FOWPI (https://www.fowpi.in/)

Project Funded by
European Union (http://eeas.europa.eu/delegations/india/index_en.htm)

Submarine Cabling

Submarine cables are the power transmission routes to evacuate the large quantity of power from one region to another beneath the sea. The power could be transmitted in AC or DC electrical mode depending on the capacity of power to be transmitted as well as the length of power route.

Generally, the AC transmission cables are manufactured as XLPE (Cross-linked polyethylene) which possess unique chemical resistance to oil and solvents, excellent tensile strength and high abrasion resistance. Today these power cables could withstand high short-circuit temperatures of above 90 °C. As an example, the power transmission capacity in AC mode has ranges up to 1.2GW nominal loading and the world peak loading is at 1.6GW for 2hrs between the link of Mainland British Columbia to Texada Island to Nile Creek Terminal which is operated at 525kV having two 3 phase circuits in twelve separate oil filled single phase cables.

Now, HVDC power transmission technology is used to transmit heavy power over longer distances. The longest power transmission link is the NorNed cable between Norway and the Netherlands which is about 580km long and capable of evacuating 700MW of power. Another major chunk HVDC power transmission is linked between Britain and France having a maximum power transmission capacity of 2GW from Sellindge (UK) to Bonningues-lès-Calais (Les Mandarins station) (France).This HVDC-link is about 70 kilometres (43 mi) between the two ends. It is operated at rated voltage of 270 kV DC at two fully independent 1GW Bipoles HVDC links.

In Offshore Wind power transmission system, famous London Array project which consists of 175 wind turbines having a cable array of more than 200kms. It has been estimated that every metre run of power cables weighs approx. to 50kg. The export cable consists of three core copper conductors having a cross-section of 630 sq.mm. for the main length and 800 sq.mm. at each end.

Basically a three core AC power cable consists of:

1. Outer corrosion protection
2. Armour wires
3. Lead sheath
4. XLPE Insulation system
5. Fiber Optic cable
6. Conductor

Similarly, HVDC transmission cable consists of two conductors, which is laid separately or bundled together or in a co-axial arrangement. The HVDC Light cable system is advantageous for long distance transmission and for connections between asynchronous networks, offshore platforms, wind farms etc.

AC vs DC Power Transmission

An important factor that influences the decision while selecting AC/DC cabling for offshore wind installations is the distance between the offshore project site and shore.

"AC or DC is decided on a project per project basis, depending mainly on power to transmit (per system) and length. HVDC cables are usually cheaper and have very limited losses. However, [the] costs and losses of DC converters are significantly higher than AC transformers. Depending of the voltage level, AC can be considered up to 200km" Olivier Angoulevant, Sales Manager–Wind at Nexans explains.

For Joe Corbett, Head of Technical Services at Mainstream Renewable Power, although AC transmission is a well known and trusted technology for control and protection, ease of connection, voltage transformation and circuit interruption, it is limited by the amount of reactive power required to energise the circuit - which is larger for underground (or undersea) cables than for overhead lines - making it expensive for high power and long distance.

"So although HVDC converter costs are high - making HVDC expensive for many design situations – as the power and distance increases, it becomes more competitive," says Corbett.

One of the key advantages of choosing HVAC cabling is that the AC transmission control and protection technology is a matured one and the capital cost associated with it is significantly lower than its counterpart. Also, it enables spreading of risk over a no. of individual systems and parallel transmission systems, rather than concentrating it on a single transmission system which often proves to be cost intensive.

On the other hand, DC power transmission solutions do not entail reactive power losses because there is no kVAr requirement. Since the DC conversion and protection technologies are significantly more expensive than AC technologies, the former shows to be attractive only when the project distance from shore increases. Also, in case of DC converters, post installation maintenance is more intensive than that of AC transformers.

Each technology has its own merits and demerits. It purely depends on the project specifications and voltage requirements.

Summing up, the recent trend of farther offshore wind farm sites and bigger turbine models might favor adoption of HVDC transmission systems during Offshore wind power development. Hence, as the system gets more complex, it ascertains the significance of efficient transmission and emphasises the need for a holistic view of electrical transmission systems to be taken at the design-phase of offshore wind farms.

Operations & Maintenance

(Credit note: This subsection has been elaborated with inputs from NKT, a global cable supplier to the energy sector)

Faults on HV power cables can be very expensive for Offshore Wind Farm owners.

Typically, faults that occur due to design failures are covered by the warranty, and response time during warranty are typically defined and agreed on the final contract. However, if the failure is due to an external mechanical damage, then warranty does not cover the repair, and if no service agreement is in place, then repair will be performed depending on availability by the cable manufacturer/cable jointing company. This can be critical & costly since the OFTO can risk having their cable out of operations for several months.

As a contingency measure, suppliers can provide cable services to ensure fast and cost-effective repairs. In short, the cable services are based on a modular agreement in which the Client can pick-choose-tailor the specific Service Level Agreement they want. This is illustrated and elaborated as follows:

- **Spare part management (SPM):** It is important to know that all the necessary spare parts are readily available in case of failures. The supplier's spare part management provides a structure method to ensure spare parts are available at any time. It is important that responsibilities of SPM are clearly defined as some components could have a lead time of several weeks.
- **Repair preparedness:** This is basically a document describing everything that needs to be known in case of a cable failure and it outlines different possible scenarios (nearshore, deep water, near foundations). Drawings, equipment's, type of vessel suitable for repair, certificates & permits in the relevant country, HSQ, etc.
- **Monitoring Solutions:** Monitoring solutions help to increase cable availability, adapt the load to existing conditions, and increase the capacity. The cable owner can check the cable's health to help reduce risk and lower insurance fees. Suppliers of Monitoring Solutions can use leading monitoring systems, ensuring maximum cable system availability. Measurement data is combined with vessel tracking systems so that you can monitor marine traffic close to the cable and play back the recorded traffic.
- **Resource on call:** 24-7/365 availability in case of a cable problem. This service guarantees an instant telephone contact with one cable engineer/expert within minutes to agree on the next steps (what needs to be done/mobilize when the worst happen)
- **Fault location:** It is important to define who is responsible for the fault location. This is a complex undertaking, especially offshore. It requires well-timed logistics, high-tech equipment, skilled and experience specialists and (in some cases) availability of vessels.
- **Cut & seal:** Also an important activity prior to repairing the cable. When a fault has been located and confirmed, the normal practice is to cut and seal the cable ASAP in order to minimize possible water ingress on the cables. Cut & Seal responsibility needs to be agreed and defined.
- **Cable Jointing and termination:** By signing a Service Agreement, the OFTO will be guaranteed a pool of highly skilled and experienced cable technicians/jointers.

- **Marine resource plan:** Marine operations contracts to reduce the time from outage to mobilizing parts. The supplier may have its own vessel or contact numerous marine brokers that can support with vessel availability

The different activities and responsibilities around Service & Maintenance agreements for subsea cabling can be described in a responsibility matrix (**R**esponsible;**C**ontributor). A template/example is illustrated below:

R= Responsible **C**=Contributor

ITEM	DESCRIPTION	EMPLOYER	JOINTING CONTRACTOR	MARINE CONTRACTOR
1	**Contract etc.**			
1.0	Permission for marine operations	R		C
1.1	Permission for installation of joints and cable sections	R		
1.2	All Risk insurance during repair works	R		
1.3	Insurance of accessories at contingency stock		R	
1.4	Insurance of accessories and necessary jointing equipment during transportation		R	
1.5	Warranty obligation for accessories and spare cable	R		
1.6	Delivery of accessories DDU key facilities		R	
1.7	Waiting on weather/standby due to reasons out of contractors' controls	R		
1.8	HSE coordination of all works	R	C	C

2	**Engineering and Planning**			
2.0	Technical details of all existing assets (As Built documentation)	R		
2.1	Project Management Plan & Procedures	R	C	C
2.2	Appropriate HV authorization courses at proper voltage level	R	C	
2.3	Installation instructions for accessories	R		
2.4	Preparation of RAMS for repair operations	C	R	R
2.5	Ensure that accessories are complete and ready for shipment from contingency stock	C	R	
2.6	System data for former FO measurements to control quality of new joint	R		
2.7	Work permissions for Contractors	R	C	C
2.8	Participation in meetings regarding planning of repair works	R	R	R
2.9	Custom clearances and expenses for associated works	R		
2.10	Notification to Authorities	R		
2.11	Operational Management	R		
3	**Loading and Transport to site**			
3.1	Transportation of accessories from contingency stock to site of failure		R	

3.2	Planning and management of loading of accessories from key facility to CLV	R	C	C
3.3	Crane assistance for loading of accessories and necessary jointing equipment onto CLV	R		
3.4	All transportation to and from CLV when offshore including crew and equipment	R		
3.5	Return transportation of necessary jointing equipment		R	
3.6	Welfare facilities and power supply onshore	R		
4	**Failure localization**			
4.1	Mobilization of fault finding equipment		R	
4.2	Assisting vessel for fault finding	R		
4.3	Direct fault finding and reporting		R	
5	**Cable handling**			
5.1	Storage of spare cables	R		
5.2	Transportation of spare cables to spooling facilities	R		
5.3	Spooling of spare cable onto CLV	C		R
5.4	Shore labour for assistance with loading and offloading of spare cable	R		
5.5	Transportation and handling of spare cable to site			R

5.6	Jetting free and recovering of damaged cable			R
5.7	Authorization for cutting the cable	R		C
5.8	Cutting the cable onboard the CLV		R	
5.9	Dismantle of damaged cable at or near the WTG/OTP			R
5.10	Lay of new cable sections			R
5.11	Pulling in and out of cable at WTG/OTP		C	R
5.12	Burial of cables			R
6	**Repair operations**			
6.1	Switching off system power and proper disconnection and earthing at end terminations	R		
6.2	Retrieve cable from seabed to CLV			R
6.3	Identification of cut location		R	C
6.4	Cut and seal operation		R	
6.5	Supply of materials for cut and seal operation		R	

For more information, refer the following informative links/material:

1. Paper on “Submarine Power Cables” by (http://www.escaeu.org/download/?Id=321&source=documents)European Subsea Cables Association (http://www.escaeu.org/download/?Id=321&source=documents).

2. Presentation “About Power Cables” by Professor Lionel Carter and Mr. Doug Burnettm, dated on November 2011 at (http://www.ecs.umass.edu/mie/labs/rerl/pubs/2002/AWEA2002Transmission.pdf)International Cable Protection Committee (http://www.ecs.umass.edu/mie/labs/rerl/pubs/2002/AWEA2002Transmission.pdf). (http://www.ecs.umass.edu/mie/labs/rerl/pubs/2002/AWEA2002Transmission.pdf)

3. Paper on “Transmission options for offshore wind farms in the United States” by Sally D. Wright(P.E.), Anthony L. Rogers(Ph.D), James F. Manwell(Ph.D), Anthony Ellis(M.S) (http://www.ecs.umass.edu/mie/labs/rerl/pubs/2002/AWEA2002Transmission.pdf).

4. Workshop report by Robert Beckman,Tara Davenport about WORKSHOP ON SUBMARINE CABLES AND LAW OF THE SEA 14 – 15 December 2009, Singapore (http://cil.nus.edu.sg/wp/wp-content/uploads/2009/10/Workshop-Report-29-Jan-2010.pdf).

5. Presentation on "Umbilicals Cables– Experience and Challenges, Tie & Back installations" by Bjørn Bjørnstad, Nexans Norway AS , dated 24th - 26th January, 2011 (http://www.ccop.or.th/download/PETRAD/PETRAD58_2011-01/Paper15_BjornBjornstad_Nexans.pdf).

6. HVDC-vs-HVAC Cables in offshore wind (http://newenergyupdate.com/wind-energy-update/hvdc-vs-hvac-cables-offshore-wind).

7. Presentation on "High Voltage Cables" by Johan Liffler, ABB Power World 2014, dated November 26th 2014 (http://new.abb.com/docs/librariesprovider46/pw2014/ac_and_dc_cable_(en).pdf?sfvrsn=2).

8. NKT Offshore Service Modules. (https://www.nkt.com/services/cable-service/offshore-cable-service)

9. Video on Skagerrak 2 Repair - NKT High Precision Turnkey Cable Repair Operation. (https://www.youtube.com/watch?v=bzFS-CaVlSw)

Updated on: **December 2018**

Disclaimer:

The content on this website is provided for information purposes only. No legal liability or other responsibility is accepted by or on behalf of FOWPI team for any errors, omissions, or statements on this site, or any site to which these pages connect.

Have any Questions? Send a Message.

FOWPI FIRST OFFSHORE WIND PROJECT OF INDIA (https://www.fowpi.in/)

(https://www.facebook.com/FOWPIIndia/) (https://twitter.com/FOWPI_I) (https://www.linkedin.com/company/first-offshore-wind-project-of-india-fowpi-/)

For more details on FOWPI project, please email:
info@fowpi.in (mailto:info@fowpi.in) or fowpi.india@gmail.com (mailto:fowpi.india@gmail.com)
Phone +91.124.4319500,
Telefax +91.124.4319501,
Direct +91.9687800983/8849012213

Nodal Ministry for Offshore Wind Energy

Ministry of New and Renewable Energy | MNRE (http://www.mnre.gov.in/)

Nodal Agency for Offshore Wind Energy

National Institute of Wind Energy | NIWE (http://niwe.res.in/)