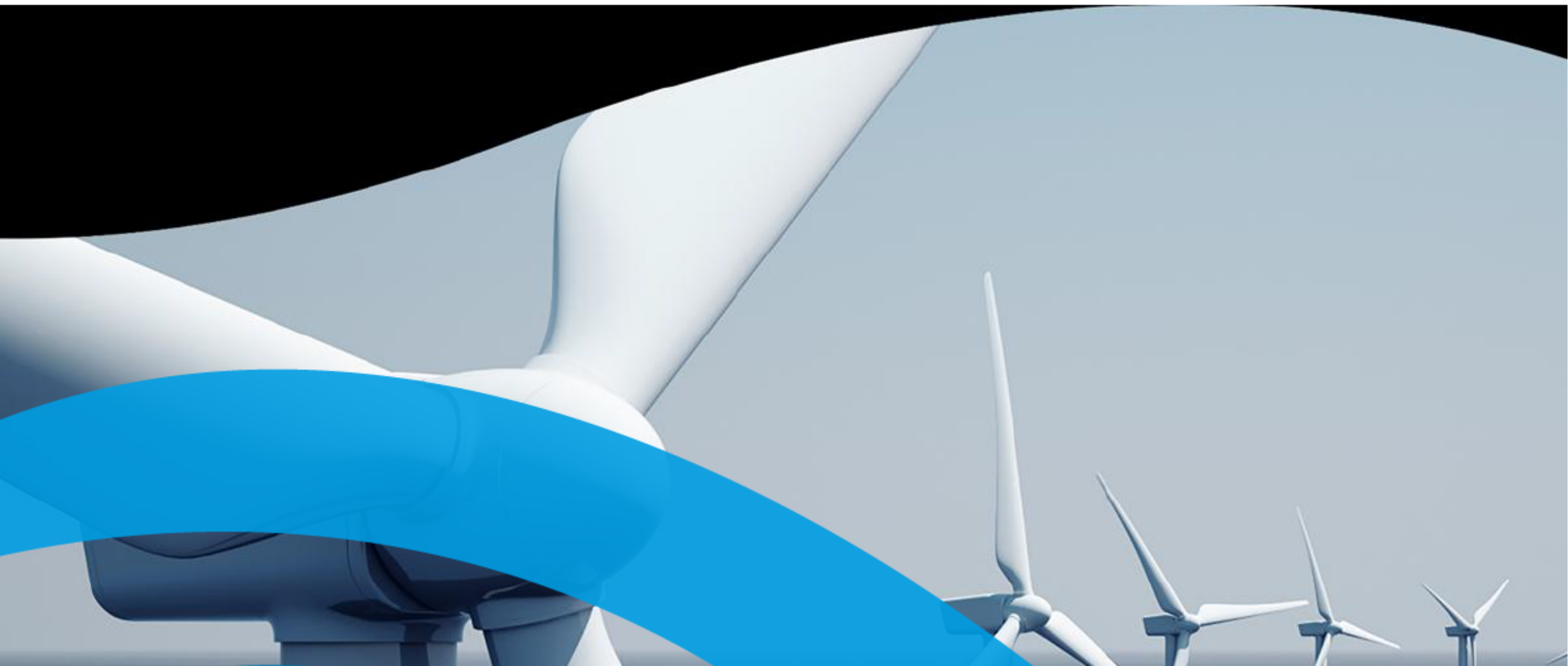
Muir Mhòr Offshore Wind Farm

Environmental Impact Assessment Report

Volume 1, Chapter 4: Site Selection and Consideration of Alternatives



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Contents

4. Site Selection and Consideration of Alternatives 1

4.1. Introduction 1
4.2. Project Evolution 3
4.3. Core Objectives of the Project 3
4.4. The 'Do Nothing' Scenario 5

Legislation and Policy Aims 5
Climate Change 6
Summary 8

4.5. Site Selection 10

Stage 1 - Development of the Sectoral Marine Plan and ScotWind Leasing Round 10
Stage 2 – Offshore Site Selection 12

4.6. Consideration of Alternatives 23

Design Envelope Definition and Refinement 23
Wind Turbine Generators 24
Mooring and Anchoring 26
Offshore Electrical platforms 26
Export Cables 27

4.7. Summary 28
4.8. References 29

Figures

Figure 3-1 Muir Mhòr Offshore Wind Farm – Array Area and Export Cable Corridor 2

Figure 3-2 Landfall Locations assessed 17

Tables

Table 3-1 The Core objectives of the Project 4

Table 3-2 Consideration of the 'Do Nothing' Scenario in the context of the Project Objectives 9

Table 3-3 Draft PO Identification: Key Stages (Scottish Government. 2020b) 11

Table 3-4 Summary of extreme metocean conditions. 14

Table 3-5 Metocean parameters for preliminary OEP(s) deep-water jacket design. 14

Table 3-6 RAG Ranking of Landfall Locations 18

Table 3-7 Assessment Summary of Landfall Locations 19

Table 3-8 Floater Concept Evaluation Matrix 25

Glossary

Term	Definition
Array Area	The area in which the generation infrastructure (including Wind Turbine Generators and associated foundations and inter-array cables), Offshore Electrical Platform(s), and an interconnector cable will be located.
Developer	Muir Mhòr Offshore Wind Farm Limited
E2	The ScotWind Plan Option Area where the Proposed Development is located
EIA Regulations	Collectively the term used to refer to The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017, The Marine Works (Environmental Impact Assessment) Regulations 2007, and The Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017.
Floating Foundations	The floating structures on which the Wind Turbine Generators are installed.
Foundation anchors	The structures which anchor the Floating Foundations to the seabed, connected to the foundation mooring.
Foundation mooring	The mooring structures which connect the Floating Foundations to the anchors.
Habitats Regulations	The Conservation (Natural Habitats, &c..) Regulations 1994, the Conservation of Offshore Marine Habitats and Species Regulations 2017 and the Conservation of Habitats and Species Regulations 2017
Inter-array cables	Cables which link the wind turbines generators to each other and the Offshore Electrical Platform(s).
Interconnector cable	Cable which links the Offshore Electrical Platform(s) to one another, allowing for power to be transferred between the platforms.
Landfall	The area between Mean High Water Springs (MHWS) and Mean Low Water Springs (MLWS) where the offshore export cables are brought onshore.
Offshore Electrical Platform (OEP(s))	Offshore platform consisting of High Voltage Alternating Current (HVAC) equipment, details depending on the final electrical set up of the Project.
Offshore Export Cable Corridor (ECC)	The area within which the offshore export cables will be installed.
Offshore export cables	The subsea electricity cable circuits running from the Offshore Electrical Platform(s) to the landfall which will transmit the electricity generated by the offshore wind farm to the onshore export cables for transmission onwards to the onshore substation and the national electrical transmission system along with auxiliary cables such as fibre optic cables.
Offshore transmission infrastructure	The proposed transmission infrastructure comprising: Offshore Electrical Platform(s) and associated foundations and substructures; the offshore export cables; and the landfall area up to Mean High Water Springs (MHWS).
Project	Muir Mhòr Offshore Wind Farm – comprises the wind farm and all associated offshore and onshore components.
Proposed Development	The offshore Muir Mhòr Offshore Wind Farm project elements to which this Offshore EIA Report relates.
Wind Turbine Generator (WTG)	The wind turbines that generate electricity consisting of tubular towers and blades attached to a nacelle housing mechanical and electrical generating equipment.

Acronyms

Term	Definition
AEP	Annual Energy Production
AI	Artificial Intelligence
AoS	Areas of Search
AOWF	Aberdeen Offshore Wind Farm
C	Celsius
CCC	Committee on Climate Change
CCUS	Carbon Capture, Utilisation and Storage
CES	Crown Estate Scotland
DND	Detailed Network Design
DPO	Draft Plan Option
ECC	Export Cable Corridor
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
ESO	Electricity System Operator
FEPM	Front-End Park Model
GHG	Greenhouse Gases
GIS	Geographic Information System
GW	Gigawatts
HDD	Horizontal Directional Drilling
HM	His Majesty
HND	Holistic Network Design
HNDFUE	Holistic Network Design Follow Up Exercise
HRA	Habitats Regulation Appraisal
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
INTOG	Innovation and Targeted Oil & Gas
IPCC	Intergovernmental Panel on Climate Change
km	Kilometre
kV	Kilovolts
MCAA	Marine and Coastal Access Act
MD-LOT	Marine Directorate-Licensing Operations Team
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
MPA	Marine Protected Area
NC MPA	Nature Conservation Marine Protected Area
NDC	Nationally Determined Contribution
NESO	National Energy System Operator

Term	Definition
NMP	National Marine Plan
NOAA	National Oceanic and Atmospheric Administration
O&C	Opportunity and Constraint
O&M	Operation and Maintenance
OCT	Open Cut Trenching
OEP(s)(s)	Offshore Electrical Platform(s)
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
OTNR	Offshore Transmission Network Review
OWEPS	Offshore Wind Energy Policy Statement
OWF	Offshore Wind Farm
PEXA	Practice and Exercise Areas
PMF	Priority Marine Feature
PO	Plan Option
RAG	Red Amber Green
RIAA	Report to Inform the Appropriate Assessment
SAC	Special Areas of Conservation
SEA	Strategic Environmental Assessment
SEIA	Social and Economic Impact Assessment
SMP	Sectoral Marine Plan
SPA	Special Protection Area
SSEN	Scottish and Southern Electricity Networks
SSSI	Site of Special Scientific Interest
TCSNP	Transitional Centralised Strategic Network Plan
TLP	Tension Leg Platform
UXO	Unexploded Ordnance
WTG	Wind Turbine Generator

4. SITE SELECTION AND CONSIDERATION OF ALTERNATIVES

4.1. INTRODUCTION

4.1.1. Muir Mhòr Offshore Wind Farm Limited (hereafter referred to as 'the Developer') is proposing to develop the Muir Mhòr Offshore Wind Farm (hereafter 'the Project'). The Project is made up of both offshore and onshore components. The subject of this offshore Environmental Impact Assessment Report (EIAR) is the offshore infrastructure of the Project seaward of Mean High-Water Springs (MHWS) which is hereafter referred to as 'the Proposed Development'.

4.1.2. The Muir Mhòr Array Area covers an area of approximately 200 km^2 and is located approximately 63 km east of Peterhead on the east coast of Scotland (Figure 4-1). The offshore infrastructure of the Proposed Development includes Wind Turbine Generators (WTGs) and associated floating foundations, the Offshore Electrical Platforms (OEP(s)) and associated foundations, the inter-array cables, interconnector cable, offshore export cables and landfall.

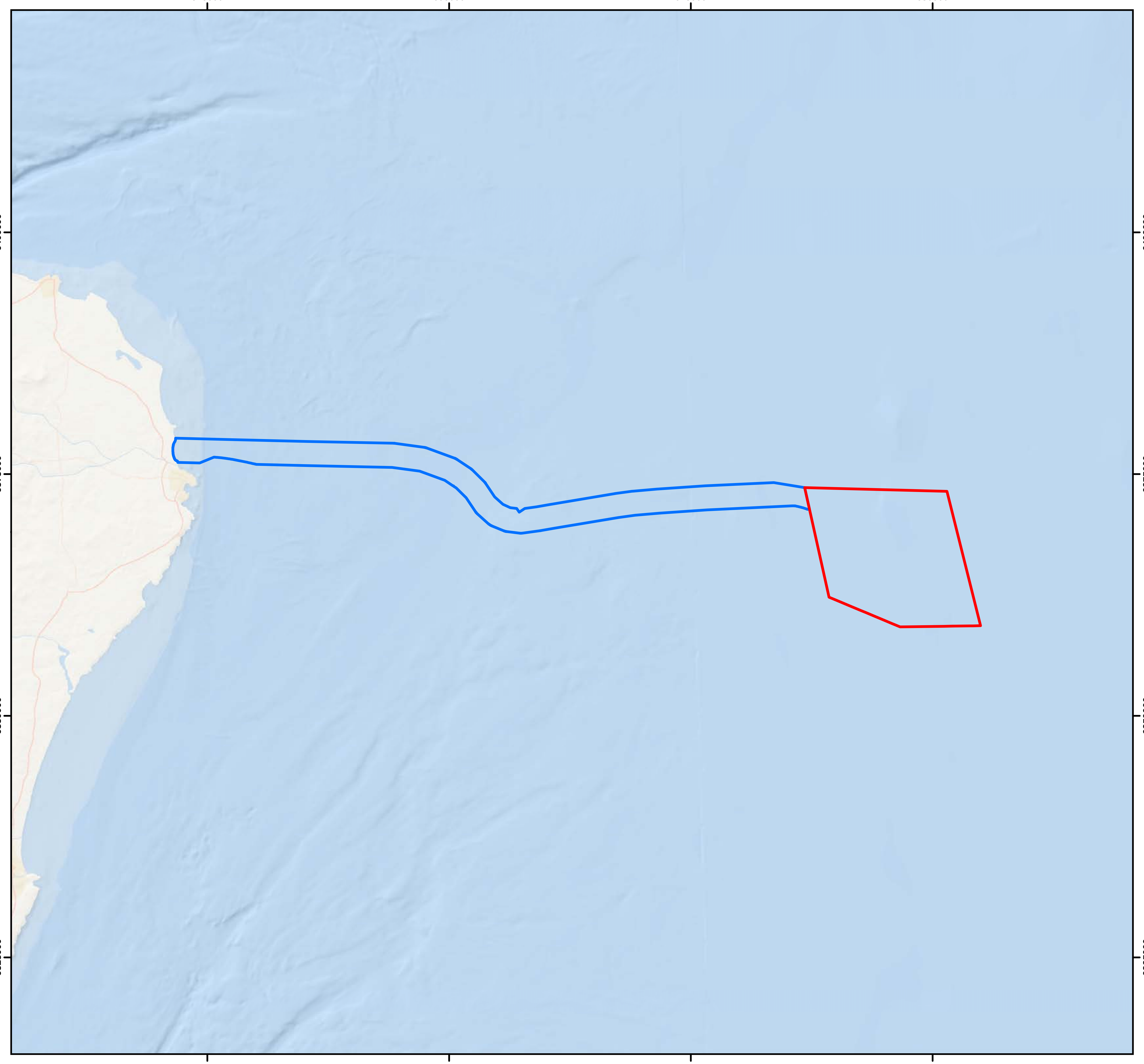
4.1.3. This Chapter outlines the site selection and alternatives process that was carried out by the Developer during the design of the Proposed Development. The process of identifying alternative sites and design options is discussed, as well as the 'do nothing' option that assesses the potential for the Project not being developed or commissioned.

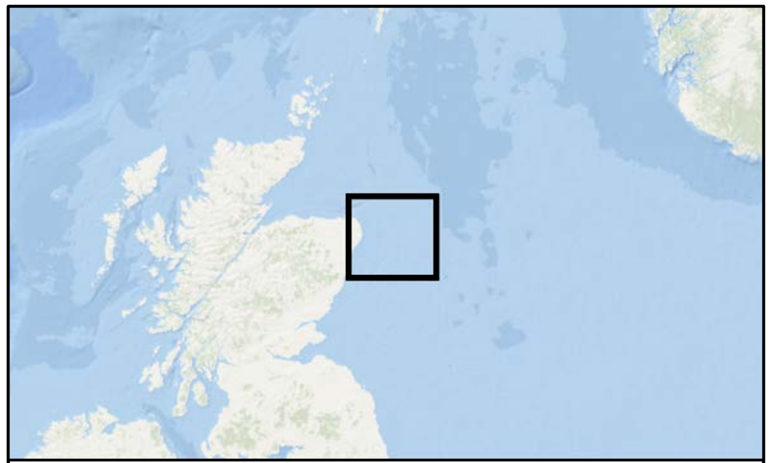
4.1.4. The Marine Works (Environmental Impact Assessment) Regulations 2007, the Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017 and the Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017 (hereafter referred to as the EIA Regulations) make provisions for the consideration of alternatives.

4.1.5. Schedule 3 of The Marine Works (Environmental Impact Assessment) Regulations 2007 state that the EIAR should include 'A description of the reasonable alternatives (for example in terms of project design, technology, location, size and scale) studied by the applicant, which are relevant to the proposed project, the regulated activity and their specific characteristics, and an indication of the main reasons for selecting the chosen option, including a comparison of the environmental effects'. Schedule 4, paragraph 2, of the Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017 and Schedule 4 paragraph 2 of the Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017 make similar provisions.

4.1.6. Accordingly, this Chapter sets out the justification for:

- The reasonable alternatives considered by the Developer in relation to the Proposed Development; and
- The process followed in defining the most appropriate design for the Proposed Development.





Legend:

- Array Area
- Offshore Export Cable Corridor

Project:	Report:
Muir Mhòr	Environmental Impact Assessment Report

Muir Mhor Offshore Wind Farm -
Array Area and Export Cable Corridor

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Map scale 1:400,000 @ A3 — 0 5 10 km

Co-ordinate system: ETRS 1989 UTM Zone 30N **EPSG:** 25830

MUIR MHÒR OFFSHORE WIND FARM
A joint venture between Fred. Olsen Seawind & Vattenfall

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4.2. PROJECT EVOLUTION

4.2.1. In response to the Scottish Government's target of net-zero emissions of all Greenhouse Gases (GHG) by 2045 and the aim to generate 50% of Scotland's overall energy consumption from renewable sources by 2030 (Scottish Government, 2020b), the Crown Estate Scotland (CES) launched the ScotWind Leasing process in June 2020, which released new areas of seabed within Scottish waters for future offshore development. The ambition was to offer 10 Gigawatts (GW) of offshore capacity within a series of Plan Option (PO) areas, identified by the Scottish Government as the most suitable areas for development as set out within the Sectoral Marine Plan (SMP) for Offshore Wind Energy.

4.2.2. As part of the CES ScotWind Leasing process in January 2022, the Developer was identified as the successful bidder and awarded an Option Agreement (granting exclusive rights) for what the Developer has named the Muir Mhòr Offshore Wind Farm, located within the E2 PO area.

4.2.3. The Developer intends to apply for the relevant consents and permissions required to enable construction, Operation and Maintenance (O&M) and decommissioning of the Proposed Development. The consents, licences and permissions which will be sought by the Developer for the Proposed Development include:

- A Section 36 consent under the Electricity Act 1989;
- A Marine Licence under the Marine and Coastal Access Act (MCAA) 2009 for the generating assets of the Project which are located beyond 12 nm limit within the Exclusive Economic Zone (EEZ); and
- A Marine Licence under the Marine (Scotland) Act 2010 for the offshore transmission infrastructure, which is within 12 nm of the coast, and under the MCAA for the offshore transmission infrastructure located beyond the 12 nm limit within the EEZ.

4.2.4. As details of design components require further refinement, the Developer has adopted a design envelope approach to the impact assessment (also known as a 'Rochdale Envelope'). In line with guidance from the Scottish Government (2022), the design envelope approach offers flexibility in the Environmental Impact Assessment (EIA) process by enabling impact assessment to be carried out against several potential design options. On the condition that sufficient detail is provided, impact assessment can be undertaken against the worst-case design parameters identified from design options. This approach enables developers to meet the requirements of the EIA Regulations for Section 36 consent applications under Electricity Act 1989, whilst the final detailed design for a project is still to be defined.

4.3. CORE OBJECTIVES OF THE PROJECT

4.3.1. The site selection and consideration of alternatives process has been informed by the overarching objectives of the Project. Details of these objectives are provided in Table 4-1.

Table 4-1 The Core objectives of the Project

Core Objective		Basis of the Objective
1	To generate low carbon renewable energy from offshore wind to support both UK and Scottish Government targets and commitments for renewable energy generation, offshore wind generation and decarbonisation	• Urgent decarbonisation is required to combat climate change and meet decarbonisation targets, including achieving Net Zero by 2045; and • A significant amount of renewable energy is required to meet these targets, of which the Project will contribute.
2	To increase energy security and stability in the UK and reduce reliance on international sources of supply	• Energy security is very important to public safety, and with events including the Covid-19 pandemic and Russian invasion of Ukraine, the UK's reliance on imported fossil fuels has been made clear; and • Increasing the renewable capacity within the UK will reduce the reliance on imported sources and therefore increase the UK's security with respect to both quantity and cost of energy.
3	To maximise renewable energy generation in Scottish waters within the 2030s	• There is limited seabed suitable for current fixed foundation based technologies, and therefore a limited generation capacity within Scotland if alternatives are not explored; and • Following decarbonisation targets and the threat of climate change, maximising the volume of generation is of great significance.
4	To lower electricity costs for the consumer in Scotland	• Imported fossil fuels have increased in end cost for the consumer following events such as Covid-19 and Russia's invasion of Ukraine; • Increasing UK energy sources will reduce the impact of external price fluctuations and reduce the end cost for the consumer; and • Low carbon renewable energy will help with the energy transition away from fossil fuels.
5	To develop a Scottish supply chain for offshore wind and other renewable energy sources	• Infrastructure must be developed for the construction and maintenance of the Project, which will result in an increased economic investment in the region.
6	To provide short and long term socio-economic benefits to local communities in Scotland	• The Project will bring investment to the local areas around the site (particularly the landfall location) resulting in increased jobs, investment, tourism and socio-economic benefits in local communities.

4.4. THE 'DO NOTHING' SCENARIO

4.4.1. The 'do nothing' scenario is a projection of the existing baseline to show what changes, if any, would take place if the Proposed Development did not go ahead. The following Section considers the 'do nothing' scenario in the context of the Project objectives set out in Table 4-1.

4.4.2. In accordance with the EIA Regulations, an assessment of the future baseline under the 'do nothing' scenario has been completed for all technical topics (see Volume 2, Chapters 7 to 20). The 'do nothing' scenario is an alternative that must be considered. If the Project does not go ahead, the core objectives set out above in Table 4-1 would not be met and the anticipated 1 GW capacity of energy from the Proposed Development would not be created. Additionally, a significant area of the seabed identified by the Scottish Government's SMP as suitable and made available for large-scale offshore wind development would not be developed in the near-term.

LEGISLATION AND POLICY AIMS

4.4.3. The Scottish Offshore Wind Energy Policy Statement (OWEPS) (Scottish Government, 2020b), building upon the ambitions outlined within the Scottish Energy Strategy: The Future of Energy in Scotland (Scottish Government, 2017) sets out the Scottish Government's ambition to capitalise on the potential that offshore wind development can bring to Scotland and the role this technology could play in meeting the commitment to reach net zero by 2045.

4.4.4. The Offshore Wind Policy Statement aims to have net-zero emissions of all GHG by 2045. Other interim targets included:

- Reducing emissions by 75 %, by 2030, against 1990 baseline;
- Reduce emissions by 90 % by 2040; and
- Limit global average temperature increase to 1.5°C or less.

4.4.5. The Scottish Government announced in April 2024 that they are to discard the target of reducing emissions by 75 % by 2030 compared to 1990 levels. The government has stated however, that it remains committed to achieving net-zero emissions by 2045 and will continue to work towards this goal.

4.4.6. Scotland, and the wider UK, have declared they face a global "climate change emergency". An emergency is a grave situation that demands an urgent response, and legal obligations have been committed to as follows:

- International: the United Nations Framework Convention on Climate Change led Paris Agreement (2015);
- Scotland: Climate Change (Scotland) Act 2009 and the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019; and
- UK: the Climate Change Act 2008 (as amended) and Glasgow Climate Pact (2021) (including Scotland and UK).

4.4.7. These legal instruments provide the commitments to become carbon neutral, by reaching "Net Zero" by 2045 in Scotland and 2050 in the UK.

4.4.8. The Scottish Energy Strategy (Scottish Government, 2017) outlines the Scottish Government's vision for the future energy system in Scotland. Renewable energy and low carbon energy solutions are two of six defined priorities. These priorities aim to enable Scotland to reach it's 2050 vision. By 2030 Scotland aims to produce 50 % of its heat, transport, and electricity consumption from renewable sources. The Scottish Energy Strategy highlights the success of Scottish projects in offshore wind and the potential of future coastal and offshore development.

4.4.9. Scotland cannot be expected to meet its target for offshore wind capacity if the Project does not go ahead. It would not be in the best interests of the climate emergency to 'do nothing'. For the Project, one of the key risks with the 'do nothing' scenario is being unable to contribute to addressing the need for decarbonisation of the UK energy supply.

4.4.10. The Proposed Development will contribute to achieving the goals set out by the Scottish Government. With targets being continuously reviewed, such as those outlined in The Climate Change (Scotland) Act 2009, the need for renewable development is increasingly important.

4.4.11. More detailed discussion of the relevant climate change regulations and obligations can be found in Volume 1, Chapter 2 (Legislation and Policy Context).

CLIMATE CHANGE

4.4.12. Human-induced global warming has reached approximately 1 ºC above pre-industrial levels and without a significant and rapid decline in carbon emissions across all sectors, global warming is not likely to be contained (Intergovernmental Panel on Climate Change (IPCC), 2021).

4.4.13. The Sixth IPCC Synthesis Report published in 2023 notes there is an urgent need for action to mitigate and reduce the probability of the most catastrophic events that could result from anthropogenic climate change. These events are forecast to have extremely adverse effects on human populations across the globe (IPCC, 2023).

4.4.14. A rise in global average temperature above 1.5°C has the potential to cause irreversible climate change, severe damage to livelihoods and widespread loss of life. Yet global GHG emissions (using Nationally Determined Contributions) are now set to result in a 1.5 °C increase by 2030 and look increasingly likely to exceed 2 °C after 2030 (IPCC 2023). Any delays in reducing carbon emissions incurred now, will make this challenge significantly more difficult in the future.

4.4.15. A review by the Committee on Climate Change (CCC) has reported the UK is not currently on track to meet the fourth (2023-2027) or fifth (2028-2032) carbon budgets and requires more challenging measures (CCC 2020; CCC undated).

SCOTTISH MARINE ENVIRONMENT

4.4.16. Specific climate change effects will be felt in UK waters. The Scottish marine environment will be subject to an increase in sea surface temperature. The rate of increase varies geographically, but between 1985 and 2009, the average rate of increase in Scottish waters has been greater than 0.2 °C per decade, with the south-east of Scotland having a higher rate of 0.5 °C per decade (Marine Scotland, 2011). A study completed over a longer period showed Scottish waters (coastal and oceanic) have warmed by between 0.05 °C and 0.07 °C per decade, calculated across the period 1870 – 2016 (Hughes *et al.*, 2018).

4.4.17. Ocean acidification is the process by which carbon dioxide in the atmosphere produced by human activities, is absorbed in the ocean which causes a decrease in pH of oceanic waters (Moffat *et al.*, 2020; National Oceanic and Atmospheric Administration (NOAA), 2020). Although the absorption of carbon dioxide from the atmosphere in oceanic waters is a natural process, increases in carbon dioxide in the atmosphere through human activities also increases the amount of carbon dioxide absorbed by oceanic waters which is driving ocean acidification and has implications on the flora and fauna which inhabit this environment (NOAA, 2020).

4.4.18. Ocean acidification impacts many species of marine life, particularly those species which form hard shells and skeletons such as shellfish and corals which can be decalcified or dissolved by decreased pH levels (IPCC, 2018). Fish species are also impacted by ocean acidification through changes in behaviour and reduction in growth, fitness and survivability (Smithsonian Institution, 2018; Fabry *et al*., 2008). As well as impacts to individual species, ocean acidification can affect whole ecosystems through disruption of food webs and changes in community structure (Doney *et al*., 2020).

4.4.19. Increased ocean acidification due to climate change will impact Scotland's marine species, habitats, and ecosystems. Crucial ecosystem services such as fisheries, shoreline protection and aquaculture will be at severe risk (Doney *et al*., 2020).

FISH AND SHELLFISH SPECIES

4.4.20. In addition, research has shown that climate change is already impacting fish species in Scottish and UK waters through changes in distribution, timing of life history events, and effects on body size (Wright *et al*., 2020). Increased occurrence of species more commonly found in warmer waters has been observed, alongside the reduction in occurrence of cold-water species, indicating shifts in distribution due to sea temperature change (Wright *et al*., 2020). A study by Townhill *et al*. (2023) which reviewed projected changes in distribution of 49 commercial fish and shellfish species due to climate change in UK waters showed they would likely become more suitable for species such as European seabass *Dicentrarchus labrax*, sardine Sardina pilchardus and anchovy *Engraulis encrasicolus*, and less suitable for species including Atlantic cod *Gadus morhua* and saithe *Pollachius virens*.

4.4.21. In addition, the frequency of occasional visitors to UK waters, such as blue-fin tuna *Thunnus thynnus*, has increased in recent years linked to increase in sea temperature and expansion of prey species range (Wright *et al*., 2020).

4.4.22. Some fish species have also been recorded to spawn earlier; four out of seven sole *Solea solea* stocks from across the UK were found to spawn at a rate of 1.5 weeks earlier per decade since 1970 (Wright *et al*., 2020). Further research indicates that sole are likely to continue spawning earlier based on the 2°C global warming scenario (Lacroix *et al*., 2018).

4.4.23. Climate change is also thought to be linked to decreases in body size of fish with one study by Baudron *et al*. (2014) showing that six out of eight commercial fish species examined from the North Sea over a 40-year period had an average decline in body size of 16 %. During this period, water temperature increased by 1°C to 2°C (Baudron *et al*., 2014). The impacts of climate change will lead to changes in marine ecosystems which will affect the productivity and economic sustainability of commercial fisheries, and food security (Wentworth and Stewart, 2019).

MARINE MAMMALS

4.4.24. Like fish species, marine mammals have also shown distribution shifts, thought to be linked to climate change. It is considered the northern extent of species is moving northward, evidenced by trends in strandings data from north-west UK waters (OSPAR III Region North) which showed that the proportion of warm water adapted species such as short-beaked common dolphin *Delphinus delphis* and striped dolphin *Stenella coeruleoalba* has increased over time, while the proportion of cold water adapted species such as Atlantic white-sided dolphin *Lagenorhynchus acutus* and white-beaked dolphin *L. albirostris* has decreased in the same region (Martin *et al*., 2023).

4.4.25. This same significant trend was also observed in north-east UK waters (OSPAR II North) however it was not as acute as north-west UK waters, (Martin *et al*., 2023). Distribution shifts of marine mammals are also thought to be related to changes in distribution of prey species which are more acutely impacted by factors such as sea temperature as discussed in paragraph 4.4.20. Changes in harbour porpoise *Phocoena phocoena* distribution in the North Sea have been observed over the past 20 years which are linked to changes in distribution of sandeel *Ammodytes spp*.

4.4.26. Changes in sea temperature has impacted the timing of phytoplankton blooms and peaks in copepod abundance which feed upon phytoplankton. Key timings in the lifecycle of sandeel rely on copepod production; changes in the peaks of copepod abundance means that sandeel lifecycles no longer correlate as effectively and recruitment (i.e. the process of small, young fish transitioning to larger, older fish [Camp *et al*., 2020]) has declined. This is thought to be a key driver in the observed distribution shifts of harbour porpoise (Martin *et al*., 2023). Increases in sea temperature, reduction in prey availability and reduction in habitat availability are likely to have severe impacts upon marine mammal species, particularly those species which are already threatened or those with a limited habitat range (Kebke *et al*., 2022).

SEABIRDS

4.4.27. Climate change is considered one of three key threats to UK seabirds (Pearce-Higgins, 2021). Seabird populations can be impacted directly and indirectly by climate change. Environmental changes, such as occurrence of storm events causing occasional high mortality of seabirds in breeding and wintering areas, and sea level increases causing breeding failure due to water inundation of low-lying nests, are examples of direct impacts to seabirds. These direct impacts are likely to increase due to climate change, both in terms of frequency and intensity (Daunt and Mitchell, 2013). Indirect impacts such as changes in prey abundance, distribution and quality, can also impact seabird abundance and distribution. A study by Johnston *et al.* (2013) indicated that under a high climate change scenario by 2080, the number of internationally important breeding seabirds around the UK are projected to decline by more than 50 %, with 40 % of species projected to be Red-listed due to climate change.

SUMMARY

4.4.28. Rapid decarbonisation is critical to tackling the climate emergency and the cost-of-living crisis by reducing Scotland and the UK's reliance on natural gas. The Proposed Development is within Scottish waters, where floating offshore wind can be delivered at scale. The Proposed Development will connect to the grid network in timescales that are essential for achieving Scotland's and the UK's path to net zero, realising Scotland's ambitions for 11 GW offshore wind connected to the grid by 2030 as set out in the Scottish Government's SMP for Offshore Wind (Scottish Government, 2020a).

4.4.29. Table 4-2 summarises the outcomes under the 'do nothing' scenario in the context of the Project objectives. The development of the Project will make a substantial contribution towards the UK's and Scotland's climate change targets and the commitments towards reaching net zero. Without the development of the Project, these targets and commitments will be more difficult to achieve.

Table 4-2 Consideration of the 'Do Nothing' Scenario in the context of the Project Objectives

Project Objective		Outcome in the 'Do Nothing' Scenario	Summary of Outcomes from Development of the Project
1	To generate low carbon renewable energy from offshore wind to support both UK and Scottish Government targets and commitments for renewable energy generation, offshore wind generation and decarbonisation	Objective not achieved Doing nothing would not contribute towards decarbonisation targets	The electricity generated by the Project will reduce carbon emissions when compared to other, conventional higher carbon emitting forms of energy generation and, as such, will contribute to meeting UK decarbonisation goals. With the expectation that the Project will generate energy in the early 2030's, it will provide an important contribution to achieving UK and Scottish legislative and policy commitments. By developing a floating offshore wind farm (OWF) in an area of seabed unavailable to other foundation types, the Project is maximising the potential for decarbonisation and climate change targets to be met.
2	To increase energy security and stability in the UK and reduce reliance on international sources of supply	Objective not achieved Doing nothing would not contribute to increasing energy security	With the potential to generate 1 GW of clean energy, the Project will make a significant contribution to the UK's offshore wind network and domestic energy supply and by connecting to the National Grid Network.
3	To maximise renewable energy generation in Scottish waters within the 2030s	Objective not achieved Doing nothing would not generate any renewable energy in Scottish waters	By developing a floating OWF in an area of seabed unavailable to other foundation types, the Project is maximising the potential for renewable energy generation in Scottish waters within the 2030s.
4	To lower electricity costs for the consumer in Scotland	Objective not achieved Doing nothing would not contribute to changing energy costs, potential increase in cost due to reliance on non-renewable sources	By increasing UK energy sources, the impact of external price fluctuations for fossil fuels will be reduced and the end cost for the consumer will therefore also decrease.
5	To develop a Scottish supply chain for offshore wind and other renewable energy sources	Objective not achieved Doing nothing would not develop the Scottish supply chain	Infrastructure must be developed for the construction and O&M of the Project, which will result in an increased economic investment in the region
6	To provide short- and long-term socio-economic benefits to local communities in Scotland	Objective not achieved Doing nothing would not provide any socio-economic benefits	The Project will bring investment to the local areas around the site (particularly the landfall location) resulting in increased jobs, investment, tourism and socio-economic benefits in local communities

4.5. SITE SELECTION

4.5.1. The site selection process for the Proposed Development has been guided and informed by key events in the Project's development timeline:

- Stage 1 – Development of the SMP and ScotWind Leasing Round; and
- Stage 2 - Offshore Site Selection - Array Area and Offshore Export Cable Corridor (ECC)

STAGE 1 - DEVELOPMENT OF THE SECTORAL MARINE PLAN AND SCOTWIND LEASING ROUND

4.5.2. In November 2017, CES announced their intention to run a leasing round for commercial scale offshore wind energy projects in Scottish Waters. This round became known as ScotWind and was the first offshore wind leasing round in Scotland for over a decade. This initiative was consistent with the Draft Energy Strategy and Just Transition Plan (Scottish Government, 2023) which envisaged further offshore wind developments playing a key role in Scotland's future energy mix. To inform the spatial development of this leasing round, Marine Scotland, as Planning Authority for Scotland's Seas was required to undertake a planning exercise, in accordance with relevant European Union, UK and Scottish legislation (CES, 2022).

4.5.3. As identified by the Scottish Government, offshore wind has the potential to play a pivotal role in Scotland's energy system over the coming decades. This resulted in the SMP being developed to identify areas suitable for the future development of commercial-scale offshore wind energy in Scotland (Scottish Government, 2020a). The Draft SMP was published in December 2019 and identified 17 Draft Plan Option (DPO) areas. The final plan was published in October 2020 and identified 15 PO areas split across four regions around Scotland, (two of the DPO areas were not progressed).

4.5.4. The SMP process was iterative, informed through stakeholder engagement and evidence from the related social, economic and environmental assessments. Information and consultation feedback was gathered throughout the process and used to support the Scottish Ministers in identifying the POs and policies included in the SMP. Included within the process are Strategic Environmental Assessments (SEA) which require reasonable alternatives to be considered. The key steps to the SMP are detailed in Table 4-3.

Table 4-3 Draft PO Identification: Key Stages (Scottish Government. 2020b)

Stage	Details
Opportunity and Constraint Analysis – Iteration 1	Areas of Search (AoS) identified using an Opportunity and Constraint (O&C) analysis; built upon work carried out by Marine Scotland Science in 2011 and production of draft regional locational guidance for potential deep water floating offshore wind test sites in 2014. The O&C analysis sought to identify areas of opportunity for the future development of offshore wind, whilst also identifying areas that minimised potential negative impacts to the environment, other sectors and users of the sea.
Opportunity and Constraint Analysis – Iteration 2 - Single Issue Constraint Analysis	AoS were then refined, considering specific spatial issues and sectoral engagement workshop feedback. No commercial or technology specific information was used in this refinement process.
Scoping Consultation	Scottish Ministers consulted on the screening and scoping stages of the Plan during June and July 2018. Screening and Scoping Reports were prepared and published online for the Strategic Environmental Assessment (SEA), Habitats Regulations Appraisal (HRA) and Social and Economic Impact Assessment (SEIA) alongside the AoS scoping study.
Opportunity and Constraint Analysis – Iteration 3	Following consultation, the AoS were refined. Areas of seabed for offshore wind development proposed by stakeholders during scoping consultation were also considered at this stage.
Identification of DPOs	Twenty-two revised AoS were made available to the SMP Project Board and two Project Steering Groups for consideration and comment. Responses from the Project Board and Steering Groups, together with outputs from the initial assessments, were presented to Scottish Ministers to inform their decision on which AoS should progress to the Sustainability Appraisal for more detailed assessment. Seventeen AoS were selected as DPOs.
Assessment of DPOs	The DPOs identified were subject to SEA, HRA and SEIA with reports produced to summarise these.
Consultation on DPOs	Statutory consultation was held on the draft SMP Plan and Sustainability Appraisal for a period of 14 weeks between 18th December 2019 and 25th March 2020. In support of this, a total of 17 consultation events were held in coastal communities across Scotland during February and March 2020. In total, 443 responses were received.
Finalisation and adaptation of the SMP	Consultation responses were used to inform the Scottish Ministers' decision on the final POs which would be offered in the ScotWind leasing round.

4.5.5. The SMP was developed in accordance with the aims of the National Marine Plan (NMP) (Scottish Government, 2015) and sits alongside the Scottish OWEPS (Scottish Government, 2020b) to build a framework towards Scotland's sustainable green recovery.

4.5.6. It should be noted that the SMP is subject to an iterative review process to ensure that the SMP and its underpinning assessments are informed by the most up-to-date scientific research and understanding, the spatial/regional context of the SMP (i.e. level of construction, operational and other activity within the region) and the potential transboundary impacts are reflected accurately, and the prevailing market conditions, technological advancements and regulatory environment are reflected in the SMP, including grid connections and connections to coastal infrastructure.

4.5.7. To support this iterative review process, requests for new evidence which could impact the implementation of the SMP and resulting development will be submitted to key stakeholder representatives on at least an annual basis. The iterative review of the SMP takes place every two years following adoption (Scottish Government, 2020a). At the time of writing, the first iterative review cycle has concluded that the plan requires updating and the Marine Directorate have confirmed their re-assessment of the plan, which will include Innovation and Targeted Oil & Gas (INTOG) plans (Scottish Government, 2020a).

4.5.8. The first ScotWind leasing round was subsequently launched by CES in June 2020. In the ScotWind Leasing round, developers were able to apply for the rights to build offshore wind farms in Scottish waters. Within specified lease areas initially based upon the DPOs as per the SMP and subject to gaining the required consents. The final PO areas were published in October 2020.

STAGE 2 – OFFSHORE SITE SELECTION

SELECTION OF PREFERRED PLAN OPTION AREA FOR BID

4.5.9. The Developer sourced data on physical characteristics and existing infrastructure from in-house models and publicly available sources for Scotland to prioritise the SMP areas with most potential.

4.5.10. The prioritisation was based on the factors outlined below:

- Wind resource;
- Water depth;
- Wave height;
- Shipping lanes;
- Distance to shore;
- Military practice areas;
- Visual impact;
- Distance to port and Operations and Maintenance facilities;
- Oil & Gas infrastructure;
- Nearby wind farms / Agreements for Lease;
- Designated sites; and
- Radar visibility.

4.5.11. The data sourced in relation to the above factors was input into the Developer's Front-End Park Model (FEPM) to produce a heatmap which, when overlayed on the Marine Scotland Draft SMP for Offshore Wind Energy (January 2020), highlighted sites which could then be ranked by the Developer based on expected environmental acceptability.

4.5.12. Once suitable sites were ranked, the Developer identified E2 as the preferred PO area.

ARRAY AREA SITE BOUNDARY

4.5.13. Having identified the E2 PO as the preferred development site, the Developer commenced work to identify the preferred development area, i.e. the Array Area, within the E2 PO.

4.5.14. In recognition of the potential complex issues associated with ornithological interests with the East PO areas and wider region, the Developer has engaged with and collaborated with other developers that were awarded projects within the East PO region via the East Ornithology Group.

4.5.15. Selection of the Array Area was an important step in the preparation of the ScotWind bid application and considerable work was done ahead of the bid application to define these areas.

4.5.16. Key technical parameters assessed to inform the selection of the Array Area (within the E2 PO), included wind resource, bathymetry, ground and metocean conditions, WTG sizing, foundation technology options as well as WTG layout flexibility.

4.5.17. A desktop study of the soil conditions of the full E2 area using available data from the British Geological Survey was conducted. The data quality provides a general understanding of the seabed soil types and the stratigraphy of the Quaternary sediments.

4.5.18. The water depths within E2 range from 60 m in the southwest to 95 m in the northwest, with a mud-filled channel reaching a maximum depth of 120 m at the eastern boundary. Seabed rugosity increases towards the east with ridges in E2 mostly orientated south to north. The seabed consists of sand, slightly gravelly sand, and gravelly sand. The gravelly sand is deposited in the shallower parts and the sand in the deeper parts. This is in general consistent with the coarser material being deposited in higher energy shallower water. The sediments below seabed, of Quaternary age, consist of soft mud, and of firm and interbedded lithologies.

4.5.19. In general, the entire E2 area seems suitable for all possible anchoring options, but the Western Section has the least rugosity and no undifferentiated sediments. Therefore, the Developer focused on this area.

4.5.20. The bathymetry map for the Array Area shows a gently sloping site from a depth of 60 m in the south-west to 95 m in the north-west, which suggested that the ground conditions are well suited for the construction of a floating wind farm with drag embedded anchoring solution.

4.5.21. The Developer embarked on a wind energy yield analysis to assess the expected future Annual Energy Production (AEP) at the site. Using WindPRO wind modelling software to provide a site-specific estimate of local wind conditions at 150 m above sea level, the site can expect constant winds from South South West at an average wind speed of 10.7 m/s, ensuring a favourable energy yield.

4.5.22. The Developer assessed local metocean conditions using regional models of wave, wind, currents, and water levels from their Metocean Database. For the proposed Array Area, publicly available data is at a resolution of the wave model is ~5 km for this region, whilst the hydrodynamic model has a resolution of 2-3 km. The database was compared to the nearest available measurements at X: 711421, Y: 6345079 ETRS 1989 UTM 30N, and a small adjustment was made to wave values based on this comparison. Metocean time series data was analysed using inhouse programs to calculate all parameters required for conceptual wind farm design, see Table 4-4.

Table 4-4 Summary of extreme metocean conditions.

Parameter	Mean	1 year max	50 year max	100 year max
Significant wave height [m]	2.01	7.6	10.3	10.7
Associated peak wave period [s]	N/A	12.3	14.1	14.4
10 minutes wind speed [m/s]	10.8	34.5	44.0	45.4
High still water level [m]	N/A	1.60	1.99	2.04
Depth-averaged current speed [m/s]	0.25	0.73	1.03	1.11

4.5.23. Further parameters were calculated to support preliminary jacket design studies for the OEP(s)s. These were calculated as per standard DNV-GL-ST-0145 and are presented in Table 4-5. Sea level rise was calculated to be 8 mm/yr.

Table 4-5 Metocean parameters for preliminary OEP(s) deep-water jacket design.

Parameter	Value
Air gap [m]	2.14
Sea level rise over jacket lifetime [m]	0.24
High still water Level (100 years) [m]	2.04
Maximum wave crest (100 years) [m]	11.83
Total [m]	**16.25**

4.5.24. The Developer's Geographic Information System (GIS) team analysed existing and planned infrastructure including oil and gas, telecommunication, and power cables, within the proposed Array Area, and its surroundings, to aid in defining the most suitable wind farm area.

4.5.25. The proposed site has no existing wells, platforms, pipelines, cables or other wind farms with just one active gas pipeline, which runs parallel to the northern boundary, and thus the proposed Array Area was deemed highly suitable for wind farm development.

4.5.26. The proposed wind farm location within SMP E2 considers potential energy yield, physical characteristics and infrastructure limitations. Using knowledge and experience of Aberdeen Offshore Wind Farm (AOWF) and North Sea development sites, environmental constraints have been reviewed to minimise impacts and maximised the likelihood of consent. Analysis conducted by the Developer's GIS team shows that the proposed CRT-2A has many desirable features for a floating offshore wind farm, including:

- No visual impact from land: The proposed site is located approximately 63 km from the shore therefore there will be no visual impacts from the WTGs once in situ;
- Key Conservation Sites: the Array Area is outside any existing Natura 2000 sites and Marine Protected Areas (MPAs). The nearest Special Protection Area (SPA) is 65 km from the site (Buchan Ness to Collieston Coast SPA). The site is adjacent to but avoids the Turbot Bank MPA;
- Areas for navigation: The proposed site is outside any main shipping routes and is in an area of low vessel density (annual average of 1-250 vessels (MMO, 2018));
- Other infrastructure: The site does not overlap with any major oil and gas infrastructure. Hywind is the closest operational wind farm and is 38 km to the west of the site;

- Commercial fishing: At the time of bidding, evidence showed that the site has low density fishing activity (MMO annual fishing effort data 2017); and
- Archaeology: There are no known wrecks within the site.

GRID CONNECTION

4.5.27. The grid infrastructure to connect the Array Area to the National Grid was considered within the National Grid's Holistic Network Design (HND) which was published in July 2022 and which details *"a single, first-of-its-kind, integrated design for connecting 23 GW of offshore wind, and was the first step towards a more centralised, strategic network planning"*. The HND seeks to coordinate the development of infrastructure *"…to bring power to the grid cohesively, ensuring maximum benefit for consumers, local communities and the environment"*. The grid infrastructure to connect the Array Area is identified in the HND 'Beyond 2030 Report' as a project that is *"in scope for coordination*.

4.5.28. The Project will have an anticipated generation capacity of approximately 1 GW using floating offshore wind technology. The Developer is required to transmit the generated wind power at the Array Area to the National Grid. Information on the potential for coordination is not yet fully defined by National Grid, but the outcome of the HND shows the Project connecting to Peterhead, and as such the application for the Proposed Development has been undertaken on the basis that a grid connection offer will be secured for the Project at a proposed new substation owned and operated by Scottish and Southern Electricity Networks (SSEN), located at Netherton, west of Peterhead (application reference: APP/2024/1714)[1]. This substation is referred to throughout the Chapter as the 'SSEN Netherton Hub'. The connection point at the SSEN Netherton Hub has been identified following discussions with National Grid and SSEN, as further explained in the landfall Section below.

4.5.29. It should be noted that the grid connection point was not confirmed during the initial stages of the site selection and design process. As such, alternatives were considered based on a number of potential grid connection points on the east coast of Scotland and the location and design of the Proposed Development evolved as more information on the eventual grid connection point became available throughout the process, as further explained below. The Developer will continue to engage with National Energy System Operator (NESO) on the HND process and to the extent coordination is required.

LANDFALL

4.5.30. As part of the initial pre-Scoping process, and prior to the identification of the SSEN Netherton Hub as the proposed grid connection point, an area of search along the coastline from approximately St. Fergus to Dundee was investigated. This was to identify suitable landfall sites for the Project in proximity to existing onshore substations owned by SSEN to allow connection to the grid. These potential grid connection points were located at Peterhead, Newmachar, Fiddes and Tealing.

4.5.31. Informed by discussions with National Grid and SSEN, it was subsequently identified that the Project would connect to the grid at a new 400 kV substation being developed by SSEN either to the north, south or west of Peterhead. The final location of the new substation was later confirmed to be at Netherton, to the west of Peterhead. The landfall area of search was

[1] An application for planning permission in principle (PPP) to construct and operate the SSEN Netherton Hub was submitted to Aberdeenshire Council and validated on 18th October 2024. Application Reference: APP/2024/1714.

therefore refined to focus on identifying a suitable landfall for the Project to the north or south of Peterhead.

4.5.32. Five potential landfall locations were initially identified as being feasible, as shown on Figure 4-2. These landfall locations were then further reviewed and appraised against technical and environmental criteria to identify, on balance, the most suitable landfall location for the Project. This exercise was undertaken by consultant J Murphy & Sons Ltd, on behalf of the Developer, and included a site visit to the landfall locations with the Project Team. The exercise included the preparation of conceptual landfall cross Section drawings. At the time it was understood that base case is for three HVAC cables for the Proposed Development.

4.5.33. J Murphy & Sons Ltd assumed the following for their analysis:

- Anticipated cable diameter will have a nominal diameter in the region of 300 mm[2]; and
- Cable system design life is currently 50 years.

4.5.34. This formed the assessment of the potential landfall and construction techniques.

[2] The parameters used in this early stage desktop study may differ from the maximum parameters noted in the Project Description Chapter. This is due to the refinement of the project design.

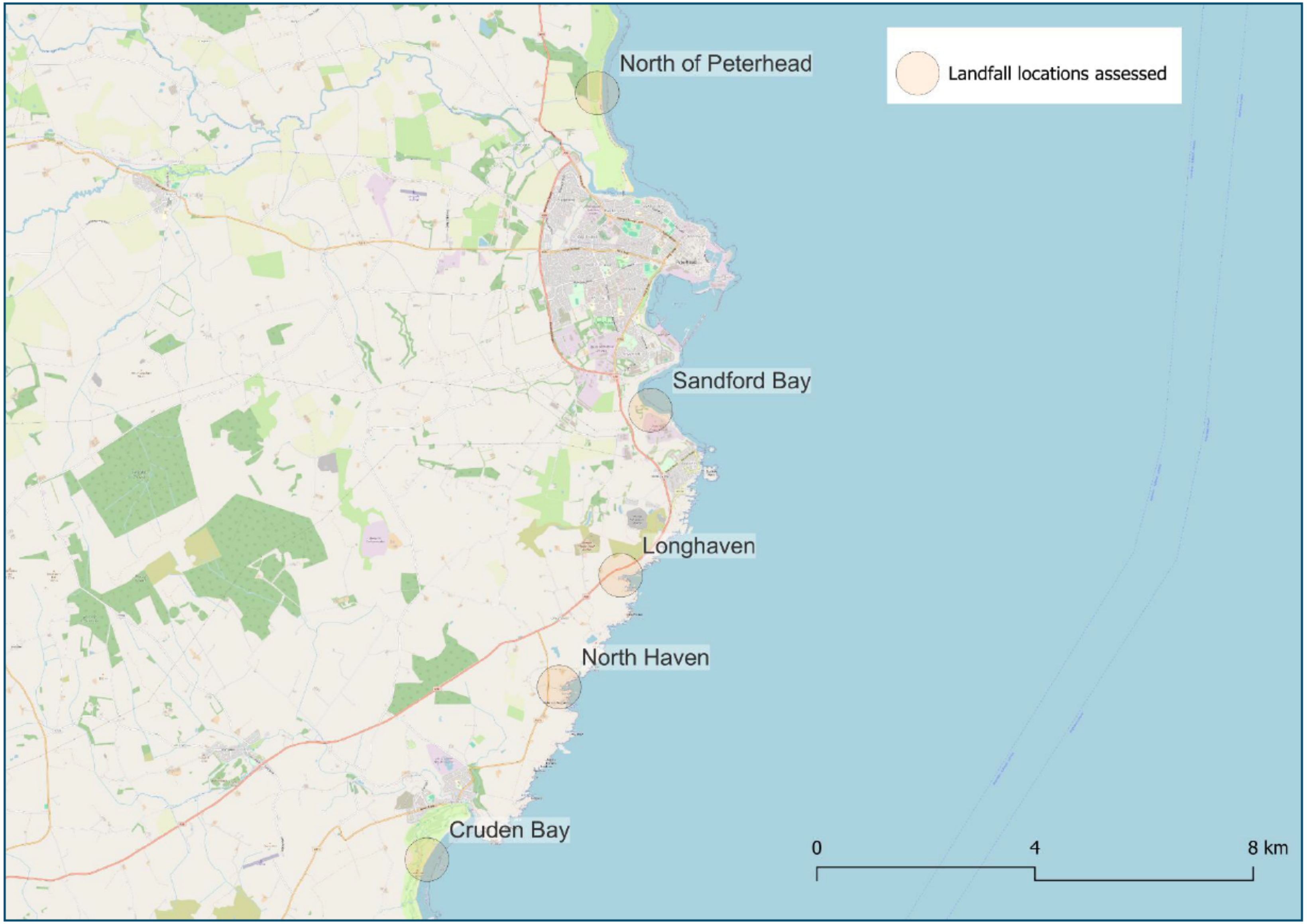

Figure 4-2 Landfall Locations assessed

4.5.35. The five potential landfalls considered are located within the EIA Scoping Area presented within the July 2023 EIA Scoping Report (Volume 3, Appendix 5.1 (Offshore Scoping Report)), shown in Figure 4-2.

4.5.36. The following criteria were used in the review:

- Topography;
- Bathymetry;
- Access;
- Geology, anticipated ground conditions for construction methods;
- Location (such as onshore cable route length to grid connection point);
- Environmental constraints; and
- Physical constraints (such as offshore infrastructure).

4.5.37. From the five locations a recommendation on the most suitable landfall location is shown in Table 4-6 below. This is based on a simple Red Amber Green (RAG) rating system.

Table 4-6 RAG Ranking of Landfall Locations

Landfall Location	Topography	Bathymetry	Access	Geology / Ground Conditions	Location	Environmental Constraints	Physical Constraints
North of Peterhead	Green	Green	Green	Green	Green	Green	Green
Sandford Bay	Amber	Green	Amber	Green	Green	Amber	Red
Longhaven	Red	Green	Green	Amber	Amber	Amber	Red
North Haven	Red	Green	Amber	Amber	Amber	Amber	Green
Cruden Bay	Amber	Green	Amber	Green	Amber	Red	Red

4.5.38. An assessment summary for each potential landfall location is also presented in Table 4-7 below.

Table 4-7 Assessment Summary of Landfall Locations

Landfall Location	Assessment	Summary
North of Peterhead	• Short distance (6.8 km linear distance) for onshore cables from landfall to SSEN Netherton Hub; • Absence of any environmental designations (SPA, SSSI, SAC or MPA) both onshore and offshore; • Suitability of various different landfall techniques and topography generally suitable for trenchless methods; • Gently sloping topography and bathymetry suitable for vessels; • No existing cables/pipelines or other offshore infrastructure; and • Good access from the A90. Approximately 600 m of new access track required to access the landfall location.	Shortlisted due to proximity to Netherton Hub, no environmental designations, good access from A90.
Sandford Bay	• Short distance (6.8 km linear distance) for onshore cables from landfall to SSEN Netherton Hub; • No offshore environmental designations (SPA, SSSI or MPA) however there is an offshore SAC in the southern part of Sandford Bay. Potential noise sensitive receptors in proximity to landfall location; • Published geology and available borehole data indicates that pinkish granite of the Peterhead Pluton is present from ground level onshore, offshore 5 m to 20 m of superficial sediments can be expected making HDD possible but challenging; • Gently sloping topography and bathymetry suitable for vessels; • Presence of existing offshore infrastructure. Landfall locations within the boundary of Scottish and Southern Electric (SSE) Peterhead Power Station. Sandford Lodge Farm Cottages may require demolition to make landfall. Eastern Greenlink Projects interact with Proposed Development; and • Good access from the A90.	Not shortlisted due to the challenging topography and ground conditions, potential conflicts with existing and new offshore infrastructure and the presence of environmental designations.
Longhaven	• Longer distance (8.1 km linear distance) for onshore cables from landfall to SSEN Netherton Hub; • Interacts with environmental designations including Buchan Ness to Collieston Coast Special Protection Area (SPA), Buchan Ness to Collieston Special Area of Conservation (SAC) and Buller of Buchan Coast Site of Special Scientific Interest (SSSI); • Significantly challenging topography with steep cliffs above the bay on either side and rock outcropping visible into the sea at the landfall location; • Deep water for vessel support and short trenchless crossing option under cliffs; • No other offshore infrastructure; and • Close proximity to the A90 for access.	Not shortlisted due to the significantly challenging topography, the confines of the small bay, the presence of the offshore reef and the presence of environmental designations.
North Haven	• Longer distance (8.8 km linear distance) for onshore cables from landfall to SSEN Netherton Hub;	Not shortlisted due to the significantly

Landfall Location	Assessment	Summary
	• Potential interaction with Buchan Ness to Collieston Coast Special Protection Area (SPA), Buchan Ness to Collieston Special Area of Conservation (SAC) and Buller of Buchan Coast Site of Special Scientific Interest (SSSI); • Published geology and available borehole data indicates that pinkish granite of the Peterhead Pluton is present from ground level onshore, offshore 5 m to 20 m of superficial sediments can be expected making HDD possible but challenging; • Significantly challenging topography with steep cliffs above the bay on either side and rock outcropping visible into the sea at the landfall location; • There is an offshore reef approximately 100 m from the coast; and • Access off A90 via A975 road to landfall location. 200 m to 500 m of new access track required to access the landfall location.	challenging topography, the confines of the small bay, the presence of the offshore reef and the presence of environmental designations.
Cruden Bay	• Significantly longer distance (10.9 km linear distance) for onshore cables from landfall to SSEN Netherton Hub; • Potential interaction with the following environmental considerations, Buchan Ness to Collieston Coast Special Protection Area (SPA), Ythan Estuary, Sands of Forvie and Meikle Loch Special Protection Area (SPA), Buchan Ness to Collieston Special Area of Conservation (SAC), Buller of Buchan Coast Site of Special Scientific Interest (SSSI) and good classification Bathing Waters within Cruden Bay; • Gently sloping topography; • Long crossing length compared to other landfall options to reach adequate water depth; • There is an offshore reef approximately 100 m from the coast; • Presence of offshore pipelines in the southern portion of Cruden Bay as well as offshore cables; and • Access off A90 via smaller roads to landfall location. 200 m to 500 m of new access track required to access the landfall location.	Not shortlisted due to the length of onshore cable to Netherton, interaction with environmental constraints, potential interaction with existing infrastructure and length of HDD required to reach adequate water depths beyond reef.

SELECTED LANDFALL LOCATION

4.5.39. The outcome of the landfall appraisal exercise shortlisted the landfall location North of Peterhead. This was due to the following key reasons:

- This location offers flexibility in the number of construction techniques that can be adopted for the installation of the offshore export cables;
- The landfall site has good accessibility to the national road network;
- No statutory designated sites of environmental interest were recorded within the landfall site[3];
- The bathymetry indicates the seabed is gently sloping and there is adequate sediment cover for the conventional anchoring of offshore support vessels;
- The site is located in proximity to the proposed SSEN grid connection location at Netherton; and
- There is also good availability of land parcels for the Project to utilise for landfall and other infrastructure required between landfall and the SSEN Netherton Hub, including the onshore substation.

4.5.40. To conclude, the proposed landfall location for the Project is located North of Peterhead, to the north of Craigewan Links Golf Course and to the east and Lunderton. The selection of North of Peterhead was completed in parallel with the offshore ECC route selection, see following Section.

OFFSHORE EXPORT CABLE CORRIDOR SITE BOUNDARY

4.5.41. The offshore ECC is the area within which the offshore export cables will be installed, from the OEP(s)(s) within the Array Area to landfall.

4.5.42. The offshore ECC was identified in parallel with the onshore scoping boundary to ensure a joined-up approach between the offshore and onshore elements of the Project, led by the selected landfall site.

4.5.43. As part of the early design work for the Proposed Development, the Developer collaborated with Consultants to utilise an Artificial Intelligence (AI) powered route engine, 'Optioneer', which can simultaneously analyse many qualitative and quantitative factors that impact onshore and offshore cable development to propose optimum route scenarios for route corridors and grid connections.

4.5.44. The Optioneer process combines both engineering requirements (e.g. route geometry, crossing requirements, protection / installation methods) and environmental constraints (e.g. no-go zones, hard and soft constraints) to quickly generate feasible route options and visualise large amounts of data along each route profile. Optioneer works by systematically exploring the study area to understand constraints such as existing seabed infrastructure, changes in seabed depth, slope and sediment, environmentally sensitive areas and determine how best to avoid or address these given different engineering requirements.

[3] It is noted that two non-statutory designated sites, Rattray Head to Peterhead Local Nature Conservation Site (LNCS) and the North East Aberdeenshire Coast Special Landscape Area (SLA), are located within the landfall area; however, the LNCS extends along the length of the coastline from Peterhead to Rattray Head the SLA extends along the coastline from Peterhead to Fraserburgh, and so are unavoidable.

4.5.45. Hard constraints are defined as environmental or technical constraints that will provide a significant risk to consenting (and subsequent offshore wind farm development) and therefore it was deemed necessary to fully avoid these areas of seabed/marine environment. Hard constraints considered within the Optioneer process included, but were not limited to:

- Other offshore wind farms;
- Oil and gas infrastructure;
- Unexploded Ordnance (UXO) dumping grounds; and
- Disposal and dumping at sea sites.

4.5.46. Soft constraints are defined as environmental or technical constraints that are likely to not provide a significant risk to consenting (and subsequent offshore wind farm development). These soft constraints were to be avoided unless no suitable alternative route is possible. Soft constraints considered within the Optioneer process included, but were not limited to:

- Geology and seabed sediments;
- Grid connection (cable length to shore);
- Subsea cables and pipelines;
- Carbon Capture, Utilisation, and Storage (CCUS);
- Practice and Exercise Area (PEXA) areas;
- Commercial fisheries;
- Areas of difficult slopes;
- Fish spawning grounds;
- Shellfish water protected areas;
- Designated bathing waters;
- Shipping and navigation;
- Designated sites for nature conservation, which included:
  - MPAs;
  - Special Areas of Conservation (SACs);
  - Special Protected Areas (SPAs);
  - Sites of Special Scientific Interest (SSSIs); and
  - Ramsar sites.
- Seal haul out sites;
- Protected habitat (Annex I);
- Priority Marine Features (PMFs);
- Archaeology (wrecks);
- Mineral safeguarding and extraction sites; and
- Recreational activity.

4.5.47. A key consideration during the offshore export cables routing was the presence of the following designated sites:

- Turbot Bank Nature Conservation Marine Protection Area (NC MPA) - designated for sandeels. It was considered that the Turbot Bank NC MPA would be elevated to a hard constraint due to the proximity of the site to the Array Area;
- Southern Trench NC MPA - designated for burrowed mud, minke whale (*Balaenoptera acutorostrata*), fronts and shelf deeps (both large scale features), and geomorphological features (Quaternary of Scotland - sub-glacial tunnel valleys, Quaternary of Scotland – moraines, and Submarine Mass Movement - slide scars); and
- Buchan Ness and Collieston Coast SPA – designated for breeding fulmar (*Fulmarus glacialis*) and breeding guillemot (*Uria aalge*). It was considered that the Buchan Ness and Collieston Coast SPA would be elevated to a hard constraint to reduce potential effects on seabirds.

4.5.48. The Optioneer process started with the collation of all geospatial data layers for the hard and soft constraints, including elevation model, ground conditions, technical and environmental constraints within the study area, into the project space. All the data layers (i.e. constraints) were then reviewed and ranked using a common ranking criterion. This formed the 'Design Rules' for the route generations.

4.5.49. Following the definition of the 'Design Rules', offshore routes between the different connections point were generated using Optioneer based on the defined 'Design Rules'.

4.5.50. For each route generated, Optioneer provided a score which could then be analysed and compared with other routes. Based on the outcome, generated routes could either be modified manually and re-evaluated or alternatively, 'Design Rules' could be updated, and routes reevaluated. This formed part of an iterative routing process.

4.5.51. Following confirmation of the grid connection location in Peterhead, the most optimal routes for the five potential landfall locations (North of Peterhead, Sandford Bay, Longhaven, North Haven and Cruden Bay) were considered in greater detail.

4.5.52. The Optioneer process concluded with the offshore ECC as presented in Figure 4-1 which then makes landfall at North of Peterhead, located north of the boundary of the Peterhead Golf Course. A corridor of 750 m width either side of the route (i.e. total corridor with of 1,500 m) was selected for survey works.

4.6. CONSIDERATION OF ALTERNATIVES

4.6.1. The sections below provide a summary of the key alternatives considered for the Proposed Development. Further detail on the final proposed design is provided in Volume 2, Chapter 3 (Project Description).

DESIGN ENVELOPE DEFINITION AND REFINEMENT

4.6.2. The 'design envelope' includes a necessary degree of flexibility to accommodate further project refinement during 'detailed design', carried out during the post consent stage. The Proposed Development requires flexibility in choice of foundation and infrastructure options, specific siting of infrastructure, and construction methodologies, to ensure that anticipated changes in available technology and project economics can be accommodated within the final design. The final design will also depend on factors including ground conditions, wave, and tidal conditions, and procurement approach.

4.6.3. The Scoping Report for the Proposed Development was submitted to the Marine Directorate-Licensing Operations Team (MD-LOT) in June 2023, see Volume 3, Appendix 5.1 (Offshore Scoping Report). The Proposed Development retained several options associated with different aspects of the design, including floating foundation options, electrical infrastructure and cable landfall installation techniques.

4.6.4. Since the submission of the Offshore Scoping Report, several refinements have been made to the design envelope presented in the EIAR. These refinements are summarised below with further details presented in Volume 1, Chapter 3 (Project Description):

- Reduction in the dimensions of all floating foundation options;
- Removal of the spar and semi-spar floating foundation options;
- Reduction in the maximum anchor pile diameter (14 m to 4 m) and maximum anchor pile penetration depth (70 m to 60 m);
- Selection of High Voltage Alternating Current (HVAC) OEP(s) (and abandonment of High Voltage Direct Current (HVDC) option);
- Removal of gravity base OEP(s) foundation option;
- Removal of subsea OEP(s) option;
- Selection of HVAC offshore export cables (and abandonment of HVDC cables); and
- Reduction in maximum offshore export cable length from 360 km to 270 km.

WIND TURBINE GENERATORS

TYPE OF WTG FOUNDATIONS

4.6.5. The Proposed Development is based on floating WTGs rather than traditional fixed bottom foundations. The selection of floating WTGs for the Proposed Development is driven primarily by the environmental constraints of the E2 Plan Option Area, a key aspect being the water depth of the site, with deeper waters requiring floating foundations.

4.6.6. If fixed foundation turbines are selected for the Proposed Development, this would result in greater environmental impacts compared to floating. Effects such as underwater noise and suspended sediment would be higher, due to the increased requirement for traditional piling methods and offshore installation activities (ICF, 2020). Additionally, there would be significant cost increases for fixed foundations in the area.

4.6.7. The Developer carried out a technological review of the different WTG concepts coming to market. This review considered site data, concept readiness, and complexity parameters, with a focus on local supply opportunities and risk limitation. This analysis was conducted in close collaboration with suppliers. The local supply chain for delivery of floating foundations is seen as a vital part of the technical feasibility study and included a review of potential contributions from manufacturers in delivering components, competences, and services.

4.6.8. Floating turbines were found to have the following benefits over bottom fixed turbines for the Proposed Development from an installation perspective:

- Floating turbines can be fully assembled at suitable local Scottish ports. The areas have extensive local employment and supply chain from the Oil and Gas Industry and the assembly will support that transition away from fossil fuels;

- Foundation fabrication and anchoring point installation is taken off the critical path, increasing schedule flexibility;
- Reduction in overall offshore installation activity, benefiting safety, cost, and risk. Offshore heavy lifting equipment is a significant project cost, which is increased in the event of weather delay. If wind turbines are assembled and commissioned inshore, a significant reduction in weather, and therefore financial, risk can be achieved as well as providing safe working for the employees; and
- During O&M, the ability to tow turbines back to a port or harbour for repairs or major component exchange, eliminates the need for unscheduled offshore heavy lifting with weather downtime risk.

4.6.9. The Developer's foundation team also carried out a technological review to determine the most suitable WTG foundation type. Each floater concept (Tension Leg Platform (TLP), Semi-submersible, Barge and Spar) was scored between 0 and 3 with 0 indicating unsuitability and 3 indicating preferable concepts (see Table 4-8). Based on the evaluation, semi-submersible floating was identified as a potentially preferred technology.

Table 4-8 Floater Concept Evaluation Matrix

System Name	TLP Concept	Semi-submersible	Barge Concept	Spar Concept
Overall Rating	18	22	20	15
Turbine Integration	2	3	3	1
Ease of Maintenance	2	3	3	2
Fit for site specific water depth	2	3	3	1
Technology Readiness Level	1	3	2	3
Anchorage/fixation Type Complexity	1	3	3	3
Manufacturing Complexity	3	2	2	2
Draft during Construction	3	2	2	1
Seabed Coverage	3	2	2	1

MINIMUM BLADE TIP CLEARANCE

4.6.10. The minimum blade tip clearance (clearance between the rotor blades and sea surface) requirements are set by MGN 654 where a 22 m minimal air gap is mandated for safe navigation.

4.6.11. Due to the horizontal and vertical movements resulting from the pitch of floating foundations increases in minimum blade tip clearance can result in increased stress on the tower, and greater wear on the turbine generator within the nacelle. Increased turbine heights could result in reduced operational lifespans of WTGs and require additional design elements to stiffen the tower and floating foundation and associated mooring and anchors therefore impacting technical and commercial feasibility.

4.6.12. Having regard to these points, the Proposed Development WTG design has an air gap of 30 m. This height has been driven by the balance of collision risk of protected seabird species with turbines and engineering considerations relating to the operational lifespan of the WTGs, with the conclusion drawn that the ability to further increase the air gap above 30 m is currently not technically feasible.

SIZE OF THE ROTORS/SWEPT AREA

4.6.13. Smaller rotors for the same number of turbines would result in a lower generation capacity which would limit the ability of the Proposed Development to contribute to the various UK and Scottish targets or the project objectives. It is considered by the Developer that most capacity currently in planning will be required to achieve the decarbonisation targets.

4.6.14. Smaller rotors to achieve the same offshore wind farm capacity would require a greater number of turbines which would increase the magnitude of potential effects on ornithology receptors and would potentially require an increased wind farm site area, and therefore increase the ecological impact associated with the Proposed Development. Therefore, this is not considered a feasible alternative.

MOORING AND ANCHORING

4.6.15. There are several mooring configurations under consideration for the Proposed Development, each with unique technical attributes. The configurations being considered are catenary mooring, semi-taut mooring, taut mooring, and tension mooring. The tension mooring configuration is specific to the TLP foundation type, whilst the other mooring configuration options may be applied across the remaining foundation topology options. The other mooring configurations are likely to include a length of mooring line running along the seabed, which is a key part of stabilising the floating foundation, along with the anchoring setup.

4.6.16. The mooring system may include a combination of mooring line materials such as chain, wire, synthetic rope and other materials that are yet to be developed for offshore wind mooring lines. Other typical ancillary components that may be present on each mooring line include clump weights (for stability); buoys/buoyancy modules; terminals and connectors for hook up and disconnection; load reduction devices; line tensioners and protection bushes. The requirement for and specification of these ancillary components is highly dependent upon the floating foundation and the site-specific metocean conditions, which will be developed as part of the engineering refinement process.

4.6.17. The anchors under consideration include drag embedded anchor (including vertical loaded anchor), plate anchor, pile anchor (driven or drilled / drilled and grouted), suction anchor and gravity anchor. The anchor type used for the Proposed Development is highly dependent on the soil conditions at the Array Area and will be developed as part of the engineering refinement process. It is foreseeable that a combination of different anchoring solutions may be required if there is a large variance in soil conditions across the site.

4.6.18. Further information on mooring and anchoring alternatives is given in Volume 2, Chapter 3 (Project Description).

OFFSHORE ELECTRICAL PLATFORMS

4.6.19. Two OEP(s) will be located in the Array Area. The OEP(s) are where the electricity carried by the Inter-Array cables is unified, transformed and then transmitted landward by the offshore export cables. The capacity of the OEP(s) will be such that there is up to 1GW of grid connection capacity.

4.6.20. The OEP(s) will step up the system voltage to 275 kV prior to export to shore. By increasing the voltage level prior to transmission, it is possible to maximise power flow, minimise electrical losses, and maintain voltage stability. Additionally, the higher power transfer per circuit reduces the number of export cables to shore, and hence reduces the environmental impact.

4.6.21. The maximum design envelope includes up to two OEP(s). It is anticipated the OEP(s) would be unmanned during operations. The location of the OEP(s) is intended to be central within the Array Area.

4.6.22. The OEP(s) will be designed as an above-sea platform with a fixed-foundation, unlike the floating WTGs. The Developer undertook concept evaluation for the OEP(s) foundation structures, comparing gravity-based foundations, monopiles, and jacket foundations. The primary consideration was ensuring a stable export to shore connection for the offshore grid infrastructure and maximising the uptime of the electricity supply.

4.6.23. The foundation designs under consideration for the fixed-foundation option are OEP(s) jacket(s) with either pin piles or with caissons.

4.6.24. Elements of the OEP(s) design will be influenced by the type of current to be transmitted by the offshore export cable infrastructure. Both HVAC and HVDC design options were originally considered for the OEP(s).

4.6.25. HVDC is capable of power transfer over significantly longer distances than HVAC. This technology is commercially available but has a far less comprehensive record in offshore wind compared to HVAC, as demonstration projects have tended to be nearshore. The relative lack of operational experience in HVDC technology compared to HVAC, significantly increases costs, and requires much larger onshore and offshore substations to be built. This higher capital intensity can only be economic for very large, multi-GW power transmission that would not be suitable for the capacity available at Peterhead.

4.6.26. HVAC power transmission is a technology with a high degree of maturity within both transmission and offshore wind sectors. To date, it has been used as the exclusive technology of choice for nearshore projects. The combined project parameters of capacity and overall export distance below 100 km place this specific project in the optimal window for an HVAC transmission solution. HVAC is therefore the selected technology for the OEP(s).

EXPORT CABLES

4.6.27. Offshore Export Cables transfer the power from the OEP(s) to the transition joint bay at landfall, where they are adapted, and the Onshore Export Cables begin which then connect to the grid. A maximum of three Offshore Export Cables is being considered as part of the Proposed Development with a maximum total length of 270 km. The Offshore Export Cables will be HVAC.

4.6.28. Due to the higher power rating requirement and longer transmission distance required, the offshore export cables will operate at a higher voltage than the Inter-Array Cables. Current commercially available marine cable technology offers export cable voltages up to 275 kV, although this technology is continuously evolving.

4.6.29. At Scoping the Developer was still considering multiple options for landfall location in the east coast of Scotland. With the refinement of the landfall location as Peterhead, the offshore cable length was reduced from 360 km to 270 km.

LANDFALL

4.6.30. At landfall two methods were investigated for crossing the intertidal area. These were Open Cut Trenching (OCT) and HDD. The selected landfall site allowed flexibility for either solution as it was a large beach with dunes further inland. When considering the options OCT was quickly seen to be less suitable due to a number of reasons. Primarily OCT means that construction of the ECC would occur within the particularity sensitive area of the intertidal area on the beach. Public access would also need to be restricted on the beach during construction and this would be detrimental to users of the beach. OCT through the dunes would be challenging due to the instability of the sand so additional reinforcing of the trench sides would be required. HDD removes the interactions at the intertidal area as HDD is set up from onshore inland of the beach. The drill will go underneath the intertidal area and seabed to a punch out location offshore. During construction the only area impacted is the HDD compound onshore.

4.7. SUMMARY

4.7.1. During the site selection and consideration of alternatives for the Proposed Development, the Developer has endeavoured, where possible to reduce environmental effects through the Proposed Development's design and the alternatives that have been considered.

4.7.2. As discussed in Volume 2, Chapter 6 (Environmental Impact Assessment Methodology), a worst case design scenario approach has been implemented when assessing any impacts arising from the Proposed Development as part of this EIAR. The final design will fall within the maximum worst case design scenario parameters to ensure that it is compliant with the Proposed Development as assessed in the EIAR.

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