Permanent Magnet Generators Join Turbine Conversation

Permanent magnet generators have shown to remove or reduce the losses during low power generation, resulting in increased capacity factors while reducing maintenance.

BY MARK DEL FRANCO

Although permanent magnet generator (PMG) technology is hardly new – PMGs have been around for decades, and their strong magnetic properties help operate everything from computer hard drives to hybrid cars – many wind turbine manufacturers are embracing the technology this year. In fact, six of the top 10 turbine manufacturers have introduced a PMG-based offering for multi-megawatt onshore and offshore wind turbine generators.

PMG-based technology can be found in direct-drive models from manufacturers such as Goldwind (2.5 MW), Siemens (SWT 3.0 MW) and GE (4.0 MW), as well as in gear-drive machines from the likes of Vestas (V112) and Sinovel (SL 3000).

According to the U.S. Department of Energy's "20% Wind Energy By 2030" report, PMGs' "high-energy density eliminates much of the weight associated with copper windings, eliminates problems associated with insulation degradation and shorting, and reduces electrical losses."

PMGs create better efficiencies and improve grid compatibility, according to Dan Shreve, managing partner at MAKE Consulting. "The rise of PMGs coincide with the wind industry's movement toward increased turbine sizes," he says, explaining that power losses in generator windings, power electronics, gears and bearings, and other electrical devices are individually quite small. However, he says, when considering the entire generator system, power losses can be significant.

"Permanent magnet generators have shown to remove or reduce the losses during low power generation, which, in turn, can increase capacity factors," says Shreve.

Tim Rosenzweig, CEO at Goldwind USA, says the company's direct-drive turbine operates without a gearbox, resulting in a system with

significantly increased reliability and reduced maintenance, adding that the elimination of associated mechanical losses that are inevitable with gearboxes also leads to improved efficiencies in the power-conversion process.

Goldwind USA is a subsidiary of China-based Goldwind, the largest global supplier of PMG-based turbines, with nearly 3,000 MW in the field.

Grid compatibility

Proponents of permanent magnets say the technology is better equipped to deal with the complexities of grid connection, a topic of increasing concern both for grid operators and wind farm owners and operators.

"As wind power continues to penetrate the market, grid operators are requiring a higher standard for compatibility," Rosenzweig explains, adding that PMG-based turbines are better to control fluctuating voltage levels and reactive power occurrences than other turbines.

PMGs' efficiencies are fully realized when combined with a variable-speed full converter, or type 4, wind turbine, according to Robert Nelson, manager of codes, regulations and standards at Siemens. Full converters, he says, are better equipped to comply with current standards of the grid than doubly-fed induction generators, or type 3, turbines, which have limited fault ride-through and voltage regulation capability.

PMG-based turbines can better control fluctuating voltage levels and reactive power occurences.

Scott Rowland, vice president of engineering at Goldwind USA, explains, "Fully converted machines offer a significant competitive advantage in that very few turbine components must be changed to accommodate either a 60 Hz grid commonly found in North America or a 50 Hz grid interconnection. In a fully converted machine, the only changes necessary to accommodate different base grid frequencies are in auxiliary loads' convenience receptacles," he says. "The contrast is a non-fully converted machine, where major parts such as the gearbox or generator are different for a change of grid frequency."

According to Nelson, the main advantage of PMGs is that their simple and robust design requires no excitation power, slip rings or excitation control systems, leading to high efficiency, even at low loads.

Jukka-Pekka Makinen, president and CEO of Finland-based The Switch, says PMGs naturally lend themselves to comply with grid codes as full-power converters control 100% of the power output, as opposed to the traditional doubly-fed converter, which controls about 33% of the power. "This gives the opportunity to implement better fault ride through functionality and higher capacity to provide reactive power to the network when needed."

Also, the turbine's power train can be more reliable, have fewer moving parts and require less maintenance.

"The U.S. market is slowly waking up to the fact that PMGs are the future and that wind farms must work more like traditional power plants," Makinen says. "There were just a few providers in the market selling PMGs when we began. Now, as evidenced by the largest turbine manufacturers coming out with PMG machines, it's now the thing to do." The Switch, which manufactures PMGs for GE's 2.5 MW and 4 MW turbines, has been manufacturing PMGs since the company's founding in 2006.

Challenges

According to MAKE Consulting's Shreve, PMG-based technology will continue to gain significant market share in the wind industry, although it will be vital to avoid potential bottlenecks in the supply of raw materi-

als, such as neodymium, needed for the generator's configuration. Neodymium, one of seventeen rare-earth metals, is found almost exclusively in China. In fact, the country controls more than 97% of rare-earth metal production.

In July, China announced that it would begin restricting the export of neodymium to 40% from 2009 levels. However, Shreve says the impact is not as dire because the export requirements relate to rare-earth materials and not to finished goods employing rare-earth materials.

"The net impact to turbine vendors is dependent upon their production and sourcing strategies," he says. While some manufacturers could be squeezed, others such as China-based Goldwind will be less affected because of investments in several Chinese mines containing rare-earth materials.

Apart from the sourcing of rare-earth metals, the long-term outlook for PMGs will largely depend on whether others in the industry, such as Siemens and GE, can avoid supply bottlenecks, Shreve predicts.

"Unlike traditional asynchronous generators, development and manufacture of sophisticated PMGs requires significant engineering resources," he says.

"New geardrive concepts that call for two versus three stage gearboxes and continued investment in new 3+MW direct-drive products, like GE's and Siemens' next-generation offshore units, further increase the need for a wide speed range of offerings that have different generator-torque levels and weights," he says. WP