American Wind Energy Association

Wind Power Today

Wind Power

Wind power is much more than the gentle breeze that causes the trees to sway or the waves to move across a lake. The power in the wind can blow a semitrailer truck off the road and flatten buildings. And it can be harnessed to be a non-polluting, never-ending source of energy to meet electric power needs around the world.

Wind power is a form of renewable energy – energy that is replenished daily by the sun. As portions of the earth are heated by the sun, air rushes to fill the low pressure areas, creating wind power. But the wind's characteristics may conceal its true power. The wind is slowed dramatically by friction as it brushes the ground and vegetation, it may not feel very windy at ground level. Yet the power in the wind may be five times greater at the height of a 40-story building (the height of the blade tip on a large, modern wind turbine) than the breeze on your face. Furthermore, the wind is accelerated by major land forms, so that entire areas of the country may be very windy while other areas are relatively calm. Since our country's founders tended to build our cities and towns where the wind doesn't blow strongly, the vast majority of people don't live in high-wind areas. Yet, when wind power is converted to electricity, it can be sent long distances to serve the needs of the cities and towns where we do live.

Creating Electricity

Wind **power** is converted to **electricity** by a **wind turbine**. In a typical, modern, large-scale wind turbine, the kinetic energy in the wind (the energy of moving air molecules) is converted to rotational motion by the **rotor** – typically a three-bladed assembly at the front of the wind turbine. The rotor turns a **shaft** which transfers the motion into the **nacelle** (the large housing at the top of a wind turbine **tower**). Inside the nacelle, the slowly rotating shaft enters a **gearbox** that greatly increases the rotational shaft speed. The output (high-speed) shaft is connected to a **generator** that converts the rotational movement into electricity at **medium voltage** (a few hundred volts). The electricity flows down heavy electric cables inside the tower to a **transformer**, which increases the voltage of the electric power to the **distribution voltage** (a few thousand volts). (Higher voltage electricity flows more easily through electric lines, generating less heat and fewer power losses.) The distribution-voltage power flows through underground lines to a collection point where the power may be combined with other turbines. In many cases, the electricity is sent to nearby farms, residences and towns where it is used. Otherwise, the distribution-voltage power is sent to a **substation** where the voltage is increased dramatically to **transmission-voltage** power (a few hundred thousand volts) and sent through very tall transmission lines many miles to distant cities and factories.

Applications

Wind turbines come in a variety of sizes, depending upon the use of the electricity. The large, **utility-scale** turbine described above may have blades over 40 meters long, meaning the diameter of the rotor is over 80 meters – nearly the length of a football field. The turbines might be mounted on towers 80 meters tall (one blade would extend about half way down the tower), produce 1.8 **megawatts** of power (1.8 **MW** or 1800 **kilowatts**, 1800 **kW**), supply enough electricity for 600 homes and cost over a million and a half dollars!

Wind turbines designed to supply part of the electricity used by a home or business are much smaller and less costly. A residential- or **farm-sized turbine** may have a rotor up to 15 meters (50 feet) in diameter and be mounted on a metal lattice tower up to 35 meters (120 ft) tall. These turbines may cost from as little as a few thousand dollars for very small units up to perhaps $40,000-$80,000.

Very small turbines may be designed to charge **batteries** to supply electricity to homes that are not connected to the utility system. In those systems, the batteries store the electricity until it is needed. Such systems usually include an **inverter** that "conditions" (modifies) the power so that it is suitable to run typical appliances. Of course, the batteries and other necessary equipment increase the cost of the system, and the quantity of electricity available is limited by the battery storage capacity.

Wind Projects

A typical large wind project involves many, many players. The main responsibility for the project lies with the **developer.** The developer negotiates with the **landowner** for the right to “harvest the wind” above the land and to place the turbine on a small plot of land – typically less than 1 acre is removed from normal use (farming, grazing, etc.) for each 50 acres of wind resource captured. (Turbines must be spaced a certain minimum distance apart to avoid "shadowing" each other and reducing power output.) Leasing the right to harvest the wind over a farm can more than double the annual net income from cultivation or grazing. The developer also must find financing, secure a contract with a **utility** to buy the electricity produced, purchase the equipment and contract to have it installed, and arrange for operation of the project. Recently, some landowners have become part owners of the projects on their land. This approach increases the **community** involvement in a project, though the legal arrangements may be quite complicated.

Wind Power Markets

Perhaps there is no “typical” wind power project. Some are built to enable utilities to comply with minimum requirements to purchase renewable energy established by state and local governments (“renewable portfolio standards” or “renewable energy standards”). Others may supply "green pricing" programs in which customers voluntarily purchase wind-generated electricity from their utility. In good wind resource areas, a new, large wind project may produce electricity at less cost (over the 25-year life of a project) than any other new power plant, regardless of the fuel source. While it is true that wind power output varies over time, utilities have learned to integrate wind power with their existing electricity generators. Nearly 20% of Denmark's electricity is generated by wind power, yet Danish utilities report no loss of reliability and no need for expensive new equipment or energy storage

Making an Impact

The wind resource in the United States is vast. Using today’s technology, there is theoretically enough wind power flowing across the country to supply all of our electricity needs. North Dakota alone could supply over 40% of the nation’s electricity. Adequate winds for commercial power production are found at sites in 46 states. However, in the near term, only a small portion of that potential will likely be tapped. Less than 1% of the nation’s electricity is currently supplied by wind power. Under an aggressive growth scenario, perhaps 6% of the nation’s electricity could be supplied by wind power by 2020. That would be about the same amount of electricity that hydroelectric power supplies today.

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Wind energy works for America's economy, environment and energy security | Contact AWEA

Wind Energy 101

Basics

What is wind energy?

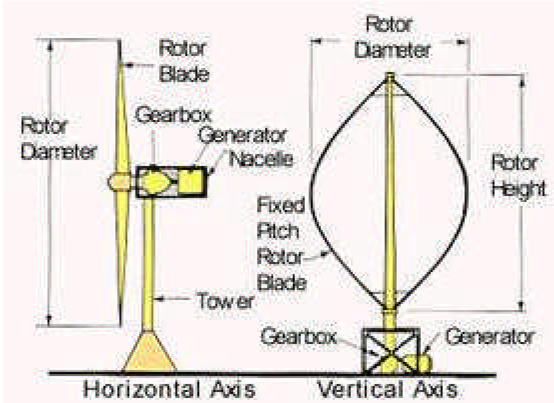
In reality, wind energy is a converted form of solar energy. The sun's radiation heats different parts of the earth at different rates—most notably during the day and night, but also when different surfaces (for example, water and land) absorb or reflect at different rates. This in turn causes portions of the atmosphere to warm differently. Hot air rises, reducing the atmospheric pressure at the earth's surface, and cooler air is drawn in to replace it. The result is wind.
Air has mass, and when it is in motion, it contains the energy of that motion — "kinetic energy." Some portion of that energy can converted into other forms — mechanical force or electricity — that we can use to perform work.

More reading:
http://www.windpower.org/en/tour/wres/index.htm contains a very extensive description of the various geographical and geophysical factors that drive the circulation of the winds around our planet.

What is a wind turbine and how does it work?
A wind energy system transforms the kinetic energy of the wind into mechanical or electrical energy that can be harnessed for practical use.

Mechanical energy is most commonly used for pumping water in rural or remote locations— the "farm windmill" still seen in many rural areas of the U.S. is a mechanical water pumper— but it can also be used for many other purposes (grinding grain, sawing, pushing a sailboat, etc.). Wind electric turbines generate electricity for homes and businesses and for sale to utilities.

There are two basic designs of wind electric turbines: vertical-axis, or "egg-beater" style, and horizontal-axis (propeller-style) machines. Horizontal-axis wind turbines are most common today, constituting nearly all of the "utility-scale" (100 kilowatts, kW, capacity and larger) turbines in the global market.



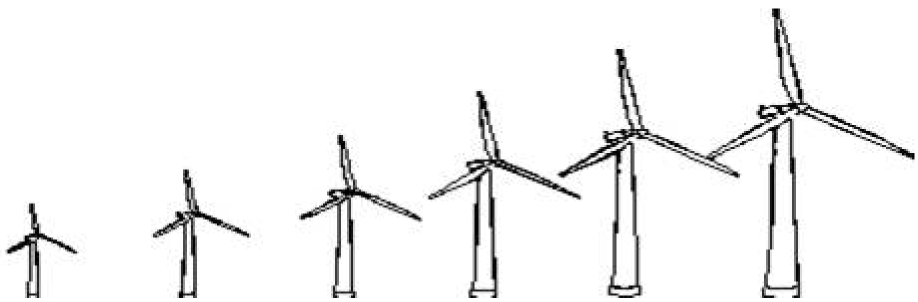
Wind Turbine Configurations

Turbine subsystems include:

- a rotor, or blades, which convert the wind's energy into rotational shaft energy;
- a nacelle (enclosure) containing a drive train, usually including a gearbox* and a generator;
- a tower, to support the rotor and drive train; and
- electronic equipment such as controls, electrical cables, ground support equipment, and interconnection equipment.

*Some turbines do not require a gearbox

Wind turbines vary in size. This chart depicts a variety of turbine sizes and the amount of electricity they are each capable of generating (the turbine's capacity, or power rating).



	1981	1985	1990	1996	1999	2000
Rotor (meters)	10	17	27	40	50	71
Rating (KW)	25	100	225	550	750	1,650
Annual MWh	45	220	550	1,480	2,200	5,600

The electricity generated by a utility-scale wind turbine is normally collected and fed into utility power lines, where it is mixed with electricity from other power plants and delivered to utility customers.

More reading:
Wind Energy—How Does It Work? at **http://www.awea.org/pubs/factsheets/HowWindWorks2003.pdf** is a fact sheet that gives additional basic information about wind energy in the U.S.

Wind Energy Technology , **http://www.bwea.com/ref/tech.html**

How much electricity can one wind turbine generate?
The ability to generate electricity is measured in watts. Watts are very small units, so the terms kilowatt (kW, 1,000 watts), megawatt (MW, 1 million watts), and gigawatt (pronounced "jig-a-watt," GW, 1 billion watts) are most commonly used to describe the capacity of generating units like wind turbines or other power plants.

Electricity production and consumption are most commonly measured in kilowatt-hours (kWh). A kilowatt-hour means one kilowatt (1,000 watts) of electricity produced or consumed for one hour. One 50-watt light bulb left on for 20 hours consumes one kilowatt-hour of electricity (50 watts x 20 hours = 1,000 watt-hours = 1 kilowatt-hour).

The output of a wind turbine depends on the turbine's size and the wind's speed through the rotor. Wind turbines being manufactured now have power ratings ranging from 250 watts to 3 megawatts (MW).

Example: A 10-kW wind turbine can generate about 10,000 kWh annually at a site with wind speeds averaging 12 miles per hour, or about enough to power a typical household. A 1.8-MW turbine can produce more than 5.2 million kWh in a year--enough to power more than 500 households. The average U.S. household consumes about 10,000 kWh of electricity each year.

Example: A 250-kW turbine installed at the elementary school in Spirit Lake, Iowa, provides an average of 350,000 kWh of electricity per year, more than is necessary for the 53,000-square-foot school. Excess electricity fed into the local utility system earned the school $25,000 in its first five years of operation. The school uses electricity from the utility at times when the wind does not blow. This project has been so successful that the Spirit Lake school district has since installed a second turbine with a capacity of 750 kW. (For further information on this project, see **http://www.greenpowergovs.org/wind/Spirit%20Lake%20case%20study.html**)

Wind speed is a crucial element in projecting turbine performance, and a site's wind speed is measured through wind resource assessment prior to a wind system's construction. Generally, an annual average wind speed greater than four meters per second (m/s) (9 mph) is required for small wind electric turbines (less wind is required for water-pumping operations). Utility-scale wind power plants require minimum average wind speeds of 6 m/s (13 mph).

The power available in the wind is proportional to the cube of its speed, which means that doubling the wind speed increases the available power by a factor of eight. Thus, a turbine operating at a site with an average wind speed of 12 mph could in theory generate about 33% more electricity than one at an 11-mph site, because the cube of 12 (1,768) is 33% larger than the cube of 11 (1,331). (In the real world, the turbine will not produce quite that much more electricity, but it will still generate much more than the 9% difference in wind speed.)

The important thing to understand is that what seems like a small difference in wind speed can mean a large difference in available energy and in electricity produced, and therefore, a large difference in the cost of the electricity generated. Also, there is little energy to be harvested at very low wind speeds (6-mph winds contain less than one-eighth the energy of 12-mph winds).

What are wind turbines made of?

The towers are mostly tubular and made of steel. The blades are made of fiberglass-reinforced polyester or wood-epoxy.

How big is a wind turbine?
Utility-scale wind turbines for land-based wind farms come in various sizes, with rotor diameters ranging from about 50 meters to about 90 meters, and with towers of roughly the same size. A 90-meter machine, definitely at the large end of the scale at this writing (2005), with a 90-meter tower would have a total height from the tower base to the tip of the rotor of approximately 135 meters (442 feet).

Offshore turbine designs now under development will have larger rotors—at the moment, the largest has a 110-meter rotor diameter—because it is easier to transport large rotor blades by ship than by land.

Small wind turbines intended for residential or small business use are much smaller. Most have rotor diameters of 8 meters or less and would be mounted on towers of 40 meters in height or less.

How many turbines does it take to make one megawatt (MW)?
Most manufacturers of utility-scale turbines offer machines in the 700-kW to 3-MW range. Ten 700-kW units would make a 7-MW wind plant, while 10 1.8-MW machines would make a 18-MW facility. In the future, machines of larger size will be available, although they will probably be installed offshore, where larger transportation and construction equipment can be used. Units larger than 4 MW in capacity are now under development.

How many homes can one megawatt of wind energy supply?
An average U.S. household uses about 10,655 kilowatt-hours (kWh) of electricity each year. One megawatt of wind energy can generate from 2.4 million to more than 3 milion kWh annually. Therefore, a megawatt of wind generates about as much electricity as 225 to 300 households use. It is important to note that since the wind does not blow all of the time, it cannot be the only power source for that many households without some form of storage system. The "number of homes served" is just a convenient way to translate a quantity of electricity into a familiar term that people can understand. (Typically, storage is not needed, because wind generators are only part of the power plants on a utility system, and other fuel sources are used when the wind is not blowing. According to the U.S. Department of Energy, "When wind is added to a utility system, no new backup is required to maintain system reliability." *Wind Energy Myths*, Wind Powering America Fact Sheet Series, **http://www.nrel.gov/docs/fy05osti/37657.pdf**.)

What is a wind power plant?
The most economical application of wind electric turbines is in groups of large machines (660 kW and up), called "wind power plants" or "wind farms." For example, a 107-MW wind farm near the community of Lake Benton, Minn., consists of turbines sited far apart on farmland along windy Buffalo Ridge. The wind farm generates electricity while agricultural use continues undisturbed.

Wind plants can range in size from a few megawatts to hundreds of megawatts in capacity. Wind power plants are "modular," which means they consist of small individual modules (the turbines) and can easily be made larger or smaller as needed. Turbines can be added as electricity demand grows. Today, a 50-MW wind farm can be completed in 18 months to four years. Most of that time is needed for measuring the wind and obtaining construction permits—the wind farm itself can be built in less than six months.

What is "capacity factor"?
Capacity factor is one element in measuring the productivity of a wind turbine or any other power production facility. It compares the plant's actual production over a given period oftime with the amount of power the plant would have produced if it had run at full capacity for the same amount of time.

$$\text{Capacity Factor} = \frac{\text{Actual amount of power produced over time}}{\text{Power that would have been produced if turbine operated at maximum output 100\% of the time}}$$

A conventional utility power plant uses fuel, so it will normally run much of the time unless it is idled by equipment problems or for maintenance. A capacity factor of 40% to 80% is typical for conventional plants.

A wind plant is "fueled" by the wind, which blows steadily at times and not at all at other times. Although modern utility-scale wind turbines typically operate 65% to 80% of the time, they often run at less than full capacity. Therefore, a capacity factor of 25% to 40% is common, although they may achieve higher capacity factors during windy weeks or months.

It is important to note that while capacity factor is almost entirely a matter of reliability for a fueled power plant, it is not for a wind plant—for a wind plant, it is a matter of economical turbine design. With a very large rotor and a very small generator, a wind turbine would run at full capacity whenever the wind blew and would have a 60-80% capacity factor—but it would produce very little electricity. The most electricity per dollar of investment is gained by using a larger generator and accepting the fact that the capacity factor will be lower as a result. Wind turbines are fundamentally different from fueled power plants in this respect.

If a wind turbine's capacity factor is 33%, doesn't that mean it is only running one-third of the time?
No. A wind turbine at a typical location in the Midwestern U.S. should run about 65-80% of the time. However, much of the time it will be generating at less than full capacity (see previous answer), making its capacity factor lower.

What is "availability" or "availability factor"?
Availability factor (or just "availability") is a measurement of the reliability of a wind turbine or other power plant. It refers to the percentage of time that a plant is ready to generate (that is, not out of service for maintenance or repairs). Modern wind turbines have an availability of more than 98%--higher than most other types of power plant. After two decades of constant engineering refinement, today's wind machines are highly reliable.

Wind Energy 101

Potential

The wind doesn't blow all the time. How much can it really contribute to a utility's generating capacity?

Utilities must maintain enough power plant capacity to meet expected customer electricity demand at all times, plus an additional reserve margin. All other things being equal, utilities generally prefer plants that can generate as needed (that is, conventional plants) to plants that cannot (such as wind plants).

However, despite the fact that the wind is variable and sometimes does not blow at all, wind plants do increase the overall statistical probability that a utility system will be able to meet demand requirements. A rough rule of thumb is that the capacity value of adding a wind plant to a utility system is about the same as the wind plant's capacity factor multiplied by its capacity. Thus, a 100-megawatt wind plant with a capacity factor of 35% would be similar in capacity value to a 35-MW conventional generator. For example, in 2001 the Colorado Public Utility Commission found the capacity value of a proposed 162-MW wind plant in eastern Colorado (with a 30% capacity factor) to be approximately 48 MW. For more information on the Commission's finding, see **http://www.dora.state.co.us/puc/decisions/2001/C01-0295_99A-549E_PHASE%20II.pdf**.

The exact amount of capacity value that a given wind project provides depends on a number of factors, including average wind speeds at the site and the match between wind patterns and utility load (demand) requirements. It also depends on how dispersed geographically wind plants on a utility system are, and how well-connected the utility is with neighboring systems that may also have wind generators. The broader the wind plants are scattered geographically, the greater the chance that some of them will be producing power at any given time.

More reading: *What Happens When the Wind Stops Blowing?*, British Wind Energy Association, **http://www.bwea.com/ref/stop.html**.

How much energy can wind realistically supply to the U.S.?

Wind energy could supply about 20% of the nation's electricity, according to Battelle Pacific Northwest Laboratory, a federal research lab. Wind energy resources useful for generating electricity can be found in nearly every state.

U.S. wind resources are even greater, however. North Dakota alone is theoretically capable (if there were enough transmission capacity) of producing enough wind-generated power to meet more than one-fourth of U.S. electricity demand. The theoretical potentials of the windiest states are shown in the following table.

THE TOP TWENTY STATES for wind energy potential, as measured by annual energy potential in the billions of kWh, factoring in environmental and land use exclusions for wind class of 3 and higher.

1	North Dakota	1,210	11	Colorado	481
2	Texas	1,190	12	New Mexico	435
3	Kansas	1,070	13	Idaho	73
4	South Dakota	1,030	14	Michigan	65
5	Montana	1,020	15	New York	62
6	Nebraska	868	16	Illinois	61
7	Wyoming	747	17	California	59
8	Oklahoma	725	18	Wisconsin	58
9	Minnesota	657	19	Maine	56
10	Iowa	551	20	Missouri	52

Source : *An Assessment of the Available Windy Land Area and Wind Energy Potential in the Contiguous United States*, Pacific Northwest Laboratory, 1991.

Experience also shows that wind power can provide at least up to a fifth of a system's electricity, and the figure could probably be higher. Wind power currently provides nearly 25% of electricity demand in the north German state of Schleswig Holstein. In western Denmark, wind supplies 100% of the electricity that is used during some hours on windy winter nights.

What is needed for wind to reach its full potential in the U.S.?

A number of factors are needed, including:

Consistent policy support . Over the past seven years (1999-2005), the federal production tax credit has been extended four times, but three times Congress allowed the credit to expire before acting, and then only approved short durations. These expiration-and-extension cycles inflict a high cost on the industry, cause large lay-offs, and hold up investments. Long-term, consistent policy support would help unleash the industry's pent-up potential.

Nondiscriminatory access to transmission lines. Transmission line operators typically charge generators large penalty fees if they fail to deliver electricity when it is scheduled to be transmitted. The purpose of these penalty fees is to punish generators and deter them from using transmission scheduling as a "gaming" technique to gain advantage against competitors, and the fees are therefore not related to whether the system operator actually loses money as a result of the generator's action. But because the wind is variable, wind plant owners cannot guarantee delivery of electricity for transmission at a scheduled time. Wind energy needs a new penalty system that recognizes the different nature of wind plants and allows them to compete on a fair basis.

New transmission lines. The entire transmission system of the wind-rich High Plains, which cover the central one-third of the U.S., needs to be extensively redesigned and redeveloped. At present, this system consists mostly of small distribution lines—instead, a series of new high-voltage transmission lines is needed to transmit electricity from wind plants to population centers. Such a redevelopment will be expensive, but it will also benefit consumers and national security, by making the electrical transmission system more reliable and by reducing shortages and price volatility of natural gas.

Transmission will be a key issue for the wind industry's future development over the next two decades.

I've heard that Denmark is pulling back on wind development. Does that mean wind is a failure?

No. In March 2004, Denmark, already the world leader in utilizing wind (which now provides 20% of national electricity needs), decided to add another 400 megawatts (MW) of onshore wind and 350 MW of offshore wind. By the year 2008, wind's share of Danish electricity supply is expected to climb to 25%.

In addition, several major differences between Denmark and the U.S. suggest a basis for much greater expansion of wind in the U.S.:

-- *Denmark is small, the U.S. is not*:

(1) Although the U.S. has nearly twice as much installed wind equipment as Denmark, wind generates only 0.5% of our electricity, far below the 10% threshold identified by most analysts as the point at which wind's variability becomes a significant issue for utility system operators.

(2) Denmark is also so small geographically (half the size of Indiana) that high winds can cause many of its wind plants to shut down almost at once--in the U.S., wind plants are much more geographically dispersed (from California to New York to Texas) and do not all experience the same wind conditions at the same time.

-- *Denmark has transformed its national power system, the U.S. has not:*

Rapid development of wind and new small-scale power plants within the past five years has brought Denmark to the point where power produced by so-called non-dispatchable resources in the country's West exceeds 100% of demand in the region. At many times, this excess generation leaves the country scrambling to increase electricity export capabilities to handle the surplus. This situation is essentially unimaginable in the U.S.

--*Danish wind plants are typically small, U.S. wind plants are not:*

Denmark 's approach encourages community involvement, but places particular stress on low-capacity distribution networks (at the "end of the line" on transmission systems). In the U.S., our larger wind plants require advance transmission planning, but feed into main transmission lines and do not affect the customer distribution network.

In Denmark, wind has been extremely successful, and utility system operators are now taking steps to manage that success; it is unfortunate that the U.S. has not dealt with its energy problems so decisively.

Since you can't count on the wind blowing, what does a utility gain by adding 100 megawatts (MW) of wind to its portfolio of generating plants? Does it gain anything? Or should it also add 100 MW of fueled generation capacity to allow for the times when the wind is calm?

First, it needs to be understood that the bulk of the "value" of any supply resource is in the energy the resource produces, not the capacity it adds to a utility system. Having said that, utilities use fairly complicated computer models to determine the value in added capacity that each new generating plant adds to the system. According to those models, the capacity value of a new wind plant is approximately equal to its capacity factor. Thus, adding a 100-MW wind plant with an average capacity factor of 35% to the system is approximately the same as adding 35 MW of conventional fueled generating capacity. The exact answer depends on, among other factors, the correlation between the time that the wind blows and the time that the utility sees peak demand. Thus wind farms whose output is highest in the spring months or early morning hours will generally have a lower capacity value than wind farms whose output is high on hot summer evenings.

Since wind is a variable energy source, doesn't its growing use present problems for utility system managers?
At current levels of use, this issue is still some distance from being a problem on most utility systems. The rule of thumb (admittedly rough) is:

- Up to the point where wind generates about 10% of the electricity that the system is delivering in a given hour of the day, it's not an issue. There is enough flexibility built into the system for reserve backup, varying loads, etc., that there is effectively little difference between such a system and a system with 0% wind. Variations introduced by wind are much smaller than routine variations in load (customer demand).
- At the point where wind is generating 10% to 20% of the electricity that the system is delivering in a given hour, it is an issue that needs to be addressed, but that can probably be resolved with wind forecasting (which is fairly accurate in the time frame of interest to utility system operators), system software adjustments, and other changes.
- Once wind is generating more than about 20% of the electricity that the system is delivering in a given hour, the system operator begins to incur significant additional expense because of the need to procure additional equipment that is solely related to the system's increased variability.

These figures assume that the utility system has an "average" amount of resources that are complementary to wind's variability (e.g., hydroelectric dams) and an "average" amount of load that can vary quickly (e.g., electric arc furnace steel mills). Actual utility systems can vary quite widely in their ability to handle as-available output resources like wind farms. However, as wholesale electricity markets grow, fewer, larger utility systems are emerging.

Therefore, over time, more and more utility systems will look like an "average" system.

For detailed information on this topic, see "*Grid Impacts of Wind Power:* A Summary of Recent Studies in the United States," Milligan et al, **http://www.nrel.gov/docs/fy03osti/34318.pdf**

More reading:
What Happens When the Wind Stops Blowing?, **http://www.bwea.com/ref/stop.html**

Since wind is a variable energy source, doesn't it cost utilities extra to accommodate on a system that mostly uses fueled power plants with predictable outputs?
Yes, but as the previous answer suggests, the added cost is modest. Three major studies of utility systems with less than 10% of their electricity supplied by wind have found the extra or "ancillary" costs of integrating it to be less than 0.2 cents per kilowatt-hour. Two major studies of systems with wind at 20% or more have found the added cost to be 0.3 to 0.6 cents per kilowatt-hour.

For detailed information on this topic, see "Grid Impacts of Wind Power: A Summary of Recent Studies in the United States," Milligan et al, **http://www.nrel.gov/docs/fy03osti/34318.pdf**

AMERICAN WIND ENERGY ASSOCIATION

Wind energy works for America's economy, environment and energy security

Contact AWEA

Wind Energy 101

Wind Supporters

Wind energy enjoys widespread support from organizations and individuals.

Individual Support – Public Polls
Wind energy consistently ranks highly in polls as an energy source that deserves to be supported.

- A poll conducted by Yale University in June 2005 found that 87% of Americans support expanded wind energy development (**http://www.yale.edu/envirocenter/environmentalpoll.htm**).
- A February 2006 poll by Pew Research Center for People & the Press found that 82% of Americans support increased federal funding for wind, solar and hydrogen energy (**http://pewresearch.org/obdeck/?ObDeckID=8**)
- A March 2006 national opinion survey by the Energy Future Coalition found 88% of Americans support financial incentives to encourage greater use of renewable energy (**http://www.agenergy.info/index.aspx?ascxid=pagedetail&pid=17674**)

Organizational Support
A diverse array of national, regional and local environmental, agricultural, economic development, faith-based and wind and renewable energy advocacy groups has come together to form the Wind nergy Works! coalition (**www.windenergyworks.org**).

In addition, a number of environmental and conservation organizations have created positions or statements of support for wind energy, some of which are listed below.

American Bird Conservancy
www.abcbirds.org/policy/windenergy.htm

Environmental Defense
www.environmentaldefense.org/program_descriptions.cfm?subnav=3

Sierra Club
www.sierraclub.org/globalwarming

Natural Resources Defense Council
www.nrdc.org/air/energy/default.asp

Clear the Air (Joint project of the Clean Air Task Force, National Environmental Trust and the U.S. PIRG Education Fund)
www.cleartheair.org

Greenpeace
www.greenpeace.org/international_en/campaigns/intro?campaign_id=3937

World Wildlife Fund
www.worldwildlife.org/climate/index.cfm

National Wildlife Federation
www.nwf.org/climate

Union of Concerned Scientists
www.ucsusa.org/global_environment/global_warming/index.cfm

World Wildlife Fund
www.worldwildlife.org/climate/pubs.cfm

The Difference Wind Makes

Wind projects provide real energy, economic, and environmental benefits

Wind energy makes a REAL CONTRIBUTION TO OUR ENERGY NEEDS

- Total installed U.S. wind power plants already serve more than 1.6 million average households with 4.3 million people, topping 6,740 megawatts (MW) in 2004. In 2005, that number will jump to more than 9,000 MW, serving over 2.3 million households with 6 million people. The wind industry is capable of supplying about 6% of our nation's electricity (as much as hydropower generates today) by 2020.
- Wind energy contributes to our energy security: an inexhaustible, domestic resource, it helps reduce our dependence on imports of natural gas (for electricity generation and residential use), oil and other fuels, often from unstable countries like Nigeria and Russia. AWEA estimates that the wind farms already in place, and those that will be installed by the end of 2005, will be saving over 0.5 billion cubic feet (Bcf) of natural gas per day in 2006.
- Although wind energy is variable, PacifiCorp, a major electric utility in the Northwest, recently assigned its wind projects a 20% capacity credit.[1] That means that 20% of the total wind energy on PacifiCorp's system can be considered base load, like traditional fossil-fuel plants, and that it helps to improve overall utility system reliability.
- Modern wind turbines are equipped with high-tech computers and power electronics that process over 200 types of data, from wind speeds and oil temperature to voltage dips on the grid. "Smart" wind turbines can help make the electricity transmission system more reliable.
- Once approved, wind farms can be built relatively quickly to respond to electricity demand.

Wind energy delivers REAL ECONOMIC BENEFITS

- AWEA predicts that up to 2,500 MW of new wind energy capacity will be installed in 2005, resulting in $2-3 billion in investment and an estimated 10,000 new job-years nationwide (that's 10,000 one-year jobs or 1,000 long-term, ten-year jobs).
- Texas saw 1,000 MW of wind projects added to the state in 2001, providing $11.6 million in property tax payments to local schools, $2.5 million in landowner royalty income, and 2,500 wind-related jobs.
- One large (108-turbine, 162-MW) project in rural Prowers County, Colorado, increased the county's tax base by 29%, adding annual payments of about $917,000 to the general school fund, $203,000 to the school bond fund, $189,000 to a county medical center, and $764,000 in new county revenues, as well as 15-20 permanent and well-paying full-time jobs at the wind farm.[2]

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[1] *Integrated Resource Plan 2004,* PacifiCorp (Jan 2005) http://www.pacificorp.com/File/File47422.pdf
[2] *From Snack Bars to Rebar*, (Mar 2004) http://www.state.co.us/oemc/events/cwade/2004/presentations/cox.pdf

- As many as 215,000 new jobs would be created by adding 50,000 MW of new wind installations in the U.S. – a $50 billion investment that could provide electricity for as many as 15 million homes with 39 million people. Many of these new positions would be in the manufacturing sector, bringing 150,000 new jobs back to a hard-hit sector of our economy.[3]
- An analysis from the Union of Concerned Scientists finds switching 10% of our electricity to clean energy sources by 2020 could save consumers as much as $13 million over 20 years, due to lower natural gas prices and higher renewable electricity consumption.[4]

Wind energy offers REAL ENVIRONMENTAL BENEFITS

Wind power offsets other, more polluting sources of energy. That is important because electricity generation is the largest industrial source of air pollution in the U.S. When wind power projects generate electricity, fuel at other power plants is not consumed.

- Wind energy requires no mining, drilling, or transportation of fuel, and does not generate radioactive or other hazardous or polluting waste.
- To generate the same amount of electricity as does the current fleet of U.S. wind turbines would require burning 9 million tons of coal (a line of 10-ton trucks stretching 3,400 miles, from Seattle to Miami) **each year.**
- A recent New York study found that if wind energy supplied 10% (3,300 MW) of the state's peak electricity demand, 65% of the energy it displaced would come from natural gas, 15% from coal, 10% from oil, and 10% from electricity imports.[5]
- Emissions from the manufacture and installation of wind turbines are negligible. The "energy payback time" (a measure of how long a power plant must operate to generate the amount of electricity required for its manufacture and construction) of a wind farm is 3 to 8 months, depending on the wind speed at the site – one of the shortest of any energy technology.

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[3] *Wind Turbine Development: Location of Manufacturing Activity*, Renewable Energy Policy Project (Sep 2004) http://www.repp.org/articles/static/1/binaries/WindLocator.pdf

[4] *EIA Studies Show a National Renewable Electricity Standard Can Save Consumers and Businesses Money*, Union of Concerned Scientists (Jun 2003) http://www.ucsusa.org/clean_energy/renewable_energy/page.cfm?pageID=1222

[5] *The Effects Of Integrating Wind Power On Transmission System Planning, Reliability, And Operations: Report On Phase 2: System Performance Evaluation*, New York State Energy Research & Development Authority (Mar 2005) http://www.nyserda.org/publications/wind_integration_report.pdf

Pittsburgh Commitment

Background

In his Advanced Energy Initiative released in February 2006, President Bush described his vision of changing the way we power our homes and businesses by increasing energy efficiency, alleviating price pressures on natural gas, and fostering alternatives for power production, including wind energy. In doing so, he declared that areas of the nation with good wind resources could provide 20 percent of total U.S. electricity demand.

Wind is an abundant and free domestic energy resource. Coupled with modern technology, it displaces the need for fossil generation and reduces U.S. dependence on imported energy. At the same time, it delivers cost-competitive electricity and environmental and economic benefits to the American people.

Commitment

The U.S. Department of Energy, National Renewable Energy Laboratory, and the American Wind Energy Association will collaborate to develop an action plan to realize the President's vision. This plan will include specific recommendations that, when implemented, will lead to a vastly increased role for wind energy in U.S. electricity supply.

The action plan will incorporate input from key stakeholders, including environmental groups, utilities, policy planners, investors, educators, communities, and others and will be made public during the WINDPOWER 2007 Conference and Exhibition in Los Angeles, Calif.

Why Wind Energy?

Large-scale wind is feasible – In recent years, grid studies focused on the feasibility of integrating greater amounts of renewable energy into New York, Minnesota, and Germany's grid systems have provided insight and established confidence in the goal to supply up to 20% of America's electricity from wind. Currently, the California Energy Commission and California Independent System Operator are also studying the limits of existing systems to absorb up to 33% renewable energy in California.

Wind is cost competitive. Wind energy generation is competitive with new conventional energy generation plants. Today, electricity production over the life of a given wind plant can be reliably predicted, providing an effective hedge against fossil fuel price volatility. Wind energy also provides a positive net energy pay-back in about 3-6 months.

Wind is environmentally sound – Wind energy creates no emissions. Using only America's free, abundant winds as fuel, every 1000 megawatt-hours of wind generation avoids about 600 tons of CO_2 emissions.

The wind resource exists – U.S. DOE studies indicate that many of the world's most abundant wind resources reside in the United States. Some exist in the Eastern and Western mountains off of the Atlantic coast and surrounding the Great Lakes. Most, however, can be found in rural, less populated areas like the Great Plains which reach from Texas into Canada. According to DOE, a fraction of this land could easily supply 20% of the nation's electricity needs. At the same time, since wind energy uses only a small footprint, the same land can continue to be used for ranching and/or farming activities, increasing local economic development.

Wind energy is secure – As an abundant, indigenous energy resource, wind power generation reduces the need for fossil fuel imports, expanding our nation's domestic prosperity. Wind energy can also provide significant economic revitalization to the nation's rural areas since investment in local wind plants creates jobs. According to AWEA, 22 man-years of employment are created for every megawatt of wind turbines manufactured, installed, or serviced.

Wind technology continues to advance – Wind energy is a good value today. Next generation wind technology, however, will further reduce the cost of wind energy, provide seamless integration with electricity grid operations, and enable powerful offshore wind turbines to be deployed which can supply major coastal load centers. Federal research and development investment will assure the availability of advanced wind energy technology necessary to meet our nation's needs moving forward.

Wind is part of the solution - The nation is best served with a balanced energy portfolio. As the United States moves toward a clean energy future, an integrated portfolio approach, including renewables and wind, will become increasingly important. Domestic renewables can provide a significant portion of the U.S. energy supply, augmenting the existing fossil fuel infrastructure. Wind is the first utility-scale renewable to become economically competitive. Solar, geothermal, and biomass are following with significant development expected to occur in the next decade.

Wind energy generation is a public benefit - Public awareness of the potential for wind and renewable energy is crucial. Stable government policy will be required to make substantive progress - particularly to ensure fair competition for new alternatives and to establish market-based pricing. Achieving 20% of the nation's electricity from wind will make a significant impact in the areas of lower natural gas prices, environmental emissions, energy security, import deficit reduction, and investment in U.S.-based jobs.

The Vision

Wind power is proven – it can provide a significant contribution toward meeting large-scale electricity needs. With America's volatile fuel pricing and growing environmental concerns, now is the time to tap into our nation's abundant wind energy resource--now is the time for us all to commit to the realization of this goal.

AMERICAN WIND ENERGY ASSOCIATION

Wind energy works for America's economy, environment and energy security | Contact AWEA

Wind Energy Facts & Myths

"Nuisance"

Myth: "Turbines Are Noisy"

Fact: Wind turbines are quiet. An operating modern wind farm at a distance of 750 to 1000 feet is no noisier than a kitchen refrigerator or a moderately quiet room. The sound turbines produce is similar to a light whooshing or swishing sound, and much more quiet than other types of modern-day equipment. Even in rural or low-density areas, where there is little additional sound to mask that of the wind turbines, the sound of the blowing wind is often louder.

Exceptions to quiet operating turbines can occur in two instances - with older turbines from the 1980s and with contemporary turbines in some types of hilly terrain. Modern wind turbines have been designed to drastically reduce the noise of mechanical components so the most audible noise is the sound of the wind interacting with the rotor blade. However, in some hilly terrain where residences are located in sheltered dips or hollows downwind from turbines, turbine sounds may carry further and be more audible. This effect can generally be anticipated and avoided in the development process through adequate setbacks from homes.

Myth: "Turbine Lighting Is Excessive"

Fact: Lights at wind farms are non-intrusive, and improvements in design will make them even less so as the technology expands. The Federal Aviation Administration (FAA) recommends lighting for most structures more than 200 feet in height to ensure aviation safety.

The wind industry is working with the FAA to test safe and non-intrusive lighting plans for wind farms.

Myth: "Nearby Residences Will Be Affected by Shadow Flicker"

Fact: Shadow flicker is the term used to describe what happens when rotating turbine blades come between the viewer and the sun, causing a moving shadow. Shadow flicker is almost never a problem for residences near new wind farms, and in the few cases where it could be, it is easily avoided. For some who have homes close to wind turbines, shadow flicker can occur under certain circumstances and can be annoying when trying to read or watch television. However, the effect can be precisely calculated to determine whether a flickering shadow will fall on a given location near a wind farm, and how many hours in a year it will do so. Potential problems can be easily identified using these methods, and solutions range from the appropriate setback from the turbines to planting trees to disrupt the effect. Normally, shadow flicker should not be a problem in the U.S. because at U.S. latitudes (except Alaska) the sun's angle is not very low in the sky. If any effect is experienced, it is generally short-lived, as in a few hours over a year's time.

Myth: "Turbines Interfere with Television and Other Communications Signals"

Fact: Interference is rare and easily avoided. Large wind turbines installed at wind farms can interfere with radio or television signals if a turbine is in the "line of sight." Improving a receiver's antenna or installing relays to transmit the signal around the wind farm solves this problem; both solutions are common practice in modern wind energy development.

Myth: "Turbines Are Ugly"

Fact: Beauty is in the eye of the beholder. Some people feel wind turbines are majestic. Wind farm developers have computer-modeling tools that accurately depict virtual views from given spots in the surrounding area. Careful design of a wind project can alleviate many visual concerns.

Wind Energy Facts & Myths

"No Benefits"

Myth: "Wind Projects Harm Property Values"

Fact:There is no evidence that the presence of a commercial windfarm within sight of a property systematically decreases that property's value. In fact, a nationwide study conducted in 2003 surveyed property near multiple wind farms and found that not only do wind farms not harm property values, but that in some cases the values increased.

Myth: "Wind Projects Depress Tourism"

Fact: There is no evidence to indicate that wind turbines drive tourists away. In some areas, wind turbines even draw tourists. Local governments frequently work with developers to install information stands and signs near wind farms, as well as pull-off areas, similar to "scenic overlooks", from nearby roads. Surveys of tourists have found that the presence of wind turbines would not affect the decision of most visitors to return. The thousands of turbines in Palm Springs, California, have had no negative impact on the tourism business; on the contrary, the local tourism center organizes bus tours to the wind farms.

Myth: "Wind Projects Don't Contribute to the Local Tax Base"

Fact: Installing millions of dollars of equipment in most areas greatly increases the local taxes assessed, and wind farms are no exception. Wind farms support the local tax base, helping to pay for schools and roads far more than their impact to local facilities. One large (108-turbine) project in rural Prowers County, Colorado, increased the county's tax base by 29%.

Economic development associated with a new wind farm extends far beyond taxes to increased employment, directly from the wind farm operation and construction, and to money pumped in the local economy through services needed to support a large construction project, including increased hotel stays and restaurant revenues.

Wind Energy Facts & Myths

"Unsafe"

Myth: "Blades Cause Dangerous Ice Throws"

Fact: Ice throw, while it can occur under certain conditions, is of little danger. Setbacks typically used to minimize noise are sufficient to protect against danger to the public. In addition, ice buildup slows a turbine's rotation and will be sensed by a turbine's control system, causing the turbine to shut down.

Myth: "Turbines May Throw Blades or Collapse"

Fact: Modern wind turbines are so safe they successfully operate near schools, in urban settings and densely populated areas, and in rural communities. Blade throws were common in the industry's early years, but are unheard-of today because of better turbine design and engineering.

Utility-scale wind turbines are certified to international engineering standards, such as those developed by Germanischer Lloyd or Det Norske Veritas, and these include ratings for withstanding different levels of hurricane-strength winds and for other criteria. There are thousands of turbines installed in Europe and thousands in the U.S. - wind turbine standards ensure a high level of operational reliability and safety in the U.S. and worldwide.

Wind Energy Facts & Myths

"Harm Wildlife"

Myth: "Turbines Kill Many Birds and Bats"

Fact: Wind energy development's overall impact on birds is extremely low compared with other human-related activities. No matter how extensively wind is developed in the future, bird deaths from wind energy are unlikely to be ever more than a small fraction of bird deaths caused by other human-related sources, such as cats and buildings.

Raptor kills (of eagles, hawks, and owls) are a problem at one large older wind farm in California, in Altamont Pass, built in the 1980s. Wind farm operators there have worked with wildlife officials and experts to reduce the impacts on raptors, and those efforts continue today.

Prior to 2003, bat kills at wind farms studied were low. However, the frequency of bat deaths at a newly constructed wind farm in West Virginia in 2003 has caused concern. In response, AWEA and several of its member companies entered into a three-year cooperative effort with Bat Conservation International, the National Renewable Energy Laboratory, and the U.S. Fish and Wildlife Service to research wind/bat interaction and test ways to reduce bat mortality. That research is ongoing, and information about the results is being published as they become available.

Despite the minimal impact wind development has on bird and bat populations in most areas, the industry takes potential impacts seriously. In addition to special intiatives such as those described above, avian studies are routinely conducted at wind sites before projects are proposed. Pre-construction wildlife surveys are now common practice throughout the industry.

Myth: "Wind Projects Fragment Wildlife Habitat"

Fact: Wind farms are most often built in areas close to transmission lines where habitat has already been modified and fragmented, typically by farming and ranching. And, wind energy has a light footprint, with only the turbine itself, along with some roads and power lines, impacting the land, while pre-existing land use continues around the turbines as before. Windy land can also often be found in undeveloped areas, however, so habitat fragmentation can be a concern, especially in unbroken stretches of prairie grasslands or forests. The industry supports more research to better understand the extent of possible habitat or wildlife impacts in these areas, but those impacts must be balanced against the effects of not developing renewable energy sources and thereby aggravating global warming and pollution pressures on wildlife and their habitats--not just in prairie or forest areas, but around the world.

Wind Energy Facts & Myths

"Expensive & Unreliable"

Myth: "Back-up Generation Is Needed for All Wind Turbines"

Fact: Because of the grid's inherent design, there is no need to back up every megawatt of wind energy with a megawatt of fossil fuel or dispatchable power. The electric grid is designed to have more generation sources than are needed at any one time because no power plant is 100% reliable. It is a complicated system designed to absorb many impacts, from electric generation sources going out of service unexpectedly to industrial customers starting up energy-intensive equipment. The grid operator matches electricity generation to electricity use, and wind energy's variability is just one more variable in the mix.

One of the most authoritative studies, conducted in 2004 for the Minnesota Department of Commerce found that adding 1,500 megawatts (MW) (enough wind to meet the needs of more than 400,000 homes) to the system of a major utility, Xcel Energy in Minnesota, would require only an additional 8 MW of conventional generation to deal with added variability.

Many sources of electricity considered highly reliable suffer from unexpected outages: for instance nuclear reactors and coal plants that shut down, often at short notice, for safety repairs or maintenance. Yet no one proposes to back up a coal or nuclear power plant with a similar amount of dedicated generation from another plant. The reality is that wind energy is naturally variable, but not unreliable. Wind farms are built in windy areas, and seasonal and daily wind generation patterns can be anticipated. Denmark and utility systems in regional areas elsewhere in Europe operate with 10-15% or more of their power coming from wind, without increased reliability problems or need for additional back-up power plants. And in contrast to conventional power plants, wind farms need not shut down altogether for maintenance and repairs-a turbine fault, when it occurs, can be repaired while the other turbines continue to operate.

Myth: "Turbines Operate Only a Small Fraction of the Time"

Fact: Wind turbines generate electricity most (65-80%) of the time, although the output amount is variable. No power plant generates at 100% "nameplate capacity" 100% of the time. Nameplate capacity refers to the maximum generation potential of a power plant. A conventional power plant is occasionally closed for maintenance or repairs, or runs below full capacity to best match demand. Wind farms are built in areas where the wind blows most of the time, but because of variations in speed, a wind farm will generate power at full rated capacity about 10% of the time, and on average throughout the year the plant will generate 30% to 35% of its rated capacity. A utility in the Northwest, PacifiCorp, added 20% of its wind projects' nameplate capacity into its baseload calculation in the utility's 2004 Integrated Resource Plan. This indicates that utilities with experience with wind energy on their system consider it able to provide some consistent power on a regular basis. The full plan can be accessed at **http://www.pacificorp.com/File/File47422.pdf**

Myth: "Wind Energy Will Never Provide More Than a Little Electricity"

Fact: The U.S. Department of Energy estimates America's wind energy potential to be much larger than total U.S. electricity consumption today. Tapping only a fraction of that potential would provide a significant part of America's electricity supply. In the United States, wind energy currently produces approximately 24 billion kilowatt-hours of electricity, equivalent to powering the equivalent of 2.3 million average American homes year-round. A typical one-megawatt turbine generates enough electricity for 250 - 300 homes. With policies to remove barriers to wind energy development, by 2020, 100,000 MW of wind energy could be installed, providing at least 6% of electricity generated in the U.S., or about the same amount as hydropower today. Wind energy is poised to be a significant part of America's diverse energy portfolio.

Myth: "Wind Turbines Are Inefficient"

Fact: Wind turbines are efficient, and that is part of their beauty. One of the simplest ways to measure overall efficiency is to look at the "energy payback" of an energy technology, i.e., the amount of energy it takes to produce a given amount of energy.

The energy payback time for wind is in fact similar to or better than that of conventional power plants. A recent study by the University of Wisconsin-Madison calculated the average energy payback of Midwestern wind farms to be between 17 and 39 times as much energy as they consume (depending on the average wind speeds at the site), while nuclear power plants generate only about 16 times and coal plants 11 times as much energy as they consume.

Wind turbines are also highly efficient in a larger sense: they generate electricity from a natural, renewable resource, without any hidden social or environmental costs-there is no need to mine for fuel or transport it, no global warming pollutants created, and no need to store, treat, or dispose of wastes.

Myth: "Wind Energy Is Expensive"

Fact: Wind energy is now in a range that is competitive with power from new conventional power plants. The up-front, capital cost of wind energy is more expensive than that of some traditional power technologies such as natural gas. However, there are no fuel costs, and in good locations the "levelized" cost (which includes the cost of capital, the cost of fuel, and the cost of operations and maintenance over the lifetime of the plant) of wind energy can now be very competitive with that of other energy sources.

Myth: "Wind Energy Is Heavily Subsidized"

Fact: Every energy technology is subsidized. Wind energy is no exception, nor should it be. Wind energy receives a tax credit based only on electricity produced (not dollars invested), equal to an inflation-adjusted 1.5 cents (currently 1.9 cents) for each kilowatt-hour generated over the first ten years of the project. This credit reduces the taxes paid by a wind farm, thereby reducing the cost of providing wind-generated electricity to the consumer.

Other energy sources receive subsidies in many forms, including tax deductions, loan guarantees, liability insurance and leasing of public lands at below market prices. Some, like the depletion allowance for oil and gas, are permanent in the tax code. Additional indirect subsidies include federal money for research and development programs and policy provisions in federal legislation. The largest subsidy, however, may be an invisible one-the fact that the environmental impacts from fossil fuel use are not reflected through higher costs of those energy sources. Instead, all of society must pay the price for dirty air, polluted water, health costs, global warming, fuel spills, and cleanup and disposal of fuel byproducts attributed to traditional energy sources. Clean, renewable, domestic wind energy produces no emissions, requires no fuel and the cost is fixed and predictable over time.

Response to "Wind Farms Provide Negligible Useful Electricity," Richard S. Courtney, Center for Science and Public Policy (CSPP), Washington, D.C., March 2006.

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<u>Courtney/CSPP Claim</u>: "Wind farms only force power stations to operate more spinning standby. They provide no useful electricity and make no reduction to emissions from power generation. . . . Wind farms have capital, maintenance and operating costs that add to the cost of electricity. These costs are their only contribution to the electricity supply system. But they disrupt operation of the system."

<u>Science</u>: Wind farms do usually require small amounts of additional spinning standby, but at the levels of "penetration" (wind on a utility system as a percentage of all generation) likely to be reached in the next decade, those amounts are very low. The primary reason? Electricity demand also varies constantly throughout the day, and utility systems must already cope with those variations.

For example, here is the result of a study by the Utility Wind Interest Group of 280 megawatts (MW) on the Xcel North system: "The cost of additional regulating reserves to accommodate the wind generation was found to be negligible. This finding is based on results of load frequency control simulations which showed essentially no change in the area control error standard deviation between scenarios with and without the wind generation." "Wind Plant Integration: Costs, Status, and Issues," DeMeo et al., *IEEE Power & Energy Magazine*, November/December 2005.

Another useful observation from the same article: "Concerns arising from wind's variability have spawned a number of misconceptions that are often voiced by utility engineers unfamiliar with wind power and by individuals wishing to impede wind power expansion. Each of these has been dispelled by either deliberate, careful examination or by actual practical experience."

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<u>Courtney/CSPP Claim</u>: "The largest wind turbine in operation is the Vestas V44-600. Its blade is 144 feet in diameter and is mounted on a 160-foot tower west of Traverse City, Michigan."

<u>Science</u>: This is a serious blunder by an author described as an expert in the field:

- **The report is dated March 2006, but larger, 48-meter, 750-kilowatt wind turbines manufactured by Zond Corp. (later purchased by GE Wind) were already entering the market as early as 1998, when 143 of them were installed in the Lake Benton I wind project on Minnesota's Buffalo Ridge. The largest wind turbine in operation today is a 5-MW unit in Germany, with more than 8 times the generating capacity of the Vestas 600-kW machine.**

- **No one familiar with wind technology would refer to a turbine rotor (which typically has three blades, like an airplane propeller) as a "blade," or discuss the "blade diameter."**

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<u>Courtney/CSPP Claim</u>: . . . [W]ind farms provide very intermittent electricity supply."

<u>Science</u>: "Variable" is a more accurate way to describe wind farm generation than "intermittent." At a typical wind farm site, some electricity is being produced 70% to 90% of the time.

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<u>Courtney/CSPP Claim</u>: "Wind farms also swat birds. One wind farm at Altamont Pass, California, kills thousands of birds – including an estimated 880 to 1300 birds of prey – each year."

<u>Science</u>: "Bird kills have caused serious scientific concern at only one location in the United States: Altamont Pass in California, one of the first areas in the country to experience significant wind development. Over the past decade, the wind community has learned that wind farms and wildlife can and do coexist successfully. Wind energy development's overall impact on birds is extremely low (<1 of 30,000) compared to other human-related causes, such as buildings, communications towers, traffic, and house cats. Birds can fly into wind turbines, as they do with other tall structures. However, conventional

fuels contribute to air and water pollution that can have far greater impact on wildlife and their habitat, as well as the environment and human health." ***Wind Energy Myths*****, U.S. Department of Energy, May 2005. http://www.nrel.gov/docs/fy05osti/37657.pdf**

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<u>Courtney/CSPP Claim</u>: "[W]ind farms provide serious noise pollution down-wind. An efficient wind turbine blade removes much energy from the air. For this reason, a rotating blade generates pulses of reduced pressure in the air flowing behind the turbine which provide loud, throbbing, often subsonic noise. This has potential to disturb breeding habits of wildlife and is certainly unpleasant for people exposed to it."

<u>Science</u>: "Modern wind turbines produce very little noise. The turbine blades produce a whooshing sound as they encounter turbulence in the air, but this noise tends to be masked by the background noise of the blowing wind. An operating modern wind farm at a distance of 750 feet to 1000 feet is no more noisy than a kitchen refrigerator." ***Wind Energy Myths*****, U.S. Department of Energy, May 2005. http://www.nrel.gov/docs/fy05osti/37657.pdf**

"[There is] No reliable evidence that infrasound [the "subsonic noise" referred to above] below the hearing threshold produces physiological or psychological effects." "Infrasound and Psychoacoustics," presentation by Anthony L. Rogers, Ph.D., to National Wind Coordinating Committee, December 2005. http://www.nationalwind.org/events/siting/presentations/rogers-infrasound.pdf

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<u>Courtney/CSPP Claim</u>: "Richard [Courtney] is a respected authority on energy issues, especially clean coal technology. He has been the Senior Materials Scientist of the UK's Coal Research Establishment, has served as a Technical Advisor to the European Coal and Steel Community (ECSC), possesses several patents, and has published papers in many journals including Nature, Microscopy and Filtration. He is the author of the chapter on coal in Kempes Engineers Yearbook."

<u>Response</u>: There are a number of experts in other energy fields who have failed notably, as Mr. Courtney has, in seriously addressing the positive and negative aspects of wind energy. Since there are many reputable sources available (e.g., U.S. Department of Energy, National

Wind Coordinating Committee, Utility Wind Interest Group), we can only speculate that this problem arises from the most fundamental failure: failure to keep an open mind and consider all of the evidence, in particular evidence which contradicts one's preconceptions.

As for the "Center for Science and Public Policy," it is troubling that an organization with such a name would lend it to such a misleading document, which obviously does not contribute to respect for science in the public policy arena.

American Wind Energy Association

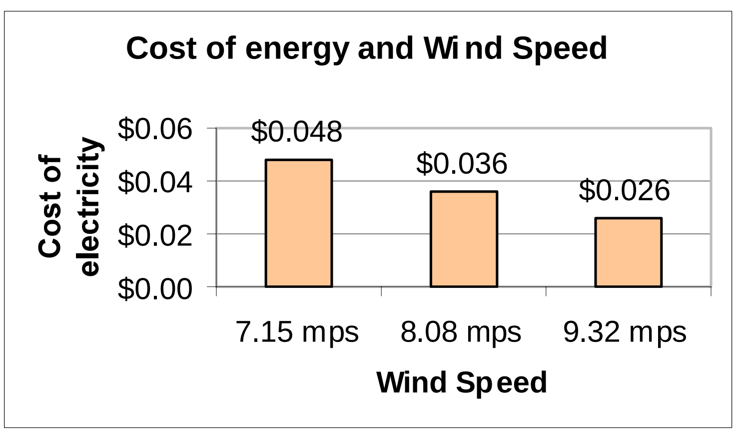
www.awea.org

The Economics of Wind Energy

The economics of wind energy have changed dramatically over the past twenty years, as the cost of wind power has fallen approximately 90 percent during that period. Despite that progress, the wind industry is still somewhat immature, with production volumes that pale in comparison to what they will be two decades from now. Thus, the factors affecting the cost of wind energy are still rapidly changing, and wind energy's costs will continue to decline as the industry grows and matures.

A number of factors determine the economics of utility-scale wind energy and its competitiveness in the energy marketplace.

The cost of wind energy varies widely depending upon the wind speed at a given project site. The energy that can be tapped from the wind is proportional to the cube of the wind speed, so a slight increase in wind speed results in a large increase in electricity generation. Consider two sites, one with an average wind speed of 14 miles per hour (mph) and the other with average winds of 16 mph. All other things being equal, a wind turbine at the second site will generate **nearly 50% more electricity** than it would at the first location.



The three examples above are for costs per kilowatt-hour for a 51 MW wind farm at three different average wind speeds expressed in meters per second. Cost figures include the current wind production tax credit.

Improvements in turbine design bring down costs. The taller the turbine tower and the larger the area swept by the blades, the more powerful and productive the turbine. The swept area of a turbine rotor (a circle) is a function of the square of the blade length (the circle's radius).

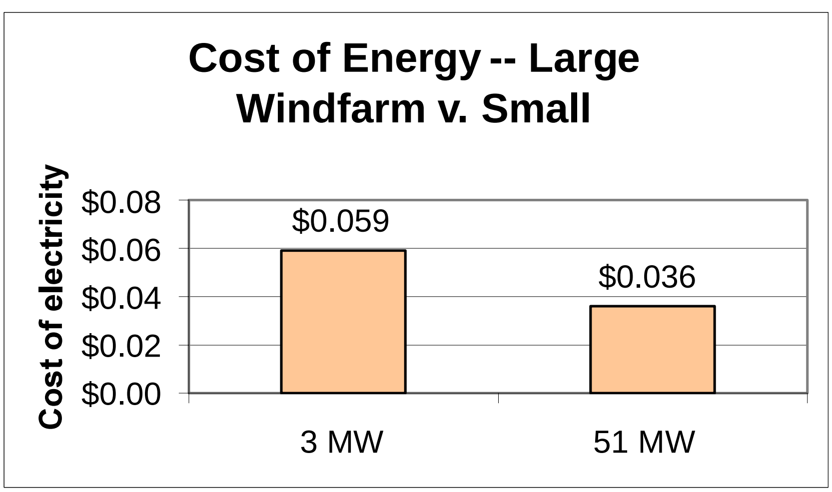
Therefore, a fivefold increase in rotor diameter (from 10 meters on a 25-kW turbine like those built in the 1980s to 50 meters on a 750-kW turbine common today) yields a 55-fold increase in yearly electricity output, partly because the swept area is 25 times larger and partly because the tower height has increased substantially, and wind speeds increase with distance from the ground.

Advances in electronic monitoring and controls, blade design, and other features have also contributed to a drop in cost. The following table shows how a modern 1.65-MW turbine generates 120 times the electricity at one-sixth the cost of an older 25-kW turbine:

	1981	2000
Rated Capacity	**1981: 25 kW**	**2000: 1,650 kW**
Rotor Diameter	**10 meters**	**71 meters**
Total Cost ($000)	**$65**	**$1,300**
Cost per kW	**$2,600**	**$790**
Output, kWh/year	**45,000**	**5.6 million**

A large wind farm is more economical than a small one. Assuming the same average wind speed of 18 mph and identical wind turbine sizes, a 3–MW wind project delivers electricity at a cost of $0.059 per kWh and a 51-MW project delivers electricity at $0.036 per kWh—**a drop in costs of $0.023, or nearly 40%.** Any project has transaction costs that can be spread over more kilowatt-hours with a larger project. Similarly, a larger project has lower O&M (operations and maintenance) costs per kilowatt-hour because of the efficiencies of managing a larger wind farm.

Cost figures include the current wind production tax credit.



Optimal configuration of the turbines to take the best advantage of micro-features on the terrain will also improve a project's productivity. [i]

The cost of financing affects the cost of wind energy. Wind energy is capital-intensive, so the cost of financing constitutes a large variable in a wind energy project's economics. For a variety of reasons, financing for wind projects remains more expensive than for mainstream forms of electricity generation.

Project ownership affects cost of financing and the economics of a wind power project. Independent ownership—that is, financing of projects by private power producers on a stand-alone basis, which is how the vast majority of U.S. wind projects are financed—is more expensive than utility-owned financing. According to a study by Lawrence Berkeley National Laboratory, [ii] utility ownership of a wind facility results in a significantly lower estimated levelized cost of energy, because lower-cost financing available to large electric utilities (IOUs, or investor-owned utilities) is not available for non-IOU wind projects. IOU ownership reduces levelized costs by approximately 30%, the study found.

In addition, although wind turbine technology has steadily progressed to a point where its reliability is today comparable to that of other energy technologies, it is still regarded as "novel" and "risky" by many members of the U.S. financial community (most U.S. projects are still financed by European-based lenders). Lenders therefore offer less favorable financing terms and demand a higher return on investment than for more “conventional” energy sources.

Table: The economics of a 50-MW wind farm at a wind site with average wind speed of 13-17 mph (class 4). Figures are indicative only.

Project size:	50 MW
Capital cost:	$65 million ($1.3 million per MW)
Annual power production (assuming 35% capacity factor)	150 million kWh
Financing:	60% debt, 40% equity
Annual gross revenue:	$6 million (assuming power purchase price of 4 cents per kWh)
Expenses:	-Debt: 60% (15 years at 9.5%) -Distribution 22% -Operation and maintenance (8%) -Land, property taxes, or rent 5% -Mgt fees, insurance 5%
Tax credit and depreciation:	-5-year depreciation on wind equipment -1.5 c/kWh credit adjusted for inflation during first ten years of operation

The Lawrence Berkeley Laboratory study found that a 50-MW wind farm delivering power at just under 5 cents per kWh would, if using typical natural gas project financing terms, generate electricity for 3.69 cents per kWh.

Transmission, tax, environmental, and other policies also affect the economics of wind.
Transmission and market access constraints can significantly affect the cost of wind energy. Since wind speeds vary, wind plant operators cannot perfectly predict the amount of electricity they will be delivering to transmission lines in a given hour. Deviations from schedule are often penalized without regard to whether they increase or decrease system costs. Interconnection procedures are not standardized, and utilities have on occasion imposed such difficult and burdensome requirement on wind plants for connection to transmission lines that wind companies have chosen to build their own lines instead. (See "Fair Transmission Access for Wind" at http://www.awea.org/policy/documents/transmission.PDF).

As electricity markets are restructured and long-term power purchase agreements give way to trading on power exchanges, transmission and market access conditions will play an increasingly important role in the economics of a wind project.

The federal tax code, which provides a variety of permanent and temporary incentives for conventional forms of energy, also includes a production tax credit (PTC) for wind energy and a 5-year accelerated depreciation schedule for wind turbines. The 1.5 cent-per-kWh PTC is adjusted for inflation (currently it stands at 1.8 cents/kWh) and supports electricity generated from utility-scale wind turbines for the first ten years of their operation. The PTC, first adopted in 1992, was extended in 1999, again, through 2003 after its expiration in 2001, and most recently through December 31, 2005 after its expiration in 2004. In order to qualify for the credit, generators must now complete installations and start production before the 2005 expiration date. The PTC may be reduced or cancelled if a project applies for state incentives such as a grant or no-interest loan, under federal "anti-double-dipping" rules. [iii]

The PTC, a key incentive, helps level the economic playing field for wind projects in energy markets where other forms of energy are also subsidized. It must be noted, however, that the current “on-again, off-again” status of the credit is hobbling project development and the industry as a whole. Uncertainty also affects relationships with vendors and substantially increases costs as orders are rushed to meet PTC deadlines or as planning grinds to a halt and income is lost while the industry awaits an extension. One major U.S. developer stated that a five-year extension of the PTC would provide enough long-term certainty to squeeze an additional 25 percent out of vendor costs. The wind energy industry is currently seeking a long-term extension of the credit.

Stricter environmental regulations enhance wind energy’s competitiveness. Wind power’s environmental impact per unit of electricity generated is much lower than that of mainstream forms of electricity generation, as wind energy neither emits pollutants, wastes, or greenhouse gases, nor damages the environment through resource extraction. The higher the air quality and other environmental standards adopted in a country, the more competitive wind energy therefore becomes in the marketplace. Conversely, a relaxation of standards or failure to internalize environmental costs through pollution charges or other processes makes polluting forms of electricity generation appear deceptively cheap.[iv] This is an important economic issue, because the hidden "subsidy" that governments and markets give to polluting energy sources by partially or fully ignoring their health and environmental costs is typically much larger than direct subsidies to such energy sources.

Wind energy provides ancillary economic benefits:

- less dependence on fossil fuels, which can be subject to rapid price fluctuations and supply problems (by the end of 2006, AWEA estimates wind energy use will save over 0.5 billion cubic feet (Bcf) of natural gas *each day*, relieving some of the current supply shortages);
- steady income for farmers or ranchers who own the land on which windfarms are built, and for the communities in which they live (in Texas, for example, ranchers have been reaping income from the wind even as their royalties from oil wells have declined);
- an increase in the property tax base for rural counties.

For information on the costs of wind energy and that of other electricity sources, see http://www.awea.org/pubs/factsheets/Cost2001.PDF

[i] "Economics of Wind Farm Layout," Alan Germain and Donald Bain, Windpower 1997 proceedings (American Wind Energy Association, Washington, D.C.).

[ii] "Alternative Windpower Ownership Structures: Financing Terms and Project Costs," Ryan Wiser and Edward Kahn, Lawrence Berkeley Laboratory, Energy and Environment Division, 1996.

[iii] "Anti-Double Dipping Rules for Federal Tax Incentives, Edwin Ing, Windpower 1997 proceedings.

[iv] The cost of producing electricity from coal or oil would double and the cost of electricity production from gas would increase by 30% if some external costs such as damage to the environment (not including that of global warming) and to health were taken into account, according to a study by the European Union (more information available at http://europa.eu.int/comm/research/press/2001/pr2007en.html). Similarly, in the U.S., state attempts to set up a process by which some of the environmental costs of electricity production, or externalities, could be taken into account in economic calculations have focused on air emissions and set externalities estimates in the range of 3-6 cents per kWh for coal and 0.5 to 2 cents per kWh for natural gas. For a comprehensive study see Ottinger et al., "Environmental Costs of Electricity," Pace University Center for Environmental Legal Studies, Oceana Publications, 1990.

Wind Energy and Wildlife: The Three C's

In terms of impacts on wildlife, wind energy has three primary benefits as an energy generation source: it is **clean**; it is **compatible** with animals and humans; and the industry is **committed** to ensuring minimal impacts on nature and the environment in wind energy development. This fact sheet provides information and statistics on each of these attributes.

- **CLEAN**: Wind energy is one of the cleanest, most environmentally friendly energy sources in the world. Wind energy development protects air quality, reduces the effects and rate of global warming, and displaces mining and drilling for natural gas, coal, and other fuels. While wind energy cannot supply all of the electricity we need, using more of it will reduce the overall environmental impact of our society's energy use.
- **COMPATIBLE**: Wind energy is also one of the healthiest energy options, and the most compatible with animals and humans. The modern wind turbine is far less harmful to birds and other wildlife than are radio towers, tall buildings, airplanes and vehicles and numerous other manmade objects. Bird deaths due to wind development will never be more than a very small fraction of those caused by other commonly-accepted human activities.
- **COMMITTED**: The wind industry is committed to, and has demonstrated, continual innovations leading to greater protection of the environment and wildlife. By offsetting impacts from other energy sources, the use of wind energy improves environmental conditions for birds and other wildlife.

CLEAN

Wind energy is one of the cleanest, most environmentally friendly energy sources in the world.

- Wind energy produces no emissions.
- Wind energy requires no mining, drilling, or transportation of fuel, and no disposal of radioactive or other hazardous or polluting waste. It is a renewable energy resource found in abundant supply in many regions of the United States.

Environmental Impacts of Electricity Sources

	Wind	Nuclear	Coal	Natural Gas
Global Warming Pollution	None	None	Yes	Yes
Air Pollution	None	None	Yes	Limited
Mercury	None	None	Yes	None
Mining/Extraction	None	Yes	Yes	Yes
Waste	None	Yes	Yes	None
Habitat Impacts	Yes	Limited	Yes	Yes

Based on AWEA's estimates and data from a 2002 study by the Natural Resources Defense Council (NRDC):

- A single 1-MW turbine displaces nearly 1,800 tons of carbon dioxide each year (equivalent to planting nearly a square mile of forest), based on the current average U.S. utility fuel mix.
- To generate the same amount of electricity as a single 1-MW turbine using the average U.S. utility fuel mix results in the emissions of 9 tons of sulfur dioxide and 4 tons of nitrogen oxide each year.
- To generate the same amount of electricity as a single 1-MW wind turbine for 20 years would require burning 29,000 tons of coal (a line of 10-ton trucks 11 miles long) or 92,000 barrels of oil.
- To generate the same amount of electricity as today's U.S. wind turbine fleet (over 6,000 MW) would require burning more than 9 million tons of coal (a train of coal cars 750 miles long) or 28 million barrels of oil each year.
- 100,000 MW of wind energy will reduce CO2 production by nearly 180 million tons annually (assuming displacement of the fuels used today by U.S. utilities to generate electricity), or about 8% of today's utility carbon dioxide emissions. Carbon dioxide is the most important global warming pollutant.

CLEAN

Wind energy development protects air quality, reduces the effects of global warming, and displaces drilling and mining for natural gas, coal, and other fuels.

- Electricity generation is the largest industrial source of air pollution in the U.S. In 1999, power plants in the U.S. emitted 13.2 million tons of sulfur dioxide and 7.9 million tons of nitrogen oxide, pollutants which cause acid rain and/or smog, and lung and heart damage. Power plants are also the largest source of mercury pollution in the U.S., releasing an estimated 48 tons of the toxic heavy metal annually into the atmosphere. This toxic heavy metal makes its way into lakes and streams, accumulating in fish and wildlife and humans who consume them (see http://www.ewg.org/reports/mercuryfalling/MercuryFalling.pdf). Wind farms emit no pollution.

- Fossil fuel power plants account for about 34% of the carbon dioxide emitted by the United States, itself the largest emitter of CO2 worldwide; the Energy Information Administration reports that in 1999, U.S. power plants emitted 2.245 billion tons of CO2. Carbon dioxide is the leading global warming pollutant, threatening habitats for wildlife and air quality for humans worldwide. A scientific study published in *Nature* (January 2004) estimated that global warming may lead to the extinction of one million species by 2050 (BBC news report at http://news.bbc.co.uk/1/hi/sci/tech/3375447.stm). Wind farms emit no carbon dioxide.

- Emissions from the manufacture and installation of wind turbines are negligible. The "energy payback time" (a measure of how long a power plant must operate to generate the amount of electricity required for its manufacture and construction) of a wind farm is 3 to 8 months, depending on the wind speed at the site--one of the shortest of any energy technology.

- Wind farm development can support preservation of habitat from suburban sprawl and other development that often has devastating impacts on wildlife. And unlike other forms of development, the footprint of a wind project is generally small, meaning that many forms of wildlife can still use the area.

- The wind farms in place in the U.S. (over 6,700 MW at the end of 2004) save about 0.5 Bcf/day of natural gas annually. Rapid expansion of the nation's wind turbine fleet to 36,000 MW would increase its output to the equivalent of nearly 3 Bcf/day (about as much natural gas as the states of Colorado and Alaska produce today), substantially reducing the need to drill for more natural gas or import liquefied natural gas (LNG). See http://www.awea.org/news/news030618gas.html

COMPATIBLE

Wind is also one of the healthiest energy options, and the most compatible with animals and humans.

- Wind has minor wildlife impacts (breaking up uninterrupted forest or grassland habitat at some locations, avian and bat collisions, noise disturbance during construction), but they are small compared to other electric generation choices.
- The list of environmental and wildlife impacts of other energy sources is long and varied, including:
  - Habitat impacts from mining (coal, uranium), drilling (natural gas, oil), and compressing fuel (natural gas). Some of these effects are local, while others can extend over fairly broad areas.
  - Habitat impacts from air and water pollution (acid rain, smog, mercury, drilling wastewater disposal – fossil fuels).
  - Habitat impacts from global warming. Significant changes in some species' ranges are already occurring, particularly in northern latitudes.
  - Habitat impacts from thermal pollution of water (nuclear and fossil power plants).
  - Habitat impacts from flooding of land and streamflow changes (hydro).
  - Habitat impacts from waste disposal (coal).
  - Direct mortality from collisions with structures (power plant smokestacks, cooling towers) and from other sources (waste oil pits, oil tanker spills).

  While wind plants and their construction definitely have local impacts, the use of wind energy largely avoids more far-reaching effects of traditional energy generation.
- The picture with human health impacts is similar. Air pollution in particular has been linked to a number of human ailments, including heart and lung problems. Greater use of wind energy will reduce these concerns.
- Many extensive studies of bird collisions at wind farms have been carried out, a practice that contrasts greatly with the lack of a systematic effort to monitor direct impacts on avian species from mining and drilling, power plant emissions or pollution, or habitat loss brought on by these activities.
- Energy policy is all about choices. Less wind energy means more of something else—almost certainly something that is more damaging to the environment.

COMPATIBLE

The modern wind turbine is far less harmful to birds and other wildlife than radio towers, tall buildings, airplanes and vehicles, and numerous other manmade objects. Bird deaths due to wind development will never be more than a very small fraction of those caused by other commonly accepted human activities.

- All avian studies at wind farm sites show that bird kills per turbine average two to five per year or less, with the exception of a single 3-turbine plant in Tennessee that has recorded eight per turbine per year. These include sites passed by millions of migrating birds each year. At some sites, no kills have been found at all. Summaries of available wind studies can be found at www.currykerlinger.com and at www.nationalwind.org.

- A reasonable, conservative estimate is that of every 10,000 human-related bird deaths in the U.S. today, wind plants cause less than one.
- Even if wind were used to generate 100% of U.S. electricity needs, at the current rate of bird kills, wind would account for only one of every 250 human-related bird deaths. See Erickson et al, "Avian Collisions With Wind Turbines," http://www.nationalwind.org/pubs/avian_collisions.pdf . This estimate, again, is a conservative one—the actual number could be one in 1,000 or higher.
- Leading human-related causes of bird kills, in the U.S. alone, include:
    - cats (1 BILLION per year)
    - buildings (100 million to 1 BILLION per year)
    - hunters (100 million per year);
    - vehicles (60 million to 80 million per year)
    - communications towers (10 million to 40 million per year)
    - pesticides (67 million per year)
    - power lines (10,000 to 174 million per year)

Data on buildings, vehicles, communications towers, power lines contained in Erickson et al, "Avian Collisions With Wind Turbines," http://www.nationalwind.org/pubs/avian_collisions.pdf and elsewhere. Data on cats in Ohio State University Extension Fact Sheet, "Managing for Forest Songbirds," http://ohioline.osu.edu/w-fact/0006.html. Data on pesticides at http://www.currykerlinger.com/birds.htm .

Wind energy simply does not constitute a significant threat to birds in general.

COMMITTED

The wind industry is committed to, and has demonstrated, continual innovations leading to greater protection of the environment and wildlife.

- In 1994, shortly after raptor deaths (of eagles, hawks, and owls) in California's Altamont Pass became a general concern, the wind energy industry joined with other stakeholders (government officials, environmental groups, utilities) to form the National Wind Coordinating Committee (NWCC), a multi-stakeholder collaborative aimed at addressing the wind/avian issue and other issues affecting the industry's future.
- At the same time, the industry began funding research on bird kills and adopting practices (equipment changes to reduce bird electrocutions, use of tubular towers to discourage perching, testing of anti-perching devices and other measures) aimed at minimizing the impact of Altamont and other wind projects on birds. (It should be noted that while raptor deaths in Altamont Pass, one of the first and oldest wind projects, are an issue, the overall number of bird kills there is very low—approximately one bird for every five turbines in the pass per year. The turbine owners recently agreed to making changes in the project’s operations such as shutting down the most risky turbines, stopping operations seasonally, and other measures to reduce mortality by 35%.)
- The wind industry has supported the NWCC’s development of a siting handbook and avian site evaluation guidelines used by wind developers to screen sites and provide research-based analysis that can avoid potential problems.
- The wind industry has also supported the NWCC's sponsoring of a series of national research summits examining wind energy's impacts on birds and bats. At these meetings, scientists

present the latest research findings and talk with other stakeholders about research gaps and future needs.

- Pre-construction wildlife surveys are common practice throughout the wind industry. Typically a wildlife consultant is retained, and efforts are made to contact state and federal fish and wildlife agencies and local wildlife groups (e.g., Audubon chapters, Izaak Walton League chapters) to identify any issues of possible concern. The consultant examines the proposed site and prepares a detailed report on impacts for review by the developer. These surveys reduce the threat to birds to minimal levels; as noted above, cats, hunters, glass windows, and communications towers are far more dangerous to birds.

- The industry has been conducting avian studies at wind sites across the country for more than twenty years. Over this period, post-construction monitoring of bird kills at several wind sites in a wide variety of geographic locations (Vansycle Ridge, Oregon; Ponnequin, Colorado; Foote Creek Rim, Wyoming; Buffalo Ridge, Minnesota; Searsburg, Vermont; Garrett, Pennsylvania) has validated the industry's ability to assess risk to birds and build safe projects. See http://www.west-inc.com/reports/avian_collisions.pdf.

- Even sites with high use by protected species need not necessarily be off limits to wind. At Foote Creek Rim in Wyoming, pre-construction surveys found that golden eagles frequently used the mesa's edge for hunting. The wind farm developer voluntarily redesigned the site to move the planned turbines 50 meters away from the rim, and the subsequent number of eagle deaths at the site has been so small that the technical advisory committee has been discontinued. See http://www.west-inc.com/reports/fcr_final_baseline.pdf.

- Prior to 2003, bat kills at wind farms studied were generally low. However, the frequency of bat deaths at a newly-constructed wind farm in West Virginia in 2003—far higher than those encountered elsewhere--has caused concern. In response, AWEA and several of its member companies have entered into a three-year cooperative effort with Bat Conservation International, the National Renewable Energy Laboratory, and the U.S. Fish and Wildlife Service to research wind/bat interaction and test ways to reduce bat mortality. See http://www.awea.org/news/news040303bat.html .

- The wind industry is currently engaged in discussions with the Federal Aviation Agency (FAA) aimed at reducing the aviation safety lighting required on wind projects. One goal of this effort is to ensure that turbine lights do not attract migrating birds on foggy nights—a phenomenon that is believed to have contributed to mass kills at some very tall communications towers and other structures in the past.

COMMITTED

By offsetting impacts from other energy sources, the use of wind energy improves environmental conditions for birds and other wildlife.

- Birds, bats, and other wildlife suffer habitat loss from mining and drilling for fossil fuels. An estimated 1 million acres are disturbed every year by mining related to electricity generation in the U.S. For example, the American Bird Conservancy has estimated that approximately one-third of the global population of cerulean warblers will be destroyed by loss of habitat due to mining in Appalachia (See "Determining Biological Significance," Winegrad, Gerald, http://www.nationalwind.org/events/wildlife/20031117/presentations/Winegrad.pdf).

- Power plants account for 70% of the sulfur dioxide (SO2) and 30% of the nitrogen oxide (NOx) emitted in the U.S. SO2 and NOx emissions acidify rain, snow and fog. Acidity depletes calcium, resulting in weaker eggshells for birds—a problem believed to account for the widespread decline of the wood thrush in the northeastern U.S. Acidity also damages trees and deters the regeneration of forests. (See http://www.epa.gov/airmarkets/acidrain/effects/forests.html and http://www.cleanairtrust.org/acidrain.html).

- The earth's temperatures are growing warmer, with build-up of carbon dioxide (CO2) and other global warming pollutants a key factor. A report by the World Wide Fund for Nature determined that global warming in the Arctic is already endangering the lives of birds in the polar region. See "Arctic Warming Signals Dire Straits for Birds," Environmental News Network, http://www.enn.com/news/enn-stories/2000/04/04052000/arcticbird_11676.asp .

- A Defenders of Wildlife report states that "The costs of not adopting alternative energy strategies based on renewable energy sources such as wind are potentially enormous. Global warming is predicted to result in countless bird deaths through large-scale alteration of breeding habitats." See http://www.defenders.org/habitat/renew/wind.html.

- As of December 31, 2004, over 6,700 MW of wind power generating capacity—generating the same output as 6 medium-size coal or 3 large nuclear power plants – were online in the U.S. Producing the same amount of electricity with the average U.S. electricity mix results in the emission of 11 million tons of CO2, 55,000 tons of SO2, 26,000 tons of NOx, and many other pollutants each year. Wind energy development helps provide cleaner air and healthier habitat for wildlife.

WIND ENERGY FACT SHEET

American Wind Energy Association

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Save the Loon with Wind Energy:

Comparative Impacts of Wind and Other Energy Sources on Wildlife

One of wind energy's important environmental benefits is its minimal impact on wildlife and natural habitat.

While no electricity generation is entirely benign, the impacts of some energy sources dwarf others in terms of the harm they cause to wildlife. Electricity in the U.S. is mostly produced from coal and other fossil fuels (70%), nuclear energy (20%), and dams, sources which take a heavy toll or impose significant risks on wildlife. [i]

Example: The common loon and other aquatic wildlife are at risk from high concentrations of the toxic heavy metal mercury, emitted largely from coal power plants, according to the National Wildlife Federation. "Rain falling over cities in the Great Lakes region contains as much as 65 times the EPA's "safe level" of mercury, which holds extremely serious health implications for both humans and wildlife," according to the Federation.[ii] Coal power plants are the single largest source of mercury emissions in the U.S., and those emissions are not regulated.[iii] Half of that mercury is airborne, and travels anywhere from 30 to 600 miles downwind of a plant.

Other impacts of U.S. electricity generation on wildlife include:

--**Harm from the sulfur dioxide (SO_2) and nitrogen oxide (NOx) released by coal and other fossil fuel power plants.** These pollutants not only cause respiratory ailments in humans—and probably also in wildlife—but also acidify rain, snow, and fog. Because of acid rain, in the Northeast in particular, many lakes and streams once thriving with aquatic creatures are now almost void of life in spite of their pristine appearance. Acidity depletes calcium, so acid rain also results in weaker eggshells for birds. Power plants account for 70% of SO_2 and 33% of NOx emitted in the U.S. "Protected" areas such as state and national parks offer no protection to wildlife from this and other forms of airborne pollution.

--Loss of habitat from mining for coal, uranium, gas and petroleum used to generate electricity. Birds and other wildlife lose their habitat and can be killed as land is blown up (for mountaintop removal, a coal-mining technique) or strip-mined for coal. An estimated 130,000 acres are disturbed every year for coal used for electricity generation in the U.S. In addition to the land and waste that fills riverbeds, acid mine drainage can occur for years after mines are closed, harming river systems and endangering waterfowl. No total national tally is kept of the impact on wildlife of extraction of fuels for electricity generation in the U.S..

--**Direct and indirect kills from hydroelectric and nuclear power plants**. Dams have caused the extinction or dramatic decline of several species of ocean-going fish, including wild salmon of the Pacific Northwest and shad of the Eastern Coast. Even if the fish get past the dams to spawn upstream thanks to fish ladders, many of the young perish in the retention ponds above the dam. Local river and coastal ecosystems are also altered by nuclear and other power plants using "once-through" river or coastal water to cool their reactors and equipment. Waters are warmed above their normal temperature, and fish and other aquatic creatures including seals can be killed in the cooling systems.[iv]

--Global warming. The earth's temperatures are growing warmer, with build-up of carbon dioxide (CO_2) and other greenhouse gases a key factor, according to the U.S. National Oceanic and Atmospheric Administration and other scientific organizations. Some species may thrive with the ecosystem changes brought about by global warming, but many others are likely to perish, as they are unable to adapt. A new report by the World Wide Fund for Nature (WWF) finds that the gradual warming of the Arctic is already endangering the lives of birds in the polar region. Fossil fuel power plants account for about 34% of CO_2 emitted by the United States, itself the largest emitter of CO_2 worldwide.

--**Risks from radioactivity and radioactive wastes.** The operation of nuclear power plants presents low-probability, but potentially catastrophic risks for wildlife as well for human beings. Transportation and storage of radioactive waste similarly pose risks to wildlife.

By contrast, the impacts of wind energy on wildlife are minimal, **even where wind energy is widely used**.

--Minimal harmful impacts on birds: In Denmark, the country with the most intensive use of wind energy, wind turbines generate 10% of electricity and are widespread, but have not been found to cause significant harm to wildlife including birds. Power lines pose a much greater threat to birds, according to Danish and U.S. studies. The National Audubon Society recently issued a statement in support of responsibly sited wind project development.[v]

--**Positive impacts on wildlife**: In 1998-99, 925 megawatts (MW)—equivalent to about four medium-size coal or one nuclear power plant—of wind energy generating capacity were added in the U.S., mostly on Iowa and Minnesota farmland. Based on the average U.S. electricity mix, this new wind power is, every year, saving 170 acres of land from mining, and displacing 10,128 tons of SO_2, over 2 million tons of CO_2, 6,500 tons of NOx, and many other pollutants, thereby helping provide cleaner air and healthier habitat for wildlife.

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[i] *The Environmental Imperative for Renewable Energy: An Update*, April 2000, Renewable Energy Policy Project.
[ii] *Great Lakes Power Plants Top List of Mercury Polluters*, Nov. 17, 1999, National Wildlife Federation press release.
[iii] *Mercury Falling, An Analysis of Mercury Pollution from Coal-Burning Power Plants,* Nov. 1999, Environmental Working Group, Clean Air Network and Natural Resources Defense Council.
[iv] Over 40 million fish die per year in the intakes of 90 Great Lakes power plants using once-through systems, according to *Environmental Costs of Electricity*, 1991, Richard Ottinger et al., Pace University Center for Environmental Studies.
[v] *National Audubon Applauds Enron Wind Corp. Decision to Pursue Alternate Site for Wind Power Development,* Nov. 3, 1999, Audubon press release. In the U.S. the only site that has caused major bird kills is the Altamont Pass, developed in the 1980s in California. See *A Continued Examination of Avian Mortality in the Altamont Pass Wind Resource Area,* BioSystems, January 1996.

WIND ENERGY FACT SHEET

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Comparative Air Emissions Of Wind and Other Fuels

Wind energy's most important environmental benefit is its lack of emissions of both air pollutants and greenhouse gases when compared with alternative methods of generating electricity.

The American Wind Energy Association (AWEA) has developed a set of statistics to quantify the comparative emissions of wind and other fuels, based on data gathered by the U.S. Department of Energy's Energy Information Administration (EIA)[1], which collects information on the U.S. utility industry.

This, and similar fact sheets, can be found online at http://www.awea.org/pubs/factsheets.html.

For carbon dioxide (CO_2), the leading greenhouse gas associated with global warming, comparative emissions during electricity generation are as follows:

Fuel	CO_2 Emitted Per Kilowatt-hour (kWh) Generated (in pounds)	KWh Generated, 1997 (billions)	CO_2 Emitted, Total Generation (billion pounds)
Coal	2.13	1,788	3,807
Natural Gas	1.03	283.6	291
Oil	1.56	77.8	122
U.S. Average Fuel Mix [2]	1.52	3,494	5,313
Wind	--0--	3.4	--0--

For sulfur dioxide (SO_2), the leading precursor of acid rain:

Fuel	SO_2 Emitted Per Kilowatt-hour (kWh) Generated (in pounds)	KWh Generated, 1997 (billions)	SO_2 Emitted, Total Generation (million pounds)
Coal	0.0134	1,788	24,028
Natural Gas	0.000007	283.6	2
Oil	0.0112	77.8	870
U.S. Average Fuel Mix [2]	0.0080	3,494	27,914
Wind	--0--	3.4	--0--

For nitrogen oxides (NOx), another acid rain precursor and the leading component of smog:

Fuel	NOx Emitted Per Kilowatt-hour (kWh) Generated (in pounds)	KWh Generated, 1997 (billions)	NOx Emitted, Total Generation (million pounds)
Coal	0.0076	1,788	13,668
Natural Gas	0.0018	283.6	504
Oil	0.0021	77.8	162
U.S. Average Fuel Mix [2]	0.0049	3,494	17,112
Wind	--0--	3.4	--0--

A single 750-kilowatt wind turbine, operated for one year at a site with Class 4 wind speeds (winds averaging 12.5-13.4 mph at 10 meters height), can be expected to displace a total of 2,697,175 pounds of carbon dioxide, 14,172 pounds of sulfur dioxide, and 8,688 pounds of nitrogen oxides, based on the U.S. average utility generation fuel mix.[3]

AWEA has prepared a spreadsheet which permits calculations based on these and other air emissions statistics and which can be e-mailed to researchers on request.

NOTE

1. Emissions data in this fact sheet are based on statistics provided in the EIA's *Annual Energy Review 1998.* (Washington, D.C.: Energy Information Administration, DOE/EIA-0384 ((98)), July 1998.) The Annual Energy Review can be accessed on the Web at <http://www.eia.doe.gov/aer>.

2. The numbers for kilowatt-hours generated and emissions for "Coal," "Natural Gas," and "Oil" are based on U.S. electric utility generation. The numbers for kilowatt-hours generated and emissions for "US Average Fuel Mix" and "Wind" are the totals for all U.S. generation, including nonutility plants."

3. Estimate derived by AWEA using data from *Renewable Energy Technology Characterizations*, published by the U.S. Department of Energy and the Electric Power Research Institute, December 1997.

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FACTS ABOUT WIND ENERGY AND NOISE

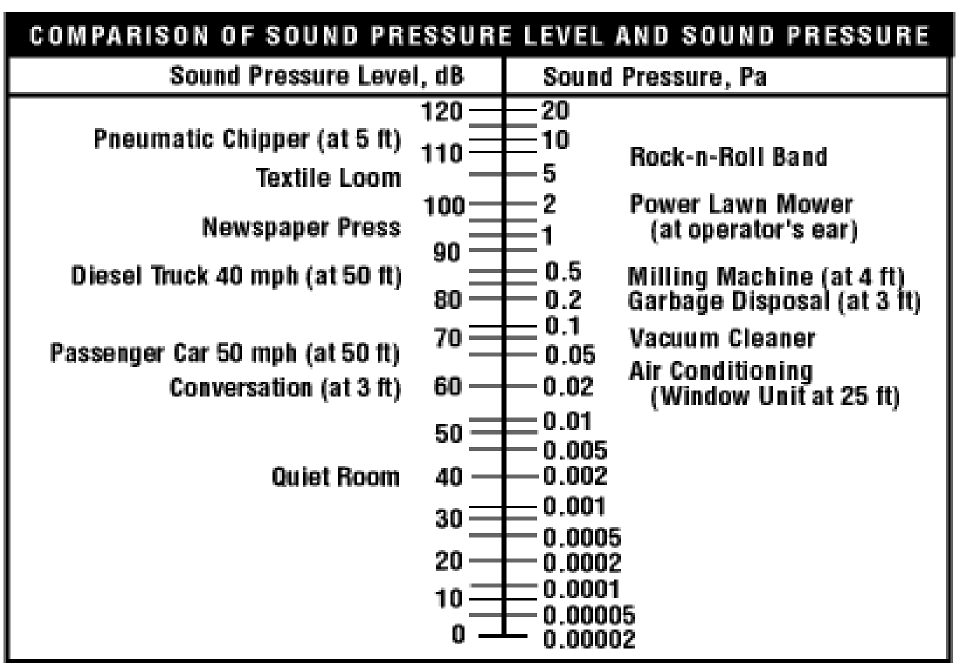
What is noise?

"Noise," when one is talking about wind energy projects, basically means "any unwanted sound."

Whether a noise is objectionable will vary depending on its type (tonal, broadband, low-frequency, impulsive, etc.) and the circumstances and sensitivity of the individual who hears it (often referred to as the "receptor").

As with beauty, often said to be "in the eye of the beholder," the degree to which a noise is bothersome or annoying is largely in the ear of the hearer. What may be a soothing and relaxing rhythmic swishing sound to one person may be quite troublesome to another.

Because of this, there is no completely satisfactory and impartial way to measure how upsetting a noise may be to any given person. Still, it **is** possible to objectively measure how loud a noise is. Here is a table showing the loudness ("sound pressure level") of some common noises:



Source: Canadian Centre for Occupational Health and Safety
(see www.ccohs.ca/oshanswers/phys_agents/noise_basic.html).

What kinds of noise do wind turbines produce?

Wind turbines most commonly produce some **broadband** noise as their revolving rotor blades encounter turbulence in the passing air. Broadband noise is usually described as a "swishing" or "whooshing" sound.

Some wind turbines (usually older ones) can also produce **tonal** sounds (a "hum" or "whine" at a steady pitch). This can be caused by mechanical components or, less commonly, by unusual wind currents interacting with turbine parts. This problem has been nearly eliminated in modern turbine design.

How noisy are wind farms?

Good question, and a difficult one.

Wind plants are very, very quiet compared to other types of industrial facilities, such as manufacturing plants, but most industrial plants are not located in rural or low-density residential areas. In those types of areas, background noise tends to be lower than in urban areas.

On the other hand, wind plants are always located where the wind speed is higher than average, and the "background" noise of the wind tends to "mask" any sounds that might be produced by operating wind turbines—especially because the turbines only run when the wind is blowing. The only occasional exception to this general rule occurs when a wind plant is sited in hilly terrain where nearby residences are in dips or hollows downwind that are sheltered from the wind—in such a case, turbine noise may carry further than on flat terrain.

Virtually everything with moving parts will make some sound, and wind turbines are no exception. However, well-designed wind turbines are generally quiet in operation, and compared to the noise of road traffic, trains, aircraft, and construction activities, to name but a few, the noise from wind turbines is very low.

Noise used to be a very serious problem for the wind energy industry. Some early, primitive types of turbines built in the early 1980s were extremely noisy, to the point that it was annoying to hear them from as much as a mile away. The industry quickly realized that this problem needed to be dealt with, however (particularly in Europe, where turbines are often located in or near residential areas), and manufacturers went to work on making their machines quieter.

Today, an operating wind farm at a distance of 750 to 1,000 feet is no noisier than a kitchen refrigerator or a moderately quiet room.

Source/Activity	Indicative noise level dB (A)
Threshold of hearing	0
Rural night-time background	20-40
Quiet bedroom	35
Wind farm at 350m	35-45
Car at 40mph at 100m	55
Busy general office	60
Truck at 30mph at 100m	65
Pneumatic drill at 7m	95
Jet aircraft at 250m	105
Threshold of pain	140

Source: The Scottish Office, Environment Department, Planning Advice Note, PAN 45, Annex A: Wind Power, A.27. Renewable Energy Technologies, August 1994. Cited in "Noise from Wind Turbines," British Wind Energy Association, http://www.britishwindenergy.co.uk/ref/noise.html.

The best test is to simply experience the noise from a turbine for yourself. You will find that you can stand directly beneath a turbine and have a normal conversation without raising your voice.

What have manufacturers done to reduce wind turbine noise?

Most rotors are upwind: A wind turbine can be either "upwind" (that is, where the rotor faces into the wind) or "downwind" (where the rotor faces away from the wind). A downwind design offers some engineering advantages, but when a rotor blade passes the "wind shadow" of the tower as the rotor revolves, it tends to produce an "impulsive" or thumping sound that can be annoying. Today, almost all of the commercial wind machines on the market are upwind designs, and the few that are downwind have incorporated design features aimed at reducing impulsive noise (for example, positioning the rotor so that it is further away from the tower).

Towers and nacelles are streamlined: Streamlining (rounding or giving an aerodynamic shape to any protruding features and to the nacelle itself) reduces any noise that is created by the wind passing the turbine. Turbines also incorporate design features to reduce vibration and any associated noise.

Soundproofing in nacelles has been increased: The generator, gears, and other moving parts located in the turbine nacelle produce mechanical noise. Soundproofing and mounting equipment on sound-dampening buffer pads helps to deal with this issue.

Wind turbine blades have become more efficient: As the wind energy industry and wind engineers gain more experience with wind turbine operations, turbine blades are constantly being redesigned to make them more efficient. The more efficient they are, the more the wind's energy is converted into rotational energy and the less aerodynamic noise is created.

Gearboxes are specially-designed for quiet operation: Wind turbines use special gearboxes, in which the gear wheels are designed to flex slightly and reduce mechanical noise. In addition, special sound-dampening buffer pads separate the gearboxes from the nacelle frame to minimize the possibility that any vibrations could become sound.

What about small wind turbines for household or battery-charging use?

Small wind turbines, paradoxically, tend to be noisier for their size than large machines, for two reasons:

(1) The rotational speed of the blade tips is higher; and

(2) Much more research money, both from government and private industry, has been invested in reducing noise from large turbines.

The manufacturer of a small wind turbine should be able to provide you with information about its noise levels, based on standard measurement techniques. In addition, you can ask owners of small turbines about their experiences on the American Wind Energy Association's Home Energy Systems discussion list. To subscribe to this discussion, send an e-mail message to awea-wind-home-subscribe@yahoogroups.com .

As with other types of equipment owned by homeowners, small wind turbines can be regulated by local communities through noise ordinances. Typically, such an ordinance will specify an allowable decibel level for noise at the property line nearest to the source.

What other noises are associated with large wind projects?

Wind turbines are large pieces of industrial equipment, and installing them is, in essence, a major construction project. The construction phase of a project lasts only a few months, but during that period, noises will be produced that are typical of heavy construction, including:

Truck traffic: A modern wind turbine is larger than a Boeing 747, with rotor blades that weigh thousands of pounds each and must be trucked to the site along with tower sections and other large components. The sound level is that caused by a highway truck moving at slow speed.

Heavy equipment: A large construction crane is usually needed to install the nacelle and rotor atop the turbine tower. Cement mixing is necessary for turbine foundations. The sound levels of this equipment is comparable to a highway truck moving at slow speed.

Foundation blasting: May occasionally be required if the wind plant is being installed in hilly or mountainous terrain where bedrock is close to the surface and cannot be broken up by other means. More frequently, foundation holes are excavated using backhoes, sometimes with a pneumatic hammer to break up subsoil rock.

Obviously, it is desirable for construction activities that are likely to produce noise to be scheduled during normal working hours.

What can be done to reduce the likelihood of a noise problem from a wind project?

A noise analysis can be done based on the operating characteristics of the specific wind turbine that will be used, the type of terrain in which the project will be located, and the distance to nearby residences. Particular attention will need to be paid if residences are sheltered from the wind.

Also, pre-construction noise surveys can be conducted to find out what the normally-occurring background noise levels are at the site, and to determine later on what, if anything, the wind project has added to those levels.

The most common method for dealing with a potential noise issue, as indicated above, is to simply require a "setback," or minimum distance between any of the wind turbines in the project and the nearest residence, that is sufficient to reduce the sound level to a regulatory threshold.

Some permitting agencies have set up noise complaint resolution processes. In such a process, typically, a telephone number through which the agency can be notified of any noise concern is made public, and agency staff work with the project owner and concerned citizens to resolve the issue. The process should include a technical assessment of the noise complaint to ensure its legitimacy.

In general, wind plants are not noisy, and wind is a good neighbor. Complaints about noise from wind projects are rare, and can usually be satisfactorily resolved.

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Wind Turbine Lighting
May 14, 2004

All structures more than 200 feet [61 meters] tall must have aircraft warning lights in accordance with requirements specified by the Federal Aviation Administration (FAA). While the wind energy industry understands the overriding importance of aviation safety, lighting every turbine at a wind project can annoy neighbors and will probably not affect aircraft safety. Additionally, certain types of lights at communications towers have been shown to attract birds and put them at risk.

The American Wind Energy Association (AWEA) has sponsored meetings with the wind industry and FAA representatives aimed at forging a compromise that enhances flying safety while also allowing for continued wind development. The U.S. Department of Energy's National Renewable Energy Laboratory (NREL) in 2002 funded a study on different wind project lighting designs with the FAA. The initial study involved FAA specialists viewing various existing wind projects with different lighting plans. The study is complete and the FAA is working on new recommendations for its Obstruction Lighting Circular.

Initial findings indicate that:

- Lighting the perimeter of wind projects with simultaneously flashing lights is sufficient to indicate one large obstacle to pilots
- No daytime lighting is needed
- Only one light is needed on each lit turbine nacelle (the nacelle is the boxlike structure at the top of a turbine's tower to which the turbine rotor is attached)

The FAA is testing simultaneously flashing red lights for a one-year period at a wind project in Oklahoma. The lights will be placed only on turbines around the project's perimeter and spaced a half-mine apart.

Avian Concerns
Steady-burning red lights can attract birds and place them in danger. Night-migrating birds are attracted by steady-burning red lights at tall communications towers, fly in circles around the towers, and are struck by guy wires. The flashing red lights being tested do not appear to attract night-migrating birds.

Neighbor Impacts
Residents near communications towers find that red lights are less intrusive than white lights, because white lights can direct a significant amount of light to the ground. The wind industry is pleased to see that the FAA is testing red lights.

The FAA's draft recommendations appear to satisfy needs of neighbors, the aviation community, and wildlife. However, until these recommendations are finalized in a revised FAA Obstruction Lighting Circular, regional FAA Obstruction Hazard Analysts will have jurisdiction over lighting requirements.

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