

INTEGRATED CABLE SOLUTIONS
FOR OFFSHORE WIND DEVELOPMENT







OFFSHORE WIND BRINGS NEW OPPORTUNITIES

Offshore wind is one of the most stable sources of renewable energy. Power fluctuations are minimal due to prevalent ocean wind patterns. And the need for standby generator capacity for peak load servicing is largely eliminated through accurate weather forecasting combined with remote databased control and management. This reduces costs, enhances network stability, and contributes to a balanced “clean” power supply.

In the coming years, offshore wind could triple capacity, from 8 GW today to 24 GW by 2020, thus becoming a trustworthy renewable resource for Europe’s integrated supergrids of the future. Indeed, offshore wind will play a key role in “keeping global warming below 2° C,” the goal of the 2015 COP21 Conference held in Paris.

Recent offshore wind trends include a move towards larger turbines and deep-water floating units. Offshore projects (up to 200 km from shore) require robust cables, precision maritime installation, and efficient long-distance transmission, involving innovative cable solutions and reliable accessories.

New trends and drivers

- Increased cost-competitiveness: Offshore wind power is still expensive. As a viable solution, production costs must be reduced both in terms of hardware (wind turbines), control software, and cable infrastructure.
- Larger and more efficient turbines: Higher energy capture, increased reliability and lower operating costs can generate 9 % savings per unit. Next-generation 6-8 MW turbines require durable, large capacity cables.
- Deeper waters farther out to sea: Offshore towers and infrastructure must be able to handle severe ocean conditions. Cables and components need to be salt- and water-resistant and display dynamic maritime qualities.
- Upgraded transmission and interconnection infrastructure: Ocean-based turbines, whether fullscale floating devices or grounded on the seabed, require appropriate infrastructure to export energy to land-based grids, and provide telecommunications for remote control.
- Improved supply chain, logistics and installation: Optimization could potentially achieve 3 % savings. This demands cable and accessories availability, as well as onsite delivery and installation using specialized cable laying vessels. This requires marine proficiency and cable-laying capability.
- Partnerships and trans-regional cooperation: This is especially crucial in research, technological development and training. International projects require specialized cable expertise, shared knowhow, and adherence to world standards.

INTEGRATING CABLES AND



POWER ACCESSORIES IN TOUGH SEA CONDITIONS

Nexans has the expertise to outfit large offshore wind turbines, interconnect them in complete windfarms, and link them to distant or local or grids. For medium and high-voltage cables, we oversee complete installation, from initial pre-qualification, design, customized production, logistics, installation, testing and pre-commissioning. This includes all accessories, a key element in any efficient energy network.

We supply and lay MV subsea cables between wind turbines and the transformer platform, and the MV or HV link to the onshore substation. We also provide power accessories and topside termination on wind turbines and transformer platforms. At the same time, we have been developing cables and power accessories for those OEMs producing a new generation of stationary and floating turbines.

Apart from a full range of energy cables and services, Nexans are also experts in the telecommunications infrastructure needed to manage offshore wind parks, including control and data cables, copper and fiber Local Area Networks.



Innovative technologies

- World supplier of submarine and underground cables, overhead conductors and data/telecom systems
- Close partnership with developers, power utilities, installers and contractors
- Mastery of maritime conditions based on oil & gas submarine energy and telecom cabling experience
- Unsurpassed offshore installation and topside termination experience using advanced equipment, special software for overhead lines, and dynamic cable solutions
- Complete range of power accessories: separable connectors, cold-shrinkable and heat-shrinkable joints and terminations for various types of cable
- A wide range of aluminum based solutions, mechanical connectors, cable lugs and pre-manufactured cable kits for offshore wind turbine manufacturers, ensuring reliable aluminum to copper connectivity
- System solutions in the transition piece where junction frames or cabinets assure the link between an inter array cable and the switch in the basement of a tower. This ensures easy and effective mounting and a clear responsibility border during build-up of the tower

WINDLINK® RELIABLE SOLUTIONS FOR WIND TURBINES

Our WINDLINK® offer proposes a full range of reliable, high-performance cable solutions for wind turbines. WINDLINK® contributes to improve wind turbine output and performance and comprises solutions for both towers and nacelles. Our fully tested electrical systems and easy-to-install kits considerably reduce installation times. Some of the main product families include:

Low-voltage loop rubber cables

- These cables (up to 1 kV) reliably transmit energy produced in the generator to the transformer, usually located at the base of the tower.
 - They come in Low-Smoke Zero-Halogen (LSZH) versions, and are also oil-, abrasion-, UV- and ozone resistant.
- > *Whenever we supply this cable we do lifetime tests according to movement and torsion requirements.*

Medium-voltage loop rubber cables



- Similar to LV loop cables, they can handle up to 66 kV between the nacelle-based transformer and the switchgear at the base.
- > *We are supplying MV loop cables in 3+1 core or 3+3 core designs to all the biggest WTG manufacturers using this solution.*

Low-voltage fixed installation cables

- Copper can be single or multicore, with EMC screening.
 - Aluminum singlecore are larger; they weigh half as much, making them cheaper, and easier to handle and install in high towers.
- > *Nexans has supplied a wide range of LV installation cables to Alstom Wind, Nordex, Siemens, Vestas, GE, etc.*

Low-voltage loop aluminum cables and accessories

- Innovative cable design to allow torsion requirements due to nacelle rotation.
- 150 mm² to 400 mm² aluminum replaces 95 mm² to 240 mm² copper.
- Mechanical connectors with shear-off-head bolts tolerate different conductor cross-sections. The force of the screw creates electrical contact between the conductor and connector body.
- Factory pre-installed solutions, including cables, lugs and connectors.



A full range of WINDLINK® rubber cables.



IMPROVING POWER OUTPUT AND PERFORMANCE



Low-voltage joints



- Able to withstand thermal cycling and tower vibration throughout a turbine's lifetime, our systems use a mechanical shear-off-head bolt connector with an innovative rubber sleeve.

• A new connector made of high-strength aluminum alloy (copper to aluminum) with a protective roll-on sleeve is fast and easy to install without special tools.

> *Roll-on sleeves offer protection, insulation, shortcircuit stability and long-term reliability.*

Medium-voltage connectors

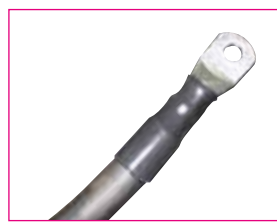


- Nexans safe-to-touch T-shaped standard outer cone connectors are designed for the new generation of compact switchgears and transformers.

• Power accessories can also accommodate larger cross-sections up to 1 200 mm² of large turbines and cable-to-cable connections up to 42 kV, all in an outer cone version.

> *The compact design makes it easy to connect to the transformer's three phases without female units.*

Low-voltage kits



- To facilitate assembly, Nexans provides pre-terminated kits which bundle energy, control and data cables for wind turbine electronics.

• Also, cut-to-length, pre-connectorized, all-power cables are supplied to tower manufacturers for generator-to-switchgear-to-main-powerline links.

> *Nordex appreciates the consolidation of several cable types into a single purchase.*



BUILDING OPTIMAL WINDFARM INFRASTRUCTURE

Medium-voltage cables



- Cost-efficient submarine 3-core cables with integrated fiber optic elements and customized armor designs.

> We provided inter-turbine/export cables for Anholt (DK),

the world's third largest offshore wind farm.

High-voltage cables for transmission



- Offshore AC transmission: submarine cables ranging from 60 kV to 500 kV with various designs available: 3-core XLPE cables (60–225 kV); single core XLPE up to 400 kV.

- Offshore DC transmission up to 525 kV applicable for high transmission requirements and long distances: mass-impregnated cables with Integrated Return Conductor, and Polymer-based insulated DC cables

> For the London Array offshore windfarm, we developed, produced and delivered four 55 km 150 kV XLPE submarine cables with fiber elements for communication and temperature monitoring being laid in parallel to the substations.



66 kV Inter-array Cables



The trend towards increasingly powerful wind turbines requires different array cabling.

Compared to 36 kV, the higher voltage 66 kV cables and associated connectors allow the familiar offshore layout to be maintained, with strings of four to five (or more) wind turbines standing in a row. These cables allow for greater power capacity

with smaller cross section and lower current, and do not require additional transformer stations.

They also offer cost savings through lower life-cycle costs and optimized intra-array cable layout. Ultimately it will drive greater capacity in offshore wind. The next objective is to develop and qualify a 66 kV subsea cable with a solid aluminium conductor, in order to meet and anticipate customer demand.



66 kV Power Accessories



With the development of the 66 kV inter-array cable, the full range of bushings, connectors, surge arresters, terminations, joints and special alloy contacts for large cross-sections were developed. The connectors are based on the outer cone standard and the piggy-back principle. Besides the easy mounting conditions of a plug-in connector, they are also easy to use in an environment of 2 or more cables for one phase. Surge arresters can be plugged into the connector.

220 kV Export Cables

The choice of a 220 kV export cable between the windfarm and the grid is based on the evolution of several aspects :

- offshore substation technology is changing
- cable transmission capacity
- turbines are becoming larger
- windfarms are increasingly bigger

In Europe, 400 - 600 MW windfarms are being built further offshore, requiring higher voltages : 220 kV cables are optimum both technically and cost-wise when considering the total cost of the system.



MV accessories designed to reduce installation time



- A range of offshore junction cabinets (OJC) or frames (OJF) for use in the transition piece of turbine towers and in substations. Pre-terminated leads offer important cost savings.
- For offshore, an OJC can be used as a connection point between tower cables and subsea array cables.
- Cabinets and frames can also be used in offshore substation solutions.

> Our terminations and joints make installation quick, easy and long lasting. Specific training courses in power accessories installation are available.

Auxiliary equipment and systems



Mechanical support (hang-off and clamping systems, protective shells/slabs/mattresses).

> Easy-to-install hang-offs to fasten energy cables above sea level, available sealed or non-sealed.

Installation services: C/S Nexans Skagerrak



Topographical surveys, design and engineering are done in close cooperation with the customer. Actual installation involves project management and carefully planned logistics. Long after commissioning and testing,

we are still there to train personnel and intervene rapidly in case of system failure.

> C/S Nexans Skagerrak was the first purpose-built vessel for transport and laying of large submarine power cables. She has a unique service record covering installation of cables and umbilicals including some of the world's largest power cables. Developments in the laying of long and heavy submarine cables at greater depths, have made it necessary to employ larger and more specialised transport and laying vessels built especially for that purpose.

Installation services: Capjet® System

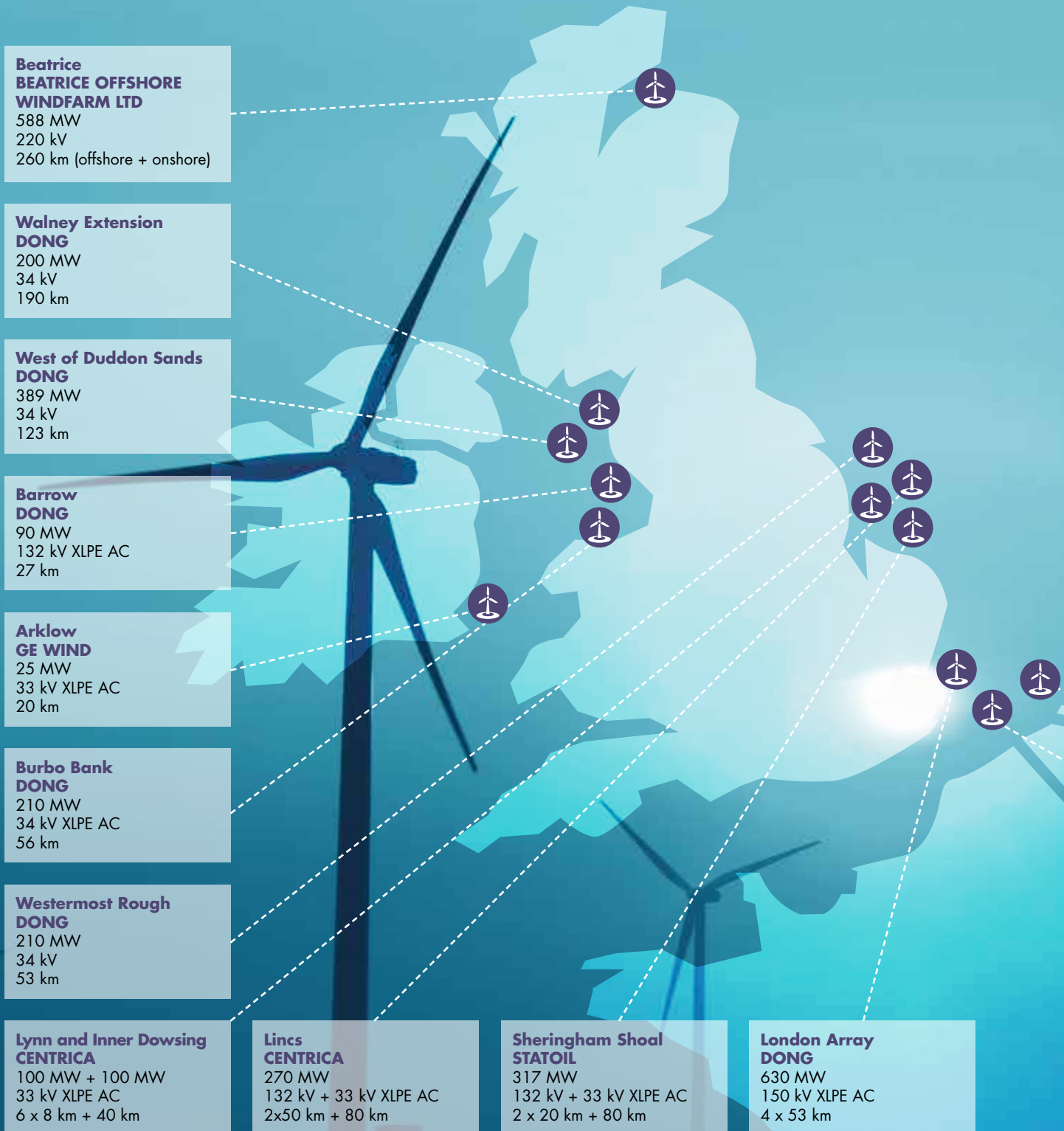


The CAPJET® system was developed as a diver-operated system in 1976, and acquired by Nexans in 1987. The Capjet® 1MW system, using a 1.1 MW underwater power supply, was developed in 1991. The system has been

subsequently enhanced with special features for flexible and steel pipelines, umbilicals and power cables, seismic cables and rock-cutting modules, as well as equipment for covering and surveying for final documentation (pipetracker, multibeam etc.).

NEXANS' PRESENCE IN MAJOR WINDFARMS

At the end of 2014, the installed capacity in Europe was about 8 GW. Nexans is present with cable solutions in approx. 50% of these windfarms, and plans to further develop this business to extend its presence with ever higher performing cable solutions.





**Hywind (floating)
STATOIL**

2,3 MW
24 kV XLPE AC
12 km dynamic



**Anholt
DONG**

400 MW
34 kV
160 km



**Arkona Südost
e.on**

400 MW
33 kV XLPE AC
77 km



**Horns Rev 1
DONG**

160 MW
150 kV + 33 kV XLPE AC
42 km

**Horns Rev 2
DONG**

210 MW
150 kV + 33 kV XLPE AC
42 km

**Borkum Riffgrund 1&2
DONG**

312 MW + 450 MW
34 kV
81 km + 105 km

**Riffgat
ENOVA / EWE**

115 MW
33 kV XLPE AC
24 km

**Belwind
VAN OORD**

165 MW
152 kV XLPE AC
52 km

**Northwind
NORTHWIND N.V.**

216 MW
220 kV XLPE AC
57 km

**Gode Wind 1&2
DONG**

330 MW + 252 MW
34 kV
134 km



Nexans brings energy to life through an extensive range of cables and cabling solutions that deliver increased performance for our customers worldwide. Nexans' teams are committed to a partnership approach that supports customers in four main business areas: Power transmission and distribution (submarine and land), Energy resources (Oil & Gas, Mining and Renewables), Transportation (Road, Rail, Air, Sea) and Building (Commercial, Residential and Data Centers). Nexans' strategy is founded on continuous innovation in products, solutions and services, employee development, customer training and the introduction of safe, low-environmental-impact industrial processes. In 2013, Nexans became the first cable player to create a Foundation to introduce sustained initiatives for access to energy for disadvantaged communities worldwide. Nexans is an active member of Europacable, the European Association of Wire & Cable Manufacturers, and a signatory of the Europacable Industry Charter. The Charter expresses its members' commitment to the principles and objectives of developing ethical, sustainable and high-quality cables. We have an industrial presence in 40 countries and commercial activities worldwide, employing close to 26,000 people and generating sales in 2015 of 6.2 billion euros. Nexans is listed on NYSE Euronext Paris, compartment A.

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