

Audience note: The audience for this description of wind power generation is a landowner who is considering leasing his property to an energy company for the construction of a wind farm. The property owner has significant mechanical knowledge, including knowledge of mechanical windmills, but has no specific knowledge of electric windmills. Thanks to Dan Morris for this process discussion.

Wind Turbine Power Generation

Much like windmills that harness the energy of wind to pump water from a well, a modern wind turbine harnesses the energy of wind to create electricity. In 2003, the United States received approximately 5% of its electricity from wind power. The U.S. Department of Energy predicts that number to grow to 20% by 2030. To reach this percentage, energy companies must build wind farms (numerous wind turbines concentrated in a geographic region). Landowners will lease to these companies the right to construct wind turbines on their property. To operate, a wind turbine must have (1) adequate wind, (2) rotors (blades) and a shaft, and (3) a generator. (See Figure 1.)

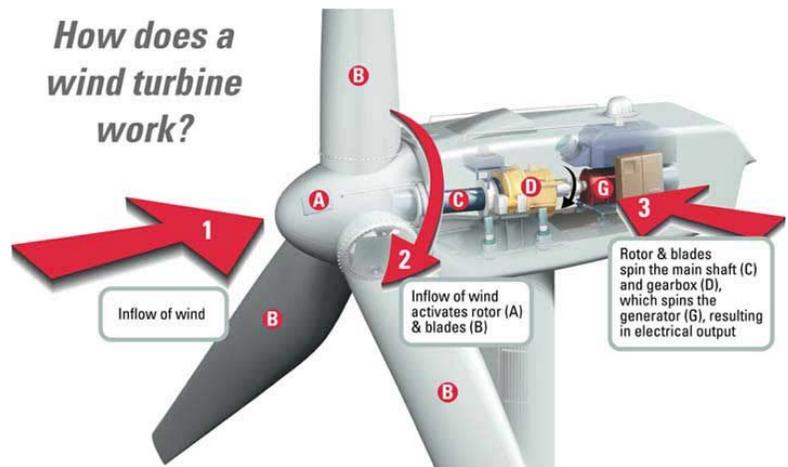


Figure 1, *Understanding Wind Power*, from TechieNation.com

Wind Requirements

While it seems obvious, the first component a wind turbine needs to operate is wind. Not just any wind, however, will suffice for a productive wind farm. Wind turbines need an adequate wind power density (WPD) to be cost effective. Researchers derive WPD from a combination of wind speed, wind sustainability, turbulence, height above ground, and other factors. Because not all areas, even areas with high winds, have an adequate WPD, engineers must carefully select locations for wind farms. Generally, small turbines need wind speeds of 10 mph to generate electricity. An increase to 12 mph, however, can theoretically provide a 70% increase in power. Large turbines, such as the ones engineers use in wind farms, need a minimum wind speed of 13 mph but are most efficient with a wind speed of 33 mph. Such turbines, however, will shut themselves down at a wind speed of 45 mph to prevent damage. When the wind is blowing correctly, it will cause the rotors and shaft to turn, which will lead to power generation.

Rotor and Shaft Construction

Modern turbines come in two main forms: vertical-axis wind turbines (VAWTs) and horizontal-axis wind turbines (HAWTs). VAWTs have vertically mounted rotor shafts. These units require less wind than HAWTs but produce less electricity and have higher maintenance costs. HAWTs (Figure 1) have horizontally mounted rotor shafts. These are the predominant type of wind turbines used by wind farms. The blades are similar to airplane wings. When wind hits the blades, a pocket of low-pressure

develops on the backside of the blade. This causes a pulling action that creates lift and turns the blades. The outer tips of the blades on HAWTs travel up to 150 mph as they convert wind energy into shaft energy, which causes the generator to turn.

Generating Power

Wind turbines are relatively simple in concept. Wind causes rotors to turn, which spin a shaft, which turns an electromagnetic motor. This is the same type of motor found in electric generators. It consists of magnets and a conductor of coiled wire. The shaft spins the magnets, which are in close proximity to the coiled wires, which produces electricity. Depending on the amount and quality of wind, the size of the rotors, and the size of the generator, a modern wind turbine can produce up to 5 megawatts of electricity. This is enough electricity to power 1,400 households in the US.