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Cable innovation is critical for the future of wind energy

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Utility-scale wind turbine energy technology has developed rapidly over the past 20 years, from a few hundred kilowatts to multi-megawatt installations capable of producing enough electricity to power thousands of households. As windfarms increase both in physical size and generation capacity, with turbines growing from 2-3 megawatt (MW) today to typically 5 MW onshore and even up to 15 MW offshore, so does the need for technical innovation.

Installed capacity for global wind power is expected to grow at 5.3 percent between 2019 and 2025. According to the 'Future of Wind' report published by the International Renewable Energy Agency (IRENA), global wind power is expected to reach over 6,000 GW by 2050.

Since 2019, onshore wind power has emerged as one of the world's most valued renewable energy sources and accounts for the largest share of growth in renewables-based energy generation. However, as the onshore market gradually reaches a saturation point, the offshore wind sector has been fast gaining momentum and is expected to witness a significant compact annual growth rate (CAGR) in the near future.

Europe is still leading the way, with installed capacity growing by nearly 30 percent each year, while the UK and Germany remain the two largest offshore wind markets. Asia-Pacific is one of the most mature and competitive regions in the wind power market, with solid demand from China. Ambitious plans in Taiwan, Japan, Vietnam and Korea will contribute to boosting demand for offshore wind in the area. But the coming decade will also see a great number of large-scale offshore windfarms installed off the US coast, with a high likelihood to see this trend accelerated by the new Biden administration.

Why cable technology is crucial

The greater scale of turbines today means that technological innovation is critical to ensure their components are built to withstand the greater forces and higher ratings required. Often overlooked by the casual eye, specialist cables play an indispensable part in wind power generation.

The turbines, nacelle, tower, and base, are served by approximately 50 to 100 different cables, all of them installed in a confined space and sometimes following a highly complex route. These cables are typically a mixture of low voltage (LV) and medium voltage (MV) and high voltage (HV), performing functions such as power transmission, control, and communication. Depending on electrical architecture, cables in a turbine could vary in total length from 3-6 km, with a vast majority of them LV systems.

The composition of electrical components in a wind turbine prescribes the type and configuration of cables to be used. The power generating components, including the generator, gearbox, drive train, and brake assembly, are all housed in the nacelle.

Cables in the nacelle may need to operate at high temperatures of 105˚C for LV cables and 180˚C for single-core MV cables. Cables also need to withstand extremely low temperatures that can reach -40˚C. They also need insulation and sheath materials resistant to aggressive chemicals, oils and ozone.

The power generating components link to the tower via a free-hanging loop or looping cable. The loop cable transmits power to the lower section of the tower, where the cable is fixed to the tower structure before connecting to the grid.

In many ways, the LV or MV looping cable is the most critical wind turbine component. It has the role of transmitting the power generated out of the nacelle, which turns to face into the wind and needs to withstand a high degree of torsion at varying temperatures.

These cables need to be light, flexible, and resistant to oil, chemicals, UV, ozone and abrasion. In addition, they need to handle temperature conditions ranging from -40 ˚C to 90 ˚C. A current trend is to specify LS0H (low smoke halogen-free) material for the insulation and sheath.

Rigorous testing

Cable manufacturers must be able to demonstrate that cables are up to standard. In addition to international certification testing to meet IEC, UL and CSA standards, loop cables must be torsion resistant. Despite it being a critical component, there is currently no official torsion testing standard.

Nexans has consequently created its own testing standard and testing device at one of its facilities. To pass the testing procedures, the cable manufacturer and the OEM must agree on the number of cycles with a minimum rotational angle per meter that the cable needs to be able to withstand during the wind turbine's service lifetime.

These cables must be able to endure several thousand of torsion cycles in their 20-year lifetime. The angle of rotation allowed depends on the cable diameter but fluctuates between 100° and 180° in either direction.

To compensate for the lack of a 100-150 m-high tower on the test site, the test team puts weights on the cable to simulate, for instance, a 100 m free-hanging length of cable. They then apply several cycles in both directions to test torsion strength, under constant electrical current.

Factors influencing cable configuration

The selection of LV and MV cables depends first and foremost on the location of the transformer, followed by the type of generator and voltage rating. Transformers can be installed inside the nacelle, at the middle or bottom of the tower, or even outside the tower.

If the transformer is located inside the nacelle, an engineer will select an MV cable rated at 20 or 36 kilovolts (kV) to connect it to the distribution point at the turbine's tower base. However, if the transformer is located at the middle or bottom of the tower, an LV cable rated at 0.6 to 1 kV connects the generator to the transformer. If the transformer is located at the top of the nacelle, the voltage will be increased to 66 kV and will therefore require a high voltage cable for safe transmission.

Occasionally, a combination of LV and 'low' MV cables are installed as loop cables between the nacelle and the tower. The transformer then steps the voltage up to MV (20 to 36 kV) before sending it to the grid.

The difference between onshore and offshore cable systems

Most wind turbines have a conventional design that is both used in onshore and offshore installations. However, offshore wind power is significantly higher than onshore, meaning cable capacity must be much higher to transport energy down to the grid.

Cable systems in onshore windfarms can operate at various voltage range: 24 kV up to 42 kV. So, cables and accessories are especially designed and tested in accordance with those specific requirements.

High voltage operation for offshore wind farms offers important life cycle cost-efficiency benefits such as:

- the possibility of reducing the number of substations required,


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- reducing the length of cables that need to be installed
- and the necessary space to be used, while ensuring a higher current capacity.

Offshore wind turbines cable systems operate up to 66 kV. Cables and accessories have been deployed to perform at this voltage range.

For both types of wind turbines, cable jumpers of high quality are crucial to ensure the lower level of risks during the turbine's lifetime

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combined with trained and specialized operators to install the accessories.

Faster installation

Rather than opting for the traditional cable by the drum or specified length options, many OEMs are increasingly showing a preference for alternatives to speed up on-site installation, some of which can be high risk and expensive. A safer and less expensive option is cable kits.

The kits include cable pre-cut to the various lengths needed for installation in the tower or nacelle. They are supplied stripped at one or both ends and come complete with connectors for speedy installation and reduced technical risks. Many OEMs are also opting to pre-install cables in sections of the tower to reduce cost and installation cycles. Shear bolt and split bolt technologies for accessories, as well as roll-on insulation tubes for connecting points, are innovative components providing time saving ratios for installation of cabling systems up to 10 to 1, while requiring the use of standard portable tools that can easily be operated on site by a single person, even at height in the tower.

Preparing for tomorrow's energy challenges

Investment in innovation and stringent product testing by cable manufacturers has led to specialist cables designed to help wind turbine operators get more from their infrastructure investments.

Vestas, the world's second-largest turbine maker, recently signed a two-year global supply contract with Nexans to provide around one million WINDLINK® cable kits for turbines in Europe, the US, China and Brazil. They will be installed in Vestas onshore wind turbines rated at 2, 3 and 4 MW some of which will feature the next-generation EnVentus platform.

The kits will provide easy-to-fit connections for power, control and communications functions within the nacelle, tower and control panels. Depending on their specific application, the pre-connected cables will feature rubber, thermoplastic, or silicone insulation. A significant new feature is the use of entirely lead-free materials for the construction of the MV cables.

The way forward

The future of energy is looking greener, with wind power technology at the heart of transformation taking place across the global energy system. Drastically lower production costs, rising concern around climate change, evolving international energy policies, and increased shareholder pressure to adopt environmental, social governance (ESG) policies, are pushing renewables into the mainstream.

Efficient use of cable is one area where turbine OEMs can streamline their processes. It will, therefore, become even more important for OEMs and utilities to install cost-efficient cable and accessory solutions provided by trusted suppliers, while adhering to the strictest safety and performance standards.

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