

1.8 WIND POWER PLANTS

Since ancient times, people have harnessed wind energy to pump water or grind grain. Wind machines were used in Persia as early as 200 B.C. to grind grain, and the first practical windmills were built in Sistan, Iran in the 7th century. Windmills were used in 14th-century Holland to pump water. The first known functional electricity-generating windmill was a battery charging machine installed in 1887 by James Blyth in Scotland. The first use of a large windmill to generate electricity was in Cleveland, Ohio, in 1888, by Charles Brush. European countries, particularly Denmark, Germany, and France, continued the developments of large-scale wind turbines from the first quarter of the 20th century. Today, Denmark, Spain, the United States, and Germany are the top four worldwide suppliers in the wind turbine market.

Over the past decade, wind power has been the fastest growing form of generation in the United States and in other parts of the world. Like solar, wind is intermittent and is highly dependent upon weather and location. Since solar power and wind power can complement each other as energy sources, a hybrid solar-wind power system may be used for base-load generation. Such a system would be a viable alternative to fossil fuels.

1.8.1 TYPE OF WIND TURBINES

Modern wind turbines come in two types: Vertical axis, or "egg-beater" style, and horizontal axis, or "propeller" style. Vertical axis turbines are particularly suited to small wind power applications because they have a small environmental impact and make no noise. The horizontal axis turbine's blades rotate in a vertical plane about a horizontal axis, and the turbine is dynamically rotated on its tower by computer-controlled motors to face the wind. Most modern utility-scale turbines are horizontal-axis turbines. Two kinds of horizontal wind turbines commonly used for electric power generation are the fixed-speed and the variable-speed turbines. The rotor of modern wind turbines typically has three blades, which converts the energy in the wind to rotational shaft energy. The center of the rotor is connected to the turbine shaft, which turns a generator, usually through a gearbox. Larger wind turbines are often grouped together in the same location known as a *wind farm* to provide power to the electrical grid. Shown in Figure 1.14 is the Dillon Wind Farm consisting of 45 MHI 1.0 Mw horizontal wind turbines located in Palm Springs, California.



FIGURE 1.14

Dillon Wind Farm, "Courtesy of DOE/NREL, Credit - Iberdrola Renewables."

1.8.2 WIND POWER

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Example 1.3

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1.8.3 FIXED-SPEED WIND TURBINE

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1.8.4 VARIABLE-SPEED WIND TURBINE

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Doubly-fed wound-rotor induction generator

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Synchronous generator