Wind and Wind Power

Introduction

Wind is the movement of air from an area of higher air pressure to an area of lower air pressure. The movement of air can be harnessed to provide power. Centuries ago, wind power was used to grind grain and to pump water. In modern times, wind has been harnessed to generate electricity. In the twentieth century, wind power has become more popular, with large arrays of windmills (wind farms) being established worldwide. While in 2008, wind power generated electricity accounts for only about 1% of the world's electricity production, it is becoming increasing attractive as the consequences of fossil fuel generated electricity on atmospheric warming have become recognized.

Historical Background and Scientific Foundations

The earliest documented record of windmills dates back to the late twelfth century in England. However, windmills may have been in use as long ago as AD 500 in Persia, and perhaps even 2,000 years ago in China.

The windmills used in England were designed to replace the use of animals to turn grinding wheels. Windmill-driven grinding of grain soon became very widely used in England and in Europe. By the mid-fifteenth century, there were some 10,000 windmills in the south and east regions of England where wheat was cultivated.

At about the same time, people began using windmills in the Netherlands as a means of draining regions called polders—land that had been created by walling off a section of the sea and draining the land. Because the land was below sea level, draining had to be continued to maintain the land for farming and the raising of livestock. Windmills, sometimes in a series of three or four, pumped water from the lowest lying areas to a higher elevation river or lake.

In North America, windmills were built for the same purposes beginning in the late seventeenth century as colonization to present-day Canada and the eastern United States occurred. As the Midwest became settled and ranging began, windmills also became used as pumps to bring water to the surface from wells. These small windmills took advantage of the near constant winds that are still a feature of prairie regions. From 1850 to 1970, over six million windmills were built on U.S. farms.

In 1888, a large windmill built in Cleveland, Ohio, is the first known version constructed specifically to generate electricity. Within a decade, wind-powered electricity had spread to Europe.

The use of wind power as a source of electricity declined in the United States in the 1930s and 1940s as the electrical demands of farmers increased and also due to the Great Depression. A federal government initiative to spur rural economies during the Depression was to extend the conventional supply of electricity, which replaced the need for an on-site windmill as a power source.

The modern era of wind power began following World War II (post 1945), when European countries such as Denmark and Germany began development of large three-bladed turbines to produce electricity. This design is still in wide use today in wind farms—facilities that house hundreds of turbines that all feed to a common collection point.

Although wind power faded again in the 1960s due to an abundance of inexpensive fossil fuel for the conventional generation of electricity, subsequently it has regained popularity due to fluctuations in fossil fuel availability and price, which increased demand for a supply of renewable energy, and the recognition of the influ-

ence on greenhouse gases such as carbon dioxide on the warming of the atmosphere.

Wind can result from the uneven heating of the land and water. Land tends to absorb the heat of the sun more quickly than does water. As well, heat is emitted back to the atmosphere more readily from land than from water. Because warm air rises, cooler air will move in to displace it. This creates wind.

Different regions of land can also heat up and cool down unevenly. For example, a sandy desert will heat up and cool down more quickly than a forested area. As a result, wind can be generated over land, as air moves from a relatively cooler area to areas where warmer air is rising.

This behavior can occur locally over small distances and, in the case of weather systems, over hundreds or thousands of miles/kilometers.

The conversion of wind into electricity begins when the moving air contacts the blades of the wind machine (turbine). The angle of the blades slows the movement of the air. The design is similar to the wings of an aircraft. The air passes more slowly over one surface of a blade than over the opposing surface. This causes a difference in air pressure, and the movement of air from the higher-pressure surface of the blade to the lower pressure area. The blades do not rise into the air as do airplane wings, but rotate about the fixed central point.

The rotating blades are attached to a shaft. As the shaft turns, an electrical generator positioned at the top of the wind machine produces electricity. A cable that runs down the center of the machine conveys the electricity to the ground, where it feeds into a transmission line. The electricity can then flow into the conventional electrical grid to supplement the conventionally generated electricity, or can be directly used on-site.

Traditionally, both the first windmills and modern electricity-generating turbines have had one of two designs. In the horizontal axis design, the blades are oriented horizontal to the ground and perpendicular to the central shaft. In the vertical axis design, the blades are positioned vertical to the ground and parallel to the central shaft.

The horizontal axis version is the most widely used. The turbines that are used in wind farms can be very large, as tall as a 20-story building with three blades that are hundreds of feet long. Even larger versions exist; the blades on the largest turbines are over 300 ft (90 m) in length, longer than a football field.

The electrical output from a wind farm can be considerable. For example, the Horse Hollow Wind Energy Center in Texas contains over 420 wind turbines. The collective electricity generated is enough to power almost one-quarter million homes for a year.

WORDS TO KNOW

ELECTRICAL GRID: Network of power lines that carry electricity from the source of generation to where the power can be used.

GIGAWATT: A unit of power that is equal to one billion watts.

RENEWABLE ENERGY SOURCE: An energy resource that is naturally replenished, such as sunlight, wind, or geothermal heat.

TURBINE: An engine that moves in a circular motion when force, such as moving water, is applied to its series of baffles (thin plates or screens) radiating from a central shaft.

Impacts and Issues

Wind power is a renewable source of electricity that does not generate carbon dioxide. In contrast, the generation of electricity by the burning of coal is non-renewable and emits carbon dioxide to the atmosphere. These attributes of wind power are advantageous both in terms of the economy of power generation and in reducing the emissions of greenhouse gas. It is now recognized that human activities such as electricity generation are the major driver of the atmospheric warming that has been occurring since the mid-nineteenth century and that has been accelerating since the mid-twentieth century. Thus, any technology that can reduce carbon dioxide emissions is potentially beneficial.

However, the advantages of wind power come with some drawbacks. The rotating blades can be lethal to birds. Besides considering the strength and regularity of prevailing winds, wind farm design also needs to consider the migration pattern of birds and avoid bird migration flyways. As well, the visual impact of dozens or hundreds of turbines can be undesirable to some people. This is subjective, however, as the same farm can be viewed approvingly by others.

Turbines do generate noise. Although wind farms tend to be in sparsely populated areas (some are even placed offshore), an individual turbine can be a disruption to those in the immediate vicinity. Whether the frequency of sound produced is merely inconvenient or has some health effects is contentious and unclear.

Despite the disadvantages, wind power is an increasingly popular technology. As an example, an offshore turbine initiative by the United Kingdom approved construction of almost 600 turbines in 2007. When these turbines become operational, combined with existing facilities, the aim is to harness enough wind energy to power the United Kingdom by the year 2020.

See Also *Alternative Fuel Impacts; Nuclear Power; Tidal or Wave Power*

BIBLIOGRAPHY

Books

Gipe, Paul. *Wind Power*. White River Junction, VT: Chelsea Green, 2004.

Spilsbury, Richard, and Louise Spilsbury. *The Pros and Cons of Wind Power*. New York: Rosen Central, 2007.

Williams, Wendy, and Robert Whitcomb. *Cape Wind: Money, Celebrity, Class, Politics, and the Battle for Our Energy Future on Nantucket Sound*. New York: PublicAffairs, 2007.

Web Sites

U.S. Department of Energy. "Wind Powering America." January 29, 2008. http://www.eere.energy.gov/windandhydro/windpoweringamerica/ (accessed April 7, 2008).

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