Wind Power

Introduction

Wind is any flow of air above Earth's surface in a roughly horizontal direction. The ultimate cause of Earth's winds is solar energy. When sunlight strikes Earth's surface, it heats that surface differently. Uneven heating of Earth's surface, in turn, causes differences in air pressure at various locations. Since the atmosphere constantly seeks to restore balance, air from areas of high pressure always flows into adjacent areas of low pressure. This flow of air is wind.

Wind power is a form of usable energy that results from converting the kinetic energy of the wind into electricity or mechanical energy that can be used in homes and industries. Wind power currently accounts for about 1% of the global energy production.

Historical Background and Scientific Foundations

Windmills were a prevalent source of energy both in Europe and in the plains of the United States in the eighteenth century. Especially in rural areas, the energy produced by windmills was used for pumping water,

Wind turbines are seen as a good source of renewable energy.

WORDS TO KNOW

FOSSIL FUELS: Fuels formed by biological processes and transformed into solid or fluid minerals over geological time. Fossil fuels include coal, petroleum, and natural gas. Fossil fuels are non-renewable on the timescale of human civilization, because their natural replenishment would take many millions of years.

KILOWATT-HOUR: Amount of energy corresponding to a power flow of 1 kilowatt (1,000 watts) sustained for 1 hour. Often used as a unit of electricity consumption. A 100-watt light bulb left on for 10 hours consumes 1 kilowatt-hour (kWh). The average U.S. household purchases about 10,000 kWh of electricity per year.

KINETIC ENERGY: The energy due to the motion of an object.

MECHANICAL ENERGY: Energy possessed by matter in motion. Winds and water currents, for example, possess mechanical energy. Mechanical energy can be transformed into other forms of energy by certain processes: for example, a hydropower generator or windmilll changes mechanical energy into electricity.

RENEWABLE ENERGY: Energy obtained from sources that are renewed at once, or fairly rapidly, by natural or managed processes that can be expected to continue indefinitely. Wind, sun, wood, crops, and waves can all be sources of renewable energy.

WATT: Unit of power or rate of expenditure of energy. One watt equals 1 joule of energy per second. A 100-watt light bulb dissipates 100 joules of energy every second, i.e., uses 100 watts of power. Earth receives power from the sun at a rate of approximately 1.75×10^{17} watts.

WIND FARM: A cluster of wind turbines generating electricity. Wind farms are the most efficient way to generate large amounts of electricity from wind because they can share a single, high-capacity line to transmit their power output to the long-distance electric-power network (grid).

producing electricity, and generating power for many farms. More than a million windmills were spread across the United States by the beginning of the twentieth century. In 1935, the Rural Electrification Act encouraged the building of hydroelectric dams and coal plants, supplanting the use of wind power.

Wind power gained renewed interest in the 1980s as the prices of fossil fuels increased. The United States became a world leader in wind technology with more than 17,000 wind turbines built in several large projects in California. Poor management and extensive government subsidies resulted in bankruptcy of a number of these developments. Currently Denmark, Germany, Spain, and Japan are the global leaders in wind power technology. In 2007, 20% of Denmark's energy supply was provided by wind power.

Two factors that influence the amount of power generated by a wind turbine are the size of the rotor and the wind speed. Typical wind turbines used on wind farms have rotor diameters of 165–295 ft (50–90 m). Such turbines have power ratings between 250 watts and 5 megawatts. The power produced by a turbine increases as the cube of the wind speed. This means that a turbine experiencing an 8-mph (12.8 km/h) wind produces eight times more power than the same turbine in a 4-mph (6.4 km/h) wind.

Wind turbines are composed of the blades (usually made of reinforced fiberglass), a tower (usually steel), a nacelle (enclosure) containing a drive train, and electronic equipment and ground support that sends the electricity generated to a power plant on the electrical utility grid. There are two major types of wind turbines. The more common type has a horizontal axis with three long blades. The Darrieus rotor looks similar to an eggbeater standing on end and has a vertical axis.

A typical household in the United States uses just over 10,000 kilowatt-hours per year. A turbine with a 10-kilowatt rating that experiences average winds of 12 mph (19 km/h) can generate enough electricity to power the average household. A large 5-megawatt wind turbine in the same wind environment can generate enough power to support 1,400 houses.

Wind turbines are often found on wind farms, which are large facilities developed by public utilities. Wind farms are sited on mountain ridges and throughout the Great Plains, where winds tend to blow constantly. In most cases, the land used for wind farms can be used simultaneously for grazing livestock or farming. Newer wind farms are being constructed in near shore regions of the ocean.

■ Impacts and Issues

Proponents of wind power argue that it is one of the most cost effective renewable energy sources available. A 2006 study by the U.S. Department of Energy reported costs for developing new capacity for power generation for various technologies. Per megawatt hour, new costs for wind power development are $55, only slightly more expensive than coal at $53.10 or natural gas at $52.50. Nuclear energy is the most expensive at $59.30.

Wind power represents a source of energy with a relatively small environmental footprint. Because it produces no emissions, wind power is significantly less

detrimental to the global climate than the burning of fossil fuels. After the environmental costs of constructing the turbines, which are not significantly greater than costs of constructing facilities for other power production, there is no real impact on the environment. In addition, wind turbines require very little maintenance.

Critics claim that noise and land use are significant detriments to wind power. Land use for wind farms is nearly one-third as large as land use for coal plants or solar power facilities. Measurements have shown that at a distance of 75 ft (23 m) from the turbine, it produces as much noise as a refrigerator. Other critics claim that wind turbines kill birds and affect migration patterns. Studies show that in the United States about 70,000 birds are killed by turbines per year. In comparison, nearly 98 million are killed by collisions with plate glass in buildings.

Other issues with wind power include scalability and variability. A study evaluated the potential for wind power throughout the globe. Choosing only those places where wind power could be produced for three to four cents per kilowatt-hour, the study found the potential for producing 72 terawatts per year, which is 15 times the world's current energy use. Because wind does not blow consistently, changes in the amount of wind power can occur in numerous time scales. However, grid storage and management technologies have been developed to address some of the problems with variability. Compared to solar power, which can only be collected during daylight hours, wind power can be generated throughout the day and night.

SEE ALSO *Carbon Footprint; Coal; Natural Gas; Seasonal Winds; Solar Energy.*

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