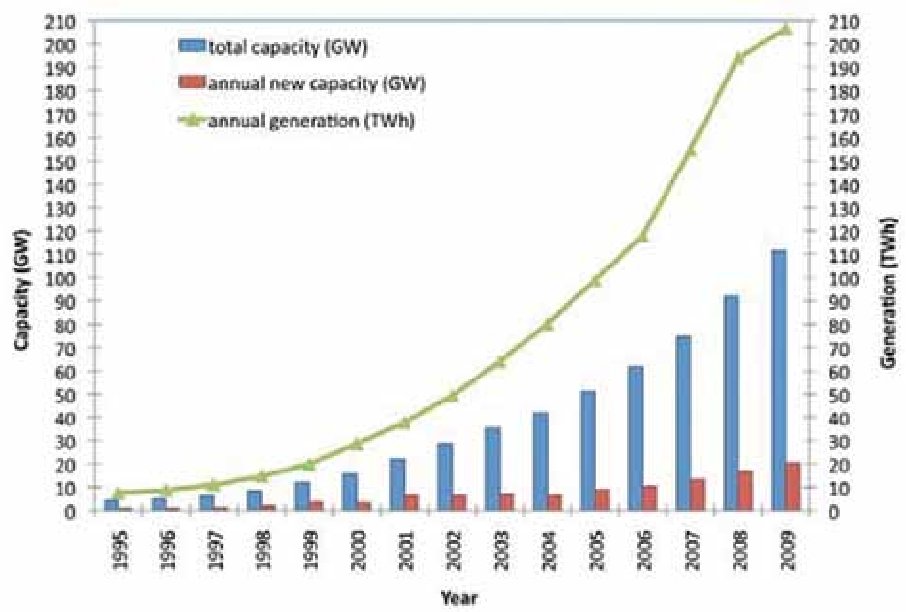
Case Study: The Evolution & Development of Medium Voltage Switchgear Designed for special wind farm applications

By Jose María Torres, Iñaki Blanco & David Goiricelaya

A worldwide increase in energy demands, and supportive renewable energy policies, have been key factors in the growth of renewables over the last decade. Between 1998 and 2007, wind power's installed capacity has grown by 30.4 per cent each year, and international organizations are expecting similar figures until the year 2030.



The expected expansion of wind power, along with the development of bigger turbines, has allowed us to build wind power farms not only on land, but now also out at sea. In such cases, requirements of medium voltage (MV) equipment are even higher. As access is more limited in water, turbine reliability and its safety features become more vital to operation. Guaranteeing maximum and continuous supply during operation and personnel safety when inside an offshore turbine are serious considerations during construction.

As a consequence of this new reality, MV switchgears have undergone developmental changes. A switchgear now must accomplish higher insulating levels and operate under much harder salinity corrosion, humidity, and temperature conditions than those established by international standards. The following describes the main developments with MV switchgear, as well as the particular type tests performed, which reproduce sea transportation conditions and the environmental conditions of offshore wind turbines. This was done by means of accelerated aging tests in salinity chambers, which has allowed certification of MV switchgears for use in offshore wind turbines, as well as on wind farms with extreme climate conditions.

Environmental impacts

Driving mechanisms are the devices responsible for opening and closing a turbine's three-position switch-disconnector and circuit breaker. It would only be opened when a fault occurs within the wind farm's MV grid, or during maintenance or operation checks. Of course, the reliability of this device is vital from a safety and performance point of view, especially if you're the wind farm operator.

In geographical places like the US and Canada, temperatures at a wind farm can be as low as -22° F (-30° C) during operation and -40° F (-40° C) while equipment is being stored.

In these conditions, operation of the driving mechanisms must be verified according to the mechanical endurance category they are listed under, and verified for leakage levels from the MV gas tank so they don't increase, losing insulating properties.

In one case study of this nature, the specific type test performed to study performance under the above conditions was to operate the circuit breaker and switch-disconnector driving mechanisms inside a climatic chamber for 12 hours at -40° F. This was done to ensure the amount of operating sequences were achieved and the speed (rad/sc), torque operation value (Nm), and rebounding (mechanical degrees) remained within the required parameters.

Another related issue to take into consideration is corrosion. International standards for indoor installed switchgears state: "Air must not be significantly contaminated with dust, smoke, corrosive/explosive gas, steam, or salt." The environmental conditions in any offshore wind farm cannot guarantee the above statement, however, due to high levels of salinity in the atmosphere. Therefore, it's necessary to apply special surface treatments for the galvanized steel elements and, most importantly, to extend the driving mechanisms lifecycle against corrosion, ensuring it will accomplish the number of operations it promises.

As per the above case study, the specific type test performed on driving mechanisms and small components (such as tripping coils, motors, relays, and steel enclosures) was to introduce them in a salt-spray chamber for 720 hours at 95° F (35° C), and spray a solution of five per cent in weight of NaCL. The goal attained: to achieve successful results and a high-corrosion resistance classification, according to international standards.

Transportation of the switchgear

Every wind project developer knows that one of the most important parameters to optimize during construction of a wind farm is the installation time because of the high costs associated of the required resources. That's why it's common to install the MV switchgear horizontally inside a turbine tower and, then, transport the tower to its offshore platform in a special vessel. However, transporting the MV switchgear under these conditions adds another challenge, as the equipment must withstand horizontal forces due to the positioning of the tower. It also must withstand the vibrations that occur during sea transportation.

To reproduce these transportation conditions on the MV switchgear, a horizontal axis 3D vibration test was used, applying a 4Hz frequency value and an acceleration of 0.875sc with a maximum amplitude of 27.2mm. The test was fixed at a low frequency, and performed to a group of three modular functional units. Afterwards, the copper circuit resistance was measured to ensure the values did not change during testing. In this case, all joint connections, screw drive connections, and the welding successfully passed.

Power & design

The power capacity of wind turbines and wind farms has increased dramatically over recent years. The power capacity of the first turbines ranged between 200 kW to 300 kW, whereas, most offshore turbines today have 3 MW machines in place. Some experimental wind farms are even being developed with 6 MW machines.

To decrease the electrical losses within a MV wind farm's grid, there's a tendency to increase distribution voltage levels, which requires higher insulation levels than those established by international standards. This is why a certain amount of wind farms use 40.5 kV units, which determine insulating levels of 95 kV for one minute at industrial power frequencies (routine tests in all compartments of the MV unit) and 185 kV for the lightning impulse test (BIL).

The particular position in which the MV switchgear is installed inside the wind turbine tower requires different designs to maximize safety in the case of an internal arc fault inside the switchgear. Though some turbine manufacturers choose a layout where the switchgear is installed above ground level, making an alternative design necessary for the gas release duct.

Keeping this requirement in mind during testing, the bottom of the unit (the cable compartment), was sealed and a backside gas-release duct designed to guarantee nobody in front of, or underneath the unit would be harmed. The testing of this special design was performed according to the IEC & IEEE standards accomplishing IAC AFL (R as an option) arc fault resistance classification for 21 kA short circuit current.

Conclusion

Wind energy technology and the construction of new wind farms in places where the operational requirements are high due to salinity, temperature, or humidity, require an MV switchgear adapted to those particular conditions - which international standards do not take into consideration. The case study described above concluded with the implementation of special solutions for the MV switchgear used in these kinds of environmental conditions. ■

Visit for more information, visit:
www.ormazabal.com