# WIND POWER GENERATORS

Lower your cost of energy with optimized permanent magnet generators

THE SWITCH
A BEMAC GROUP COMPANY

Source: MHI Vestas

# MAXIMIZED ENERGY YIELDS

Wind turbine manufacturers, owners and operators are seeking the ideal drive train configuration to increase annual energy production (AEP), minimize total life cycle costs (TLCs) and fulfill the strictest grid code requirements.

The Switch offers fully optimized and tailor-made The Switch permanent magnet generators (PMGs). Together with a full-power converter, they enable high reliability, better overall efficiency and the ultimate future-proof grid code compliance.

Today, PMGs are widely adopted by the wind power industry. Because there are no wearing parts, PMGs ensure low failure rates and require less maintenance. The use of permanent magnets requires no external power source to initiate a magnetic field. This reduces costs, simplifies the system and improves system efficiency.

As a pioneer, The Switch has challenged the wind industry first by making PMGs the preferred technology for offshore wind turbines and then making them commercially available to onshore turbines.

Source: MHI Vestas

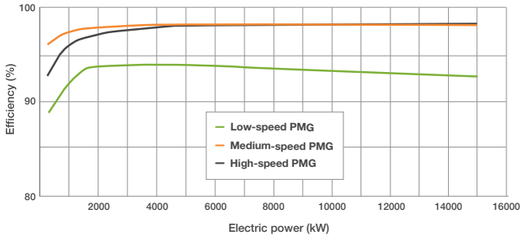
# A WINNING COMBINATION FOR **LOWERING THE COST OF ENERGY**

### High availability

The Switch PMGs typically have an average availability of 97% or higher in all operating conditions. A highly serviceable design with no wearing parts minimizes the need for maintenance and increases production time.

### Outstanding system efficiency

Each of The Switch PMGs delivers superior efficiency over the entire wind speed range. PMGs start producing power at lower wind speeds and demonstrate very high efficiency, even at partial loads where turbines operate most of the time. This results in proven higher efficiency and increased AEP rates.




### Optimal design

For each project, we work in close collaboration with our customers to optimize and tailor our products specifically for their wind turbine. Every solution is purpose-built for the environment in which it will operate. This significantly lowers operation and maintenance (O&M) costs over the lifetime of the equipment. Streamlined processes and short lead times result in predictable time to market.

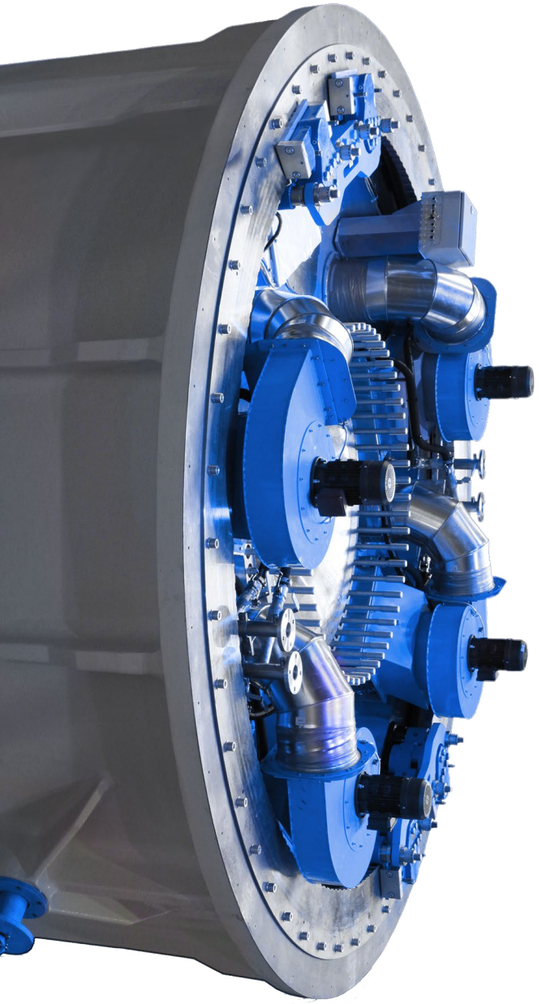
### Minimal maintenance

All products require minimal maintenance and feature a highly serviceable design to speed up maintenance routines. PMG technology eliminates the use of wearing parts, which ensures fewer failures and significantly reduces the need for maintenance. Our remote equipment monitoring system and 24/7 technical support allow our customers to implement a proactive service plan, avoiding unexpected downtime and costly failures.

### Superior grid connection behavior

The Switch PMG coupled with a full-power converter provides future-proof grid code compliance, including FRT and 100% reactive power compensation capability. The active power extracted from the turbine, the reactive power produced, and the generator shaft torque can be individually and precisely controlled over the entire speed range.

# PERMANENT MAGNET GENERATOR
# TOPOLOGIES



We can provide permanent magnet generators for three different drive train topologies to cover power ranges from 1 MW to 10 MW and higher. Each PMG is optimized and tailored for a customer-specific wind turbine to match targeted wind conditions.

**Low-speed, direct-drive permanent magnet generators**
Low-speed, direct-drive PMGs operate without any gearbox or fast-rotating parts, resulting in high reliability and drive train efficiency. The typical speed range is between 8 rpm and 14 rpm.

Direct-drive generators should be designed and built as an integral part of the wind turbine. The Switch can partner with wind turbine manufacturers by designing and supplying the active parts. A segmented structure provides redundancy and makes it easier to manufacture. In addition, direct-drive generator designs typically use a common bearing for both the turbine main bearing and the generator bearing. It is also necessary to integrate the turbine brake system into the generator's mechanical construction. The benefits are simplicity and fewer components, resulting in higher reliability.

**Medium-speed permanent magnet generators**
The Switch medium-speed PMGs can be integrated with gearboxes to provide a typical generator speed of between 300 rpm and 600 rpm. Combining the advantages of low- and high-speed technology, these PMGs offer extremely high availability and reliability, resulting in increased AEP.

The generator and gearbox can be integrated in various ways. The highest level of integration uses the same oil lubrication system and bearings for both gearbox and generator. The next integration level allows a significant reduction in mass and in the dimensions of the generator and gear combination.

**High-speed permanent magnet generators**
The Switch high-speed PMGs can be optimized to operate with a three-stage gearbox featuring a speed range from 1,000 rpm to 2,000 rpm depending on the frame size. They also offer an extremely small generator size and high efficiency at partial loads.

As a standalone component, these PMGs can be used with many different turbine designs. Existing doubly-fed induction generators can be easily replaced with The Switch high-speed PMGs with minimal changes to the nacelle layout.

The Switch PMGs are available for low and medium voltage with several cooling concepts.

# PERMANENT MAGNET GENERATOR
# DESIGN ADVANTAGES

To guarantee flawless functionality at different operational points, our engineering teams design customer-specific PMGs using the stage-gate-based product development process.

The concept design stage includes the selection of the topology together with our customers and optimization of the PMG using our proven analytical machine calculation programs. In the second stage, the design is finalized. Both electromagnetic and mechanical designs are verified using the finite element method.

We consider worst-case scenarios in all our PMG designs, including short circuits at maximum operating temperatures. Torque ripple and other excitations are also simulated and reduced to a minimum.

The Switch PMGs are designed for reliable operation under all normal and abnormal conditions, as well as a long lifetime, which is currently calculated to be more than 25 years.

### Windings
The Switch PMG comes with two different winding options. Form wound is the most standard winding option in the market with proven operational reliability. Litz wire is the ideal option for high-speed applications, offering a minimized AC losses.

### Insulation
We have selected a reliability-tested, mica-based insulation system with vacuum pressure impregnation for all applications, because it can tolerate any elevated voltage stress coming from the frequency converter.

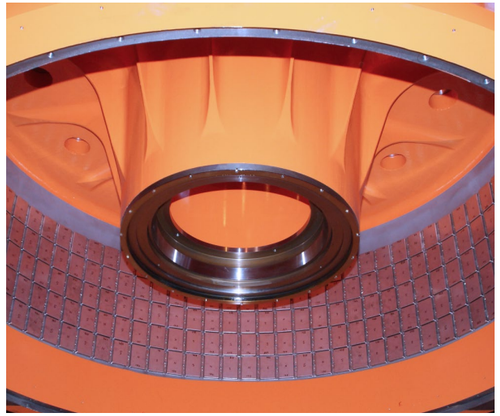
### Cooling design
Even though the losses in a PMG rotor are extremely low, it is necessary to cool the rotor and stator efficiently to ensure the highest performance and a long lifetime. Typically, our PMG cooling concept is based on internal forced air cooling. The secondary cooling circuit can be based on direct filtered air, an air-to-air heat exchanger or air-to-liquid heat exchanger.

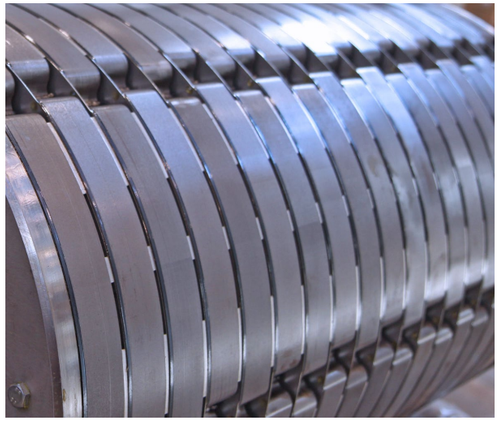
The IP54-class enclosure effectively protects the generator against corrosion, making the cooling concept safe for offshore applications.

### Rotor design
In every The Switch PMG, high-quality Neodymium-Iron-Boron (NdFeB) magnets are used. These rare-earth magnets have a very high energy density and deliver excellent performance with corrosion resistance and temperature tolerance. High remanence flux density and coercivity force make them an ideal choice for wind generators. All magnets used in The Switch PMGs are coated against corrosion and typically are also hermetically sealed to maximize safety.

**Surface-mounted magnets inside a hermetically sealed magnet module construction are used** in direct-drive PMGs. This magnet arrangement takes advantage of the full magnetic excitation and allows maximum power to be captured from the magnet.

**Embedded magnets are typically used** for high-speed and medium-speed PMGs. The magnets are built inside a hermetically sealed corrosion-resistant lamination to increase mechanical strength and protection from the environment.



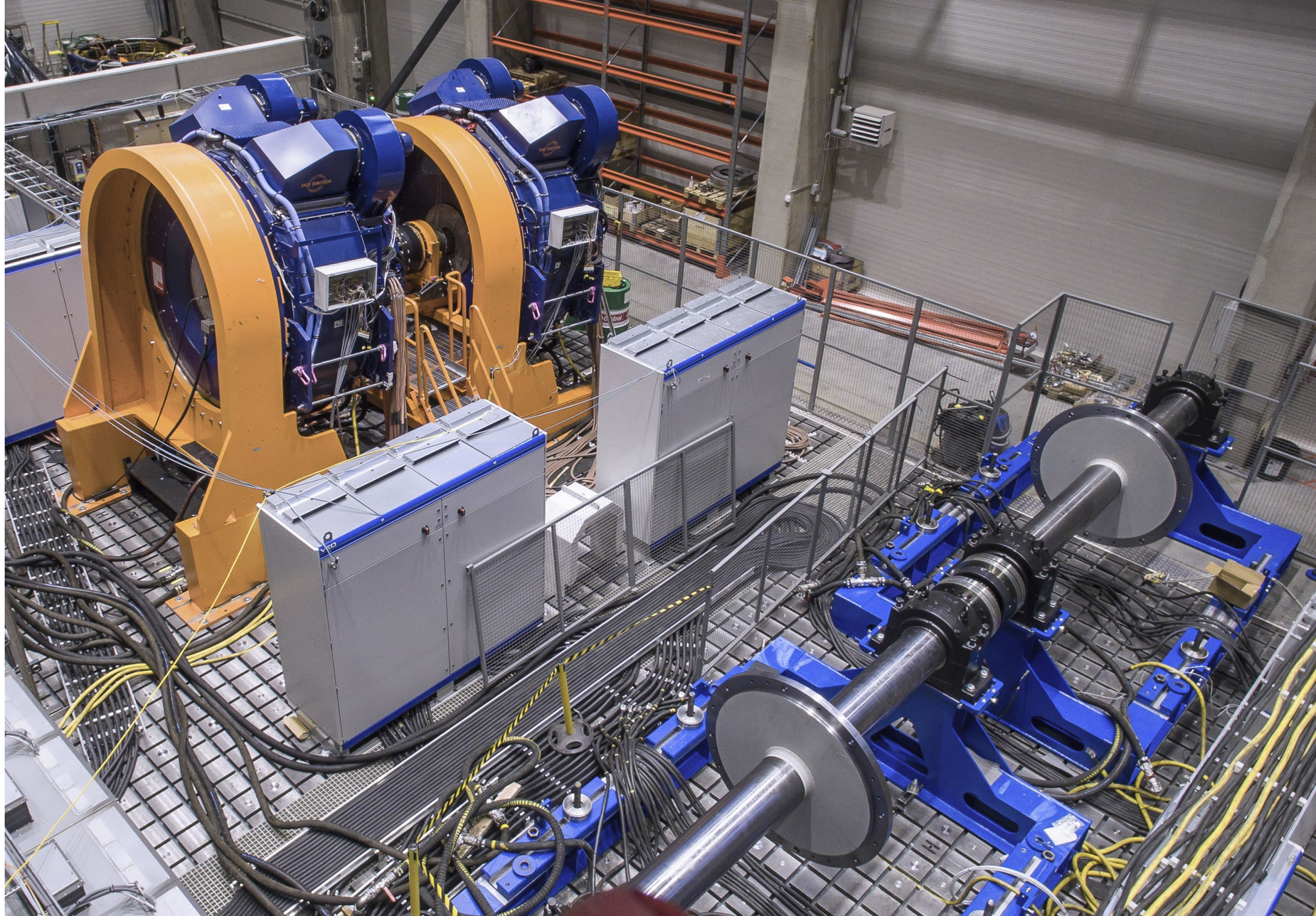


# TESTED FOR **OUTSTANDING PERFORMANCE**

We believe that everything relevant to efficiency and reliability needs to be tested to ensure outstanding equipment performance. We follow IEC 60034 testing standards for rotating electrical machinery and have all the mandatory equipment to carry out the tests in our own facilities.

Every PMG completes routine testing before leaving the factory. New designs pass an even more comprehensive type testing to verify system operation and performance. The Switch type testing includes full-load and back-to-back tests. Additional tests, such as overload tests or short-circuit tests, can also be made.

Our specially designed test facilities accurately simulate the operating conditions in a wind turbine, including all challenging operating conditions. This allows us to optimize PMG performance so that our customers are able to achieve the highest possible system availability and efficiency, resulting in increased AEP rates.



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