



MORAY EAST

OFFSHORE WINDFARM

Piling Strategy

**Moray East Offshore Wind Farm Offshore Transmission
Infrastructure**

March 2019

Moray Offshore Windfarm (East) Limited

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List of Abbreviations

ADD	Acoustic Deterrent Device
CMS	Construction Method Statement
CoP	Construction Programme
CPT	Core Penetration Test
DDD	Drive – Drill - Drive
DSLPL	Development Specification and Layout Plan
ECoW	Ecological/Environmental Clerk of Works
EMP	Environmental Management Plan
EPS	European Protected Species
ES	Environmental Statement
FEED	Front End Engineering Design
JNCC	Joint Nature Conservation Committee
JUP	Jack-Up Construction Vessel
MFRAG	Moray Firth Regional Advisory Group
MMMP	Marine Mammal Monitoring Programme
MORL	Moray Offshore Renewables Limited
MS-LOT	Marine Scotland Licensing Operations Team
OfTI	Offshore Transmission Infrastructure
OSP	Offshore Substation Platform
PEMP	Project Environmental Monitoring Programme
PS	Piling Strategy
SNH	Scottish Natural Heritage
TI	Transmission Infrastructure
WTG	Wind Turbine Generator

Definitions

The following definitions have been used throughout this document with respect to the company, the consented wind farms and how these definitions have changed since submission of the Moray East Environmental Statement (ES) in 2012 and the Modified Transmission Infrastructure ES in 2014.

- **Moray Offshore Windfarm (East) Limited (formerly known as Moray Offshore Renewables Limited and hereinafter referred to as Moray East)** – the legal entity submitting this Offshore Transmission Infrastructure Piling Strategy (OfTI PS);
- **Moray East Offshore Wind Farm** – the wind farm to be developed in the Moray East site (also referred as the Wind Farm);
- **The Moray East site** – the area in which the Moray East Offshore Wind Farm will be located. Section 36 Consents and associated Marine Licences to develop and operate up to three generating stations on the Moray East site were granted in March 2014. At that time the Moray East site was known as the “Eastern Development Area” and was made up of three sites known as the Telford, Stevenson and MacColl Offshore Wind Farm sites. The Section 36 Consents and Marine Licences were subsequently varied in March 2018;
- **Telford, Stevenson and MacColl wind farms** – these names refer to the three consented offshore wind farm sites located within the Moray East site;
- **Transmission Infrastructure (TI)** – includes both offshore and onshore electricity transmission infrastructure for the consented Telford, Stevenson and MacColl wind farms. Includes connection to the national electricity transmission system near New Deer in Aberdeenshire encompassing AC offshore substation platforms (OSPs), AC OSP interconnector cables, AC export cables offshore to landfall point at Inverboyndie continuing onshore to the AC collector station (onshore substation) and the additional regional Transmission Operator substation near New Deer. A Marine Licence for the offshore TI was granted in September 2014 and a further Marine Licence for two additional distributed OSPs was granted in September 2017. The onshore TI was awarded Planning Permission in Principle in September 2014 by Aberdeenshire Council and a Planning Permission in Principle under Section 42 in June 2015;
- **Offshore Transmission Infrastructure (OfTI)** – the offshore elements of the transmission infrastructure, comprising AC OSPs, OSP inter-connector cables and AC export cables offshore to landfall;
- **Moray East ES 2012** – The ES for the Telford, Stevenson and MacColl wind farms and Associated Transmission Infrastructure, submitted August 2012;
- **Moray East Modified TI ES 2014** – the ES for the Modified Transmission Infrastructure works (revised export cable route) in respect to the Telford, Stevenson and MacColl wind farms, submitted June 2014;
- **The Development** – the Moray East Offshore Wind Farm and Offshore Transmission Infrastructure (OfTI);
- **Design Envelope** – the range of design parameters used to inform the assessment of impacts;
- **OfTI Corridor** – the export cable route corridor, i.e. the OfTI area excluding the Moray East site;
- **Wind Farm PS** – The PS produced to meet the requirements under the Telford, Stevenson and MacColl Offshore Wind Farms Section 36 Consents condition 11.

- **Moray East Offshore Wind Farm Consents** – are comprised of the following:

Section 36 Consents:

- Section 36 consent for the Telford Offshore Wind Farm (as varied) – consent under section 36 of the Electricity Act 1989 for the construction and operation of the Telford Offshore Wind Farm assigned to Moray East on 19 June 2018.
- Section 36 consent for the Stevenson Offshore Wind Farm (as varied) – consent under section 36 of the Electricity Act 1989 for the construction and operation of the Stevenson Offshore Wind Farm assigned to Moray East on 19 June 2018.
- Section 36 consent for the MacColl Offshore Wind Farm (as varied) – consent under section 36 of the Electricity Act 1989 for the construction and operation of the MacColl Offshore Wind Farm assigned to Moray East on 19 June 2018.

Marine Licences

- Marine Licence for the Telford Offshore Wind Farm (as varied) – Licence Number: 04629/18/1 – consent under the Marine (Scotland) Act 2010 & Marine and Coastal Access Act 2009, Part 4 marine licensing for marine renewables construction works and deposits of substances or objects in the Scottish Marine Area and the United Kingdom Marine Licensing Area transferred to Moray East on 19 July 2018.
- Marine Licence for the Stevenson Offshore Wind Farm (as varied) – Licence Number: 04627/18/1 – consent under the Marine (Scotland) Act 2010 & Marine and Coastal Access Act 2009, Part 4 marine licensing for marine renewables construction works and deposits of substances or objects in the Scottish Marine Area and the United Kingdom Marine Licensing Area transferred to Moray East on 19 July 2018.
- Marine Licence for the MacColl Offshore Wind Farm (as varied) – Licence Number: 04628/18/2 (as varied) - consent under the Marine (Scotland) Act 2010 & Marine and Coastal Access Act 2009, Part 4 marine licensing for marine renewables construction works and deposits of substances or objects in the Scottish Marine Area and the United Kingdom Marine Licensing Area transferred to Moray East on 19 July 2018.

- OfTI Licences** – are comprised of the following:

- Marine Licence for the Offshore Transmission infrastructure – Licence Number 05340/14/0 – consent under the Marine (Scotland) Act 2010 & Marine and Coastal Access Act 2009, Part 4 marine licensing for marine renewables construction works and deposits of substances or objects in the Scottish Marine Area and the United Kingdom Marine Licensing Area (referred to as the “OfTI Marine Licence”).
- Marine Licence for two additional distributed OSPs – Licence Number 06347/17/1 – consent under the Marine (Scotland) Act 2010 & Marine and Coastal Access Act 2009, Part 4 marine licensing for marine renewables construction, operation and maintenance works and the deposit of substances or objects in the Scottish Marine Area and the United Kingdom Marine Licensing Area (referred to as the “OSP Marine Licence”).

Executive Summary

This Offshore Transmission Infrastructure Piling Strategy (OfTI PS) has been prepared by Moray Offshore Windfarm (East) Limited (Moray East) to inform Marine Scotland Licensing Operations Team (MS-LOT) and relevant stakeholders of the intending scope of the piling activities associated with the Moray East Offshore Wind Farm Offshore Substation Platforms (OSPs). This document has been prepared to meet the requirements of the OfTI Marine Licence condition 3.2.2.5 and the OSP Marine Licence condition 3.2.2.6.

A separate PS has been produced for the Wind Farm (Wind Farm PS) and links to this document have been made throughout the OfTI PS.

Links to other consent plans have also been made in this document, namely the Construction Programme (CoP) and Construction Method Statement (CMS) document, the Environmental Management Plan (EMP) and the Project Environmental Monitoring Programme (PEMP).

1 Introduction

1.1 Background

Section 36 Consents were granted in March 2014 for the construction and operation of three offshore wind farms (Telford, Stevenson and MacColl) within the Moray East site. Marine Licences for the three offshore wind farms were granted in September 2014 (together the Section 36 Consents and Marine Licences for the Wind Farm are referred as the Moray East Offshore Wind Farm Consents).

Moray East was granted a Marine Licence for two Offshore Substation Platforms (OSPs) in September 2014 (OfTI Marine Licence) and in 2017 a Marine Licence was granted for two additional distributed OSFs (OSP Marine Licence) (together these licences are referred to as the OfTI Licences). This OfTI Piling Strategy (PS) has been produced to meet the requirements of the PS consent conditions associated with the OfTI Licences.

A separate PS has been produced for the wind farm (Wind Farm PS). This document is available within the Marine Scotland Website¹. It is currently being updated following approval of the Development Specification and Layout Plan (DSLPL) to take account of the approved final design and reflect updated advice on mitigation received from SNH in 2018 as detailed in Section 1.5 of revision 3 of the Wind Farm PS.

Moray East is a joint venture partnership between EDP Renewables, Engie, and Diamond Generating and China Three Gorges, and has been established to develop, finance, construct, operate, maintain and decommission the Moray East Offshore Wind Farm.

1.2 Objectives of this Document

The Moray East Offshore Wind Farm Consents and OfTI Licences for the Wind Farm and Transmission Infrastructure (TI) contain a variety of conditions that must be discharged through approval by the Scottish Ministers prior to the commencement of offshore construction.

The relevant conditions setting out the requirement for an OfTI PS for approval are set out in full in Table 1-1 below.

This document is intended to fully satisfy the requirements of the OfTI Licences conditions.

Table 1-1: OfTI PS consent conditions to be discharged by this plan.

Consent Document	Condition Reference	Condition Text	Reference in this OfTI PS
OfTI Marine Licence	3.2.2.5	The Licensee must, no later than 6 months prior to the Commencement of the Works, submit a PS, in writing, to the Licensing Authority for their written approval.	This document sets out the OfTI PS for approval by the Licensing Authority
		Such approval may only be granted following consultation by the Licensing Authority with the JNCC, SNH and any such other advisors as may be required at the discretion of the Licensing Authority.	Consultation to be undertaken by the Licensing Authority
		The PS must include: a) Full details of the proposed method and anticipated duration of pile-driving at all locations; b) Details of soft-start piling procedures and anticipated maximum piling energy required at each pile location; and	Sections 3 and 4

¹ <http://www.gov.scot/Topics/marine/Licensing/marine/scoping/Moray3/piling-strategy>

Consent Document	Condition Reference	Condition Text	Reference in this OfTI PS
		c) Details of mitigation and monitoring to be employed during pile-driving, as agreed by the Licensing Authority.	
		The PS must be in accordance with the Application and reflect any surveys carried out after submission of the Application. The PS must demonstrate how the exposure to and/or the effects of underwater noise have been mitigated in respect of the following species: bottlenose dolphin; harbour seal; Atlantic salmon; cod; and herring.	Section 4
		The PS must, so far as is reasonably practicable, be consistent with the EMP, the PEMP and the CMS.	Table 1-2 and cross-reference to other consent plans throughout this OfTI PS.
OSP Marine Licence	3.2.2.6	The Licensee must, no later than 6 months prior to the Commencement of the Works, submit a PS, in writing, to the Licensing Authority for their written approval.	This document sets out the OfTI PS for approval by the Licensing Authority.
		Such approval may only be granted following consultation by the Licensing Authority with SNH and any such other advisors as may be required at the discretion of the Licensing Authority.	Consultation to be undertaken by the Licensing Authority.
		The PS must include: a) Full details of the proposed method and anticipated duration of pile-driving at all locations; b) Details of soft-start piling procedures and anticipated maximum piling energy required at each pile location; and c) Details of mitigation and monitoring to be employed during pile-driving, as agreed by the Licensing Authority.	Sections 3 and 4
		The PS must be in accordance with the Application and reflect any surveys carried out after submission of the Application. The PS must demonstrate how the exposure to and/or the effects of underwater noise have been mitigated in respect of the following species: bottlenose dolphin; harbour seal; Atlantic salmon; cod; and herring.	Section 4
		The PS must, so far as is reasonably practicable, be consistent with the EMP, the PEMP and the CMS.	Table 1-2 and cross-reference to other consent plans throughout this OfTI PS.

1.3 Linkages with other Consent Plans

This OfTI PS document sets out the proposed approach for piling of the OSPs foundations, including reference to relevant mitigation measures. However, ultimately it will form part of a suite of approved documents that will provide the framework for the construction process – namely the Wind Farm PS and other consent plans required under the Section 36 Consents and OfTI Licences. This framework of documents will be used to ensure contractors are compliant with approved construction processes and environmental responsibilities. They also outline communication and reporting mechanisms with Marine Scotland and key stakeholders.

Other plans named in the consent clearly have a link to the OfTI PS in so far as they either provide additional details on the construction methodology and / or provide details on the control of construction to mitigate or manage potential environmental impacts.

Consistency between these documents and the OfTI PS will be achieved by ensuring that the documents produced at a later stage are consistent with the terms of the OfTI PS.

The interaction of this OfTI PS other consent plans is detailed in Table 1-2 below.

Table 1-2: CMS consistency and links to other Consent Plans.

Condition	Consent Plan	Consistency with and linkage to CMS
Section 36: Condition 11	Wind Farm (PS)	The Wind Farm PS contains further and greater detail on how the piling methods and programme for the WTGs have been developed to reduce effects on noise sensitive species. It provides a detailed description of the piling procedures (and associated mitigation and monitoring) for the wind farm. The detailed information contained within the Wind Farm PS is cross referenced within this OfTI PS as relevant.
Section 36: Condition 10; Modified OfTI & OSP Marine Licences: Condition 3.2.2.4	Construction Method Statement (CMS)	The CMS provides detailed information on construction procedures and good working practices for installing the Development. This OfTI PS is consistent with the information provided within the CMS, particularly with regards to information on piling activities, including mitigations measures.
Section 36: Condition 9; Modified OfTI Marine Licence Condition 3.2.2.6 & OSP Marine Licence: Condition 3.2.2.3	Construction Programme (CoP)	The CoP provides information on the construction activities, including piling of the OSPs as considered within this OfTI PS.
Section 36: Condition 14; Modified OfTI & OSP Marine Licences: Condition 3.2.1.2	Environmental Management Plan (EMP)	The EMP sets out the environmental management framework for the construction and operation of the Wind Farm and OfTI. The piling activities described in this OfTI PS will be undertaken in line with the environmental management measures described in the EMP. In addition, specific good practice measures and mitigation measures are detailed within this OfTI PS (these being consistent with the measures described in the EMP, where relevant).
Section 36: Condition 26; Modified OfTI & OSP Marine Licences: Condition 3.2.2.1	Project Environmental Monitoring Programme (PEMP)	The PEMP sets out Moray East's proposed monitoring for the Development, including marine mammals, Atlantic salmon, cod and herring. Cross reference is made in this OfTI PS to relevant monitoring proposals within the PEMP.

1.4 General Approach

This OfTI PS is informed by project engineering parameters (including piling methodologies and programme) and environmental sensitivities as identified through the baseline surveys undertaken (and updated through pre-construction survey results where applicable).

This OfTI PS aims to mitigate potential significant effects on the receptors' population taking into account the assessments presented in the Modified TI ES 2014. The OfTI PS is also designed to demonstrate how mitigation measures have been incorporated into pile driving requirements which installation contractors will be required to incorporate into their CMS.

This OfTI PS contains piling methodologies, construction mitigation and monitoring methods which will aim to mitigate potential effects associated with piling activities, in particular underwater noise, with respect to harbour seals, bottlenose dolphins, harbour porpoise, Atlantic salmon, cod and herring, using an approach appropriate for the Development. The construction programme will take into the steps to

minimise the duration of piling activities in developing the final construction programme are set out in Sections 3 and 4.

The OfTI PS implementation will be executed by the foundation installation contractor and monitored by the Ecological / Environmental Clerk of Works (ECoW). Monitoring reports will be provided to the Scottish Ministers on PS compliance at timescales to be determined by the Scottish Ministers.

1.5 Document Control

The OfTI PS has been updated based on further information on project design (in line with updated information provided within the Development Specification and Layout Plan (DSLPP)) and taking into account updated advice on the mitigation procedure to be followed during piling (provided during the consultation on version 1 of this PS).

Updates made to this document have been recorded using the document tracker provided at the beginning of this document. The need to update the PS document has been identified through Moray East's change management system (as detailed within the EMP), which records changes to the Development and details the process required to record and implement the change successfully.

1.6 Stakeholder Consultation

The approach for the PS has been focus of detailed discussions / consultations with MS-LOT and stakeholders (including through the Moray Firth Regional Advisory Group, MFRAG) as detailed within the Wind Farm PS.

The discussions related to the Wind Farm PS are relevant to this OfTI PS. Please see Section 1.5 of the Wind Farm PS for further details on the stakeholder consultation relevant to this OfTI PS.

1.7 Additional Consents and Licences

A European Protected Species (EPS) licence to disturb cetaceans was issued by MS-LOT on 02/11/2018 for disturbance during construction including pile driving. The information provided in this OfTI PS, the Wind Farm PS and other associated documents (such as those detailed within Section 1.3 above) was also provided as part of the EPS licence application.

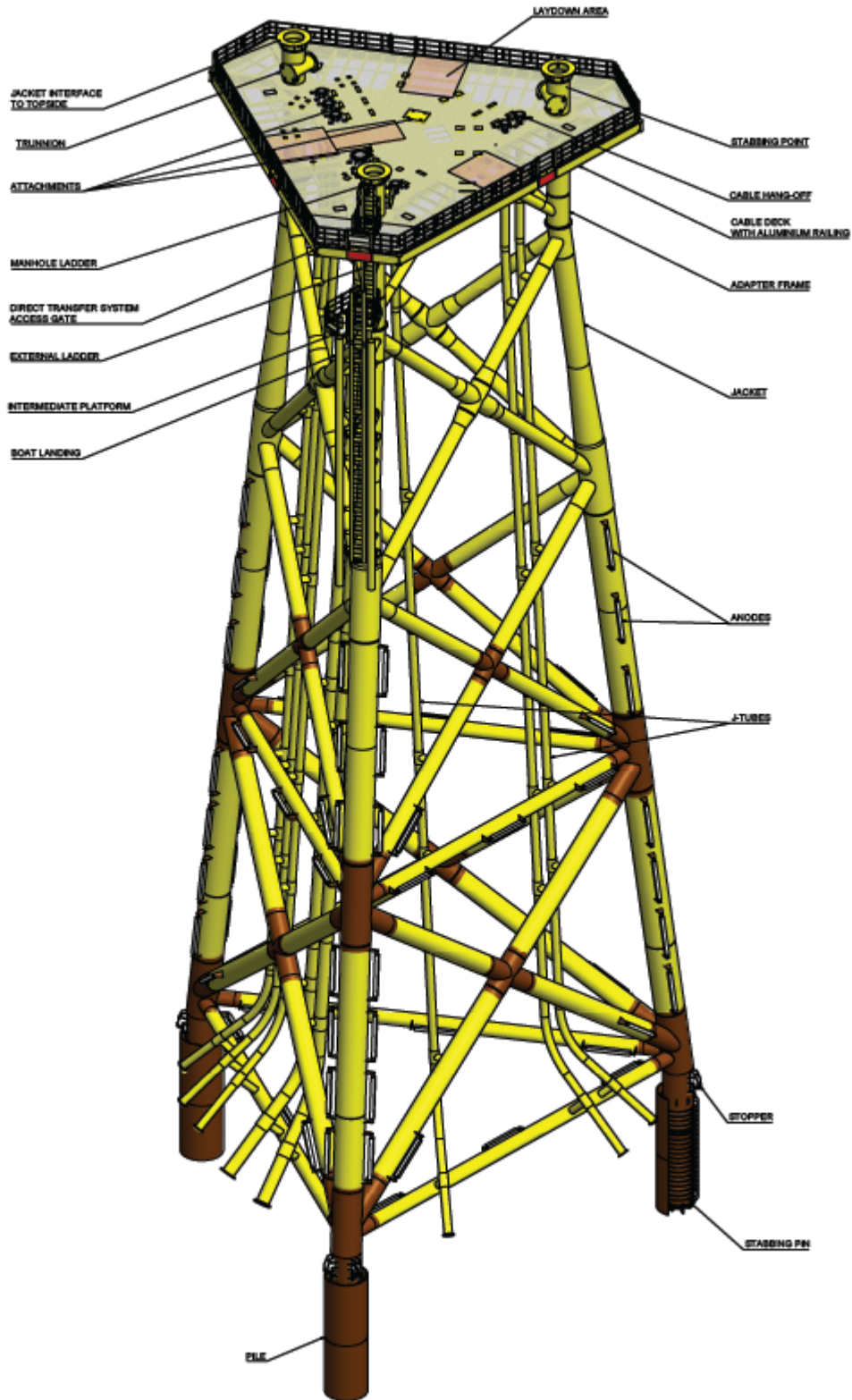
2 Engineering Background

2.1 Development Plan / Layout

The Moray East Offshore Wind Farm will consist of 100 Wind Turbine Generators (WTGs) and three OSPs. The WTG and OSP locations are presented within the Moray East DSLP.

The three OSPs will be supported on three leg steel 'jacket' foundation structures secured to the seabed via driven piles. The OSP jackets and piles will be of a similar design to the WTG supporting substructures maintaining the same seabed footprint and construction / installation methodology.

The OSP jackets will be identical in design apart from differences in the top section 'adapter frame' (Figure 2-1) which will vary in elevation in order to account for the varying in water depths at each location.



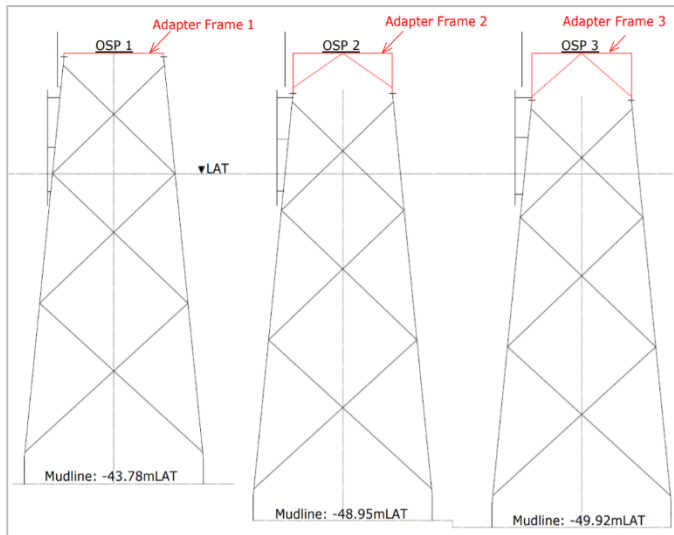


Figure 2-1: Substructure 3D View and schematics showing configuration for each location.

2.2 Geotechnical and Geophysical Survey Results

A number of seismic surveys and geotechnical investigations of sub-bottom geology have been performed over successive years in order to develop a detailed understanding of the site soil conditions across the Moray East site, including at the WTGs and OSPs locations.

Geotechnical investigations have indicated that the soils across the Moray East site are heterogeneous and laterally variable. For this reason geotechnical data consisting of a number of sampling boreholes across the site and downhole cone penetration tests (CPT) at each foundation location have been carried out in order to fully characterise the soil conditions at each location.

Data for the OSP locations was acquired in Q1 / Q2 2018. Interpretations of site specific soil conditions for each OSP have been conducted in order to determine the anticipated envelope of pile design and corresponding driving characteristics for the OSP foundation piles.

3 Piling Strategy

3.1 Pile Parameters

The OSP supporting foundation and substructure will be a steel lattice ‘jacket’ structure comprised of three braced legs each with a ‘grouted’ or mechanical connection to driven tubular pin-piles. The jacket type and therefore the number of piles has been determined by Moray East as part of the Front-End Engineering Design (FEED) process, and has been further validated and refined during the detailed design phase of the project. Variants of the selected jacket type will be designed for each OSP to accommodate water depth variation. Pile length will also vary between OSP foundations depending on the particular soil condition at each location and will penetrate no more than 60 m into the seabed.

Table 3-1: OSP Pile Parameters

Feature	Parameter
Pile diameter (maximum)	2.5 m
Number of piles per OSP	3
Maximum embedded length of pile*	< 60 m (see Table 3-2 below)
Maximum distance between piles within a jacket foundation	27 m

*maximum embedment length of the OSP piles has been determined from preliminary evaluation of soil data at each location and OSP loading conditions.

3.2 Piling Installation and Equipment

3.2.1 Vessel Requirements

Piles will be installed from a pile installation vessel (or vessels) mobilized on to the site. The vessel(s) will be a self-propelled jack-up construction vessel (JUP), equipped with heavy lift craneage suitable for pile lifting and installation operations. Once maneuvered into the correct position the JUP will deploy the vessel legs and jack-up clear of the water level each location. Leg penetration in to the seabed may be up to 20 m below the mudline, though penetrations of 5 m are deemed more likely.



Figure 3-1: Typical jack-up vessel for piling operation

Typically piles will be brought to the installation vessel whilst on site using dynamically position controlled supply vessels (PSV) for JUP. Piles will be lifted from the supply vessels horizontally and placed onto the installation vessel deck using the installation vessel crane.

3.2.2 Construction Methodology

The construction methodology, including the main tasks involved and explanation of the main process and tools used during the piling, is detailed within the Moray East CoP and CMS document.

3.3 Pile Driving

The pile driving procedure starts after the piling template has been installed on the seabed and the piles have self-penetrated. Pile inclination will be monitored during piling operations. The piling hammer is suspended from the installation vessel crane and lowered onto the top of the pile.

Pile driving is commenced following the soft start and impact energy ramp up in accordance with the information provided within Wind Farm PS. Further detail on construction methodology is also provided within the CoP and CMS document.

3.3.1 Hammer Energies and Driveability

The pile driving methodology proposed, with the associated piling hammer energies, is designed to minimise risk to environmental receptors whilst satisfying the engineering requirements necessary to successfully complete the work and reduce the risk of pile refusal. There is the potential that due to ground conditions piles may not reach their required penetration depth through piling alone and that drilling may be required (see Section 3.3.4 below). The pile driving methodology proposed, with the associated piling hammer energies, is designed to minimise risk to environmental receptors whilst satisfying the engineering requirements necessary to successfully complete the work and reduce the risk of pile refusal. Increases in anticipated rates of pile refusal and the need to use drilling rather than piling at higher blow energies will extend the overall construction programme.

Preliminary pile penetrations and thereby pile lengths have been calculated assuming that scour protection will be installed after piles are in place. This is based on preliminary analysis of OSP location specific soil data gathered from survey campaigns in 2018. Based on these pile lengths Moray East have completed preliminary pile driving assessments in order to determine the maximum piling energies that may be encountered in order to fully embed the jacket piles. These are provided in Table 3-2 below.

Table 3-2: Predicted maximum hammer energy for OSPs.

OSP ID	Pile length ²	Highest Expected Hammer Energy
OSP1 -ME06	58 m	2,250 kJ
OSP2 -MF15	32.8 m	1,200 kJ
OSP3 -MI10	45.4 m	1,800 kJ

² Based on current design information, however no longer than 60 m as detailed within Table 3-1.

The preliminary assessment provided in Table 3-1 above indicates that there is a single OSP location (OSP1) where the maximum foreseen hammer energy may be up to the 2,250 kJ maximum hammer energy approved by MS-LOT.

3.3.2 Ramp Up

From an engineering perspective, hammer blow energy is gradually increased during the piling operation to a sufficient level to maintain a steady rate of pile penetration. This ‘ramp up’ will include an initial five to six single blows at a low rate (approximately one blow per 10 seconds) using as low an energy as practically possible (not exceeding 300 kJ) to check hammer operation and initially embed the pile. This is followed by a soft-start procedure (see Section 3.3.3 below) after which hammer energy is then increased / adjusted to maintain a steady rate of pile penetration until the target depth is reached.

A more detailed analysis has of the ramp up procedure is provided within the Wind Farm PS.

3.3.3 Soft Start Mitigation

During the 20 minute period required for soft start mitigation, hammering ramp up will not exceed 500 kJ.

On completion of the soft start period, the ramp up of hammer energy will be increased in line with engineering requirements. To reiterate, a key aim of the piling contractor will be to install the pile using the lowest energy possible to minimise fatigue on the pile and hammer. This is compatible with minimising effects on marine mammals and fish ecology.

3.3.4 Pile Refusal and Relief Drilling

Pile drivability analysis has identified the potential risk that pile refusal may occur at some locations before reaching the required depth. The ability to drive the piles with hammer energies up to 2,250 kJ reduces the risk of pile refusal, however, if premature pile refusal is encountered an additional relief drilling operation may be required in order to allow the pile to be driven further. Pile refusal is likely to be the result of increased soil friction to a level where penetration can no longer be achieved. This pile friction can be reduced by removing the soil from the inside of the pile, known as “relief drilling”.

The Drive-Drill-Drive (DDD) operational sequence consists of the following steps (see Table 3-4 below):

- driving the pile until pile refusal;
- removal of the soil inside the pile by a custom built drilling tool; and
- driving the pile until target depth.

Table 3-3: Operations and durations of drill drive drill

Typical operational sequence for DDD method (three pile jacket scenario)														
Operation	Time													
Positioning and jacking up														
Deploy piling template														
Pile 1			Drive	Drill			Restrike							
Pile 2				Drive	Drill			Restrike						
Pile 3					Drive	Drill				Restrike				
Transfer pile for following location														
Jacking down and transit														

In the case of unforeseen early pile refusal during installation works and where relief drilling is not an option (due to potential issues on pile structural integrity) the pile may need to be cut at just below the seabed and the piling location abandoned and an alternative backup location selected in line with the DSLP.

3.3.5 Potential Simultaneous Piling

Within the Moray East ES 2012 Moray East made a commitment to limit piling to a maximum of two simultaneous piling events in each of the offshore wind farm sites (i.e. Stevenson, Telford and MacColl), therefore six in total. Moray East is now committing to limiting the number of concurrent piling activities to two within the Moray East site. This represents a reduction from the commitment made within the Wind Farm PS submitted in 2016¹ where a maximum of three simultaneous piling events had been considered.

Given that the spacing between the WTGs and OSPs within wind farm sites will be over 1 km (please see Moray East DSLP) there will be no navigational safety issues for simultaneous piling.

The spacing between BOWL and Moray East infrastructure will be over 1.5 km and the BOWL piling campaign has already completed and therefore there will be no safety issues with simultaneous piling.

3.3.6 After Pile Driving

Once piling has been completed, a number of construction tasks are required before the vessels can move to the next WTG / OSP location, depending on the construction methodology being utilised. However a minimum planned break of around 14.5 hours is expected.

3.4 Piling Base Case Programme

It is anticipated that the installation of WTG and OSP foundations and support structures for the Moray East Offshore Wind Farm will be completed within a 24 month period (please see construction programme within the CoP and CMS document). During this timeframe both pile installation and jacket installation activities for the three OSPs will be completed (jacket installation is not covered by this OfTI PS and is detailed in the CoP and CMS document). The piling activities on the Moray East site are planned to commence in May 2019 and expected to take up to a year to complete.

3.4.1 Piling Timescales

The overall timing of construction activities for the OSP foundation installation can vary significantly depending on a number of factors, including the construction methodology, operational sequence, vessel capabilities, however the overall time taken for driving each pile (i.e. period when the piling hammer is in use) will generally only vary with soil conditions. In addition to predicting hammer blow energies, the pile driveability analysis provides an estimate for the duration of pile driving required for a pile in each of the soil profiles.

More detailed information regarding the estimated pile driving duration per pile for different soil profiles and the approximate operational timescales can be found in the Wind Farm PS.

3.4.2 Construction Programme Constraints

Construction of the Moray East Offshore Wind Farm and associated OfTI will commence in May 2019. Further details are provided within the CoP and CMS document.

The base case is for one piling vessel operating at one time, however there could be up to two vessels operating within the Moray East site, which would reduce the piling duration for the Development.

3.5 Piling Mitigation Measures / Procedures

The piling of foundations for the WTGs and OSPs will be carried out by the same installation contractor during a single installation campaign (i.e. the 309 piles related to the 100 WTGs plus three OSPs x three piles per substructure will be installed during the Development piling campaign as detailed within CoP and CMS document). The approved mitigation measures under the Wind Farm PS are therefore relevant for the piling of the OSPs.

A summary of the mitigations measures is provided below, with further details provided within the Wind Farm PS.

- **Shipping** – Moray East has applied for safety zones within the Moray East site during the construction activities (including piling). In order to minimise disruption to navigation by users of the sea, safety zones are expected to be established around such areas of the total site that have activities actually taking place at a given time (i.e. there will be “rolling” safety zones established around each WTG and OSP and/or their foundations whilst construction works are in progress).
- **Underwater noise (marine mammals and fish)** – the key mitigation aimed at reducing the exposure and/or impacts from underwater noise on bottlenose dolphin, harbour seal, Atlantic salmon, cod and herring (as per PS OfTI Licence conditions) in addition to harbour porpoise is:
 - Deployment of acoustic deterrent devices (ADDs) for 5-10 minutes prior to piling;
 - Use of individual 5-6 blows at a low rate using as low an energy as possible at the start of piling (not exceeding 300 kJ), followed by soft start with blow energies remaining at less than 500 kJ for 20 minutes; and
 - Minimise hammer energies at levels sufficient for pile driving, resulting in an energy ramp up throughout the piling operation.
 - ADDs will be deployed before the first pile in each set of three, followed by soft start and ramp up (as described above). No additional mitigation will be required in case of a break less than 10 minutes. For breaks in piling between 10 minutes and 6 hours a short soft start (of approximately 5-6 single blows at low energy) will be employed prior to the ramp up of energy to levels required to maintain pile movement at approximately 2.5 cm/blow. Following a break in piling of over 6 hours, the mitigation measures described for the start in piling activity (as detailed further in the Wind Farm PS) will apply.

4 Monitoring and Validation of Assessment Results

4.1.1 Validation of Assessment Results

As stated in Section 3.3.1 above, the maximum piling energy required to install one of the three OSP foundations is currently predicted to be 2,250 kJ, and above the assumption on maximum piling energy used within the Moray East Modified TI ES 2014. Nevertheless, it is considered that the predicted impacts will be no worse than those assessed for the following reasons:

- **Less piling required** – The Moray East ES 2012 included provision for 339 WTGs (assuming a worst case scenario of four piles per jacket foundation) and up to eight OSPs (assuming a worst case scenario of up to 16 piles per foundation). This equates to a total of 1,484 piles. The number of OSPs has been reduced to three and total number of piles (for turbines and OSPs) to be installed during the piling campaign is now 309 (excluding pile refusal allowance), which is significantly lower than assessed and the overall piling duration is shorter;
- **Smaller piles considered** – the OSP pile design considers piles of 2.5 m diameter whilst piles of 3 m were considered within the Moray East Modified TI ES 2014;
- **Maximum hammer energy only required for small period of time** - only one of the OSP foundations is predicted to require a higher hammer energy than considered within the Moray East Modified TI ES 2014, with one of the OSPs likely to require significantly lower hammer energy. In addition, and as set out within the Wind Farm PS, those higher energies would only be for a small proportion of the overall pile driving (towards the end of the pile driving in order to achieve target depth);
- **Consideration of OSP piling in context of WTG piling** - a maximum hammer energy of 2,250 kJ was considered within the Wind Farm PS in the context of up to 100 WTGs, where it was considered that around 17 % of the locations (68 piles) would be located in stiffer soils potentially requiring this level of hammer energy. The Wind Farm PS (as submitted in December 2016¹) considered that the substructure design could be a 3 or 4-legged jacket design and therefore the 4-legged jacket was assessed as the worst case scenario. With a 3-legged jacket selected for the WTG substructures there will be 25 % less piling including at those locations where higher energies are required (i.e. there will be less 17 piles assumed to require energies of up to 2,250 kJ). As stated above only three OSP piles are considered to potentially require a maximum energy of up to 2,250 kJ, and therefore these three piles are less than the number of piling events reduced due to the selection of a 3-legged design for the Wind Farm PS (17 piles).

A summary of the piling assumptions considered within the Moray East Modified TI ES, those considered within the Wind Farm PS (as submitted in December 2016¹) and the parameters for the Development design is provided within Table 4-1 below.

Table 4-1: Development Piling Parameters.

Parameter	Wind Farm PS (2016) assumptions	Moray East Modified TI ES assumptions	2019 Development Design
Number of piles	400 (100 x 4-legged jackets)	32	Development – 309 (excluding pile refusal allowance) <ul style="list-style-type: none"> • Moray East Offshore Wind Farm – 300 (100 x 3-legged jackets); • OfTI – 9 (3 x 3-legged jackets).

Parameter	Wind Farm PS (2016) assumptions	Moray East Modified TI ES assumptions	2019 Development Design
Pile design	Diameter – 2.5 m Length – 55 m	Diameter – 3 m Length – 60 m	Development (WTG and OSP piles): Diameter – 2.5 m Length – no larger than 60 m
Maximum hammer energy	Up to 17 % of WTGs in soil profile 2 (up to 2,250 kJ)	1,800 kJ	<ul style="list-style-type: none"> Moray East Offshore Wind Farm – as per assumptions within Wind farm PS (although smaller number of piles due to a 3-legged jacket design instead of a 4-legged jacket design); OfTI – 1 OSP (3 piles) potentially requiring up to 2,250 kJ (although 1 OSP with maximum hammer energy of 1,200 kJ and another of up to 1,800 kJ).
Piling Duration	Piling campaign of up to 2 years.	Piling duration assumed to be less than 6 days ³ for the 32 piles.	Development (WTG and OSP piling): piling campaign of approximately 1 year (please see the Moray East CoP and CMS document for details).
Simultaneous piling	2 per wind farm site (Telford, Stevenson and MacColl Offshore Wind Farms) and overall 3 for the entire Moray East site.	2 per wind farm site (Telford, Stevenson and MacColl Offshore Wind Farms).	Maximum of two for the entire Moray East site.

4.1.2 Monitoring

The Wind Farm PS and the Moray East PEMP provide details on the proposed monitoring to be carried out. Monitoring will include the following:

- **Underwater Noise Monitoring** – underwater noise measurements will be collected during the Development piling campaign. The monitoring design has been agreed during discussions with MFRAG and MFRAG-MM taking into account agreed monitoring objectives (validation of noise modelling as stated within Section 3.6.1.1 of the Wind farm PS) and ongoing strategic monitoring (e.g. Marine Scotland Science East Coast Passive Acoustic Monitoring).
- **Mitigation/Monitoring for Marine Mammals** – marine mammal monitoring will be carried out in line with agreed construction Marine Mammal Monitoring Programme (cMMMP) as detailed within the Moray East PEMP.
- **Mitigation/Monitoring for Fish** – soft start will be employed at the start of piling. Monitoring for fish is detailed within the PEMP.

Compliance Monitoring

Compliance monitoring details are included within the Wind Farm PS. This will include the completing of the noise register (underwater noise monitoring), through compliance reports produced during piling to

³ The Moray East Modified ES 2014 considered that it would take up to 260 minutes to drive an OSP pile to full depth.

demonstrate that the ADD operations and soft start protocols are in agreement with agreed methods and that any spawning piling restriction is adhered to. Further details are provided within the PEMP.



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