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## 2014 in Review: Permanent Magnet Machines

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Permanent magnet machines have already made their mark in the offshore wind industry, bringing increased reliability and efficiency. The needs of the industry are aligned with tidal energy and also shipping when it comes to the desire to reduce operating costs, and it's no surprise that environmental leader Wallenius Lines will be the first to take on the latest onboard technology next year.

The Switch, a specialist manufacturer of megawatt-class permanent magnet (PM) machines and frequency converters, has just completed testing the industry's first PM shaft generator. The efficiency performance during testing was an outstanding 97 percent over the entire speed range, and the company's first machines are being delivered by WE Tech Solutions of Finland for Wallenius Lines of Sweden. The generators will be installed on Wallenius 8000 PCTCs, a post-Panamax high-efficiency Ro-Ro newbuild series being built in China. The first vessel is due for completion in Q4 2015, and additional orders have been placed by WE Tech for delivery to Terntank Rederi of Denmark and Torvald Klaveness of Norway.

"This is the next big thing in marine," says Mårten Storbacka, managing director of WE Tech Solutions. "Over the past three years, we've been developing our solution together with The Switch and other close suppliers. The main advantage of this technology is that it significantly increases marine energy efficiency. Depending on how you calculate it, fuel savings are approximately 20-30 percent. Since this technology lowers the need for installed power on a ship, energy generation and weight are reduced significantly, thereby lowering fuel consumption and the need for maintenance."

Permanent magnet machines are already being used in electric propulsion, but The Switch is at the forefront of using the technology for shaft generators. For Jukka-Pekka Mäkinen, CEO of The Switch, experience has proven the technology can provide unmatched power density, energy efficiency, design flexibility and operational reliability compared to induction machines. "Our unique offering is advanced drive train packages which provide a power source which, under most conditions, generates cheaper energy than auxiliary diesel generator sets."

Permanent magnet machines have been around for decades, and have typically been used for small electric motors. Their breakthrough in high-power applications occurred during the last 20 years or so and was made possible with the invention of Neodymium magnets in the early 1980s. Neodymium magnets have extremely high energy density, making it possible to build high-efficiency, high-power generators and motors in a megawatt range. Currently, the largest PM generators already exceed 10 MW in power, and the field of application is large, ranging from wind power generation, marine propulsion and elevators to hybrid cars.



Traditional electrically excited synchronous generators have been the standard for ship power generation, including shaft generators and gensets. However, for low-speed applications such as shaft generators, they lead to a low power conversion efficiency. This limitation is becoming more and more critical due to rising fuel costs and more stringent environmental regulations.

The low efficiency occurs because low operating speed results in weak electromagnetic induction in the generator winding. This must be compensated for by adding lots of coil turns to the rotor field winding to generate a strong enough magnetic induction. A large number of coil turns in the field winding consequently results in high electrical resistance, and as the current flows in the field winding, large losses are generated in the rotor, resulting in poor efficiency. Losses must also be dissipated from the machine, requiring large cooling capacity.

In a PM generator, the magnetic field is simply produced by using permanent magnets attached to the rotor. This means that no rotor field winding or magnetization devices are needed. The lack of field winding and related losses means superior efficiency, significantly less complex construction and low rotor inertia and weight.

Mäkinen has watched permanent magnet technology take hold in the wind industry. “Some of the disbelievers are hesitant due to the perceived costs of permanent magnet material or because of the bad reputation that the rare earth mines have created for themselves. Today, we know that the price of rare earth materials has stabilized and that new mines have adapted sustainable practices as illegal mining is weeded out and strict international standards are implemented. Therefore, we continue to believe strongly that the advantages of PM generator technology will prevail.”

In the wind industry, companies such as Vestas, Goldwind, Siemens, GE, Enercon and Gamesa have taken up the technology already, but the global scene is variable. The renewable energy market is still increasing, but it is no longer the same as it was during the 2006-2009 gold rush, says The Switch business development manager, Carlo Cecchi. There are still a lot of issues related to energy storage and energy transportation that must be addressed.

“The wind industry is plagued with overcapacity and overproduction. Independent power producers are still waiting for overdue provincial subsidized payments from the past 1.5 years. Too many wind turbine OEMs exist only for the domestic market, and quality is still not up to par.”

China looked to the west back in 2010 with poor results in terms of finalized deals. Cecchi says the equipment manufacturers and power producers need to change their mindset, make the shift in technology to PM generators and forget old-school thinking that paying less now for double-fed induction generator (DFIG) technology is better than producing more energy tomorrow.

“PM generator technology is capable of attracting fresh capital and non-institutional investors who are ready to place their bets. Investment banks are now including an extra risk fee for DFIG technology. The PM generator solution is a real bankable asset that is able to pass any form of technological assessment.”

Energy is a service that meets a need. As technical needs change, so must the service, says Cecchi. “This is not only the situation in wind, but also in the marine sector. Operational costs and pollution control are quite hot issues right now in Hong Kong due to extremely busy harbor activity.

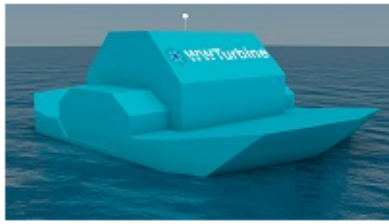
“Here, we are seeing shipowners trying to solve the problem with radical means. This includes moving their business to places with less strict rules or hiding the problem behind energy efficiency, which means switching off the vessel’s lights or air conditioning to reduce fuel consumption and emissions.”

As cost pressures mount and environmental regulations become more stringent, the need for a smarter approach now is becoming ever more apparent, he says. Using PM motors and generators as key elements in advanced drive trains allows shipowners to take advantage of a more flexible, modular, efficient and lightweight propulsion system.

“As a bonus, PM technology helps future-proof ships when it comes to even the strictest environmental legislation. The technology enables ships to lower their operational costs by optimizing fuel consumption through superior efficiency, reliability and design flexibility. The simple advantages of more power (5 percent higher than traditional electrical drive trains) and lower fuel consumption add up to fast ROI and less pollution as well as higher reliability.”

The technology is also entering the tidal energy industry, where power generation costs are proving critical, just as they are in offshore wind and maritime applications. Vancouver-based Water Wall Turbine (WWT) selected The Switch to provide a 500 kW full-power converter for its innovative self-floating power plant. This new commercially viable system extracts potential and kinetic energy from large, fast moving water currents for conversion into electric energy.





The Switch supplied its first 500 kW full-power converter in October 2014 for WWT's prototype project. The tidal power plant which will be used for the Dent Island Resort, near Vancouver Island off the west coast of British Columbia, Canada.

The vessel will power the resort, replacing existing diesel generators as the primary energy source, and is integrated with battery energy storage. Power extraction is extremely efficient in deep or shallow water currents. Environmental impact is minimal, and the technology is scalable from 500 kW to 1 MW, 2 MW and up to 5 MW per unit. The vessels provide bi- or mono-directional operation for tidal and river currents.

The next few years will be challenging for the renewables sector, says Risto Ahvo, U.S. general manager of The Switch. Global oil consumption is expected to grow by around three percent this year, and North America in particular is looking to shale gas for cheap energy.

"The renewable energy systems' sales climate is simply too placid; buyers and plant owners are waiting for legislators' energy decisions. Companies are delaying the start of projects to be sure that they are eligible for possible extended or new incentives. This is not good for businesses, as it creates a cycle of high workloads and then no work at all. Is this good for the employees or employers? Definitely not. For every business, a stable climate is much better over the long run than periodic cycles of highs and lows caused by legislators," says Risto Ahvo.

"A good combination of various energy sources sounds right to me, as then we will have a more stable and sustainable energy portfolio with reasonable costs for future generations."

Lowering the cost of energy involves lowering Capex and Opex while boosting the amount of energy generated. This formula works even better with renewables as the cost of wind, solar, wave and tidal is free. "Wind has experienced an extremely fast transition to permanent magnet machines and full-power converters. Now these same merits can be enjoyed as competitive advantages by other industries. That's why we're making our wind-proven designs available for marine propulsion and power generation, along with wave and tidal, and even other industrial applications," says The Switch CEO Jukka-Pekka Mäkinen.

"As we move forward in these unpredictable times, we've been sharpening our strategy to offer our customers even more value so they can succeed at what they do best. As we have the world's largest PM machine and frequency converter product range, we can offer customers predictable time-to-market with this latest, advanced technology. We've streamlined our processes to shorten the lead times in customer projects to give them the edge to come out with the bestsellers of the future."

