

APPENDIX A: WIND TURBINE TECHNOLOGY

Today's utility-scale wind turbines have three blades that face into the wind. Their blades, which are airfoils similar to airplane wings, use the lift created by the wind to spin the turbine. The rotation of the blades is transferred to a gearbox and on to the generator, creating three-phase electricity. While the basic structure of today's utility-scale turbines is the same between manufacturers, individual components can vary. These differences can affect how a turbine performs at a particular site, so it is useful to know how the different components function. The diagram below illustrates the main components of a utility-scale wind turbine. The descriptions that follow the diagram include the different types of each component and under what conditions that type of component might be appropriate.

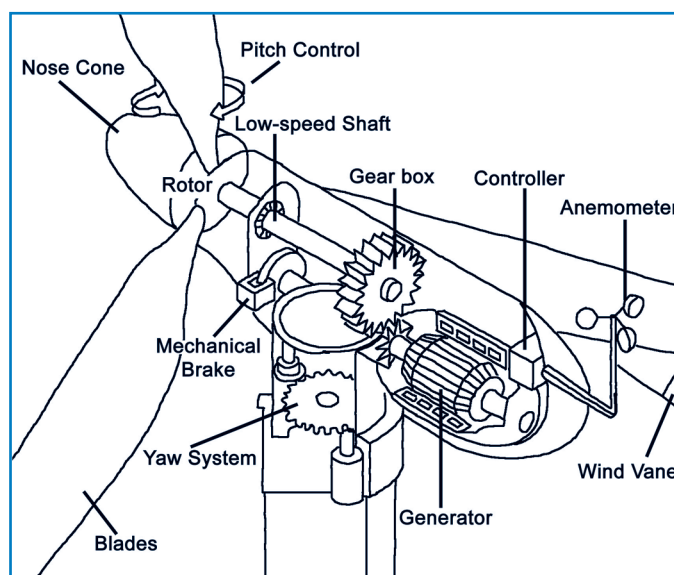
Braking Systems. The primary braking system is either a change in blade pitch, in the case of pitch-controlled turbines, or tip brakes in the case of stall-controlled turbines. Turbines also have a backup mechanical braking system that can be used as a parking brake during turbine maintenance.

Controller. The turbine controller is generally located in the tower at the base. It regulates all of the equipment necessary to maintain proper function of the turbine and includes a Supervisory Control and Data Acquisition (SCADA) system that collects and transmits information on turbine parameters and provides a control device for remote regulation.

Gearing. The rotor of the turbine spins a low-speed shaft in the nacelle that enters a gearbox. This gearbox transfers the energy from the low-speed shaft to a shaft that spins much more quickly, at a rate appropriate for the generator(s).

TURBINE DIAGRAM

FIGURE A.1



Courtesy of DOE Wind and Hydropower

Generator Types. A review of several of the major turbine manufacturers reveals that the majority of today's turbines are asynchronous, otherwise known as induction, generators. These generators are very similar to electric motors that are commonly used in household appliances such as refrigerators and fans. Rather than using electricity to spin the motor, these generators use the spin to create electricity. In order to make more efficient use of low wind speeds, some turbines are

built with two generators, one smaller generator for low wind speeds, and a larger generator for stronger winds.

Nacelle. The nacelle is the enclosure that sits on top of the turbine tower. It houses the gearbox, the generator, and other turbine controls and has enough room for maintenance personnel to work on the turbine.

Rotor. The rotor is the visibly spinning part of the turbine. It includes the nose cone, or hub, and the blades.

Rotor Blades. The majority of turbine blades on turbines rated at 600 kW and above are made of glass fiber–reinforced plastics. Other materials can be used, but this is currently the most cost-effective option. The airfoil shape of the blades is used both to spin the turbine, and also to “spill” wind to brake the turbine when wind speeds are too high. One method of accomplishing both the lifting and braking is to design the airfoil such that high wind speeds cause the turbine to stall. These are called *stall-controlled turbines*. These blades have an additional safety measure in that the tips of the blades can rotate to act as brakes when the turbine begins to spin too quickly. Another blade design involves rotating the entire blade along its longitudinal axis. Blades that can change pitch during operation to optimize power output and brake under unsafe conditions are called *pitch-controlled turbines*. While pitch-controlled turbines have an advantage over stall-controlled turbines in their ability to manage power output at varying wind speeds, the extra moving parts add to the complexity of the design and the control system.

Tower Types. There are currently two basic types of towers used for the majority of wind turbines, lattice and tubular. Lattice towers use less

material and are less expensive, but may not be as aesthetically appealing, do not provide a sheltered area for the controller, and may increase avian mortality by providing perches. Tubular towers provide an enclosure which houses the controller as well as a ladder so that maintenance workers are sheltered during the climb to the nacelle. These can become hot for maintenance workers during warm weather and may have a greater visual impact as they are visible from greater distances.

Yaw System. Most wind turbines over 500 kW have an active yaw system. A controller checks the wind direction measurement supplied by the wind vane and ensures the rotor is pointed directly into the wind using a series of electric motors and brakes.

Other Turbine Information

Operational Data. A turbine’s operational data provides information on the *cut-in wind speed*, i.e. the wind speed at which the turbine will start to produce power, the *nominal wind speed*, i.e. the wind speed at which the turbine reaches its nameplate capacity, and the *cut-out wind speed*, i.e. the wind speed at which the turbine shuts down to avoid damage. Cut-in wind speeds are generally between 2.5 and 4 m/s (5.6 and 8.9 mph), nominal wind speeds vary from 12 to 16 m/s (26.8 and 35.8 mph), and cut-out wind speeds are generally 20 or 25 m/s (44.7 or 55.9 mph). A turbine with a lower cut-in and nominal wind speed may be more appropriate for a low-wind site, while a turbine with a higher, cut-out wind speed may be better suited for a high-wind site.

Sound Data. Sound data is available from turbine manufacturers and should be considered when choosing a turbine. Data on both the increases in sound levels with increasing wind speed and the sound versus the distance from the turbine are important considerations.

APPENDIX B: EFSC SITE CERTIFICATE REVIEW PROCESS

Key characteristics of the EFSC Site Certificate review process are:

- Projects up to 105 MW capacity can choose to pursue permitting through their local planning department or apply for a site certificate from the state Energy Facility Siting Council (EFSC). Projects of at least 105 MW in size must go through the EFSC process. Community wind projects as described in this Guidebook—that is, of 600 kW to 10 MW in size—would be allowed to opt in to the state process, but would not be required to do so.
- To receive a site certificate, the project must meet state siting standards for a number of criteria, including organizational expertise, retirement and financial assurance, land use, soil protection, protected areas, scenic and aesthetic values, fish and wildlife habitat, threatened and endangered species, recreation, public health and safety standards for wind energy facilities, siting standards for wind energy facilities, and siting standards for transmission lines. In addition, although the Siting Council cannot apply the following standards when determining whether to approve a site certificate, the Council may impose conditions on the site certificate based on the standards for public services, waste minimization, historic, cultural and archeological resources, and structural standards. These review criteria may be similar or identical to those applied by authorities governing a local permitting process.
- If a site certificate is issued by EFSC, other state agencies or local government departments

must issue relevant permits. These permits may subject the project to conditions imposed by EFSC. However, the project developer must obtain certain federal permits (e.g. regarding air or water quality) directly from the relevant agency. The Oregon Department of Environmental Quality (DEQ) administers these federal permits in the state. The EFSC site certificate is not binding for these federal permits; these permit applications will be separately evaluated by Oregon DEQ. Federal Aviation Administration lighting permits and Corps of Engineers permits are not handled by Oregon DEQ, but must be obtained from the agencies involved.

For a complete description of the EFSC process as it relates to wind projects, see the Oregon Department of Energy's Web site on the "Siting Process of Energy Facilities" at: <http://egov.oregon.gov/ENERGY/SITING/process.shtml>.

APPENDIX C: GLOSSARY OF INTERCONNECTION TERMS

Disconnect. Disconnect switches are used to isolate electrical equipment from the rest of the system. They act as important safety measures by allowing the turbine to disconnect from the rest of the utility grid. This prevents islanding in the case of power outages and allows for maintenance of the wind turbine without shutting down the grid. It is generally the responsibility of the party requesting the interconnection to pay for the necessary disconnect switches.

Distribution. Distribution lines carry power from substations to electricity end-users. These lines are generally between 4 and 13 kV. If a three-phase line with capacity is available and the line is relatively “stiff” (see *Stiffness* below), a single large turbine can interconnect to the distribution system.

Interconnection. The process by which power produced by the wind project is transferred to the utility’s grid.

Line Capacity. The amount of power a transmission or distribution line can transmit safely.

Power Quality. Wind turbines have the potential to affect power quality in several ways. The output power from wind turbines can vary due to changes in wind speed, turbulence, and on/off status. These variations can affect *voltage levels* and degrade power quality. Some, but not all, wind turbines can also improve the voltage level by injecting reactive power into the system. Wind turbines can also

have an affect on the power factor of a distribution line. The *power factor* is determined by how closely the phases of current and voltage match. Power is the product of current and voltage, which means that any difference in phase decreases the power as experienced by the end-user. Wind turbines can be ordered and operated with different power factors and can also provide leading power factor power. Yet another potential impact of the wind turbine is the possible presence of harmonics in the power generated by the wind turbine due to the turbine’s power electronics. *Harmonics* occur when the power output of a generator or power converter is not a perfect sinusoidal waveform with a frequency of 60 Hz. When analyzing such imperfect waveforms, an engineer looks at a combination of power with the fundamental frequency and other frequencies around the fundamental. Harmonics can cause malfunctions of various equipment and heat transformers and cause telecommunication interference. High quality power has constant voltage, a power factor close to one, and a sinusoidal waveform consisting of only the fundamental frequency.

SCADA. Supervisory control and data acquisition (SCADA) equipment collects data from the turbines and provides a means of control from a centralized station. SCADA is used to regulate the output of the turbines to maintain proper grid function. Large wind projects must have SCADA systems so the utility can control the impact of the wind project on the grid.

Stiffness. The ability of a feeder line to maintain constant voltage during periods of high current.

(J. Green, et al) Utilities will often refer to the stiffness of a line when talking about whether or not a wind project can interconnect at a certain point. Lines that are not stiff are more prone to the power quality problems that are associated with wind turbines and loads such as the starting of large motors.

Substation. Substation facilities contain the equipment necessary to modify voltage levels between the transmission, subtransmission, and distribution systems, as well as voltage regulators and safety switches to prevent harm to utility workers and customer equipment.

Subtransmission. Subtransmission systems carry lower voltages than transmission systems. Subtransmission lines carry power to regional distribution centers and to some large customers. Subtransmission does not have a strictly defined voltage range with definitions ranging as low as 26 kV and as high as 115 kV. Wind developments at least as large as 10 MW can connect to subtransmission lines effectively, subject to other determining factors.

Three-Phase Electricity. Electricity in the U.S. transmission system is Alternating Current (AC), which means that the direction of the current alternates as a sinusoidal wave. In three-phase current there are three sinusoidal current waves traveling simultaneously, each in a separate conductor. The staggered phases of the electricity make for a more constant power transfer. Transmission and subtransmission lines always carry three-phase electricity, while some distribution lines carry single-phase electricity. Since utility-scale wind turbines produce

three-phase electricity, it may be necessary to upgrade utility lines when connecting at the distribution level.

Transformer. A transformer is often necessary to step up the voltage coming from the wind turbine to match that of the distribution/transmission system.

Transmission. The high-voltage lines and associated equipment used to transmit electric power over long distances, generally from generators to subtransmission and distribution grids. Transmission lines have voltages ranging from 115 kV to more than 500 kV.

Voltage Flicker. The short time-scale variations in power output caused by wind speed changes can cause variations in line voltage. These can lead to flickering lights and computer problems. Voltage flicker is prevented by the same power electronics that control the power factor.

Wheeling. Wheeling involves the use of a local utility's transmission and/or distribution system to sell generated electricity to another utility. The utility whose service area the electricity is generated in can charge for the use of its lines to move the electricity to another service area. In some cases, the difference in the rates paid by the two utilities for the electricity generated will make wheeling an economical option.

APPENDIX D

Case Study: Klondike Wind Project in Sherman County, Oregon

At the time of Guidebook development, there were no examples of community wind projects—at least none meeting our definition—operating in Oregon. The Klondike Wind Project is far larger than the upper limit of our definition of community wind. Therefore, the following case study is intended not to redefine community wind, but to provide a real example of a community's involvement in successful wind development. Many of the challenges, approaches, benefits, and lessons learned here can be useful to planning community-scale wind projects in Oregon.

Project Snapshot

Location: Sherman County, Oregon

Developer: Northwestern Wind Power

Capacity: 24 MW

Cost: \$26 million

Turbines: 16 variable-speed GE turbines, 1.5 MW each

Online: December 2002

Post-construction: Sold to PPM Energy (2004) and expanded to 99 MW (2005)

In Sherman County, just south of the Columbia River Gorge in northern central Oregon, economic livelihood is based primarily on wheat farming. Recently, five years of drought, along with the perennial risks of single-crop farming, posed great challenges to the community.

In 2000, the community took another hit when Bonneville Power Administration (BPA)

announced it could not meet the electricity demands of the local aluminum smelter. BPA paid Golden Northwest Aluminum to cease the smelter's operations, and with adversity came an opportunity. Brett Wilcox, president and owner of Golden Northwest Aluminum, used BPA's payment to start a new company: Northwestern Wind Power (NWWP). Through NWWP, Wilcox was determined to provide a secure source of power for the smelter, and in 2001 began development of the Klondike Wind Project.

It became clear early on that the site proposed for wind development in Sherman County had many things going for it. The wind resource coming up through the Columbia River Gorge is strong and steady. The location with respect to the transmission grid was also opportune. Located between load centers and a congested area meant the project would face less cost and create greater value connecting to the power grid. Moreover, as the land had previously been disturbed for agricultural use, the project was unlikely to cause negative local environmental impacts. The project's positive environmental impacts include the production of enough clean energy to offset approximately 36,000 tons of CO₂, 156 tons of SO₂, 77 tons of NO_x, and 3,600 pounds of mercury each year.

While the site made sense for wind development, wind development didn't yet make sense to the entire community. In order to move forward, the project developers knew that community support was essential. As is the case with most new projects, local residents were not well informed about modern use of wind energy. NWWP and its project team took community concerns seriously. They held many

local meetings, met with people who had various concerns, and even distributed a new publication called *The Wind Farmer*.

Of course, economic impact was the strongest driver of community support for the project. The investment in wind energy in the county was predicted to, and did indeed, yield far-reaching economic value for the community. It turns out that the wind farm would not only provide power for the aluminum smelter, but it would help diversify and strengthen the local economy. For site landowners, the benefits were obvious. Landowners traded production of wheat on one-half acre per turbine (a farm income of about \$125 per wheat crop) for royalties of \$2,000 to \$4,000 per turbine, per year. It was important, though, for developers to communicate the economic impact to the community as a whole, rather than just a few individuals. Broader benefits included the local job creation during development, installation, and even through ongoing operations and maintenance. In addition, the development brought people into the county, spending money in local establishments, which flowed through the local economy. And finally, the property tax revenues could not be ignored, and were a key factor in widespread community support. In the first year of operation, the project's property tax revenues of more than \$300,000 increased tax revenues in the struggling county by ten percent, providing valuable dollars and a lasting effect to the county as a whole.

Even with potential economic gains, community members did have additional concerns about the project's potential impacts. It was the developer's open communication and serious interest in addressing these questions that many attribute to the project's overall

success. Once the size, scale, speed, aesthetics, avian concerns, and land-use impacts of modern turbines were addressed with public participation, there was little to no opposition to the project. Mike McArthur, who was a judge in Sherman County at the time, reports: "Before the turbines were installed, people just weren't familiar with the modern equipment. The developers did a great job informing and involving community members so that there really wasn't any opposition to the project. After the installation, many commented that the aesthetics were pleasing and that there weren't really any drawbacks to the wind farm."

In 2002, project development sped along. The Oregon Solutions Program of Governor John Kitzhaber helped expedite the project to meet the Federal Production Tax Credit deadline of December 31, 2002. NWWP negotiated a twenty-year Power Purchase Agreement with the Bonneville Power Administration, and the project began operation in December 2002. Just over one year later, PPM Energy purchased Klondike for \$16.8 million, and proceeded with plans to add an additional 75 MW of capacity with the Klondike II Expansion Wind Project. Portland General Electric has agreed to a thirty-year purchase of the full output from the expansion project beginning December 2005. In addition to the amount of clean energy added to the region's power grid, the additional 75 MW expands Sherman County's economic benefits as well.

The Klondike Wind Farm in Sherman County not only demonstrates the importance of community involvement to a successful wind project, but also continues to demonstrate the viability of wind in Oregon, and specifically, the benefits to rural counties.

APPENDIX E

USDA FUNDING OPPORTUNITIES

	VAPG	9006	RCDI	RCDG	
Name of Program	Value Added Producers Grant	Renewable Energy System and Energy Efficiency Improvements	Rural Community Development Initiative	Rural Cooperative Development Grant	
Website	http://www.rurdev.usda.gov/rbs/coops/vadg.htm	http://www.rurdev.usda.gov/rd/farbill/9006resources.html	http://www.rurdev.usda.gov/rhs/rcdi/	http://www.rurdev.usda.gov/rbs/coops/rcdg/rcdg.htm	
Purpose	This program, Section 6401 of the Federal Farm Bill, offers grants for business planning, feasibility studies and working capital related to value-added agricultural activity.	This program, Section 9006 of the Federal Farm Bill, provides grants for purchases of renewable energy systems and energy improvements for agricultural producers and rural small businesses.	These grants come through the Rural Housing Service (RHS) to develop capacity and ability to undertake projects related to housing, community facilities, or community and economic development.	Rural cooperative development grants will be used to facilitate the creation or retention of jobs in rural areas through the development of new rural cooperatives, Value-Added processing and rural businesses.	
Type of funding	Grant	Grant & Loan Guarantee	Grant	Grant	
Funding Max	\$100,000 (planning), \$150,000 (wkg capital)	\$500,000 - grant, 50% of project costs - loan guarantee	\$500,000	\$300,000	
Eligibility	Independent producers, Agricultural producer groups, Farmer or Rancher cooperatives and Majority-Controlled Producer-Based Business Ventures, are eligible for grants under this subpart.	The applicant or borrower must be an agricultural producer or rural small business (in which case the business headquarters and the project to be funded must both be in a rural area).	Eligible applicants include qualified private, nonprofit and public (including tribal) intermediary organizations. "Intermediary" cannot be the same entity as "recipient" or "beneficiary."	Grants may be made to nonprofit corporations and institutions of higher education. Grants may not be made to Public bodies. No grants can be made to cities or states under his program.	
Use of Funds	Grant funds may be used to pay up to 50% of the costs for carrying out relevant projects. (a) Planning Grants - Grants to facilitate the development of a defined program of economic activities to determine the viability of a potential Value-Added venture, including feasibility studies, marketing strategies, business plans and legal evaluations. (b) Working Capital Grants - Grants to provide funds to operate ventures and pay the normal expenses of the venture that are eligible uses of grant funds.	Grant funds can be used for both hard (equipment, construction) and soft (studies, fees) costs. The grant request must not exceed 25% of the eligible project costs. 1) The project must be for the purchase of a renewable energy system or to make energy efficiency improvements. 2) The project must be for a pre-commercial or commercially available and replicable technology. 3) The project must be technically feasible. 4) The project must be located in a rural area. 5) The applicant must be the owner of the system and control the operation and maintenance of the proposed project. 6) All projects must be based on satisfactory sources of revenues in an amount sufficient to provide for the O&M of the system or project.	The purpose of this initiative is to develop or increase the recipient's capacity through a program of financial and technical assistance to perform in the areas of housing, community facilities, or community and economic development. Strengthening the recipient's capacity in these areas will benefit the communities they serve. The RCDI structure requires the intermediary (grantee) to provide a program of financial and technical assistance to recipients. The recipients will, in turn, provide programs to their communities (beneficiaries).	Grant funds may be used for 75% of the cost to establish and operate centers for rural cooperative development. (a) Applied research, feasibility, environmental and other studies that may be useful for the purpose of cooperative development. (b) Grant funds cannot be used for basic or academic research, or for research and development. (c) Collection, interpretation and dissemination of principles, facts, technical knowledge, or other information for the purpose of cooperative development. (d) Providing training and instruction for the purpose of cooperative development. (e) Providing loans and grants for the purpose of cooperative development in accordance with the subpart. (f) Providing technical assistance, research services and advisory services for the purpose of cooperative development.	
Match	Matching funds must be at least equal to the grant amount. Cash and/or in-kind.	75% match (65% cash, 10% in-kind)	Matching funds must be at least equal to the grant amount. Cash match only, no in-kind.	25% match, cash and/or in-kind	

RBOG	B&I	IRP	RBEG	RUS
Rural Business Opportunity Grants	Business/Industry Guaranteed Loan Program	Intermediary Relending Program	Rural Business Enterprise Grants	Renewable Energy Program of the Rural Utilities Service
http://www.rurdev.usda.gov/rbs/busp/rbog.htm	http://www.rurdev.usda.gov/rbs/busp/b&i_gar.htm	http://www.rurdev.usda.gov/rbs/busp/irp.htm	http://www.rurdev.usda.gov/rbs/busp/rbeg.htm	http://www.usda.gov/rus/electric/loans.htm
Grants to provide technical assistance for business development and conduct economic development planning in rural areas.	The Business and Industry (B&I) Guaranteed Loan Program provides guarantees on loans to improve, develop or finance business, industry, and employment, and to improve the economic and environmental climate in rural communities.	The purpose of the Intermediary Relending Program (IRP) is to finance business facilities and community development projects in rural areas.	Rural Business Enterprise Grants are for financing or developing small and emerging businesses.	RUS is an entity of USDA's Office of Rural Development that gives loans to maintain, upgrade and expand generation, transmission and distribution in rural areas. Funds can be used to finance renewable energy systems.
Grant	Loan guarantees	Subsidized loans	Grant	Loan
1.5M, average grant size \$50,000 or less.			Not established.	No Maximum.
Grants may be made to public bodies, nonprofit corporations, Indian tribes on Federal or State reservations and other Federally recognized tribal groups, and cooperatives with members that are primarily rural residents and that conduct activities for the mutual benefit of the members.	The lender can be any federal or state chartered bank, credit union, savings and loan association, or Farm Credit Bank. The borrower can be any legal entity including a cooperative, corporation, or partnership organized and operated on a profit or non profit basis, Indian Tribe, public body or individual.	Intermediaries may be private non-profit corporations, public agencies, Indian groups, or cooperatives. Loan recipients may be any of the above, plus private businesses.	The RBEG program is for nonprofits and public bodies to assist small and emerging businesses in rural areas.	Loans may be made to Municipalities, public utility districts, subdivisions, states, rural electric cooperatives, as well as non-profit, limited dividend and mutual associations that provide retail electric service needs to rural areas or supply the power needs of distribution borrowers in rural areas.
Technical assistance for business development and economic development planning: (1) Identify and analyze business opportunities that will use local rural materials or human resources. This includes feasibility and business plan studies; (2) Identify, train, and provide technical assistance to rural entrepreneurs and managers; (3) Establish business support centers and assist in the creation of new rural businesses; (4) Conduct local community economic development planning; (5) Establish centers for training, technology, and trade; (6) Conduct leadership development training for rural entrepreneurs and managers; or (7) Pay reasonable fees and charges for professional services necessary to conduct the assistance.	Eligible loan purposes can include machinery and equipment, buildings and real estate, working capital and certain types of debt refinancing. Guarantees can be for a maximum of 80 percent and can be issued on loans up to \$5 million (with lesser guarantees on loans up to \$25 million). Interest rates are negotiated between borrower and lender and may be variable or fixed.	This program offers subsidized loans to qualified intermediaries to establish revolving loan funds to be used for business development and expansion or other community development projects.	Uses of funds include: technical assistance (providing assistance on complete marketing studies, feasibility studies, business plans, training, etc.) to start a small and emerging business; purchase machinery and equipment; create a revolving loan fund, or construct a building. Although these grants cannot be made directly to a private business, a non-profit or public group could receive a grant and, in turn, use the funds as seed money or as a revolving loan fund for wind projects.	The loan funds may be used to maintain, upgrade and expand generation, transmission and distribution in rural areas. Although there are no renewable energy-specific elements to the loan application process, the RUS Administrator has set aside \$200 million per year to be used for renewable projects. See the web link above for details on loan terms, interest rates, etc.
				No match required.