VEKTA GROUP

Technical Note
Onshore Substation Layout Philosophy

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CONFIDENTIALITY

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1. Introduction

Floventis is developing the Llyr projects, comprising two separate floating wind farm development sites located in the Celtic Sea, approximately 40 km offshore. It is intended that each site will be connected by a separate dedicated circuit to a new purpose-built onshore substation (Llyr Wind Farm Onshore Substation) located approximately 1 km from National Grid's Pembroke 400/132kV Substation. The connection to the National Grid transmission network is proposed to be via a single 400kV circuit between the Llyr Wind Farm Onshore Substation and Pembroke 400/132kV Substation.

This technical note outlines the high-level principles used for the preliminary layout of the Llyr Wind Farm Onshore Substation.

Note that the substation design will mature as the project progresses and the final layout will be developed with an appointed designer/contractor/supplier in accordance with planning requirements.

2. Reference Drawings

Drawing No	Title / Description
Llyr DRL SLD v01	Power Factory Single Line Diagram
5218226-EL-DRG-0001	LLYR ONSHORE SUBSTATION OPTION 1 – Air Insulated Switchgear Option
5218226-EL-DRG-0002	LLYR ONSHORE SUBSTATION OPTION 2 – Gas Insulated Switchgear Option
5218226-EL-DRG-0003	LLYR ONSHORE SUBSTATION OPTION 1 ELEVATION
5218226-EL-DRG-0004	LLYR ONSHORE SUBSTATION OPTION 2 ELEVATION

3. Substation Layout Philosophy

The high-level principles used for the preliminary layout of the Llyr Wind Farm Onshore Substation are listed below.

3.1. General

The preliminary layout uses a planning envelope approach that allows for a number of design options. For example, an Air Insulated Switchgear (AIS) substation may require a larger area than a Gas Insulated Switchgear (GIS) substation, but a GIS building may present a higher maximum height than an AIS option. Also space for harmonic filters and reactive power compensation equipment needs to be allowed for at this stage of the project but the requirement for this equipment will be subject to power system studies and detailed design.

In general the approach taken has been to allow sufficient space for optionality, construction, operation, and replacement of major items of equipment. If land costs or space becomes a key consideration for the site then the layout can be re assessed but space restrictions generally lead to increased costs and engineering challenges.

3.2. Perimeter Fencing

It has been anticipated that the substation perimeter will be secured using palisade fencing of a height appropriate for the location. This will typically be 2.4m. There may be an additional 1.0m of electric fence if deemed appropriate.

The purpose of the perimeter palisade fence is to secure the substation and protect the public from danger.

Gates to allow vehicular and personnel access will be included.

Warning signs will be mounted on the perimeter palisade fence in accordance with the Electricity Safety, Quality and Continuity Regulations 2002.

If the perimeter palisade fence is independently earthed a minimum separation of 2.0m will be required between the fence and any extraneous metalwork within the substation.

3.3. Cable sealing ends

Cable sealing ends will be used to terminate the incoming 400kV cable circuit(s) from National Grid if substation option 2 is selected.

Cable sealing ends will be mounted on steel gantries which will also support the incoming 400kV cables. The height of the combined structure can typically be 10.0m. There will be three cable sealing ends per circuit at a separation of typically 5.0m.

The 400kV cables from National grid will be buried and will enter the substation in ducts that will exit adjacent to each cable sealing end structure.

The substation orientation will typically be such that the 400kV cable sealing ends are located to align with the incoming 400kV cables.

The preliminary design has allowed for two 400kV cables from National Grid as a worst-case scenario though it is understood that the current proposal is for a single 400kV circuit between the Llyr Wind Farm Onshore Substation and Pembroke 400/132kV Substation.

3.4. 400kV AIS

The 400kV AIS for option 2 will consist of motorised disconnectors, earth switches, circuit breakers, and ancillary equipment.

The purpose of the AIS is to provide: isolation and earthing of the 400kV circuit to Pembroke 400/132kV Substation; and, isolation, earthing, and electrical protection of Llyr Wind Farm Onshore Substation apparatus.

The AIS will be mounted on steel frames to provide sufficient height and separation between phases and circuits to allow safe access during construction and operation. The height of the structure will typically be 10m.

A 400kV busbar may be required if there is a single 400kV circuit to the substation and two 400/66kV transformers are installed.

Each AIS assembly will be contained in a palisade fence compound similar to the perimeter fence to prevent unauthorised access and appropriate separation to other equipment.

3.5. 400/66kV Transformers

The 400/66kV Transformer(s) will be used to convert from National Grid transmission voltage of 400kV to the Llyr Wind Farm collector voltage of 66kV.

66kV apparatus is now commonly used for offshore windfarms and provides a suitable balance between cost, availability and power transfer capability.

The Transformer(s) may be a single 250MVA unit or two 125MVA units. The transformers will be oil filled with natural or forced cooling. Each transformer will include ancillary equipment including oil conservator, radiators, bushings, control cabinets, condition monitoring equipment and breathers.

Each transformer will be bunded to minimise the environmental impact of an oil leak.

Sufficient space for delivery / replacement of transformers has been considered. Access routes to site for delivery / replacement should be considered. A 250MVA transformer may weigh 250,000kg (180,000kg without oil) and be 9m x 4m x 5m (L W H).

Distance to other equipment should allow for catastrophic failure of a transformer. Fire and blast should be considered. Blast walls may be required to protect equipment and/or personnel. The spacing between transformers, and between transformers and other oil filled equipment should be assessed for fire and blast. Generally, the spacing between transformers, and between transformers and other oil filled equipment should not be less than 12m and may be more for the selected transformers.

Noise suppression may be required subject to planning conditions.

The transformer(s) will be secured to prevent unauthorised access.

3.6. Control Building for AIS Option

The Substation Control Building for option 2 will typically be a brick built single storey structure. Usually, the building would have steel doors with 3 points of locking. There would usually be no windows. The building will include rooms for metering, SCADA and communications, batteries, protection and control panels, and storage. There will usually be office and welfare facilities.

There will be parking adjacent to the building and walkways will be well illuminated.

3.7. GIS Switchgear and Control Building

A GIS Switchgear and Control Building has been shown for option 1. GIS buildings can be up to 15m in height and will usually be steel frame, metal clad structures. Usually the building would have steel doors with 3 points of locking for personnel access. Access for delivery and change out of the switchgear will usually be through roller shutter or sliding “hanger” doors. There would usually be no windows. The building will include the switchgear hall(s), rooms for metering, SCADA and communications, batteries, protection and control panels, and storage. There will usually be office and welfare facilities.

There will be parking adjacent to the building and walkways will be well illuminated.

3.8. 66kV AIS Compound

The 66kV AIS for option 2 will consist of motorised disconnectors, earth switches, circuit breakers, busbars, and ancillary equipment.

The purpose of the 66kV AIS is to provide protection, switching, isolation and earthing of the windfarm cables and substation 66kV apparatus including reactive compensation equipment, harmonic filters, and transformers.

The bus arrangement shown is a single bus with a bus section between circuits. Single bus generally provides the lowest capex option but will require more outages for maintenance and repair. Final arrangements will be subject to final design and operational arrangements between the two wind farms.

The AIS will be mounted on steel frames to provide sufficient height and separation between phases and circuits to allow safe access during construction and operation. The height of the structure will typically be 10m. Steel support structures will generally have concrete foundations. Concrete support structures can also be utilised.

The 66kV AIS compound is shown contained in a palisade fence compound similar to the perimeter fence to prevent unauthorised access.

3.9. Auxiliary Transformers

Auxiliary Transformer(s) will be used to supply the substation house load. These have been shown in separate compounds to prevent unauthorised access.

The transformers will be oil filled with natural cooling. Each transformer will include ancillary equipment including oil conservator, radiators, bushings, and cable boxes. The units are likely to be standard design with a rating of 50kVA – 200kVA.

Each transformer will be bunded to minimise the environmental impact of an oil leak.

Sufficient space for delivery / replacement of transformers has been considered.

3.10. Reactive Power Compensation Equipment

The reactive compensation equipment is shown in the Reactive Compensation Yard. There is a Reactive Compensation Yard for each windfarm circuit and these will be secured to prevent unauthorised access.

The final configuration of the reactive compensation equipment will be subject to detailed design. It is likely to consist of Static VAR Compensators (SVC) and / or Static Synchronous Compensators (STATCOM).

Any oil filled Equipment will require bunding and / or concrete plinths.

Sufficient space for delivery / replacement of equipment should be considered.

3.11. Harmonic Filters

Harmonic filtering equipment is shown in a separate compound for each windfarm circuit and these will be secured to prevent unauthorised access.

The final configuration of the harmonic filtering equipment will be subject to detailed design. It is likely to consist of a combination of resistors, reactors, and capacitors.

Any oil filled Equipment will require bunding and / or concrete plinths.

Sufficient space for delivery / replacement of equipment should be considered.

3.12. Access Tracks and Parking

Access tracks are shown for both options. Consideration has been given to allow sufficient space and turning circles for construction deliveries, installation of major equipment, operation, and replacement of equipment.

Designated parking areas should be identified. It is now common practice to include EV charging facilities inside substation compounds.

3.13. Other Facilities

Other substation facilities not shown on the current drawings and subject to detailed design are:

- Lighting
- CCTV
- Security systems
- Earthing
- Lightning protection
- Drainage / SuDS
- Oil separator
- Septic tank
- Fire separation zones
- Acoustic / fire walls
- Internal roads and crane pad areas

3.14. Construction and Installation

Allowance needs to be made for sufficient space for a temporary construction compound, and delivery / storage area.