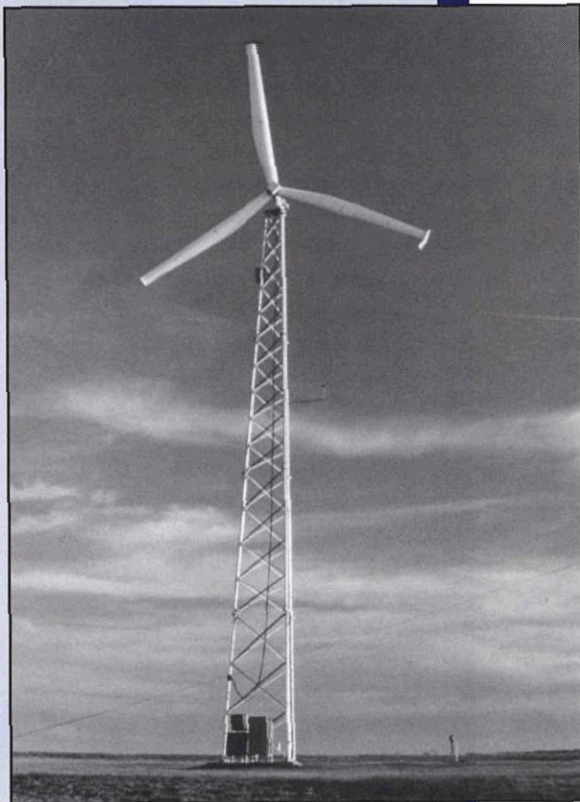


# Renewable Energy Technologies for Federal Facilities

# FEMP

FEDERAL ENERGY MANAGEMENT PROGRAM



PIX7028

## Wind Energy

### *From Coast to Coast, Wind Turbines Are Generating Electricity*

Wind is caused by the earth's rotation and by air-pressure differences from uneven heating of the earth's surface. The energy of the wind is widely distributed geographically and relatively concentrated, and it has a long history of use as an energy source. In general, wind-energy resources are best along coastlines, at elevated sites in hilly terrain, and in the Great Plains, although usable wind resources are available in every state.

The U.S. Department of Energy (DOE) has compiled an atlas containing wind-resource maps for the entire world. These reports—available through the National Renewable

Energy Laboratory—provide wind data that help to predict the performance of wind turbines at virtually any location.

Wind turbines are machines that capture wind energy with a rotor formed by two or three propeller-like blades attached to a central hub mounted on a shaft. This rotor assembly converts wind velocity to rotary motion. And the rotating shaft turns a generator to convert mechanical energy to electrical energy. Wind is faster and less turbulent at 100 feet or more above the ground. So wind turbines are mounted on tall towers to capture the most energy.

*Modern wind turbines, such as this 50-kW system, can be used in both stand-alone and hybrid applications.*

### **What are the opportunities?**

Wind applications may be either stand-alone or grid-connected. *Stand-alone* applications involve wind-generated power apart from utility lines and established power grids. The best opportunities for small wind turbines, which generate less than 50 kilowatts, are stand-alone applications in which grid power is more than 1 kilometer (0.6 mile) away. The turbines are designed for high reliability, minimum maintenance, and lower wind resources. Complete wind-power systems using batteries and modern power electronics can readily replace small diesel- and propane-powered generators. They can also be helpful in mitigating the cost of environmental compliance.

Typical small wind turbine applications include

- Telecommunications
- Remote residences
- Cathodic protection
- Navigation aids
- Monitoring/security
- Pumping/irrigation
- Desalination/treatment
- Crisis response
- Environmental compliance
- Peak shaving
- Uninterruptible power.

*Grid-connected* applications involve wind-generated power—usually from an interconnected group of turbines in a wind farm—that feeds into a central power distribution grid. Large wind turbines, which generate more than 100 kilowatts, are designed to achieve minimum costs of energy when installed in high-wind resource areas. These units are typically clustered in wind farms of 1 megawatt or more, where they provide bulk power



## What are the important terms?

**Annual Energy Output**—the amount of energy produced by a wind turbine in a year.

**Availability**—the total number of hours the turbine is available to produce power divided by the total hours in a year (or other time period).

**Capacity Factor**—amount of energy a system produces at a particular location as a percentage of the total amount that it would produce if operated at Rated Power during the entire year (or other time period). Capacity factor for a wind farm ranges from 20% to 35%.

**Cut-In Wind Speed**—the lowest wind speed at which a wind turbine will begin to have a net energy output.

**Rated Power**—the power that a wind turbine is designed to generate at its Rated Wind Speed—for example, 100 kilowatts at 20 mph.

**Variable-Speed Machine**—the turbine's rotor speed increases and decreases with changing wind speed, producing electricity with a variable frequency. A power converter transforms the variable frequency to constant frequency compatible with the utility grid.

**Wind Class**—from Class 1 (lowest) to Class 7 (highest); each class represents a range of wind power densities and associated average annual wind speeds.

**Wind Power Curve**—a graph that shows the relation of a turbine's net power to wind speed. Power increases proportionally with the cube of wind speed.

generation at costs competitive with new fossil fuel plants.

Extensive sections of federal land may be leased to a developer who will site a wind farm on this land and pay the government for the use of the land. Under a power-purchase agreement,

a supplier bears the cost and risks associated with installing the wind equipment in return for guaranteed purchase of power during a specified period. The wind farm may meet a federal agency's power needs in the vicinity, or the power can be sold to someone else. Also, wind turbines operate in harmony with other land uses such as farming and ranching.

A hybrid system using photovoltaics and wind turbines may meet overall power needs better than either system could alone. This is true if the solar and wind resources are complementary—for example, if in the winter, as sunlight decreases, the wind resource increases.

## What is required?

An environmental impact statement is required for any construction or refurbishment involving power generation systems

For *stand-alone* applications, the following criteria are preferable:

- Diesel or fossil fuel must be transported to site for power generation
- Cost of electricity is high (greater than 12 cents per kilowatt-hour)
- Wind resource is moderate (at least class 3)
- Air-pollution requirements pose a problem for diesel system.

For *grid-connected* applications, the following criteria are preferable:

- Diesel or fossil fuel must be transported to site for power generation
- Cost of electricity is high (greater than 8 cents per kilowatt-hour)
- Must meet air pollution requirements
- Near transmission lines with adequate capacity
- Wind resource has been measured and is moderate to high (class 3 to 7).

## What does it cost?

Wind-energy costs have improved dramatically during the past decade. For grid-connected applications of large wind turbines, energy costs typically range from 4–10 cents per kilowatt-hour. For grid-connected

applications of small wind turbines, energy costs typically range from 7–15 cents per kilowatt-hour. And for stand-alone applications of small wind turbines, energy costs typically range from 8–30 cents per kilowatt-hour. Costs for all applications are continuing to decline as technology advances.



## For More Information

For additional information about wind energy, contact:

Ed Cannon  
National Renewable Energy  
Laboratory  
1617 Cole Boulevard  
Golden, CO 80401-3393  
(303) 384-6920  
Fax: (303) 384-6901

For a list of manufacturers, contact:

American Wind Energy Association  
122 C Street, NW, 4th Floor  
Washington, DC 20001  
(202) 383-2500  
Fax: (202) 383-2505

To inquire about renewables design assistance available through FEMP, contact:

Nancy Carlisle  
National Renewable Energy  
Laboratory  
1617 Cole Boulevard  
Golden, CO 80401-3393  
(303) 384-7509

FEMP Help Line: 1-800-566-2877  
Fax: 1-202-586-3000

Internet: <http://www.eren.doe.gov/femp>



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