Wind turbine generator functions

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The article provides an overview of wind turbine components (parts), including the tower, rotor, nacelle, generator, and foundation. It highlights their functions, the role of control systems, and the importance of maintenance to optimize turbine performance.

A wind turbine consists of five major and many auxiliary parts. The major parts are the tower, rotor, nacelle, generator, and foundation or base. Without all of these, a wind turbine cannot function.

For offshore turbines, the base is under the water and cannot be seen. In offshore turbines that are well into the sea the base is floating, but it is of sufficient mass to support the turbine weight and all the forces exerted on it and to hold it upright.

The tower in most modern turbines is round tubular steel of a diameter of 3-4 m (10-13 ft), with a height of 75-110 m (250-370 ft), depending on the size of the turbine and its location. The rule of thumb for a turbine tower is that it has the same height as the diameter of the circle its blades make when rotating. Normally, the taller a turbine is, it is subject to more of the wind with higher speed. This is because the farther we are from the ground, the faster the wind (wind does not have the same speed at various distances from the ground).

The rotor is the rotating part of a turbine; it consists of (mostly) three blades and the central part that the blades are attached to, the hub. A turbine does not necessarily have to have three blades; it can have two, four, or another number of blades. But the three-blade rotor has the best efficiency and other advantages.

Blades are not solid; they are hollow and are made of composite material to be light and strong. The trend is to make them larger (for more power), lighter, and stronger. The blades have the form of an airfoil (same as the wings of an airplane) to be aerodynamic. As well, they are not flat and have a twist between their root and their tip. The blades can rotate up to 90? about their axes. This motion is called blade pitch.

The nacelle is housing on top of the tower that accommodates all the components that need to be on a turbine top. There are quite a number of components for the proper and healthy operation of a complicated electromechanical system that a turbine is. A major turbine part among these components is the generator and the turbine shaft that transfers the harvested power from wind to the generator through a gearbox.

The gearbox is a vital component of wind turbines; it resides in the nacelle. A gearbox increases the main shaft speed from around 12-25 rpm* (for most of today"s turbines) to a speed suitable for its generator. For this reason, the shaft on the generator side is called "high-speed shaft."

Because a turbine must follow the wind and adjust its orientation to the wind direction, its rotor needs to rotate with respect to the tower. This rotation is called yaw motion in which the nacelle and the rotor revolve about

the tower axis.

At the commercial production level, all electricity generation is in the three-phase alternative current. In general, the choice of generator, therefore, is synchronous or asynchronous (induction) generator. Nevertheless, the generator associated with wind turbines, thus far, is the induction generator because a synchronous generator must turn at a tightly controlled constant speed (to maintain a constant frequency). Some of a wind turbine"s principal components are depicted in Figure 1.

Because a generator must be rotated at a speed corresponding to the frequency of the electric network (50 or 60 Hz in most countries), it must be rotated faster than the turbine rotor. Most generators need to be turned at 1500 rpm (for 50 Hz) and 1800 rpm (for 60 Hz). In no way, it is feasible for a turbine rotor to move that fast. A gearbox, therefore, must increase the turbine rotor (main shaft) rotational speed to a speed that can be used by the generator.

Experience has shown that the gearbox in a turbine is a problematic component. This is due to the fact that the energy in the wind does not remain constant for a relatively acceptable length of time. It continuously fluctuates, because of the nature of wind. This causes the gear teeth to undergo overload and hammering stress that leads to fatigue and failure. In addition, the gearbox is a heavy item in the nacelle on the top of a turbine.