Hornsea Project Four:

Outline Energy Balancing Infrastructure HazID Report TRACKED

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Revision Summary

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Revision Change Log

Rev	Page	Section	Description
01	N/A	N/A	Submitted as part of DCO Application
02	12	4.4.4	Addition of sub-section securing measures identified in AS-020, in response to ExA written question ES.1.5.

Table of Contents

List of Figures

Glossary

Term	Definition
Active Risk Management (ARM)	A software tool used to record and share risk profiles of equipment or project packages.
Design Risk Management (DRM)	A means by which designers can demonstrate that their designs can be built, used, maintained and eventually demolished without negatively affecting the safety, health and wellbeing of those involved in the construction process or those who may be impacted by the structure. Orsted has it's own DRM philosophy.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Projects (NSIP).
Energy balancing infrastructure / EBI	The onshore substation includes energy balancing Infrastructure. These provide valuable services to the electrical grid, such as storing energy to meet periods of peak demand and improving overall reliability.
Energy Storage Solution (ESS)	The device for converting electrical energy from power systems into a form that can be stored for converting back to electrical energy when needed
High Voltage Alternating Current (HVAC)	High voltage alternating current is the bulk transmission of electricity by alternating current (AC), whereby the flow of electric charge periodically reverses direction.
High Voltage Direct Current (HVDC)	High voltage direct current is the bulk transmission of electricity by direct current (DC), whereby the flow of electric charge is in one direction.
Hornsea Project Four offshore wind farm	The term covers all elements of the project (i.e. both the offshore and onshore). Hornsea Four infrastructure will include offshore generating stations (wind turbines), electrical export cables to landfall, and connection to the electricity transmission network. Hereafter referred to as Hornsea Four.
National Grid Electricity Transmission (NGET) substation	The grid connection location for Hornsea Four.
Onshore substation (OnSS)	Comprises a compound containing the electrical components for transforming the power supplied from Hornsea Project Four to 400 kV and to adjust the power quality and power factor, as required to meet the UK Grid Code for supply to the National Grid. If a HVDC system is used the OnSS will also house equipment to convert the power from HVDC to HVAC.
Order Limits	The limits within which Hornsea Project Four (the 'authorised project) may be carried out.
Orsted Hornsea Project Four Ltd.	The Applicant for the proposed Hornsea Project Four Offshore Wind Farm Development Consent Order (DCO).

Acronyms

Acronym	Definition
ARM	Active Risk Management (ARM)
CoHE	Control of Hazardous Energy
DCO	Development Consent Order
DRM	Design Risk Management
EBI	Energy Balancing Infrastructure
ERP	Emergency Response Plan
ESS	Energy Storage Solution
EU	European Union
FMEA	Failure Mode Effects Analysis
FMECA	Failure Mode Effect and Criticality Analysis
HAZiD	Hazard Identification
HAZOP	Hazard and operability study
HSE	Health and Safety Executive
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
LOTO	Lock-Out, Tag-Out
NGET	National Grid Electricity Transmission
NIOSH	American National Institute for Occupational Safety and Health
OnSS	Onshore Substation
PPE	Personal Protective Equipment
PtD	Prevention through Design
SSoW	Safe System of Work
WTSR	Wind Turbine Safety Rules

1 Introduction

1.1 Project Background

1.1.1.1 Orsted Hornsea Project Four Limited (the 'Applicant') is proposing to develop the Hornsea Project Four Offshore Wind Farm (hereafter 'Hornsea Four') which will be located approximately 69 km from the East Riding of Yorkshire in the southern North Sea and will be the fourth project to be developed in the former Hornsea Zone. Hornsea Four will include both offshore and onshore infrastructure including an offshore generating station (wind farm), export cables to landfall, and on to an onshore substation (OnSS) with energy balancing infrastructure (EBI), and connection to the electricity transmission network.

1.1.1.2 Details of the activities and infrastructure associated with Hornsea Four are fully set out in **Volume A1, Chapter 4: Project Description**.

1.2 Purpose

1.2.1.1 The Outline EBI Safety Management Report sets out measures to inform the detailed design of the Hornsea Four EBI in respect of hazard identification. In the event that Hornsea Four is granted development consent, a detailed EBI Hazard Identification (HazID) Report will be prepared and agreed with the relevant planning authority prior to construction of DCO Work No. 7(b), in accordance with the principles established in this Outline EBI HazID Report. This is secured by Requirement 26 of the draft DCO (**Volume C1.1**) which states:

> ***26.***—*(1) Work No. 7(b) must not commence until an energy balancing infrastructure HazID report (which accords with the outline energy balancing infrastructure HazID report) has been submitted to and approved in writing by the relevant planning authority.*
>
> *(2) The energy balancing infrastructure HazID report must be implemented as approved.*

1.3 Aims and objectives

1.3.1.1 This Outline EBI Safety Management Report aims to identify potential hazards associated with the EBI, outline key guidance, stakeholders, design approach in respect of hazards, and emergency response planning.

2 Energy Balancing Infrastructure

2.1.1.1 As the UK decarbonises power generation by moving away from conventional thermal generation that the electricity grid was designed to work with, and move towards greener but intermittent renewable energy sources, whilst at the same time changing how and when we use electricity, managing grid operations is becoming increasingly complex.

2.1.1.2 One of the many solutions required to enable this transition and ensure a continuous robust supply of electricity is energy storage, which can be used in many ways to help manage the complex physical behaviour created as a result of how we produce and use electricity.

2.1.1.3 Hornsea Four therefore includes energy storage as part of the proposed onshore infrastructure EBI, to manage current and future challenges of our changing energy system. The energy storage technologies that form part of this EBI are developing and improving rapidly and the project aims to select the best technology solution closer to the time of construction.

3 Standards, Guidance and Legislation

3.1.1.1 The Applicant utilises and will abide by standards set out by the parent company Orsted, who has a strong base in standards compliance, involved in developing new industry standards for the wind industry, and a leading member of global industry organisations. The work done as an organisation tries, where possible, to provide a global framework that can be locally applied.

3.1.1.2 An example of this is the Control of Hazardous Energy (CoHE) Committee. As the wind industry grew, on and offshore, a range of protocols to protect operatives from hazardous energy were developed. The differences between company systems were small, but each company was required to ensure their operatives and any other staff working on their systems had training in the relevant protocol.

3.1.1.3 This caused huge difficulty for mobility of operatives, and disputes between organisations on whether to use Lock-Out, Tag-Out (LOTO) or Wind Turbine Safety Rules (WTSR), both essentially the same requirements but applied in a different way. Orsted set up the CoHE Committee and mapped out all known protocols against the most widely applied international standard for this area, that being EN50110.

3.1.1.4 This approach meant that within Orsted there is a common set of requirements for CoHE that are anchored in a known and widely accepted standard. Provided any protocol a supplier or partner wishes to use meets the requirements of that standard, then Orsted will accept the protocol. This structure also gives the organisation a means to audit and control the quality of the application of any given CoHE protocol.

3.1.1.5 This example illustrates how Orsted approach global and regional matters which can pose some difficulty in terms of legal and other standards. In terms of Energy Storage Solution (ESS), Orsted would look into three main areas:

- Technical documentation;
- Standards documentation (Health and Safety Executive (HSE) Design); and
- Legal documentation (UK and EU [ADR Orange Book] HSE).

3.1.1.6 Some of the standards have been discussed in this document, others are set out in the Orsted Design Risk Management (DRM) Process document. The following list comprises the key UK Statutory Instruments that must be complied with for EBI:

- Health and Safety at Work etc Act 1974;
- Management of Health and Safety at Work Regulations 1999 Regulation 3;
- Dangerous Substances and Explosive Atmosphere Regulations 2002;
- Electricity Safety, Quality and Continuity Regulations (ESQCR) 2002;
- Construction (Design and Management) Regulations 2015;
- The Workplace (Health, Safety and Welfare) Regulations 1992;
- The Work at Height Regulations 2005;
- Electricity at Work Regulations 1989;
- The Provision and Use of Work Equipment Regulations 1998;
- The Manual Handling Operations Regulations 1992;
- The Control of Electromagnetic Fields at Work Regulations 2016;
- Low Voltage Directive and the Electrical Equipment (Safety) Regulations 1994; and
- Engineering Recommendation G59.

4 Design Approach

4.1 Recent Experience, Lessons Learned and Continuing Consultation

4.1.1.1 Lessons learned from recent fires involving battery storage highlight the need to ensure Emergency Services can have vision of what is taking place inside the battery storage units without entering those units. This comprises remote monitoring of battery rooms etc. avoiding key risks such as flame blow back and chemical risk.

4.1.1.2 Another important lesson is in situations where suppressant gases have failed to contain and extinguish the fire, water to cool the fire source and surrounding area must be used, for this to affect the seat of the fire, either Emergency Services must be able to direct water onto the seat of the fire, or an internal water mist system must be fitted.

4.1.1.3 Therefore, going forward, in addition to employing the DRM process (see **Section 4.2**), the Applicant will actively engage the chosen technology provider and the local Fire and Rescue Service to develop a fire management strategy to ensure all parties are aware of the necessary processes in the unfortunate event that a fire may occur.

4.2 The Orsted DRM Process

4.2.1.1 Design decisions are made throughout the development of any given design. **Figure 1** illustrates how those design decisions are recorded and used with the Active Risk Management (ARM) system to form a common risk register which is developed from concept to implementation.

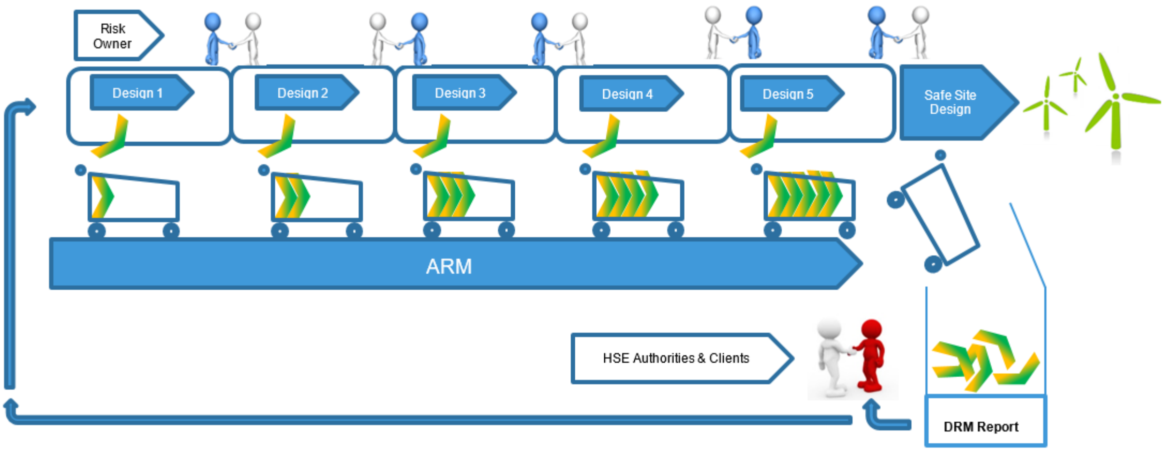

Figure 1: Orsted DRM Process illustrated.

4.2.1.2 In line with ISO31000 the DRM Process requires a "*risk owner*" at each stage of development. Orsted have a *gate model* for all asset development, and the DRM process utilises the gate model to identify both risk owners and *interfaces* between the risk owners. The interfaces are the 'gates' in the gate model, where the downstream risk owner accepts the asset project from the upstream risk owner; as the common risk register is part of the deliverables to be handed over, management of risk is *embedded* in the Orsted business model.

4.3 Principles of Prevention & Hierarchy of Control

4.3.1.1 UK HSE set out *principles of prevention* in Schedule 1 of The Management of Health and Safety at Work Regulations 1999. They are listed below for reference, with particular attention being drawn to item g). This is embodied in the Orsted DRM Process, with other notable principles embedded in process, namely a) c) and e), all aimed at "*avoiding risk*" by design.

a. avoiding risks;
b. evaluating the risks which cannot be avoided;
c. combating the risks at source;
d. adapting the work to the individual, especially as regards the design of workplaces, the choice of work equipment and the choice of working and production methods, with a view, in particular, to alleviating monotonous work and work at a predetermined work-rate and to reducing their effect on health;
e. adapting to technical progress;
f. replacing the dangerous by the non-dangerous or the less dangerous;
g. developing a coherent overall prevention policy which covers technology, organisation of work, working conditions, social relationships and the influence of factors relating to the working environment;
h. giving collective protective measures priority over individual protective measures; and
i. giving appropriate instructions to employees.

4.3.1.2 Use of the hierarchy of control in all design and management functions is detailed in the DRM Process, and aligns with the DRM governing standards of ISO31000, ISO12100, ISO14000, ISO45000. **Figure 2** is from the American National Institute for Occupational Safety and Health (NIOSH)[4], which leads the initiative called Prevention through Design (PtD) to prevent or reduce occupational injuries, illnesses and fatalities through safe design.

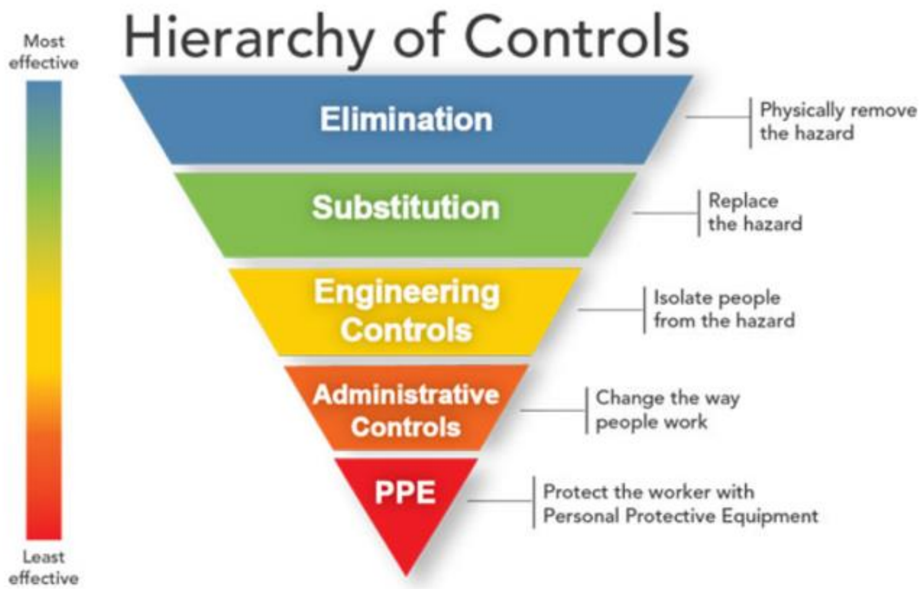

Figure 2: NIOSH (America) Prevention thought Design initiative Hierarchy of Control.

4.4 Risk Controls and Incident Mitigations

4.4.1.1 Orsted apply the hierarchy of control as shown in **Figure 2** to *eliminate* as much risk through design as possible, an example in EBI is to remove the need for Firefighters to enter the site by allowing fire control to be managed remotely. *Substituting* water for fire suppressant gas as first stage action to knock down the fire prevents the healthy batteries being shorted and potentially adding to the fire. Use of collective *engineering controls* to reduce risk, the residual risk can be seen in the compartmentation and site layout, as well as the inbuilt fire control and monitoring systems discussing in this document. Finally, "*administrative controls (procedures)" and "personal protective equipment (PPE)"* are used to ensure all who access the EBI understand the inherent hazards and the associated risks on-site and known how to behave in every foreseeable and any unforeseen incident.

4.4.1.2 The DRM Process relies on the output of verified risk analysis, which if not available through the supply chain is obtained by use of the following hazard identification and risk analysis tools. Some of these are applied by internal subject matter experts, others are managed by selected external subject matter experts, but all feed the DRM Process with accurate up to date information.

4.4.1.3 Below are some of the *Risk Control Studies* that would be used in any major facility design process. The outcome of these studies would feed information into the *Risk Consideration in Design* workflow; the list here illustrates some of the consideration for an EBI. Finally, for any remaining risk, Incident Mitigation Measures would be considered; the list provided illustrates what these may contain for an EBI.

- Risk Control Studies:
  - Failure Mode and Effects Analysis (FMEA);
  - Technology Risk Assessment;
  - Technology Maturity Study;
  - Technology Qualification;
  - Bow Tie Analysis (define multiple barriers);
  - Human Factor (Design) Analysis;
  - Fault Current Analysis Study – Incident energy generation and release;
  - HazID;
  - Hazard and operability study (HAZOP);
  - Emergency Response Plan (ERP) effectiveness study;
  - Task based Risk Assessment (RA); and
  - Method Statement – Safe System of Work (SSoW) using CoHE with LOTO/WTSR isolation protocols.

- Risk Consideration in Design:
  - Energy storage selection and layout;
  - Internal segregation of modules inside storage units;
  - Isolation of storage units within the facility;
  - External ancillary, monitoring, and switching equipment (remove spark and maintain control);
  - Remote Ventilation System;
  - Remote electrical isolation of facility;
  - Overcurrent detection and protection; and
  - Short circuit protection.

4.4.1.4 Condition Monitoring (Failure modes and effects analysis (FMEA and FMECA) 5.3.5); other energy storage units and so lead to a major accident at the site or on any associated transmission equipment.

4.4.1.5 An example of the information Orsted can already use as verified data input to the design and risk analysis process can be taken from an extract from Considerations for ESS Fire Safety, Jan 18th 2017, DNV-GL:

"Application of UN 38.8 Abuse Tests identified 8 abuse factors, and for all known fire at that time, the cause of the fire could be traced to one or more of these 8 factors:

1. *Low ambient pressure*
2. *Overheating*
3. *Vibration*
4. *Shock*
5. *External short circuit*
6. *Impact*
7. *Overcharge*
8. *Forced discharge"*

4.4.1.6 Taking these 8 factors into the initial design discussions and into the HazID part of the design phase will allow specific verification that they have been suitably mitigated against.

4.4.2 Protection Controls

4.4.2.1 With generator sourced energy, an electrical fault will activate a suitable *protective device* that cuts off the energy source and even trips the generator/energy storage facility, with wind down energy diverted to dump loads. This is a well understood and mature system of control to protect people and the system.

4.4.3 EES Security, Access, and Facility Building

4.4.3.1 All energy production facilities are designed to be secure, including those unstaffed facilities such as wind turbines and substations that Orsted routinely build and operate. The EBI will share the same security arrangements.

4.4.3.2 Fencing surrounding the EBI is secured through Requirement 12 of the Hornsea Four draft DCO (**Volume C1.1**). Access is taken from the A1079 via a dedicated construction and operational access track, ensuring access for operational and emergency vehicles if required.

4.4.3.3 Access to site for authorised persons will be by prior arrangement, and where appropriate will require a Permit to Access and/or a Permit to Work.

4.4.3.4 All buildings and equipment will be made secure in that no exposed conductors will be part of the facility design, and measures to prevent theft of such conductors or misadventure by a member of the public, will be taken. Security alarms, and suitable response arrangements will be made should any foreseeable breach of the security measures be made.

4.4.4 Measures identified by Environmental Risk Assessment

4.4.4.1 An environmental risk assessment (**G1.2 Environmental Risk Assessment of the Onshore Substation and Energy Balancing Infrastructure (AS-020)**) has identified measures to be incorporated during the detailed design and operation of the EBI. These will be considered as part of the detailed design process and the creation of the detailed HazID Report, pre-construction:

- EBI technology safety will be considered at the time of detailed design;
- An Emergency Action Plan will be developed with key stakeholders including Humberside Fire and Rescue Service, as part of the detailed HazID Report;
- The following operational systems and design features will be considered as part of the detailed design:
  - Battery Management Systems (if used, dependant on technology choice during detailed design) used on all batteries installed in EBI;
  - Use of power quality meters to check for damage to the electrical equipment and condition monitoring system installed.;
  - Ground fault detection;
  - Buildings separated into fire zones so that a fire cannot spread from one zone to another;
  - Fire walls utilised to separate components from each other to avoid spread;
  - Onsite firefighting equipment where applicable;
  - Fire detection and suppression systems installed;
  - Sprinkler systems and CO_2 systems in place where such systems can be used to eliminate a fire;
  - F-Stop system installed to electrically isolate batteries (if used, dependant on technology choice during detailed design) in the event of a fire or other emergency situation;
  - Oil-filled components installed with oil dump tanks so that the oil can be removed from the components quickly and there is a flame trap between the component and dump tank so that the fire cannot spread;
  - Automatic shutoff valves installed on drainage systems(s) to contain and prevent the release of fire water;
  - The volumes of hazardous substances stored onsite are likely to be small and will be stored in suitable primary containers that comply with relevant legislation and/ or best practice guidance;
  - Primary containers are stored within suitable secondary containment system designed to hold 110% of largest container/ 25% of the total volume, whichever is the greater of the two; and
  - Suitable spill response equipment provided with personnel trained in spill response, including the provision of annual drills.

5 Subsequent Hazard Identification and Risk Analysis Process

5.1.1.1 **Hazard Analysis** - Following a decision to build the EBI, the outline hazard identification that underpins this document would be developed significantly using *process hazard* analysis tools such as FMEA/FMECA, HIRA, HAZID, HAZCON, and HAZOP.

5.1.1.2 **Risk Rating** - As preparation for these design, operation, and failure mode risk analysis events, the document review undertaken for this submission would be revisited and updated. As the Applicant has an active interest in EES, monitoring of new and developing technology as well as incidents and failures in this area are tracked. Orsted's risk matrix provides a common framework to help risk assessors ensure a consistent approach to rating a wide range of risks.

5.1.1.3 Teams of subject matter Experts are consulted or assembled, and a QHSE Specialist from the Design HSE department facilitates the process of risk rating. Information from the extensive experience within Orsted is leveraged during this process and lessons learned from previous projects and known industry developments are implemented. This begins in the design phase to achieve 'safety by design' and continues at every stage of the project development resulting in the lowest possible risk profile within the given business case.

5.1.1.4 **Recording of Risk** - Orsted DRM process guides each Risk Owner along the hazard identification and risk analysis journey. From conceptual design through to operation, suitable hazard analysis and risk management protocols ensure all risk is managed to ALARP levels. Design decision logs are maintained by the design teams in a manner most suitable to each discipline. These feed into the company Active Risk Management (ARM) system, which is the common platform to record all risk. ARM follows the design and project through to implementation.

5.1.1.5 **Best Available Information** – Orsted's DRM is bult on a standards architecture including ISO31000 for management of risk which requires assessors to use 'the best available information' at the time of the risk assessment. The design teams consult with QHSE and other departments in Orsted to ensure they not only provide *the best available information* but also use the best available information within their designs.

5.1.1.6 **Continual Improvement** - Operations continue to use ARM in daily management of the assets to ensure we maintain all risk to ALARP and utilise the the PDCA cycle as set out in ISO principles. This continual improvement cycle also underpins the next projects design phase, with detailed data and information being linked from ARM back to the company document and process systems respectively.

5.1.1.7 **Management Oversight** – Every stage in the design, construction, commissioning and operation of any asset has management oversight. Large infrastructure projects utilise many different disciplines, each with their own Managers and leaders. As Orsted appoint a specific Senior Manager to every Asset Project, all the skill and knowledge of these many disciplines is orchestrated and managed to ensure every project is delivered on time in full, to the quality and low risk profile defined during development. This final stage of risk management is critical and results in a smooth transition from construction into operation of every Orsted project.

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