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Offshore Wind in the Australian National Electricity Market

Background

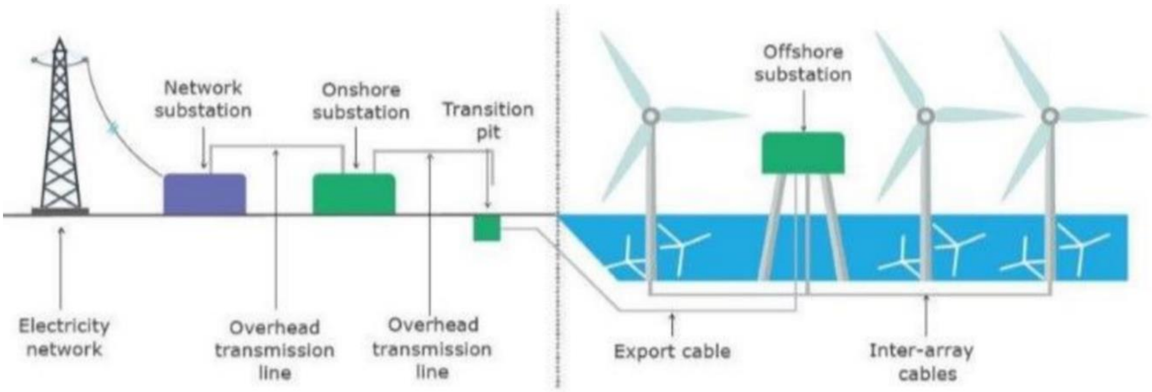
Australia is undertaking a major energy transformation by converting to renewable generation. Offshore wind is emerging as a key component of the pathway to net zero with the Federal Government announcing several offshore wind zones for further investigation. Offshore wind has key technical features and constraints which impact upon substation design and require special design consideration.

Offshore Wind Zones

The Federal Govt has recently announced a number of Offshore Wind zones, with the area off the Gippsland coast of Victoria, the first area of study.

Offshore Wind Farm Components

A typical offshore wind farm arrangement is shown below :-



Component selection and grid compliance requirements will influence onshore and offshore substation configuration as discussed in the following sections.

Windfarm Components and Technical Constraints
Offshore wind turbine generators may be fixed or floating and lie in the 5-15MW range. Fixed type are limited by sea bed depth and in Gippsland woudl typically lie up to 30-40km offshore turbines. The selection of floating wind turbines will allow installations further offshore and may drive the selection of HVDC connection over HVAC submarine cables.

Inter-array subsea cabling is typically at 66kV - as distinct from the 33kV typically seen for onshore wind turbines - but may operate at higher voltages for larger turbines. The voltage selection will be influenced by turbine rating and the cable sizing by minimum Short Circuit Rating considerations at the furthest generator.

Offshore substations will be platform mounted and there may be one or more depending on the size and distrubiton of the turbines. The objective is to minimise losses in the inter-array cabling. Offshore platform switchgear voltage and configuration and transformer selection will be driven by the voltage selected for inter-array cabling and the EHV transmission export cable. Offshore platforms are typically space constrained so there will be emphasis on equipment with a smaller footprint, eg. GIS switchgear. Shunt reactors will be required for compensation purposes

The subsea transmission cable for an AC scheme will typically operate at 220kV or 275kV with 220kV being the more widely available. A 1600mm2 Cu conductor is typically the largest easily available cable size and is likely to define the limit of subsea power transfer for AC systems. Restrictions will typically occur at onshore transitions (beach crossings).

Onshore cabling is typically available up to 2500mm2 Cu. The number of circuits is limited by the wind farm rating. Teh selection of overhead lines has cost advantages but is frequently resricted by landowner/environmental objections.

Onshore substations are required to enable load sharing between cable circuits and for reactive compensation (may be switched or non-switched). At 220kV, compensation at 50-75km is expected to achieve an economic outcome. Switchgear configuration and type will be influenced by the reliabilty and planning constraints.

Reactive compensation, including dynamic reactive plant (STATCOMs, SVCs, MCSRs, etc) and harmonic filters are required ath the POC to achieve technical compliance with grid requirements.

Special considerations

The following design considerations should be borne in mind during substation design for offshore wind.

- Reactive support during system disturbances is not likely to be available from the WTGs at the POC due to the distance of the turbines from the grid and the offshore cable rating limits (which maximises the transfer of MW). Dynamic reactive plant (DRP) will be required at POC to meet these grid requirements

- Shunt reactor sizing location and switching requirements are subject to cable parameters (length, voltage, charging current). Multiple compensation stations may be required.

- Short Circuit Ratings may be marginal (SCR<1-1.5) at the furthest turbines due to the impedance of the cable network from the POC, impacting stability under system disturbances. The transmission asset design including the transformer impedances and array cables) must accomodate this - or additional short circuit support (synchronous condensers) may be required on offshore substations where space is at a premium.

- The main grid transformers require careful design if STATCOMs connected via tertiary winding are to be used to save on high voltage switchgear. This is due to the large rating required and the significant reactive power variation through the tertiary. This is a key design feature and must be deterined at an early stage to allow primary configuration of the substation plant. If tertiary connected plant is not possible, then dedicated transformer circuits must be used.

- Harmonic filter design is influenced by background level requirements at POC and the type and quantity of dynamic reactive plant required. Details may not be available until later in the design phase.

- Grid connections are frequently subject to signficant competition from other onshore and offshore renewable projects. This may influence the equpment selection, location or primary configuration as well as harmonic limits, fault levels and requirement for short-circuit support.

Conclusion

Offshore wind is in the early stages of development in Australia. Many key learnings from worldwide experience are relevant but unique problems remain, mainly related to the nature of the Australian Energy Market and its relatively small size. Environmental and planning restrictions are also likely to significantly influence onshore asset designs including onshore substations.

Submitted,

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