PERMANENT SOLUTION?

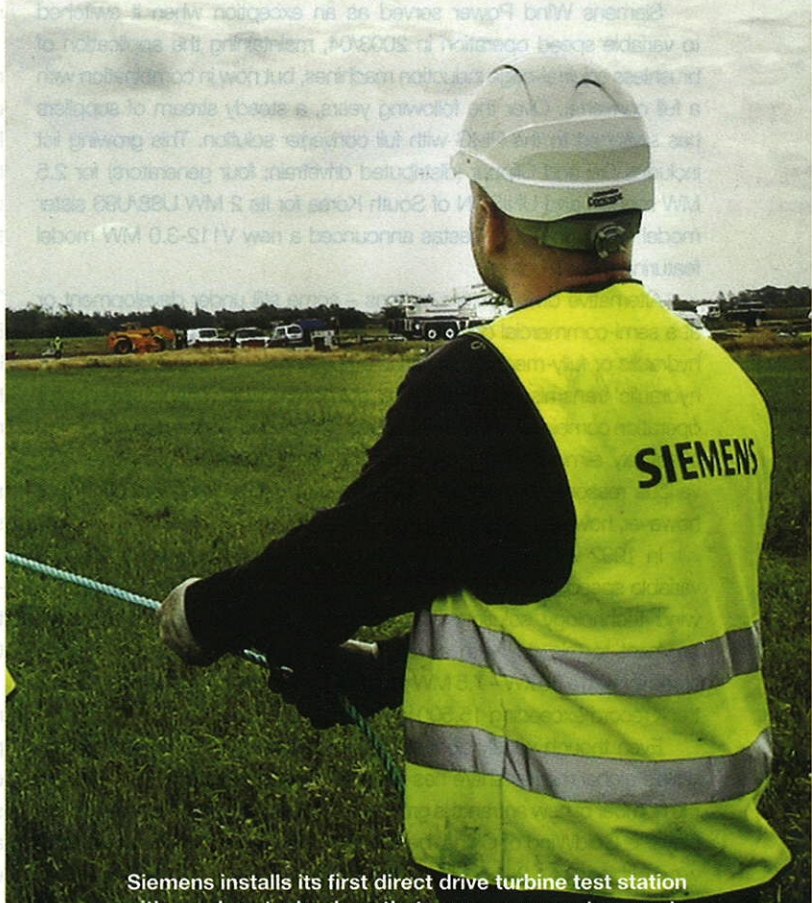
The application of permanent magnet generators is gaining ground in the wind turbine industry. **Eize de Vries** talks to specialists in the field about their benefits and the potential alternatives available, and highlights concerns over China's near-monopoly supply position in the rare-earth materials needed for the devices.

The application of permanent magnet generators (PMGs) to wind turbines is a relatively new, but growing, trend in the energy industry. According to specialist providers, they offer advantages in key areas such as efficiency and design flexibility and PMGs are now being used by leading manufacturers in the industry.

However, the dominant Neodymium-Iron-Boron (NdFeB) rare-earth material used for magnet manufacturing is also in high demand for many alternative hi-tech applications. And, the fact that China controls up to 95% of the production market for rare-earth materials, including NdFeB has also caused some unease elsewhere in the world (see box panel).

PMGs are being applied to an increasing number of the latest turbine designs, potentially marking another significant chapter in the industry's technical evolution. Since the birth of modern industrial wind turbine manufacturing in the late 1970s, conventional fast speed geared wind systems have dominated the global market. This success can largely be attributed to a pioneering fixed-speed concept known as the 'Danish Concept', featuring stall-type power output limitation, three blades and a non-integrated drive system. The generators in these turbines were typically squirrel-cage induction machines of the sort widely used for many industrial applications.

Variable speed operation was already active by the late 1970s/early 1980s thanks to wind technology pioneers like the former Lagerwey of the Netherlands. From the second half of the 1990s variable speed operation steadily gained ground, with the doubly-fed induction generator (DFIG) becoming the semi-standard wind industry solution. Generator power is typically fed into the grid with the aid of an AC/DC-DC/AC frequency converter. In a key cost advantage,



Siemens installs its first direct drive turbine test station with gearless technology that uses permanent magnets

SIEMENS

Mining of rare earth materials may be stepped up outside China in response to supply concerns
CATERPILLAR

DFIG machines only require a partial (approximately 35% rated capacity) converter.

Siemens Wind Power served as an exception when it switched to variable speed operation in 2003/04, maintaining the application of brushless squirrel-cage induction machines, but now in combination with a full converter. Over the following years, a steady stream of suppliers has switched to the PMG with full converter solution. This growing list includes GE and Clipper (distributed drivetrain; four generators) for 2.5 MW models and UNISON of South Korea for its 2 MW U88/U93 sister model series. In 2009, Vestas announced a new V112-3.0 MW model featuring a PMG design.

Alternative drive system options – some still under development or at a semi-commercial development stage – either involve a mechanical-hydraulic or fully-mechanical variable speed gearbox system, or a 'fully-hydraulic' transmission. These latter solutions enable variable speed rotor operation combined with a fixed-speed directly grid-connected generator, effectively eliminating the need for an electronic power converter. For various reasons, fixed-speed systems with direct grid-connection are, however, now only a minority segment.

In 1992 wind pioneer Enercon of Germany introduced a 500 kW variable speed, direct drive system (no gearbox) as a distinct alternative wind technology solution. The company dominates the direct drive segment to this day with an evolutionary range of successor models currently with a 30 kW – 7.5 MW range of power ratings and an operational track record exceeding 15,500 wind turbines.

Even though widely accepted as a mature wind technology, direct drive's global market share has never exceeded roughly 10%–15%, but the number of new entrants is growing rapidly. One strong new direct drive player is GoldWind of China, believed to have delivered over a thousand wind turbines of 1.2–1.5 MW, using licensed designs that originate from Vensys of Germany. Among other powerful newcomers in the direct drive segment are GE Energy and Siemens Wind Power. These two, and almost all other new international entrants, apply PMGs in their designs. In contrast, Enercon and Mtorres of Spain chose in-house developed and manufactured generators with electrical field excitation.

A mix between fast-speed geared and direct drive wind systems is often referred to as a 'Hybrid' solution. This third, medium speed segment occupies only a minority market position. Areva Multibrid of Germany/France and WinWinD of Finland today manufacture these commercial hybrid-type turbines under aerodyn license, while Gamesa of Spain is currently testing a different 4.5 MW medium-speed prototype. Again, all three of these suppliers incorporate PMGs into their designs.

THE SWITCH. A PMG SPECIALIST WITH BIG AMBITIONS.

Early in 2009, The Switch of Vantaa, Finland, achieved a 1600 MW installed capacity mark, with a product portfolio comprising a range of high-performance permanent magnet-type and induction-type electrical machines, full-power converters and controls equipment. Today over 1000 wind turbines of different power ratings are running its technology, subdivided into low speed (direct drive), medium speed and high speed systems.

The Switch was founded in 2006 via a merger of three companies – Rotatek Finland, Verteco and Youtility. It employs 185 and comprises three divisions: The Switch Electrical Machines, The Switch High Power Converters, and US-based The Switch Controls and Converters.

Late last year [2009], The Switch Electrical Machines inaugurated a new factory in Lappeenranta, Finland. The latter uses a customer-focused product and process development concept aimed at maximizing return on investment, including optimised materials flow control. It also aims to serve as a blueprint for multi-site production with global partners. Known as The Switch Circle, the concept comprises three interdependent major elements or project phases: Design, Production, and Proactive.

Design extends from initial evaluation and consulting to product design, prototype testing and optimization up to a 5 MW power rating.