some wind plants have been cash-financed, but trends point to larger projects, using better financing instruments and longer terms.

The primary incentive that has driven wind development in the U.S. is the tax-based Production Tax Credit (PTC), which does not apply to electric co-ops or public power utilities. Wind development partnerships may pass some benefits of the PTC on to non-taxable partners (see below), but for the most part, the PTC is not useful in a co-op ownership model.

The Clean Renewable Energy Bond Program (CREBs) has provided a significant incentive for co-op wind projects, on par with the PTC. CREBs financing is administered by the U.S. Treasury and administered by the Internal Revenue Service. While co-ops must compete with other applicants for CREBs financing, it is a strong instrument for those who can use it (see details below).

Alternative incentives for co-ops include the Renewable Energy Production Incentive (REPI), an incentive program administered by the U.S. DOE. REPI is set at 1.5 cents per kWh, inflation adjusted. In 2007, it aimed to provide about 2 cents per kWh, although inadequate program funding meant that recipients received far less of a subsidy. To its credit, the REPI is mandated through 2026, to support projects initiated through 2016. However, adequate funding may not be available for all applicants in all years, since this is a budget-authorized program. For that reason,

REPI is usually treated as an extra benefit, but not as a central piece in any co-op wind financing plan.

The Rural Energy for America Program (REAP, previously called Section 9006 of the Farm Bill) offers additional incentives for co-op wind ownership. REAP provides grants and loan guarantees to farmers, ranchers and rural, small businesses for renewable energy development and energy efficiency improvements. The 2008 REAP cycle offered a total of \$176.5 million in loan guarantees and \$11.4 million in grants to support investments in renewable energy and energy efficiency improvements by agricultural producers and small businesses, including qualifying electric co-ops. Funding for future cycles is expected to increase, but co-ops are advised to check the status of the program at <http://www.usda.gov>. Other incentives that encourage utility ownership of wind projects are listed and updated frequently at <http://www.dsireusa.org>.

While these incentives have been crucial to wind development so far, it is important to note that some wind projects are cost-effective without access to special incentive programs.

### **CREBs Financing for Electric Co-op Wind Projects**

The Energy Tax Incentive Act of 2005, under Title XIII of the Energy Policy Act of 2005, established Clean Energy Renewable Bonds (CREBs) as a financing mechanism for public sector and co-op renewable energy projects. CREBs are designed with close to a 0% interest rate. Essentially, the borrower pays back only the principal of the bond, and the bondholder receives federal tax credits in lieu of the traditional bond interest. The financing mechanism is modeled on one used successfully for school finance.

In the first round of financing, the Treasury made \$800 million of tax credit bonds available. Of this, co-ops were eligible for a maximum total of \$300 million, with \$400 million set aside for government sector projects. Overall, the program was greatly oversubscribed, but about 90 percent of co-op applicants won financing. The IRS awarded the allocations on a "smallest-to-largest" project basis. Thirteen wind projects were among the 78 electric co-op renewable energy projects selected.

Plumas-Sierra Rural Electric Cooperative in California received the largest cooperative wind project allocation in the first round of CREBs awards. Plumas-Sierra received \$31 million in financing for the planned 25-MW Black Mountain Wind Project. That project also received support from the Rural Utility Service.

In the second round, the Internal Revenue Service made an additional \$400 million in CREBs financing available. Awards were announced in February 2008. As in the first round, the program was greatly oversubscribed.

In the electric cooperatives sector, 28 applicants requested a total of \$170 million. Awards totaled \$143 million for projects ranging from \$300,000 to \$30 million. Approved projects included 14 wind projects, as well as projects involving landfill gas (4), hydropower (6), solar (1) and open-loop biomass (1) technologies.

Governmental borrowers, including counties, cities, municipal utilities, and others, submitted applications for the same cycle totaling \$728 million. \$263 million was awarded for 286 projects, in increments ranging from \$15,000 to \$2.95 million. Eighty-eight of these were wind projects.

In 2008, Congress authorized an additional \$800 million overall for CREBs that can be applied for in 2009, and made modifications to the program. For more information see <http://www.irs.gov> or contact the Cooperative Finance Corporation, <http://www.nrucfc.org>, which has assisted with most of the successful electric co-op CREBs applications.

### **5.4.2 Power Purchase Agreement Model**

Power purchase agreements are familiar to electric co-ops that do not own all their own generating resources. As applied to wind power, a Power Purchase Agreement (PPA) is a long-term agreement between the seller of wind energy and the purchaser. For the non-utility wind developer, securing a PPA is often crucial because it assures a long-term revenue stream from the project and provides evidence that the energy is needed by the purchaser. The PPA usually must be secured before financing can move ahead.

From the electric co-op's perspective, the purchase model is attractive because it allows the co-op to:

- Outsource expertise needed for wind project development, maintenance, and operations,
- Outsource many project risks, including financing risk,
- Specify the amount of wind power it needs and the terms of delivery, and
- Enjoy cost advantages associated with large, private wind developers and marketers.

While price terms are often considered the most important element of a PPA, typical PPAs include other important provisions, too. These address issues such as the length of the agreement, commissioning process, "take-or-pay" or curtailment agreements, early termination rights, construction milestones, defaults and penalties, and ownership of credit flowing to the project owner and power purchaser. Co-ops that have used the PPA approach have found that it is crucial to ask "what if" questions, to be sure the PPA agreement will work for them under changeable wind production and market conditions.

### **5.4.3 Innovative Financing Partnership Model**

Since the PTC is not directly useful to electric co-ops and other tax-exempt entities, most wind projects rely on private developers. In recent years, these developers have tested financing structures that use partnerships, including investors with large tax appetites and community or utility partners who bring other kinds of value to a wind project.

Note that some wind developers will use a tax-partner structure to finance the wind project, while presenting the electric co-op with a fairly standard PPA. In these cases, the co-op must carefully assess the developer's credit-worthiness, but it does not become directly involved in project finance.

One common partnership structure is generically called a flip. Here, the tax benefits and most of the cash benefits flow to the tax investor until the wind asset is depreciated. After the depreciation period, the cash benefits are "flipped" primarily to the project developer and both parties earn their required returns on investment. In this structure, the electric co-op might take on the role of joint developer. In some cases, the co-op would become the long-term owner of the wind asset—a logical role for a utility. Alternatively, depending on regulatory requirements and tax-benefit accounting, a separate entity might acquire and maintain the wind plant for the long term.

According to at least one study from the U.S. DOE Lawrence Berkeley National Laboratory, consumer-owned utilities can use REPI or CREBs financing to achieve a levelized cost of wind energy that is as low, or lower than the flip model provides. However, in a highly competitive market for wind development, co-ops may want to consider innovative partnership structures for

other reasons (e.g., to share project risk, capture economies of scale). For example, members of the Last Mile Electric Cooperative in the Northwest are utilizing a separate LLC wind development company that includes investment firms, to complete a 200-MW wind project. Four sponsoring utilities have entered into long-term PPAs with the new entity, White Creek Wind I in Oregon. They will have the option to repurchase the project after ten years.

Co-ops must be very cautious in their approach to innovative financing, relying on their own judgment and on legal and accounting expertise. At the same time, it is likely that tax partnership structures will be used by co-ops and municipal utilities more and more, especially for large wind projects. One good source of background information is the report on *Wind Project Financing Structures: A Review and Comparative Analysis*, September 2007, from U.S. DOE, Lawrence Berkeley Laboratory, <http://etid.lbl.gov/ea/emp>. That report is geared primarily to investor-owned utilities and other private developers, but it offers useful insights on seven generic project financing structures.

#### **5.4.5 Wind Acquisition by Certificate Model**

One more model exists for electric co-ops that want to support wind development. They can purchase the green attributes of wind and other renewable energy resources without actually taking delivery of the green kilowatt-hours. The utility industry tracks and trades these green attributes via tradable renewable certificates also known as green tags or renewable energy certificates (RECs). RECs are also the currency for tracking utility compliance with state renewable portfolio standards. One REC represents the green attributes of one megawatt-hour of renewably generated electricity.

More than 20 companies offer certificate-based green power products directly to retail customers, usually sold over the Internet. But utilities may purchase RECs at wholesale and re-bundle them with their conventional electricity to create a green power product for their customers.

Some co-ops buy RECs from a specific wind project. More often, they buy RECs from a green power marketer that works with diverse market sources. This approach offers several advantages:

1. Co-ops that use RECs can support green power regardless of local resource conditions. For example, coops in the Southeast may not have access to wind energy, but they can buy RECs from projects located in the mountain states.
2. Co-ops can obtain wholesale RECs through contracts that ensure delivery on time and in the right amounts. REC contracts tend to be shorter and more flexible than power purchase agreements. This is advantageous for serving changeable green power programs.
3. Some utilities buy RECs to support their voluntary green power programs, but use utility-owned wind resources as well. In this way, they know they can meet rising consumer demand for green power, regardless of whether they want to own significant wind resources.

A utility that buys RECs must evaluate the provider and the contract carefully. Some wholesale REC marketers certify their products, so customers know the origin of the REC and that the green attributes were not sold more than once.

By the same token, some co-ops that have no regulatory mandate for renewable energy can develop wind resources and then sell the RECs to other utilities that do. The only problem is that customers will continue to perceive that they are served by green kilowatt-hours, so long as they can see the wind machine poised on a nearby ridge. It is difficult to explain the concept of a disembodied REC to most electric customers.

### **Green Pricing on the Rise**

According to the National Renewable Energy Laboratory, more than 750 utilities nationwide, including more than 300 electric distribution cooperatives and G&Ts, offer green pricing programs. Through these programs, more than half of all U.S. electric customers have the choice to voluntarily support renewable energy development. They may purchase some portion of their power supply as renewable energy—almost always at a higher price—or contribute to a fund that helps the utility invest in renewable energy development. The term “green pricing” refers to all these programs.

In addition to utility-sponsored green pricing programs, customers may support renewable energy through dozens of non-utility programs, many of them selling over the Internet. Altogether, green pricing programs supported the sale of 12 billion kilowatt-hours (kWh) of renewable energy in 2006, or about 0.3% of total U.S. electricity sales. Wind energy provided 62 percent of these green power sales, followed by biomass (23%), geothermal (7%), hydropower (6%), and solar (1%).

Specifically, utility green power sales increased by 33 percent from 2004 to 2005, and by 39 percent from 2005 to 2006. Some of these programs sell “whole wind,” meaning the output of identifiable wind turbines, owned or under contract to the co-op. Others deal in green tags or RECs that represent the environmental attributes of wind power generated at one or more wind sites. Either way, customers can know that they support wind and other renewable resources through their participation. Co-ops generally have been successful in gaining customer support for their programs. For years, the National Renewable Energy Laboratory has ranked co-ops among the top green pricing programs in the country, based on participation rates. These include Holy Cross Energy in Colorado with nearly 6 percent participation; Central Electric Cooperative in Oregon, and Orcas Power and Light Cooperative in Washington. The average participation rate for utility green power programs nationwide is 1.8 percent, with a median of 1 percent.

Another significant green power co-op is the Green Power Electric Membership Corp., in Georgia. With 36 member co-ops, Green Power EMC brings renewable energy choices to 1.6 million Georgia households. It deals primarily in non-wind green power, but has been instrumental in developing one of the first utility-scale wind projects in the region.

As green pricing programs evolve, the average cost to participants has started to decline. In 2006, the average premium price per kWh of green power was 2.12 cents, down from 3.48 cents in 2000. The lowest reported premium in 2006 was 0.1 cent and the median was 1.78 cents. Co-ops that have sponsored green pricing programs report that the price is only one indicator for program success. Strong marketing, ideally to residential, commercial, and industrial customers, is also key. One review of successful co-op green pricing programs, completed for the Cooperative Research Network, noted that these programs have strong appeal beyond the stereotypical upscale environmentalist customer.

For more information, see *Green Power Marketing in the United States* (10<sup>th</sup> Edition), National Renewable Energy Laboratory, December 2007. NREL/TP-670-42502.

## 5.5 Step 4: Regulatory Assessment

There are two broad categories of approvals needed for wind project development:

- Land Use and Environmental
- Utility Interconnection

Utility interconnection issues were described above, in Section 4, Wind Integration. The discussion here will focus on general public acceptance, as indicated by land use and environmental permitting. Again, most of these issues were introduced in previous sections of this handbook, so this discussion will address the practical aspects of moving through regulatory and permitting processes.

The National Wind Coordinating Coalition (<http://www.nationalwind.org>) is a widely representative group that is focused on regulatory and permitting processes for wind. It provides numerous workshops, white papers, and briefs to assist utilities and others in the wind development process. The 2002 NWCC publication, *Permitting of Wind Energy Facilities—A Handbook*, remains a key resource, frequently cited here.

### 5.5.1 Permitting Process Guidelines

The NWCC provides eight guidelines, listed below, for wind permitting to support successful project development:

1. *Significant Public Involvement.* Providing opportunities for early and meaningful public involvement is crucial to a successful process. This will be somewhat different for each co-op and each specific wind development project.
2. *Issue-Oriented Approach.* An issue-oriented approach can help focus the debate, educate the public and decision-makers, and provide an analytic basis for decisions.
3. *Clear Decision Criteria.* All stakeholders should know early-on what criteria will be used for making decisions about siting and project design.
4. *Coordinated Permitting Process.* Usually several agencies are involved in permitting for wind development. They should be encouraged to coordinate so that project review can proceed simultaneously and so that redundant, conflicting, or inconsistent requirements, standards, and processes can be avoided. Often the utility appoints one person to be the permitting coordinator.
5. *Reasonable Time Frames.* The co-op should encourage permitting agencies to establish reasonable time frames for each of the major phases of the permitting process, and it should manage the process to stay within those time frames.
6. *Advance Planning.* Both wind developers and permitting agencies should know as much as possible about the project, the process, the participants, and the issues as they begin the process.
7. *Timely Administrative and Judicial Review.* Follow procedures designed to systematically narrow the issues of concern and produce fact-based decisions. This will help limit any administrative or judicial appeals and allow them to proceed efficiently.
8. *Active Compliance Monitoring.* Most agencies include in their permits specific conditions that must be met during construction, operation and maintenance, and eventual

decommissioning. Make sure at the outset that these conditions are specific, measurable, agreed upon by all parties, realistic, enforceable, and actually enforced.

### **5.5.2 Typical Permitting Authorities and Process Steps**

When co-op managers first confront the long list of review requirements and applications for wind development, they should not be discouraged. The permitting process typically takes about a year for most wind projects and sometimes less. It is not much different from any utility construction process, and is often easier, given that there are no emissions and relatively few hazards associated with wind. With good preparation and support, the process can move swiftly. In general, permitting covers these issues:

- Land use (e.g., zoning)
- Noise
- Birds and other biological resources
- Visual impacts
- Soil erosion and water quality
- Public health and safety
- Cultural and paleological.

The types of permitting authorities involved include local, state, and federal agencies listed below:

***Local permitting authorities:*** Local planning commission, zoning board, city council or county board of supervisors, building commission or agency, and sometimes a transportation commission to approve access roads.

***State permitting authorities:*** Natural resource and environmental protection agencies, state historic preservation office, industrial development and regulation agencies, public utility commission (transmission), tax and commerce agencies for some developments. Often, states have coordinators in place to help streamline related state and federal environmental requirements.

***Federal permitting authorities:*** U.S. Environmental Protection Agency, for the National Environmental Policy Act (NEPA). Others as needed include Bureau of Land Management or U.S. Forest Service, Federal power agencies such as Bonneville Power Administration or Western Area Power Administration, Federal Aviation Administration, Fish and Wildlife Service and US Military radar installations.

Typical phases in permitting include pre-application, application, decision-making, administrative and judicial review, and permit compliance. The pre-application phase is important because communications with permitting agencies early-on can clear up questions about exactly which permits will be required. This phase also gives the co-op or wind developer a chance to educate agency personnel about the project and its benefits to the community. It is also an opportunity to establish communications with the public and to build community support.

Occasionally a project presents difficulties, where the permit could be difficult to obtain. Project investors may hesitate to back a project unless they know that all the necessary permits have been or will be obtained without challenge. The sooner a co-op and its partners can assess permitting requirements, the better.

## **5.6 Step 5: Procurement and Construction**

The electric co-op's experience with wind procurement and construction depends on its approach to wind procurement. Does the co-op plan to procure wind through a PPA, or is the co-op a project owner/developer? The following discussion is geared more to the latter—a co-op that plans to own or co-own the wind development and needs to be directly involved in its construction. Other co-ops, using other approaches to acquiring wind, will find the discussion useful, though their responsibilities will not be as great.

### **5.6.1 Develop Specifications and Issue a Request for Bids**

A wind development consultant can be extremely helpful at this point, working with his or her own project engineers or with other engineering expertise. Bid specifications should include:

- A summary of the project, including desired output and load characteristics
- Any restrictions, such as zoning limitations on size or noise
- Interconnection, monitoring and control, and who is responsible for which aspects
- Requirements for maintenance or service warranties
- Construction schedule and deadlines
- Applicable penalties and incentives.

It is also useful to provide a scoring system, so bidders will know the relative importance of different utility concerns. These include cost, evidence of technology performance, evidence of contractor experience, optional points for community economic benefits, etc. The co-op or its wind consultant should make site plans and feasibility data available to bidders, and should be available, within limits, to respond to bidders' questions.

The co-op's wind development consultant should be involved in the review process, too, helping to answer technical questions and to sort out unique aspects of some of the respondents' bids. Bids are seldom perfectly comparable, so be prepared to make a sound judgment, and then support the decision before the co-op board or other decision-makers.

### **5.6.2 Construction and Commissioning**

This discussion glosses over the contract negotiation process, which can be straightforward or quite complicated, depending on the specific project. Once the contracts are in place, construction may begin. Early steps include:

- Site preparation, including access roads,
- Excavating and pouring the foundation,
- Anchoring the base of the tower (or embedding it) on the foundation,
- Lifting tower sections,
- Lifting the nacelle and attaching it to the top of the tower,
- Lifting the rotor and attaching it to the nacelle,
- Completion of monitoring and control systems, and
- Additional T&D infrastructure as needed.

Depending on weather conditions and the size of the project, construction usually takes a few months. Then, once the turbines are up, the commissioning process begins. This may take a few days or weeks, depending on the complexity of the project and on other factors, including seasonal winds. The process includes checks of turbine operation and its monitoring, integration, and control systems. These checks may be done by the contractor or by an independent agency. For example, the local co-op and its G&T are usually involved, and depending on the project location and size, a power supply agency, such as Western Area Power Administration or Bonneville Power Administration, may also be involved.



Figure 5.3. Hoisting a turbine blade in Hull, Mass.

### 5.6.3 Operations and Maintenance

Whether a co-op is the wind project owner, or whether it has a PPA with the project owner, it should be concerned with the project's approach to operations and maintenance (O&M). According to research by Lawrence Berkeley National Laboratory (LBNL), the cost of wind project operations and maintenance have generally declined since about 2000, though costs still vary considerably. In looking at 89 projects installed through 2005, LBNL noted capacity-weighted current O&M costs of about \$30/MWh for projects installed in the 1980s, dropping to \$20/MWh for projects installed in the 1990s, and down to \$8/MWh for projects installed in this decade. LBNL suggests that the increasing size and sophistication of newer equipment designs as possible reasons for this trend. LBNL also expects O&M costs to rise for aging projects.

Several co-ops and municipal utilities that have been involved with wind development cite the importance of warranties. Some report that the extra cost of an extended warranty has proved worthwhile. This is not only to avoid the cost of replacing equipment if it fails, but also, for many smaller utilities, it is important to minimize the hassle of securing expertise and parts in an emergency. Each project owner/operator must balance the costs and benefits of extra warranties.

## **Distribution-Level Projects or G&T Projects: Co-ops Choose Their Best Approach**

The electric co-op sector includes both local distribution co-ops and regional generation and transmission co-ops (G&Ts). Some distribution co-ops that are sponsoring wind projects, such as Plumas-Sierra Rural Electric Cooperative in California, are not members of any specific G&T. They arrange power supply contracts and may own their own generating facilities. These co-ops may also be fully responsible for wind acquisitions, whether through power purchase agreements or as a project owner or co-owner.

Another model is suggested by the Last Mile Electric Cooperative, which was formed specifically to develop renewable and innovative energy projects for its members. Today, members of Last Mile are engaged in a large wind project in Oregon.

Distribution co-ops that are members of a G&T generally take a different approach to wind development, since their actions affect all members of the G&T, directly or indirectly. In some cases, a G&T will own or contract for wind projects and spread the costs and benefits across the membership. In other cases, the G&T may allow the distribution co-op to own and operate a wind project. This usually requires that the project be interconnected at the distribution level. Also in most cases, the distribution co-op's total acquisition from distributed generation projects (wind, solar, small hydro, etc.) must fall under an agreed-upon capacity figure, in MW or as a percentage of total capacity requirements.

## **Illinois G&T Supports Local Ownership of Community-Scale Wind**

The Illinois Rural Electric Cooperative (IREC) in western Illinois demonstrates a successful relationship between this distribution co-op and its G&T supplier, Soyland Power Cooperative. Soyland allows its member co-ops to own generation up to 5 percent of their peak load. IREC's 1.65 MW wind turbine, installed in 2005, can meet about 4 percent of its peak load.

IREC decided to give wind power a try, primarily because it looked like a good strategy for the future. Farmers in the region had been asking a lot of questions about wind—whether it could work in Western Illinois and whether it might be a good opportunity for economic development. According to IREC General Manager Bruce Giffen, this project was a way to start the ball rolling—or more aptly, the wind blowing.

The project did not require transmission, since the utility uses the energy locally. IREC has some occasions, usually in spring, when the turbine is generating more power than the co-op can use. At that time, it must put wind power on the transmission grid, but it has not experienced any technical problems related to integration. According to staff engineer Sean Middleton, “The newer (wind) machines are to come up and sync with the grid automatically.”

Not all co-ops may have the same fortunate experience as IREC in finding economic assistance for wind development. Yet Middleton encourages others to look around for opportunities. IREC received a \$440,000 grant from the USDA Section 9006 (Farm Bill) program and \$250,000 from the Illinois Department of Commerce and Economic Opportunity. It also received \$175,000 from the Illinois Clean Energy Community Foundation, representing an advance on the value of the RECs produced from wind generation. Additional financing was secured through RUS. The total project cost was \$1.878 million, plus an additional \$300,000 for a related distribution system upgrade. Thanks to the financial assistance, IREC is able to generate wind power for slightly less than the wholesale contract rate, assuming a 30 percent capacity factor.

The U.S. DOE Wind Powering America Program recognized IREC in 2005 for its leadership in wind development, as Wind Co-op of the Year.



The IREC wind tower rises into the Illinois prairie sky.

### **Basin Electric Provides Wind Power in Partnership With Member Co-ops**

Basin Electric, the North Dakota-based G&T, has succeeded in bringing an enormous amount of wind power online. The NREL Green Power Network has ranked Basin sixth among all utilities nationwide for the volume of green power sold to its consumers in 2006, the most recent year on record. Basin sold a total of 217,427 MWh of green power—mostly wind—that year. It has about 136 MW of wind in its generating portfolio. Further, it is planning two additional wind projects in North Dakota – a 115.5 MW project and a 4.5 MW project. The 115.5 MW project will be the largest wind project owned by an electric co-op. Additionally, Basin Electric is developing another large project in South Dakota. The G&T is committed to “greening” 10 percent of its supply portfolio by 2010.

Basin's largest wind acquisitions to date are secured through power purchase agreements with FPL Energy, a major wind supplier. Basin buys the full output of three FPL projects: the North Dakota I Wind Energy Center near Edgeley and Kulm, the South Dakota Wind Energy Center near Highmore, and the Wilton Wind Energy Center north of Bismarck, ND. An additional 50 MW potential project is in negotiations. This wind energy goes into the Basin supply mix for all its member co-ops.

In addition, Basin has encouraged several smaller, community wind projects in partnership with regional G&T's and local distribution co-ops. For example, Basin helped to pioneer community wind development in 2000, working with East River Electric Cooperative (G&T) of Madison, South Dakota. At the encouragement of its members, Basin looked at the economics of building one utility-scale turbine near Chamberlain, SD, but the numbers didn't add up. Instead of giving up, Basin suggested building two 1.3 MW turbines at Chamberlain, with plans to add two more turbines the following year near Minot, North Dakota. This increased the economy of scale. East River agreed to pick up about half the cost for the project at Chamberlain, and East River added substation improvements to support the interconnection.

An almost identical project was then developed between Basin Electric and Central Power Electric Cooperative, of Minot, ND under the same cost-sharing concept. This second project was completed in 2001. Station service for the respective projects is supplied by East River member, Central Electric Power Cooperative of Mitchell, SD and Central Power's member, Verendrye Electric Cooperative of Velva, ND. The projects came together, and even today, serve as an example for community wind development in the region. According to Ron Rebenitsch, Basin Manager of Alternative Technologies, this kind of grassroots energy development is welcomed by Basin, which has supported other small wind power projects through power purchase agreements, since those initial projects. The key, Rebenitsch says, is that “the partners have to work together to make sure the economics work for all the G&T's member co-ops.” For its leadership in wind development Basin Electric won the Wind Powering America Co-op of the Year Award in 2003.

# Appendix

## Resources

### General

#### **National Rural Electric Cooperative Association (NRECA),**

<http://www.nreca.org/publicpolicy/electricindustry/renewableenergy.htm>. NRECA is an active participant in the development of a national renewable energy policy and believes that any such policy must

- Provide appropriate funding for research and development
- Include incentives to fully utilize domestic resources that are available to all segments of the industry on an equitable basis, including Clean Renewable Energy Bonds (CREBs)
- Not impose mandates on electric utilities if they would undermine local board control of power supply decision-making, threaten system reliability, or unduly raise the cost of electricity for members
- Recognize that electric power from federally-owned hydroelectric projects is an especially important source of affordable electricity for electric co-ops.

In addition to Web links to renewable energy news and resources, this site links to an interactive map of co-op renewable energy projects nationwide.

**Public Renewables Partnership (PRP)** Web site, <http://www.repartners.org>, is a one-stop shop for public power utilities, cooperatives, and tribal utility authorities working to establish renewable energy programs. The site is supported by DOE and other federal agencies, American Public Power Association, National Rural Electric Cooperative Association, state agencies, and non-profit organizations. Visitors can find state-specific wind information, technical references, and updates about special events.

**Utility Wind Integration Group**, <http://www.uwig.org>, is focused on technical issues associated with utility systems planning, design, and operation to accommodate significant amounts of wind energy. Provides training and guides for all aspects of wind integration. UWIG members include utility professionals working in close association with DOE and NREL wind programs.

**American Wind Energy Association**, <http://www.awea.org>, is the trade association for the wind industry. While it has an industry bias, it provides useful facts, news, and publications, as well as training and conference announcements.

**Database of State Incentives for Renewable Energy**, <http://www.dsireusa.org>, is an interactive Web site providing updated information on state incentives, regulations, and guidelines for renewable energy.

**The Green Power Network**, at <http://www.eere.energy.gov/greenpower>, offers information and support for utility green pricing programs. It features the NREL “Top Ten” listings of utility green power programs and information on renewable energy certificates.

**National Wind Coordinating Collaborative**, <http://www.nationalwind.org>, identifies wind issues, establishes dialogue among key stakeholders, and catalyzes activities to support the development of environmentally, economically, and politically sustainable commercial markets for wind. Publications include many focused on siting issues.

**Wind Powering America**, <http://www.windpoweringamerica.gov>, is DOE program aimed at reducing barriers to wind development, to achieve targeted regional economic development, enhanced power generation options, local environmental protection, and energy and national security. Links to numerous

publications, with emphasis on regional, state, and sector-specific resources, including resources for electric co-ops.

**Windustry**, <http://www.windustry.org>, promotes community wind development through educational materials, technical assistance, and collaborative efforts to assist rural landowners, local communities, and utilities. Windustry serves interests of both distributed and grid-integrated wind development.

## Utility Wind Acquisition Planning

**Green Power Marketing in the United States** (10<sup>th</sup> Edition), from NREL, December 2007 (NREL/TP-670-42502) details how electric utilities, including co-ops can use green tag, or REC purchases as a way to acquire green power for their customers.

**Guidebook to Expanding the Role of Renewables in a Power Supply Portfolio**, produced for the American Public Power Association with support from the Western Area Power Administration and Gila Resources (2004), provides a detailed review of the development process for wind and other renewable energy resources. See <http://www.repartners.org> to download or order.

**Practical Guide to Wind Energy Development**, produced by the Minnesota Municipal Utilities Association and the Center for Energy and Environment, July 1999, is available from <http://www.mmua.org>.

**What Generation Mix Suits Your State? Tools for Comparing Fourteen Technologies across Nine Criteria**, by McGarvey, J., Costello, K., *et al*, National Regulatory Research Institute, for National Association of Regulatory Commissioners, (07-03), 2007.

**Wind Workshop in a Box** CD-ROM links users to updated Web-based information. It also includes resources to help create a workshop for local decision makers. It was developed by the Western Area Power Administration in partnership with the Interstate Renewable Energy Council and DOE Wind Powering America Program. See <http://www.repartners.org>.

## Wind Siting

**NWCC Mitigation Toolbox**, produced by the National Wind Coordinating Council as a living document, May 2007, is available from <http://www.nationalwind.org>. It covers bird and wildlife conservation in relation to wind development.

**Permitting of Wind Energy Facilities—A Handbook**, from the National Wind Coordinating Coalition, <http://www.nationalwind.org>, was published in 2002 and is partly out of date, but it useful on every aspect of the siting an permitting process. NWCC also has a set of case studies focused on community response, available on its Web site.

**State Wind Working Group Handbook** (NREL/BK-500-34600), August 2003 is a product of DOE's NREL and Wind Powering America program, <http://www.windpoweringamerica.gov>. While partly out of date, it is a compendium of short articles and PowerPoint presentations on every aspect of wind development.

**Wind Energy Guide for County Commissioners** (DOE/GO-102006-2370), from DOE EERE Information Center, Wind Powering America, and National Association of Counties, is available from <http://www.windpoweringamerica.gov> or <http://www.eere.gov>. It provides quick-reference lists for early aspects of wind development, including local economic development benefits, public involvement, siting issues and processes, and more.

**Wind Energy: A Guide for Wind Site Development** from the New York State Energy Development Agency (NYSERDA) is available at <http://www.powernaturally.org>.

**Wind monitoring equipment** may be loaned to utilities served by the Western Area Power Administration. See <http://www.wapa.gov/es/loan>. Utilities also may check the open listing of consultants that specialize in wind resource assessment, provided by the American Wind Energy Association, <http://www.awea.org>.

**Wind resource maps** are easy to find on the U.S. DOE Wind Powering America Web site, <http://www.eere.energy.gov/windandhydro/windpoweringamerica>, or through a quick link on the wind page of the PRP Web site, <http://www.repartners.org>. These recently refined maps show wind resources from Class 1 (low) to Class 7. To be cost-effective, a utility-scale wind project usually requires wind resources of Class 3 or above. Microclimates greatly affect wind resources, as does the height of the wind tower. Onsite monitoring should follow the map-based resource review.

## Wind Economics and Finance

**Annual Report on U.S. Wind Power Installation, Cost, and Performance Trends: 2006** (DOE-GO-102007-2433), from DOE NREL, May 2007. The research for this document was completed under direction of Ryan Wiser, Lawrence Berkeley National Laboratory (<http://eetd.lbl.gov/ea/ems>), and it is the source for much of the current industry data used in this handbook. Updates are expected annually.

**25 by 25 Action Plan** was produced by a consortium of stakeholders in rural energy development, including NRECA, which hopes to meet 25% of overall U.S. energy needs with rural-based renewable energy by 2025. The plan discusses direct and indirect economic benefits of wind development (February 2007). Available from <http://www.25x25.org>.

**Links to updated information on CREBs**, Section 9006 Farm Bill program, REPI incentives, Tribal Incentives, etc., is available from [http://www.eere.energy.gov/windandhydro/windpoweringamerica/ne\\_policy\\_federalgrants.asp](http://www.eere.energy.gov/windandhydro/windpoweringamerica/ne_policy_federalgrants.asp). See also <http://www.nrucfc.coop/extranet/creb.htm>, for updates from the Cooperative Finance Corporation.

**Wind Project Financing Structures: A Review & Comparative Analysis**, by Harper, J., M. Karcher, and M. Bolinger (LBNL-63434), September 2007 is available from <http://eetd.lbl.gov/ea/ems>. This study looks closely at financing mechanisms for taxable project sponsors, including investor-owned utilities. While it does not address co-op issues directly, it is highly instructive regarding financing partnerships.

## Utility Wind Integration

**Federal Energy Regulatory Commission**, "Preventing Undue Discrimination and Preference in Transmission Service," Federal Register, volume 71, no. 108, pp. 32685-32734, 2007.

**IEEE Power & Energy Magazine**, special issue on Wind Integration: Driving Technology, Policy, and Economics, November/December 2007. See <http://www.ieee.org/power> for details. This special issue follows a special issue published in November/December of 2005 on the same topic. It provides excellent, detailed summaries of integration issues including forecasting, grid reliability, and transmission access.

**Utility Wind Integration: State of the Art**, May 2006, from <http://www.uwig.org>, is a summary of work by the Utility Wind Integration Group in cooperation with the American Public Power Association, the Edison Electric Institute, and the National Rural Electric Cooperative Association. It references more detailed documents and training projects from UWIG.