Cable in pipe in a offshore windfarm

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ABSTRACT

Traditional offshore cables are cost intensive and made to order for each project. The Cable in Pipe solution aims at using unarmored cables in a PE pipe, simpler cable fabrication and installation to reduce costs for purchasing and installation of array- and infield-cables in relation to offshore wind turbines by 30% compared to traditionally employed offshore cable fabrication and installation techniques.

The presentation will cover the developments so far, the first installation on a commercial project (start of operation in early 2018) as well as an outlook on further developments such as using the concept in conjunction with 66kV multicore cables and further innovations on installation methods.

KEYWORDS

Offshore wind farms, New cable systems, Future grid access, Offshore cable installation technologies, onshore cable in a pipe, easy replacement of cable,

INTRODUCTION

The innovation process involves desk study, practical onshore demonstrations, full scale tests of parts and installation procedure in harbor or other protected environments.

Design of the system was done in close cooperation with external partners such as cable suppliers, pipe suppliers, installation vessel owners and certifying bodies.

Installation techniques were discussed and optimized, resulting in a series of tests to prove the concept as well as the installation process.

The first commercial installation was based on the learnings from the technology development and has been in operation since early 2018.

Main body of abstract

Installation of cables between offshore wind turbines are typically performed using expensive cable laying vessels installing armored cables through a steel J-tube at each turbine foundation and through steel J-tubes at the offshore transformer station. There are a number of disadvantages with this traditional installation method, e.g.

- High cost for cable laying vessels
- Installation through J-tube is time consuming and weather sensitive
- A lot of the damages seen on array cables originate from the installation process, especially on the sections of the cables closest to the turbines.

Solutions developed to lower the costs for the cable system are:

- Flexible J-tube
- Pre-installation of a pipe from turbine foundation to turbine foundation
- Pre-installation of cable on drum onshore prior to offshore installation
- Introduction of a push-pull system for easy installation of the cable in the preinstalled pipe
- Low cost vessel for installation of pipe between turbines

Advantages of the Cable in Pipe solution are

- Ability to utilize un-armored cables
- PE pipe as well as cable can be installed with low cost vessels
- Trenching of pipe and installation of cable will be less critical and can be performed independent of other operations
- Damages on pipe during installation are easy to repair
- Consequences of poor weather conditions will be less due to more cost efficient vessels
- Cable will be exposed to less risk of damage during installation
- A wider range of cable suppliers will be able to bid for the array- and infield cable packages

A series of tests has been performed to validate the cable and pipe design

- Onshore concept test at Lindø (Denmark)
- Full scale concept test in Thyborøn harbor (Denmark)
- Intelligent pigging of installed pipe
- Impact test on pipe and cable
- Stop and Go test in Kalundborg (Denmark)
- Test of installation on cable installation vessel in Fredericia (Denmark)
- Prototype installation in Nissum Bredning project in Denmark

Nissum Bredning Pilot Project

The innovative 28 MW offshore wind power project located in the waters of North-western Denmark is fully operational, producing power for customers Nissum Bredning Vindmøllelaug and Jysk Energi since early 2018. Utilizing the first serial-manufactured SWT-7.0-154 direct drive offshore wind turbines, the project is a showcase of Siemens Gamesa's commitment to innovation and reducing costs. The turbines and further technological advancements have fulfilled expectations and are now in preparation to become available for commercial deployment.

Watch the video on YouTube

"Nissum Bredning Vind is a small project capacity-wise, especially when compared to other offshore wind power projects. But it is extremely significant in terms of innovation: we've tested and validated several new technologies here, from a 66 kV transmission system to jacket foundations with concrete transition pieces to a cable-in-pipe installation," says Andreas Nauen, CEO of the Offshore Business Unit at Siemens Gamesa Renewable Energy (SGRE). "These innovations all share the common goal of reducing the Levelized Cost of Electricity (LCoE) from offshore wind. Successfully completing this project proves that they are capable of doing so, including being available for commercial deployment."

Cost reductions of up to 30% compared to traditional elements can be provided by some of the elements installed at Nissum Bredning Vind. The innovative cable-in-pipe installation, where standard onshore cables are installed in plastic pipes from the mainland as well as between the turbines, lowers capital expenditures compared to employing offshore cables. Gravity jacket foundations provide a soil interface at normal water depths which can be made more cost-efficient versus classic jacket foundations. Furthermore, the concrete transition piece can be made at a cost level of up to 30% lower than a steel transition piece. Also, the 66 kV transmission system reduces transmission losses, providing the customer with a higher energy output - and thus higher revenue - from each turbine.

"We at Siemens Gamesa have been leaders in the offshore wind industry for many years. Our strong ambition is to continue to be so. Testing new technologies on projects like Nissum Bredning Vind helps us to stay at the forefront of technology, driving our company and the entire industry forward," Nauen concludes.

Siemens Gamesa is a global leader in the wind power industry, with a strong presence in all facets of the wind business: offshore (#1), onshore (#2) and services (#2). In 2017 Siemens Gamesa was the number-one company in the sector, with a 17% share of new capacity installed, according to MAKE Consulting.Through its advanced digital capabilities, the company offers one of the broadest product portfolios in the industry as well as industry-leading service solutions, helping to make clean energy more affordable and reliable. With 85 GW installed worldwide, Siemens Gamesa manufactures, installs and maintains wind turbines in the onshore and offshore segments. Its order backlog stands at €22 billion. The company is headquartered in Spain and listed on the Spanish stock exchange (traded in the Ibex-35 index).

The 4 # Element in the windfarm- Prototype test cables in Pipes (CIP)

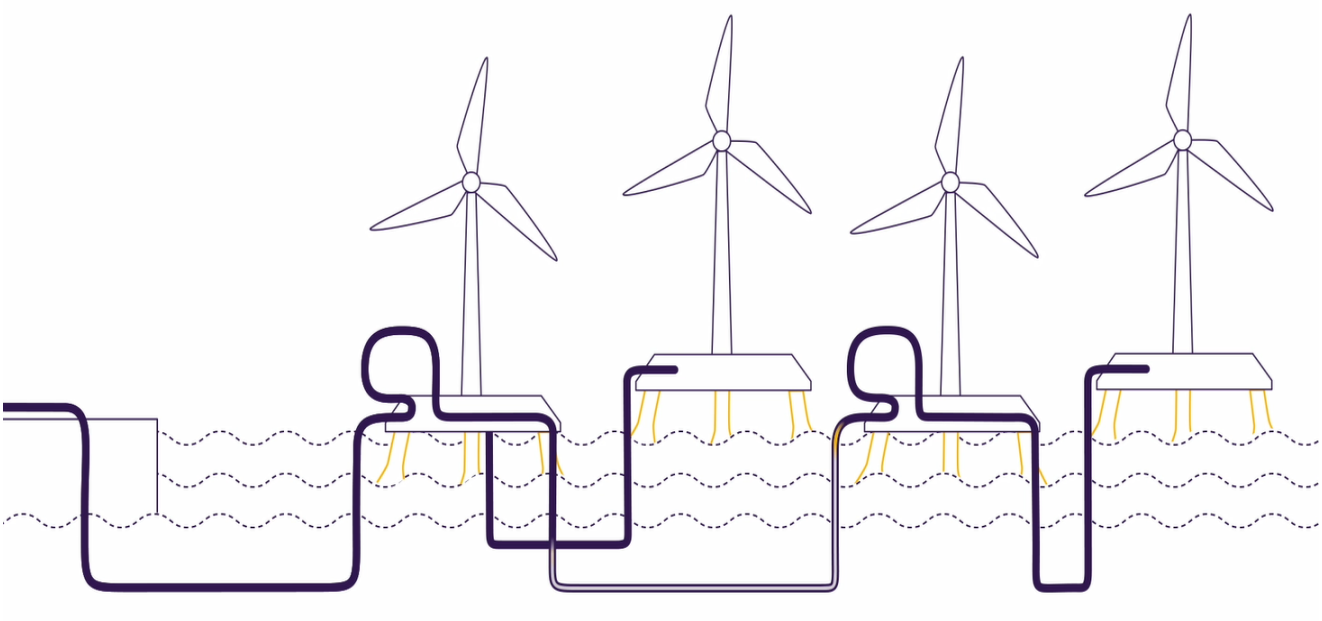
The Siemens cable in pipe concept will be introduced on this project. The concept involves the pre-installation of HDPE (High Density Polyethylene) pipes in the seabed, via horizontal drilling and/or laying/trenching or jetting.

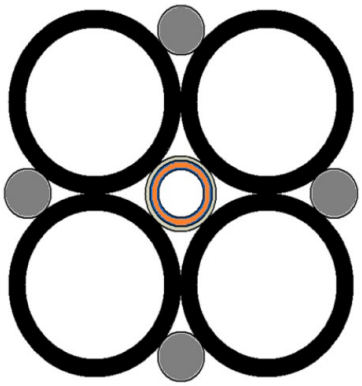
Five HDPE pipes will be installed in a combined bundle for three single phase cables – one in each pipe and one pipe for fiber installation plus one spare pipe. The power cables and fibers will be installed in the pipes after pipe installation between shore and the foundations – and foundation to foundation.

Main components concept

Main components of the onshore cable in pipes concept:

- Onshore cable type in a “Off the shelf” available design and size.
- Standard High Density Polyethylene (HDPE)
- Standard cable fasteners for securing of cable
- Use of Horizontal Directional Drilling for the Export Cables
- Installation of Export and Array power cables by means of “float in solution” – Watucab Machine, developed by Swiss company Plumettaz
- Post lay Burial of HDPE bundle/cables by standard jetting method

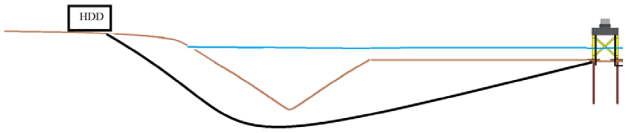




Example of HDPE bundle design

Geometry and Elevations

Water depth at the windfarm site is assumed to be between 2-7m. The Export ducts and cables have to be installed under the dredged shipping channel Sælhundeløbet with a designed depth of up to 60 meters below sea level, see sketch below. The latest proposed route is passing under the new Thyboroen South Harbor area and required extension will be considered into the design together with Kystdirektoratets possible extension for the sail route (200. from Centerline of existing sailing route)



Sketch showing the HDD

Installation

Installation of HDPE pipes will be performed in 2 different methods

a) Cables between turbines: Pipe HDPE bundle will be surface lay on the seafloor with a barge setup and supporting vessels. Post laid burial of HDPE pipes will be done by jetting tool.

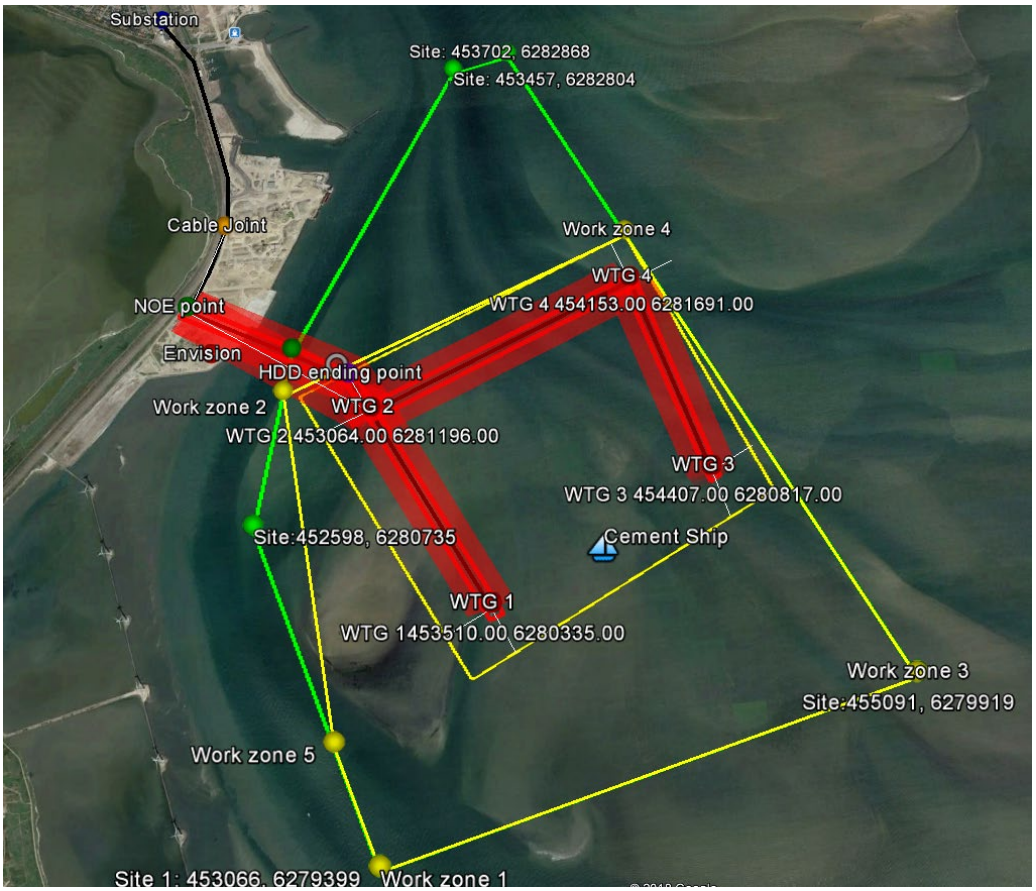
b) Export cable: Horizontal Directional Drilling (HDD) will be performed from Connecting Point (on land) to WTG 2 location app. 1 km - the HDPE pipe bundle will be pulled back from WTG 2 location to connecting point.

After the HDPE pipe bundles are pulled into the TP via the J-tube power cables and fiber optic cable installation will be done from shore concerning the export cable part by means of Watucab machine and Array cables from foundation to foundation using the Watucab machine positioned on the foundation.

Watucab installation method

Watucab machine installing cable

Horizontal Directional drilling of app 1 km, in an area with similar sub-ground conditions, has not been performed previously. Should it be proven during installation that HDD is not possible, we have mitigated the possible delay, related to redesign of alternative installation method as per above pos. 5.3 a), by planning the HHD activities early in the installation phase.



Element #5 - 66 (72kV) kV cables and switchgear solution

Testing the 66 kV (72kV) voltage level for offshore WTGs at a large-scale wind farm is essential for the future. Future sizes of wind turbines will require as a minimum this voltage level to enable cable sizes that are manageable by installation vessels. The NBV project with a 66kV (72kV) solution will be an important step for the development of larger WTGs.

By applying a 72kV system in larger offshore wind farms will give us the possibility to reduce the cost of energy, because the amount of high voltage cables between WTGs and the substation can be reduced. This is due to the fact that more WTGs can be connected to the same connection to the substation. Instead of connecting typically five (5) WTGs per cable to the power station, we can now increase this up to 10 WTGs on the same cable system. The expected reduction by applying a 66kV (72kV) solution is approx. 0.5% of the electrical loss of the total annual production. The 66kV (72kV) switchgear and cable design inside the foundations and towers requires new solutions due to larger cable diameter and therefore larger bending radius than the normal 33 kV systems - such solutions are being developed.

- Gravity jacket concept for cost-efficient foundations
- First offshore installation of SWT-7.0-154 wind turbine including 66kV transformer, cable and switchgear
- Cable in pipe for cost-efficient cable systems

Four wind turbines and related equipment take a large step into the future of offshore wind technology: Nissum Bredning Vindmøllelaug and Jysk Energi placed the winning bid for Nissum Bredning Vind following a tender from Danish Energy Agency's (DEA) tender for the construction of the 28-megawatt pilot project in northern Denmark. The final investment decision has been made for the project, which includes important tests for future offshore wind technology: Siemens will not only supply its new 7-megawatt direct drive wind turbine, but also an innovative and cost efficient gravity jacket foundation solution, its new 66kV voltage solution including a new transformer, cable and switchgear systems, along with further innovations regarding tower and controller settings.

The commercial aspect of the offshore wind technology to be tested in the project is expected to show a significant positive impact on the Levelized Cost of Electricity (LCoE). The DEA believes that the elements to be tested at Nissum Bredning will bring significant savings within both capital and operating costs. A major contributor is Siemens' innovative gravity jacket foundation concept, allowing the construction of jacket foundations at lower costs than monopiles. Foundations generally account for approximately 20-30% of the costs of an offshore wind power project. Building on its innovation strengths and extensive knowledge of the necessary supply chain, Siemens will continue to run a series of projects out of its R&D functions in Brande and Vejle, Denmark, to lower the cost of energy from offshore wind.

The four Siemens SWT-7.0-154 wind turbines will be grid connected using a new cable and turbine concept with a 66kV voltage. Siemens expects this to be the standard voltage for future offshore wind power plants. This higher voltage results in lower costs for cabling and lower losses. Additionally, cable in pipe solutions allow for simpler cables to potentially be used between turbines. Further material savings will be provided by the slender tower concept using prototypes of a new lightweight turbine tower especially suited for jacket foundations.

"We are proud to be part of Nissum Bredning Vind offshore wind power plant. Since the Danish Ministry of Energy tendered the project as an official test bed for new technologies and integrated design, we've looked forward to this exciting project," says Michael Hannibal, CEO Offshore at Siemens Wind Power and Renewables Division. "This gives us the opportunity to simultaneously test and promote our innovations to achieve further cost reductions in offshore wind."

Nissum Bredning Vind offshore wind power plant will get support by receiving a guaranteed feed-in tariff of DKK 0.7/kWh (EUR 0.09/kWh) for the initial 10 years for the first 50,000 full load hours of operation. Turbine installation is scheduled for summer 2017. Commissioning will be in the third quarter of next year.

CONCLUSIONS

Significant cost savings can be realized by using less expensive cables, enabling faster installation and easier maintenance.

Innovative hang-off and J-tube free solutions will allow for savings on the secondary steel on foundations, the parts that demonstrate the highest costs per kilo.

Further improvements and cost savings are expected by developing a 66kV multicore cable solution, innovative laying and burial concepts.

Pipes delivered on drums will render the classical, expensive cable installation vessels mainly deployable for export cables.

An innovative array cable in pipe concept will realize significant cost reduction and subsequently LCoE reduction.

Cost efficient replacement option of cable with minimum vessel setup.

ACKNOWLEDGMENTS

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REFERENCES

Video Nissum Bredning:

https://youtu.be/_wYM-RBPGHE

TP Nissum

https://youtu.be/jI7y8TlZm6o