Race for Wind Turbine Generator Dominance Continues

Stiffer grid compliance regulations, higher wind turbine manufacturing costs, and growing operational expenses of existing systems are all factors converging to create a highly competitive environment for generator technology dominance within the wind industry. Though gearbox designs have enjoyed popularity for some time now, many are betting that a return to old, gearless systems based on permanent magnet configurations will win the day for both profitability and ease of grid compliance.

Ideal Generator Technologies for Grid Compliance

For a couple of decades now, dual-fed induction generators have been the leading technology used for manufacturing wind turbines for both onshore and offshore applications. Duel-fed induction generators have depended on high-speed gearboxes, and have been favoured because of their ability to provide variable speed turbine options. This has been important for reaching grid compliance in many regions. With a 35% rated capacity, these generators are able to feed much of their energy directly into the grid to increase efficiency – little power is lost via the converter. Additionally, this technology allows generators to import and export reactive power into the grid during outages.

For this reason, companies like Sinovel continue to develop gearbox-style projects, such as their recent venture in China using its SL3000 and SL6000 series which are suitable for onshore and offshore installations. These turbines are equipped with a variable speed control and double-fed inductive generator to make it adaptable to a variety of wind energy resource conditions. The advanced generators combined with the gearbox transmission systems provide high economy and reliability.[i]

That's only one example of a recent project that employs geared, dual-fed induction technology, yet most duel-fed induction generators are not able to meet more stringent grid codes. As a result, many existing systems using this technology have had to be retrofitted in recent years with the addition of extra electronics. And in their wake, the winds of generator technology are shifting, bringing with them the promise of lower cost and greater reliability.

Turning to Permanent Magnet Generator Technologies

Dual-fed induction generators are diminishing in popularity for many manufacturers, giving way to permanent magnet generators. Though many have favoured gearbox-style systems in order to achieve higher rotations from the generator's internal shaft to provide low noise levels and high efficiency, many are shirking this technology for more basic, reliable systems that operate without gearboxes. Additionally, the high cost of maintaining and refurbishing gearboxes seems to be behind the change in the industry. In fact, direct drive turbines have grown from around 18% of the market in 2006 to 22% in 2011, with an expected increase to 29% by 2020. Manufacturers such as Siemens and GE and many others are shifting away from gearbox-dependent systems to permanent magnet direct drive turbines.[ii]

One of the reasons direct drive technology is seeing a resurgence in popularity is the fact that it operates without a gearbox, offering lower operating hassles and reduced wear and tear on the system as a whole. Perhaps more importantly, permanent magnet generators are able to meet the more stringent grid compliance regulations.

True, permanent magnet technologies rely on expensive full power converters (which can be up to three times more expensive) to deal with the full power output of a turbine.[iii] But permanent magnet designs are more reliable, serviceable, and lightweight, especially when it comes to the larger turbine designs we're seeing today.

Not only that, their very design makes them better suited to grid connectivity. One of the primary reasons is the fact the full power converters, such as those in gearless designs, are able to support grid voltage during voltage dips by injecting reactive current. By being completely decoupled from the grid, full power converters are able to provide longer, lower drips than partial converters.

On example of a company turning sharply toward permanent magnet designs is Alstom which recently completed tests with its first prototype 6 MW machine with 150 metre rotor diameter called Haliade 150. This turbine uses a permanent magnet generator from Converteam which reduces maintenance costs and time, and significantly increases overall reliability because of the fact that it has fewer moving parts. As a result, this type of technology promises improved returns and higher production time.

Alstom's Haliade 150 and was installed offshore in the Loire-Atlantique in France. This model reduces offshore wind power costs by increasing reliability, energy availability, improved drivetrain efficiency, increased energy yields, and lower operating costs.[iv] Alstom is betting that their new turbines will play a big role in the growth of the offshore wind industry in years to come.

In fact, Alstom recently started construction on a new plant (with two factories) in France where they will produce the key components of the 6 MW Haliade 150 turbines, including the nacelles and the generators. The factories are scheduled to be complete and in production by 2014, with a production capacity of 100 units per year.[v]

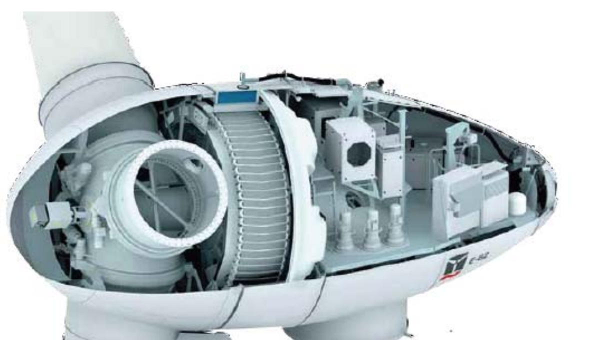
Alstom's Haliade 150 offshore wind turbines are set to figure largely in the development of America's wind industry, as well. They are a member of the Dominion Virginia Power's team which was awarded $4 million (USD) for developing an offshore wind demonstration project in Virginia that utilize the Haliade 150 design 22 miles offshore from Virginia Beach.

This type of system is also being adapted for low-wind turbines to increase the number of regions that can be developed for wind energy. An example is the new Siemens direct drive and a compact permanent magnet generator being used in the SWT-2.3-113 prototype installed in the Netherlands. With a capacity of 2.3 MW and rotor diameter of 113 metres, the turbine is designed to provide maximum power at sites with low to moderate wind speeds.

Leitwind is also developing a new generation of direct drive wind turbines with models LTW101 and LTW104 which are designed to work well in low and medium wind speed regions. These turbines use a synchronous generator with permanent magnets and have been installed in many rugged locations, proving both the reliability and safety of the technology many times over. The direct drive turbine with synchronous generator maximizes performance at all operating levels and offers simple assembly and maintenance to lower operational costs and profitability.[vi]

Danotek, a manufacturer of permanent magnet generators, has also been developing medium-speed drive trains that work with their generators to deliver better performance in regions where wind speeds are slower. They've so far completed Phase I of their study to develop a permanent magnet generator, and power electronics that enhance reliability and capacity while vastly reducing cost. Their Phase II has now begun and will involve incorporating lessons learned into a scalable 1.5 MW prototype that will be tested by NREL.[vii]

Another recent example of the shift in technology preference can be seen in the deal struck between Siemens and DONG Energy for wind projects in the UK. The two companies signed a framework agreement in mid-2012 that would see 300 of Siemens' SWT-6.0-154 direct drive wind turbines installed in power plants off the British coast between 2014 and 2017. These turbines contain 50% fewer components (including fewer parts that rotate), which will provide a significant boost to reliability for the offshore turbines. The 300 machines will be part of the UK target to produce 18 MW of offshore wind energy by 2020.



ENERCON direct drive – fewer rotating components increase the lifespan (e.g. ENERCON E-82)

Yet not all manufacturers are relying on permanent magnet technologies. ENERCON GmbH of Germany has been perfecting its direct drive turbines with their annular multiple poles generator that reduces the number of moving parts used. [viii] They stress that this design reduces both maintenance and service costs by lowering the number of worn parts, gear oil changes, and operating expenses.

The annular generator is one of the key components of the gearless design used in ENERCON's turbines. By directly integrating the rotor of the generator with the rotor hub to form one consolidated unit that is mounted on a fixed axis, the system can operate with slow-moving rolling element bearings to offer nearly frictionless energy production for minimal material wear. This makes it particularly ideal for heavy loads and guarantees a long service life.[ix]

Another unique feature of the annular generator for ENERCON is the fact that the stator uses insulation class F copper winding that is hand-wound by humans in order to provide a high level of precision. Not only that, but each individual wire strand is continuous from start to end.

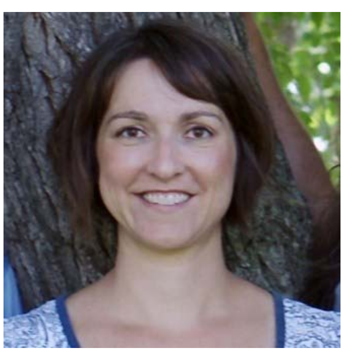
One of the complicating factors to using permanent magnet direct drive systems is that they rely on rare earth metals, such as neodymium, which can vary in price quite substantially. With growing concerns over the scarcity of such resources, it remains to be seen whether permanent magnet style turbines will continue to be cost effective in the decades to come.[x]

The fact that ENERCON's turbine technology is not based on permanent magnet technology gives the annular generator another advantage: its price doesn't hinge on the cost of rare earth elements like neodymium. Instead, the ENERCON design relies on pole shoes mounted on the rotor to excite the magnet field of the stator winding. This has the knock-on benefit of generating virtually no tonal noise since the pole shoes are precisely adapted to the slow rotation of the annular generator. [xi]

Competition to Continue

The race to see which technology will win the day will rage on, likely for many years in an age where turbine sizes are increasing but costs must decrease. Competition to prove which designs will provide the greatest reliability, best efficiency, and lowest costs will no doubt prove to be beneficial for the industry as a whole.

Maryruth Belsey Priebe



A student of all things green, Maryruth has a special interest in cleantech and green buildings. In recent years, Maryruth has worked as the senior editor of The Green Economy magazine, is a regular blogger for several green business ventures, and has contributed to the editorial content of not one, but two eco-living websites: www.ecolife.com and www.GreenYour.com. You can learn more about Maryruth's work by visiting her site, www.jadecreative.com.

Images via Sinovel and ENERCON.

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