Topic Page: Wind power

Definition: **wind power** from *Collins English Dictionary*

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1 power produced from windmills and wind turbines

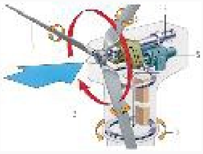

Image from: **A wind generator converts the energy of the wind...** in *Philip's Encyclopedia*

Summary Article: **Wind Power**
From *Encyclopedia of Science and Technology Communication*

The requirement for energy is expected to increase into the foreseeable future, with much of this current and future demand for energy being in the form of electricity. More media and public attention than ever is being directed toward discussion of viable alternatives to our existing energy sources. The world electrical energy demand is forecasted to grow by at least 3% annually through 2020. As in much of the world, the United States is developing new sustainable (sometimes referred to as renewable) energy sources to augment the current sources of coal, nuclear, and natural gas power plants. One of the most economical and technically feasible forms of sustainable electrical energy is derived from wind.

Wind energy has been used since ancient times to directly perform mechanical tasks, such as pumping water for irrigation or grinding grain for flour. A better use of the energy stored in wind is to convert the mechanical energy into electrical form because electricity provides a convenient, high-quality form of energy that can be transported over long distances. Current technology uses highly specialized turbines and associated electrical conversion electronics and controls to harness the available wind energy and make it available as electricity. The increasing costs of energy and the increasing demand for electricity have helped create a favorable environment for wind energy expansion. The cost of wind power generation is 4 cents to 6 cents per kilowatt-hour (/kWh), which compares favorably with newly installed coal-fired power generating plants. The U.S. Department of Energy (DOE) has a stated target of 20% of the nation's electricity being generated from wind sources by the year 2030. The 20% generation goal represents a large increase over the current power generation of 16 gigawatts (GW) to over 300 GW. A large amount of information concerning wind power is available on the DOE Web site.

The advantages of wind generation are numerous. Modern power plants require large amounts of cooling water. Coal-fired plants also emit various nitrous and sulfurous gasses, as well as carbon dioxide (CO_2) and some heavy metals such as mercury. Wind turbines do not require any water for their operation and have no metal or gas emissions, hence providing a very clean and environmentally sound form of electricity production. Many areas of the country that have good wind resources are sparsely populated. People living in these rural and remote areas can often benefit economically from wind energy development through increased local tax revenue, land lease payments, and job creation during construction and installation, as well as the potential for local manufacturing and maintenance jobs.

A major disadvantage associated with wind energy is that it is an intermittent source. Typically stronger winds blow in the winter, whereas larger electrical demands occur in the summer months due to air conditioning and irrigation. Currently, there are no technologies available to store large amounts of electrical energy for use on demand. Other issues of concern are related to the noise created by the rotating turbine blades, the potential for bird and bat strikes, and the visual effects on the landscape, including that in coastal regions (for offshore installations). Another potential disadvantage is that wind resources are often in remote areas that have few if any electrical transmission lines nearby, though the lack of transmission infrastructure is beginning to be addressed.

Wind turbines use aerodynamic lift to produce a net positive torque on a rotating shaft connected to an electric generator. Large turbines use a gearbox to modify the low-speed shaft rotation to a higher speed driving the generator. Newer generator designs allow for elimination of the gearbox (a major subsystem cost and point of failure in turbines). The generator output must be conditioned through power electronics to provide an electrical output that is in a usable form. Variations in wind speed and direction must be accounted for by the power electronics conditioning system and the turbine control system. For large turbines, this control system alters the pitch (orientation) of the wind turbine blades and axis of rotation of the turbine.

Turbines range in power output capability from a few kilowatts (kW) to about 2.5 megawatts (MW). The blades of the largest wind turbines are over 130 feet (40 meters) in length with the rotor height at 260 feet above the ground. Most commercially available wind turbines, including those connected to the power grid, are horizontal axis types, a propeller-like design where the airflow is parallel to the axis of rotation. These horizontal axis wind turbines (HAWT) typically have three blades. Having an odd number of blades improves the dynamic stability of the turbine, and using three blades optimizes the surface area interacting with the wind without having too much material to impede the airflow. Vertical axis wind turbines (VAWT) are designed with their rotational shaft standing vertically upright from the ground, including two to three blades connected at the top and bottom of the axis while bowing out in the center, similar in shape to an eggbeater. The advantages of a VAWT compared to a HAWT are that no tower is needed, gearboxes and electronics equipment can be placed on the ground, and there is no need for a complicated control system to properly protect and orient the turbine blades. The disadvantages for the VAWT are that it is typically placed near the ground, where air speeds are low and turbulence from the ground affects the efficiency of operation, and that maintenance of rotor bearings typically requires disassembly of the entire turbine.

There are two orientations in HAWT design, upwind (rotor faces into the wind) and downwind (turbine tower is upwind while rotor faces downwind). The upwind types have the advantage that the airflow is not affected by the “shading” of the support tower as occurs when the rotors are on the leeward side (downwind design). However, blades for upwind turbines must be manufactured to be more rigid—making them heavier as well—than blades for downwind designs.

It can be theoretically shown that the maximum power that can be extracted from the wind is 59% of the total power in the wind (Betz limit), no matter how a turbine is designed. Also, the power extracted from the wind by the turbine blades is proportional to the cube of the wind velocity (v^3_{wind}) over some range of wind speeds. Therefore, small changes in average wind velocity can have a large impact on energy production from wind turbines. This is why so much effort is expended to determine suitable installation locations. It takes a minimum wind velocity, called the cut-in speed, to start the rotation of the turbine blades. This cut-in wind speed is around 8 to 10 miles per hour (mph, or 3.5 meters per second) for small turbines. The output power rating of a turbine is specified at a rated wind speed above the cut-in speed. There is also a survival wind speed specified (140 mph, for example) that the turbine and its support structure can endure without damage.

See also

Alternative Energy, Overview, Biofuels, Fuel Cell Technology, Solar Energy

Further Readings

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