Chapter 3

Wind Power

Throughout history the wind has been used by humans as an energy source for such things as transportation and food production. Energy released by the trade winds—winds that almost always blow in the same direction—was first captured in the sails of ships and used to transport the ship and its cargo across oceans. There are few large ships that still use wind power, although many people continue to enjoy sailing smaller crafts using the power of wind.

Food production, such as grinding flour for baking bread, was sometimes powered by wind-driven windmills. Those windmills were eventually modified to run water pumps and even later, to generate electricity. Today, the modern windmill, called a wind turbine, is used to generate large quantities of electricity. Through advances in technology, energy producers can even generate electricity from a whole series of wind turbines, called a wind farm. These wind farms are beginning to spread through parts of the United States and the rest of the world.

Harnessing the Wind

For centuries farmers have used windmills to harness the wind to grind grain into flour for baking. Windmills were known to be in use in Europe as long ago as the twelfth century. In more recent history, the windmill was adapted for pumping water to irrigate fields, to provide drinking water, or to run small sawmills. This type of windmill was quite common on farms in the United States until the 1940s when utility companies became

Throughout history, sails have been used to harness the power of the wind to propel watercraft like these sailboats.

more widespread and many farmers began to use more modern forms of electricity.

A classic windmill has a fairly simple design with several blades on a rotor that turns on top of a tower as the wind blows through them. Blades may be constructed of various materials, including wood, cloth, and metal. They generally have a large surface to capture as much wind power as possible. The tower they sit atop can also be quite tall, sometimes up to fifty feet, as the wind tends to be stronger higher above the ground.

As the wind blows, it turns the blades of the windmill, which spin a central shaft (or pole) that extends from the top to the bottom of the tower of the windmill. The spinning shaft may be attached to many different mechanisms at the base of the windmill, depending upon the windmill's use. If a farmer wishes to grind grain, the spinning shaft is attached to a gear that turns a grain mill; if the farmer wants to pump water into the fields, the shaft is designed to drive a pump.

Despite the age of this technology, many water-pumping windmills are still used in rural areas of developing countries to irrigate field crops. For example, more than three hundred thousand wind-driven water pumps are in place in parts of South Africa as a low-cost, low-maintenance method of supplying water to people, livestock, and fields. In rural United States, how-

ever, few water-pumping windmills are used except in some remote areas such as parts of west Texas, where the water is needed mainly for cattle. There, windmills are used because it is too difficult and expensive to string miles and miles of power lines to those remote areas.

Wind Turbines: The Modern Windmill

Wind turbines work much like windmills, but they are used specifically to generate electricity. A wind turbine usually has fewer blades and is made of lighter materials, such as plastics, which allow the blades to turn more quickly and with less wind. The blades of the wind turbine capture the energy of the wind and send it down a shaft inside the nacelle. This shaft spins the turbines of a generator. Inside the generator is a large pole with metal wires wrapped around it. On the inside walls of the generator are magnets. As the turbine poles spin, the magnets draw electrons from the wire and produce electricity. A wind turbine can produce enough electricity to satisfy the needs of a home. In some cases, a single

turbine may also produce excess energy that can be stored in batteries or sold to a local utility company.

Wind turbines can also be grouped together to create large quantities of electricity. This is referred to as a wind farm. Wind farms are becoming more widespread throughout the world. In Denmark, for example, 10 percent of its power needs are met with wind farms. Denmark has also created laws that allow wind machine owners to easily sell their excess electricity to local utility companies. Often, individual families in Denmark will buy several large wind machines that produce enough electricity to power the homes of fifty to seventy-five families. Since the Danish government fully supports this form of green energy, the use of wind power is expected to keep increasing in their country. It is estimated that in northern European countries, including Denmark, nearly three times the amount of electricity is produced by wind machines than in the United States. This figure is expected to increase even more as several developing countries, such as Argentina, Pakistan, and a number of African countries, are exploring the use of wind farms as they establish their own energy infrastructures.

In the United States, California, followed by Texas, generates the most electricity from wind farms. California was also the first state to pursue wind farm development in the early 1980s. Wind farms have been slow to develop in the United States, however, due in part to the high cost for building and then maintaining the facilities. Independent ownership, which is how most of the wind farms in the United States are owned, is also more expensive than utility-owned wind farms. But in recent years the towers and rotors of wind turbines have been made much bigger, from 50 feet to 180 feet, producing more energy at a lower cost. In fact, the overall cost of wind power generation has fallen by about 90 percent over the last twenty years.

Plentiful Winds

Like solar power, wind power is a renewable energy source. The energy of the sun drives the production of

wind. Since the sun is in daily supply, the energy required to create wind is continuously available. Unlike solar power, however, the energy of wind is also present during the nighttime as land and water absorb the heat of the sun.

Wind power can also be available in great supply. Strong and consistent winds tend to occur where there are large areas of flat land, such as prairies and deserts, that are heated by sunlight. The midwestern United States, such as North and South Dakota, Colorado, Kansas, Nebraska, Iowa, Indiana, Illinois, Minnesota,

and Ohio, is an ideal place for the creation of such winds. The American Wind Energy Association calculates there is enough available land in the Midwest, or in just one hundred square miles of Nevada's windiest areas, to house enough wind farms to meet the energy needs of the entire United States. The construction of wind farms would do little to alter these landscapes, as farming of crops and wind power generation could occur on the same lands.

Winds are generated in high amounts in desert areas. The desert sands trap the heat of the sun and slowly release the energy throughout the troposphere during the night. One such desert area, Tehachapi-Mojave, California, is home to a wind farm of five thousand wind turbines. This wind farm can produce enough electricity to satisfy the needs of five hundred thousand homes at a cost of four cents per kilowatt-hour. This cost is comparable to the other local energy sources. As the efficiency of wind farms increases, this cost will decrease even further.

Small-Scale Production Potential

Wind power can also be produced on a smaller scale, serving the needs of rural homes. A home that is off the grid (not connected to the utility company) and in a windy location can easily tap into the power of the wind. Such a home simply needs a stand-alone wind machine. The wind machine takes up relatively little space and does not alter the natural landscape. These are two strong arguments for anyone that hopes to have electricity in a remote home, but does not wish to change the natural environment surrounding the home.

Although the initial investment for such small wind systems is quite high, the cost of energy is reduced in the long run. A typical wind system can be installed for twenty thousand dollars and pay for itself within ten years. In addition, a wind turbine requires minimal maintenance, such as keeping the moving parts lubri-

cated. Currently the average cost of producing one kilowatt-hour of electricity using wind power is about six cents, although some wind farms can produce at a lower cost. This is only slightly more than the cost of producing electricity by burning fossil fuels. As the cost of burning fossil fuels to create electricity increases yearly throughout the nation, this feature of wind power becomes more and more attractive.

Some Drawbacks

Wind power can be an easily viable source of energy for many people, but there are some drawbacks. Perhaps the biggest drawback to wind power is that a person must live in a windy area to harness it. These areas tend to be rather flat or desertlike and do not often attract many people. In addition, few people tend to use stand-alone systems in these areas, as more traditional sources of electricity are already available. These areas can still be used to build wind farms, however, as the electricity produced can be connected to the grid.

Even when living in a windy area, the wind cannot be counted on to always be blowing. Some days are windier than others and some seasons are prone to higher winds than others. With such an intermittent source of power, the electricity produced by wind turbines often requires battery storage. These batteries generally have a long life span of about ten to twenty years, but eventually require replacement. As with solar power systems that use batteries to store energy, battery disposal is an issue as the materials used to create batteries are toxic to the environment.

Some people prefer to use gasoline-powered generators as a secondary source of power on the days when there is little wind. These generators usually burn fossil fuels. The burning of fossil fuels contributes to air pollution. It also emits greenhouse gases, which are damaging to the atmosphere.

Wind machines can also cause noise pollution. The whirling of the blades and the spinning of the turbine

In areas where wind power is abundant, wind farms like this one in Palm Springs, California, can generate electricity in a very cost-effective manner.

in a ten-kilowatt wind machine positioned three hundred feet from a home produces noise that is comparable to wind blowing through trees. Many people find this noise to be an irritant and consider it noise pollution.

For some people wind machines are a pleasing sight. The straight lines against a blue sky make a beautiful view. For others wind machines and wind farms are an eyesore. They disrupt the view and break up the natural landscape. The blades are dizzying, the towers block the sun, and their bases are large blocks of unattractive cement.

Deadly to Birds

Wind machines can also have an environmental impact on wildlife. They are considered something of a hazard to migratory birds. The birds fly into the blades and are

killed. Since many migratory birds already suffer the hardship of lost habitat, this can pose quite a secondary threat to their population. For example, in a study conducted in 1992 by the California Energy Commission, thirty-nine golden eagles, out of about five hundred breeding pairs, were killed at the Altamont Pass wind farm. For this reason, scientists are studying the flight patterns of migratory birds more thoroughly, and wind farmers are trying not to build in migratory birds' flight paths.

Researchers are also experimenting with painting the blades to make the blades more visible to birds. For example, instead of the usual white, researchers are painting the blades with black and orange stripes. "We go out and look for any environmental issues or concerns, like migratory birds' flight paths, water fowl, any threatened or endangered plants or animals, as well as for any cultural artifacts," says Vito Giarrusso, Florida Power and Light Operations production manager for the Stateline Wind Project. "We have to make sure we aren't in, around, or imposing on any of those."[16]

A Changing Industry

Wind machines are becoming more popular as their reliability increases. Wind machines are also becoming far more simplified in structure and no longer require as much maintenance. In the early days of the industry, blades were made from materials such as wood and cloth that needed frequent repair or replacement, the internal workings of the machines needed regular lubrication, and the overall size of the structures was small compared to those of today. Scientists and technicians are working to improve the efficiency of wind turbines even further, which would provide a boost to the wind power industry. Some of the specifics of the investigations include redesigning the shape of the blades and the materials they are made of, improving the internal mechanisms, and exploring optimum locations for the machines.

The largest wind farm now under construction in the United States is being built by American National Wind Power. The wind farm, located in Texas, is expected to have the capacity to supply sixty thousand homes with electricity. David Butterworth, the head of business development at American National Wind Power, believes this project will be a success. "Texas residents have expressed a preference for energy from clean, renewable sources," he said. "Wind power is one of the cleanest and greenest of all the commercial methods for generating electricity. It produces no gas emissions which contribute to global warming and climate change, no waste products and no radioactive contaminants."[17]

Consumer and Company Support Critical

Many wind farm developers feel that as wind power becomes better understood and accepted by the American consumer, the wind farm industry will become a viable power choice in the U.S. energy market. The 1990s saw a massive increase in the use of stand-alone wind machines in the United States. That trend has continued with about five times as many wind machines now in use as there were in 1995. Today, people living off the grid in appropriately windy locations are building their homes with wind power in mind. Many are now looking at the environmental and economic impacts of their energy choices and are choosing wind power. This consumer demand for wind power will be a critical factor in its development. Wind machine owners may ask to net meter the electricity they produce at their own homes. This means they can generate electricity using wind power and sell their excess electricity to the power company. Sonja Ling of the Renewable Northwest Project believes, "Net-metering for small-scale, clean, renewable energy systems is one important step towards diversifying the region's energy mix and reducing our over-dependence on hydropower and fossil fuels."[18] In other words, every small contribution to the net amount of electricity will serve to make a difference in the long term.

Technologically advanced wind machines like the eggbeater windmill (left) and the vertical axis turbine (right) are extremely efficient.

For this to work, however, the utility companies must be willing to participate in the net-metering program. Paul Gipe of Real Goods points out that, in contrast to other countries, American utilities pay small-scale wind power producers only 35 to 40 percent of the retail rate, or three or four cents per kilowatt-hour. "This effectively discourages the sale of excess electricity to the utility, even though it is legally permitted," Gipe says. "Under these conditions, the wind turbine must be sized to meet only domestic consumption, limiting homeowners in the United States to small wind turbines."[19]

Several companies are helping to spur the growth of larger scale wind projects. White Wave, the nation's largest

Large-scale wind farms like this one in Altamont, California, are becoming more practical sources of power as energy-conscious businesses commit to using them.

soy foods manufacturer, has decided to go "green." They are converting all of the energy their company uses to wind energy. The Environmental Protection Agency estimates White Wave's purchase of wind power will keep 32 million pounds of carbon dioxide from being released into the atmosphere. This is the same amount of carbon dioxide released by thirty-five hundred cars being driven for a year. "White Wave has always been committed to socially responsible and environmentally sustainable business practices," says Steve Demos, company founder and president. "This energy ethic is exactly what is needed to bring change in our use of energy."[20]

The U.S. Department of Energy is seeking to have 5 percent of the energy produced in the United States come from wind power by the year 2020. In theory, however, the department says that the world's winds could supply fifteen times the amount of energy currently used worldwide.