Technology Focus

An update on technologies for energy and resource management prepared by the New Technology Demonstration Program

Ed McKenna, NREL/PIX06056

New 225-kilowatt wind turbines generate electricity for the Navy on San Clemente Island off the coast of California.

New Wind Energy Technologies Are Cost-Effective in Federal Applications

Today's wind systems are performing well at several Federal installations, reducing life-cycle energy costs as well as air pollution and noise

Wind energy systems are producing electricity in some areas of the United States for 5¢ per kilowatt-hour (kWh) or less. As the demand for advanced wind systems increases, wind turbines can be manufactured on a larger scale. This demand, coupled with improvements in the technology, will further reduce the cost of wind-generated electricity.

Today, using wind systems to generate electricity can be a cost-effective option for many Federal facilities. This is especially true for facilities that have access to good wind resources and relatively high utility costs, and those that depend on diesel power generation. Applications for wind systems are similar to those for solar systems:

- Remote communications equipment
- Ranger stations
- Military installations
- Visitor centers and other facilities in national parks
- Navigation aids
- Pumping and irrigation systems
- Desalination and water treatment systems.

Wind turbines are particularly effective in hybrid energy systems that include solar power and a backup diesel generator. One of the benefits of wind and solar power is that they do not result in the carbon dioxide and nitrogen oxide emissions associated with burning fossil fuels.

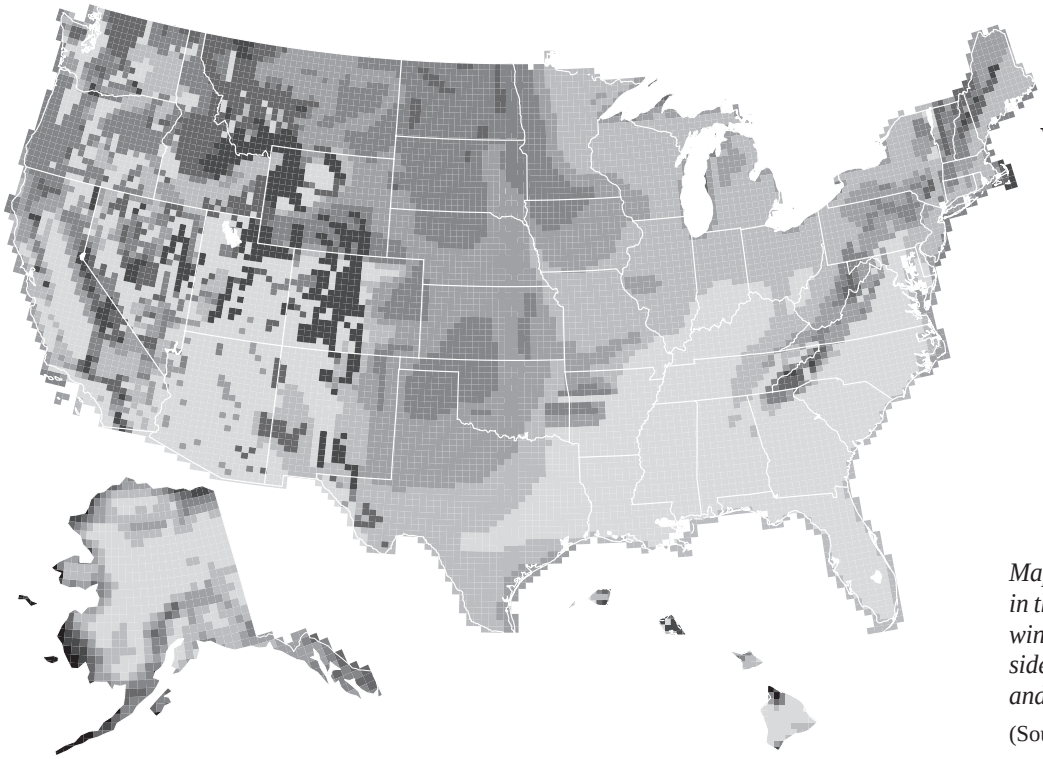
Obtaining electricity from wind systems helps to conserve fossil fuel resources and reduce the nation's dependence on imported fuels. In addition, this helps agencies respond to Executive Order 12902 and other regulations that call for the Federal government to increase its use of renewable energy technologies.

Wind Resources in the United States

The U.S. wind resource is substantial (see large map on next page). Researchers at the U.S. Department of Energy's (DOE's) national laboratories have estimated that harvesting U.S. winds would supply more electricity than the nation can consume.

Excellent wind resources are found in places with average annual wind speeds of about 7 meters per second (m/s) or more [15.5 miles per hour (mph)] at about 50 meters (164 feet) above ground. Although there are good resources along the coasts, about 90% of the best winds for electricity generation blow in the 12 states in the nation's heartland, from Colorado on the west to Iowa on the east, and from Texas north to the Canadian border. DOE has assessed the U.S. wind resource and produced maps that provide wind energy developers with information on average wind speeds throughout the United States. Wind specialists can also assist in identifying good wind sites that do not appear on the maps.

DOE's wind energy experts estimate that if only 0.6% of the land in the contiguous United States were



Wind Energy Classification

Power Class	Wind Power* (W/m^3)	Speed (m/s)
1	<200	<5.6
2	200–300	5.6–6.4
3	300–400	6.4–7.0
4	400–500	7.0–7.5
5	500–600	7.5–8.0
6	600–800	8.0–8.8
7	>800	>8.8

* At 50 m (164 ft)

Map of the annual wind energy resource in the United States; many areas with a wind power class of 3 or higher are considered good candidates for wind energy and hybrid systems.

(Source: U.S. DOE Wind Energy Program)

developed with modern wind power plants, they would supply at least 20% of the nation's current electricity needs. Only 5% to 10% of that land would have to be developed with wind turbines; the rest could be used for farming or ranching.

Criteria for Choosing Wind Technology

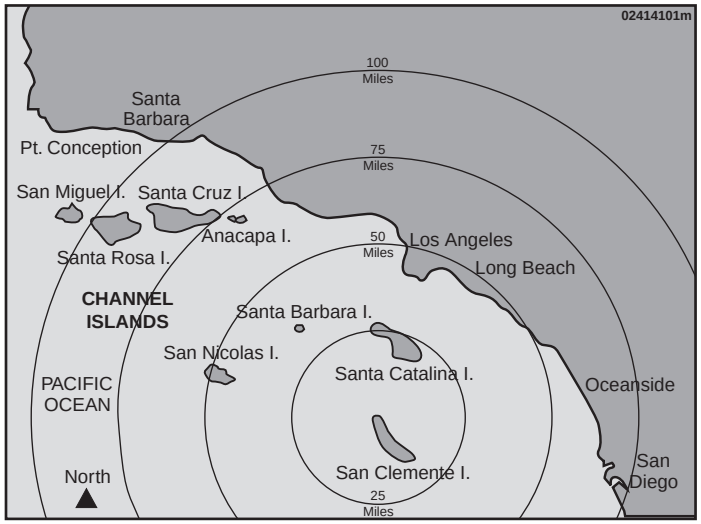
Wind systems are a good choice among several renewable energy options when a facility meets the following criteria:

- The facility has access to good wind resources, i.e., the site has been designated as Wind Class 3 or higher (see map above).
- The current cost of electricity at the facility is 8¢-12¢/ per kilowatt-hour (kWh) or more.
- Diesel oil or another fossil fuel is being transported to the site for power generation.
- Using the current power generation system results in noncompliance with air-pollution regulations.

Federal agencies have been evaluating the cost and risk associated with transporting fossil fuels such as diesel oil to particular sites. Several are replacing conventional power generation systems with renewable energy systems. They are finding that installing wind turbines or a hybrid energy system reduces life-cycle energy costs at the site and significantly lowers the risk of fuel spills, which are costly to clean up as well as potentially damaging to the environment.

Wind turbines can be installed in Federal facilities as either stand-alone or utility-grid-connected systems, depending on a facility's needs and characteristics. Grid-connected systems are a good choice when they can be readily interconnected with the local utility's electricity transmission and distribution system.

Today, wind turbines are often part of a hybrid energy system. Hybrid systems usually include one or more wind turbines along with one or two additional power sources, such as a photovoltaic (PV) solar array and a diesel generator for backup power when winds are calm for extended periods of time. Battery banks can store wind-generated electricity for several days at a time.



Hybrid wind/photovoltaic/diesel systems and hybrid wind/diesel systems generate electricity in the Channel Islands at sites administered by the National Park Service and the Department of Defense.

(Source: Department of Defense, U.S. Navy)

Wind Technology in the Federal Sector: Two Examples

Hybrid energy systems recently began providing power in the Channel Islands off the coast of California at both National Park Service (NPS) and Department of Defense (DoD) sites (see small map on previous page). The wind technologies installed at these sites are just a few of several different kinds manufactured in the United States (see list of manufacturers).

Channel Islands National Park. This national park consists of five of the eight Channel Islands located off the coast of southern California. On two of them, Santa Rosa and San Miguel, new hybrid wind/PV/ diesel power-generating systems are reducing life-cycle energy costs, carbon dioxide emissions, and generator noise.

On Santa Rosa Island, renewable energy technologies are virtually replacing a 35-kW diesel generator that consumed more than 66,000 liters (about 17,500 gallons) of diesel fuel and at least 450 liters (120 gallons) of motor oil each year. The diesel generator has been retained for backup power, however. The hybrid renewable energy system consists of the following:

- Two 10-kW wind turbines
- One 12.6-kW PV array
- One 30-kW, 3-phase bimodal inverter providing 208/120 AC electricity
- A system controller to monitor and regulate power from the wind turbines
- A 300-kW battery bank for electricity storage.

Tower heights for this type of wind turbine can range from about 18.3 to 36.6 m (60 to 120 ft). Other turbine specifications include the following:

- Turbine type: three-blade upwind
- Rated power: 10 kW
- Rotor diameter: 7 m (23 ft)
- Generator type: Permanent magnet alternator
- Start-up wind speed: 3.4 m/s (7.6 mph)
- Cut-in wind speed: 3.1 m/s (7 mph)
- Rated wind speed: 13 m/s (29 mph)
- Maximum design wind speed: 53.6 m/s (120 mph)
- Output form: 3-phase alternating current (AC), variable frequency regulated to 60 Hz.

The estimated 20-year life-cycle cost of the hybrid system is a little more than half that of the diesel generator power system: $450,000 for the wind/ PV/diesel hybrid in comparison to $870,000 for the diesel system alone. The majority of the savings result from eliminating the high cost of transporting, loading, and unloading diesel fuel.

Additional hybrid systems were also planned for other islands in the park. On small San Miguel Island, for example, a 900-W wind/PV system is providing power for a new ranger station there. Many other energy efficiency and renewable energy measures have been implemented in the islands, as well.

Describing the park's commitment to renewable energy, Kent Bullard of the NPS said, "Channel Islands National Park has 63 renewable energy applications. Renewable energy is a viable alternative in remote areas where fuel is expensive or difficult to transport." Renewable energy also helps to preserve the ecosystems of the nation's parks.

San Clemente Island. The DoD is also making use of wind energy systems at its U.S. Navy installations in the Channel Islands. Two new wind turbines were installed in early 1998 on San Clemente Island (SCI), where the Navy conducts research, development, testing, evaluation, and training activities.

The wind systems on SCI were installed primarily to reduce the island's use of diesel generators and thus avoid carbon dioxide and nitrogen oxide emissions. Diesel power generation will continue at the installation, but on a limited basis, and there are diesel

Wind System Manufacturers in the United States

Atlantic Orient Corporation, Norwich, VT

Bergey Windpower Company, Norman, OK

Cannon Energy Corp., Tehachapi, CA

Lake Michigan Wind & Sun, Ltd., Sturgeon Bay, WI

NEG Micon USA, Inc., Marshall, MN

New World Grid Power Co., Palm Springs, CA

New World Power Technology Co., Moretown, VT

Southwest Windpower, Flagstaff, AZ

WindTech International, L.L.C., Bedford, NY

Wind Turbine Industries Corp., Prior Lake, MN

World Power Technologies, Duluth, MN

Zond Energy Systems, Inc., Tehachapi, CA (a Division of Enron Wind Corp.)

Note: These firms were identified as manufacturers at the time this document was developed. This list does not purport to be complete, to indicate the right to practice the technology, or to reflect future market conditions.

Kent Bullard, National Park Service/PIX05533

Wind turbines have been installed at a National Park Service site on Santa Rosa Island in the Channel Islands.

generators to back up the turbines when winds are very low or calm for an extended time.

The new wind systems are 225-kW turbines on tubular steel towers. They were installed to provide at least 25%-30% of the island's electricity. With optimum production winds, however, the new systems could meet at least half the island's total electricity demand. They meet or exceed the requirements for power production at a Class 3 wind site; preliminary tests show that they are performing well in the Class 2 winds at the installation site, which average 6 m/s (13.4 mph) at a height of about 43 m (140 ft) above ground.

The specifications for the new turbines are as follows:

- Turbine type: 225-kW three-blade turbine on tubular steel tower
- Hub height: 30 m (91 ft)
- Rated power: 225/40 kW
- Peak power: 275 kW
- Nominal voltage: 480 V
- Nominal frequency: 60 Hz
- Power regulation: stall
- Rotor diameter: 29.8 m (100 ft)
- Generator type: Asynchronous, 3-phase, air-cooled, two-speed
- Cut-in wind speed: Approx. 3 m/s (approx. 7 mph)
- Cut-out wind speed: 25 m/s (56 mph)
- Extreme wind speed: 39.3 m/s (approx. 88 mph)
- Output form: 3-phase, 480 volts, 60 Hz
- Controller: PC-compatible electronic monitoring and control system.

The turbines have innovative operational and safety features and can be operated both locally and remotely through a computerized system monitor and control interface. Energy cost savings resulting from the use of the hybrid wind system have been estimated at $112,000 per year, and the payback period could be as low as 5 to 6 years. The levelized cost of energy for the hybrid system has been estimated at between 3¢ and 4¢/kWh.

According to project team member Ed McKenna of the National Renewable Energy Laboratory (NREL), "The wind turbines are operating very well, producing high-quality electricity to assist the Navy's Public Works diesel power plant on SCI."

A similar wind system is being considered for the DoD installation on San Nicolas Island, as well as another system for SCI for water desalination. The desalination system could produce as much as 135,000 liters (about 500,000 gallons) of freshwater each week, saving thousands of dollars each year in water transport costs.

For assistance in determining whether to install a hybrid wind system at your facility, please contact Ted Collins, DOE, at the number listed on this page. See also:

U.S. Department of Energy. April 1996. *Wind Energy Information Guide*. DOE/GO-10095-238. Washington, DC: U.S. DOE. Available from Superintendent of Documents, Washington, DC, (202) 512-1800.

U.S. DOE Federal Energy Management Program. November 1997. "Renewable Energy at Channel Islands National Park." DOE/GO-10097-275. Golden, CO: National Renewable Energy Laboratory.

FEMP
FEDERAL ENERGY MANAGEMENT PROGRAM

For More Information

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