Direct drive turbine

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Wind energy generated by wind turbine technology is one of the fastest developing sustainable power sources due to its promising potential. Two types of wind turbines share the focus of current development efforts, and are competing to be recognized as the dominant design: the gearbox, and the direct-drive wind turbines. This article will examine both types of turbine, and discuss the advantages and disadvantages, as well as tackle their potential to become the dominant type of wind turbines in the market.

There has been a shift in wind turbine technology in the last few decades, which has lead to the variable speed wind turbine with a multi-stage gearbox. This type of turbine has a gearbox between the low-speed rotor and a higher speed electrical generator (usually a relatively standard doubly-fed induction generator). The purpose of the gearbox is to increase the rotational rotor speed before feeding it to the generator.

For this wind turbine type, the blades rotate by a shaft connected via a gearbox to the generator. For example, to generate electricity in the case of a 1 MW wind turbine, the gearbox increases the rotation speed of the blades from 15 to 20 rotations per minute up to the about 1,800 rotations per minute that is required.

This type of wind turbine presents a challenge for designers because of the loading and environmental conditions required for the gearbox operation. The power is generated via torque from the rotor; however, large moments and forces are also applied by the turbine rotor on the wind-turbine drivetrain. To prevent stress concentration and failures, designers must adjust the gearbox to support the loads and stress. Seals and lubrication systems must operate consistently in wide temperature variations; otherwise, dirt and moisture may collect and build-up inside the gearbox.

To eliminate gearbox failure and transmission losses, manufacturers have developed wind turbines without gearboxes. This type of wind turbine was introduced in 1991, and is known as the variable speed direct-drive wind turbine. Direct-drive technology is the basis for direct-drive wind turbines; as Shown in the image below, the synchronous generator is directly powered by the rotor.

A direct-drive wind turbine’s generator speed is equivalent to the rotor speed, because the rotor is connected directly to the generator. As the rotational generator speed is low, designers placed several magnetic poles in the generator to achieve the appropriate high output frequency.

The there are two categories of wind turbine generators: permanent magnet generators (PMGs) and electrically excited synchronous generators (EESGs).

EESGs do not have permanent magnets made from rare materials, such as neodymium, the extraction of which can cause environmental damage. On the other hand, PMGs have several advantages such as high efficiency with the elimination of field loss, in addition to being small and lightweight compared to the EESGs. PMGs

are usually used in small-scale wind turbines, but can also be used in large MW applications.

However, because the high torque requirements are large, direct-drive wind turbines up to 7-10 MW require significantly larger and heavier generators. In this case, a single or two-stage gearbox is the better choice, as it is a much smaller, lighter solution and it provides the same advantages as the direct-drive generator.

To produce electricity at a low rotary speed, the manufacturers had to design a specific generator. Since traditional generators have a cylindrical shape, the permanent magnet synchronous generators provide a better fit for direct-drive due to their “doughnut” configuration. However, to achieve the required high torques, the effective permanent magnet rotary motion must be increased. Ultimately, this means that a significantly larger diameter generator must be provided.

An advantage of direct-drive turbines is the high efficiency of synchronous permanent magnet generators. An important fact is that due to wind inconsistency, the turbines often operate at partial loads. The efficiency of the PM generator excels even in these conditions because it continues working nearly to nominal values.

Several benefits are added here within the advanced control features, which provide users with high energy yield, quiet operation and long-term reliability and availability. Because the direct-drive wind turbines do not have a gearbox, mechanical noise is reduced as well as fewer rotating components. Moreover, this type of wind turbine has a single main bearing for the rotor assembly and generator, which additionally reduces the number of moving parts, as well as the maintenance and repair costs.

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