Outer Dowsing Offshore Wind

Preliminary Environmental Information Report

Volume 2, Appendix 3.2

Outline Onshore Substation Design Principles

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OUTER DOWSING OFFSHORE WIND

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1 Introduction

1.1 The Outer Dowsing Project Onshore Substation (OnSS)

1.1.1 Please refer to PEIR Chapter 3 Project Description (document 6.3) for a detailed description and figures associated with the Project's grid connection options and proposed substation sites.

1.1.2 The two grid connection options for the project currently under consideration are;

- Lincolnshire Node, or
- Weston Marsh.

1.1.3 National Grid Electricity Transmission (NGET) are continuing with their evaluation of these options, through the Offshore Transmission Network Review (OTNR). The Project cannot make any assumptions regarding NGET's selection while the OTNR is still ongoing. Therefore, the Project's PEIR includes assessments of both connection points.

1.1.4 For a connection at Weston Marsh, two potential substation sites (WM North and WM South) are being considered. Until the final decision has been made by NGET, the Project will continue to consult on both the Lincolnshire Node option and the two potential sites at Weston Marsh.

1.1.5 Preliminary visualisations of all the Project's OnSS options are included in PEIR Chapter 28 Landscape and Visual Impacts Assessment (document 6.2.28.1).

1.1.6 The final Development Consent Order (DCO) application and Environmental Statement (ES) will be for a connection at the single point determined by NGET.

1.2 Design and Development Process

1.2.1 The Project is a Nationally Significant Infrastructure Project, as defined by the Planning Act 2008, under which an application for consent will be made in order to obtain a Development Consent Order (DCO) authorising the Project.

1.2.2 The DCO application process involves extensive engagement and consultation with local communities and other stakeholders during the pre-application stage (See PEIR Chapter 6 Consultation Process (document 6.1.6) and the Consultation Summary Report (document 5.1) submitted alongside the PEIR). The Project is currently at the Preliminary Environmental Information Report (PEIR) stage and this document has been drafted to support PEIR Chapter 3 Project Description (document 6.1.3).

1.2.3 This document will be updated as decisions are made regarding the design of the substation and in response to consultation. A final design envelope will be set out in the Project Description Chapter of the Environmental Statement which will be submitted as part of the DCO Application.

1.2.4 The detailed design of the substation will be carried out post-consent by the contractor selected to design, supply and build the substation and will be submitted for approval by the relevant local planning authority, under a DCO requirement, in advance of construction.

1.3 Consultation on the Design Process

1.3.1 The Project is dedicated to working with the local community to develop the design of the OnSS. There are certain areas of the design that the Project will not be able to consult on or, provide flexibility for as they are driven by other considerations such as: adherence to safety standards; technical constraints (size, type and suitability of equipment); legislative requirements; and interfaces with other key receptors (e.g. ecology and ornithology). However, there will be a number of key elements that will significantly influence the design, look and presence of the OnSS that the Project propose to design in consultation with the community local to it.

1.3.2 As outlined in Section 1.2, the final design of the OnSS will be subject to a detailed design phase which will occur post-consent. In order to minimise visual impacts as far as practicable, the appropriate building design and materials will be considered, subject to functional requirements, to support and, where possible enhance, the natural and built environment.

1.3.3 An updated version of this document; an OnSS Design Principles Document, will be developed and submitted as part of the DCO Application. This will set out the design principles to be followed and guidance documents that will be considered to guide the detailed design. The following guidance has been identified by the Project as a key document outlining the principles to guide the Project's design:

- National Infrastructure Commissions' Design Principles for National Infrastructure (National Infrastructure Commission (NIC), 2020).

1.3.4 Within the NIC guidance, reference is made to the use of design panels on nationally significant infrastructure at an early stage to ensure their advice is considered early enough to shape the project design.

1.3.5 The Project therefore propose to develop a design panel in line with their established Community Liaison Groups (CLGs) (Document 5.1 Consultation Summary report) following confirmation of the Project's grid connection location. The CLGs have been consulted with on the OnSS and the Project intends to work with the relevant group, following confirmation of the grid connection, to help establish a design panel, develop the design process and identify the elements of the design that would be consulted on during the detailed design phase. This would then be secured through the Project's DCO.

1.4 The requirement for an onshore substation

1.4.1 The purpose of the Project is to generate electricity from wind power offshore, bring this power ashore and feed it into the UK National Grid, operated by NGET. The electrical transmission infrastructure required includes offshore substation platforms, offshore export cables, a landfall and transition joint bays and buried onshore cables leading to the Project's confirmed connection point. An essential component to enable the grid connection is a substation and associated enabling works[1], at or close to the point where the project connects to National Grids transmission system.

1.4.2 The onshore substation performs a number of functions, in order that the connection can comply with the requirements of the NGET Grid Code, which regulates connections, and can be summarised under the following headings:

[1] The associated enabling works will be provided by National grid following the conclusion of the OTNR. See PEIR Chapter 3 Project Description (Document 6.1.3).

- Switching – controlling, connecting, protecting and disconnecting the project circuits between ODOW and NGET.
- Voltage alignment – raising the voltage of the ODOW transmission system to the operating voltage of the NGET system.
- Power 'quality control' - in relation to factors including active and reactive power, phase balances and voltage and oscillation frequency.

1.5 The Purpose of this Design Principles Statement (PEIR)

1.5.1 This draft design statement has been prepared as an appendix to PEIR Volume 1 Chapter 3: Project Description and a supporting document to the PEIR. Its purpose, at this stage, is to identify the main design aspects of the OnSS and how the design will evolve to final approval.

1.5.2 Where design principles or processes are agreed with the local authority or other consultees, these will be secured as commitments and recorded in the final version of this document.

1.5.3 This document will be updated following the Project's Phase 2 Consultation and any other consultation undertaken prior to the finalisation of the Application. This document will then be submitted as part of the DCO Application.

1.5.4 A number of factors and assumptions in the PEIR will influence the Project's impact assessment and the mitigation measures proposed, in turn the results of these assessments will influence the design of the OnSS. This document signposts to the relevant sections of the PEIR where these are considered.

1.5.5 The detailed design will be carried out post-consent and will adhere to the parameters as defined in the final DCO.

1.6 Onshore Substation Location Options

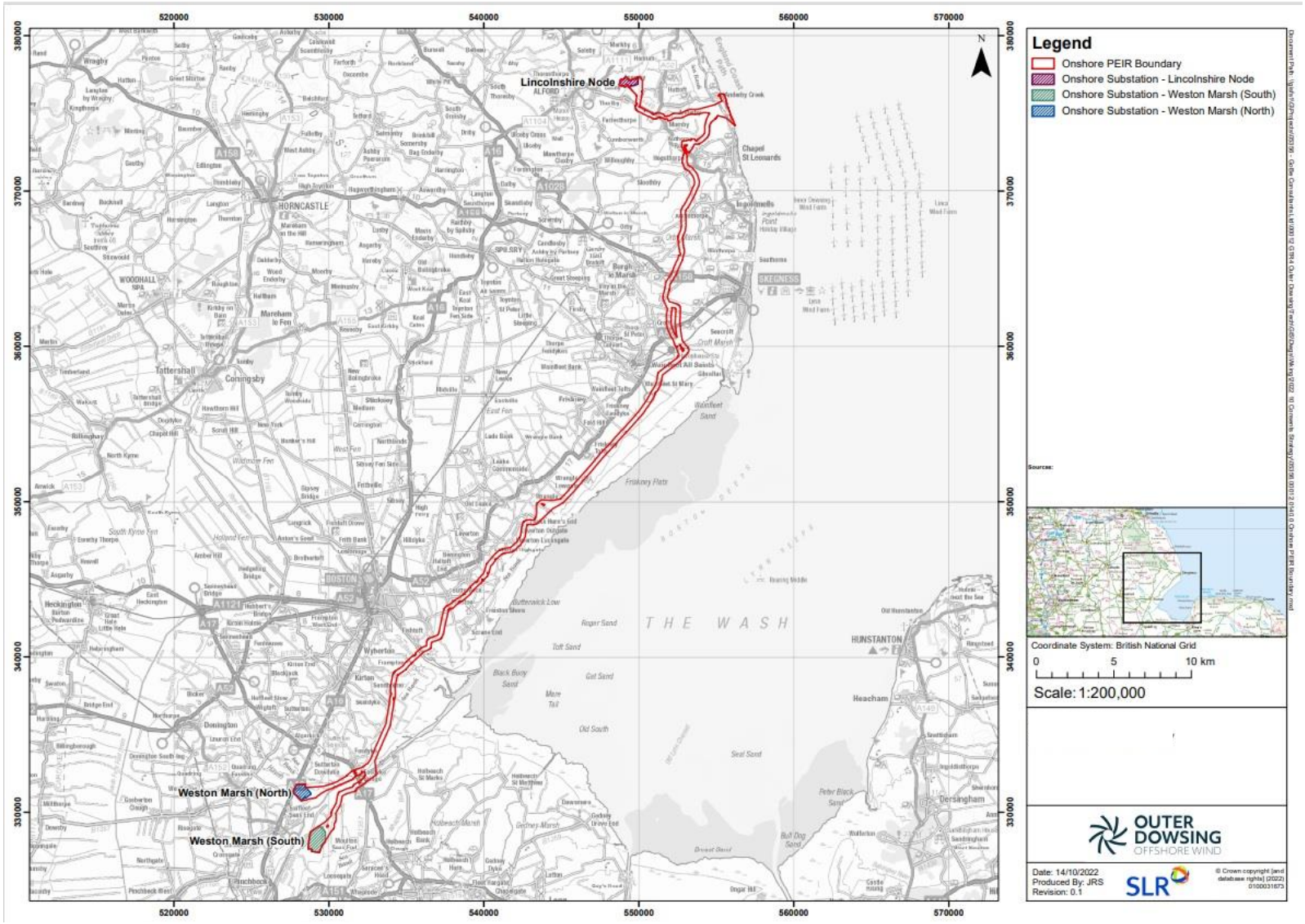

Figure 1.1: The Project's onshore ECC and potential OnSS locations at Weston Marsh (North and South) and Lincolnshire Node

2 Design considerations

2.1 Functional Requirements

2.1.1 The substation is a functional infrastructure installation, housing hazardous equipment. Functionality and safety are essential to the design which must comply with appropriate technical and safety standards.

2.1.2 A major consideration and constraint to the layout will be the position of the existing grid infrastructure to which the connection will be made and the entry point for the cables coming into the site.

2.2 Key Considerations

2.2.1 The detailed design of the substation will be undertaken post consent, within the design envelope authorised by the DCO. Key design parameters will be set in the DCO, including the maximum footprint and maximum heights of structures. An indicative layout will be used for the Environmental Statement to assess the environmental impacts of the site and identify mitigation measures that need to be incorporated.

2.2.2 The Project will also taken into consideration the following key principles relating to substation design as identified by National Grid in the Horlock Rules[2]:

- The siting, orientation and layout of a substation will look to take advantage of existing screening provided by the topography and vegetation, in combination with an assessment of the receptors in the area surrounding the site.
- Consideration will be given to the positioning of buildings which can provide screening of external equipment and noise attenuation where appropriate.
- The external design, materials and colour of buildings and fencing can be adapted to be appropriate within the local area.
- The use of lightweight, narrow materials and lattices for high level external structures, such as gantries is preferable to solid designs and should be used where practicable.
- The requirement for landscaping (Section 4.11) will be considered at an early stage as an integral part of the design process and an indicative landscaping plan included with the consent application.
- The interface with NGET and the NGET requirements which will influence the overall, will be incorporated into the design as early as possible (Section 3.2).

[2] https://www.nationalgrid.com/sites/default/files/documents/13796-The%20Horlock%20Rules.pdf

2.3 Maximum Design Parameters

2.3.1 The design of the OnSS will be undertaken post-consent within the maximum design envelope defined in the DCO and assessed in the ES. The assessments in the PEIR have been based on the maximum design parameters for two different types of technology still under consideration by the Project. A description of these technology options can be found in Section 2.4 and the Project's maximum design parameters for each of these are outlined in Table 2.1. Figure 2.1 shows schematic representations of these design envelopes. Following consultation on the PEIR, these will be refined for the final ES and DCO Application. The figures give a robust basis for the assessment and an 'envelope' within which the design can be developed.

2.3.2 For purposes of the Project's visualisations, for the PEIR these have been based on a worst case (Maximum design scenario) GIS Layout. These can be found in PEIR Chapter 28 Landscape and Visual Impacts Assessment (document 6.2.28.1).

Table 2.1: Maximum Design Parameters

Design aspect	Technology / Site	Max. Parameter Footprint	Max. Height from Finished Floor Level[3]
Temporary construction area	AIS / GIS	27ha (270,000m^2)	-
Permanent overall site area	AIS / GIS	18ha (180,000m^2)	-
Operational area	AIS	9.27ha (92,700m^2)	12m
Operational area	GIS	7.26ha (72,600m^2)	12m
GIS building (See Figure 2.1))	GIS	0.45ha (4,500m^2)	19m
Lightning protection masts	AIS / GIS		30m

[3] The Finished Floor Level is the height of the levelled site for which the OnSS would be built on (See Section 4.4)

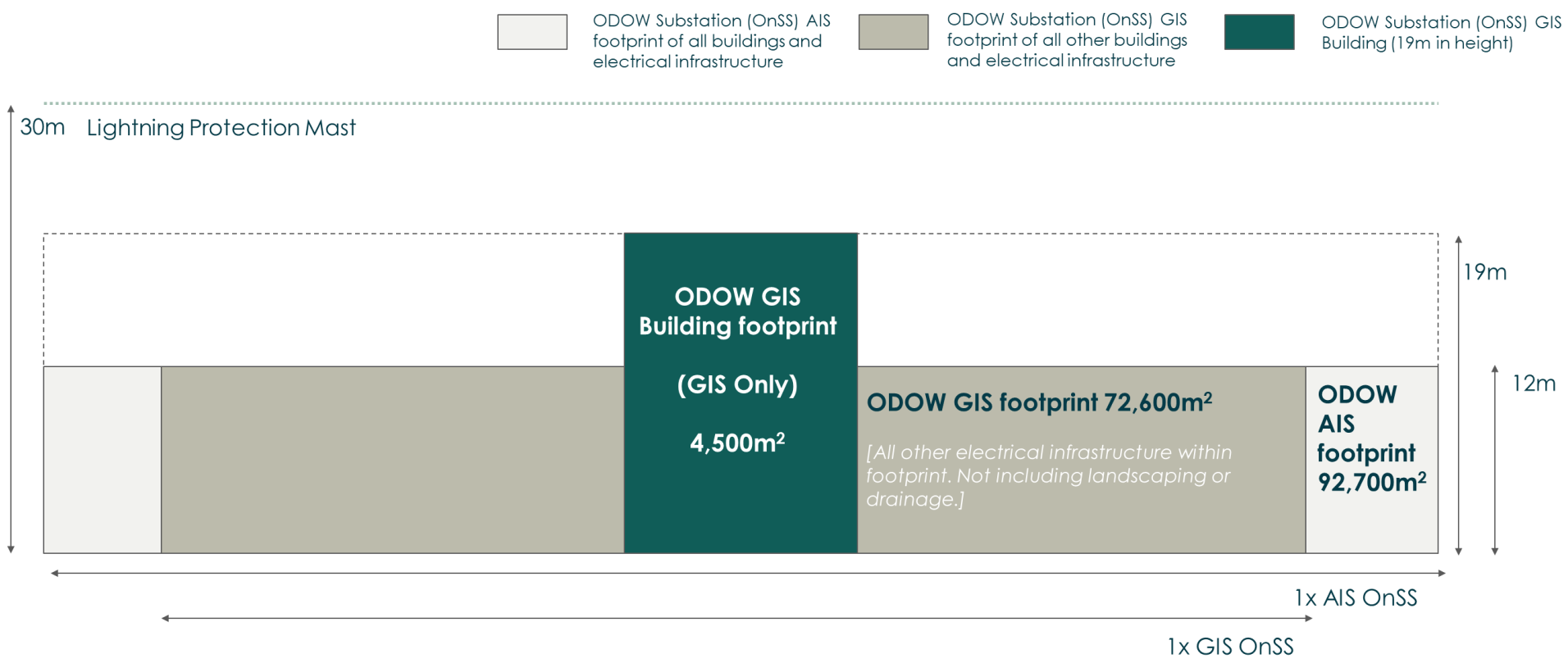

Figure 2.1 Maximum Design Parameters - Profiles for AIS & GIS

2.4 Specific Environmental Topics and Assessments

2.4.1 The environmental impacts of the substation are assessed under the individual topic chapters throughout the PEIR. Table 2.2 below identifies the chapters that are most relevant to the design. The assessments also include embedded mitigation measures that the Project is committed to and will be recorded as commitments to be included in the final design.

Table 2.2: PEIR chapters with specific relevance to the OnSS design

PEIR Chapter/ Document	Chapter Title	Design Relevant Content
Chapter 3	Project Description	Maximum Footprint and maximum building dimensions.
Chapter 4	Site Selection and Consideration of Alternatives	The process and factors leading to the selection of the site.
Chapter 21	Onshore Ecology	Identification of ecological factors that can be incorporated into the design.
Chapter 23	Geology and Ground Conditions	Ground conditions, influencing the design of foundations and permeability.
Chapter 24	Hydrology & Flood Risk	Flood risk and mitigation measures. Drainage mitigation requirements.
Chapter 26	Noise & Vibration	Noise modelling and requirements for mitigation.
Chapter 27	Traffic & Transport	Access requirements incorporated into the design.
Chapter 28	Landscape and Visual	Visualisations and proposals for landscaping.
8.2	Planning statement	Compliance with national, regional, and local planning guidance and policies.
8.8	Baseline Flood Risk Assessment	The FRA against the relevant tests, including the proposed level.

2.4.2 Along with this document, the above chapters and supporting outline documents will be updated in line with ongoing consultation and as the project evolves to DCO Application stage. As more survey data comes available and the technical considerations can incorporate new information alongside feedback from the ongoing consultation, the OnSS design and considerations will evolve in line with this and will be reported in the DCO Application (See Section 1.3).

3 Technology Options

3.1 Switchgear Technology Options (AIS / GIS)

3.1.1 Two primary options exist for the switchgear element of the substation and the selection of the technology will result in designs with different characteristics. The selection of the technology may not be made until the detailed design is carried out post-consent and therefore both options will be included in the consent application. The selection is between external or internal switchgear, using external Air Insulated Switchgear or internal Gas Insulated Switchgear and the options are described below:

Air insulated switchgear (AIS) utilises an external switching yard, where the air gap between the metallic electrical contacts and the ground provides the necessary insulation. The circuit breakers rely on the distance of separation between the contacts.

3.1.2 Figure 3.1 shows an image of typical external AIS switchgear.

AIS substations have large external switch yards containing the equipment. AIS switchgear typically includes galvanised vertical supports, with ceramic insulators and high-level cables and connectors.

3.1.3 **Gas insulated switchgear (GIS)** houses the switchgear inside metal vessels charged with an insulating gas (typically Sulphur Hexafluoride or SF6). The gas insulated switchgear is housed inside a GIS building.

3.1.4 The main characteristic of a GIS substation is the requirement for a 'main building' that houses the switchgear, this is not required for an AIS substation.

3.1.5 Figure 3.2 below is typical of the internal of a GIS building. In this example, the switching is carried out inside the metal cylinders.

Figure 3.1 Typical AIS external switchgear

Figure 3.2 Typical GIS switchgear

3.2 NGET Interface

3.2.1 The connection location options are shown in Figure 1.1 and at either connection location, an important design aspect will be the interface of the ODOW substation with the NGET (National Grid Electricity Transmission) infrastructure.

3.2.2 For the connection at the Lincolnshire Node connection option, NGET are proposing to build a new substation to provide a node for multiple connections and the ODOW substation would be located in close proximity to this, with underground cables leading from the OnSS to the connection point.

3.2.3 For the connection at the Weston Marsh connection option, the detail of the infrastructure required has to be provided by NGET and will likely involve an NGET substation and associated enabling works (such as connection to, and/or reinforcement of, overhead lines). As with Lincolnshire Node the ODOW OnSS would be located in close proximity to the NGET substation to facilitate an efficient connection to the National Grid Transmission System (See PEIR Chapter 4 Site Selection and Consideration of Alternatives (document 6.1.4)).

3.2.4 Whichever connection location is selected, integration of the design with the NGET infrastructure will be an important consideration in the layout and overall design.

4 Design Elements and Typical Examples

4.1 Buildings

4.1.1 A GIS substation will require a main building (Figure 2.1) and both AIS and GIS designs will require a smaller control room building. Up to 10 other small buildings may be included in the layout, for example to provide storage and a workshop, if these are not incorporated into one of the larger buildings.

4.1.2 GIS and control room buildings are typically portal frame, steel clad constructions, similar in design to large agricultural, industrial or distribution buildings. Taller buildings are likely to be flat roofed, to reduce the overall height, but where height is less critical, apex or mono-pitch roofs are also options. The cladding of the building is typically box profile steel sheeting.

4.1.3 An example of a GIS main building is shown in Figure 4.1.

Figure 4.1 Typical GIS building

4.1.4 External steps and fittings are typically made from steel with a galvanised finish. The external colours are typically based on the best colour to help the building blend into the landscape.

4.2 External equipment

4.2.1 External equipment is required in both the AIS and GIS layouts (Figure 2.1); this typically comprises external switchgear and gantries, plus individual items such as transformers.

External switchgear is typically constructed from galvanised steel with porcelain or composite insulators (visible in

4.2.2 Figure 3.1). The switchgear on concrete plinths and vertical supports and horizontal gantries are typically constructed from galvanised lattice steelwork.

4.2.3 Transformers are the largest individual ‘solid’ external structures. These are typically located on concrete plinths with concrete fire / explosion barrier walls separating them from other equipment. The bushings on top of the transformers can be of a similar height to AIS switching equipment. Transformers are typically coloured light or dark grey

4.2.4 Figure 4.2 and the illustration below shows a typical design.

Figure 4.2 Transformer – typical appearance

4.2.5 Other smaller items of external ancillary equipment will also be required and details of these individual components will be included in the updated design for the DCO Application. This other equipment is typically constructed from metal and typically painted grey or galvanised.

4.2.6 Diesel or low-carbon alternative powered backup generators are typically included in the design to provide backup power for the control room, lighting and control functions in the event of a failure or an outage of the normal 'works power' supply. Generators can either be located externally, within containers or can be housed inside or alongside buildings.

4.3 Noise attenuation

4.3.1 Potential impacts from Noise have been assessed in PEIR Chapter 26 Noise and Vibration (document 6.1.26). Where modelling of the noise levels around the substation identifies that noise mitigation is required, this could be achieved by installing noise mitigation measures within the substation design. Noise mitigation is generally most effective when applied as close as possible to the source and is therefore typically incorporated into the design.

4.3.2 Where necessary, the following mitigation measures can be incorporated into the design:

- Locating equipment inside buildings or enclosures incorporating sound proofing materials and multiple skins;
- Installing panels around external equipment or an internal noise fence;
- Incorporating noise mitigation materials into the perimeter fence; and
- The use of earth bunds around the site, often incorporated into the landscaping design.

4.3.3 The need to incorporate any of these measures will be determined by the noise modelling and assessment process. Figure 4.3 shows an example of a typical acoustic enclose for a transformer.

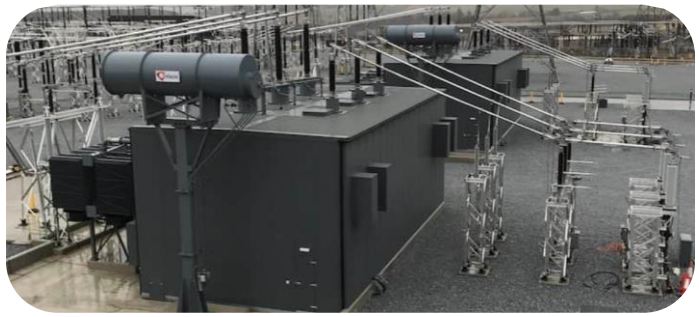

Figure 4.3 A typical transformer acoustic enclosure

4.4 Finished Ground Level

4.4.1 The construction of a substation requires a levelled site to form a base from which the substation is built up which is typically formed from imported aggregate.

4.4.2 The Finished Floor level for the OnSS will be confirmed following the finalisation of the Project's Flood Risk Assessment (FRA) which will be submitted as part of the DCO Application.

4.4.3 The final finished ground level will be established during detailed design post consent.

4.4.4 There are a number of factors that could influence the maximum finished ground level, including:

- Surface water drainage design requirements, to ensure adequate surface water run-off from the onshore substation and a suitable connection to the existing surface water drainage system;
- Existing ground levels and practicable cut and fill requirements, to optimise the cut and fill balance of the onshore substation and minimise the need to import or export spoil material during the onshore substation construction; and
- Groundwater constraints, to ensure appropriate management and control of groundwater interactions in the design of the onshore substation.

4.4.5 The Project has submitted a Baseline Flood Risk Assessment (FRA) (document 8.8) a final version of which will be submitted as part of the DCO Application. The Environment Agency will be a key consultee in relation to the appropriate level of flood protection.

4.5 External Ground Surfaces

4.5.1 The ground finish around external equipment is typically finished in single sized angular stone, pebbles or, in some circumstances, asphalt. The purpose of ground finish is to:

- Increase the touch and step potential for operators reducing the risk of electric shock and discharges to earth.
- Prevent standing water and allow movement of drainage water.
- Increase the resistance between feet and the ground and prevent slips.
- Prevent weed growth.
- Reduce the fire risk from spilt oil.

4.5.2 The selection of the type of stone or asphalt will be made as part of the detailed design.

4.5.3 Internal roadways will typically be constructed from concrete with upstanding kerbs, although some areas that will only receive light traffic may also be surfaced with asphalt.

4.6 Lightning protection

4.6.1 Lightning protection masts are structures placed to intercept lightning and provide a safe route to earth before the lighting makes contact with other electrical components. Lightning protection masts are typically slender metal poles, or lattice towers, extending above the level of other equipment.

4.6.2 Lightning protection masts are typically constructed from galvanised steel, set on a concrete base with a connection to a buried earth grid.

4.7 Access and Vehicle Parking

4.7.1 During the operational life of the substation, it is possible that any of the components could fail and require replacement. The access will therefore need to be designed to accommodate the vehicles necessary to transport the largest components and crane hard standings are likely to be required and included in the layout.

4.7.2 The substation will be unmanned during the operational stage but will receive regular maintenance visits, requiring safe areas to park vehicles and access routes into the site. The substation layout will be designed to allow safe access to the control room for visiting staff without the need to enter or take vehicles into hazardous areas.

4.8 Fencing

4.8.1 The external fencing of the substation is designed to make it safe and secure. OnSS Fencing is typically constructed from galvanised steel, typically using mesh panels, with electrified fencing above the panel.

Figure 4.4: Typical examples of external fencing

4.9 Drainage

4.9.1 The design of the surface water drainage system will incorporate mitigation to achieve the required run-off rate for any discharge from the site. Where possible the principles of Sustainable Drainage Systems (SuDS) will be applied to the design of the site, to minimise the volume of rainwater that is collected and discharged.

4.9.2 The discharge attenuation options will be determined following ground investigations and it is likely that this will include both storage and infiltration options. The site area will include the necessary space to incorporate the likely number of attenuation ponds required, based upon preliminary assessment.

4.9.3 A large proportion of the substation area will likely be surfaced with a permeable finish to allow a degree of infiltration and slow the rate of discharge. In some situations, such as alongside access roads, run-off can potentially be directed into swales or French drains, subject to the space being available and the ground conditions and water table being suitable.

4.9.4 Certain equipment, such as transformers, are filled with insulating oil and these will likely be located within bunded compounds, where the drainage system incorporates individual oil traps, preventing any oil leakage migrating outside of the confined area. Similar arrangements are typically included for areas of oil storage or where diesel powered generators are located.

4.9.5 The drainage of hard-standings, internal roads and parking areas will incorporate an oil interceptor to protect against leakages or spillages within these areas.

4.9.6 The OnSS will have likely only a very small water requirement during the operational phase but opportunities will be considered for rainwater harvesting, although this is unlikely to have a significant impact upon the overall drainage strategy.

4.9.7 These sites require a foul drainage system for the toilet, shower and kitchen serving the control room and a suitable system will need to be incorporated in the design for approval.

4.9.8 Options include a septic tank or small package treatment unit, and the design will take account of the ground conditions and discharge options. Foul water volumes are typically assumed to be less than a residential property.

4.9.9 It is anticipated the substation drainage plan will be submitted for approval by the local authority as part of the detailed design process.

4.10 Artificial Lighting

4.10.1 The overall artificial lighting strategy will aim to minimise the time for which lighting is used, the area lit, the intensity of lighting and the potential for light spillage.

4.10.2 The substation will not normally be illuminated, but lighting will be required for both security and safety purposes, when staff are working within the site or accessing or leaving the control room. Security lighting would be motion activated and the lighting of other areas would only be required when staff are accessing or working at the site during hours of dusk or darkness.

4.10.3 Industry standards are available for guidance regarding the appropriate minimum lux levels for different areas within the substation. Typically, the external area of the substation is lit by tubular steel lighting columns with downward facing LED luminaries.

4.10.4 The lighting plan will be developed in accordance with the Outline Artificial Light Emissions Management Plan (document 8.1.10) submitted alongside the PEIR. An update of which will be provided as part of the DCO Application.

4.10.5 It is typical that the Light Emissions Management Plan, is first approved by the relevant local authority.

4.11 Landscaping

4.11.1 The design of the substation will take into consideration the existing landscape, including any trees or woodland with a view to retaining these wherever possible. Landscaping will be designed to mitigate visual impacts and impacts on environmental receptors. The landscape design is informed by the landscape and visual impact assessment. PEIR Chapter 28 Landscape and Visual Assessment (LVIA) (document 6.1.28) provides some examples of how mitigation planting can be utilised to assist with screening of a substation as well as taking consideration of enhancing biodiversity and mitigating impacts on environmental receptors.

4.11.2 Landscaping can be installed around the perimeter of the substation or closer to the receptor. For example, planting hedgerows or similar, alongside a road is considered an effective way to screen a substation from view by motorists.

4.11.3 The LVIA takes consideration of the sensitive visual and environmental receptors and, once a grid connection is confirmed, will set out a more detailed design in line with the Landscape and Ecology Design Principles Plan (LEDPP) (document 8.7).

4.11.4 It is typical that the detailed substation landscaping plan, with species, planting and aftercare methods, is first approved by the relevant local authority.

5 Conclusions

5.1.1 This draft document sets out the key considerations relating to the OnSS design process and the interface between the elements of the design and the environmental studies that are being undertaken as part of the Environmental Impact Assessment (EIA).

5.1.2 This document will be updated for inclusion as part of DCO Application. The key principles and any mitigation measures that the Project identify will be included in the updated version of this document and will be secured through the relevant requirement(s) of the DCO.

5.1.3 The final design will be within the authorised design envelope defined by the DCO. It is anticipated that the final details such as building style, materials and colours could form part of the design review process as outlined in Section 1.3.