wire 2018:
Cables for offshore wind turbines

Wind power is steadily growing as a source of energy: In 2015 German wind farms increased their output by around two thirds compared with the previous year. According to the Fraunhofer Institute for Solar Energy Systems, wind turbines between the North Sea and the Alps generated a total of 85.4 billion kilowatt hours of electricity last year. Figures in the wind power sector show that its share accounted for more than 13 per cent of all gross electricity generation and about 14.5 per cent of electric power consumption that year.

By far the largest share of power generation comes from onshore wind turbines. However, following a record year in 2014, offshore wind turbines continued to achieve record figures in 2015, when 546 such turbines were set up, totalling an output of 2,282.4 megawatts (MW). At the end of December 2015 the total number of offshore wind turbines was 792 with 3,294.9 MW (source: Deutsche WindGuard "Status des Offshore-Windenergieausbaus in Deutschland"). According to the industry, 2016 is likely to have seen an additional 700 MW.

Compared with onshore wind, offshore wind power is more expensive, as it poses far greater technical challenges. This is because offshore turbines must be firmly anchored, wired up, installed and operated at sea. Moreover, the load level under operation is greater than on land, while maintenance and servicing are more expensive, too. On the other hand, the wind yield is much higher at sea, so that offshore wind farms can in fact be very lucrative. The basic disadvantage of long distances between power generation and consumption even has benefits for an entire industry: cable manufacturers. To take electricity from a wind turbine to a power socket, offshore wind farms need considerable lengths of cables.

Take, for example, the cabling at the offshore wind farm Amrumbank West, which started regular operation in October 2015. Covering an area of 32 square kilometres (12 square miles), around 35 kilometres (22 miles) north-west of Heligoland, 80 wind turbines were set up at a depth of 20 to 25 metres (66 to 82 feet) below the sea, as well as a transformer platform and a measuring platform. Each of the wind turbines has a rated output of around 3.6 MW and a rotor diameter of 120 metres (394 feet). This is enough for around 300,000 households.

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The cables installed within the wind farm itself run from the eight turbines to the transformer platform, amounting to around 100 kilometres (60 miles). The transformer platform serves to transform a three-phase alternating current from 33 kilovolt (kV) to 155 kV. The electric power is then taken along an 8-km (5-mile) export cable to a converter platform which transforms the three-phase alternating current to a voltage level of ± 320 kV and subsequently to direct current. The next stage is high-voltage direct current transmission along an undersea cable, situated on the seabed, to Büsum. This involves a distance of 85 kilometres (53 miles) and then another 45 kilometres (28 miles) to the grid connection point in Brunsbüttel, where the direct current is transformed back to alternating current.

Germany's very first offshore wind farm Alpha Ventus, erected in the middle of the North Sea in late 2009, is much smaller, Yet the electricity it produces is sufficient for 50,000 households. It consists of 12 turbines, each with a rated output of 5 MW and an offshore substation which houses the transformer and all the necessary electrotechnical equipment.

Here, too, the electric power travels a long way from production to the consumer. Within the wind farm the electricity is first taken from the turbines to an offshore substation along 33-kV undersea cables. 16 kilometres (10 miles) of cables had to be buried at least 60 centimetres (nearly 2 feet) below the seabed. Once the electric energy has been transformed at the offshore substation to 110 kV, it is taken along a 60-kilometre (37-mile) undersea cable, as thick as an arm, across the seabed, via the island of Norderney, to the northern German coast. It then enters Germany's power grid at the Hagermarsch substation. The undersea cable also has optical-fibre data cables integrated into it, connecting the wind farm to contemporary communication and monitoring systems.

Control and monitoring on land

Offshore wind turbines are usually controlled and monitored on land. In the case of Alpha Ventus the control centre is situated in a town called Norden in the district of Aurich. This is where all information and all data are collected. The operating status of the wind farm is shown in real time on several monitors that display images, maps, charts and figures. The operating data that is recorded includes the wind speed, power output, rotation speeds, oil temperatures and the orientation of each nacelle. The data is monitored and analysed by a condition monitoring system (CMS), so that any unusual values are detected at an early stage and suitable measures can be taken. The operations manager also coordinates and monitors the deployment of service teams at the wind farm. Furthermore, using a controllable webcam and several fixed webcams, the operations manager traces helicopter flights and the movements of ships within the wind farm.

Long distances also characters the Sandbank offshore wind farm. Situated around 90 kilometres (56 miles) off Sylt and 110 kilometres (68 miles) from the coast, 72 wind turbines are currently being installed here, at a water depth of 24 to 33 metres (79 to 108 feet). Each has a rated output of 4 MW, and the wind farm will eventually produce 1.4 terawatt hours per year, enough to serve around 400,000 German households. The wind farm is 60 square kilometres (23 square miles) in size, and the cable from the converter station to the coast is 165 kilometres (103 miles) in length. In addition, there is another 45 kilometres (28 miles) from the starting point of the cable in Büsum to the substation. Sandbank is scheduled to become operational in 2017.

Cabling within the wind farm takes the electric power from 72 wind turbines to the farm's own substation. Each cable harness serves nine turbines, connecting them to the substation. Two harnesses can each be connected to one another in such a way that turbine operation will continue in the event of cable damage. In all, around 96 kilometres (60 miles) of cables are being layed within the wind farm, using two different diameters of 630 and 185 square millimetres, respectively (10 and 2.9 square inches). In addition, the cables contain fibre-optic cables for data exchange between the wind turbines and the substation and also for the remote control and monitoring of the wind farm from the control centre in Esbjerg, Denmark. The cables are first deposited on the seabed and are then buried underneath it at a depth of at least 0.6 metres (nearly 2 feet). This work is done by a special cable-laying vessel which also takes the cables from the manufacturer in the UK to its destination at sea.

However, large wind farms are being built not only in the North Sea, but also in the Baltic Sea – for example, EnBW Baltic 1 and 2. Baltic 1, Germany's first commercial offshore wind farm in the Baltic Sea, has 21 turbines with a total capacity of 48.3 MW. Covering around 7 square kilometres (2.7 square miles), it produces some 185 million kilowatt hours per year, catering for 50,000 households. The cabling of the wind farm comprises 23 kilometres (14 miles) of 33-kV undersea cables. The total track length covered by the power lines is about 77 kilometres (48 miles), of which around 61 kilometres (38 miles) are undersea cables and 16 kilometres (10 miles) are situated on land.

Baltic 2, commissioned in September 2015, is much bigger, with 80 turbines and a total capacity of 288 MW. Connecting all 80 turbines to the substation meant laying an undersea cable of around 85 kilometres (53 miles). It conveys not only electric power, but also information and data between the turbines and the control station in Barhöft, using highly sensitive fibre-optic cables, integrated into the main cable. Once the electric power has been transformed from 33 to 150 kV, it is transported by a special export cable from the substation via EnBW Baltic 1 to the Bentwisch substation on land. It is now transformed from 150 to 380 kV and fed into the German grid. The cable runs for about 120 kilometres (75 miles) at sea and 16 kilometres (10 miles) on land.

Major installation work is required for this purpose, including not only the substation, the bases and the turbines, but also the cabling within the wind farm. A Uniconsult study, based on experience and target values, has estimated the average installation times for each of the major components at an offshore wind farm. A base apparently takes two days, and each wind turbine around 1.5 days. The transformer platform is even more time-consuming and like to take around 70 days. The greatest amount of time, however, is required for the cabling, which takes six to eight months per wind farm.

Manufacturing and laying of undersea cables

Offshore undersea cables are so-called three-core cables. According to 50Hertz Transmission GmbH, each individual conductor consists of the actual copper conductor, the inner and outer conductive layers to control the fields and some high-voltage insulation, made from cross-linked polyethylene (XLPE). To enable the transmission of measured and control signals, the undersea cable also has a fibre-optic cable integrated into it. The core is surrounded by galvanised steel wires which protect the cable against mechanical damage, for instance from anchors. The dimensions of an undersea cable are calculated from scratch and are adjusted specially from case to case. It can have a diameter of up to 25 centimetres (10 inches) and weigh around 100 kilograms per metre.

Laying cables on the seabed, says the company, can be a major challenge. First, the cables are rolled up by the manufacturer onto large drums, whereupon they are loaded onto a cable-laying ship and taken out to sea. Near the coast the cable is pulled onto land from the ship. Floats are used to keep the cable on the surface of the water for cable-laying purposes. This is to prevent damage from rocks or uneven surfaces on the seabed. When the cable is linked to its connecting point on land, the floats are removed and the cable gradually sinks down to the seabed. As the ship moves out, the cable is unravelled from the reel and settles on the seabed. The end of the cable is connected to the end of the next cable via a sleeve.

Depending on the condition of the seabed, there are numerous different methods and tools for the laying of cables. If, for instance, the seabed is hard and rocky, it is common to use a plough-like tool slide. A sandy seabed, on the other hand, rather simplifies matters, and it is possible to use an underwater jet sled that runs across the entire length of the cable, creating a one-metre (three-foot) groove. The cable then sinks into the groove and is embedded on the seabed by the current. Finally, the end of the cable is connected to the transformer and the platform. It takes about three days to lay a cable section of 15 kilometres (just over 9 miles). In many places this means using undersea workers, i.e. divers.

One offshore cable manufacturer is Nexans Germany who claims to be among Europe's leading players in this industry. Operating from its plant in Hanover, it has supplied a variety of XLPE-insulated undersea cables throughout the world for nearly 30 years now. The structure of a cable is determined by a range of requirements, environmental conditions and of course national and international standards. As the requirement and environment profile of a cable can vary substantially, undersea cables are always customised specially for each project.

The best type of cable for use within the actual wind farm, according to Nexans, is a maintenance-free 36-kV XLPE cable with integrated optical fibre elements for data communication. Cable designs can come with and without longitudinal and transverse water protection. A beneficial design is one that has an aluminium coat, as the weight is relatively low, the diameter is smaller and the bending radius is also smaller than that of a lead-coated cable. This makes the cable much easier to handle when it is laid and also when it is fed into a turbine tower.

Steel reinforcement, says Nexans, has proved to be ideal. Stranding three power cables together with an overlay of steel reinforcement makes it possible to reduce any magnetic fields to a technical minimum. Moreover, steel reinforcement provides mechanical protection, thus cushioning the enormous tensile forces which are at work while laying the cable and while fixing it to a tower.

wire and Tube – a successful trade fair duo in Düsseldorf

Cable manufacturers have always been at the heart of *wire*, the world's leading trade fair for the wire and cable industries, a trade fair that can look back to a 30-year success story in Düsseldorf this year. wire 2016 featured 1,337 exhibitors from 53 countries, occupied a net exhibition space of 59,700 square metres and covered everything associated with wires and cables. In all, it attracted around 69,500 trade visitors from over 130 countries to Düsseldorf, the state capital of North Rhine Westphalia in April, all of them wanting to attend the two trade fairs, wire and Tube. The successful trade fair duo will be back again two years later, and the next wire and Tube have been scheduled to run from 16 to 20 April 2018.

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