The European Association of the Electricity Transmission and Distribution Equipment and Services Industry

Position Paper on Requirements for Offshore Wind Farms
16th July 2012

In 2010 the Executive Committee decided to create a Task Force to provide a proposal on T&D functionalities (excluding construction) for the connection of offshore wind farms to the general grid onshore.

Terms of Reference of the Task Force

Identify missing technology and standards, if any. Identify topics for further funded research. Make proposals to member companies for funding applications. Prepare a T&D Europe position paper on requirements for offshore wind farms.

The Task Force kept in mind the EU 20/20/20 initiative that requires member states to reach several challenging targets by the year 2020:

20% increase in energy efficiency
20% reduction of greenhouse gases emissions
20% of energy needs to be covered by renewables

Also, the task force was cognizant of the EWIS (The European Wind Integration Study) initiative established by ENTSO-E.

General

Offshore wind farm substation equipment is subject to sea spray, salt fog, etc, i.e. severe environmental conditions, is in an elevated position above sea level and is located up to 100km offshore.

The offshore wind farm installations to-date have not been designed for extension, interconnection or HV networking with other wind farm substations, which would make any extension and/or upgrading activity very difficult. Initial investors and operators had no incentive to consider networking of offshore substation platforms in the original design and the subsequent increased fault level would need careful consideration from an original equipment capability perspective. Future installations would need to consider interconnectivity.

HV & MV Switchgear

This shall be standard equipment made to current (normal) standards. The equipment shall be located inside equipment rooms or within containers to protect the standard equipment from the harsh environment. The equipment shall normally be assembled completely onshore and transported as a whole assembly which may need to be braced to give more rigid support whilst remaining sufficiently flexible to prevent damage. Physical constraints of the platform, the environment and location make it difficult to equip spare bays, provide extensions, etc, making it necessary to produce the final solution from the outset. Regular maintenance needs to be eliminated or reduced as access is difficult.

Increasing wind farm rated voltage above 36kV and transform onshore up to 132/155 kV would eliminate HV switchgear on platforms.

T&D Europe aisbl ▪ Diamant building ▪ Boulevard A Reyers 80 ▪ B 1030 Brussels ▪ Belgium
Tel : +32 (0)2 706 82 68 ▪ fax : +32 2 706 82 53 ▪ e-mail : secretariat@tdeurope.eu ▪ www.tdeurope.eu
VAT BE 0898.208.617

'Bio-degradable fluid' filled transformers are already available to make this possible. Issues that need to be addressed are the availability of suitable HV flexible cables, HV dry type transformers and wind turbine standard designs would need reviewing for larger equipment in turbine bases.

Power Transformers, Distribution transformers and Reactors

Allowance shall be made for movement of the platform and accessibility for maintenance. Small components must be protecting from the harsh environment and rotating parts, e.g. cooling fans, would seize if not used. All paint finishes of the equipment must be appropriate for the offshore environmental conditions. Once in service the equipment would be many metres above sea level making filling, oil processing, etc, more difficult at such a height. All oil filled equipment shall be bunded in case of oil leak or spill. As the platform is subjected to movement from sea currents the transformers and reactors shall be physically bolted down to the deck to prevent them moving and, therefore, straining the electrical and mechanical connections.

'Bio-degradable fluid' filled transformer technology is readily available and considered environmentally acceptable. Issues that need to be addressed are the non-availability of high voltage dry or non-oil type versions, other than SF6 filled. Increasing wind farm rated voltage above 36kV and transform onshore up to 132/155 kV would eliminate power transformers on platforms.

Efficient and cost advantageous AC/AC technology is readily available to connect offshore wind farms to the onshore grids.

Diesel generators

Due to the harsh environment the standard diesel generator would be located inside an equipment room or within a container. The diesel fuel storage tank would be bunded to protect against accidental spilling into the environment. This equipment would be located many metres from sea level making storage tank refilling more difficult with pumping from low level obviously possible.

The capacity of the fuel storage is risk related, i.e. large capacity requiring less topping-up or smaller requiring frequent topping-up. Bad weather preventing refilling would seriously affect the equipment operation and platform condition as it is essential that the equipment is dry and corrosion free.

Fire fighting equipment

The spray would be seriously affected by the prevailing wind and could affect the ability to quench the fire. Gas or gas/water/foam types would be used to cover the fire (exclude any oxygen) and wind shields are necessary to ensure the fire is extinguished effectively. Replenishing the fire fighting system requires access and materials to be elevated to the platform level.

Fire fighting equipment would be eliminated if the fire risk was removed, e.g. replacing the mineral oil in transformers with a non-flammable version (technology is available) or increasing wind farm rated voltage above 36kV and transform onshore up to 132/155 kV, either by using 'bio-degradable fluid' filled transformers or if dry type transformers were available for the new operating voltages.

Control and Protection

Due to accessibility of the platform increased monitoring and system redundancy allows decision making to be based on precise data. Access can be planned rather than reactive or regular nonproductive visits. IEC 61850 developments should be accelerated to take advantage of the benefits from better system communication. Communication by submarine cable embedded fibre would have an alternative medium, e.g. microwave, in case of damage caused by a ships anchor.

AC and DC Systems

Secure LV systems are critical to offshore installations for continuity of supply and prolonged asset life. Fuses are not acceptable as once ruptured must be physically replaced. However, MCB's would need resetting but no consumable parts are necessary and MCCB's can be reset from a remote (on-shore) location.

Power cables & accessories Auxiliary cables & accessories

To prevent ingress of moisture into cable joints and sealing ends marine grade fittings with marine grade stainless steel fixings would be used to prevent degradation of the insulation. Tray work, conduits and other accessories must be of marine grade materials such as stainless steel, glass reinforced plastic, etc.

HVAC (Heating, Ventilation and Air Conditioning), Cooling Systems

Containerised modules or equipment rooms must have temperature and humidity controlled environments, with exhaust and inlets positioned appropriately and which are suitable for the harsh environment. The standard equipment must be used within the temperature range and humidity levels to which it has been type tested. Extremes of temperature and humidity must be avoided if it is to work satisfactorily throughout its expected design life and to keep the maintenance level to a minimum. Failure of these critical systems can affect the asset life expectancy of the platform.

Installation Aspects

The substation platform shall be built in a dockyard where substation equipment is delivered to be incorporated into the platform. Oil and diesel filled equipment, after fully assembling on the platform, are filled/fuelled and fully processed as this would be more difficult offshore. All interface connections and interface power cables would be installed and the whole assembly fully tested.

Once complete the whole assembly would be lifted by a heavy lift floating crane from the dockyard onto a barge for the journey out to sea where it then rendezvous with the "jacket", base frame/legs or monopole. Fitting of movement recorders to the equipment would confirm if any of the equipment has faced any adverse shocks during the journey or lifting operations. Very few specialised floating lifting equipment exist so their availability must be organised well in advance as they are fully utilised. Bad weather can seriously affect the delivery of the vessel to the dockyard and a contingency must be allowed for to mitigate any risk of missing the delivery window.

Asset Management

There needs to be a regime of preventive maintenance, i.e. planned maintenance, and an acceptance that there would be emergency or unplanned maintenance. Making the platform and the equipment as maintenance friendly as possible is a key requirement. Accessibility would always be difficult and being able to visit and maintain the equipment quickly shall be a priority.

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Monitoring

Equipment self monitoring is necessary to identify any abnormal situation. Remote monitoring from onshore would allow access to the platform to be coordinated with other actions. Condition based monitoring allows for continuous indication of the equipments current situation coordinated with SMART, self healing communication would support continuous operation.

Load management

Interaction between platform and dispatch centre is possible as each wind farm has its own SCADA system, connected via fibre optic cables located in the inner array cabling to each wind turbine. In case of a grid failure or any other event preventing power transfer, the grid system operator needs to be able to control power production of the offshore wind farm.

Power Quality & Harmonics

Power quality is to be monitored, i.e. voltage fluctuations, current harmonics, inter-harmonics, higher frequency components, etc. Network studies are required to determine the harmonic levels and the necessary compensation via static or dynamic compensation systems located at either the offshore platform or the onshore installation.

Redundancy and reliability

Offshore platforms would be designed according to n-1. Backup equipment would be provided in case a piece of essential equipment fails.

Recommendations

- Development of a market model and suitable tools for investment decisions.
- Funding arrangements for network strengthening to accommodate larger cross-border energy flows from wind and other generation.
- Evaluation of the proposed additional reinforcements by ENTSO-E.
- Enhance capability and flexibility of the existing transmission grid by using dynamic line rating management and enhancing power flow control through operational switching and by use of phase shifters.
- Ensure necessary network infrastructure is given equivalent priority as that given to renewable generation developments so as to act in a timely fashion.
- Develop improved operational tools and procedures that would permit shared wind forecasting, coordinated operation of power flow control devices, coordinated voltage control, reserve monitoring and management actions across the European network.
- Urgently progress ENTSO-E pilot work on harmonising wind grid code.
- Network representations in day ahead and intraday markets.
- Develop control facilities for the wide area supervision and strategic operation of networks with wind generation, including coordination of flexible generation, demand, storage and wind curtailment.

- Inform about wind support mechanisms and network access rules.
- Organize R&D and standardization of "the offshore grid code and power quality requirements in case offshore wind farms are connected via DC grid connections".
- Consider the synergies between offshore wind connections and cross-border links for the long tem (2020-2025) development of offshore grids and consider the implications of offshore grids on the required development of onshore grids.

Concluding Remarks

There are no important gaps in technologies or standards used on offshore wind farm substations today. All the substation components and systems are being used successfully already and have been used for many years on oil platforms, on ships and in substations under harsh and onerous environmental conditions.

Minor adaptations maybe necessary but there is definitely no fundamental research into new technologies necessary.

The big difference with today's approach, that authorities should introduce, is the notion of mandatory interconnection and extendibility of the offshore wind farms, rather than "stand-alone" offshore wind farms.

Proposals for joint funded research could include the following topics of an overall interest:
1) "performing an FMEA study to assess the best model to adopt as far as the future way of working is concerned".
2) R&D and standardization of "the offshore grid code and the power quality requirements in case offshore wind farms are connected via DC grid connections.