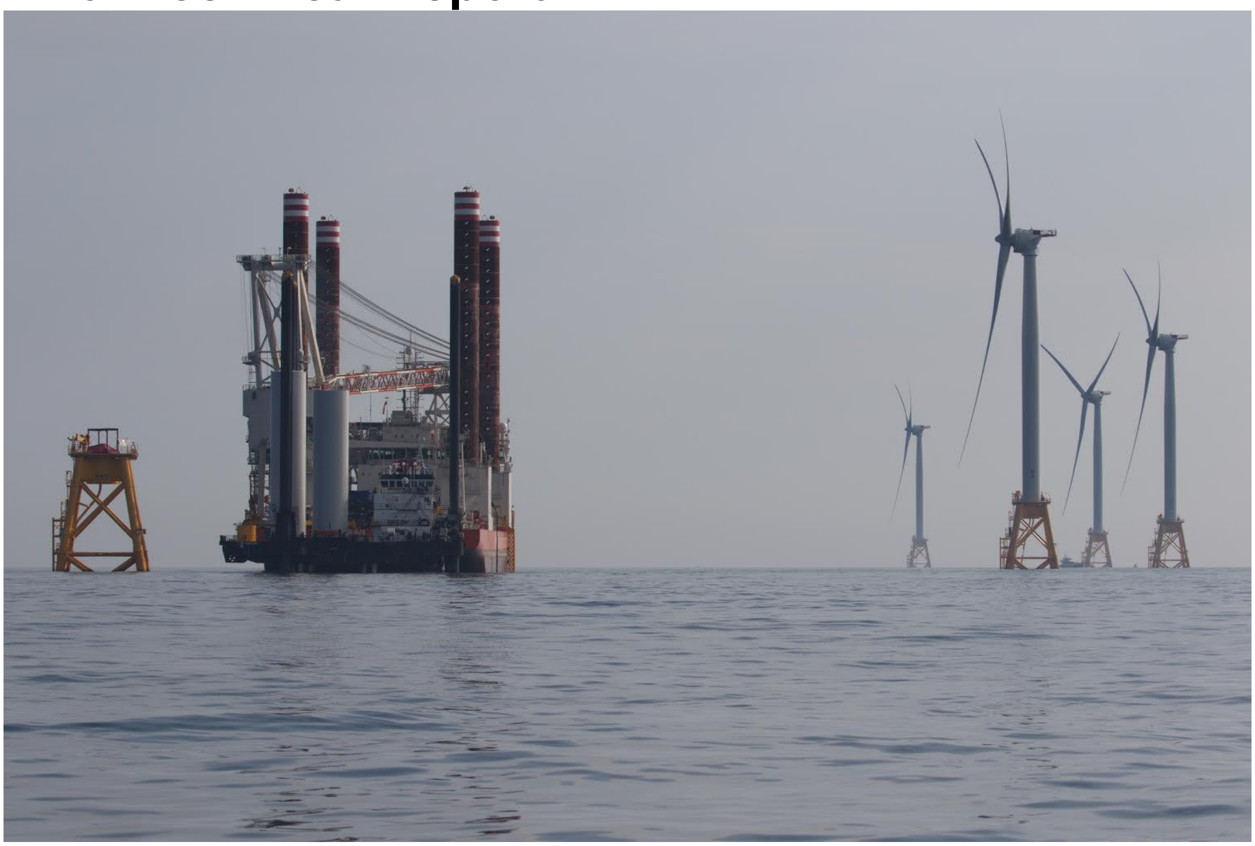
OCS Study
BOEM 2017-057

Phased Approaches to Offshore Wind Developments and Use of the Project Design Envelope

Final Technical Report



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Final Technical Report

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ABOUT THE COVER

Cover photo: Block Island Wind Farm construction in August 2016. Photo taken as part of the Real-time Opportunity for Development Environmental Observations (RODEO) study by HDR Engineering staff.

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Abbreviations, Acronyms, & Units

AfL	Agreement for Lease
BOEM	Bureau of Ocean Energy Management
CfD	Contracts for Difference
CFR	Code of Federal Regulations
COP	Construction and Operations Plan
CZMA	Coastal Zone Management Act
DCO	Development Consent Order
DOD	U.S. Department of Defense
EA	Environmental Assessment
EFH	Essential Fish Habitat
EIA	Environmental Impact Assessment
EIA	Environmental Impact Statement
ES	Environmental Statement
ESA	Endangered Species Act
EU	European Union
FDR	Facilities Design Report
FIR	Fabrication and Installation Report
FWS	U.S. Fish and Wildlife Service
GFS	Gunfleet Sands
GW	Gigawatt
HDD	Horizontal Directional Drilling
MBC	Metropolitan Borough Council
MBTA	Migratory Bird Treaty Act
MMPA	Marine Mammal Protection Act
MS-LOT	Marine Scotland Licensing Operations Team
MW	Megawatt
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOA	Notice of Availability
NSIP	Nationally Significant Infrastructure Project
OCS	Outer Continental Shelf

OESEA	Offshore Energy Strategic Environmental Assessment
OWF	Offshore Wind Farm
PDE	Project Design Envelope
PEIR	Preliminary Environmental Impact Report
PINS	Planning Inspectorate
ROC	Renewables Obligation Certificate
ROD	Record of Decision
ROW	Right-of-way
RUE	Right-of-use and easement
SAP	Site Assessment Plan
SEA	Strategic Environmental Assessment
SDM	Survey, Deploy and Monitor
SSC	Suspended Sediment Concentrations
TCE	The Crown Estate
U.K.	United Kingdom of Great Britain and Northern Ireland
U.S.	United States of America
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
ZDA	Zone Development Agreement

1. Introduction

This report presents the results of research undertaken into phased approaches to development of offshore wind farms, how this is represented in the Project Design Envelope (PDE) and how such approaches might be applied to the offshore wind sector in the U.S. The objective is to utilize lessons learned from phased approaches in the U.K., examine the current approach to phased development within the Construction and Operations Plan (COP) and the National Environmental Policy Act (NEPA) process and make recommendations as to how such approaches might be adopted by the U.S. offshore wind sector and by the Bureau of Ocean Energy Management (BOEM) in their permitting process. This document provides the outputs from this study and provides a summary of the key aspects of the research undertaken. Further detail on the approach, methodologies and results of the analysis can be found in Appendices A to D.

1.1. Overview

To undertake this analysis, a review of offshore wind farms that have employed different phased approaches in the U.K. was undertaken. The review considered phasing from an environmental and consenting / permitting perspective only and consisted of an overview of each development, presentation of the PDE in the application documents for development and analysis of the risks and benefits for the developer, regulators and the environment. This was then followed by a review of the Survey, Deploy and Monitor (SDM) policy used in Scotland to support the nascent wave and tidal industry, which uses phasing as a mechanism to allow projects to be deployed despite significant uncertainty regarding environmental impact. As part of this review, a hypothetical PDE was developed based on our knowledge of the offshore wind industry in the U.K. and U.S. The hypothetical PDE was developed as a tool to investigate how aspects of the SDM Policy might be applied to offshore wind developments. It has also been used to demonstrate how the PDE approach may assist in the implementation of phasing within an environmental assessment, and to ensure that a robust assessment of a project including phasing is completed. The study aimed to illustrate how the PDE is interpreted to ensure assessment is completed of the 'maximum design scenario' (see Table 1 in Section 1.5) and how the phasing of a development's construction may influence the 'maximum design scenario' when assessing potential impacts of a development on the environment.

Specific outputs of the review of phased approaches in the U.K. included:

- A detailed review of three case studies showing different types of phased development and an analysis of the risks and benefits of each approach;
- Review of the SDM Policy employed in Scotland for the nascent wave and tidal sector;
    - A review of two case studies of projects where the SDM Policy has been applied including an analysis of the risks and benefits of the application of the Policy for each project;
    - Using a hypothetical PDE to demonstrate how aspects of the SDM Policy could be applied to offshore wind, and
- Using the hypothetical PDE to investigate how phasing aspects of the PDE are interpreted and assessed when considering potential environmental effects of a development.

Following review of the U.K. developments and approaches, the study then examined the current approach in the U.S. for offshore wind farms and other developments, looking at whether phasing could be applied or adapted to be applied within the U.S. regulatory process. Finally, recommendations based on the outcomes of the research are presented, which will allow BOEM to take on board some of the findings and, where possible, apply these to their processes as the offshore wind sector develops. Specific outputs from the review of approaches to phasing in the U.S. included:

- An overview of the current regulatory regimes / process for offshore wind in the U.K. and the U.S.;
- Comparison of the two processes, and
- A description of how the phased approach to development is currently being applied within the U.S. system for offshore wind and other industries.

1.2. Project Background/Description of Tasks

The intention of this strategic study is to consider phased approaches to offshore wind development in the context of the development of offshore wind facilities in the U.S. The outputs are intended to inform BOEM on how phased approaches could be implemented for environmental reviews of offshore wind facility Construction and Operations Plans (COPs), thus reducing the need for further reviews later in the development lifecycle. A phased approach in the context of this report is defined as an offshore wind farm being developed in several stages. In other words, the construction of a project according to a series of defined stages (or phases).

A COP for Outer Continental Shelf (OCS) renewable energy activities on a commercial lease is required by 30 CFR Part 585. BOEM published the regulations found in 30 CFR Part 585 to establish procedures for the issuance and administration of leases, right-of-way (ROW) grants, and right-of-use and easement (RUE) grants for renewable energy production on the OCS, as well as RUEs for the alternate use of OCS facilities for energy or marine-related purposes. A COP contains information describing all facilities that the commercial lease applicant, the leaseholder, or operator of facilities on a commercial lease plans to construct and use for their project, including onshore and support facilities. The COP covers all proposed activities including construction, commercial operations, and conceptual decommissioning plans for all planned facilities, including onshore and support facilities (BOEM, 2017).

Under the current COP process, projects submit the details of their initial phase with information provided on subsequent phases, such as the proposed schedule and data collection for remaining phases. The COP is then revisited and amended for each subsequent phase, resulting in several potential revisions of the COP for each individual phase. This project has investigated whether there are different ways of implementing phasing based on experience from the U.K.

1.3. Objectives

The objective of the wider study was to research the concept of phased approaches to offshore wind development in the U.S. This has drawn upon experience of the application of phasing to offshore wind developments in the U.K and reviews lessons to identify best practice that could be applied to the U.S.

The overall aim of the project was to investigate how to ensure a robust environmental assessment process is completed that captures impacts from the entire project and not just one individual phase. Through this process, the need for new documents or significant revisions for each phase should be reduced, ensuring a streamlined process that fully captures all potential environmental effects to relevant resources, such as protected species, sensitive habitats, commercial fisheries, and essential fish habitats used for spawning and nursery grounds. The aim of the study was to investigate the merit of having documents which capture all phases of a development, such that all phases can be permitted without the need for significant updates when the project design is changed, and to consider this approach in context of the U.S. regulatory system.

The content and purpose of each of the tasks undertaken throughout the study is outlined in the following subsections.

1.3.1. Task 1A: Review of Phased Development in U.K. Offshore Wind Farms

The review of phased approaches to offshore wind development in the U.K. examined the risks and benefits of different approaches and how these affect the PDE. The review identified best practices in phased development; described what the PDE of a typical phased project may look like, and identified the key parameters needed for regulators and advisors to assess the potential environmental impacts of all phases of a project in a single permit. This is the current approach taken in the U.K. and the study was aimed at exploring suitable mechanisms for employing such approaches in the U.S.

1.3.2. Task 1B: Survey, Deploy and Monitor Policy

The current SDM policy employed by Marine Scotland on large scale marine renewable (wave and tidal) and novel technology projects was reviewed as part of this study. The development of the PDE and the use of a phased deployment strategy was also examined. The review further examined how the information collected during monitoring of the initial phase informs decisions on whether future phases can be deployed. Relevant Environmental Statements (ESs) were reviewed to understand how the SDM policy had been implemented in practice. The discussion examined how the SDM policy might be employed within the offshore wind sector. Following completion of this Task, a hypothetical PDE was developed using data from PDEs presented in application documents from U.K. developers and through consultation with U.S. developers. The hypothetical PDE was developed to examine how the principles of SDM might be applied to offshore wind and to investigate how phasing might influence the interpretation of the PDE when assessing potential environmental effects.

1.3.3. Task 1C: Review Workshop

The first of two workshops was held February 16, 2017 and was used to present initial findings of the review of the U.K. case studies, the benefits and risks associated with the different approaches and to work with BOEM to examine which approaches might be best suited to further support BOEM's processes. The workshop presented the findings of the review of phased approaches from the U.K.; the review of the SDM approach and the development of a hypothetical PDE; application of the SDM policy, and interpretation of phasing in the PDE. The final part of the workshop established the framework for the second phase of the project. The workshop also took BOEM through the hypothetical PDE and how this might be interpreted in the environmental assessment process, using the 'maximum design scenario' concept, based on a series of exercises to demonstrate the PDE approach to impact assessment. The workshop established the key aspects of the phased approaches from the U.K. and the SDM policy approach which could be employed in the U.S. and identified issues that required further exploration as the project progressed.

1.3.4. Task 2: Permitting Phased Development in the U.S.

Current regulations (30 CFR 585.629) allow for phased development of offshore wind farms. A lessee or applicant may include in its COP a request to develop its commercial lease in phases. If a lessee or applicant plans to construct its project in phases, one must follow the regulatory requirements for a COP submission, and provide a schedule detailing the timeline for subsequent phased development. As per BOEM's *Guidelines for Information Requirements for a Renewable Energy Construction and Operations Plan (COP),* the initial COP should include all relevant details of the initial phase (Phase 1) and for subsequent phases varying levels of site characterization data, as agreed upon with BOEM, should be included. Thus, for each subsequent phase the COP must be updated to include the relevant information for subsequent phases such that BOEM can undertake their technical and environmental reviews. Each update for each subsequent phase is again taken through the approval process and must include the information required by BOEM to enable them to undertake the environmental and technical review of the COP.

Following review of the current U.S. process, the aim of the study was to examine approaches from U.K. case studies that could potentially be applied to offshore wind in the U.S. The recommendations made within this report intend to identify the key elements that would be required to allow phased development using the PDE approach to be implemented within the U.S. system.

1.3.5. Task 2A: Recommendations for Offshore Wind in the U.S.

To make recommendations for phased development within the U.S. system, the current guidance and process for allowing phased development within NEPA documents and the COP were reviewed. BOEM's view of the current approach and the motivation for seeking a review and alternative approaches to phased development was also sought through the workshops held during Task 1C (see Section 1.4.3) and Task 2B (see Section 1.4.6). The review sought to identify where improvements could be made and drew upon the results of Task 1 to identify lessons learned from the U.K. that could be implemented within the U.S. system.

Based on the outcome of this analysis, recommendations were made on the key elements that may allow phased development to take place and the tools that could be used while making an informed permitting decision.

1.3.6. Task 2B: Workshop

The second workshop was held April 25, 2017. The workshop provided a recap of Task 1 and the key recommendations made based on the outcomes of Task 1 and the first workshop. The workshop also presented the initial findings of the research into the current U.S. system (Task 2A). Discussion centered on key aspects of the U.S. system that could prove problematic in implementing a phased approach and using a PDE in the COP. The outcomes of the workshop were fed back into the project and recommendations revised accordingly.

1.3.7. Task 2C: Technical Report on Phased Approaches

Once the review of the current system in the U.S. was completed (Task 2A) and the recommendations developed during the workshop under Task 2B (Section 1.3.6 above) were considered, the results of the study were compiled and are presented in this technical report. This report provides recommendations on the use of the phased approach and the PDE within the U.S. system; provides an understanding of how the phased approach can be implemented within the PDE, and discusses the process for assessing the potential impacts of an entire development deployed in a series of phases.

1.4. Report Structure

To present the results of the analysis, the remainder of the report is structured as follows:

- Section 2: Project Findings – Provides a summary of the results of each of the tasks undertaken as part of the study;
  - Section 2.1: Review and Comparison of U.K. and U.S. Regulations – Provides a review of the relevant regulatory regimes in the U.K. and the U.S. and notes key differences between the approaches;
  - Section 2.2: Phased Offshore Wind Case Studies – Summarizes the results of the case studies and the risk / benefit analysis for each case study;
  - Section 2.3: Survey, Deploy and Monitor (SDM) Policy – Summarizes the review of the SDM policy, including the case study reviews and application of SDM Policy to offshore renewables;

    - Section 2.4: Project Design Envelope Process and Phasing Implementation – Summarizes the results of the review of how the concept of phasing within the PDE is implemented and interpreted, and
- Section 3: Recommendations – Provides the key recommendations from Tasks 1 and 2 and the overarching recommendations drawn out from the study.

It should be noted that the above structure is not the same as the original task order from BOEM. However, after review of the relevant information, it was decided that the above structure provides a more coherent presentation of the results.

In addition to the above report structure, a series of appendices are provided which present the full analysis undertaken during the study. For further detail on the methodology and the detailed analysis undertaken, the following appendices should be referred to during reading:

- Appendix A: U.K. and U.S. Offshore Wind Regulatory Regimes;
- Appendix B: Review of Phased Development in U.K. Offshore Wind Farms;
- Appendix C: Survey, Deploy and Monitor (SDM) Policy, and
- Appendix D: Development of the Hypothetical PDE and Implementation into Phased Approach.

1.5. Key Concepts

There are clear differences in terminology between the U.S. and U.K. systems and some key concepts which are common terminology in the U.K. but are not yet in use within the U.S. offshore wind sector. Many of these terms and phrases are used within this document to describe the U.K. processes, during the discussion of phased approaches, and to provide context to the analysis. To fully understand these concepts, a description for each term has been provided in Table 1 for reference during the remainder of this document.

One of the main concepts to clarify, as outlined in Table 1 and discussed in further detail in Section 2.4.1, is the difference between phased development and Project Design Envelope (PDE). The important distinction is that PDE is an approach applied in the U.K. offshore wind industry to allow for permitting a range of different development scenarios and design. A phased approach in the context of this report is defined as a project that is developed in several stages. In other words, the construction of a project according to a series of defined stages (or phases). It should be noted that phasing could be considered from several perspectives; however, for the purposes of this study phasing has been considered from the perspective of the permitting process and supporting environmental assessment. If phasing is introduced into a project in the U.K., then the nature of the phased build-out needs to be captured within the PDE; thus, providing a range of options for phased build-out as part of the PDE.

Table 1. Key Concepts and Terminology from the U.K. Offshore Wind Industry.

Concept	Description
Agreement for Lease (AfL)	Rights for offshore renewable energy developments in the United Kingdom are generally granted by The Crown Estate under an AfL. An AfL generally grants a developer an option over an area of seabed. Exercise of the option by the developer will be conditional on it satisfying certain conditions. If the conditions are satisfied and the developer exercises the option, The Crown Estate will be obliged to grant a Lease of the seabed to the developer. The conditions to be satisfied before the developer may exercise the option include the developer obtaining all statutory consents for the proposed development. If the developer is unable to satisfy all the conditions within a certain time provided in the AfL, the option will lapse. During the option period, the developer will be permitted to undertake surveys and deploy anemometry (device used to measure the speed and direction of wind) equipment. However, the developer is not permitted to commence construction of its development until and unless all statutory consents and a Lease are granted.
Environmental Impact Assessment (EIA)	The aim of the Environmental Impact Assessment (EIA) process is to ensure that, when deciding whether to grant consent for a project, a regulator does so in the full knowledge of the potential significant effects of the project on the environment, and takes these into account in the decision-making process. Regulations in the European Union (E.U.) (transposed into relevant U.K. regulations) set out a procedure for identifying those projects which should be subject to an EIA (which includes offshore wind) and for assessing, consulting and coming to a decision on those projects which are likely to have significant environmental effects. The aim of the EIA process is also to ensure that the public are given early and effective opportunities to participate in the decision-making procedures. There are five broad stages to the process: • **Screening** – Determine whether a proposed project is likely to have a significant effect on the environment and therefore requires an assessment; • **Scoping** – Determine the extent of issues to be considered in the assessment and reported in the ES. The applicant can ask the appropriate planning and / or consenting authority for their opinion on what information needs to be included; • **Preparing an Environmental Statement (ES)** – see below row on ES for further details; • **Making a planning application and consultation** – The ES (and the application for development to which it relates) must be publicized. The statutory ‘Consultation Bodies’ (bodies that must be consulted on for every application) and the public must be given an opportunity to give their views about the proposed development and the ES, and • **Decision making** – The ES, together with any other information which is relevant to the decision, comments and representations made on it, must be considered by the regulator when deciding whether to give consent for the development. The public must be informed of the decision and the main reasons for it. Note that an applicant can decide to prepare an ES without seeking a screening or scoping opinion from the regulator. This would be equivalent to the Planning and Analysis Phase of BOEM’s Renewable Energy Program, as discussed in more

Concept	Description
	detail in Section 2.1 of this technical report.
Environmental Statement (ES)	Where it is decided that an assessment of potential environmental impacts is required, the applicant must compile the information reasonably required to assess the likely significant environmental effects of the development. To help the applicant, public authorities must make available any relevant environmental information in their possession. The information finally compiled by the applicant is known as an ES. An ES is produced by the developer to support their application for consent to develop an offshore wind farm (or any other type of development). It aims to provide environmental information to the public and other interested parties regarding the environmental impact of a particular development or activity being proposed by a developer. The ES is a document prepared to describe the effects of proposed activities on the environment. "Environment," in this case, is defined as the natural and physical characteristics of the surroundings of the proposed project and the relationship of people with those surroundings. The ES may, of necessity, contain complex scientific data and analysis in a form which is not readily understandable by the lay person. The main findings must be set out in accessible plain English in a non-technical summary, to ensure that the findings can be more readily disseminated to the general public and that the conclusions can be easily understood by non-experts as well as decision makers. The ES summarizes the outcome of the EIA process. The EIA is the process undertaken to assess the potential impacts of a development (see next row on Project Design Envelope) and the ES is the document that presents the conclusions of the EIA process. The ES is prepared by the developer (usually by employing independent consultants) and delivered to the regulator alongside the license application. This would be somewhat equivalent to the COP EIS that would be developed by BOEM, as discussed in Section 2.1 of this technical report.
Project Design Envelope (PDE) (formally known as Rochdale Envelope)	The Project Design Envelope (PDE) is an approach to permitting which allows a project description to be broadly defined, within several agreed parameters, for the purposes of a permit application. This allows for a certain level of flexibility while a project is in the early stages of development. Originally, this concept was commonly referred to as the 'Rochdale Envelope' after U.K. planning law cases, which involved a retail complex in the city of Rochdale, northern England. The Rochdale Envelope was developed following two cases: R. v Rochdale Metropolitan Borough Council (MBC) ex parte Milne (No. 1) and R. v Rochdale MBC ex parte Tew [1999] and R. v Rochdale MBC ex parte Milne (No. 2) [2000], see Shearer (2013) and Gudiña, (2014). It has since become the standard approach in the U.K. offshore renewables industry (offshore wind, wave and tidal energy developments) to describe project parameters and undertake 'maximum design scenario' or 'worst-case scenario' assessments of environmental impact against project parameters. The PDE identifies the range of potential project design values for all relevant components of a development (such as the foundation options; e.g., monopiles, gravity based or floating foundations). The PDE is then used to assess potential impacts on key resources (e.g., marine mammals, fish, benthic habitats, commercial fisheries, etc.) focusing on the design parameter that represents the greatest potential impact (i.e., the worst-case scenario). For example, if several foundation types are possible, the assessment of the project is based on the foundation type known to have the greatest impact, such as the largest footprint or the greatest noise level generated, on the receptor under consideration. Ultimately, this can result in different individual impacts

Concept	Description
Project Design Envelope (continued)	being assessed against different parameters. However, overall the impact assessment process assesses a worst-case envelope, such that the 'as built' development should result in impacts that are similar to, or less than, those considered in the impact assessment during the permitting stage. It has become the standard approach in the U.K. to undertake 'maximum design scenario' or 'worst-case scenario' assessments of environmental impact against project parameters. This is undertaken on an impact by impact basis for each receptor. So, for instance, for ornithology, each impact will have its own designated 'maximum design scenario'. In other words, there will be one 'maximum design scenario' for displacement effects and another for collision risk and so on. The 'maximum design scenario' for each of these individual impact / receptor combinations is then identified by the practitioner undertaking the assessment based on the project parameters provided within the PDE. They will undertake an initial assessment of the design and identify which parameters are likely to result in the largest potential impact. If they have more than one option, then there may be a need for further investigation, either through undertaking a full environmental assessment of through modeling studies. However, it is unlikely that this would be the case for most impact / receptor combinations and it is relatively straightforward to identify the 'maximum design scenario' for each impact for each receptor being assessed. It should be noted that the 'maximum design scenario' for some impacts for different receptors may be identical (e.g., piling noise impacts for fish and marine mammals), but for other receptors may be slightly different depending on their sensitivity and response to the impact being addressed. If the impact assessment shows that no significant effect is anticipated, then any project parameters equal to or less than those presented in the PDE can also be assumed to have no significant effect. When the final construction is undertaken, as long as the design falls in the range of values for each parameter established to have no significant effect, the consent issued is not invalidated by changes in design. In other words, the consent awarded (to a project that uses the PDE approach) allows construction of the development to take place within a range of parameters. Effects of greater adverse significance are not predicted to arise should any other development scenario based on details within the PDE to that assessed be taken forward in the final design scheme. As long as the design that is actually constructed remains within the range of parameters that were assessed with the environmental assessment and consented by the regulator, then the consent remains valid and the change can be made. However, if the design goes outside of the assessed envelope (by introducing a larger turbine size for instance), an amendment to the consent with supporting environmental assessment would be required. By employing the PDE approach, a project retains essential flexibility in design within certain maximum extents and ranges, all of which are fully assessed. Retaining this flexibility is particularly important in an evolving sector such as offshore wind, to ensure that the final engineering design can incorporate new technological developments in the envelope of parameters considered in the environmental assessment. This approach has been applied in several different project types in the U.K. and ensures that the assessment can address all potential impacts, even where there is uncertainty over the final design. It should be noted that the PDE approach should not give developers an excuse to provide inadequate descriptions of their projects. In the U.K., if the regulator considers that an unnecessary degree of flexibility, and hence uncertainty as to the likely significant environmental effects, has been incorporated into the description of the development, then it may request more detail and / or information to be provided to make its decision. Further details on the PDE approach are provided by Marine Scotland (2012), Shearer (2013); Gudiña (2014); PINS (2012), and Wright (2016).

Concept	Description
Phased Approach	A phased approach in the context of this technical report is defined as a project that is developed in several stages. In other words, the construction of a project according to a series of defined stages (or phases). It should be noted that phasing could be considered from several perspectives; however, for the purposes of this study phasing has been considered from the perspective of the permitting process and supporting environmental assessment.
Survey, Deploy and Monitor (SDM) Policy	The intention of the Survey Deploy and Monitor (SDM) Policy (Marine Scotland, 2016) is to provide regulators and developers, with an efficient risk-based approach for taking forward wave and tidal energy developments. The policy has been specifically designed to allow new technologies, for which potential effects are poorly understood, to be deployed in a manner that will simultaneously reduce scientific uncertainty over time while also enabling a level of activity that is proportionate to the risks. It allows for projects to reduce the amount of pre-application survey needed to inform consent decisions where there are sufficient grounds for a reduction in the amount of wildlife survey effort (in the U.K., usually 2 years of survey data) and analysis to develop site characterization. However, it will also allow for determination of projects that require a greater level of effort due to site sensitivities, technology risk and the overall scale of the project. Once the pre-application survey effort is determined, the policy then highlights how developments will be deployed and monitored. Where significant risk and uncertainty are considered to be present within a project, the policy determines that a development may need to be deployed in several phases, with monitoring undertaken between each phase. The results of the monitoring will then be used to determine whether subsequent phases can be deployed and whether further mitigation and / or monitoring is required. Rather than a "one size fits all" approach, it is a risk management process with the purpose of applying an appropriate and proportionate approach to permitting which considers the individual circumstances in relation to each individual development.
Determination	Determination is the stage in the development process during which an application to develop a project is reviewed by the regulator. It represents the period between the application being submitted by the developer to the regulator and the consent / license being awarded (or refused) for the development. This would be equivalent to the review of the lessee's COP by BOEM, as discussed in Section 2.1 of this technical report.
Consenting	In the U.K., projects are awarded consent when the regulator decides that their project is suitable for development, and the assessment of potential impacts submitted alongside their license application demonstrates there will be no significant impacts on the environment. It is essentially the permission granted by the regulator for the project to go ahead. The consenting process is the process undertaken by the developer to submit their application, including undertaking consultation with relevant stakeholders, submission of an application form providing details of the development and submission of an accompanying ES (see above for description). A 'consent' received by an offshore wind farm in the U.K. is the equivalent terminology and is used in a similar general context as a U.S. offshore wind farm receiving a 'permit'.
Permitting	Permitting is used to describe the process of obtaining a permit to develop an offshore wind farm in the U.S.
License	A license is issued to a developer once they have been awarded consent. The license outlines what the consent is for, how long it will be in place, and the conditions that must be met for the license to remain valid. This would be referred to as a permit in the U.S.

Concept	Description
Consent Conditions	Consent conditions are often attached to a licensee and are conditions that a developer must adhere to during the pre-construction, construction, operation and decommissioning stages of a development. Conditions often relate to specific mitigation or monitoring that must be carried out during the lifetime of the development. If these conditions are not met, then a developer will be in breach of their consent. Consent conditions in the U.K. are equivalent to Terms and Conditions of Approval in the U.S.
Consultation	Consultation is a process by which a developer seeks the opinions of relevant statutory bodies (which must be consulted on for every development) and other stakeholders regarding the development. This is often through a series of meetings with relevant statutory bodies and / or other stakeholders or through e-mail exchanges and telephone calls. The issues raised by stakeholders must be addressed within the EIA process and the ES.
Stakeholders	Stakeholders are bodies or persons that can affect or be affected by the actions of a developer and more specifically by the development that is being proposed. Stakeholders can also be interested parties that may benefit from the development (e.g., the supply chain), conservation organizations, government (and its agencies), and the community within which the development is being proposed.
Marine Renewables	Marine renewables refer to wave and tidal energy developments.

2. Project Findings

2.1. Review and Comparison of U.K. and U.S. Regulations

To make recommendations for phased development within the U.S. system, this study reviewed the current regulatory process for allowing phased development of energy and transportation sector projects in the U.S. This review provides an overview of the current regulations for offshore wind in the U.S. and a comparison of the U.S. and U.K. regulatory systems to determine whether at least some aspects of the phased approaches implemented in the U.K. for offshore wind development can be considered within the U.S. regulatory system. The review of U.S. regulations pertaining to phased development of offshore wind farms (30 CFR 565.629) was based primarily on presentations created by BOEM regulators available on the internet (BOEM, 2012; BOEM, 2015) and BOEM instructions for applicants and guide for citizens (BOEM, 2016; BOEM, 2017).

Additionally, a preliminary review of the relevant laws and how phased developments are currently used in the U.S. is provided to address questions that arose during communications with U.S. offshore wind developers and BOEM on whether the use of a phased approach can be considered valid under U.S. law.

Refer to Appendix A for further detail on the review of the U.K. and U.S. regulatory systems.

2.1.1. Offshore Wind Regulations in the U.S.

The National Environmental Policy Act, 42 U.S.C. § 4321 et seq. ("NEPA"), was established by Congress in 1969 to create a framework within the Federal government where agencies undertake an assessment of the environmental effects of their proposed actions prior to making decisions. Two important aims of the NEPA environmental review process are to allow for making better informed decisions and for public engagement.

There are four distinct stages in BOEM's renewable energy program, including 1) planning and analysis, 2) lease issuance, 3) site assessment, and 4) construction and operation (BOEM, 2017). The stages of the process that would be most influenced by the inclusion of a phased approach to development are the third and fourth stages, involving the approval of a Site Assessment Plan (SAP) and approval of a Construction and Operations Plan (COP), since these documents may require the most iterative cycles of review between the lessee (or applicant) and BOEM as the regulatory agency. The specific requirements for the information required in the SAP and COP can be found in 30 CFR 585.610 and 585.626, respectively. An overview of BOEM's process for authorizing wind energy leases is provided in Figure 1.

As described in Stage #3 (Figure 1), the regulations require that a lessee provide the results of shallow hazard, geological, geotechnical, biological, and archaeological surveys with its SAP and COP. BOEM refers to these surveys as "site characterization" activities. Although BOEM does not issue permits for these site characterization activities, BOEM regulations require that a lessee include the results of these surveys in its application for SAP and COP approval (see 30 CFR 585.610[b] and 585.626 [a]).

BOEM's process for authorizing wind energy leases involves three rounds of review and consultations pursuant to NEPA (Figure 1). The first NEPA review involves BOEM preparing an Environmental Assessment (EA) for lease issuance, site characterization surveys and site assessment activities. Once a SAP is submitted, BOEM will conduct a categorical exclusion review for met buoys, and prepare a determination of NEPA adequacy for met towers or conduct site-specific NEPA analyses if the proposed activities and/or effects are outside the scope of BOEM's previous analysis (which occurs under the Planning and Analysis stage). This is the second round of NEPA review and consultations. The third round of NEPA review and consultations occurs if and when the lessee is prepared to propose wind energy generation on its lease by submitting a COP.

BOEM Process for Authorizing Wind Energy Leases

1 Round 1 of NEPA Review and Consultation: Planning and Analysis

- Identify suitable areas to be considered for wind energy project leases through collaborative, consultative, and analytical processes, including using the Intergovernmental Task Force, public information meetings and input from federal, state and local governments, Federally Recognized Tribes and other stakeholders.
- BOEM prepares an Environmental Assessment (EA) for Lease Issuance, Site Characterization and Site Assessment Activities.

2 Lease Issuance

- Issuance of commercial wind energy lease.
- Gives lessee exclusive right to seek BOEM approval for the development of the leasehold.
- Lease does not grant the lessee the right to construct any facilities, but does grant them the right to develop the plans (see Step 3) which must be approved by BOEM before the lessee can move on to the next stage of the process.

3 Round 2 of NEPA Review and Consultations: Approval of Site Assessment Plan

- Site Characterization – Lessee conducts site characterization activities and desktop studies (e.g., shallow hazards, geological, geotechnical, biological conditions, environmental conditions and hazards, etc.).
- Site Assessment Plan (SAP) – Lessee submits SAP detailing installation and operation plans for meteorological towers and/or buoys.
- Once a SAP is submitted, BOEM will conduct a categorical exclusion review for met buoys, prepare a determination of NEPA adequacy for met towers, or conduct site-specific NEPA analyses if the proposed activities and/or effects are outside the scope of BOEM's previous analysis (which occurs under the Planning and Analysis stage).
- Site Assessment – Lessee conducts site assessment upon SAP approval.

4 Round 3 of NEPA Review and Consultations: Approval of Construction & Operations Plan

- Construction and Operations Plan (COP) – Lessee develops and submits COP.
- COP – BOEM will prepare a project-specific NEPA analysis, which may take the form of an Environmental Impact Statement (EIS).
- First COP EIS comment period – BOEM publishes a Notice of Intent in the Federal Register to prepare an EIS. Comment period = 30 days
- COP EIS comment period – BOEM publishes a Notice of Availability (NOA) in Federal Register of draft EIS for public comment. Comment period = 45 days
- Final EIS – BOEM publishes the Final EIS and ROD (Record of Decision). BOEM approves, approves with modification or disapproves the COP.

Figure 1. BOEM's Process for Authorizing Wind Energy Leases

If a lessee's COP is approved or approved with modification, the lessee must submit a Fabrication and Installation Report (FIR) and a Facility Design Report (FDR) for BOEM's review, and procced through the regulatory process outlined at 30 CFR 585.700-702, prior to fabricating and installing those proposed facilities. If a lessee's FIR and FDR describe a project that deviates substantially from the range of parameters outlined in the PDE in a lessee's approved COP, BOEM may require a revision to a lessee's COP and may initiate additional NEPA review and consultations**.**

It is important to note that during BOEM's evaluation process (Figure 1), there are other simultaneous regulatory processes occurring. These include the engagement of task forces, coordinating with other Federal agencies (e.g. USACE, USCG and DOD) and conducting environmental consultations with permitting agencies such as the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) (among others). BOEM has established Intergovernmental Renewable Energy Task Forces in states that have expressed interest in the development of offshore renewable energy. Each Task Force has the role of collecting and sharing relevant information that would be useful to BOEM during its decision-making process. The environmental consultations that run concurrently with the BOEM environmental review process are those pertaining to the following regulations:

- **National Historic Preservation Act (NHPA)**: requires Federal agencies to consider the effects of their proposed action on historic properties;
- **Migratory Bird Treaty Act (MBTA)**: BOEM coordinates with the U.S. FWS to confirm that all aspects of this act pertaining to migratory birds are being followed;
- **Endangered Species Act (ESA)**: BOEM coordinates with the NMFS and U.S. FWS and consultation is required if BOEM believes a proposed action may affect ESA-listed species or adversely modify designated critical habitat;
- **Magnuson-Stevens Fishery Conservation and Management Act (Essential Fish Habitat [EFH])**: BOEM is required to consult with NMFS if they fund, permit, or undertake activities that may adversely affect EFH;
- **Marine Mammal Protection Act (MMPA)**: This Act prohibits, with certain exceptions, the "take" of marine mammals in U.S. waters. The lessee is required to consult with the NMFS regarding any marine mammal concerns, and
- **Coastal Zone Management Act (CZMA)**: This Act requires that Federal actions that are reasonably likely to affect coastal use or coastal resource be "consistent to the maximum extent practicable" with relevant enforceable policies of the State's federally approved coastal management program. For this consultation, BOEM coordinates appropriately with the affected State.

Currently within the BOEM renewables energy regulatory system, a leaseholder or an applicant may include in its COP (pursuant to 30 CRF 585.629) a request to develop its commercial lease in phases. Developers should use the PDE to describe later phases of their project, since those parameters will be less certain. A lessee's COP should present a PDE that includes a high-level construction program demonstrating the different phases of development. This will help ensure that phasing of the development can be fully interpreted by BOEM and the implications fully understood. Each time a lessee is ready to proceed with development of an additional phase of its commercial lease area, in accordance with the schedule included in its approved COP, if needed, the lessee must submit a revision to its COP for BOEM's review and approval. The extent to which the revision to the COP falls within the original PDE assessed by BOEM will determine the level of additional NEPA review necessary for BOEM's approval of the revisions.

When proposing phased commercial development of a lease area, there are a variety of site characterization data that BOEM recommends that the lessee submit with the initial COP for the first phase, as well as site characterization data required for the subsequent development of the remaining portions of the lease area. The recommended site characterization data to submit with the COP for the first phase of development and the preliminary information for the subsequent phases of development are summarized in Table 2. For some of these resources, such as fisheries, BOEM requires a full biological survey for the initial COP for the first phase of development followed by a desktop analysis for proposed development in subsequent phases. However, the site characteristic requirements for each resource differ and details of the required survey work should be discussed further with BOEM at one or more pre-survey meetings prior to the submission of the initial COP. For more detail on these recommendations from BOEM, refer to BOEM's Guidelines for Information Requirements for a Renewable Energy COP (BOEM, 2016) and BOEM's guidelines for renewable energy activities.

BOEM is fully aware of lessees' concerns regarding the timing of specific surveys, as it is a requirement to submit the results of these surveys with a COP, a lessee should discuss its options with BOEM. This may include submitting, for BOEM's consideration, a request for a departure from the regulations.

Table 2. Phased Development Site Characterization Data (BOEM, 2016)

Resource	Site Characterization Data Submitted in Initial COP for First Phase of Development	Site Characterization Data Submitted in Initial COP for Proposed Activities of Subsequent Phases of Development
Avian	Biological survey conducted in accordance with BOEM's Guidelines for Providing Avian Survey Information for Renewable Energy Development on the Atlantic Outer Continental Shelf Pursuant to 30 CFR Part 585.	For Atlantic Region, follow BOEM's Guidelines as stated for the first phase of development. For other geographic regions, recommended information for desktop or level of survey data collection can be discussed during pre-survey coordination with BOEM.
Marine Mammals and Turtles	Biological survey conducted in accordance with BOEM's Guidelines for Providing Information on Marine Mammals and Sea Turtles for Renewable Energy Development on the Atlantic Outer Continental Shelf Pursuant to 30 CFR Part 585.	For Atlantic Region, follow BOEM's Guidelines as stated for the first phase of development. For other geographic regions, recommended information can be discussed during pre-survey coordination with BOEM.
Fisheries	Biological survey conducted in accordance with BOEM's Guidelines for Providing Information on Fisheries Survey for Renewable Energy Development on the Atlantic Outer Continental Shelf Pursuant to 30 CFR Part 585.	Desktop analysis for fisheries resources that occur in subsequent area(s).

Resource	Site Characterization Data Submitted in Initial COP for First Phase of Development	Site Characterization Data Submitted in Initial COP for Proposed Activities of Subsequent Phases of Development
Benthic Habitats	Biological survey conducted in accordance with BOEM's Guidelines for Providing Benthic Habitat Survey Information for Renewable Energy Development on the Atlantic Outer Continental Shelf Pursuant to 30 CFR Part 585.	Identify known sensitive benthic sites and essential fish habitat susceptible to impacts from proposed phased development in subsequent area(s); data can be collected via existing publicly available data, broad-scale high resolution geophysical surveys within subsequent area(s), broad-scale grab samples and/or seafloor and sediment profile imagery.
Archaeological/ Cultural Resources	BOEM requests the identification of historic properties within the Area of Potential Effects for the first phase which includes: - The depth and breadth of the seabed potentially impacted by any bottom-disturbing activities; - The depth and breadth of terrestrial areas potentially impacted by any ground disturbing activities; - The viewshed from which renewable energy structures, whether located offshore or onshore, would be visible, and - Any temporary or permanent construction or staging areas.	Reconnaissance level analysis; a complete visual impact assessment of future phases of development; historic property identification survey within onshore viewshed for all potential future phases of development.
Hazards	Shallow hazards survey and supporting data to determine presence of surface and subsurface geological features and conditions.	For subsequent area(s), data from desktop studies on offshore activities and hazard identification, including anthropogenic conditions and hazards and environmental conditions and hazards.

As BOEM's COP guidelines are currently written, each time the lessee is ready to proceed with an additional phase of the commercial lease according to the schedule included in their initial COP, they must submit a revision to their COP for BOEM's review and approval, per 30 CFR 585.634. The information described in 30 CFR 585.626 and 585.627 must be included in each revision for each individual phase of development. Therefore, based on current guidelines, the review process is iterative with BOEM conducting a review cycle with each revision to the COP (i.e., at every phase of development). Additionally, as eluded to above, BOEM recommends (and may require) that the lessee develop a survey plan and schedule one or more pre-survey meetings to discuss the survey plan before proceeding with survey work necessary to support each COP revision. However, in the current outline for the process for phasing on an incremental basis, there is no information on how phasing should be included if all phases were to be included within the COP. The guidelines do not say that permitting of all phases under a single COP is not possible; however, at the same time, the guidelines do not say that permitting of all phases under a single COP is possible. Given that it is not explicitly stated in the guidance, the project team for this study has assumed that phasing is only allowed where an initial phase is applied for in the COP with subsequent phases being added through revised COPs submitted to BOEM at a later date.

2.1.2. Overview of U.K. Consenting and Licensing Regime

Since one of the main objectives of this study is to compare the use of phased development in the U.S. with that currently implemented in the U.K., it is important to note the differences between regions. Appendix A provides a general overview of the U.K. Consenting and Licensing Regime, and a further description to compare the U.K. regulatory process with that of the U.S. is provided herein.

In the U.K., the EIA process is iterative and includes multiple feedback loops. While there are a series of commonly accepted and well understood steps within the EIA practice, their application will vary between individual assessments. These feedback loops are an important aspect to the EIA process as they allow the development's design to become amended to better reflect the environmental sensitivities that are relevant to the proposed site (IEMA, 2011). Figure 2 provides an overview of the stages within the U.K. EIA process and demonstrates these feedback loops with a more detailed version of the process outlined in Figure 3.

Figure 2 describes the EIA process generically. Renewable energy projects over 100 MW are now termed Nationally Significant Infrastructure Projects (NSIPs) in England and Wales. These apply the generic EIA process in Figure 2 but within a wider prescribed process as defined by the Planning Act 2008 and described in Figure 3.

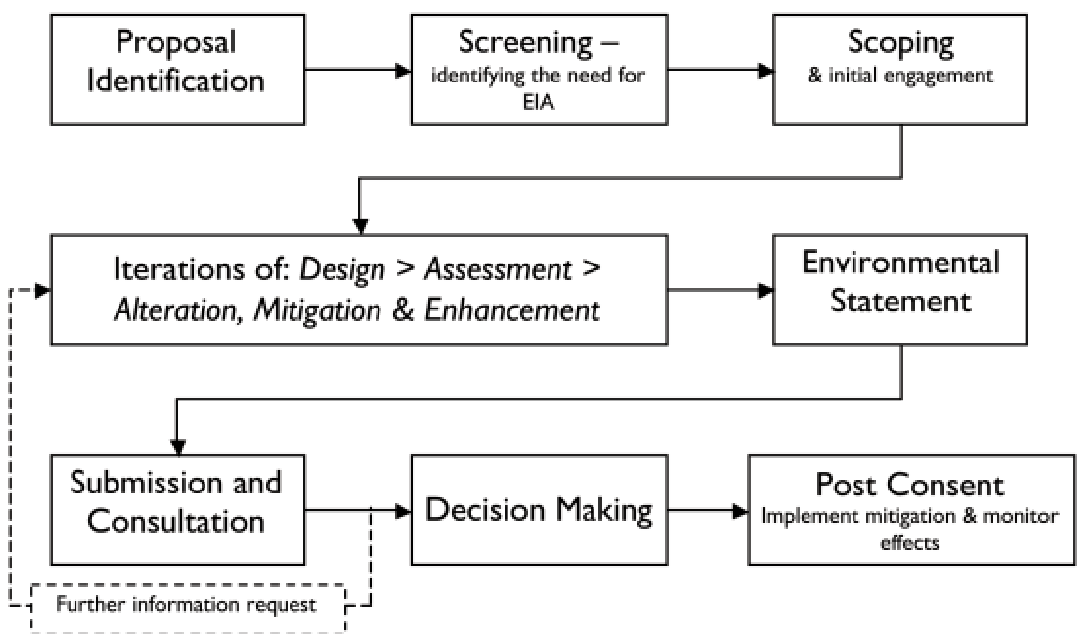

Figure 2. Stages of EIA Process in U.K. (Source: IEMA, 2011)

It is generally best practice to discuss the scope of baseline / site characterization surveys at an early stage (i.e., well before the environmental assessment begins) with the regulator, statutory consultees, and key stakeholders, with the aim of the regulator agreeing to the scope of these surveys prior to commencement.

The scoping phase (Stage #3 in Figure 3) is a non-statutory process. A scoping report is provided by the applicant, and in turn a scoping opinion is provided by the competent authority. This scoping opinion provides a view on what can be scoped in and out of the following environmental assessment.

For Stages #4 and #5 in Figure 3, it is also important to clarify that, as described in Section 1.5, the EIA is a process while the Environmental Statement (ES) is the document that is drafted as the output of this process.

In regards to the Consultation phase (Stage #6 in Figure 3), the consultation process normally starts prior to submission of the application. Therefore, within the DCO process, formal consultation would first occur on the draft ES (termed Preliminary Environmental Impact Report or PEIR) for NSIPs. For non-NSIP projects, formal consultation may be undertaken before or after the application is submitted and in some instances, both before and after. The ES would then be updated based on comments received on the PEIR. Once the ES has been finalized and all stakeholder issues addressed, the ES would be submitted in support of the application to the Planning Inspectorate (PINS) in England and Wales (or Marine Scotland in Scotland). It should be noted that in many cases, informal consultation is undertaken throughout the application process. It is important to engage stakeholders informally as well as through the formal process.

In England and Wales, the Decision-Making stage (Stage #7 in Figure 3) may undergo further stages in the DCO process, particularly if any changes are made to the development or serious concerns are raised by stakeholders and / or the regulator. This is the procedure through which an application is processed to gain consent / permission and is followed for projects over a certain size, termed NSIPs (Figure 4). The DCO process occurs only within England and Wales and is not followed in the devolved administrations of Scotland and Northern Ireland. The size criteria for offshore wind projects to be considered an NSIP is an electricity generating station of over 100 MW. This applies to most offshore wind farms currently consented or under development in England and Wales. If a project meets this criterion, it must go through the DCO process (Figure 4); however, if it does not meet the criteria, it would still need to go through the generic EIA process outlined in Figure 3. Essentially, Stages #1 through #6 in the EIA process outlined in Figure 3 are combined into the Pre-Application stage of the DCO process (Figure 4) with the Decision-Making stage (i.e., Stage #7 in Figure 3) being broken into four additional steps (i.e., Stages #2 to #6 in Figure 4).

It should be noted that Figure 3 is an amalgamation of several different processes in the U.K. undertaken during the offshore wind development process. This has been done to make direct comparison with the authorization process for offshore wind within the U.S. easier and to provide a background against which differences between the two systems can be more easily identified.

U.K. Development Consent Order (DCO) Process for Authorizing Offshore Wind Development Categorized as NSIPs

1 National / Strategic Planning

- DECC produce Offshore Energy Strategic Environmental Assessment (OESEA)* identifying areas with good offshore wind development.
- The Crown Estate (TCE) then identify development zones and tender them to interested parties.
- Successful developers awarded Zone Development Agreements (ZDAs) and complete zonal studies.
- Final projects brought forward for development by developers.

2 Agreement for Lease

Once final project brought forward developers apply for a seabed lease from The Crown Estate (TCE), the seabed owner. Successful applicants are issued an Agreement for Lease (AfL) from TCE. The AfL does not give the developer the right to develop a wind farm but does allow them to undertake baseline and characterization studies in order to prepare their application.

3 Proposal Identification

Development is identified, alternatives considered, and draft plans compiled with initial design concepts.

4 Screening

Regulatory agency screens project to determine whether an EIA is needed. Data collection (e.g., surveys) may in some cases happen before Stage 3 Scoping stage for some species requiring multi-year surveys (i.e., birds and marine mammals).

5 Scoping

Focuses the assessment (when EIA is required) on only the aspects of the environment that are likely to be significantly affected. A high level version of the Project Design Envelope (PDE) begins in this stage.

6 Preliminary Environmental Impact Report (PEIR)

EIA process that considers current conditions of the environment, likely future changes after development and significance of effects. Significant effects reduced through alterations to design or mitigation measures. The PDE is fully fleshed out at this stage and is equivalent to BOEM's COP assessment stage. Shorter-term surveys (e.g., benthic or fish surveys) occur in this stage. It should be noted that non DCO / NSIP applications can proceed to Stage 5 without submitting a PEIR. However, the same consideration of effects is still required.

7 Pre-Application Consultation

Allows stakeholders and public to participate. Identifies any deficiencies and the agency determines whether or not they hinder the decision-making process and if they do, more information is requested from applicant. There is no fixed duration for this stage.

8 Application

The Environmental Statement (ES) is the report (including non-technical summary) that results from Stages #1-5 and is submitted to the regulator as the key application document.

9 Decision-Making

Review of application, including ES and public consultation comments. The duration of this stage is 28 days to validate application.

10 Post Consent

If consented, mitigation measures are implemented and effects can be monitored to ensure outcomes are no worse than predicted by EIA. This is sometimes managed via a series of Consent Plans implemented through license conditions.

*The Offshore Energy SEA (Strategic Environmental Assessment) proceeds the site identification process. SEA is a decision support process which aims to assess the environmental and sustainability aspects of a given policy, plan or programme. It is a process applied at a strategic level to assess the impact of plans (i.e. to develop a licensing round of offshore wind farms) on the environment and the public. It is an evidence based process aimed at adding scientific rigour to policy and decision making.

NB: The above stages are specific to the most recent licensing round in the UK (Round 3). In previous rounds (i.e. Rounds 1 and 2, the Scottish Territorial Waters licensing round) and for individual developments outside of the main licensing rounds the development stages have not followed the same process. In most instances the areas for wind energy development have been identified by relevant government agencies (e.g. DECC) and TCE. However, in some instances developers have identified the areas and then approached TCE for an AfL.

Figure 3. Overview of the EIA Process in England and Wales for Nationally Significant Infrastructure Projects (NSIPs)

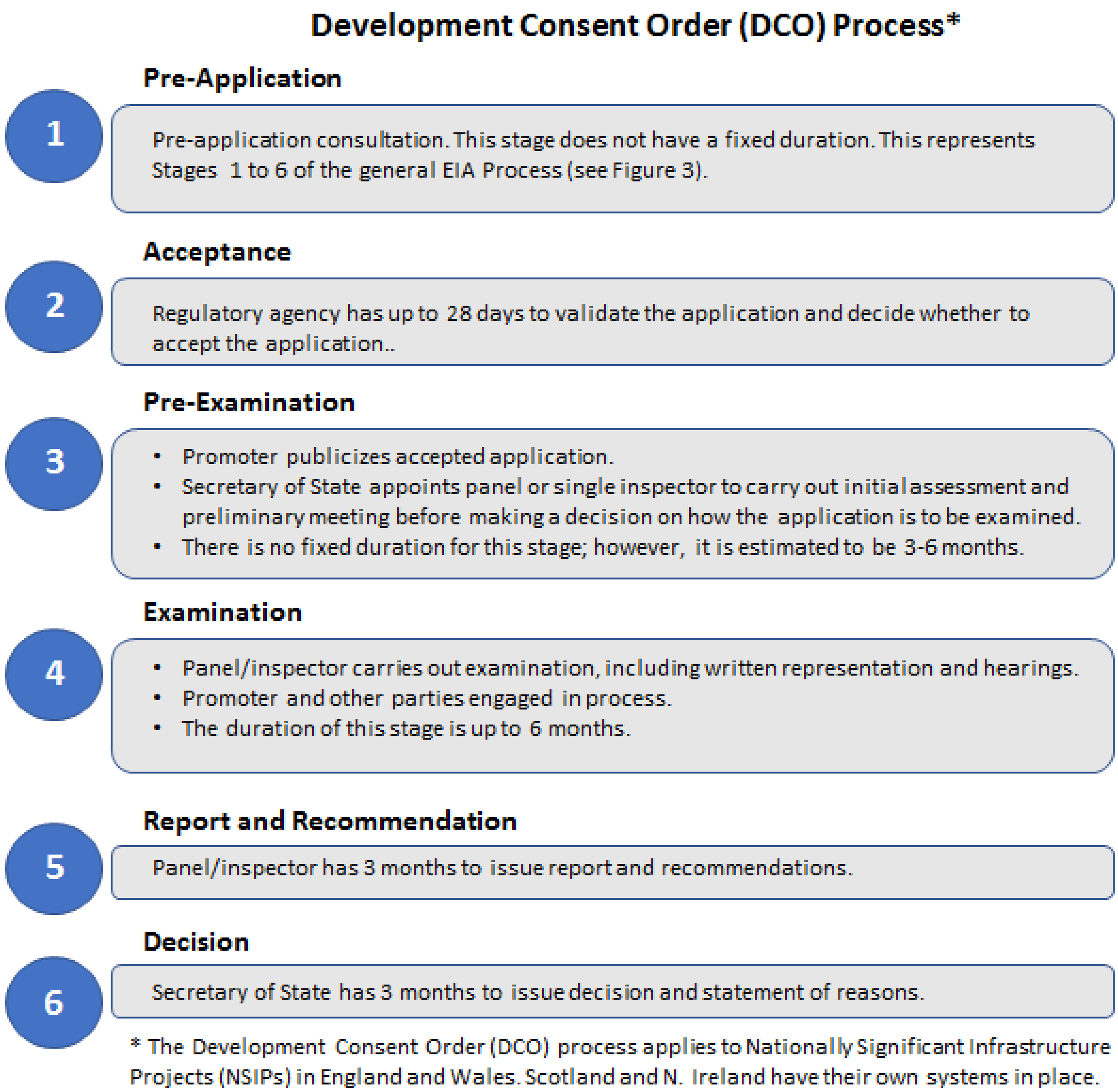

Figure 4. Development Consent Order (DCO) Process (Source: SMartWind, 2015)

2.1.3. Comparison of Regulatory Processes

The primary differences between the regulatory processes for offshore wind development in the U.S. and U.K. can be summarized as the following:

1. There are significant differences in the level of experience in offshore wind development in the U.K. versus the U.S. The streamlining of the U.K. process has been possible after years of experience consenting / permitting offshore wind projects and through gathering evidence on the impacts of the infrastructure required. There is a significant difference in the experience level of regulators and project promotors in the U.S., with only one federal offshore wind project permitted and no federal offshore wind farms built to date.

2. In the U.K., most of the stages within the regulatory process for NSIPs (i.e., the DCO application process under the Planning Act 2008) contain limits to the duration in which they can occur (e.g., the PINS has up to 28 days to decide whether to accept an application). There is also a statute of limitations, whereby there is a 3-month duration during which a Judicial Review (JR)of the decision by the Secretary of State can be called. Following this period, no further challenges can be made. The DCO process (Figure 4), which is relatively new, was ultimately designed to achieve this concept and to provide a fixed duration from application to a consent decision. Prior to the DCO process, there was potential for projects to become involved in lengthy "public inquiries", whereby the project promoter had no certainty of the duration to a consent decision. However, it is important to note that, in the U.K., this statute of limitations only applies once the application has been made. The pre-application phase has no time limits and can be lengthy because the process puts the onus on consulting and addressing stakeholder concerns *before* the application is made and not afterwards. In the U.S., while there is a 45-day comment period for the COP EIS and a 30-day minimum for scoping periods, there is no clear statute of limitations set either before or after the project is permitted.

3. As discussed in Section 2.1.1., in the U.S. there are other simultaneous regulatory processes (e.g., the engagement of tasks forces, coordinating with cooperating agencies and environmental consultations with permitting agencies) occurring during BOEM's evaluation process. While these are very important and require unique timing within the process, the environmental consultations could prolong the NEPA process toward the project approval. In the U.K. (England and Wales), PINS acts as a 'one stop shop' and will award all relevant permits/licenses for a development. It should be noted that while PINS are the agency responsible for administering the DCO process on behalf of the Secretary of State, ultimately the decision maker is the Secretary of State. However, other agencies, statutory stakeholders and the public can provide comments and raise concerns with the application which must be considered by PINS during decision-making. The final decision rests with the Secretary of State based on the advice provided by PINS. In England and Wales, the DCO process captures all the required licenses and consents under the DCO. Therefore, for example, the applicant could receive a "deemed" marine license under the DCO, whereas for non-DCO application a project promotor would be required to obtain a marine license for works in the marine environment under the Marine and Coastal Access Act separately.

4. BOEM's renewable energy program essentially contains three rounds of NEPA review (see Figure 1) with the potential for several iterations of review and revisions of the plans (SAP or COP) between BOEM and the lessee prior to plan approval. While the DCO process in the U.K. involves two rounds of review, the overall process of review and approval is quite different. It is important to note that BOEM's regulations do not necessarily envision an iterative process as employed in the U.K. Each environmental review that occurs is constructed quite narrowly (e.g., the environmental review of the commercial lease issuance does not consider wind energy development). A Plan in the U.S. is not viewed as a preliminary proposal for a project, as it is in the U.K., it is intended as the final submittal to be approved.

5. In the U.S., the review and approval process is based on two separate documents (i.e. SAP and COP); while in the U.K., it is the same document being reviewed twice (for a draft and

final version). For the DCO process in the U.K. (England and Wales_, an initial draft ES (i.e., the PEIR) is submitted to PINS and made public. All interested parties are then able to comment and provide their input and raised any issues. This input is then taken into consideration and the project promotor then updates and revises their assessment taking into account the comments made on the PEIR. The revised document is the final ES submitted at Stage #5 of the process shown in Figure 3. It is important to note that there may be more than one stage of the PEIR. If the project changes in a material way since it was consulted on in the PEIR, another phase of consultation may be required prior to submission. If this additional phase of consultation is not followed, there is potential the applicant could be seen as not consulting fully or providing the stakeholders with the opportunity to comment on the development. The PEIR stage of the U.K. EIA process (Figure 3) is therefore most similar to the COP assessment stage in the U.S. process (Figure 1). However, by using a fully fleshed out PDE in the U.K. during this stage (i.e., with a broad description of potential development scenarios and project phasing), it is possible to reduce the iterations of review and revisions of the document.

6. In the U.S., full-scale site characterization activities (i.e., shallow hazard, high resolution geological, geotechnical and biological, surveys) need to be conducted by the lessee prior to the first round of NEPA review and consultations involving site characterization[1]. Prior to lease issuance, BOEM prepares an EA to consider impacts of issuance of lease(s), associated site characterization surveys (i.e., shallow hazard, geological, geophysical, geotechnical, biological, and archaeological surveys) and subsequent approval of site assessment activities. Once a SAP is submitted, BOEM will conduct a categorical exclusion review for met buoys, prepare a determination of NEPA adequacy for met towers or conduct site-specific NEPA analyses, if the proposed activities and/or effects are outside the scope of BOEM's previous analysis. These data are required to be submitted by the lessee as part of the SAP and COP pursuant to 30 CFR 585.626 and 585.627, respectively. In general, the collection of baseline site characterization information is similar to that required in the U.K., with substantial data collection undertaken for some key receptors such as seabirds and marine mammals which require multi-year surveys for appropriate baseline data. Other surveys, such as benthic environmental surveys, are generally only carried out once prior to an application being made. The key difference is that, in the U.K., high resolution geotechnical and geophysical data for detailed foundation engineering and for the identification of key historic / archaeological receptors is not required until post-consent (i.e., after the permit has been issued). Conversely, in the U.S., detailed geotechnical information is required for each individual foundation location for input to the COP and the NHPA requires BOEM to identify and consider effects to historic properties prior to approving a COP. The identification of historic property is undertaken through analysis of high resolution geophysical and geotechnical data collected by the project promotor prior to submission of the COP, and following BOEM's Guidelines for Providing Archaeological and Historic Property Information Pursuant to 30 CFR Part 585. The collection of high resolution geotechnical and geophysical data for foundations and historic environment purposes represents a significant difference in initial expenditure by a developer or lessee prior to being awarded a permit to develop their offshore wind farm.

[1] Please note that BOEM will accept the use of existing data rather than requiring surveys, particularly for birds and marine mammals. BOEM have funded several studies to acquire baseline data, as has the DOE and various states. Therefore, the use of existing data (if it is of sufficient coverage) may be acceptable.

7. In the U.S., if the lessee requests to use a phased approach to development they must provide details as to what portions of the lease will be initially developed for commercial operations and what portions of the lease will be reserved for subsequent phased development. Also, the lessee must provide a schedule detailing the timeline for the subsequent phased development. Each time the lessee is prepared to proceed with an additional phase of the development, a revision to the COP must be submitted. In the U.K., through the use of a PDE which incorporates parameters covering all phases of the project and is finalized during the PEIR stage of the EIA process (i.e., Stage #4 in Figure 3), all phases of the project are consented/permitted at one time without further revisions to the consent/permit at a later time. However, in the U.K., in instances where a zone has been established within which several separate projects can be developed, each individual project may potentially be developed separately with each project subject to its own individual phasing (see Section 2.2).

Key Points from Section 2.1
There are important differences between the U.K and U.S regulatory systems, particularly with regards to the permitting process. The U.K. system provides a degree of certainty of timeframes for a permit to be received once an application is submitted and allows all phases of a development to be consented in a single application. The U.S. process provides less certainty of timeframes from application to gaining a permit and guidelines only provide for an initial phase to be submitted, with subsequent phases requiring revision to the application and reissue of the permit.

2.2. Phased Development Approaches

The purpose of this section is to summarize the outcomes of the analysis undertaken on the three project examples from the U.K. which have phases, with the aim of drawing out the key findings from the risk/benefit analysis and identifying the best practice and tools utilized in developing the PDE for each project. It also aims to identify the key drivers behind each of these projects and the phased approaches used and the risks and/or benefits each approach brings to the development of a project.

For further detail on the review undertaken, including more detail on the three project case studies and the discussion of the PDE for each project and the risk / benefit analysis of each case study, please refer to Appendix B.

2.2.1. Phased Approaches in the U.K.

To select the case studies for this project, a high-level review of offshore wind farms in the U.K. was undertaken. The review examined the Project Description chapter of the ESs for each of the projects currently permitted in the U.K., to identify whether the project was developed in phases or not and the type of phasing undertaken by each project. To reduce the number of projects to a manageable number, those with a similar approach were compared with each other, with the one chosen to be taken forward identified based on whether the information available allowed a full understanding of the project development process and the reviewers existing knowledge of each project. Through this elimination process, the number of projects was reduced to three final projects taken forward to be reviewed as case studies (Figure 5). It was also identified that there were three general approaches to phasing in the UK:

- **Incremental**: A phasing approach whereby a series of projects are consented through separate applications which once built from a much larger single development.

- **Grampian**: A phasing approach whereby development of subsequent phases is only allowed once a certain action has been undertaken (i.e., monitoring of a potentially impact species).
- **Zonal**: A large multi-gigawatt development zone which is developed across a series of individual projects. Each individual project also has two or more phases of construction.

These projects were chosen as they represented examples of the different approaches to phasing undertaken within the U.K. market (incremental, Grampian and zonal approach):

- Gunfleet Sands (GSFI, GSFII and GSFIII) were chosen as examples of incremental development as developments consisted of three separate projects and represented a good example of multiple project phases consented separately / incrementally;
- London Array was selected as an example of a project with separate phases permitted under a single license and given a Grampian consent[2]. In this instance, the second phase was not constructed due to several constraints. It has been used as an example where phasing and monitoring requirements may have been a factor in a latter phase not being completed, and
- Hornsea Project Two was chosen as an example of a large gigawatt size project that was permitted under a single DCO, which was to be built in up to four separate phases. This project represents a typical phased development and is therefore key to the review. Hornsea Project Two is also one development within a wider development Zone (Hornsea Round 3 Zone) where several projects (each with their own phasing) have been developed separately to provide several GW of capacity.

The example projects were selected to provide a full review of the benefits and risks of employing different phased approaches. The projects were developed during different stages of the U.K. offshore wind sector: Gunfleet Sands I was a Round One project; London Array was a Round Two project, and Hornsea Project Two is a Round Three project. Thus, these projects are representative of the evolving thinking in the U.K. sector over the course of the industry's development.

[2] A 'Grampian' consent is defined as 'prohibiting development authorized by the planning permission or other aspects linked to the planning permission until a specified action has been taken (such as the provision of supporting infrastructure or additional monitoring)' – see Scottish Executive Central Research Unit (2001) for further details.

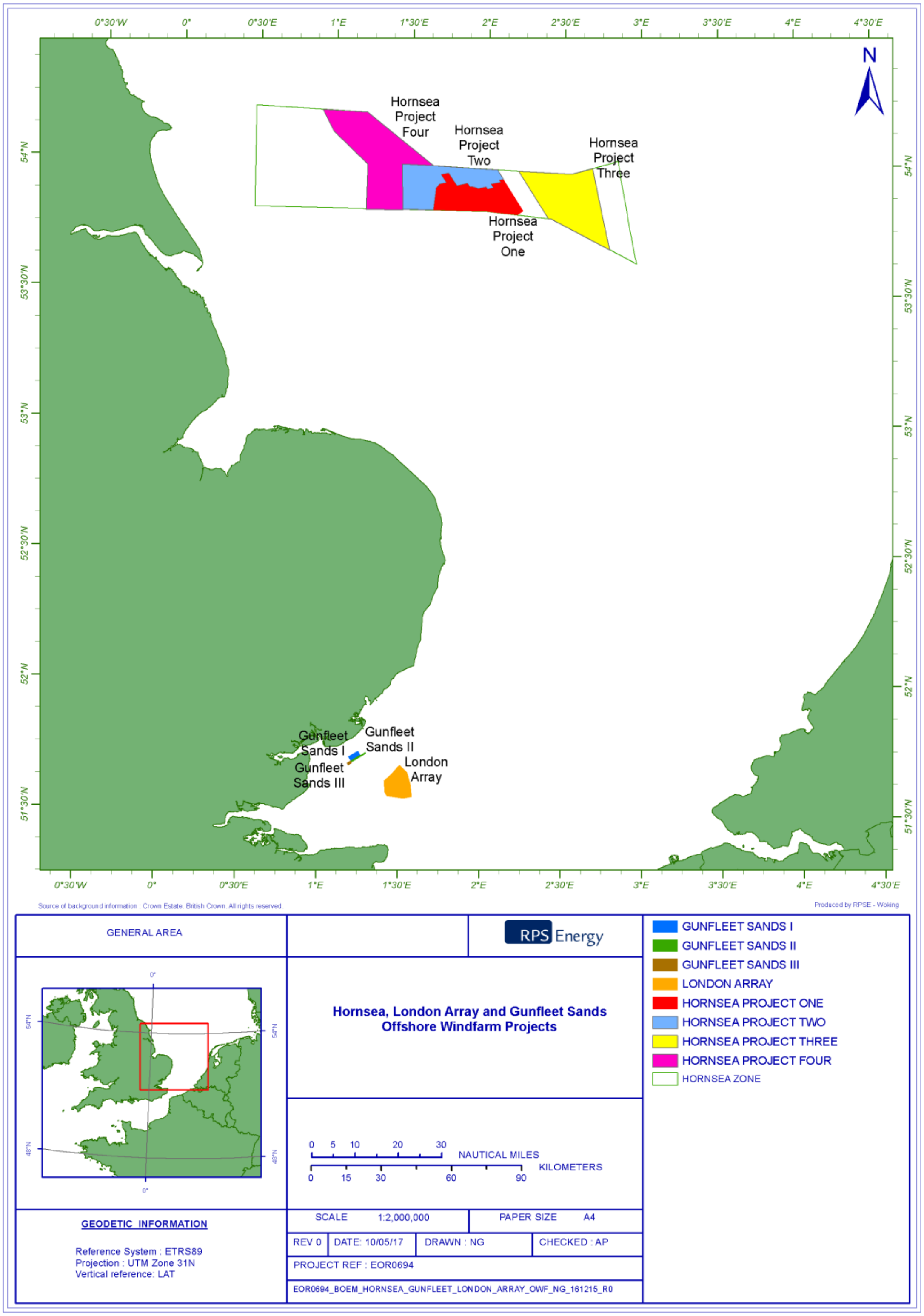

Figure 5. Location of the Hornsea Round 3 Zone (with Hornsea Project Two, and other projects within the Zone shown), London Array and Gunfleet Sands I, II and III offshore wind farms (Source: The Crown Estate)

2.2.2. Summary of Case Studies in the U.K.

The following summarizes the findings of the case studies reviewed as part of Task 1A, including PDE, risk/benefit analysis and consultation with project developers. For more detail on the methodologies employed in this review, please refer to Appendix B.

Gunfleet Sands

The Gunfleet Sands (GFSI, GSFII and GFSIII) projects were permitted separately; thus, PDEs were developed for each individual project. These PDEs outline the parameters for each individual project within each individual application, as opposed to capturing the totality of the developments and their phased implementation within one PDE. This approach is indicative of incremental phased developments characteristic of early offshore wind projects in the U.K., as opposed to the more strategic, planned, phased developments that are being consented and built today.

While in many instances the PDEs do not vary much between GFSI and GFSII, there are some minor differences, mainly in the number of turbines, the turbine parameters and the overall area of the development. As GFSIII was a much smaller project, there are significant differences in the area and the number of turbines, and due to the nature of the project (i.e., a demonstration project) the turbine parameters are very different indeed. However, due to the nature of the projects and the fact these projects were undertaken at the early stages of the offshore wind industry in the U.K., the PDEs are relatively concise, straight-forward and non-complex.

In terms of the advantages of this incremental approach to project consenting, one of the key advantages is that any lessons learned from the previous project(s) (in terms of both potential environmental impacts and engineering / design aspects of the project) can be implemented in subsequent applications. In addition, any environmental data collected post consent can be used in undertaking the assessment for the next project in the sequence, and therefore further informing the assessment process. This has the potential to speed up the consenting process for each phase. A small PDE with less variability in parameters provide greater certainty to the regulator (and stakeholders) and allows for easier understanding of the project and how it will be built. Smaller PDEs also tend to increase the confidence of the regulator and their advisors that the project will be built as presented within the ES and that any potential impacts are covered by using the PDE approach.

However, the concise approach and consenting of the developments separately also presents several risks. For instance, the PDE of each project does not capture the phased aspect of the development, such that each PDE for each project does not consider the parameters of the previous or subsequent projects (although previous or subsequent projects will have been included in the cumulative assessment). Thus, there is a risk that the potential impacts of the whole development may not be captured (unless the cumulative assessment successfully captures them). There is also the risk that the cumulative effects of other developments alongside those of the first project could consume all environmental carrying capacity (of an area) before subsequent applications for additional phases have been submitted. Potentially, this could lead to consent not being awarded for subsequent projects.

Gunfleet Sands is an example of an early approach in the U.K. to develop areas in 'phases' via separate consent applications for new projects which added capacity to already consented and installed projects. As outlined above, it is not necessarily the approach that would be taken if a phased approach was planned from the outset (from either a regulatory or developer perspective). It should be noted that several the projects developed during the U.K. Round 1 and 2 leasing rounds have taken a similar approach via 'extension' projects, whereby the capacity of an already consented / constructed offshore wind farm has been increased by gaining consent for additional turbines. GFSI and GFSII are now, to some extent treated as one project, in part because GFS2 uses the transmission infrastructure of GFSI and as these projects now have the same ownership and license conditions are jointly discharged by the projects. GFSIII remains under separate ownership (and has separate transmission infrastructure).

London Array

London Array was originally to be built over three or four phases, but the project was eventually split into two phases, of which the second phase was not constructed. The consent was granted with a condition that the second phase could not be built until monitoring had been undertaken to ensure potential impacts to a protected bird species (red throated diver *Gavia stellata*) were considered further. Ultimately, the decision was taken not to build the second phase due to a lack of guarantee that monitoring would be able to demonstrate the required lack of impact. Coupled with other constraints, the decision was made by the developer on the basis that economically, the risk of undertaking the monitoring outweighed the potential benefits. This clearly demonstrates that attaching potentially onerous conditions to subsequent phases has the potential to cause developers to re-evaluate their investment decisions and potentially reduce the size of the overall project.

The PDE for London Array was a relatively broad PDE which provided for a wide range for key parameters (e.g., turbine capacity and foundation design). A single PDE was presented which covered all phases of the entire development and the phasing itself. The PDE was significantly larger and presents a much broader PDE with wider variation in key parameters than those of the GFS projects. For instance, four different types of foundation were considered (gravity based foundations, monopiles, steel tripod (jacket) foundations and piled concrete tripods (jackets)), allowing flexibility in selecting the most economical and technically feasible approach. GFS only considered a single foundation solution, monopiles. Considerable variation in turbine capacity was also considered for London Array, with overall capacity varying from 3 to 7 MW.

For the developer, the key benefits of this phased approached, and the over-arching PDE that captured this phasing, is the essential flexibility in developing and constructing the individual and successive phases of the project. In addition, the construction of several phases together can reduce costs and consolidate the risk to the overall project and to each individual phase. A single consent application can also reduce the initial costs of the development by ensuring a single set of surveys, a single application document (ES) and a single round of consultation. Ensuring all phases are captured within the PDE allows for many of the activities and tasks for the project to be undertaken at the same time, providing opportunities for significant cost savings for such a large project. Risk can also be spread across several phases while at the same time providing certainty through a single permit covering all phases. Thus, the project (if it remains within the permitted PDE) can be developed without delays caused by further rounds of permitting.

From a regulatory perspective, the key benefit of the approach undertaken for London Array is a potential reduction in administrative burden through having a permit that covers a variety of scenarios. If the developer stays within these parameters, the need for additional permits is reduced. In addition, once a permit is issued, consent conditions can be discharged together, further reducing the administrative burden. In relation to the EIA, the use of a PDE for the phased project ensures that all development scenarios are considered, ensuring that the maximum design scenario is considered for each receptor/impact, which gives the regulator greater confidence in the assessment.

It could be argued that the approach taken by the London Array development was not appropriate. However, there is the potential that if the approach had been to consent the entire project as a single phase, it may not have received a permit due to the perceived risk of impact to red throated divers. By the same token, incremental development may have resulted in the same outcome, with the final portion being denied consent. This phased approach allowed the project to receive its permit albeit with a caveat that allowed only the first phase to proceed immediately. While a pathway to allowing the remainder of the project to be built was available, the cost, effort and resources were too great to warrant further investment, particularly with no guarantee of a positive outcome. In this instance, it was a risk the developer was not prepared to take. It is clear from the review that the Grampian condition applied to the London Array is potentially very problematic for developers, as it has the potential to reduce the size of a project and/or make development of a project unattractive.

Hornsea Project Two

Hornsea Project Two is the second development within the former Hornsea Round 3 development zone (following on from Hornsea Project One) and is the most recent project to be granted consent in the U.K. (at the time of writing). The permit provides maximum flexibility so that there is also the potential that the full 1.8GW may be built as a single project or as two individual projects; Optimus and Breesea. However, it should be noted that although the permit has been issued for the full 1.8GW, which encompasses both Optimus and Breesea and all four potential phases, a single PDE has been presented which covers all eventualities for the entire Hornsea Project Two. This approach is significantly different from that used at Gunfleet Sands, in that there is a single permit which covers all phases of the project. The PDE is significantly wider than both GFS and London Array. For instance, the potential turbine capacity ranges from 6MW to 15MW, allowing a high degree of flexibility and future proofing for turbine technology developments.

It should be noted that an Agreement for Lease (AfL) from The Crown Estate was granted for a large development zone in which each individual project (e.g., Hornsea One, Two and Three, Four) can be built (see Appendix B for further details). This allows for the development of several individual projects within the zone (each with potentially their own phases to development, as per Hornsea Project Two).

Since Hornsea Project Two was permitted as a single project, a single PDE was presented which covers the aspects of the project that may vary across the different phases. For instance, the earliest phase may use 8MW turbines, but as technology advances and turbine capacities increase, later phases may want to use 15MW turbines. There is for a high likelihood that fewer turbines than permitted (up to 300) and included in the PDE will be built. If all turbines were 6MW machines then 300 would be used, but if all turbines were 15MW, only 120 would be installed, while still ensuring a total capacity of 1.8GW. A high level of flexibility through a wide PDE allows projects to take advantage of technological advancements, making a project more efficient and reducing the overall costs of electricity generation.

Using such a wide design envelope, provides significant flexibility in the project design given by the permit, which may be obtained before final project design is completed. Therefore, the developer(s) can proceed with the project (if it remains within the permitted PDE) without delays being introduced. It also allows for flexibility of different construction scenarios through providing a PDE that covers all potential parameters and a construction program that covers the entire project, but allows for phasing to be introduced to the development as required. Another key advantage of this approach is that it allows for two undertakers to develop the project, providing flexibility in financing. To achieve this kind of consent from the regulator, the ES thoroughly assessed the impact of phasing on some key consenting risk topics (e.g., piling noise impacts on marine mammals). Therefore, the assessment of phasing for a large scale several GW project needs very careful design to ensure a robust EIA, to give confidence to regulators and stakeholders that potential impacts are adequately assessed and mitigated.

From a regulatory perspective, the key benefit of the phased approach employed is that only a single application needs to be considered, reducing administrative burden. The approach taken allows the regulator to understand the potential impacts that will encompass the maximum design scenario for each of the receptors and impacts considered. This provides them with confidence that the project as a whole (i.e., all phases) has been considered and that any mitigation and management measures will be implemented for the entire project, rather than on incremental parts of the project. This provides comfort that the PDE envelope covers all phases of the project such that the final build out of the project will result in impacts that are less than or the same as those predicted by the assessment. This provides greater confidence that the regulator can permit such a large project which may be built over many years in an ever-changing industry.

From an environmental perspective, this is also of benefit as the approach ensures that the maximum design scenario for each environmental receptor is assessed, so that when the project is built, impacts that are experienced as a result are similar to or less than those considered in the environmental assessment. As the assessment captures all potential construction scenarios, it can capture any variability in the final design of the project and can cover the potential impacts of the as built final design.

For the regulator, a key risk is that the complexity of the project makes it difficult to ascertain whether the maximum design scenario has been assessed and to understand what the worst-case parameter is for each receptor/impact. The developer needs to ensure that the explanation of the PDE and how this applies to each receptor/impact is clear. Therefore, interrogation of the assessment by the regulator is an important aspect of the determination process. To reduce this risk, the regulator needs expertise in impact assessment and in the technical areas that are assessed (i.e., ornithology, marine mammals, shipping and navigation, etc.).

A key risk of this approach in relation to the environment and the impact assessment is that environmental monitoring feedback is not introduced between project phases and lessons learned from previous phases cannot be applied to subsequent phases of construction. This approach could be a potential risk to the environment, particularly if something is missed because monitoring between phases is not applied. However, where there is a mature industry and the impacts are well understood (i.e., the U.K.), this kind of approach can be used successfully. The approach applied to Hornsea Project Two may not suit an emerging industry or a new environment although lessons learnt / monitoring from elsewhere could be applied, where applicable, to allow this type of phasing to be undertaken.

The complexity and variety of scenarios that were presented in the Hornsea Project Two ES were understood by the U.K. regulators and key stakeholders due to carefully planned and executed communication and extensive consultation. This was very important to progress the project through the consenting process. These elements must be communicated and written in a manner that will be understood by all stakeholders. Adopting a transparent and uncomplicated approach to communicating what can sometimes be a very complicated process or set of scenarios can reduce project risk (with the caveat of a quality assessment and acceptable impacts).

This approach offers the developer significant flexibility. In addition, it also provides several cost savings, not only due to going through one consenting process but also through allowing tasks and activities during permitting to be undertaken simultaneously for each of the phases, including undertaking a single EIA and permitting process, a single consultation exercise and undertaking surveys across the entire project rather than for individual phases. Thus, for much larger projects, phased approaches with a broad PDE are becoming more common and likely to be the norm going forward. Increased PDE flexibility (with phasing incorporated) typically allows projects to be more competitive in bidding auctions, enabling reductions in the cost of energy that will ultimately benefit consumers with cheaper electricity prices.

Summary

The Hornsea Zone (within which Hornsea Project Two is being developed) represents an excellent example of a comprehensive phased approach involving multiple individual projects. This project is one of several large projects that are being developed within a larger zone (essentially one large phase of a much larger development) which itself is being developed over a series of phases (up to four). This type of 'multiple phasing' (multiple projects within a leasing area, each project being developed in phases) is becoming more common within the U.K. Development zones for the Round 3 leasing were much larger than previous leasing rounds and are capable of supporting several GWs of wind turbines. This approach provides projects with the maximum amount of flexibility to be able to cope with improvements in technology and to be developed at an optimum size, which allows projects to continue to reduce the cost of development.

In general, the implementation of a phased approach requires a broad PDE to be used. This allows the project ultimate flexibility such that as the project progresses, there are options open to the developer. This allows the project to adapt to changes in technology and evolve as the project progresses. Not only does this allow flexibility in project engineering, but a well described broad PDE also ensures adequate assessment of potential environmental effects by ensuring that the maximum design scenario for each receptor is assessed. Thus, the need for further permitting is reduced. However, it should be noted that the use of a broad PDE does not guarantee that future changes to a permit for an offshore wind farm will not be made, should the developer wish to build out a development scenario not captured in the PDE, and therefore not assessed.

While it could be argued that Hornsea Project Two is just one project within a wider incremental approach, the approach is very different to that undertaken for the GFS projects. In the Hornsea case, an Agreement for Lease (AfL) from The Crown Estate has been granted for a larger zone in which each individual project (Hornsea One, Two, Three, Four) can be built. The approach taken by GFS was to gain an AfL and consent for each individual project, the risk being that future phases may not have been granted AfLs and/or the environmental carrying capacity may have already been used by other developments in the area, reducing the likelihood of gaining consent. The zonal approach avoids this by awarding a lease for a large zone which can then be built out over several different projects each with its own consent (and each with its own phasing). If undertaken appropriately, a zonal appraisal prior to the development of projects within a zone, can highlight any potential key sensitivities and cumulative issues within the zone, so that these can be avoided/minimized by the developer. In so doing, the risk of projects not gaining consent is greatly reduced. This is not currently a formal requirement in the U.K., so its application in the Round 3 leasing was variable.

From a developer's perspective, a Grampian style consent should potentially be avoided, particularly where to resolve and discharge the condition may result in significant burden with no guarantee of a successful outcome. Grampian conditions have been applied to other development (S. Hartfield pers. comm, 2016) where the condition was resolved and further development was permitted. However, in the case of London Array, it was seen as being considerable effort and expenditure when the outcome was far from certain. Therefore, there is the risk that this type of consent could be less attractive to developers, particularly where there is no guarantee of a solution.

One of the key risks of the implementation of phased approach to offshore wind development and the use of a broad PDE is the potential for stakeholders to misunderstand what the implications are or misinterpret the key elements of the proposed development. Thus, there is potential for stakeholders to raise significant concerns (and potentially objections) to a development through a lack of understanding. Communication regarding a development is therefore a key aspect of the implementation of the PDE (and the inclusion of a phased approach within a PDE), both within an application for consent and in stakeholder engagement. For instance, the complexity and variety of development scenarios that were presented in the Hornsea Project Two ES were ultimately well understood by the regulators and key stakeholders. This was achieved through multiple phases of formal consultation and extensive informal consultation with key parties. This was fundamental to progressing with the project through the consenting process. At this stage of the industry in the U.S. this is a key consideration, where fewer projects have progressed through the permitting process and been constructed and hence organizations are less familiar with these concepts.

In addition to the above points drawn out from the case studies, several further conclusions were identified based on consultation with developers and through the workshops with BOEM. One key aspect was in relation to the provision of guidance on the application of phasing and to the PDE. Due to the complexity involved in developing phasing within a project, completing the required environmental assessments and implementation of phasing, it would be difficult to provide prescriptive guidance on phasing. Thus, any guidance should be high level.

Phasing of projects is likely to be very important in emerging markets (such as the U.S.) where the industry will need to evolve and the supply chain expand as it progresses, works through the regulatory system and as lessons from early stage developments are taken on board. Phasing will allow projects to be built out at a size that the market can successfully carry and allows the supply chain to develop at a rate suitable to support the industry as it grows and as technology advances. Lessons learned from early phases can then be implemented by the supply chain as they move into later phases. Essentially, phasing allows projects (or phases of projects) to be built out at an appropriate size in the early stages of the industry while at the same time ensuring developers interest in the sector remains high. However, it should be noted that the size of each individual phase may be influenced by the support mechanism available in a given country.

It should be noted that phasing would not be suited to all developers/developments and that for some early stage projects, particularly smaller developments, or developments being undertaken by small developers with limited funds, phasing may be detrimental. Therefore, phasing should not be mandatory, but should be an option available to developers should they wish to use phasing to develop their projects.

2.2.3. Phased Approaches in the U.S.

RPS undertook a preliminary review of the current use of phased development for U.S. industries that fall under NEPA regulation and have integrated the use of phased development into their permitting. Since the offshore wind industry is relatively new in the U.S., currently no offshore wind projects which include a phased approach to development have been permitted. In fact, at the time of this writing, only one offshore wind farm (i.e., the Block Island Wind Farm) has currently been installed in U.S. waters. While this approach has not yet been taken in any offshore wind development which has received a permit in the U.S., it has been used for many years in the development of highways and infrastructure.

The U.S. Federal Highway Administration (FHWA) takes into consideration projects that will be built over time with multiple work phases based on one NEPA decision document (FHWA, 2011). Additionally, some municipalities allow for the use of phased development in their land use regulations. For instance, the municipal code for the city of Seattle, WA allows an applicant to seek a Major Phased Development proposal subject to provisions of the zone (Seattle Municipal Code, 2017). In this particular case, the application submitted needs to contain a level of detail which is sufficient to reasonably assess anticipated impacts, including those associated with a maximum build out. For these projects, the developer is required to assess the anticipated impacts, such as traffic, open space, shadows, construction impacts and air quality, and conclude these impacts are not significant or can be effectively monitored with conditions put in place to mitigate impacts over the entire life of the permit (Seattle Municipal Code, 2017).

To address one of the questions that arose from the U.S. offshore wind developers and BOEM during the consultation process of this project (as discussed in more detail in Appendix A), RPS conducted a preliminary examination of whether phasing would fall within current U.S. law. The review aimed to determine whether phasing might be construed as "improper segmentation". The review of this concept is discussed in Appendix A.2. The conclusion of this preliminary review was that the concept of segmentation would need to be considered when assessing whether phased approaches to development can be incorporated into BOEM's regulatory process for authorizing wind energy leases. In any event, the incorporation of all phases of a project within a PDE, as currently implemented in the U.K., may moot the issue of segmentation because the entire project would be considered during the development of the PDE and in the final COP submitted to BOEM, even if that project is to be conducted in phases. In such a circumstance, BOEM would analyze all potential impacts at once, and the phasing could not be considered "improper segmentation."

Key Points from Section 2.2

Phasing in the U.K. has been implemented in several ways, with the zonal approach now becoming the chosen approach. Phasing is a key tool for providing developers with flexibility in developing their lease areas and individual projects. Phasing is implemented through the PDE and is likely to be important in emerging markets where the supply chain may not have the experience of constructing large multiple MW projects in the offshore environment. Currently in the U.S., phasing has not been implemented in a permitted offshore wind project and the only permitted examples are from FHWA.

2.3. SDM Policy

Currently, the Survey Deploy and Monitor (SDM) Policy is employed in the U.K. (Scotland) by Marine Scotland on large scale marine renewable (wave and tidal) and novel technology projects. Many of these projects have been phased to allow for monitoring between phases, to provide empirical evidence regarding key environmental uncertainties. The SDM Policy has been reviewed to provide commentary on its application, use, and how it influences phasing where it has been employed. Relevant ESs have been reviewed to understand how the SDM Policy has been implemented in practice and how the SDM Policy has been employed within the offshore wind sector. This section provides a summary of the results of the review of the SDM Policy for two case studies, the MeyGen and Hywind projects (see Figure 6). In the case of MeyGen, the policy was applied in full whereas for Hywind only, the early phase risk assessment aspect of the SDM was applied (see Appendix C for further details).

The intention of the Survey Deploy and Monitor (SDM) Policy (Marine Scotland, 2016) is to provide regulators, and developers with an efficient risk-based approach for taking forward marine renewables developments. Although the guidance has been developed specifically for marine renewables, the principles have been applied to floating wind projects as they are considered novel technologies.

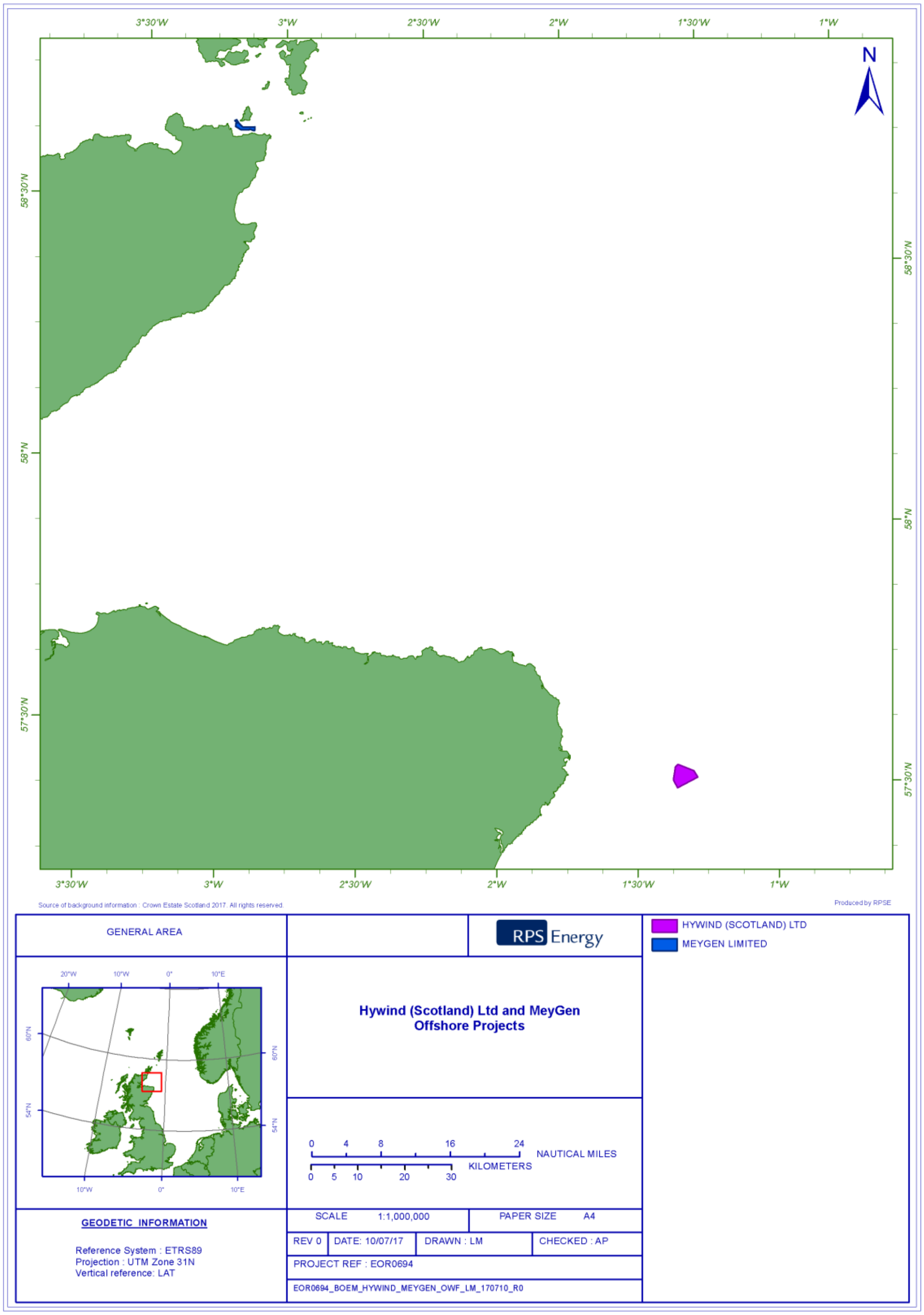

Figure 6. Location of the MeyGen Tidal Energy Project and Hywind offshore wind farm (Source: Crown Estate Scotland)

The policy has been specifically designed to allow new technologies, whose potential effects are poorly understood, to be deployed in a manner that will simultaneously reduce scientific uncertainty while also enabling a level of activity that is proportionate to the risks. It allows for projects to reduce the amount of pre-application survey that is needed to inform the consent decision where there are sufficient grounds for a reduction (usually 2 years of survey data). However, it will also allow for determination of projects that require a greater level of effort due to site sensitivities, technology risk and the overall scale of the project. Once the pre-application survey effort is determined, the policy then highlights how those developments will be deployed and monitored.

Guidance is provided for each step of the SDM policy and a description of how each stage is implemented and assessed to determine the level of effort required at each stage. This is separated into the following stages (see Appendix C.1 for more details):

- **Pre-consent survey**: includes a risk assessment of the proposed development based upon an understanding of risk informed by 3 general factors:
    - Environmental Sensitivity (of the proposed development location) (High, Medium or Low);
    - Scale of Development (Small, Medium or Large depending on the MW capacity), and
    - Device (or Technology) Classification based on the risk in relation to environmental hazards related to the proposed device or technology (High, Medium or Low for each hazard identified);
- **Deploy:** deployment of the development. Consent is likely to be conditional upon deploying in a phased approach, and
- **Monitoring**: Monitoring, post-construction is likely to be a condition on most consents granted to provide information necessary to support subsequent applications for further schemes.

Rather than a "one size fits all" approach, it is a risk management process with the purpose of applying an appropriate and proportionate approach to permitting which takes into account the individual circumstances in relation to each individual development. It should be noted that the SDM policy does not replace the need for a developer to undertake the full EIA process and submit an ES in support of their application. However, the policy informs the ES, EIA and the determination by Scottish Ministers.

2.3.1. Summary of Case Studies

The following summarizes the findings of this case study review, including the risk/benefit analysis and the consultation between Marine Scotland Licensing Operations Team (MS-LOT) and MeyGen Limited.

MeyGen Tidal Energy Project Phase 1

The MeyGen Tidal Energy Project Phase 1 ("Phase 1") is located in the Inner Sound, a body of water between the north coast of the Scotland and the island of Stroma. The project is for the development of a tidal-powered electricity generating station of up to 61 tidal turbines with a maximum capacity of 86MW. MeyGen obtained a Section 36 consent and Marine License for the project in 2013 and 2014, respectively. Consent conditions restricted the initial stage to a maximum of 6 turbines. MeyGen decided to proceed with 4 turbines and call this Phase 1A. Phase 1A will include the installation of 4 x 1.5 MW turbines offshore as well as the construction of all onshore infrastructure to support the project, including substation, grid connection and export cables. Phase 1A was commissioned and fully operational in early 2017.

The SDM policy was applied to the MeyGen project in full due to the size of development, the uncertainty surrounding the potential environmental impacts of the technology and the overall risk presented by the project. The phasing of the MeyGen project has clearly been influenced by the application of the SDM Policy. While consent was awarded for a total of 86MW, this was conditional upon MeyGen deploying the turbines in stages. The initial stage (Phase 1A) was limited to a maximum of six turbines and all subsequent stages of the project are subject to prior written consent by the Scottish Ministers (through MS-LOT)[3]. Once Phase 1A is operating, the project will monitor key potential environmental impacts, including collision risk for marine mammals (specifically harbor seals). Following completion of monitoring and subsequent analysis, it is intended that the results will demonstrate that potential impacts are similar to or less than those predicted in the ES, so that subsequent stages and phases will be granted consent.

The key benefit of the application of SDM is that it allows turbines to be deployed despite a high degree of uncertainty in the potential impacts. Under a more restrictive precautionary approach, it is unlikely that such a development would receive approval as there is currently little, if any, empirical data to validate the ES predictions made. It also ensures that a sufficient level of MW's can be consented (in this case 86MW, albeit with a smaller initial deployment of 6MW) which provides investors with more certainty and enables financing of the project. Under a more precautionary approach, consent may only be given for 6MW with an incremental approach for future phases, which would take longer to consent each project phase individually, and would therefore be costlier and less attractive to investors. The SDM Policy also provides a feedback loop, which allows the monitoring data from the project to be used to provide evidence to support further development of the AfL area and further development within the wider tidal energy industry.

However, the SDM Policy does limit the extent of the initial phases to only a few turbines, which could potentially cause some investors to be unwilling to finance a project. There is also the risk that monitoring data may not provide the answers required to allow the next phase to be constructed, requiring further monitoring, more onerous mitigation requirements, increasing costs and delaying the overall development. Ultimately, this could lead to the project being cancelled. However, an advisory group was set up for the project to coordinate efforts between the developer, regulator and relevant stakeholders to develop solutions to allow the project to continue.

For the regulator, the key benefit of applying the SDM Policy is in providing flexibility in the approach to data collection throughout the lifetime of the project. This allows the collection of evidence that will inform decisions on whether future phases and future development of other projects can or cannot take place. The evidence collected from the MeyGen monitoring program will allow MS-LOT to make more informed consenting / licensing decision on future projects, having gained empirical data on potential impacts. Through this mechanism, more evidence-based consenting can be implemented, improving the decision-making process and providing a more robust dataset against which impacts can be assessed. This will benefit the industry as a whole, while de-risking the consenting process. These benefits are balanced against the risk of the potential impacts being greater than predicted in the ES. If this were the case, then MS-LOT and the Scottish Government may be criticized for implementing the SDM Policy rather than taking a precautionary approach. This could affect the industry; thus, resulting in a more precautionary approach and/or investor confidence being reduced.

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[3] It should be noted that while written consent is needed for subsequent phases to proceed there is no need for further application documents to be submitted for each phase to proceed. The written consents for each subsequent phase are simply based on monitoring results and are significantly streamlined and less costly and time consuming that further submission of application documents.

The data collected will also benefit the environment (and the industry) through improving the efficacy of mitigation measures and refinement of future monitoring requirements, and ensuring data collection is focused on gathering the right data which can fill key data gaps and reduce uncertainty. The risks for the environment are very similar to those for the regulator, in that impacts have the potential to be greater than predicted with potentially severe consequences for species of conservation concern. For the MeyGen project, the SDM approach was key to allowing the project to be consented, reach financial close and to undergo deployment/installation activities. Without the SDM approach, the likelihood of the project being consented was much lower. While it may not be the model that all projects of this nature will adopt, it does provide some insights into how the SDM policy works in practice. It essentially allows projects of significant size with significant uncertainty of their potential impacts, to achieve consent by making the developer build the project in phases, with monitoring in between each phase. In so doing, it provides a framework for data collection whereby monitoring is considered at an early stage, forms an integral part of the phasing process, and feeds back into decision making for future phases and future developments.

Hywind Scotland Pilot Park

The Norwegian Energy company Statoil has invested in the development of the world's first full scale floating wind turbine. A full-scale demonstration turbine has been in operation 10 km off the Norwegian west-coast since 2009 and was successfully tested for five years. Thus, Hywind Scotland Limited (HSL) is currently constructing a Pilot Park in an area known as the Buchan Deep with water depths between 95 and 120 m off the coast of Peterhead, Aberdeenshire, on the east coast of Scotland. The Project involves the installation of five 6 MW wind turbine generator (WTG) units and will be expected to produce between 15 and 30 GWh[4] per year of electricity each.

Based on the Hywind Demo slender buoy (SPAR2) concept, the Hywind Scotland WTG Units consist of a steel tower and substructure partly filled with ballast water and solid ballast. Three anchors will be required per turbine and the radius of the mooring system will extend out 600 to 1,200 m from each turbine. The Hywind project applied directly to TCE for an AfL outside of the main leasing rounds due to its novel nature and the small size of the development.

The SDM Policy was applied to the Hywind Project due to the novel nature of the project and the small scale of the development. However, as most impacts associated with offshore wind were well understood only the risk assessment process was applied to reduce the time period over which survey data collection was required (the pre-consent survey stage of SDM). This allowed the developer to submit their application sooner than would usually be the case.

For the Hywind project, it should be noted that construction will be completed in a single phase. This is mainly due to the small size of the development (five 6MW turbines, total of 30MW) not requiring a phased approach to development. Although the PDE considered a large number of parameters, generally the key parameters had a very narrow range. According to Statoil (2015), this was mainly due to a large amount of work having already been undertaken to design the project. Thus, the SDM Policy did not affect whether the project undertook a phased approach to development or the parameters and the PDE. However, in the U.K., the Hywind project serves as the best example to date of the application of SDM to an offshore wind project.

The key benefit of the application of SDM was the reduction in the required length of the pre-application survey. Usually two years' worth of data is required before an offshore wind application is submitted, due to the potential for impacts on birds and marine mammals and the need to

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[4]Gigawatt hours, abbreviated to GWh, is a unit of energy representing one billion (1,000,000,000) watt hours and is equivalent to one million kilowatt hours. A kilowatt hour is equivalent to a steady power of one kilowatt running for one hour

understand the baseline population that could be affected. Through the risk assessment process as part of the pre-consent survey element of the SDM Policy, it was established that due to the size, location and nature of the development, it was of low enough risk to reduce the length of data collection. This is of benefit as it reduces the overall timescale for submitting an application, and reduces the financial burden of undertaking lengthy surveys. For Statoil, this fast tracking of the survey was vital for the development, as they hoped for the project to receive Renewables Obligation Certificates (ROCs) through the U.K. incentive scheme which ends in 2017. The project needs to be commissioned and electricity transported to the grid before mid-2017 to receive ROCs. However, the risk to the developer was that this timeline (i.e., to be operating before the ROCs deadline) may not be guaranteed and that further data collection may be required by the regulator once the first year's data has been analyzed and reported. For Hywind, a further 6 months of data collection, thus delaying the determination period. While this was not a major delay, there was the potential for a further years' worth of data collection, which may have delayed the project sufficiently to have missed the ROCs deadline.

For the regulator, the key benefit of applying the SDM Policy to Hywind is in providing flexibility to the approach of data collection prior to the determination of consent. If something unexpected is discovered, it offers the opportunity to request further data collection. For the Hywind project, significant numbers of razorbills (*Alca torda*) were observed rafting on the sea surface in the project location during the first year of data collection, and therefore additional data collection was requested. It also gives the regulator an early opportunity to assess the project and provide guidance to the developer that should result in a smoother transition through the consenting process. The risk is that additional resources may be required to analyze any new data presented by the developer and that further resources are required in the early stages to ensure the data collection methodologies are adequate and sufficient data is collected pre-application.

From an environment perspective, the use of the SDM approach ensures an adequate assessment of the potential risk posed by the project at an early stage in the project life cycle. This ensures any identified risk is adequately managed and adequate characterization of the baseline environment is undertaken, while also providing flexibility if the data identifies the need for further investigation. It also ensures the pre-application survey is designed with post-construction monitoring in mind. However, the risk of the approach is that long term trends in bird populations at the project site may not be identified in the 12 to 18-month dataset collected. This could miss declines in populations or changes in distributions that occur from year to year. These patterns, if detected (and indeed present), could potentially influence the outcome of the assessment and the consent decision. While this may not result in the project being denied consent, there is the potential for more onerous consent and/or monitoring conditions placed on the license if such population changes were detected.

Summary

The SDM policy has been implemented by Marine Scotland to allow the development of novel wave and tidal technology projects within Scottish waters, where under normal circumstances these projects would be refused due to a lack of understanding regarding potential impacts. SDM accepts that there is a higher likelihood of adverse effects than a more precautionary approach, but tempers this with allowing small projects to be deployed initially, which can then be monitored to understand the real significance of any impacts if they occur. This is a pragmatic approach and realistically the only way forward to determine whether there are significant impacts to sensitive species from the operation of tidal turbines. The application of the SDM Policy and the monitoring that will take place at the MeyGen site is absolutely necessary to progress understanding of the environmental interactions of marine renewables (wave and tidal devices) from an environmental, regulatory, and development perspective. SDM provides a risk assessment process at an early stage of the project, which allows the regulator to understand the level of risk posed by a project before entering the consenting process. They can then work with the developer to develop a phased approach for large high risk projects and a monitoring program that will improve understanding of potential effects to support future phases and the industry as a whole. The SDM Policy forces certain developments to be phased to manage potentially high risks in relation to environmental impact, such that each phase is monitored to address key uncertainties and future phases can be permitted to continue.

The main conclusion drawn from examining the SDM Policy is that it is ideal for novel technology where there is uncertainty regarding potential impacts. It allows projects to progress and be financed that would otherwise not be consented under a more precautionary approach to consenting. While the policy is not necessarily just applicable to small scale projects (it has also been applied to the 200MW Brims Tidal development off the coast of the Orkney islands), it is likely to be too restrictive for much larger offshore wind developments. For mature technologies, such as offshore wind where potential impacts are relatively well understood, this type of phasing is likely to be unattractive to investors and developers. The monitoring requirements of the SDM Policy are likely to be prohibitively costly and would be more like the Grampian consent placed on London Array. This could potentially result in subsequent phases not being developed or the entire development being cancelled.

During discussion with the regulator Marine Scotland, it was clear that the SDM Policy would only be applied to small scale novel offshore wind technologies which may need less survey effort than much larger scale projects. It is unlikely that such an approach would be adopted for projects of hundreds of MW or GW scale projects, certainly at the current stage of the industry in the U.K. However, the risk assessment process undertaken at the start of a project where the SDM Policy has been applied is a useful tool and could be adapted to provide the regulator and the developer with an early warning of the types of issues that might be encountered during the permitting process. The risk assessment process can be used to identify the level of baseline characterization needed for projects, in some instances lessening the time required to gather data where the risk is considered low and therefore reducing the overall timeframe of the consenting process. For projects with much higher risk, it can provide a framework for collaborative approaches to addressing key issues at a strategic level, spreading the cost across developers, regulators, and relevant stakeholders. This has the potential to result in significant savings in both surveys costs and the timescale to develop the application. However, this is balanced against the risk that further data collection may still need to be collected. The flexibility of the SDM approach gives both the regulator and the developer sufficient capacity to be able to adapt to any changes, while ensuring the environment is sufficiently understood to provide a robust assessment in a compressed timescale.

The use of advisory groups in the U.K. to foster a collaborative approach to data collection and monitoring between regulators, developers, and key stakeholders has proven particularly successful for the wave and tidal industry. Similar groups have also been in operation in the offshore wind industry in the U.K for some time. Project specific and regional development Evidence Working Groups have been set up to share information and to provide collaborative approaches to common challenges. The setting up of these groups is a strategy from which the offshore wind industry in the U.S. could potentially learn. Not only does it standardize data collection, improving the robustness of the results and the application across the industry, it encourages all concerned parties to come together to find solutions to problems as they emerge. The upfront planning approach from site selection, through the data collection, assessment process, consent and beyond into operation provides a much closer working relationship between the developers and the regulator who are working towards a common goal. This must be carefully managed to avoid conflicts of interest. However, for the wider industry, it is more beneficial due to the collaborative approach and shared learning through the consenting process and the monitoring of each phase as projects are developed.

2.3.1. SDM Application

The initial aim of this task was to review the application of the SDM Policy, how the different phases might be delineated in practice and how monitoring could be utilized to inform the deployment of each subsequent phase. However, one of the main conclusions drawn from examining the SDM Policy (see Section 2.3.1) is that it is likely to be too restrictive for larger offshore wind developments if implemented in its entirety. However, the examination of risks associated with a project is useful for understanding potential risk to the environment at an early stage of development. It is this process that formed the basis of the review of the SDM Policy application (see Appendix C.3.2.).

The application of the SDM Policy to the two example projects (hypothetical examples designed specifically for this exercise, one of 300 MW (Project A) and one of 2400 MW (Project B)) (see Appendix C.3.2.4) demonstrates how an upfront risk assessment can be of benefit to the overall process of developing a project. By reviewing the potential risks of a project based on the size of project, the sensitivity of the environment in which it is placed and the potential interaction with the environment (albeit at a high level), allows the data collection process to be proportional to the potential risk of a development. For instance, the moderately sized Project A when developed in a low sensitivity environment had a low overall potential risk. Thus, there may be the potential to reduce site characterization requirements. However, if the need for further data collection (i.e., because of high numbers of protected species) is later identified, then there is still the ability for the regulator to request further data collection.

As projects move into more sensitive environments or become larger, the characterization requirements will also increase proportionally. Where risk is identified as medium, an intermediate approach may be applied, where data collection is reviewed at an interim point. If it is considered that the risk is lower than expected or the data collected is adequate, then further characterization may not be required, but this would very much depend on the design of the development, the receptors, and the hazards that may be present. However, it would be hard to plan the program of a development when there is no certainty over the level of data collection required pre-application. There are potential issues of practicality that would require some further development. For high risk projects, the license application would require a full suite of characterization data. Due to the high risk, there would be no benefit in reducing the requirements for site characterization.

It should be noted that for projects that are in the high-risk category in the marine renewables sector (for which the SDM Policy was initially designed), there would be a requirement to monitor in between a series of development phases to confirm that there were no significant impacts on the environment. However, offshore wind developers and their financiers are likely to be cautious about such an approach (as per the Grampian consent example in Section 2.2.1). In addition, the uncertainty inherent in the marine renewables sector is considerably higher than for offshore wind. Studies across Europe have provided a wealth of data and there are several empirical studies which provide important understanding of potential impacts, missing in the marine renewables sector.

To date, Marine Scotland has only implemented some aspects of the SDM Policy for three offshore wind developments, all using novel floating offshore wind turbines (e.g., Hywind, Kincardine, Dounreay Tri). For larger developments using fixed turbines where potential impacts are relatively well understood, this type of phasing is likely to be unattractive to investors and is unnecessarily precautionary. If implemented, it is likely to result in much slower progress of development, particularly if phases need to be separated by considerable amounts of time to allow monitoring to be implemented fully. Therefore, any application of the SDM Policy to offshore wind should only consider the upfront risk assessment process. While the risk assessment process might need some adaptation to offshore wind, the process used and applied to the hypothetical projects exampled in Appendix C.3.2 provides some indication of how this might be undertaken. It is clear from this study that the phased aspects of SDM are not relevant to OWFs and have therefore not been carried through as recommendation from this project.

Key Points from Section 2.3
The main reason the SDM Policy was introduced was to deal with the inherent uncertainty in the marine renewables sector. This uncertainty does not exist to the same degree in the offshore wind industry. Therefore, the SDM Policy is not applicable to offshore wind, particularly the need to monitor between different phases. However, the upfront risk assessment is a tool that has been used to ensure proportional baseline characterization for offshore wind projects and could be further adapted for much larger projects.

2.4. Project Design Envelope Process and Phasing Implementation

The following section provides a summary of the outcomes of the study into the application and interpretation of the PDE and phasing when applied to the environmental assessment process. The full analysis is provided in Appendix D, which includes the full hypothetical PDE developed for the purposes of this study and for undertaking the analysis.

2.4.1. Overview of the Project Design Envelope (PDE) Process

The PDE approach (i.e., Rochdale Envelope) is an approach that the U.K offshore wind industry uses, which allows for the permitting of a range of different development scenarios and design. The PDE is used to illustrate the range of possible values (as opposed to providing fixed design parameters) under a certain design parameter (e.g. foundation design, turbine capacity). The range represents the different options being considered by the developer that could be installed once the offshore wind farm has received its permit and enters construction. A typical offshore wind farm PDE used in the U.K. includes details of the following elements of the offshore wind farm design:

- Offshore infrastructure within the array (e.g., turbine parameters, foundation options, scour protection, inter-array cabling etc.);
- Offshore transmission infrastructure (e.g., export cable infrastructure, offshore transmission platforms (e.g. offshore substations), cable protection measures etc.);
- Vessel and helicopter details (e.g., number and type of vessels, number of return trips to port, number of flights);
- Landfall details (e.g., trenched of Horizontal Directional Drilling (HDD) methodologies), and
- Onshore transmission infrastructure (e.g., cable details, trenching information, substations, area of temporary construction compounds, number of buildings etc.)

As initially discussed in Section 1.5, if phasing is introduced into a project in the U.K., then the nature of the phased build out needs to be captured within the PDE, providing a range of options for phased build out as part of the envelope. The maximum design scenario for potential environmental impacts for which phasing is relevant is then selected from the description of phasing within the PDE and a full environmental impact assessment completed. In this way, as for the rest of the PDE, a full assessment is completed of the maximum scenario and any phased build out within that described within the PDE will have been assessed. Therefore, once a developer reaches construction they do not need to submit a revised or new application if they select a phasing option that is within the assessed envelope.

The PDE identifies the range of potential project design values for all relevant components of a development (such as the foundation options, e.g., monopiles, gravity based or floating foundations). The PDE is then utilized to assess potential impacts on key resources (e.g., marine mammals, fish, benthic habitats, commercial fisheries, etc.) with the assessment focusing on the design parameter that is considered to give rise to the greatest potential impact. For example, if several foundation types remain possible, then the assessment of the project is based on the foundation type known to have the greatest impact on a given receptor, such as the largest footprint, or the greatest noise level generated, depending upon the topic under consideration. If, after undertaking the impact assessment, it is shown that no significant effect is anticipated, it can be assumed that any project parameters equal to or less than those presented in the PDE will have environmental effects of the same level or less and will therefore also have no significant effect. The project parameters that would have the greatest impact on a given receptor are referred to as the maximum design scenario or worst-case (the maximum design scenario is generally the preferred terminology, over the worst-case, given that the impact could be positive as well as negative). The maximum design scenario is selected from the range of parameters presented in the PDE. When the project progresses to construction, if the final design parameters sit within the range of values for each parameter presented within the PDE, then the permit or consent remains valid. By employing the PDE approach, a project retains essential flexibility in design within certain maximum extents and ranges, all of which are fully assessed. Retaining this flexibility is particularly important in an evolving sector such as offshore wind, to ensure the ability for the final engineering design to incorporate new developments (but within the envelope of parameters considered in the environmental assessment). This approach has been applied in several different project types and ensures that the assessment can address all potential impacts, even where there is uncertainty over final design. This process also ensures that the totality of impacts from an entire project is considered and not just a single phase at a time.

Further detail on the Project Design Envelope/Rochdale Envelope concept is provided in Table 1 in Section 1.5 of this report and by Marine Scotland (2012), Shearer (2013), Gudiña (2014), PINS (2012), and Wright (2016).

As part of this study, a hypothetical PDE scenario was developed to explore how phasing is applied to the PDE and how potential impacts as a result of a project are interpreted. This hypothetical PDE was developed to explore the current range of parameters that have been presented in application documents in the U.K. and could possibly appear in future application in the U.S., and were used to explore how the phasing is interpreted within the impact assessment process. Appendix D.2 provides the hypothetical PDE used in this study and describes the typical broad scale design parameters considered in this study. It does not cover all the parameters used to define an offshore wind farm project; rather, it includes those parameters that may influence consenting or permitting together with the associated program and cost. To investigate how the PDE and phasing are implemented and interpreted within an assessment of the potential effects on the environment, a hypothetical example of a project was developed. The hypothetical PDE was developed as a tool to examine how a project might interact with the environment and how the process of interpreting the PDE and phasing might be used within the U.S. system.

It should be noted at this point that the Hypothetical PDE in Table D-3, Appendix D.2 was developed for demonstration purposes only and should not be used as an example of likely parameter values outside of the context of this report. The parameters and their values contained within Table D-3 are for example purposes only. Therefore, any project that uses a PDE would have its own project-specific PDE and should not be based on the parameters or

values provided in the example in Table D-3. It should also be noted that the PDE for projects are not usually presented in a single table as in Table D-3, but as a series of envelopes for each relevant design parameter (i.e., the foundation envelope, turbine envelope, substation envelope, etc.) and the parameters have only been placed in a single table to aid interpretation for the purposes of this study.

To develop a hypothetical example of a project design envelope, the most recent projects in the U.K. were reviewed, including projects that have been awarded consent, those still in determination, and one project still at the early planning stage. Using publicly available information, the review examined the common parameters included in each PDE and the range of values that were included for each parameter. The projects that were reviewed included some of the largest examples of offshore wind farms currently consented in the U.K. and some examples of floating wind technology as this represents the next phase of development in the offshore wind industry. In addition, the Hornsea Project Three scoping report was reviewed as this represents the most up-to-date thinking in terms of the range of values included within the PDE. Publicly available information from U.S. developers' and NREL (2015) was used to check the feasibility of the values in the context of projects being developed within the U.S. These projects (see Appendix D.1.3) were examined to identify the most typical parameters presented within each PDE. The PDEs were then systematically compared to develop a realistic range of parameter values.

All information that has been reviewed and analyzed as part of this report has been derived from publicly available sources including DONG (2016), Dounreay Trì Limited (2016), Kincardine Offshore Wind Limited (2016), East Anglia Three Limited, (2015), SmartWind, (2015), Statoil, (2015) and Forewind (2013 & 2014). Additional information was obtained through consultation with developers in the U.S. (see Appendix D.1.4).

2.4.2. Interpreting Phasing within the PDE

To understand how phasing is assessed when undertaking an impact assessment, it is important to understand how the phasing presented in the PDE is interpreted. To demonstrate this point, the hypothetical PDE was used as an example project against which some common impacts where phasing might influence the maximum design scenario taken from the PDE and the impact assessment that is then undertaken on the maximum design scenario. This is important as it enables us to understand the information on phasing that is required within the PDE when presenting the PDE in application documents. This information is key to enabling assessment practitioners to undertake the assessment while ensuring that phasing is fully considered in their presentation of the potential impacts to relevant receptors.

Appendix D.1.5.4 demonstrates how the interpretation of phased approaches is a key element of understanding the PDE and how the development might interact with the environment. For each of the example impacts identified for a typical offshore wind farm, the maximum design is presented. This represents the options within the PDE for a particular impact that would result in the greatest potential effect. All other options would result in effects that would be the same as or lesser than those presented within Table D-4. In addition, the phasing approach that results in the greatest level of potential impact is also identified to demonstrate how the definition of the 'maximum design scenario' is influenced by the phasing strategy.

For each of the examples, the maximum design has been calculated based on the parameters provided within the hypothetical PDE and can be summarized at a high level as:

- Marine physical processes – the greatest volume of sediment disturbed during cable laying;
- Benthic, subtidal and intertidal ecology – the greatest area of seabed disturbed during cable laying, and

- Marine mammals:
    - Spatially the greatest distance between piling events using monopiles would produce the greatest magnitude of sound, and
    - Temporally the longest amount of time spent piling would occur using jacket piles, which while they take less time to pile there are 4 times more.

It should be noted that other impacts may also be relevant for each receptor group. It also should be noted that these examples do not necessarily represent the greatest level of impact across a project, but have been selected to demonstrate how phasing influences the interpretation of the PDE.

For each of the above examples, the maximum design scenario is further defined by selecting the phasing strategy that would result in the greatest potential impact on the environment. While phasing will not necessarily change the maximum design scenario that has been defined based on the parameters in the PDE, it does further influence that potential effect and demonstrates that it must be considered when interpreting the PDE where phasing is proposed. The phasing strategy essentially modifies the potential effects on the environment identified from the PDE. To demonstrate how phasing might influence the selection of the maximum design scenario four different phasing strategies were developed. These include:

- Single phase – the wind farm is constructed in a single phase as a single development;
- Sequential (with gap) - two or more phases, each one occurring after the previous phase has completed;
- Sequential (overlapping) - two or more phases, construction overlapping but each component (i.e., wind turbines) only occurring after the previous phase has completed, and
- Simultaneous - two or more phases, each with a different undertaker / construction contractor, each constructed at the same time, although not necessarily the same aspect being constructed at the same time (e.g., one may be installing wind turbines and the other the export cable). However, the maximum design scenario would include the construction of the same elements at the same time.

In many instances, the introduction of phasing results in repeat effects on a given receptor, such that disturbance occurs several times (e.g., seabed disturbance). While it may not occur across exactly the same area of seabed, it may overlap when deposition of disturbed sediment and increases in suspended sediment concentrations (SSC) are considered. This is the case for marine physical processes, benthic, subtidal and intertidal ecology and marine archaeology, where installation of the cable route over up to three phases may cause disturbance a number of times rather than once under a single-phase strategy. While this may occur, and increase the potential magnitude of the impact, it does not necessarily mean that the impact is significant. This will very much depend on the magnitude of the impact and the sensitivity of the receptor and the judgement of the practitioner undertaking the assessment. Furthermore, whether phasing affects the maximum design scenario will very much depend on the sensitivity and recoverability of the receptor affected. For instance, sandy areas which are subjected to tidal currents may recover quite quickly, and therefore several disturbances due to phasing will not change the maximum design scenario significantly. However, for more sensitive habitats which take longer to recover from disturbance, the phasing may be more of an issue, particularly if there is not sufficient time for the habitat to recover between phases. It should also be noted that in some instances and for some impacts, phasing has no influence at all and is not considered if this is judged to be the case by the practitioner undertaking the assessment.

Introducing a gap may also represent the worst-case scenario in terms of the phasing strategy, as it will allow some recovery between phases, only for the impact to occur again during the second (or even third) phase. This is especially pertinent for species with specific life cycle periods (e.g., breeding) that occur at certain times of the year, such as marine mammals. Under the sequential (with gap) scenario, the marine mammals would be initially disturbed and move away from the noisy activity until it has ceased, only to be exposed once again when the next phase begins. Under a single-phase strategy, the disturbance would occur once and animals would return once noise has ceased and would not be disturbed again. The same would occur under the sequential (overlapping) or simultaneous strategy. However, it should be noted that employing the phased strategy will result in an impact that is of greater magnitude than the other strategies if they were to be employed but does not necessarily result in a significant impact. Again, the influence of phasing on the effect will very much depend on the sensitivity of the receptor to the relevant impact and the maximum design scenario as a result of the phasing strategy included within the PDE.

In some instances, the spatial nature of the impact is important to understand. Again, with piling noise, if the development were to be constructed in a single phase, then there is the potential that the spatial separation between piling could be at its greatest. This could also happen under the simultaneous strategy, although this would depend on whether two undertakers at the furthest ends of the development were piling at the same time and at the points furthest from each other. A spatial element also has the potential to affect other users of the sea. For instance, seismic surveys for oil exploration would not be able to be undertaken in areas where construction is taking place or where infrastructure has already been installed. The simultaneous strategy is most likely to result in the largest area unavailable for seismic survey at any one time, particularly if construction occurs in more than one area at a time or if higher density of vessels is present.

In general, the effects of phasing on the maximum design scenario and the potential impact being addressed are dealt within a qualitative manner. The level to which phasing affects the maximum design scenario and the outcome of the impact assessment will very much depend on the sensitivity of the receptor to the impact, the effect of phasing being introduced and the expert judgement of the practitioner as to whether phasing has an influence of the outcome of the assessment. Where there is the potential for this to occur, it does not necessarily follow that the impact will be significant which will again depend on the magnitude, sensitivity and judgement of the practitioner. Generally, where impacts are affected by phasing, mitigation will need to be tailored to take phasing into account, with the mitigation measure reapplied during each phase (i.e., soft start procedures etc. for marine mammals during piling).

It is clear from the results of the analysis of the interpretation of the PDE, considering the relevant phasing strategy, that the indicative phasing schedule needs to be understood. How and when each phase will be implemented needs to be outlined in an indicative schedule to enable interpretation and assessment. Therefore, there needs to be a good indication of construction schedules required. While this does not need to be overtly detailed, it does need to ensure it covers all the possibilities of when key activities (piling for instance) are likely to occur and interact with key receptors.

Key Points from Section 2.4

Understanding the implications of phasing on the maximum design scenario is a key process in assessing the potential impacts of a phased development. The mechanism through which this is presented is the PDE and subsequent interpretation of what the maximum design scenario is during the impact assessment process. To allow a robust assessment to take place that takes phasing into account, an indicative schedule outlining the phasing of key activities and the time period over which these occur needs to be included in application documents.

3. Recommendations

This section presents the key findings and recommendations that have been drawn out from the study and draws upon the results of the consultation undertaken in the U.K., with U.S. developers, and from the workshops held with BOEM in February and April 2017.

3.1. Key Findings and Recommendations

The following recommendations are based on the findings of the review of approaches to phased offshore wind developments in the U.K., the SDM Policy and the existing U.S. process (including the approaches/processes that can be applied to the U.S. offshore wind sector and regulatory system).

- The PDE is a key tool for large, complex projects (e.g., zones designated for Offshore Wind Farm [OWF] development with multiple projects and phasing within projects). It allows the developer flexibility in design parameters at an early stage in development and is now the standard tool used in the U.K. to communicate the project (and its parameters, both offshore and onshore) in the application for a permit to develop an offshore wind farm.
- The PDE is a mechanism by which phasing can be presented, interpreted and assessed for a development. In the U.K., the parameters presented within a PDE for phased development of a project must cover all phases of the project if the developer wishes to receive a consent/permit for the entire project at once. This means that a 'maximum design scenario' can be selected and assessed in terms of the phased aspects of the project, with the PDE approach ensuring that the environmental implications of phasing can be assessed. If the developer wishes to consent/permit each phase separately, then they only need to include the relevant information for the phase(s) that are to be developed.
- There are several different ways that a phased project can be taken forward. For the latest developments in the U.K., a zonal approach has been used, whereby a large zone with several different but separate projects are developed individually with a single permit/consent for each individual project within the zone. Each separate project may then be phased, such that each individual project is developed over two or more phases but as a single project under a single permit. In large zonal development areas, it may be that several projects are undertaken, each with their own phasing. For each individual project in the zone, an individual application will need to be made within which the phases for that project will need to be detailed, including a PDE that covers all phases of the individual project.
- Interpretation of the PDE should be integral to the assessment of potential impacts on the environment. Assessments are required to be carried out through a 'maximum design scenario', whereby the parameter (or combination of parameters) which represents the greatest effect is selected for the assessment of each individual impact for each receptor/receptor group.
- It should be noted that if a "most likely" case scenario was to be used and this assesses an element which does not represent the greatest impact, then there is the potential for the permit issued to a developer to be invalidated if they use an option that results in a greater impact than the 'most likely' case. If those options are eventually selected, then a revised COP and technical and environmental assessment would need to be undertaken, resulting in further delay to the permitting process.

- The SDM policy in its entirety is not appropriate for offshore wind. The impacts of offshore wind are better understood than for wave and tidal and monitoring imposed between phases could potentially stifle development. The London Array example demonstrates how such monitoring with no guarantee of a positive outcome may result in subsequent phases being discontinued. However, this is not to say that monitoring may not be part of the permit, but that the permit of later phases would not necessarily be linked to the outcome of such monitoring (unless there a notable uncertainty/concern).
- The risk assessment presented by Marine Scotland (2016) in the SDM policy is a useful tool for understanding the potential risks posed by a project during the early stages of development. It is a tool that can be used to ensure that data collection and early baseline characterization surveys are proportionate to the risk presented by the project and the sensitivity of the environment in which the project is proposed. However, the risk assessment will need to be further developed to make it more appropriate to the U.S. offshore wind sector. It is recommended that BOEM discuss options with MS-LOT to examine how this might be possible and to further understand the application of the risk assessment.
- The permitted/consented PDE provides essential flexibility to a developer in an industry that is rapidly evolving in terms of new technology and methodologies. This approach allows developers to include future innovations that may be ready for deployment at the time of construction but have not yet been deployed elsewhere (e.g., higher capacity turbines than are currently deployed or available in the market or larger dimension foundations than are currently available). The selection of a ‘maximum design scenario’ means this flexibility can be designed into the consent or application, while also maintaining robust environmental assessments that provide confidence in the outcomes. This should ensure that there is no future need to revisit the assessments once final design decisions have been made, if the final design consists of parameters that have been covered within the PDE.
- There are likely benefits to integrating the use of a PDE approach to the process of permitting offshore wind projects in the U.S., in terms of the developer and regulator being able to view a project in its entirety (i.e., the inclusion of all phases). This integration will allow both the developer and the regulator to identify, consider and assess all potential impacts, regardless of whether a development is proposed as being constructed in a series of phases or the whole construction is undertaken in a single phase. However, it should be noted that mandatory use of the PDE is not necessary as some developers may wish to take a more incremental phased approach with smaller projects of MW scale.
- From examining the current regulatory process in the U.S., it could be possible to incorporate phased approaches and the use of a PDE approach; however, the concept of improper segmentation needs to be taken into consideration as well as a potential further analysis of some of current BOEM regulations. To implement the approach, applicants will need to ensure they provide all the information requirements of 30 CFR 585.626 and 585.627 for each phase of development, so that BOEM can proceed with the necessary environmental and technical reviews of the COP, otherwise the COP may not be accepted or disapproved by BOEM. Specifically, one challenge of a PDE approach is when a COP is submitted without all the necessary information (e.g., geophysical and geotechnical, etc.) required under

BOEM regulations. To address this particular challenge, this scenario may require a departure[5] from the current BOEM regulations and development of an alternate decision making process. And, while this may not be determined necessarily as a legal challenge, it does warrant further legal consideration.

- In current U.S. regulations, pursuant to 30 CFR 585.629, an applicant may include a request within the COP to develop a commercial lease in phases. The COP submission must still follow the regulatory requirements and provide a schedule detailing the timeline proposed for subsequent phases. The COP must provide full details for the initial phase (or phases) so that the initial COP meets BOEM's regulatory data and information requirements. Each time that the developer is ready to proceed with a subsequent phase (or phases) a revision to the COP must be submitted with each revision including the information described in 30 CFR 585.626 and 585.627 for each phase of development, so that BOEM can proceed with the necessary environmental and technical reviews of the revised COP. During the review of the COP guidelines (BOEM 2016), there was some uncertainty as to whether a COP can contain all phases of a phased development approach. Upon further discussion with BOEM, this was resolved. However, it is recommended that BOEM review the current COP guidelines to clarify whether all phases of a development can be submitted in a single COP as an application for a single permit.
- Phasing and the PDE need to be outlined within the COP when it is submitted and then assessed using a maximum design scenario process. How this is undertaken will need to be decided by BOEM, although it would seem the section of the COP that deals with the engineering and design of the development would be the natural home. Based on the Cape Wind COP (ESS, 2011), the Project Information section would be the most likely location for the description of the phased approach being taken (under the Project Construction Schedule, Section 2 is ESS (2011)). Key construction parameters that form the PDE would need to be outlined in the "Construction Plan" and "Operations Plan and Maintenance Plan" sections of the COP document (Sections 4 and 5 respectively in ESS (2011)), with the envelope for each design feature presented in the relevant section (i.e., the foundation envelope, turbine envelope, etc.). The COP would need to include a PDE that includes a high-level construction program demonstrating the different phases of development. This is to ensure that phasing of the development can be fully interpreted and the implications fully understood. An indicative schedule/construction program will need to outline the periods over which key elements of the development will take place (i.e., when piling takes place, when the export cable is installed, etc.).
- The PDE must provide all the relevant information pertinent to the design of a development which is required by BOEM to undertake their environmental and technical reviews and pursuant to 30 CFR 585.626 and 585.627, particularly for design parameters that may change or vary as the design progresses and before a project moves into the final design stage. While BOEM should provide advice on the elements they need to understand to assess the potential effect on the environment, the structure, parameters and values provided in the PDE should be provided by the developer.

[5] Refer to Cornell Law School (2017) and DOI MMS (2009) for more detail on the BOEM Departure Process.

- Once the COP has been approved, the Facilities Design Report (FDR) and Fabrication and Installation Report (FIR) will both need to be developed to include all phases of the project that have been permitted and are included in the COP.
- The "maximum design scenario" concept needs to be communicated to all BOEM and ultimately the developers (particularly those with no experience in Europe and the U.K.). A workshop could be used to facilitate this process through working through examples that interpret the PDE from real projects (i.e., a project that has been developed in the U.K.). The workshop would need to be mediated by consultants familiar with the process and interpretation of the PDE and the "maximum design scenario".
- Clear communication of the phased approach and the PDE (and the PDE approach) is a critical element to successfully implementing these tools/processes. Work will need to be undertaken with key/statutory agencies and other relevant stakeholders as to how the approach works. A robust and clear assessment of the potential environmental impacts of a phased development will ensure the implications of phasing are understood, the PDE approach can proceed and that flexibility can be delivered in a permit approval. The key reason that clear communication is needed is that both PDE and phasing concepts can be complex subjects to communicate to all stakeholders involved in terms of how a project is proposed to be developed and for understanding the potential environmental implications.
- Ultimately, the implementation of the phased approach and the use of the PDE need to be adapted to the U.S. system rather than the system being adapted to be more like the U.K. approach. This will ensure the process is fit for purpose and the transition takes place in a timely manner and allows the process to fit to the current system. Changing the current system significantly may introduce further uncertainty and will certainly result in greater delay to the industry as a whole, while the regulatory landscape is shifted.
- It is recommended that there is a series of cross agency and developer workshops to work through issues with implementing phased approaches within the COP (possibly arranged through establishing / established Expert Working Groups). Through this process, any potential issues could be ironed out as phased approaches and the use of the PDE is integrated into the permitting process. This also ensures that any changes are not undertaken in regulatory isolation. Developers and regulators should combine efforts to develop a robust and workable process, which will then be implemented by BOEM and other relevant agencies. This will also ensure that all relevant bodies key to the regulatory and development process have an opportunity to contribute early to identifying problems and finding solutions that futureproof the process, and ensure projects that are phased and use the PDE approach run smoothly through the permitting process.
- The further development of expert working groups (which are already in place in the U.S. system) to deal with key strategic industry issues will continue to be a useful tool as the offshore wind industry develops in the U.S. These can be used to standardize methodology and research programs so any data can be used by the industry as a whole. A collaborative approach, as seen in the wave and tidal industry, is beneficial as the industry can move forward through the application of learning from multiple developers. This may also be beneficial in implementing the PDE and phased approaches, with the industry and regulators (and other agencies)

learning together as early projects progress and move forward using these approaches.

- Consideration should be given to the development of a BOEM Guidance Document on the Project Design Envelope approach (or 'Rochdale Envelope') to development applications. The Planning Inspectorate produced such an advice note, or guidance document, for the Rochdale Envelope approach (PINS, 2012) which could be used as a template in the U.S. However, the guidance document will need to be tailored to the NEPA Process and the development of the COP. Prescriptive guidance is likely to be challenging to develop and unlikely to be able to cover all the potential permutations presented by the wide variety of projects and technologies (particularly given the changing nature of the offshore wind sector). Given the current rate of technology development, it is likely that any guidance will quickly be out of date. In addition, prescriptive guidance may stifle the inclusion of innovative solutions. It is also likely to be poorly received by industry if there is a perception that such guidance reduces essential flexibility in future project design.
- Active engagement by the regulator and developers is a key element in de-risking of projects and the industry as a whole. While this will ensure stakeholders do not misinterpret the phased approach and the PDE, it also presents an opportunity for the regulator to steer the project(s) and the industry.

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Appendix A: U.K. and U.S. Offshore Wind Regulatory Regimes

A.1. Overview of the U.K. Consenting and Licensing Regime

This section has been included as important background to the consenting regime within the U.K. and is required to provide context to the consenting process for each of the cases reviewed in Appendix B. Over the course of the period within which the projects selected as case studies have been developed, there have been significant changes to the licensing regime in the U.K. As a result, different project has been consented under different consenting and licensing regimes. Before 2008, projects were consented under several different pieces of legislation (Town and Country Planning Act, Electricity Act, Food and Environment Protection Act and Coast Protection Act). Post 2008, the consenting regime has been streamlined so that consenting and licensing is undertaken through the Planning Act and Marine and Coastal Access Act. Both processes are outlined below.

A.1.1. Environmental Impact Assessment (EIA) Process

Under European Environmental law, European Commission (EC) Directive 85/337/EEC, as amended by Directive 2011/92/E (known as the ''EIA Directive''), requires an EIA to be completed in support of certain types of projects. Offshore wind farms are listed in Annex II of the Directive, as ''*installations for the harnessing of wind power for energy production (wind farms)*''. These provisions have been transposed into U.K. legislation. In the U.K., the Directive is applied to offshore wind farm projects and associated onshore infrastructure through the Infrastructure Planning (Environmental Impact Assessment) Regulations (2009). These Regulations set out the statutory process and minimum requirements for the provision of adequate environmental information to enable the EIA process. The EIA, activities, surveys and studies are presented in an ES.

A.1.2. U.K. Consenting and Licensing Regime

A.1.2.1 Projects Pre-2008

The principal licenses, consents and permissions required for projects brought forward for consent before the year 2008 are listed below, with further detail in the following sections:

- Planning permission: Town and Country Planning Act
- Electricity Act 1989: Section 36 consent;
- Electricity Act 1989: Section 36A declaration;
- Food and Environment Protection Act (FEPA) 1985: FEPA license, and
- Coast Protection Act (CPA) 1934: CPA consent.

Town and Country Planning Act 1990

Planning permission under Section 57 of the Town and Country Planning Act 1990 is required for all operational development (as defined by Section 55) (i.e., '*carrying out of building engineering mining or other operations in on over or under land*' or any material change of use of buildings or land) under the jurisdiction of the local planning authorities.

Section 36 of the Electricity Act 1989

Under Section 36 of the Electricity Act 1989, consent is required from the Secretary of State for Trade and Industry to construct, extend or operate a generating station with a capacity of greater than 50 MW. The requirement was extended on 1 December 2001 by means of a Statutory Order (SI2001/3642) to cover all offshore wind and water driven developments of above 1 MW capacity. The proposal in a Section 36 application may also include associated onshore project elements such as an electrical substation.

Section 36A of the Electricity Act 1989

Where a consent is granted by the Secretary of State in relation to the construction or operation of a generating station, that comprises or is to comprise, renewable energy installations situated in or adjacent to Great Britain (between the Mean Low Water Mark and Seaward Limits of the territorial sea) they may at the same time make a declaration with respect to rights of navigation. A declaration under Section 36A is one declaring that the rights of navigation are extinguished, suspended or subject to specified restrictions for a specified period of time.

Food and Environment Protection Act 1985

Under Section 5 of the Food and Environment Protection Act 1985, a license is required from the Secretary of State for the Environment, Food and Rural Affairs for:

i. The placement of materials or structures in U.K. waters, either in the sea or under the seabed during construction, and related actions, and

ii. The disposal of waste at sea (primarily dredged material including its use for beneficial purposes).

Coast Protection Act 1934

Consent is required from the Secretary of State for the Environment, Food and Rural Affairs for:

- The construction or improvement of any works on, under or over any part of the seashore lying below the level of Mean High Water Springs (MHWS);
- The deposit of any object or materials on any part of the seashore below the level of MHWS, and
- Removal of any object or materials from the seashore below the level of MHWS (e.g., dredging).

Relevant Projects

London Array, Gunfleet Sands I and II were both consented prior to 2008 and were therefore consented under the above legislation and awarded planning permission for onshore infrastructure under the Town and Country Planning Act, Consent under Section 36 of the Electricity Act, CPA consent and a FEPA license.

A.1.2.2 Projects 2008 and Beyond

Planning Act 2008

One of the objectives of the introduction of the Planning Act 2008 was to address the need for, and to speed up the delivery of, large infrastructure projects, referred to as Nationally Significant Infrastructure Projects (NSIPs).

Section 31 of the Planning Act 2008 states the Development Consent is required for development which is, or forms part of, a NSIP. In accordance with Section 15(3) of the Planning Act 2008, an offshore energy generating station with a generating capacity of more than 100 MW constitutes a NSIP. Section 37 of the Planning Act 2008 requires that an application for an order granting Development Consent must be made to the Secretary of State for Business, Energy and Industrial Strategy.

The Planning Act 2008, and corresponding secondary legislation, sets out a comprehensive statutory framework for the granting of all the principal consents required to develop, operate and decommission NSIPs and their associated infrastructure. Specifically, the Planning Act 2008 provides that a Development Consent Order (DCO) will replace the need for certain other consents to be obtained, specifically planning permission under the Town and Country Planning Act 1990, listed building and conservation area consent under the Planning (Listed Buildings and Conservation Areas) Act 1990 and scheduled monument consent under the Ancient Monuments and Archaeological Areas Act 1979.

In addition, other consents can either be deemed within the DCO (i.e., a Marine License under Section 149A of the Planning Act 2008), or the requirement for them can be removed. See below (under the subheading "The Marine and Coastal Access Act 2009) for further information on Marine Licenses.

The Marine and Coastal Access Act 2009

The Marine and Coastal Access Act 2009 (MCAA) introduced a new planning system for overseeing the marine environment and a requirement to obtain Marine Licenses for projects at sea. The MCAA inserted a new section (Section 149A) into the Planning Act 2008 which enables an applicant for a DCO to apply for deemed Marine Licenses as part of the DCO process. The Marine Management Organization (MMO) is the responsible authority and works with the Planning Inspectorate (PINS) to ensure that the deemed Marine Licenses are transposed properly into the DCO. The MMO remains the monitoring and enforcement body with respect to the conditions and restrictions set out in the deemed marine licenses within the DCO.

Localism Act 2011

Several amendments were made to the Planning Act 2008 following the enactment of the Localism Act 2011. The key change was the abolition of the Infrastructure Planning Commission (IPC) on April 1st, 2012. Following the abolition of the IPC, the Planning Inspectorate (PINS) became the agency responsible for operating the consenting process for NSIPs. The IPC's decision making functions were transferred to the Secretary of State for Business, Energy and Industrial Strategy (BEIS) and the examining functions are now administered by the National Infrastructure Directorate of PINS. The other statutory processes in the Planning Act 2008 remain largely unaltered.

Relevant Projects

Hornsea Project Two was awarded a DCO under the Planning Act 2008, which included a deemed Marine License in August 2016. Gunfleet Sands III, as a small project below 100MW, was not required to go through the DCO process and was awarded a Marine License under the Marine and Coastal Access Act.

A.1.3. The Crown Estate

The Crown Estate is a diverse property business with a capital value of £11.5 billion (Crowne Estate, 2015). It has a statutory duty under The Crown Estate Act 1961 to maintain and enhance the value of the estate and the returns obtained from it, with due regard to the requirements of good management. The net revenues generated by The Crown Estate go to the U.K. Treasury. As managers of the United Kingdom's (U.K.'s) seabed out to the 12-nautical mile (NM) limit, and with rights to the exploitation of natural resources to generate electricity within the U.K. Exclusive Economic Zone (EEZ), The Crown Estate plays a major role in the development of the offshore renewable energy industry. The Crown Estate has run six rounds of offshore wind leasing in U.K. waters since 2000.

Rights for renewable energy developments are generally granted by The Crown Estate under an Agreement for Lease. An Agreement for Lease generally grants a developer an option over an area of seabed. Exercise of the option by the developer will be conditional on it satisfying certain conditions. If the conditions are satisfied and the developer exercises the option, The Crown Estate will be obliged to grant a lease of the seabed to the developer. The conditions to be satisfied before the developer may exercise the option includes that the developer obtains of all statutory consents (see Section A.1.2 and Section A.1.4 for the proposed development). If the developer is unable to satisfy all the conditions within a certain time provided for in the Agreement for Lease, the option will lapse.

During the option period, the developer will be permitted to undertake surveys and deploy anemometry equipment. However, the developer is not permitted to commence construction of its development until and unless all statutory consents and a lease are granted.

A.1.4. Consenting and Licensing in Scotland

Scotland, as a devolved administration within the U.K. has its own legislation in relation to consenting and licensing for renewable energy developments in Scottish waters under the Marine (Scotland) Act, 2010 (M(S)A) and the Marine and Coastal Access Act 2009 (MCAA).

Under the M(S)A 2010 Scottish Ministers are responsible for marine licensing system and enforcement in the Scottish inshore region from 0 to 12 nm and under the MCAA 2009 Scottish Ministers have responsibility for licensing and enforcement in Scottish offshore region from 12 to 200 nm. The licensing regime regulates the deposit and removal of substances and objects in the seas (and sea bed) around Scotland. Under both pieces of legislation Scottish Ministers are able to award marine licenses to projects which have gained consent under either (or in some instances both) pieces of legislation. Activities must take place in accordance with marine license conditions.

Marine licenses are issued by Scottish Ministers through the Marine Scotland Licensing Operations Team (MS LOT). MS LOT provides a ‘one-stop-shop’ for all marine license applications in Scottish waters.

Any proposal to construct, extend or operate a generating station situated in the territorial sea (out to 12 nm) and wholly or mainly driven by water or wind with a generation capacity in excess of 1 megawatt, requires consent under Section 36 of the Electricity Act 1989 (as amended) (‘the Electricity Act’). This substituted reduced capacity is implemented through the Electricity Act 1989 (Requirement of Consent for Offshore Generating Stations) (Scotland) Order 2002.

Any proposal to construct, extend or operate a generating station situated in the Scottish offshore region (12 to 200 nm from the shore) with a generation capacity in excess of 50 MW requires consent under Section 36 of the Electricity Act 1989 (as amended). Section 93 of the Energy Act 2004 extends the requirement for Section 36 consent to the construction, extension or operation of a generating station situated in the Renewable Energy Zone (12 to 200 nm).

A consent under Section 36 may include such conditions (including conditions as to the ownership or operation of the generating station) as appear to the Scottish Ministers to be appropriate. The Section 36 consent shall continue in force for such period as may be specified in or determined by or under the consent.

The Marine Licensing (Pre-application Consultation) (Scotland) Regulations 2013 require applicants for certain activities in the Scottish Inshore Region to carry out a public pre-application consultation. Applications affected will include those activities covered by the M(S)A 2010 with the potential to have significant impacts upon the environment, local communities and other legitimate uses of the sea. The purpose of these new requirements is to allow local communities, environmental groups and other interested parties to comment upon proposed marine developments at an early stage, before a marine license application is submitted.

The MeyGen development, as it was located within 12 nm of the coast, was consented under the M(S)A 2010 and as it was over 1MW, under Section 36 of the Electricity Act 1989. However, the Pre-application Consultation regulations were not yet in force and so did not apply to this development. The Hywind development was consented under the MCAA 2009 (as the wind farm was outside of 12 nm) and the M(S)A 2010 (as the cable to shore was inside 12 nm). The Pre-application Consultation regulations were also applied to this application. However, as the Hywind project was below 50MW total capacity a Section 36 consent under the Electricity Act 1989 was not required.

A.2. U.S. Regulatory Process for Offshore Wind

To address one of the questions that arose from the U.S. offshore wind developers and BOEM during the consultation process of this project (as discussed in more detail in Appendix D), an examination of whether phasing would fall under the current U.S. laws was necessary. The review aimed to determine whether phasing might be construed as improper segmentation.

A.2.1. Concept of Segmentation

Under NEPA, the Council of Environmental Quality (CEQ) was created to assist in the development of the U.S. policies to meet the purposes of NEPA. Within the guidelines mandated by the CEQ, an environmental analysis is intended to assess the entire scope of a single or complete project (Veenendaal, 2012). However, one important aspect to assess in the scope of a federal action is the issue of segmentation, the division of a project, program, or decision into component parts or temporal "phases" (Chertok, 2005; Veenendaal, 2012). Because all projects must have a start and end point, under NEPA all project components may have "independent utility" and can be considered individually (Veenendaal, 2012). The "independent utility" of a project is determined based on whether it is "connected" to another action in such a way that a collective environmental impact assessment is required under NEPA (Chertok, 2005). However, if an agency intentionally attempts to circumvent the NEPA process by dividing a federal action into smaller components with fewer perceived impacts to permit those components and avoid studying the overall impacts of a single project, it is referred to as "improper segmentation" (Veenendaal, 2012). While the concept of segmentation is not necessarily unlawful, it is considered unlawful for agencies to shirk their responsibilities under NEPA if a major federal action is artificially divided into smaller components to determine that each action does not pose a significant impact, but when the project is taken as a whole, a significant impact does exist (Chertok, 2005; Veenendaal, 2012).

Segmentation was frequently used in relation to federal highway funding when the U.S. Federal Highway Administration (FHWA) would release funds for a small segment of a federal highway and consider only that segment, rather than the entire highway, when determining whether an EIS was required (Chertok, 2005). However, for the most part, these divisions of an action have been prohibited by the federal courts both in highway and other contexts (Chertok, 2005). Under certain circumstances, a federal agency may still focus on a single federal action while excluding other federal actions that, if considered, would transform the project into a major federal action[6] (Chertok, 2005). According to CEQ regulations, agencies are only required to consider "connected actions" defined as those actions that 1) automatically trigger other actions requiring environmental impact statements; 2) cannot or will not proceed until other previous or simultaneous actions occur, and 3) are interdependent portions of a larger action and can only be justified based on that larger action (Chertok, 2005). Therefore, federal courts have since permitted segmentation in the context of highways when it was demonstrated that there was "independent utility" for the segment. In other words, the sole purpose of the segment permitted was not merely

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[6] A "major federal action" is defined in CEQ regulations as an action with effects that may be considered major and which are potentially subject to federal control and responsibility (Veenendall, 2012).

as one necessary piece of a larger planned road or network of roads (Chertok, 2005). This test of "independent justification" or "independent utility" has been also applied in other cases outside the context of highways (Chertok, 2005).

The temporal aspect of the definition of "action" is important, and the determination of when an action is determined a "proposal", which is subject to NEPA, or "contemplated", which is not subject to NEPA (Chertok, 2005). If an action or part of an action is described as "hypothetical" or future phases are not definite, the NEPA process does not apply (Chertok, 2005). However, federal courts will be skeptical if the planned and definite future stages of an action are characterized as "indefinite" to avoid a determination of significant effects and the requirement to prepare and EIS (Chertok, 2005).

In general, segmentation is a relevant consideration in assessing whether phased approaches to development can be incorporated into BOEM's regulatory process for authorizing wind energy projects. For instance, in determining whether the first phase of a developed lease has independent utility, BOEM should consider whether phase 1 is *only* commercially viable if one or more of the remaining phases are also built (e.g., if phase). If the answer is yes, BOEM should consider analyzing the subsequent phases as indirect impacts. If BOEM chooses not to fully analyze subsequent phases in a NEPA document, the document should explain why those phases are not part of the proposed action—and should consider analyzing those phases as reasonably foreseeable cumulative impacts.

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Appendix B: Review of Phased Development in U.K. Offshore Wind Farms

B.1. Methodology

This section provides the methodology used in the review of phased approaches in the U.K. and the review and the SDM policy. The section describes the selection process undertaken to review relevant projects and case studies, the review method applied to the reviews of phased approaches and the risk/benefit analysis methods employed.

B.1.1. Review of Phased Development in U.K. Offshore Wind Farms

The following outlines the specific methods used to review phased approaches implemented in offshore wind developments in the U.K.

B.1.1.1 Case Study Selection Process

To select the case studies for this project, a high-level review of offshore wind farms in the U.K. was undertaken. The review examined the Project Description chapter of each of the projects currently consented (or permitted) in the U.K. to identify whether the project was developed in phases or not. The aim was to identify a good range of different project examples to illustrate the PDE concept and how it has been used within phased developments.

Basic data were collected on each of the projects, including location, status (planned, construction, operational), capacity, turbine numbers, operator and phased development approach. Following this review, the number of U.K. projects that could be considered within the review was narrowed down to a total of six that involved phased developments. This long list of projects is presented in Table B-1.

To reduce the number of projects, those where a consent application has not yet been made, and hence an ES is not available (i.e., Hornsea Project Three, which has not yet been submitted) were eliminated first. Then, projects with a similar approach were compared with only one chosen depending on existing knowledge of the project and the understanding of how the project was developed. Through this elimination process, the number of projects was reduced to three final projects which were taken forward to be reviewed as case studies.

Table B-1. Long List of Six Selected U.K. Phased Developments

Wind Farm	Location	Status	Capacity	No. Turbines	Operator	Phased Development Approach
Gunfleet Sands	Outer Thames Estuary	Operational	185 MW	50	DONG Energy	Three separately consented developments (I, II and III)
Walney	Irish Sea	Operational	367 MW	102	DONG Energy	Two separately consented developments (Walney 1 and Walney 2)
Walney Extension	Irish Sea	Pre-construction	659 MW	207	DONG Energy	Consented as two phases

Wind Farm	Location	Status	Capacity	No. Turbines	Operator	Phased Development Approach
Hornsea Project One	Southern North Sea	Construction	1200 MW	240	DONG Energy	Consented as three separate projects that could be built out in up to three phases in total
Hornsea Project Two	Southern North Sea	Pre-construction	1800 MW	300	DONG Energy	Consented as two separate projects that could be built out in up to four phases in total
Hornsea Project Three	Southern North Sea	Development (pre-consent)	2400 MW	400	DONG Energy	Current understanding is that project will be built in phases
London Array Phase One	Outer Thames Estuary	Operational	630 MW	175	E.On	Consented as two phases. Second phase cancelled.

B.1.1.2 Final Case Studies Selected

The final projects selected and their reasons for selection were as follows:

- Gunfleet Sands I, II and II were chosen as examples of incremental development, where individual projects (or phases) were permitted separately to develop a much larger project. Gunfleet Sands consisted of three separate projects (rather than an initial project consisting of two phases followed by a separate extension project as was the case for Walney) and therefore represented a good example of multiple project phases consented separately.
- London Array was selected as an example of another project with separate phases permitted under a single license. However, in this instance the second phase was not constructed due to several constraints (but particularly monitoring requirements) that made the construction of the second phase unviable. This is used as an example of a project where phasing and monitoring requirements may have been a factor in causing a latter phase to not be completed.
- Hornsea Project Two was chosen as an example of a large gigawatt size project that was permitted under a single Development Consent, with two Marine Licenses (one for each project), that was to be built in up to four separate phases. This project represents a typical phased development and is therefore key to the review.

These three examples were used to provide a good cross section of the type of phased projects employed in the U.K. and to ensure a full review of both the benefits and risks of employing a phased approach. In addition, the projects selected were developed during different stages of development of the U.K. offshore wind sector. For instance, Gunfleet Sands I was a Round 1 project, London Array was a Round Two project, Gunfleet Sands III was a Demonstration round project and Hornsea Project Two is a Round three project. As a result, they are representative of the evolving thinking in the U.K. sector over the course of the industry's development. Hornsea Project Two represents the current thinking and industry approach to developing phased projects. As the most recent project example reviewed, and the most recent offshore wind farm project given consent in the U.K., Hornsea Project Two represents the most up to date phased project and PDE approach.

B.1.1.3 Case Study Reviews

Once the final three projects were selected, their Project Description chapters were reviewed to understand their individual PDE's and how the phasing in each project was represented within the PDE.

Firstly, each project as a whole was summarized and reviewed in terms of its location, when it was permitted, when it was built, the number of turbines, type and size of turbines, foundation types, etc. The Project Description chapter for each project was then reviewed to identify the parameters and values presented in the PDE and to understand the key elements of the PDE that are relevant to the phasing of the project. Finally, the relevant risks and benefits of the phased approach in relation to the perspective of the developer, regulator, and the environment were examined.

Data Sources

All information that has been reviewed and analyzed as part of this report has been derived from publicly available sources. The main project information has been drawn from the ES and supporting documentation for the relevant case study projects. The following documents were reviewed to undertake the analysis:

- GE Wind Energy (2002). Gunfleet Sands Offshore Wind Farm. Environmental Statement.
- London Array Limited (2005). Environmental Statement. Volumes 1 and 2.
- DONG Energy (2007). Gunfleet Sands 2 Offshore Wind Farm. Environmental Statement.
- SmartWind (2015). Hornsea Offshore Wind Farm Project Two. Environmental Statement. Volumes 1 to 6.

Additional information has been obtained through consultation with DONG Energy U.K. (see Section B.1.1.4).

Risk / Benefit Analysis

Key parameters were identified for the risk/benefit analysis as the review progressed. Chosen parameters were considered to be the key aspects of the project and its application that are common to phased projects. For each parameter, the risk and/or benefits of the approach were reviewed from the perspectives of the developer, regulator, and environment. The qualitative analysis was based on the expert opinion of the reviewer and their understanding of the project under review.

B.1.1.4 Consultation Meeting Notes

To provide further detail and context for each of the case studies reviewed as part of this report (and the wider Phased Approaches study) a series of targeted consultation meetings were held with relevant organizations in the U.K. These discussions were held with DONG Energy U.K. to cover the Gunfleet Sands projects, London Array and Hornsea Project Two offshore wind case studies.

The goal of the consultation was to further understand the key aspects of the PDEs for phased offshore wind developments in the U.K. and the advantages and disadvantages of the approaches undertaken within each case study. The goal of the consultation with DONG Energy was to gain further understanding of:

- the phased approaches taken for each project;
- the main advantages and disadvantages of a phased approach to offshore wind energy development;
- the key challenges of phased development approaches;
- any recommendations or changes that could be implemented in the future for phased development approaches and the further development of the PDE for phased developments, and
- the issues presented by the Grampian Consent applied on the London Array Offshore Wind Farm from the developers' perspective.

RPS met with DONG Energy at their U.K. head office in London on November 30th 2016. The results of the discussions added context to the review of the phased offshore wind projects from the U.K. and have been incorporated into the benefits and risk analysis of these projects in Section B.2. Discussions were also held with Marine Scotland Licensing Operations Team (MS-LOT) on November 11th 2016 to discuss the SDM Policy (see Appendix C). During the discussion, the PDEs and the phased approach were discussed. The main points raised by both DONG Energy and MS-LOT are provided in Table B-2.

Table B-2. Consultation Summary

Organization	Key Topics Discussed	Key Points Raised
DONG Energy UK **Pernille Hermansen (Environment and Consent Manager)** **Andrew Henderson (Lead Project Engineer)** **Sophie Hartfield (Head of**	Phased Approach	• Hornsea Zonal example (e.g. as followed by Hornsea Project Two) is the most advantageous approach to follow. • In general, for larger areas (from a developer's perspective) there are more advantages in terms of flexibility to having a 'zonal' approach with multiple projects within a zone that are consented individually and incorporation of phasing within each project. • Phasing is very important in emerging markets in allowing the industry to evolve and expand in the sense that is allows projects (or phases of projects) to be built out in an appropriate size. • DE also noted that the size of phases may be influenced by the support mechanism (i.e., what size of project is commercially viable in a given country). • The maturity of a sector in a country (including the parties involved – regulators, stakeholders etc.) will contribute to a large degree how projects are interpreted.

Organization	Key Topics Discussed	Key Points Raised
Specialists, Environment and Consents) **Emma Hospes (Environment and Consent Manager)** **30th November 2016**	Project Design Envelope	• Project flexibility and a wide project design envelope (PDE) is vital to future proof a project, especially in the last 3-4 years because there is additional pressure and opportunity to reduce the cost of building offshore wind farms. DE highlighted that increased flexibility in a PDE and incorporation of phasing will allow projects to be more competitive in bidding auctions, reduce the cost of energy production and ultimately benefit the consumer if cheaper to develop. • To build enough flexibility into a single consent, an agreement must take place in terms of the level of flexibility required for a project. This must be planned from the start to be effective.
Marine Scotland **Roger May (Renewables Section Head, Marine Scotland License Operations Team (MS-LOT))** **11th November 2016**	Project Design Envelope	• Regulators are finding that adjustments to the PDE are still being made post consent (e.g. changes in turbine size) which may introduce new environmental risks and have an impact in terms of additional consenting and assessment requirements. • If changes to the PDE results in a material change to the project (i.e. change in turbine size or height) then a new application for a new consent/license will need to be submitted. • If the PDE envelope is too big then stakeholders can find it contains too many variables to consider. • With the current system, there is the potential for exceeding the PDE without exceeding any of the impacts assessed within the original application. In other words, changes could be made that are outside of the PDE but do not change the environmental impacts. • There needs to be more proportionate assessment and definition of the PDE as well as consent/license conditions.
MeyGen Limited **Cameron Smith (Project Director)** **Cara Donovan (Project Developer)** **26th October 2016**	Project Design Envelope	• In general, the PDE is valid until a project enters the tendering stage with manufacturers and contractors – then it is likely to change. The PDE should have a shelf life of approximately 2-3 years. There will inevitably be changes and this seems to happen quite regularly. • The PDE may also change because of more detailed environmental or resource data being gathered, new innovations or technology being available. • Regulators need to be aware that instances of these and other scenarios are likely to occur throughout the early lifecycle of a project and will require adequate processes and resources to deal with variation requests. • In the early days of the project the PDE is all about minimizing detail. • There is a serious need to consider what actual parameters a project requires from its PDE to be able to construct and these must be within a range of parameters that enables the required consent to be granted.

Organization	Key Topics Discussed	Key Points Raised
		• Care must be taken to ensure the PDE does not constrain a project. A pragmatic approach should be taken and this will be influenced by the scale of development and the resources available within the developers engineering and environmental teams to establish the PDE.

B.2. Phased Offshore Wind Case Studies

The following section provides the results of the review of the selected case studies using the methodology provided in Section B-1. Each case study provides an overview of the project; presents the PDE presented within the ES for each application, and provides the results of the risk/benefit analysis undertaken for each project.

B.2.1. Gunfleet Sands I, II and III

B.2.1.1 Development Overview

The Gunfleet Sands Offshore Wind Farms (GFS OWF) are located approximately 8.5 km south-east of Clacton-on-Sea, Essex, U.K. (Figure B-1) and consists of two fully operational commercial phases and one demonstration phase as follows:

- Gunfleet Sands 1 (GFS 1) is a 30 x 3.6MW turbine commercial project;
- Gunfleet Sands 2 (GFS 2) is an 18 x 3.6MW turbine commercial project, and
- Gunfleet Sands 3 (GFS 3) is a 2 x 6MW turbine demonstration project.

Each of the GFS OWF projects was separately leased and consented. Therefore, these projects represent an example of an Incremental Phased Approach to offshore wind energy development in the U.K. It should be noted that this was not the intention at the outset of the first development at GFS. It is more an example of the evolution of the industry in the U.K. whereby existing projects have had further projects added, either as R2 developments or extension projects and demo projects. However, the end point (multiple projects located adjacent to one another) is one valid type of example of a phased development.

The wind farm was constructed by DONG Energy and is co-owned by DONG Energy (50.1%), Marubeni Corporation (24.95%), and the Development Bank of Japan Inc. (24.95%).

Background

In 2001 and 2003, respectively, Gunfleet Sands was awarded two separate lease agreements by The Crown Estate to develop offshore wind farms at the Gunfleet Sands site under Rounds 1 and 2 of the offshore wind leasing process.

Round 1 started in December 2000, and was the beginning of The Crown Estate's leasing of areas of the seabed for commercial development of offshore wind farms in U.K. waters. Typically, the projects had no more than 30 turbines placed in small scale areas selected by developers (e.g., typically 100MW and close to the shore). There are 13 Round 1 projects that are fully operational with a generating capacity of 1.2GW.

Round 2 started in July 2003 for projects near the Greater Wash, the Thames Estuary, and Liverpool Bay, including some outside the 12 NM territorial waters limit. These wind farms were larger in scale and generally further offshore than the Round 1 projects. There are 16 Round 2 projects with a total generating capacity of nearly 6 GW.

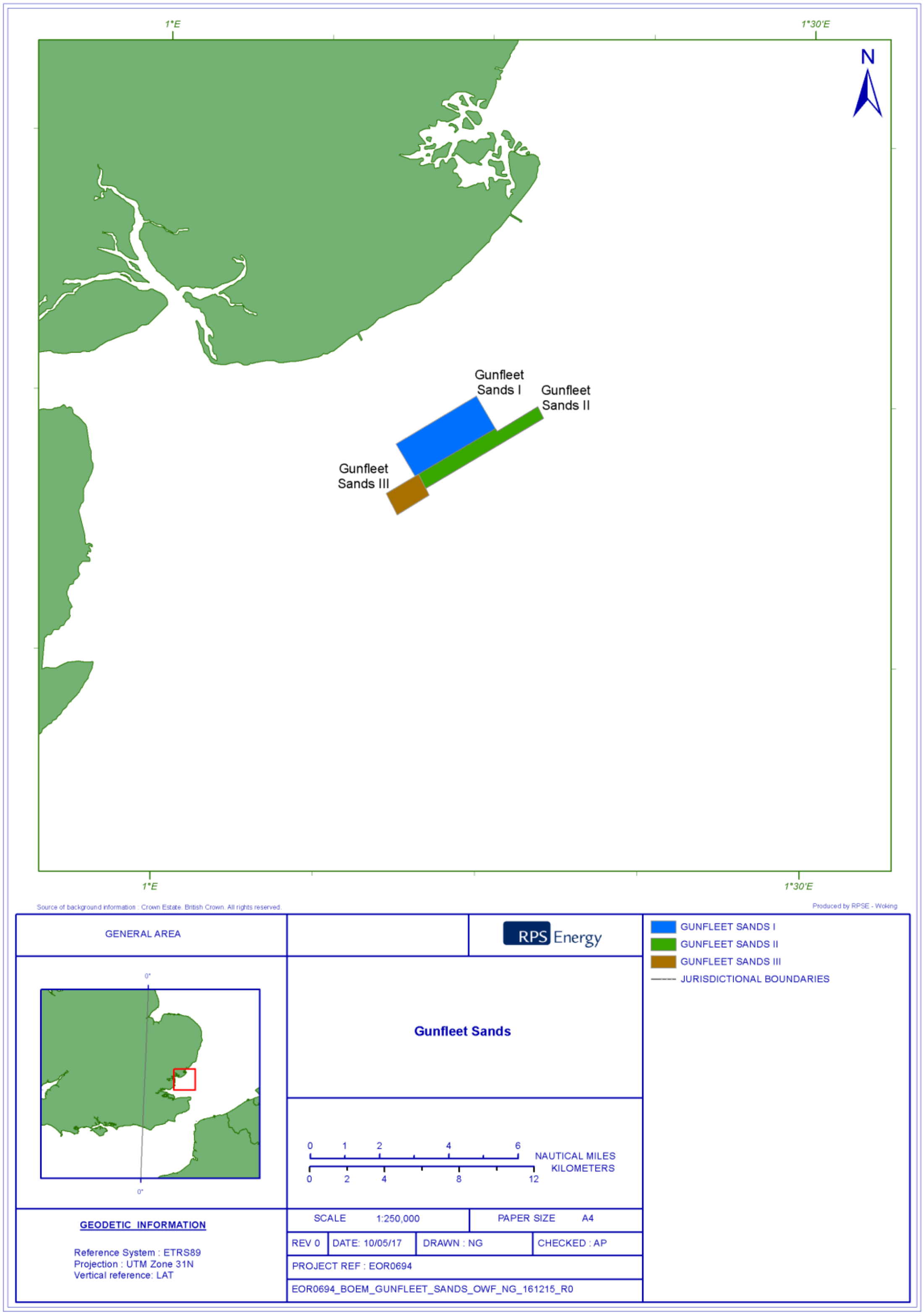

Figure B-1. Location of Gunfleet Sands I, II and II offshore wind farms (Data Source: The Crown Estate)

In December 2006, DONG Energy acquired the GFS 1 and GFS 2 offshore wind farm projects from GE Wind Energy. Consent was granted for GFS 1 in 2004 and the GFS 2 extension phase was consented in 2008. The two projects combined consist of 48 operational turbines, each of a maximum capacity of 3.6MW. Generation capacity for GFS1 and 3 is restricted and capped at 164 MW.

GFS 1 and 2

Construction of the two projects began together in 2008 and the first turbine was erected in April 2009. First power was produced by GFS 1 and generated to the grid in August 2009 and both projects were completed in June 2010.

The rotor diameter of the turbines is 107 m, with a maximum height of 129 m from blade tip to sea level. The total area of the Phase 1 development is 10 km^2 and Phase 2 is 7.5 km^2. The turbines are mounted on top of a monopile foundation. The monopile foundations are 4.7 m in diameter, with an overall length of up to 50 m and a seabed penetration of up to 40 m.

GFS 3

In August 2010, DONG Energy was awarded a demonstration lease site to the south-west of the GFS 2 array. In 2012, consent was awarded for GFS 3 – Demonstration Project, to test two of new 6MW turbines. Construction began in 2012 and the demonstration project was completed at Gunfleet Sands in 2013. At the time, the two Siemens 6MW turbines were the largest offshore wind turbines in the world.

The GFS 3 project was not considered an extension of the GFS 1/GFS 2 projects, but rather a free-standing demonstration project with the aim of providing a facility to test new wind turbine technology in advance of larger commercial developments in the future.

Project Design Envelope (PDE)

The PDEs of the GFS projects as presented in the ES are outlined in Table B-3. The key parameters shown represent a relatively narrow design envelope[7].

Table B-3. Key Gunfleet Sands Project Parameters Presented within the Environmental Statement

PDE Parameter	GFS1	GFS2	GFS3
Project Area	Up to 10 km^2	7.5 km^2	Up to 1 km^2
Water Depth	0.3m – 9.9m	2m – 15m	2m – 15m
Turbine Capacity	3.6MW	3.6MW	Up to 10MW
Number of Turbines	30	Up to 22	2
Max Blade Tip Height	135m	135m	180m

[7] It should be noted that this phrase is a relative phrase and is being used in this report to describe the level of complexity and detail contained in the PDE (e.g., the number of parameters). Therefore, a medium PDE will have significantly more parameters than a narrow PDE and a wide PDE will have many more than a medium PDE.

PDE Parameter	GFS1	GFS2	GFS3
Max Blade/Rotor Diameter	110m	107m	150m
Max Hub Height	80m	81.5m	130m
Clearance (From Lower Blade Tip)	-	Min 22m (MHWS)	Min 22m (MHWS)
Turbine Foundation Types	Monopile steel cylinder (5-6m) Max penetration depth 38m	Monopile steel cylinder (4.5-5m) Overall length 50-75m Max penetration depth 50m	Monopile steel cylinder (5-6m) Overall length 50-75m Max penetration depth 60m
Turbine Installation Method	The construction used several vessels, which typically consisted of: - 2-3 transport barges - 2 towing boats - 1 jack-up rig - 1 large jack-up rig with crane - 1 inflatable boat Full methodology provided in the text below.	Transport barge and installation vessel (with crane) or by installation vessel. Multiple lifting operations where topside modules are lifted into position on previously installed foundations.	Transport barge and installation vessel (with crane) or by installation vessel.
Export Cable Installation Method	Plowing to a depth of up to 3m Directional drilling to be used in the nearshore areas to burrow beneath intertidal zone and cliffs.	Plowing, trenching or jetting to a depth of up to 3m.	Plowing, trenching or jetting to a depth of up to 3m. Horizontal Directional Drilling (HDD) to be used in the nearshore areas to burrow beneath intertidal zone.
Inter-Array Cable Installation Method	Plowing to a depth of up to 3m	Plowing, trenching or jetting.	Plowing, trenching or jetting.
Construction Timeline	8 months Project built out as one project (see text below that shows the outline construction program as presented in the ES).		Q3 2011 – Q3/Q4 2012

The GFS 1 ES stated that the construction phase was to use several vessels that include: 2-3 transport barges, 2 towing boats 1 jack-up rig, 1 large jack-up rig with crane, and 1 inflatable boat. The ES stated that a hydraulic hammer would also be needed to drive in the monopiles. It was proposed to erect the turbines in small groups, with an exclusion zone around the construction area for safety considerations. After installation of each small group was completed, the construction works, and exclusion zone, would then move to the next group. Construction was stated to probably involve a jack-up barge/rig which would remain in place, while vessels supply equipment and consumables as necessary.

The erection of each individual turbine would follow a set sequence of established procedures. The monopile would be driven into the seabed at a rate of 1 cm/hammer-blow. The tower sections would be erected onto the foundation. These would then be screwed together via ring flange connections. Then, the bottom part of the base frame, which incorporates the yaw system, would be mounted. After that, the top part of the nacelle (the 'hub' of the turbine) that contains the drive train, would be fixed to the bottom part of the base frame. The container was then fixed underneath the nacelle. Finally, the rotor would be mounted. The method of assembling the rotors is dependent on the site conditions in which they are assembled. In the case of single blade assembly, the hub would be screwed to the shaft flange first, and then the blades assembled individually in horizontal position by means of a special lifting device. If the wind conditions are suitable, the rotor star with all three blades would be pre-assembled at sea level, then lifted and screwed to the rotor shaft flange.

Each section would be lifted by a high capacity crane mounted on a jack-up barge. For safety reasons, when large components are lifted a second barge with crane may be required to steady the items being lifted. In addition, there would be a 500-m exclusion zone around the works during construction. There was to be an integral crane positioned within the nacelle of the 3.6 MW turbines, which can be used to lift the containerized transformer into position below the nacelle itself. Once the structure is complete, the control and power cables were to be lowered down within the tower.

The jack-up barge was then to be moved from one location to the next either under tow by tug boats, or by winching itself on pre-placed anchors.

The indicative constructive program of the GFS 1 project (from the ES) is presented in Figure B-2 and displays the original timelines. GFS 1 and GFS 2 were constructed at the same time and both projects use the same export cable and electrical grid infrastructure to transport power to the national grid.

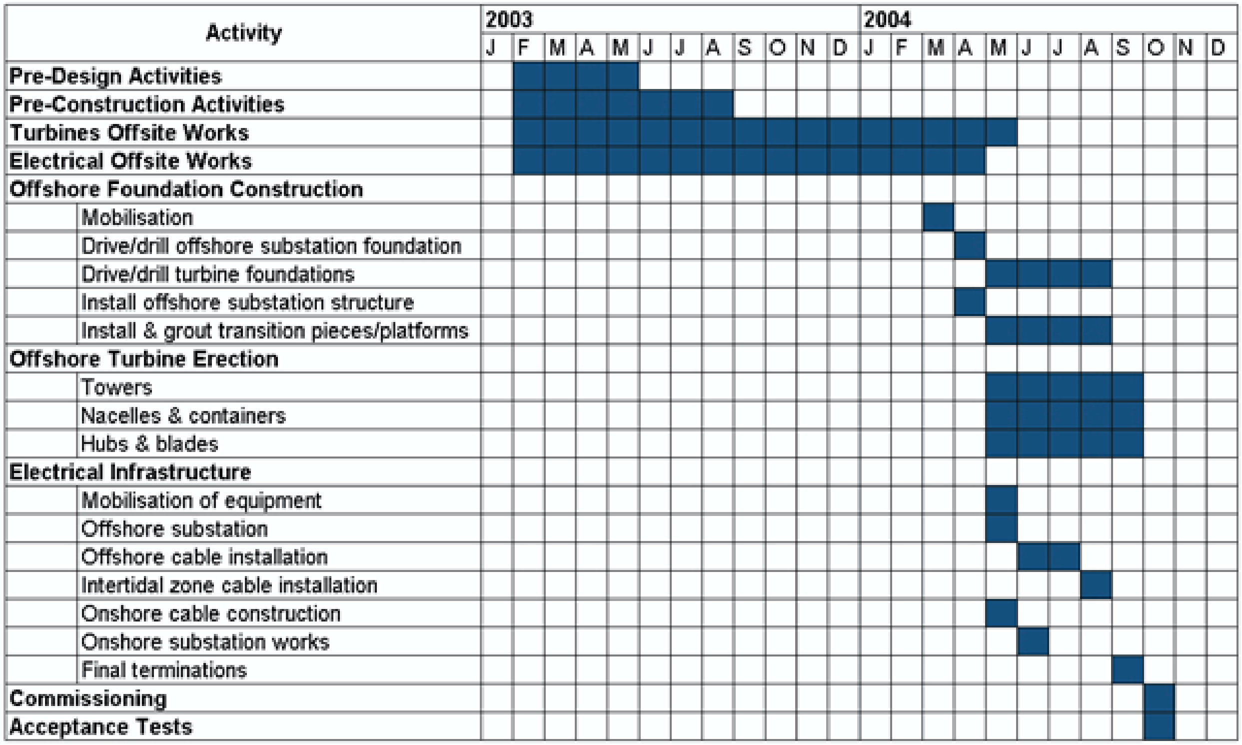

Figure B-2. Outline of the Construction Program for GFS 1

GFS 3, on the other hand, is a stand-alone project that aimed to test and validate newer, more modern wind turbine technology (at the time) for use in future developments. All three phases had relatively small/simple PDEs that were well-developed and therefore avoided the requirement of complicated assessments of multiple worst-case scenarios of PDE parameters.

All three phases of the Gunfleet Sands Offshore Wind Farm were consented and assessed separately. Each phase employed the use of a PDE. Therefore, the maximum design scenario of each parameter in the PDE was assessed. The demonstration turbines were initially envisioned to use the existing GFS 1/ GFS 2 offshore substation, export cable, and onshore infrastructure. However, the export cable constructed for GFS 1 and GFS 2 was not sufficient to enable GFS 3 to produce power at maximum capacity and allow test conditions to be achieved. Accordingly, DONG Energy amended the initial application so that it included a new export cable that ran directly from GFS 3 to the 33kV distribution network in Clacton-on-Sea.

The GFS projects were indicative of the early stages of the offshore wind industry in the U.K. There were less options in terms of established turbine designs/technologies and installation methodologies. Therefore, the PDE was what we have labelled as small (or simple) due to the low level of detail provided within the PDE. This was not because developers did not want greater degrees of flexibility for projects, but rather there was a limited set of project design parameters and construction methodologies that ensured project delivery, successful commissioning and timely delivery of electricity to the grid.

The key point in relation to phasing of the project was that the Gunfleet Sands projects did not consider the whole of the project (i.e., GFS I, II and III) in each of the assessments. For instance, the GFS I the PDE only described GFS I and would have been relatively simple and narrow. When it came to GFS II, the PDE envelope again only described the elements of GFS II and did not consider the PDE already described for GFS I. The potential impacts of GFS I and II were considered in the cumulative assessment only and were therefore treated as separate projects. The same process was undertaken for GFS III, whereby GFS I and II were only considered in the cumulative assessment and the project design of these projects was not considered in the PDE for the GFS III project. As a result, each project had its own, standalone PDE which did not consider the other projects in the Gunfleet Sands area.

B.2.1.2 Risk/Benefit Analysis of PDE and Environmental Impact Assessment

A risk/benefit analysis of the phased approach taken for the Gunfleet Sands projects is presented in Table B-4 to Table B-6. Table B-4 provides the results of the risk /benefit analysis for the developer and puts them into the context of the width of the PDE, the phased approach taken and the impact assessment process. Table B-5 provides the results of the risk / benefit analysis for the regulator, again in the context of the width of the PDE, the phased approach applied to the Gunfleet Sands projects and the impact assessment process employed for the developments. Table B-6 presents the same analysis with respect to the environment.

Table B-4. Risk / Benefit Analysis of the Incremental Phased Approach for the Developer (Gunfleet Sands Offshore Wind Farm (All Phases))

Aspect Description	Benefit	Risk
PDE Width Narrow PDE for each project with an individual permit FEPA license and CPA consent for each project.	• Less design parameters (and associated worst-case scenarios) to assess which streamlined the EIA and helped speed up the consenting process. • Typically, phases should be easier to permit (caveat of project specific issues and general quality of the application applies). • Small PDEs give certainty to funders, stakeholders, consultees and regulators of what exactly is being proposed and therefore each stage of project development is more straight forward to progress through.	• Less flexible design envelopes may require a higher number of variations and modifications to original consents and permits compared to projects with larger PDEs. • Project specific and normal regulatory risks apply.
Phased Approach GFS 1 and 2 were permitted separately (2003/2004 and 2008, respectively) but constructed together between the years of 2008 and 2010. GFS 3 was permitted separately in 2012 and construction took place between the years of 2012 and 2013	• Construction of the two commercial phases simultaneously consolidated risk and reduced installation costs	• The key risk to the developer is the need to go through the consenting process twice, which is likely to have high cost implications – i.e. separate surveys and consenting processes for each new project. • For GFS, there were few risks to the phased construction approach because both commercial projects were constructed together thereby reducing administrative and construction burdens.
Impact Assessment All three phases of the Gunfleet Sands Offshore Wind Farm were consented and assessed separately. Each application employed the use of a PDE.	• Potentially easier to consent first project and to assess/manage environmental impacts because its smaller size compared to all phases combined. • Ability to learn from the consenting of the previous phases of development and therefore increased awareness of risks and methods of reducing and removing consenting risks. Allows for better allocation of resources into known contentious issues that may require extra surveys, stakeholder engagement or mitigation strategy development.	• New impact assessment for each development phase will require additional resources to re-establish new baseline and produce new application (ES, AA, consultation procedure). • Cumulative effects of other projects could take up/consume all environmental carrying capacity (of an area) before second or third application for the additional phase has been submitted.

Table B-5. Risk / Benefit Analysis of the Incremental Phased Approach for the Regulator (Gunfleet Sands Offshore Wind Farm (All Phases))

Aspect Description	Benefit	Risk
PDE Width Narrow PDE for each project with an individual permit FEPA license and CPA consent for each project.	• Initially streamlines and simplifies the regulatory and impact assessment processes. • The regulator is more confident in decisions when PDEs are well developed (meaning there is a narrow range of parameters). • Typically, easier to permit (caveat of project specific issues and general quality of the application applies).	• Less flexible design envelopes may require a higher number of variations and modifications to original consents and permits compared to projects with larger PDEs. • Project specific and normal regulatory risks apply.
Phased Approach GFS 1 and 2 were permitted separately (2003/2004 and 2008, respectively) but constructed together between the years of 2008 and 2010. GFS 3 was permitted separately in 2012 and construction took place between the years of 2012 and 2013	• Allowed consent and permit conditions to be discharged more easily and simultaneously in the case of GFS 1 and 2. • Conditions for both GFS 1 and 2 discharged together. The benefits included conditions of both wind farms were discharged at the same time thereby reducing the resources/ time required to carry out these activities.	• As consents and permits were granted prior to construction of each phase, there was no opportunity for lessons learned/further information to be obtained on the environmental impact of these phases in this region.
Impact Assessment All three phases of the Gunfleet Sands Offshore Wind Farm were consented and assessed separately. Each application employed the use of a PDE.	• Less complicated to consent first phase(s) because of the higher carrying capacity of the environment. • Lessons learned from GFS 1 could be applied to subsequent phases of development.	• Risk of consenting a 'salami-sliced' project (and being in breach of EIA legislation) if the impact assessment of second and third phases have not considered in their assessments of each of the previous projects. • Potential for the impacts from all the projects together to be lost due to the impacts being assessed separately in different applications. This may be a concern to a regulator. Not seeing the entire development (i.e., all three projects) at the same time may also make it more difficult to develop appropriate license conditions / mitigation.

Table B-6. Risk / Benefit Analysis of the Incremental Phased Approach for the Environment (Gunfleet Sands Offshore Wind Farm (All Phases))

Aspect Description	Benefit	Risk
PDE Width Narrow PDE for each project with an individual permit FEPA license and CPA consent for each project.	• Facilitated a more accurate assessment of the predicted environmental impacts of each phase of the project (within the design parameters of the PDE)	• Environmental risk is determined by the sensitivity of the receiving environment and the impacts of the construction, operation and decommissioning stages of each phase of a project. This in turn is based on the specific design parameters of the PDEs (irrespective of small, medium or large PDE) of each phase of the project. • Depends on the actual parameters (irrespective of the whether PDE is small, medium or large) • The low detail of the PDE potentially introduces more uncertainty. A more detailed PDE is likely to result in a more detailed impact assessment. As a result, there will be less uncertainty regarding potential impacts and therefore, greater degree of environmental protection. A less detailed PDE might result in greater uncertainty and the potential for impacts to be greater than predicted in the EIA.
Phased Approach GFS 1 and 2 were permitted separately (2003/2004 and 2008, respectively) but constructed together between the years of 2008 and 2010. GFS 3 was permitted separately in 2012 and construction took place between the years of 2012 and 2013	• The combination of GFS 1 and 2 construction phases resulted in a shorter construction program. This decreased the length of time that potential environmental impacts could over.	• Higher density of activity occurred during the construction of GFS1 and 2 compared to a more sequential or staggered construction program, which typically will occur over a longer duration of time (and associated lower density of activity occurring at any one time).

Aspect Description	Benefit	Risk
Impact Assessment All three phases of the Gunfleet Sands Offshore Wind Farm were consented and assessed separately. Each application employed the use of a PDE.	• Lessons learned to improve quality of subsequent phases of EIAs. An understanding was built up in terms of what worked and what could be improved to enhance the EIA of future phases.	• Increased complexity of the phase 2 and 3 EIAs due to reduced carrying capacity of the environment to absorb change and difficult to describe and reliably predict what the cumulative impacts on each phase would be.

B.2.2. London Array

B.2.2.1 Development Overview

The London Array Offshore Wind Farm is located on and adjacent to two sandbanks located approximately 20 km from both the Essex and Kent coasts in the outer Thames Estuary of the U.K. (Figure B-3). The project consists of 175 x 3.6 MW turbines with a capacity for 630 MW that was constructed in what is known as Phase One. Phase Two was never constructed.

London Array is owned by four shareholders: a consortium involving E.ON (30%), DONG Energy (25%), La Caisse de dépôt et placement du Québec (25%) and Masdar (20%).

Background

London Array was originally awarded an Area for Lease (AfL) from The Crown Estate in its Round 2 leasing process for an offshore wind farm of up to 1,000 MW (1 GW) to be constructed in four phases. Having been awarded the AfL, the developer would then need to apply for consent to build the project from the regulator.

Considering the scale of the development, the financing and construction of the London Array project was sub-divided amongst the original consortium members as follows:

- E.ON U.K. Renewables and Core would be responsible for financing and constructing three phases (Phases 1, 2 & 4), comprising 667 MW of the wind farm (London Array West), and
- Shell Wind Energy would be responsible for financing and building Phase 3, being 333 MW.

In June 2005, London Array became the first Round 2 offshore wind farm to apply for planning consent. Consent was granted for the whole 1000 MW offshore works in December 2006 and planning permission for the onshore application followed in August 2007.

Phases One and Two

The original consent for London Array was for a wind farm of up to 1,000MW, with 630MW in Phase One and a further 370MW in Phase Two. From the start, Phase Two was conditional upon a Grampian condition regarding the impact on red throated divers (*Gavia stellate*), a species of bird that overwinters in the wind farm's boundaries. This required London Array to demonstrate any change caused by additional turbines in Phase Two on Red Throated Divers habitat would not compromise that part of the Thames Estuary's status as a designated Special Protection Area.

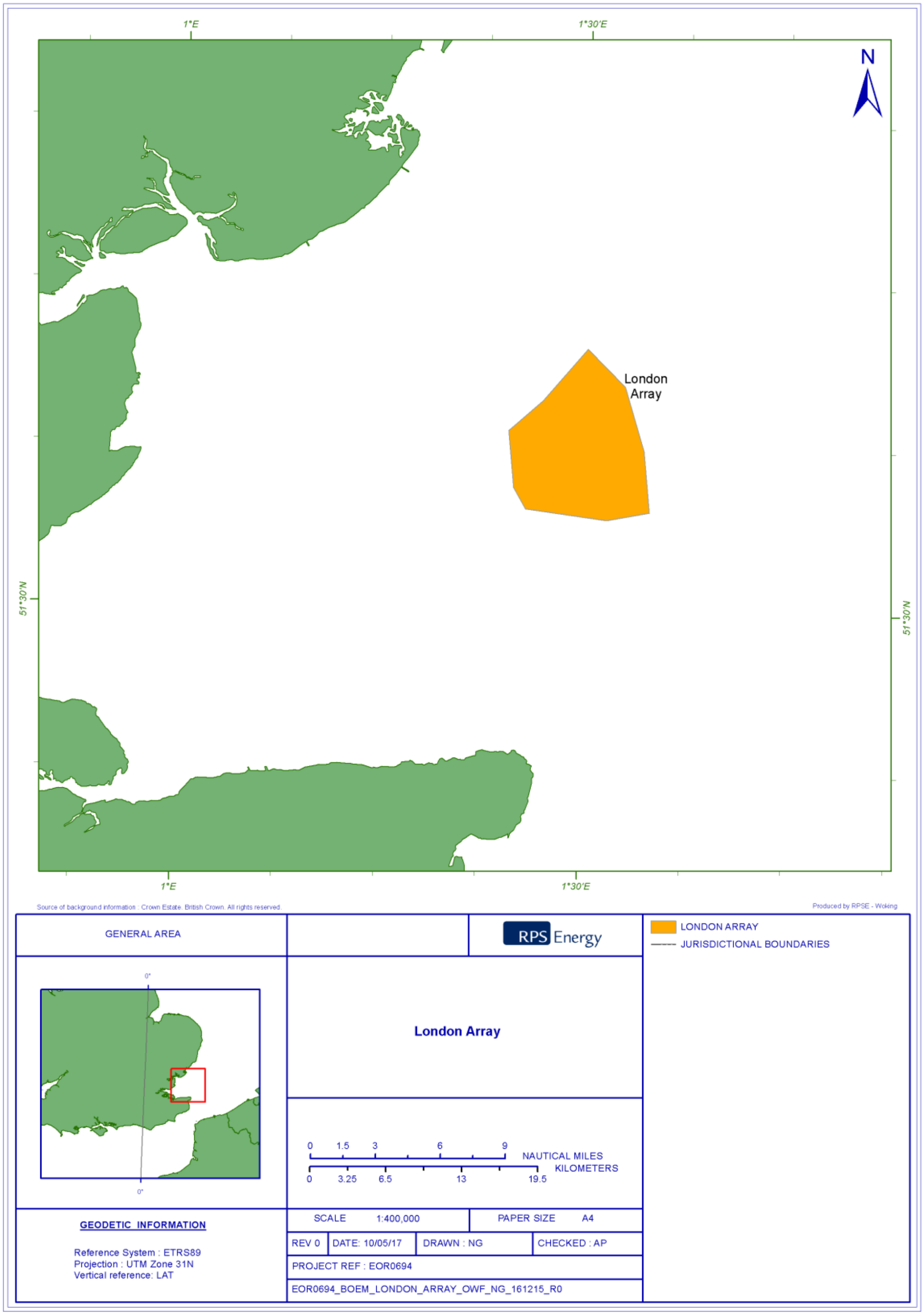

Figure B-3. Location of London Array offshore wind farm (Data Source: The Crown Estate)

Grampian condition[8]

From the beginning, a condition in the developers' license stated that Phase Two of the project was under a Grampian condition regarding the impact on red throated divers. This required London Array to demonstrate any change caused by additional turbines to the habitat of red throated divers would not affect the population of these birds. In other words, they would need to demonstrate that the second phase of the project would not have an impact on the red throated diver population.

Although Phase Two had the potential to provide capacity for a further 370MW, known constraints resulted in an application for just 240MW being made with an expectation that the final capacity would be closer to 200MW. However, even at this scaled-down level, an assessment in early 2014 indicated it would take until at least 2017 for sufficient bird monitoring data to be collected with no guarantee London Array would be able to satisfy the authorities regarding potential impacts on the red throated diver population. Although initial findings from the existing Phase One site looked positive, there could be no assurance at the end of three years of monitoring surveys that Phase Two would be able to satisfy the requirements of the Grampian condition and prove the impacts on the Red Throated Diver bird species would be acceptable. Combined with known technical challenges surrounding the Phase Two site such as shallow water, longer cable routes and an exclusion zone for aggregates operations, these environmental uncertainties led London Array's shareholders to withdraw from Phase Two and concentrate on other projects in their individual portfolios. In February 2014, London Array announced it had formally requested The Crown Estate to terminate the Phase Two agreement for lease and had cancelled their grid connection option.

Construction

In May 2009, Phase One (Phases 1, 2 & 4) of the project received formal approval and London Array's shareholders announced they would jointly invest €2.2 billion in building the initial 630MW phase. In 2011, the first monopile was installed, followed by installation of the offshore substations and the first array and export cables. In December 2012, the final turbine was installed. The project became fully operational in April 2013, with the official inauguration taking place in July 2013.

Project Design Envelope

The PDE of the London Array Offshore Wind Farm is outlined below in Table B-7 and the key parameters shown represent a large design envelope.

Table B-7. Key London Array Project Parameters Presented within the Environmental Statement

PDE Parameter	London Array
Project Area	Up to 245 km^2
Water Depth	1.5m – 23m
Turbine Capacity	3 MW – 7 MW
Number of Turbines	Up to 258
Max Blade Tip Height	150m – 175m (MHWS) and 155m – 180m (LAT)

[8] A 'Grampian' condition is defined as 'prohibiting development authorized by the planning permission or other aspects linked to the planning permission until a specified action has been taken (such as the provision of supporting infrastructure or additional monitoring)' – see Scottish Executive Central Research Unit (2011) for further details.

PDE Parameter	London Array
Max Blade/Rotor Diameter	90m – 150m
Max Hub Height	67m – 100m (MHWS) and 90m – 105m (LAT)
Clearance (From Lower Blade Tip)	Minimum 22m (MHWS)
Turbine Foundation Types	Concrete gravity foundation Monopile in steel Steel tripod Piled concrete tripod
Max Hammer Force (Pile Driving)	Noise levels are likely to be approximately 266 dB re 1 μPa @ 1 m, with a depth uncertainty of +/- 5 dB
Turbine Installation Method	The construction used several vessels including: - jack-up vessels (barges and/or ships) with crane - transport/towing barges - work boats (transporting personnel and equipment) - standby vessels - anchor handling vessels - tug boats Full methodology provided in the text below.
Export Cable Installation Method	Plowing, Trenching and Jetting Dumb barge, anchor boats and dynamic positioning vessels will be used during the installation of cables.
Inter-Array Cable Installation Method	Plowing, Trenching and Jetting Dumb barge, anchor boats and dynamic positioning vessels will be used during the installation of cables.
Construction Timeline	Two phased construction programs were proposed, both indicating a 4-year construction period where multiple phases would be constructed in the same year. Project built out as one project (see text below that shows the outline construction programs as presented in the ES).

The tendering process set out to establish, in the limits of the PDE, which type(s) of foundation(s) were the most cost effective for London Array. As stated above, the following foundation concepts were considered:

- Concrete gravity foundation;
- Monopile in steel;
- Steel tripod, and
- Piled concrete tripod.

The exact offshore wind turbine model was not decided until after the consenting process. It was expected that the turbines would have an installed capacity of between 3 and 7 MW. As the London Array offshore wind farm was intended to be constructed during three to four years, the turbines installed in the later phases were expected to be of a different size compared to the first phase. This was mainly due to the rapid development in the wind turbine industry. Most of the offshore wind farm projects that were constructed between 2005 and 2007 were >3 MW turbine models. Few turbines of the class 4.2 to 4.5 MW had already been installed onshore pre-2005 and these were expected to be proven technology for offshore wind farms within a couple of years post 2005.

The turbines were proposed to be installed using an installation crane of suitable size located on a jack up vessel. The turbines would be transported to the development site either already on the jack-up vessel or to the jack-up vessel on a barge or another jack up vessel. The installation crane lifts the turbine parts from the jack-up/barge onto the foundation. The ES stated that it normally takes 24 hours to position the jack up and erect a turbine requiring a total of 4–5 lifts per turbine to complete installation. Normal procedure would be that the bottom tower is mounted first followed by the top section. Following the top section the nacelle and the rotor/blades are mounted.

The two proposed construction programs presented and assessed within the ES are outlined below in Figure B-4 and Figure B-5.

The construction programs vary widely with Option I (Figure B-) proposing the following:

- Phase 1 (270 MW) is built in years 2/3;
- Phase 2 (200 MW) is built in years 3/4;
- Phase 3 (330 MW) is built in years 3/4, and
- Phase 4 (200 MW) is built in years 4/5.

The Option II Construction Program (Figure B-) proposes that Phase 2 may be delayed and combined with Phase 4 to make a combined 400MW deployment. This combined phase would be subject to the lessons learned from Phase 1. Similarly, Phase 3 may also be delayed and constructed in the same year as combined Phase 2 and 4:

- Phase 1 (270 MW) is built in years 2/3;
- Phase 2 and 4 (200 MW + 200 MW) is built in years 4/5, and
- Phase 3 (330 MW) is built in years 4/5.

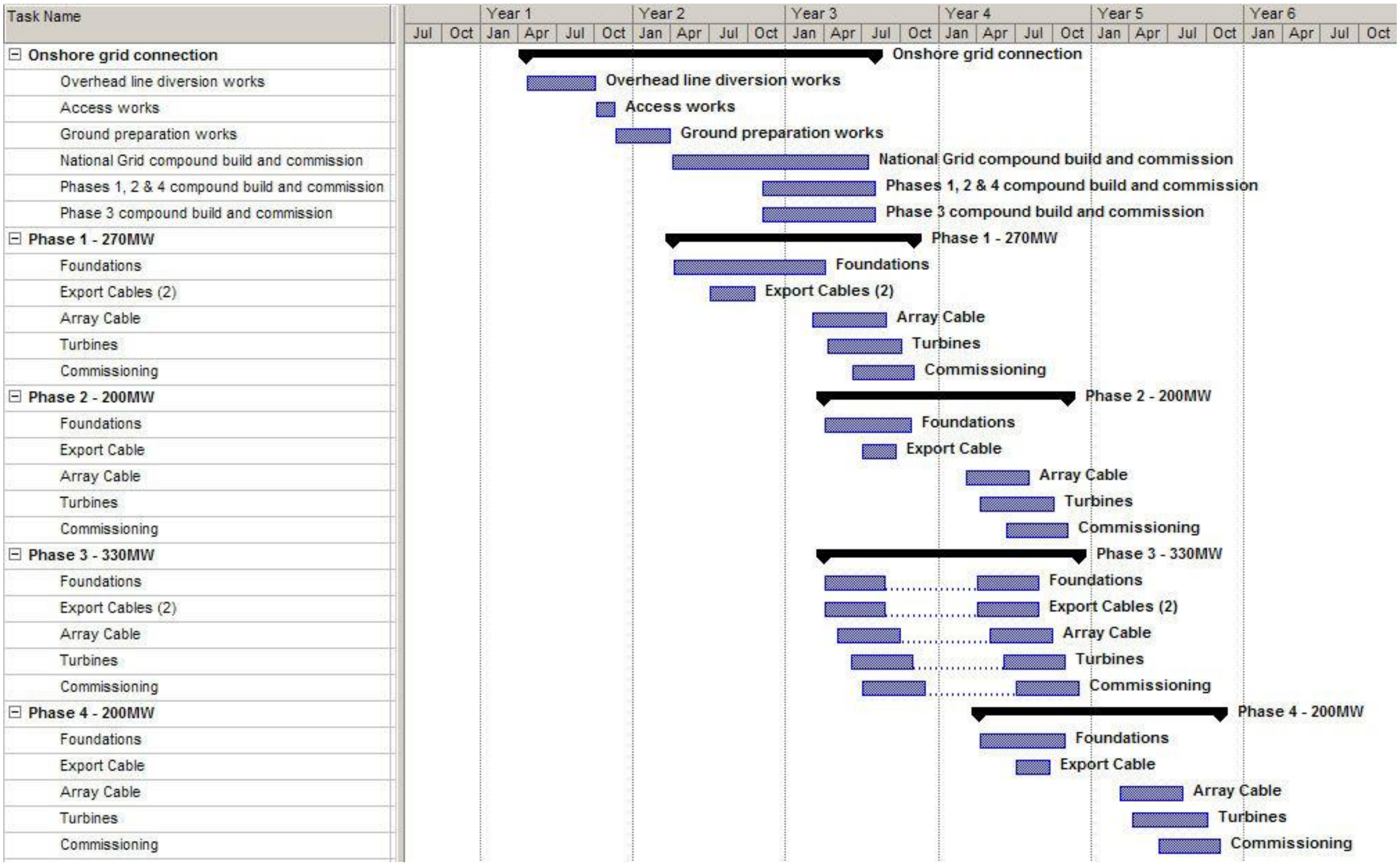

Figure B-4. Option I Construction Program

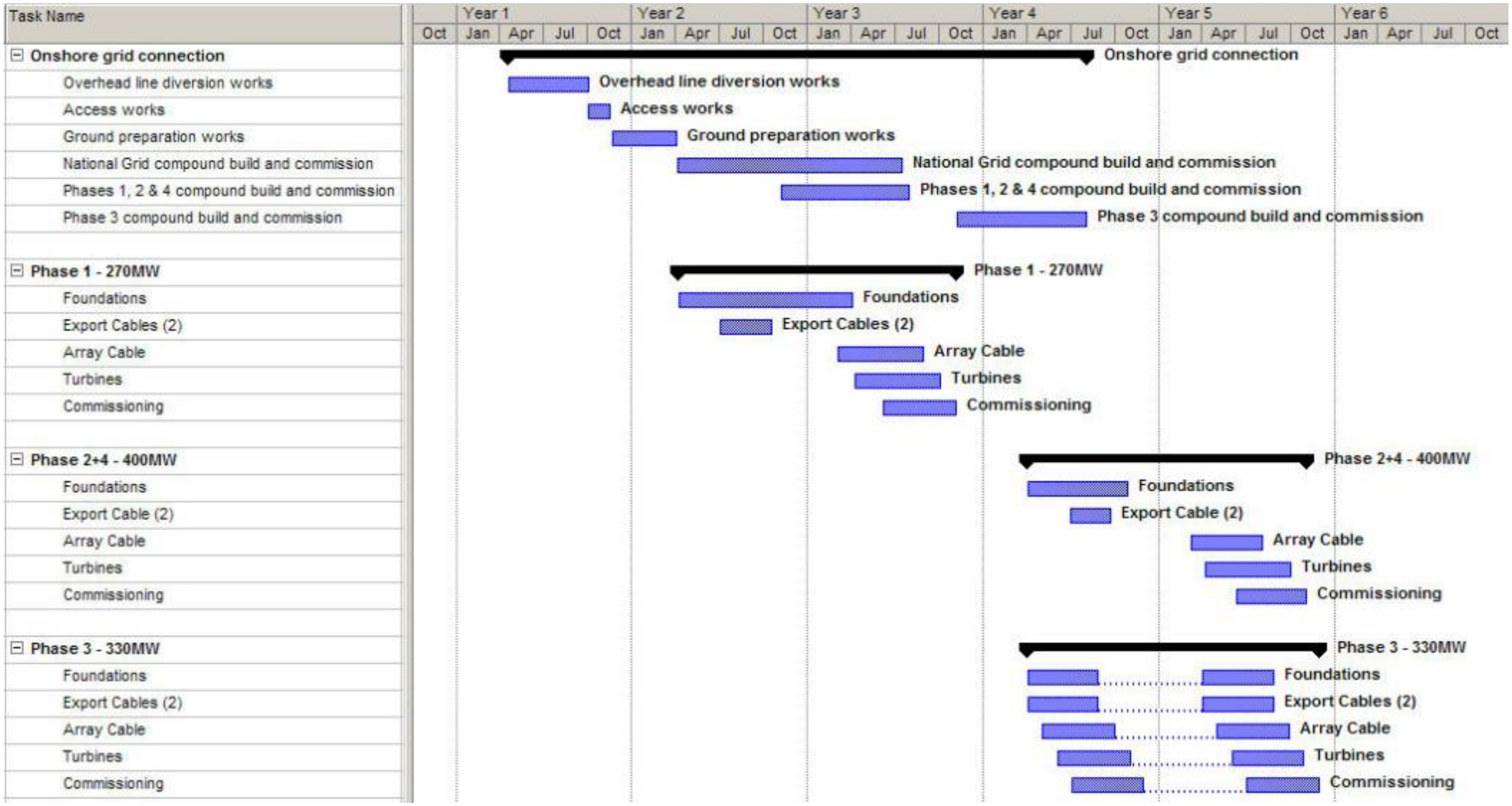

Figure B-5. Option II Construction Program

B.2.2.2 Risk/Benefit Analysis

A risk/benefit analysis of the phased approach taken for London Array is presented in Table B-8 to Table B-10. Table B-8 provides the results of the risk / benefit analysis for the developer and puts them into the context of the width of the PDE, the phased approach taken and the impact assessment process. Table B-9 provides the results of the risk / benefit analysis for the regulator, again in the context of the width of the PDE, the phased approach applied to the London Array project and the impact assessment process employed for the development. Table B-10 presents the same analysis with respect to the environment.

Table B-8. Risk / Benefit Analysis of the Grampian Consent Phased Approach for the Developer (London Array Offshore Wind Farm)

Aspect Description	Benefit	Risk
PDE Width Wide (Large / Complex) PDE covering all phases of the project	• Increased flexibility in developing and constructing individual and successive phases of the overall project.	• Wider range of design parameters to assess (including associated worst-case scenarios) increased the complexity of the EIA. • Increased likelihood of delays in the consenting process. • Typically, projects are more difficult to permit (caveat of project specific issues and general quality of the application applies).
Phased Approach Multiple project phases (three out of four phases) were combined into a single construction phase over a two-year period between 2011 and 2012. Grampian condition resulted in the second phase of the project not being constructed.	• Construction of three phases simultaneously consolidated risk and reduced installation costs. • Reduction in administrative and construction burdens in terms of resources required.	• Fewer risks to the construction of the London Array because three phases of the project were combined and constructed together. • A conditional consent places part of the project at considerable technical and commercial risk and creates uncertainty regarding (1) the duration to obtain consent for the remaining phase (uncertainty is bad for investment) (2) the cost of undertaking the work required to gain approval and (3) the likelihood of gaining approval.
Impact Assessment All four phases of the London Array project were assessed and consented together. The EIA presented two construction program options and incorporated a wide PDE.	• Fewer resources required to produce one EIA for multiple phases.	• More difficult to assess large project with multiple phases, broad PDE and multiple construction program options. • Cumulative effects of first three phases on Red Throated Diver resulted in the Grampian condition (and considered to be enough to prevent the approval of the final phase without additional monitoring to determine effects of the final phase).

Table B-9. Risk / Benefit Analysis of the Grampian Consent Phased Approach for the Regulator (London Array Offshore Wind Farm)

Aspect Description	Benefit	Risk
PDE Width Wide (Large / Complex) PDE covering all phases of the project	• Flexible design envelope may reduce the number of variations and modifications to original consents and permits compared to projects with a narrow range of design parameters. • Opportunity to develop understanding of how to consent more complex projects (considering the prospect that these will likely become more frequent)	• Complicates the regulatory and impact assessment processes. • The regulator is less confident in decisions when a project has a large PDE (i.e., there is less certainty over the details of the project that will be constructed). • Normally more difficult to permit if the PDE parameters are too broad (caveat of project specific issues and general quality of the application applies).
Phased Approach Multiple project phases (three out of four phases) were combined into a single construction phase over a two-year period between 2011 and 2012. Grampian condition resulted in the second phase of the project not being constructed.	• The single project approval consent allowed conditions of three phases to be discharged more easily and simultaneously; thereby reducing the resources/ time required to carry out these activities.	• As consents and permits were granted prior to construction of each phase, there was no opportunity for lessons learned/further information to be obtained on the environmental impact of these phases in this region.
Impact Assessment All four phases of the London Array project were assessed and consented together. The EIA presented two construction program options and incorporated a wide PDE.	• Fewer resources required to process application through the consenting process. • The EIA fully considers all potential construction scenarios therefore the maximum design scenario is fully assessed.	• More difficult to consent larger project because of the predicted environmental impacts and increased level of complexity with the EIA. • No opportunity to learn from early phases because initial project application was for entire 1000 MW project. • Increased complexity of the EIA due to numerous different construction scenarios – difficult to always ascertain what the maximum design scenario is for each receptor / impact.

Table B-10. Risk / Benefit Analysis of the Grampian Consent Phased Approach for the Environment (London Array Offshore Wind Farm)

Aspect Description	Benefit	Risk
PDE Width Wide (Large / Complex) PDE covering all phases of the project	• Worst-case scenario of each phase (and sub-components of each phase) is assessed to determine the predicted environmental impacts, ensuring the totality of the project and all phases are captured. • Environmental impact of the project (and constituent phases) is normally less than the worst-case scenario as presented in the EIA.	• Environmental risk is determined by the sensitivity of the receiving environment and the impacts of the construction, operation and decommissioning stages of each phase of a project. This in turn is based on the specific design parameters of the PDE (irrespective of small, medium or large PDE) of each phase of the project.
Phased Approach Multiple project phases (three out of four phases) were combined into a single construction phase over a two-year period between 2011 and 2012. Grampian condition resulted in the second phase of the project not being constructed.	• Shorter construction program timeline decreased the length of time that potential environmental impacts could over.	• Higher density of activity occurred during the construction of the three phases compared to a more staggered construction program, which would normally occur over a longer period of time (and associated lower density of activity occurring at any one time).
Impact Assessment All four phases of the London Array project were assessed and consented together. The EIA presented two construction program options and incorporated a wide PDE.	• The EIA fully considers all potential construction scenarios; therefore, the maximum design scenario is fully assessed.	• Greater level of environmental impacts predicted to occur as the project was very large. • Increased complexity of the EIA due to numerous different construction scenarios – difficult to always ascertain what the maximum design scenario is for each receptor / impact.

B.2.3. Hornsea Project Two

B.2.3.1 Development Overview

Hornsea Project Two will comprise of up to two offshore wind farms (Project A and Project B) in the southern North Sea with a total generating capacity of up to 1,800 MW.

The area of Hornsea Project Two in which turbines and inter-array cabling, as well as associated infrastructure (e.g. substations and accommodation platforms), will be placed, is called 'Subzone 2'. Subzone 2 has a total area of 462 km^2, the western boundary of which lies 89 km from the coast of the East Riding of Yorkshire and the eastern boundary is 50 km from the median line between U.K. and Dutch waters (Figure B-6).

There will be up to 300 turbines located within Subzone 2, with turbine generating capacities ranging from 6 MW to 15 MW.

Background

The promoter of Hornsea Project Two is SMart Wind, which was a 50/50 joint venture between International Mainstream Renewable Power (Offshore) Limited (IMRPOL) and Siemens Project Ventures GmbH (SPV).

SMart Wind was awarded the 'Hornsea Zone' by the Crown Estate as part of the Offshore Wind Round 3 Tender Round in 2010. The zone lies between 31km and 190km off the Yorkshire coast. The Zone's eastern boundary is 1 km from the median line between U.K. and Netherlands waters. The Hornsea Zone covers an area of 4,735 km^2 with water depths predominantly spanning between 30 and 40m, with maximum depths of 70m. The offshore array elements of projects will be developed in Subzones of the larger Hornsea Zone.

The offshore array element of Hornsea Project Two is being developed in Subzone 2 of the larger Hornsea Zone. As well as the infrastructure contained in Subzone 2 Hornsea Project Two consists of the offshore export cables, additional substations, cable landfall, onshore cables, onshore substation and associated onshore infrastructure.

SMart Wind was established specifically for promoting the development of the Hornsea Zone. In August 2015, DONG Energy Power (U.K.) Ltd. acquired the Hornsea Zone from SMart Wind Ltd (including the Smart Wind Company itself) and Hornsea Project Two, which had already submitted an application to develop Hornsea Project Two in January 2015.

Hornsea Zone – Projects One, Two and Three

Hornsea Project Two has a capacity of up to 1,800 MW and is the second of several offshore wind farm projects planned for the Hornsea Zone. The first wind farm project within the Hornsea Zone, Project One, has a capacity of up to 1,200 MW and was granted development consent in December 2014. Dong Energy is now planning to develop a third offshore wind farm (Hornsea Project Three) in the Hornsea Zone that proposes to generate up to 2,400 MW.

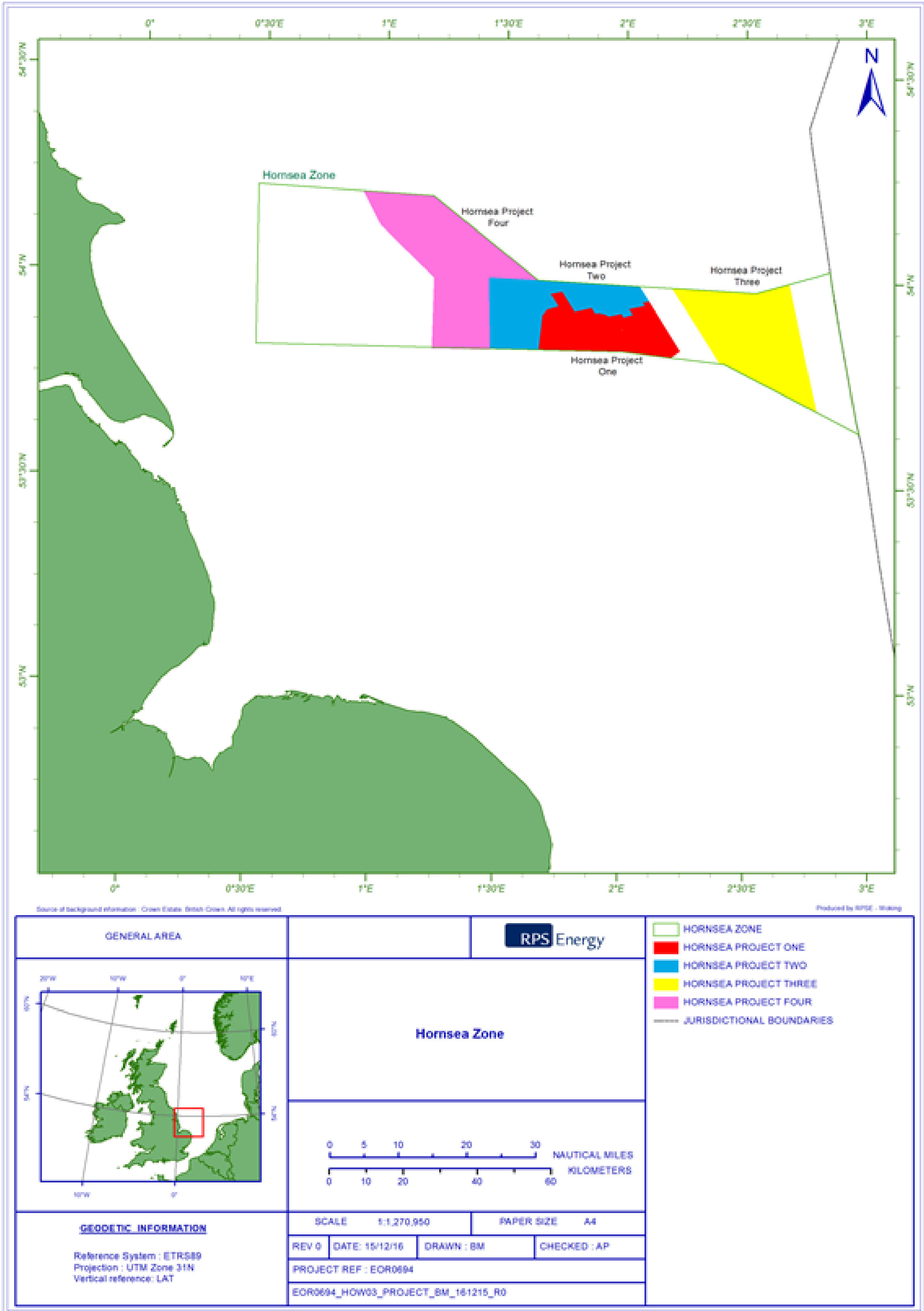

Figure B-6. The Hornsea Zone Showing the Location of Projects One to Four (Data Source: The Crown Estate)

It could be argued that Hornsea Project Two is just one project within a wider incremental approach (if considering Hornsea Project One and Three as the other increments of the wider project). However, In the Hornsea case an Agreement for Lease (AfL) from The Crown Estate has been granted for a larger zone in which each individual project (Hornsea One, Two, Three etc.) can be built (see Figure B-6). Essentially the zone allows for the development of several phases of project within the zone (each with their own individual phases).

Hornsea Project Two – Projects

Hornsea Project Two will comprise of up to two offshore wind farms, which can be considered phases. The Development Consent Order (DCO) provides for a maximum of two generating stations (offshore wind farms), each the responsibility of a separate undertaker. The DCO authorizes two offshore wind farms: Project A and Project B together with the associated development and grid connection for each project. Both wind farms have the same connection point into the National Grid and follow the same cable route. Project A and Project B are likely to be constructed by different operators: Optimus Wind Ltd. in the case of Project A and Breesea Ltd. in the case of Project B.

The marine license permissions have been drafted in a way that allows for maximum flexibility as to whether Hornsea Project Two is constructed as one project (Project A only) or whether the development is built out as two projects (Project A and B). For example, the deemed marine licenses for Project A permit all the offshore infrastructure required in the event that the development is to be built out as one project so that the full capacity of 1.8 GW can be achieved as one project and in such circumstances, deemed marine licenses for Project B will not be required. In the event that Project A and Project B are both constructed, the deemed marine licenses restrict what can be constructed across the two projects to that assessed in the project's application package and particularly the ES element of this. In addition, there are overarching controls within the DCO preventing the construction of infrastructure out-with what has been assessed in the ES and what is permitted by the DCO.

Hornsea Project Two – Phasing within Projects

Hornsea Project Two may be constructed as a single project or in phases (up to a maximum of four). For the purposes of the ES, several construction scenarios were generated to describe the realistic maximum design scenario construction programs for each of the topic assessments. These are described further, along with indicative construction program, in the Project Design Envelope section.

Construction

Hornsea Project Two was granted consent by the UK Secretary of State for Energy on the 16th August 2016.

Hornsea Project Two could begin construction in 2017. However, definitive construction timelines have yet to be finalized.

Project Design Envelope

The project design envelope of the Hornsea Project Two Offshore Wind Farm is outlined in Table B-11 and the key parameters shown represent a large design envelope, which provides significant detail on the potential options and is relatively wide.

Table B-11. Key Hornsea Project Two Parameters Presented within the Environmental Statement.

Parameter	Maximum Size	
Offshore		
Array Area		
Turbine Capacity	6 MW to 15 MW	
Number of Turbines	Up to 300	
Turbine Orientation	The final layout will be determined during detailed design. The four principles below will be used to determine the final layout design that will be subject to approvals as required by the Deemed Marine License: i) No (Wind Turbine Generator (WTG) will be positioned closer than 810 m away from the nearest neighboring WTG; ii) The WTGs will be spaced approximately evenly within the wind farm in at least one straight line of orientation with the exception of the WTGs around the perimeter which could have a smaller spacing compared to the WTGs within the wind farm array (Edge Weighted Layouts). This will not breach principle 1; iii) Wake recovery gaps (large areas without WTGs) will not be included within the Subzone 2, and iv) There may be micro siting or changes to the approximate grid or grids where WTGs are sited around environmental constraints such as oil and gas infrastructure, wrecks, or where ground conditions dictate or to give adequate spacing between other infrastructure.	
Maximum Blade Tip Height	276 m (relative to LAT)	
Minimum Blade Tip Height	34.97 m (relative to LAT)	
Maximum Rotor Diameter	241.03 m	
Turbine Foundation Types	Monopile, Jacket, Suction Buckets and Gravity Base	
Maximum Hammer Energy to Install Foundations	Up to 3,000 kJ	
Water Depth	25 m to 76 m	
Number of Accommodation Platforms	Up to 2	
Offshore Electrical Infrastructure		
Inter-array Cable Length	Up to 675 km	
Export Cable Circuits	Up to 2	
Offshore Export Cable Length	Up to 150 km	
Electrical Infrastructure	HVDC	HVAC
Offshore HVAC Collectors	Up to 6	Up to 6
Offshore HVDC Converters	Up to 2	N/A

Parameter	Maximum Size	
Offshore HVAC Reactive Compensation Substations	N/A	Up to 2
Offshore Export Cables Comprising the Circuits	4 HVDC cables (up to 2 single core cables per circuit)	8 HVAC cables (single 3 core cable per circuit)
Offshore Export Cable Trenches	Up to 4 (1 offshore HVDC cable per circuit)	Up to 8 (1 offshore HVAC cable per trench)
Onshore		
Onshore Cable		
Onshore Cable Route Corridor Width	The width of the permanent works will be up to 20 m, within which the cable trenches will be located in an arrangement to be confirmed. The permanent works width will increase to up to 30 m where a physical obstacle is encountered. During installation, the width of the corridor will expand temporarily to 40 m to accommodate access and haul roads for construction vehicles and storage areas for excavated soil.	
Electrical Infrastructure	HVDC	HVAC
Onshore Export Cables Comprising the Circuits	4 HVDC cables (up to 2 single core cables per circuit)	24 HVAC cables (up to 3 core cables per circuit)
Onshore Export Cable Trenches	Up to 4 (1 onshore HVDC cable per trench)	Up to 8 (3 onshore HVAC cables per trench)
Onshore Substation		
Electrical Infrastructure	HVDC	HVAC
Onshore Substation Equipment	Includes HVDC converter equipment	Includes HVAC equipment only
Onshore Substation/Converter Station Site Area	60,000 m^2	60,000 m^2
Number of Main Buildings	Up to 2	1
Onshore Substation / Converter Station Main Building	69.5 m (w) x 135 m (l) x 40 m (h)	18.5 m (w) x 82.5 m (l) x 15 m (h)
Durations		
Duration of Construction Phase	The onshore construction program, including all phases and gaps between phases, will be completed within five and a half years from the start of onshore construction. The offshore construction, including all phases and gaps between phases, will be completed within six years from the start of offshore construction.	
Construction Schedule	Project built out either as one project or in phases (up to a maximum of four). See text below for further information on the construction program.	
Duration of Operation and Maintenance Phase	25 years	

Parameter	Maximum Size
Duration of Decommissioning Phase	As per the duration of the construction phase.

As stated earlier Hornsea Project Two may be constructed as a single project or in phases (up to a maximum of four). For the purposes of the ES, several construction scenarios were generated to describe the realistic maximum design scenario construction programs for each of the topic assessments. As an example, an indicative construction program, showing the scenario of a single phase of construction, is presented in Figure B-7. The durations identified for the single-phase construction program were a realistic worst case estimate for the build of the maximum project capacity and number of components. Actual durations will be dependent on several factors including component and vessel availability, weather and final construction strategy.

Although Figure B-7 shows a single phased construction program, Project Two could be built in up to four phases. In a multiphase construction scenario, the program would differ from that shown in Figure B-7 in several ways. Particularly, 'gaps' could open within bars that represent the construction activities. Following the completion of certain tasks (WTG foundation installation, for example) for a given phase, some amount of time could pass prior to those tasks being resumed for subsequent phases. This 'phasing' of the construction introduces some degree of necessary flexibility, but was constrained in the following ways:

- Onshore cable ducting for all phases will be laid during the first phase. Work in subsequent phases will be limited to pulling cables into the ducts, jointing them (including creating joint pits and installing link boxes), and commissioning them;
- Civil works at the onshore substation site for all phases will be completed during the first phase. Subsequent phases will be limited to installing and commissioning electrical equipment and associated control, cooling infrastructure, etc.
- Unless otherwise agreed upon with the relevant stakeholders, cable ducts will be installed under the sea defenses into the intertidal area in the first phase. Subsequent phases will be limited to pulling the offshore cables into the ducts and into the TJBs and jointing them with the land cables (including installing link boxes).
- Each phase will lay, bury, and protect (where relevant) their own offshore cables, including in the intertidal area.
- Each phase will install its own WTG foundations. However, there will be at most two vessels undertaking operations to install these foundations using hydraulic impact hammers at any one time.
- All piles will be installed over the course of at most five years with no 'gaps' in pile installation work longer than one year.
- Each phase will install its own HVAC collector substation(s) and inter-array cables. However, offshore HVDC converter and HVAC reactive compensation substations may be shared between multiple phases.
- Each phase will install and commission its own WTGs.
- The onshore construction program, including all phases and gaps between phases, will be completed within five and a half years from the start of onshore construction.

- The intertidal construction, including all phases and gaps between phases, will be completed within four and a half years from the start of intertidal construction, including the installation of ducts under the sea defenses and installing cables in the ducts and laying them out to sea. The installation of cables in the ducts and laying them out to sea will be completed within three and a half years from the start of cable installation in the intertidal area. No plant or materials will be left in the intertidal area between periods when work is being actively carried out.
- The offshore construction, including all phases and gaps between phases, will be completed within six years from the start of offshore construction.

From the construction program shown in Figure B-7 and the constraints described above, several construction scenarios were generated to describe the realistic worst case construction programs for each of the assessments in the Hornsea Project Two ES.

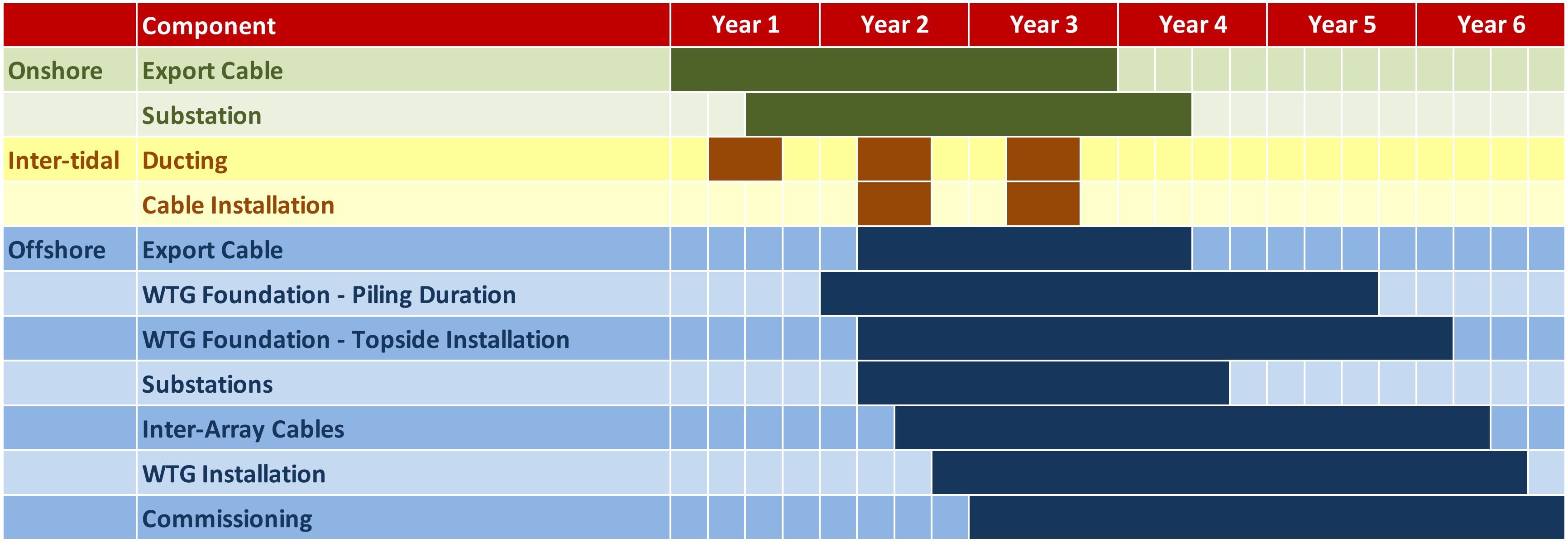

Figure B-7. Indicative Single Phased Construction Program for Hornsea Project Two.

B.2.3.2 Risk/Benefit Analysis

A risks/benefit analysis of the phased approach taken for Hornsea Project Two is presented in Table B-12 to Table B-14.

Table B-12 presents the results of the risk /benefit analysis for the developer and puts them into the context of the width of the PDE, the phased approach taken and the impact assessment process. Table B-13 provides the results of the risk / benefit analysis for the regulator, again in the context of the width of the PDE, the phased approach applied to the Hornsea Project Two and the impact assessment process employed for the development. Table B-14 presents the same analysis with respect to the environment.

Table B-12. Risk / Benefit Analysis of the Phased Approach for the Developer (Hornsea Project Two)

Aspect Description	Benefit	Risk
Phased Approach DCO/Marine License - Two projects (each with their own undertaker (/developer))	• Allows for up to two undertakers therefore flexibility in the financing of the project(s). • All activities/tasks undertaken for projects at the same time, therefore an opportunity for significant cost/program savings (e.g., survey costs, stakeholder consultation, a single EIA/HRA process and consenting).	• Restricts the project to a maximum of two undertakers. If additional undertakers are required, this would require an amendment to the DCO/Marine License (there is a lengthy process associated with this). • Where two undertakers occur, requires discharge of the consents associated with two Marine Licenses (i.e., program/cost implications). • Although each undertaker has a separate Marine License (and therefore separate conditions associated with each project), requires collaboration between the two undertakers. • As the two projects are granted consent at the same time, restricts how the undertakers develop each project (e.g., have the same export cable route corridor, grid connection etc.).
Phased Approach Construction - Project to be built out either in one phase or a series of phases (up to four).	• Allows for a high level of flexibility in the number of different construction program scenarios. • All activities/tasks undertaken for projects at the same time, therefore an opportunity for significant cost/program savings (e.g.; survey costs, stakeholder consultation, a single EIA/HRA process and consenting).	• Potentially four separate teams are required to manage/undertake the build out of the four phases during times of peak activity- ultimately cost implications. • Stakeholders need to be carefully managed at a project level, rather than for each phase, to ensure consistency of message. • Restricts the project to a maximum of four phases. If the project is divided up in to additional phases, this would need to be agreed with the MMO.
Impact Assessment Each impact assessment selected the construction scenario which resulted in the realistic maximum design scenario.	• Covers a large variety of construction scenarios and parameters; therefore, ensuring ultimate flexibility in the ultimate project (significant procurement advantages when selecting the final design).	• Complex assessments have associated program and cost implications with regards to the ES. • Stakeholder consultation needs to be carefully managed to ensure a full understanding of the project description and the impact assessments.

Table B-13. Risk / Benefit Analysis of the Phased Approach for the Regulator (Hornsea Project Two)

Aspect Description	Benefit	Risk
Phased Approach DCO/Marine License - Two projects (each with their own undertaker (/developer))	• Pre-consent – One DCO (which includes the Marine Licenses); therefore, less administrative burden (when compared with multiple DCO projects). • The impact of the project is assessed as a whole (i.e., within the project alone assessment); therefore, implementation of mitigation is also developed taking into account the impact of the project as a whole, rather than on incremental parts of the project.	• Post consent - Up to two Marine Licenses therefore additional administrative burden (when compared with a project with a single Marine License and therefore only one set of conditions/ requirements). • As the DCO/Marine License is granted prior to the construction of either project, there is no opportunity for lessons learned/further information to be obtained on the environmental impact of this type of project in this region.
Phased Approach Construction - Project to be built out either in one phase or a series of phases (up to four).	• The impact of the project is assessed as a whole (i.e., within the project alone assessment); therefore, implementation of mitigation is also developed taking into account the impact of the project as a whole, rather than on incremental parts of the project.	• Increased complexity of the EIA due to numerous different construction scenarios – difficult to always ascertain what the maximum design scenario is for each receptor/impact. • As the DCO/Marine License is granted prior to the construction of either project, there is no opportunity for lessons learned/further information to be obtained on the environmental impact of this type of project in this region.
Impact Assessment Each impact assessment selected the construction scenario which resulted in the realistic maximum design scenario.	• The EIA fully considers all potential construction scenarios therefore the maximum design scenario is fully assessed.	• More difficult to consent larger project because of the predicted environmental impacts and increased level of complexity with the EIA. • Increased complexity of the EIA due to numerous different construction scenarios – difficult to always ascertain what the maximum design scenario is for each receptor / impact.

Table B-14. Risk / Benefit Analysis of the Phased Approach for the Environment (Hornsea Project Two)

Aspect Description	Benefit	Risk
Phased Approach DCO/Marine License - Two projects (each with their own undertaker (/developer))	• The impact of the project is assessed as a whole (i.e., within the project alone assessment); therefore, implementation of mitigation is also developed taking into account the impact of the project as a whole, rather than on incremental parts of the project.	• As the DCO/Marine License is granted prior to the construction of either project, there is no opportunity for lessons learned/further information to be obtained on the environmental impact of this type of project in this region. However, it is worth noting that this only becomes an issue where there is a high level of residual uncertainty regarding a particular impact or a concern regarding the predicted significance of a certain impact. If neither of these are the case, then there is no need for lessons learned or further information to be obtained to inform the consent.
Phased Approach Construction - Project to be built out either in one phase or a series of phases (up to four).	• Both a single phase and multi-phase construction scenario have environmental risks and benefits. A single phase or multi-phase concurrent construction program will typically result in a shorter construction program; however, this is associated with a high density of activity at any one time. A multi-phase sequential or staggered construction program will typically occur over a longer duration of time; however, this is associated with a low density of activity at any one time.	
Impact Assessment Each impact assessment selected the construction scenario which resulted in the realistic maximum design scenario.	• The EIA fully considers all potential construction scenarios, and therefore is able to capture all potential variability within the Design Envelope and in relation to potential impacts considered in the assessment.	• More difficult to consent larger project because of the predicted environmental impacts and increased level of complexity with the EIA. • Increased complexity of the EIA due to numerous different construction scenarios – difficult to always ascertain what the maximum design scenario is for each receptor / impact. • Environmental monitoring feedback is not introduced between project phases and lessons learned from previous phases cannot be applied to subsequent phases of construction.

B.3. Appendix B References

DONG Energy. 2007. Gunfleet Sands 2 Offshore Wind Farm. Environmental Statement.

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Scottish Executive Central Research Unit. 2001. The Use and Effectiveness of Planning Agreements. Available online at: http://www.gov.scot/Resource/Doc/83397/0050553.pdf. Accessed July 2017.

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Appendix C: Survey, Deploy and Monitor (SDM) Policy

C.1. Survey, Deploy and Monitor (SDM) Policy

The intention of the Survey Deploy and Monitor (SDM) Policy (Marine Scotland, 2016) is to provide regulators, and developers, with an efficient risk-based approach for taking forward wave and tidal energy developments. Although the guidance has been developed specifically for wave and tidal development, the principles have been applied to other renewables developments, particularly floating wind projects, which are considered to be novel technologies.

The policy has been specifically designed to allow new technologies, whose potential effects are poorly understood, to be deployed in a manner that will simultaneously reduce scientific uncertainty over time while also enabling a level of activity that is proportionate to the risks. It allows for projects to reduce the amount of pre-application survey that is need to inform the consent decision where there are sufficient grounds for a reduction in the amount of wildlife survey effort (usually 2 years of survey data) and analysis to develop site characterization. However, it will also allow for determination of projects that require a greater level of effort due to site sensitivities, technology risk and the overall scale of the project. Once the pre-application survey effort is determined the policy then highlights how those developments will be deployed and monitored.

It should be noted that the SDM policy does not replace the need for a developer to undertake the full EIA process and submit an ES in support of their application. However, the policy will inform the ES, EIA and the determination by Scottish Ministers.

Guidance is provided for each step of the SDM policy and a description of how each stage is implemented and assessed to determine the level of effort required at each stage. This is separated into the following stages:

- Pre-consent survey;
- Deploy, and
- Monitoring.

Rather than a "one size fits all" approach, it is a risk management process with the purpose of applying an appropriate and proportionate approach to permitting which takes into account the individual circumstances in relation to each individual development.

C.1.1. Pre-consent Survey

For pre-consent survey the policy looks to establish the level of effort required to characterize the baseline environment based upon the detail required to inform the consenting process. Reduced data collection requirements, in relation to lower risk proposals, should facilitate earlier consenting decisions and more rapid build out of overall low risk projects. However, higher risk proposals are likely to be subject to a greater level of pre-consent survey effort.

In order to assess pre-consent survey requirements an assessment is made upon an understanding of risk informed by 3 general factors:

- **Environmental Sensitivity (of the proposed development location)** - An assessment is undertaken of the relative environmental sensitivity of a proposed location, based on environmental sensitivity maps that combine data from 19 different environmental datasets, enabling areas of relatively higher and lower sensitivity to be distinguished.
- **Scale of Development** – Based on the proposed generating capacity, and assessed as either: Low (up to 10MW); Medium (10MW to 50MW); or High (greater than 50MW) risk.

- **Device (or Technology) Classification** – Device (or Technology) Risk is a function of how the device is installed, operates and behaves and interacts with the environment and is a broad assessment of the potential impacts on marine life. An assessment of the device risk is undertaken against several environmental hazards which have been identified by Aquatera (2012) (e.g. collision risk between marine mammals and tidal energy devices, potential barriers to movement etc.).

The individual assessments above are combined into an overall Device (or Technology) risk assessment by the Marine Scotland Licensing Operations Team (MS-LOT), expressed as Low, Medium, or High using the scoring system as described in Annex 1 of the Draft[9] Policy (see Appendix B). The outcome of the risk assessment is then used to guide advice form Marine Scotland in relation to the level of effort required for pre-application site characterization (i.e. surveys). If a project is assessed as low or medium, then this might allow for a reduction in the amount of data collected for site characterization and to inform the EIA process.

Table C-1 provides a summary of the outcome of the risk assessment process.

Table C-1. Outcome of the Risk Assessment Process (Marine Scotland, 2016)

Risk Assessment Outcome	Description	Required Survey Effort
High Risk / High Uncertainty	For high risk / high uncertainty developments, there would be little scope to apply a fast-tracking approach. In addition, the developer would normally be expected to undertake testing and impact monitoring of a test device or demonstration array* elsewhere, providing the results of studies on wildlife interactions with their device(s) in support of their application.	A minimum of 2 years of site characterization data would be necessary to support an application.
Medium Risk / Medium Uncertainty	An approach intermediate to that of High and Low risk schemes would be required for a Medium Risk / Medium Uncertainty development. An application for a scheme assessed as Medium risk should also normally be supported by impact monitoring data from a relevant demonstration device or devices.	The initial presumption would be that 2 years of site characterization data would be required. However, if it is considered after one year that the risk is less than originally assessed, or that the data gathered to date are adequate to inform the consent application, then discussion on the relaxation of requirements for further site characterization can be undertaken. This is known as a 2 minus 1 approach.
Low Risk / Low Uncertainty	A small development proposed for an area of low environmental sensitivity made up of devices with limited device risk would have an overall project environmental risk assessment of Low. In such a case, if the environmental risk information was considered robust or underpinned by strategic survey	Up to 1 year of site characterization data (or equivalent) to inform the license application will be required for low risk projects. However, the survey data may alert the regulator that further data collection is required (e.g. because of unexpectedly

[9] Although in use, it should be noted that the SDM Policy is still in draft

Risk Assessment Outcome	Description	Required Survey Effort
	information fast tracking of an application might be considered. Impact monitoring of a test device is not a pre-requisite for a Low risk application. However, provision of such data is considered to facilitate consenting decisions.	high numbers of a protected species). Should that be the case, the application may go forward in parallel with the additional survey work. However, consent will not be determined until the additional data has been analyzed.

*A proposal for a large (>50MW) array should be informed by studies of a smaller 'demonstration array'; a proposal for a demonstration array should be informed by studies of a single demonstration device (and/or relatively smaller demonstration array).

C.1.2. Deploy

Once the above strategy for pre-application data collection has been implemented and the application for the project submitted the 'deploy' aspect of the SDM policy is applied and consent is likely to be granted under the condition that the company deploys the project in a series of phases (i.e. a phased approach). The initial phase will be limited to a discrete number of devices with subsequent phases subject to prior written approval by Scottish Ministers. Therefore, while a project may receive consent for a full 100MW development, they may only initially deploy 5MW. Each subsequent phase will only be allowed to proceed once instructions to do so are received from Scottish Ministers.

The application of phased deployment is likely to start at a small scale (i.e. 2 or 3 devices) to allow the implementation of a demonstration strategy (see Section C.1.3). This will consist of intensive monitoring to provide empirical data against which the conclusions of the EIA can be compared and which are used to re-evaluate the key risks identified during the initial risk assessment. Approval for subsequent phases will only be given when Scottish Ministers are certain the risks associated with key environmental impacts are appropriately understood and managed.

C.1.3. Monitor

Post-construction monitoring is a requirement of consents granted for early marine renewable projects, not least to provide the information necessary to support subsequent applications for subsequent phases and future developments. The nature and duration of any monitoring will be project specific and only determined and agreed post-consent. Any work undertaken through such a condition would complement work being undertaken through the Demonstration Strategy.

Demonstration Strategy

Demonstration projects provide an opportunity for addressing some of the scientific uncertainty surrounding the licensing of marine renewable developments. The principle behind the demonstration strategy is that Marine Scotland forms partnerships with developers to take advantage of opportunities presented by early projects to make targeted investigations of particular aspects of the environmental interactions of each development. Information obtained from demonstration projects, will be available for, and used by, other developers and regulators to inform the consenting of future marine renewable developments. Thus, the strategy provides a feedback loop into the industry as a whole so that lessons from early projects can provide evidence for the assessment of effects for future projects.

As monitoring results are produced, these will give a better understanding of interactions, enabling decision making associated with subsequent phases and licensing future project to be better informed.

C.1.4. Implementation

To date, the full SDM Policy has not been implemented in a project as projects which are currently being assessed under the SDM Policy are either in the early stages of development and yet to submit an application for consent or have been consented but have not yet been deployed. The project which has been the furthest through the process is the MeyGen Tidal Energy Project Phase 1, which as of December 2016, has installed its first turbine and exported electricity to the grid.

However, the MeyGen project has been assessed through the SDM policy and as a result was required to undertake 2 years' worth of characterization surveys prior to submission of their application. Due to the size of the development (86MW), the sensitivity of the environment in which it was to be deployed and the lack of previous data available from a test or demonstration project or other developments, the project was considered to be of high risk / high uncertainty. Therefore 2 years' worth of survey data was required under the SDM policy. In addition, the project is required to deploy in a series of phases with monitoring undertaken in between phases, the result of which will inform the decision on whether to deploy the remaining phases of the project. Monitoring has been agreed upon for the first phase and the results of this monitoring will be available in the next year and will provide further information on how the SDM policy has been implemented. Currently this project represents the best example of the SDM policy in action, particularly in relation to a phased approach to development for a high-risk project.

Other projects have also been assessed according to the SDM policy. These include a further four tidal and two wave energy projects which have completed the consenting process (one of these projects was not awarded consent), although none of these projects are as far developed as MeyGen. Two further tidal projects have been submitted and are currently in determination and a further three wave projects are at the pre-application stage. In addition, two offshore wind projects have had the SDM policy applied to them, the Hywind Scotland Pilot Park (which has been awarded consent) and the Kincardine Offshore Wind Farm (currently in determination). These projects were considered to be novel technologies due to their deployment of floating offshore wind turbines (as opposed to fixed foundations).

C.2. SDM Policy Case Studies

C.2.1. Methodology

The following outlines the specific methodology implemented in order to review the Survey, Deploy and Monitor policy currently used in the marine renewables sector in Scotland. The review aims to establish the key advantages and disadvantages of this approach in the context of the marine renewables sector and whether there are specific aspects of the SDM Policy approach that could be applied to the offshore wind industry.

Case studies of developments where the SDM Policy has been applied were reviewed to examine how the policy was implemented, the key advantages and disadvantages of the approach and whether any aspects of the approach could be applied to offshore wind developments. The review process for each project is presented alongside the risk assessment criteria. The review presents information on how the SDM Policy has been implemented to date, including in relation to offshore wind farm developments.

C.2.1.1. Case Study Selection Process

Due to the nascent stage of the marine renewables sector the number of potential projects that could be selected for review is relatively small. To date only six wave and tidal projects have been consented by Marine Scotland and the majority of these are either very small projects (10 MW or less) or have not progressed beyond gaining consent. The MeyGen 86MW tidal energy project on the north coast of Scotland is the exception and has recently installed its first turbine and exported electricity to the grid. Therefore, the MeyGen project represents the best example of the application of the SDM policy and is the main case study examined.

During consultation with Marine Scotland (see Section C.2.1.3) it was identified that the SDM Policy had been applied to two wind farm projects, the Hywind Scotland Pilot Park and the Kincardine Offshore Wind Farm (OWF). These developments both employ floating wind technology and were therefore considered by Marine Scotland to require initial assessment under the SDM Policy. The Hywind project is the most advanced, having received consent in November 2015, while Kincardine OWF is still in determination. Therefore, the Hywind project was selected as a case study for review.

C.2.1.2. Case Study Reviews

Data Sources

All information that has been reviewed for this analysis has been derived from publicly available sources. The main project information has been drawn from the ES and supporting documentation for the relevant case study projects and information on the SDM Policy from Marine Scotland information available on their website. The following documents were reviewed:

- MeyGen (2012). MeyGen Tidal Energy Project Phase 1. Environmental Statement.
- Marine Scotland (2016). Survey, Deploy and Monitor Licensing Policy Guidance. Version 2.
- Statoil (2015). Hywind Scotland Pilot Park. Environmental Statement. April 2015

Additional information was obtained through consultation with relevant developers and Marine Scotland (see Section C.2.1.3).

Risk / Benefit Analysis

Key project information available for each of the case studies was reviewed, particularly the Project Design data presented within the ES. Initially, the development as a whole was examined, including the Project Description of the ES and the key parameters from the PDE. Next, the implementation of the SDM Policy on the project was examined based on the case studies. The risk / benefit analysis then summarized the key advantages and disadvantages of the SDM Policy for each project, in terms of the developer, the regulator, and the environment. The risk / benefit analysis also noted, where relevant, the effects that the SDM Policy application had on the PDE and the phasing of the project and associated risks of this approach.

C.2.1.3. Consultation

To provide further detail and context for each of the case studies reviewed as part of this report a series of targeted consultation meetings were held with relevant organizations in the U.K. Discussions were held with the following:

- MeyGen Limited to cover the MeyGen Tidal Energy Project, Phase 1 project consented under the SDM Policy and utilizing a phased approach to development.
- Marine Scotland to cover the SDM Policy, its development, application, purpose and potential application to the offshore wind sector.

The goal of the consultation was to further understand the key aspects of the application of the SDM policy within the wave and tidal industry and whether aspects of the SDM policy could be applied to offshore wind. The goal of the consultation with MeyGen and Marine Scotland Licensing Operations Team (MS-LOT) was to gain further understanding of:

- the phased approaches taken for each project;
- the key challenges of phased development approaches;
- any recommendations or changes that could be implemented in the future for phased development approaches and the further development of the PDE for phased developments;
- the main advantages and disadvantages of the SDM approach to phased development within the wave and tidal sector, and
- whether the SDM policy could be adapted for use within the offshore wind sector.

RPS met with MS-LOT at their offices on November 11th 2016. The results of the discussions added context to the review of the SDM Policy and have been incorporated into analysis of the SDM Policy in Section C.2.2.1 and Section C.2.2.2. During discussions phased development and the use of the PDE were also discussed and the results of these discussions were used throughout this document. The results of the discussion regarding the phased approaches and the PDE with MS-LOT are included in Table B-2. Table C-2 provides a summary of the outcome of consultation undertaken with MS-LOT regarding the SDM Policy.

Table C-2. Marine Scotland Consultation Outcome

Organization	Key Topics Discussed	Key Points Raised
Marine Scotland **Roger May (Renewables Section Head, Marine Scotland License Operations Team (MS-LOT))** **11th November 2016**	SDM Policy	• The SDM policy mainly affects the pre-and post-installation elements of a project. • If projects are not too large in scale, then the pre-consent surveying can be reduced with focus on post consent monitoring. This is the cost of a quicker turn around at the start of the project. • Developers are also identifying in all offshore renewables projects additional risks not captured within the bounds of the PDE that require further licensing. In some instances, they may never use the license but it de-risks the project and ensures it can go ahead if the original methodology doesn't work (i.e., there is an alternative they can turn to). This reduces the level of risk for projects, makes them more commercially viable and practical to develop. • The offshore wind sector knows what its risk are – Birds. If you have a good area without many birds, then this reduces the overall risk considerably. So, moving further offshore can reduced risk in relation to birds considerably. Screening and scoping of sites is key to the whole process. The first offshore wind projects in the UK were not identified properly – need a proper GIS based site selection process to identify suitable sites. • Common currency approach is required – i.e. data and data analysis must be readily comparable across several sites / projects. Up until now there have been several different

Organization	Key Topics Discussed	Key Points Raised
		methodologies and no agreement on which is the standard. Survey areas also tend to be too small to give enough statistical power to undertake meaningful analysis. If the survey areas had been expanded for first projects, then some of the issues still surrounding birds might have been already addressed and the amount of surveying required might have already been reduced.
	Advantages of SDM	• SDM gives you that first step of going from 1 machine to something that is commercial or semi-commercial considering the uncertainty regarding potential environmental effects from marine renewables. It allows projects to be deployed where a precautionary approach might prevent deployment of a project. • A 5-year process can be reduced to 3 – 4 years by the implementation of SDM (if good site selection process undertaking from the start). There is no guarantee in reducing timeframes; it is simply a potential benefit of SDM.
MeyGen Limited **Cameron Smith (Project Director)** **Cara Donovan (Project Developer)** **26th October 2016**	SDM Policy	• Top down approach encourages investment as it allows projects to operate without a shut off condition [e.g. having to shut off a tidal turbine when a marine mammal approaches]. • The approach is far more pragmatic than the precautionary approach applied elsewhere. • The SDM approach can lead to quite sensible permitting process which is of benefit to developers, regulators and stakeholders. • A necessary tool to allow the [wave and tidal] industry to progress. • The SDM policy provides a framework for a risk based approach and has found a way through the precautionary approach. • SDM provides a mechanism that addresses potential adverse consequences in a manner that does not affect the ability to finance a project. • Allows phased installation where uncertainty regarding potential environmental issues is present. This facilitates industry to finance projects and makes them viable investment opportunities. • Benefits the regulator, stakeholders and the industry as provides a framework for data collection which can in turn be used to inform decisions on future phases and other developments. • Collaboration between industry, the regulator and other stakeholders ensures all parties are moving in the same direction. • Promotes evidence based decision making and helps to

Organization	Key Topics Discussed	Key Points Raised
		increase knowledge of potential impacts.
	SDM Policy in relation to offshore wind	• There is less collaboration among environmental specialists in the offshore wind industry than there is in the wave and tidal industry. SDM promotes collaboration and appears to be more effective at driving the wave and tidal industry forward at this nascent stage. • In general, and for the offshore wind industry there is huge value in the SDM policy and the approach that has been developed for the wave and tidal sector. • Standardizing the way data is collected, interpreted and presented would improve the environmental impact assessment and cumulative impact assessment processes. • This would allow a more accurate and transparent determination of the environmental effects of projects thereby making the consenting process more efficient and consequently less time consuming.

C.2.2. Case Studies Analysis

The following section provides the results of the review of the Survey Deploy and Monitor (SDM) policy employed in Scotland in relation to marine renewables projects (wave and tidal). The section provides an overview of the SDM policy and how it is used by Marine Scotland in advising developers and planning project development, particularly the consenting process. Two case studies are then presented where the SDM policy has been applied and the review will examine how the PDE has been developed and whether a phased approach has been employed. The review uses the methodology provided in Section 2.1.

Two case studies were identified which would provide examples of how the SDM policy has been implemented and whether the phasing of the project, PDE and monitoring strategies were influenced by the application of the SDM policy:

- MeyGen, Tidal Energy Project Phase 1 – An 86MW tidal energy development off the north coast of Scotland.
- Hywind Scotland Pilot Park – a floating wind development off the east coast of Scotland.

C.2.2.1. MeyGen Tidal Energy Project Phase 1

Development Overview

The MeyGen Tidal Energy Project Phase 1 (“Phase 1”) is located in the Inner Sound, the body of water in the Pentland Firth between the north coast of the Scottish mainland and the island of Stroma (Figure C-1). The project is for the development of a tidal-powered electricity generating station of up to 61 tidal turbines with a maximum capacity of 86MW.

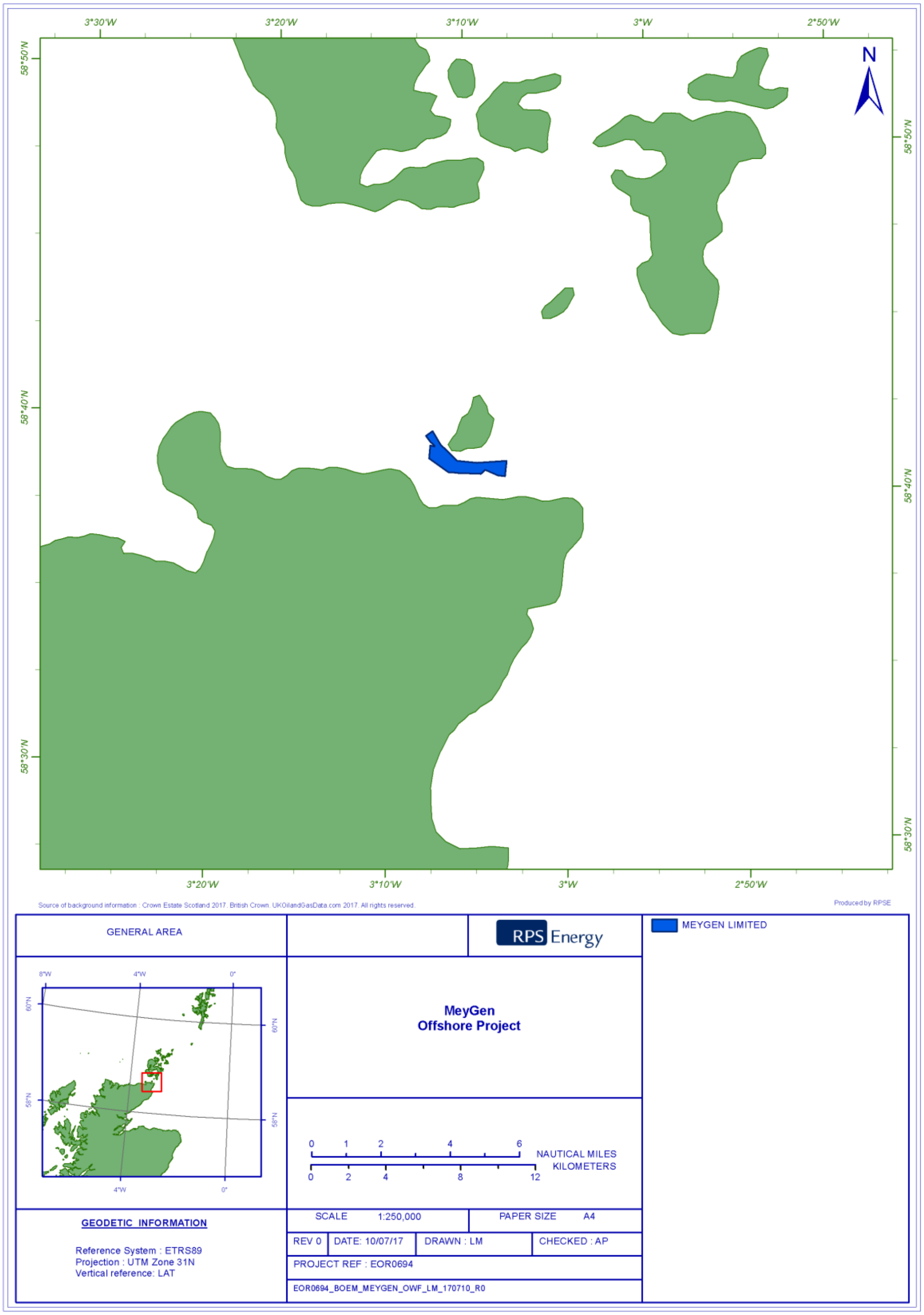

Figure C-1. Location of the MeyGen Project (Source: Crown Estate Scotland)

MeyGen Limited ("MeyGen") obtained a Section 36 consent and Marine License for the project in 2013 and 2014 respectively. Consent conditions required build out of the project to take place in a staged manner. The conditions restricted the initial stage to a maximum of 6 turbines. MeyGen decided to proceed with 4 turbines and call this Phase 1A.

Phase 1A will include the installation of 4 x 1.5 MW turbines offshore as well as the construction of all onshore infrastructure to support the project, including substation, grid connection and export cables. The build out of Phase 1A is currently taking place at the time of writing (December 2016) and first power was produced by one of the turbines on 15th November 2016. Once all four turbines are installed they will be commissioned to make Phase 1A fully operational in early 2017.

Background

MeyGen was awarded an Agreement for Lease (AfL) for the Inner Sound tidal development site on 21st October 2010 by TCE. The Inner Sound AfL is for the installation of a total of 398MW that will be developed over several different developments, the first of which is the consented 86MW Phase 1 project. By the early 2020s MeyGen intends to deploy up to 398MW of offshore tidal stream turbines.

Phase 1 is part of the larger project but has been consented as a stand-alone project. This 86MW Phase 1 project and initial development stage of 6MW, Phase 1A, is the primary focus at present. However, this case study will concentrate on the full 86MW Phase 1 project and the following sections are written based on this.

Funding for the development of Phase 1A project was secured on the August 21st 2014. A total of £51.3 million was secured from a syndicate comprising the U.K. government (through the Department of Energy and Climate Change), the Scottish Executive, Highlands and Islands Enterprise, The Crown Estate and Atlantis.

On financial close of Phase 1A, the Scottish Executive committed to subscribe to acquire equity in MeyGen through a holding company, Tidal Power Scotland Holding Limited ("TPSHL"), sufficient to provide the Scottish Executive with approximately a 14% equity stake in TPSHL.

Phase 1

The Phase 1 application and ES was submitted to Marine Scotland Licensing Operations Team (MS-LOT), on July 13th 2012 (supplementary information was submitted on 15th April 2013). After the required consultation period, Scottish Ministers (through MS-LOT) made their determination to grant the project Section 36 consent in September 2013 and issue a marine license in January 2014.

Stringent conditions for mitigation and monitoring were included within the Section 36 consent because of the predicted environmental impacts of the Phase 1 project on harbor seals, cetaceans and salmonid species, specifically the collision risk posed to harbor seals. It was determined that the predicted collisions (12 per year) for harbor seals for a six-turbine deployment, based on an avoidance rate of 98%, is the maximum that would avoid an adverse impact on the population within the Orkney and North Coast Management Unit in 2013.

Overall the environmental impacts of the original proposed build out of the full 86MW were considered (with existing information) to be far too great to approve the project as originally proposed. Therefore Phase 1 was subject to a reduction in the initial deployment from up to sixty-one turbines to six turbines and detailed monitoring undertaken to gain evidence to understand interactions with the turbines at the site.

Phase 1A

The first stage (Phase 1A) of the project comprises the installation of four 1.5 megawatt turbines offshore as well as the construction of the onshore infrastructure to support the project. Construction of Phase 1A began in January 2015 and first power was being produced by one of the installed turbines on the 15th November 2016.

For work to begin on Phase 1A, several consent/license conditions had to be discharged. A considerable effort was put into writing documentation that described how the project would be built and how mitigation and monitoring activities would be carried out (as per conditions).

A significant challenge for Phase 1A was that there was no existing methodology or precedence for the specific monitoring required for Phase 1A. Similar monitoring had been carried out at Strangford Lough, Northern Ireland for the SeaGen tidal turbine. However, every time a seal or cetacean approached the SeaGen turbine it was automatically shut off due to the conditions placed on the project by its consent. Phase 1A required monitoring to take place while turbines operated continuously (no shut off condition), register any collisions that occurred, identify the species that collided with the turbine and determine the effects of the collision. This type of monitoring had never been undertaken before and considerable effort/resource from industry, government and the academic community was engaged to find a solution that could adequately monitor the operational tidal turbines and collect the required information. The information and data collected for Phase 1A is required to understand the environmental impacts of the project that will directly influence the decision on whether future stages and phases at the MeyGen site can be approved.

The data collected from the initial stage of development will be essential to validating models, analyzing whether the predicted impacts of the development are correct and to discharge conditions of the Section 36 consent and Marine License that will allow further stages of Phase 1 and subsequent phases of development to proceed.

Construction

In August 2014, Phase 1A reached financial close and MeyGen announced that a total of £51.3 million had been secured from a syndicate of private and public bodies. Onshore construction commenced in January 2015 and in July 2015 four horizontally directional drilled boreholes were successfully completed (ready to receive export cables). The four turbine support structures were installed in October 2016, tidal turbine installation commenced in November 2016 and first power was produced on the 15th November 2016. Once all four turbines are in place at the site they will be commissioned to make Phase 1A fully operational in early 2017.

MeyGen aims to build out subsequent stages of Phase 1 after sufficient monitoring (as required by conditions of their Section 36 consent) of the initial array takes place. The results obtained from monitoring the four operational turbines will determine if any further stages and phases can proceed as well as the scale of future deployments.

Project Design Envelope

The PDE of the Phase 1 is outlined below in Table C-3. The key parameters shown represent a relatively small but well defined design envelope. While not greatly detailed there is lots of precision in the parameters and very little variation.

Table C-3. Key Phase 1 Parameters Presented within the Environmental Statement.

Parameter	Maximum Size
Offshore	
Tidal Turbine Units	
Project Area	2.4km^2 (1.1km^2 turbine deployment area 1.3km^2 cable corridor)
Water Depth	31 – 48.6 m (at Lowest Astronomical Tide (LAT))
Turbine Capacity	1 – 2.4MW (total aggregate installed capacity of 86MW)
Number of Turbines	Up to 86 (will depend on the rated capacity of the selected turbines)
Number of rotors	1
Number of blades per rotor	2 or 3
Rotor Diameter	16 – 20 m
Blade Swept Area	201 - 314 m^2
Height above seabed (to center of nacelle)	13.5 – 16 m
Total Height above seabed (to blade tip)	21.5 – 26 m
Minimum Clearance – Blade Tip to Seabed	4.5 m
Minimum Clearance – Blade Tip to Sea Surface	8 m (at LAT)
Length of Turbine Nacelle	12 – 23 m
Turbine Foundation Types	Option 1 – Gravity Based Structure (Tripod) • Steel tripod with large steel weights on each of the three legs • 30 m x 20 m footprint • Approx. 1,350 tonnes of steel • Requires use of Dynamic Positioning (DP) vessel Option 2 – Drilled Pin Pile Tripod • Braced steel tripod secured to the seabed with three small diameter pin piles • A socket is drilled into the rock, into which the pile is inserted and fixed using high strength grout • Installation is possible from DP vessel using a subsea drilling technique Option 3 – Monopile • Single monopile • A larger diameter socket (compared to pin pile) is drilled into the rock using a temporary subsea frame into which the pile is inserted and fixed using high strength grout

Parameter	Maximum Size
	• Installation is possible from DP vessel using a subsea drilling technique
Turbine Layout	Final array configuration to be finalized at a later date but most likely will be placed in rows aligned perpendicular to the dominant flow direction. Array optimization will continue as new data is collected on the site Indicative layout included in the ES, based on an 86-turbine array with minimum separation distance of 45 m cross-flow and 160 m down-flow spacing
Vessel Installation/Construction Activities	
Laying cable bundles	DP cable laying vessel (260 max. operating days)
Joining jumper cables to export cable	Lightweight vessel with ROV (100 max. operating days)
Deploying gravity base, pin pile or monopile Turbine foundation and positioning turbines into support	• DP installation/construction vessel (345 max. operating days) lowers nacelle to foundation, or • Nacelle is pulled down onto foundation by a cable
Transporting turbines to site	On deck of DP vessel (170 max. operating days), or Under tow by an installation vessel
Towing floating turbine to array site	Tug (20 max. operating days)
Operations	
Design options for generation in ebb and flood tides	• Mechanical/electrical system to rotate the nacelle into the principal flow direction • Thruster in the nacelle tail to rotate the turbine into principal flow direction • Bidirectional blades that can generate from flows in opposite directions • Mechanical/electrical system to pitch blades 180o to principle flow direction
Cut in flow speed	Approximately 1.0m/s
Cut out flow speed	3.4 – 5.0m/s
Operating rotational speed	8-20rpm (3 bladed) 12-20rpm (2 bladed)
Options for power conditioning equipment	All power conditioning is onshore at the Power Conversion Centre (PCC), the onshore facility that receives generated power Power conditioning within turbine nacelle and onshore transformer at the PCC
Offshore Electrical Infrastructure	
Export Cable Options	• Dedicated export cable for each turbine (up to 120mm external diameter) • Alternative 1 – Three circuit cable (up to 130mm diameter) • Alternative 2 – Five circuit cable (up to 250mm diameter)

Parameter	Maximum Size
Cable Installation Method	Horizontal Directionally Drilled (HDD) and Seabed Cable Laying from a modified DP construction vessel or a dedicated cable installation vessel
Export Cable HDD Bores	• 86 individual cable bores, 300mm diameter bores extending 2,000m from the shore or • 29 multi-cable bores, 600mm diameter extending 700m from shore
Offshore Export Cable Length	Up to 2 km 100 – 1,300 m cable laid on the seabed 700 – 2,000 m cable HDD

The policy has had a profound influence on the project and has affected the pre-application, construction and operation elements of Phase 1 and will also determine viability of the wider MeyGen project into the future.

As MeyGen had an overall project environmental risk assessment of "High" and was considered to be a large-scale project under the SDM policy (i.e., more than 50MW) it was subject to two years of baseline characterization surveys, deployment restrictions and intensive operational monitoring requirements.

The SDM policy was the basis on which the Section 36 consent and marine license were granted and directly influenced consent/license conditions. The SDM policy is one of the primary reasons why the project is being currently built out in a staged manner. However, it must also be stated that the ES did initially propose to develop a small array (up to 10MW in the first year).

There are many aspects of the SDM Policy that directly relate to Phase 1. For example, in the "Deploy" section the policy states:

"*for larger scale projects consent is likely to be conditional upon the company deploying the devices in a phased approach. Phase one of the development will be limited to a maximum number of devices and all subsequent stages of the development will be subject to the prior written approval of the Scottish Ministers*".

This element of the SDM policy has been translated into conditions of the Section 36 consent outlined in previous sections of this case study. The restriction of the initial deployments of Phase 1 to a small demonstration array (up to six devices as specified in the Section 36 consent) is example of how the SDM policy is currently and actively being implemented today. The approval of the next stages of Phase 1 and subsequent phases of the wider MeyGen project will only be granted when Scottish Ministers are certain the risks associated with potential environmental impacts are appropriately understood.

To date the SDM Policy has not influenced the project design envelope (PDE) of Phase 1. However, the policy did heavily influence the build out of the project by restricting the number of turbines initially deployed and requiring extensive environmental monitoring. Thus, there is now potential for the policy to indirectly affect the PDE in the future because as time moves forward tidal technology will progress and this may involve significant turbine design changes. If this occurs, it is likely that the PDE will require an update or adjustment which will be as an indirect result of the SDM Policy. In other words, if phasing is implemented in this way and introduces a delay to the build out, then the PDE may need to be wider than would otherwise be needed to futureproof the project against advances in technology.

Benefits / Risks of SDM approach

The following tables (Table C-4, Table C-5 and Table C-6) provide analysis of the risks and benefits of the application of the SDM Policy to the MeyGen Tidal Energy Project Phase 1. Table C-4 presents the risk / benefit analysis of the SDM approach for the developer in relation to the MeyGen Tidal Energy Project Phase 1.

Table C-4. Risk Benefit Analysis of the SDM Approach for the Developer

Benefit	Risk
• SDM allowed the full MeyGen Phase 1 86MW project to be consented and licensed where otherwise it might not achieve consent due to the uncertainties regarding potential environmental impacts, particularly on species of conservation importance • SDM benefitted the developer for this specific project but also gives confidence to the same developer (and the wider industry) of the prospects for their other projects in their Scottish portfolio which are located in much different locations around Scotland • SDM clearly sets out how the regulator plans to manage risk. Even if this may have negative implications for the project the policy at least allows the developer to predict and manage project development risk more efficiently. SDM also gives comfort in knowing that there is a plan for how offshore renewable energy development and associated impacts are being adaptively managed (contrasting the precautionary approach adopted in other jurisdictions e.g. Northern Ireland and Wales which have turbine shut off conditions)	• The risk is the restrictive nature of the build out and having to prove no effect in line with conditions • SDM was the principle for several important consent/license conditions that restricted build out of the entire project at once, limiting the initial stage of development to up to 6 devices • Results of monitoring data could have negative effects on the project e.g. no further stages of phase 1 may be constructed or, as a worst case, the project may be decommissioned early • Monitoring data may not be adequate to make a decision on whether further stages of phase 1 can proceed • If monitoring data has a negative outcome, then it could potentially affect the commercial viability of the whole development

Table C-5 presents the risk / benefit analysis of the SDM approach for the regulator (MS-LOT) in relation to the MeyGen Tidal Energy Project Phase 1.

Table C-5. Risk Benefit Analysis of the SDM Approach for the Regulator

Benefit	Risk
• Provides flexibility in the approach to data collection prior to determination allowing for further data collection should it be required • Data gaps need to be filled for the industry to move forward (in line with SG Policy and energy targets), SDM facilitates this and specifically the potential for collision impacts	• The risk that the possible negative effects on the environment and the impacts of the project when monitored will be significantly worse than predicted in the project application and as assessed and interpreted by the regulator • The knock-on effects on other projects depends on the results of monitoring and data obtained. There

Benefit	Risk
on harbor seals, cetaceans and salmonids will be assessed and hopefully determined • Enables important data to be gathered that allows better consenting/licensing decisions to be made. With evidence, evidence based decisions can be made • Data gathered for the MeyGen project will allow numerical models to be validated and refined and enable mitigation measures to be tailored (if required) for the project and its receptors • Allows progress to be made in terms of generating knowledge (information/data) that will allow decisions to be made on whether other projects currently in the consenting and licensing process can be granted approval or not. If granted approval the learnings and knowledge gained from the MeyGen project under SDM will inform consent and marine license conditions • Progressive approach to regulation that will improve the regulatory process and enable better evidence based decision making	is a lot of potential to negatively impact the consenting process for other projects if the results of monitoring are worse than predicted in MeyGen's EIS • Risk of setting negative precedent in the way environmental risk is managed • Risk of questions being asked on the appropriateness of using SDM policy if no further stages are approved for build out (also possible legal ramifications) because of the impacts monitored during the operation of the first stage of Phase 1 • If monitoring demonstrates negative consequences of the technology, there is a risk MS-LOT will be criticized for employing the SDM policy and approach.

Table C-6 presents the risk / benefit analysis of the SDM approach for the environment in relation to the MeyGen Tidal Energy Project Phase 1.

Table C-6. Risk Benefit Analysis of the SDM Approach for the Environment

Benefit	Risk
• Once data is gathered it will allow better informed management decisions to take place that should benefit the environment. The right data and analysis/interpretation of this data will benefit the environment and its sensitive components • The policy prevents unrestricted development from taking place (as does precautionary approach) and attempts to quantify the level of project risk (although there is still an unknown as to what the environmental effects might be) • Numerical models will likely be improved by data gathered which should have a positive effect in terms of improving accuracy of future impact assessment predictions • Mitigation measures will be refined based on the monitoring data collected. This should improve and further protect the environment and its components more comprehensively	• A large risk is the potential negative effects to the environment and its constituent components especially if the impacts of the project are worse than predicted in the project application and ES. Specifically, the risk of adverse impacts to harbor seal, cetaceans and salmonid species from collisions with operating tidal turbines are key concerns • SDM represents a move away from the more conservative, traditional and 'safer' approach of the precautionary principle and thus poses an increased likelihood of negative environmental effects • SDM could be considered a risky approach to sensitive receptors such as harbor seals because of the low PBR* threshold of this species and its capacity to absorb a reduction in population is close to being exceeded with the first stage of the MeyGen project. In fact, this approach is considered too risky for regulators in other

Benefit	Risk
	jurisdictions (Northern Ireland and Wales) and thus turbine shut off conditions have been incorporated into the consent/license conditions of tidal energy projects in these jurisdictions.

*Potential Biological Removal (PBR) is the threshold number of individual seals that can be removed from the population without causing a decline in the population, and is calculated annually by the Sea Mammal Research Unit (SMRU) using the latest seal counts. http://www.gov.scot/Topics/marine/Licensing/SealLicensing/PBR

C.2.2.2. Hywind Scotland Pilot Park

Development Overview

The Norwegian Energy company Statoil has invested in the development of the world's first full scale floating wind turbine. A full-scale demonstration turbine has been in operation 10 km off the Norwegian west-coast since 2009 and was successfully tested for five years. Thus, Hywind Scotland Limited (HSL) is now planning to develop a Pilot Park to demonstrate technological improvements, operation of multiple units, and cost reductions for floating wind farms on a commercial scale. HSL was awarded an AfL by TCE for the deployment of the Pilot Park in the Buchan Deep with water depths between 95 and 120 m off the coast of Peterhead on the east coast of Scotland. The proposed Pilot Park is located approximately 25 km off the coast just outside the 12-nm territorial water limit (Figure C-2). The Project will involve the installation of five 6 MW wind turbine generator (WTG) units and will be expected to produce between 15 and 30 GWh[10] per year of electricity each.

Based on the Hywind Demo slender buoy (SPAR2) concept, the Hywind Scotland WTG Units consist of a steel tower and substructure partly filled with ballast water and solid ballast. Three anchors will be required per turbine and the radius of the mooring system will extend from 600 to 1,200 m out from each turbine.

In addition to the proposed Pilot Park area and associated offshore and onshore infrastructure, the Project will use a deep water inshore area, to assemble the turbines prior to installation. The location of this inshore assembly is still to be decided; however, suitable facilities on the west coast of Norway have been identified. Once assembled, the turbines will be towed in an upright position from the assembly point to the turbine deployment area in the Buchan Deep.

[10]Gigawatt hours, abbreviated to GWh, is a unit of energy representing one billion (1,000,000,000) watt hours and is equivalent to one million kilowatt hours. A kilowatt hour is equivalent to a steady power of one kilowatt running for one hour

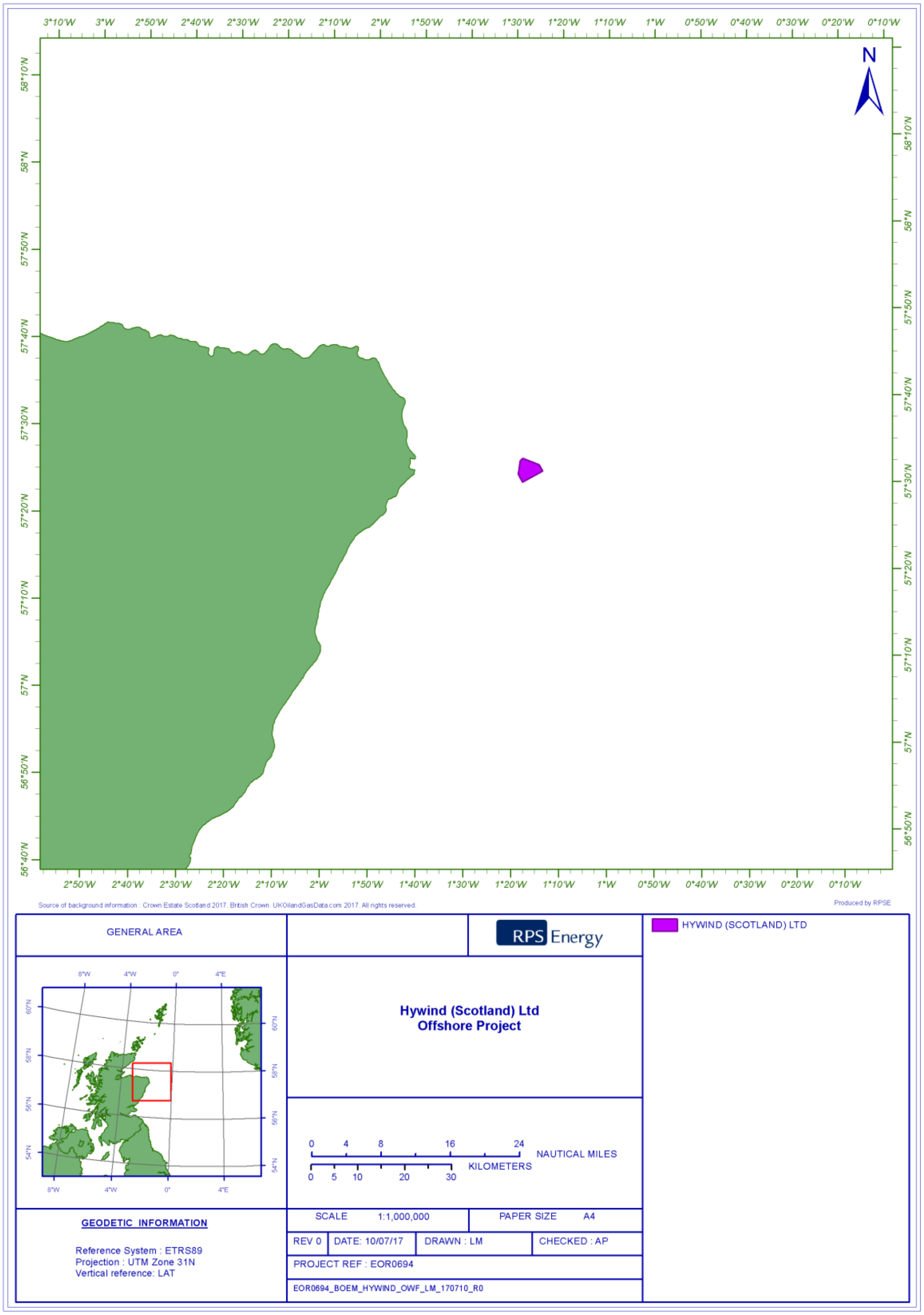

Figure C-2. Location of the Hywind Project (Source: Crown Estate Scotland)

Construction

The exact size of the Pilot Park will be dependent on the actual spacing between the WTG Units and location of the anchors and mooring lines. However, it is expected that the total area of seabed that will be occupied by the turbine deployment area will be 15 km^2. The base case is for the WTG Units to be secured to the seabed using suction anchors with a maximum diameter of 7 m (maximum footprint of 38.5 m^2 per anchor). The turbines will be positioned between 720 to 1,600 m apart and attached to the seabed by a three-point mooring spread and anchoring system.

The turbines will be connected by inter-array cables which may require stabilization in some locations. The export cable, which will transport electricity from the Pilot Park to the shore at Peterhead, will be buried where seabed conditions allow. Where this is not possible cable protection in the form of concrete mattresses and rock will be used. The export cable route extends from the proposed landfall north of Peterhead harbor in Aberdeenshire, offshore in an easterly direction to the western boundary of the Pilot Park. The offshore route is approximately 35 km in length. From the proposed landfall point, onshore cables, approximately 1.5 km in length, will connect the offshore wind farms to the onshore substation via a switchgear yard. The project will connect to the existing Scottish and Southern Energy (SSE) Peterhead Grange Substation, a distance of approximately 3 km.

Onshore construction is scheduled to start in 2016 / 2017 followed by offshore construction in 2017, with final commissioning in 2017. The expected operational life of the Pilot Park is expected to be 20 years with decommissioning commencing in the late 2030's.

Project Design Envelope

The key parameters associated with the Hywind Scotland Pilot Park are shown in Table C-7. It should be noted that due to the small scale of the onshore aspects of the Hywind Pilot Park and the total area of the onshore components being below the required threshold for a full EIA being required, assessment of the onshore aspects of the project was not required. Therefore, the onshore components of the project (i.e. onshore substation and cable route) were therefore not captured within the PDE. The offshore aspects of the project were the focus of the ES and therefore the PDE only captured the offshore components.

Table C-7. Key Hywind Parameters Presented within the Environmental Statement.

Parameter	Maximum Size
Offshore	
WTG Units	
Turbine Capacity	6 MW
Number of Turbines	5
Operational Power	75 – 150 GWh / year in total
	15 – 30 GWh per WTG Unit
Spacing between Wind Turbine Generator (WTG) Units	800 – 1,600 m
Operational Draft	70 – 82 m
Top head mass (rotor and nacelle)	310 – 420 tonnes
Displacement	11,500 – 13,500 m^3

Parameter	Maximum Size
Maximum Blade Tip Height	140 - 181 m (relative to MSL)
Minimum Blade Tip Height	22 m (relative to MSL)
Rotor Diameter	154 m
Swept Area	18,627 m^2
Blade Width	4 – 5.5 m
Turbine Foundation Types	Floating spar buoy
Substructure diameter	15 m
Steel weight	1,700 – 2,500 tonnes
Plate thickness	40 – 130 mm
Water Depth	95 to 120 m
WTG Unit Mooring System	
Mooring Spread	3 point
Number of Anchors per WTG Unit	3 (15 in total)
Anchor Type	Suction anchors
Anchor Footprint	Maximum 40 m^2
Scour Protection	15 m from anchor perimeter
Total Anchor Footprint (including scour)	900 – 1,000m^2 per anchor
Maximum Total Footprint of all Anchors	15,000 m^2
Mooring Line Composition	100 – 168 mm chain
Length of mooring line left on the seabed attached to the anchor prior to WTG unit installation	150 – 850 m
Radius of Mooring Lines from Centre	600 – 1,200 m
Offshore Electrical Infrastructure	
Export Cable Circuits	1
Offshore Export Cable Length	25 – 35 km
Number of inter-array cables	5 (maximum)
Length of each cable	3 km (maximum)
Total length of inter-array cable where protection required	7.5 km (maximum)
Total length of export cable where protection required	2 km (maximum)
Stabilization method	Rock dumping, mattresses or sand/grout bags.

Parameter	Maximum Size
Cable diameter	0.5 m (maximum)
Transmission	AC to 50 Hz
Rating and transfer voltage	33 kV
Position on seabed	Buried or surface laid. The base case is to surface lay the inter-array cables Burial depth up to 1.5 m for the export cable (and if an option for the inter-array cables)
Distance from the turbine where cable hits the seafloor	250 m from substructure
Period in wet store	Up to 18 months
Cable trench width	Up to 6 m
Cable crossings	Rectangular rock berm no larger than 15 x 24 m
Burial Depth	Up to 1.5 m
Cable Burial Method	Jet and mechanical trenchers (plow)
Inter-tidal export cable	
Corridor length	200 m
Cable Duct Width	4 m
Method of cable installation	Surface laid in the duct weighted down with clump weights and mattresses
Vessels and timescales	
Anchor and mooring installation	1 anchor handler vessel and light subsea construction vessel or similar 12 hours per anchor, 2 – 3-week duration Anchors and lower mooring installed 4 weeks to 1 year before installation of WTG Units
Inter-array cable installation	1 installation vessel and 1 crew transfer vessel 10 to 15 days
Hook up and mooring of WTG Units	1 light subsea construction vessel and 2 ocean-going tugs 24 hours per WTG Unit, 1 week duration
Export cable installation	1 cable lay vessel and 1 trenching vessel 5 to 8 days' installation
Export cable trenching	1 cable trenching vessel 8 to 12 days
Duration of total export cable installation	2 to 3 weeks

Parameter	Maximum Size
Operation and Maintenance	
Export cable inspection	Inspection every 1 - 4 years by supply vessel with an ROV. Each inspection to take 1 - 4 days
WTG Units	Annual service 1 crew transfer vessel 50 to 70 hours per year
Substructure, moorings and inter-array cables	Inspection every 1 - 4 years 1 crew transfer vessel and 1 supply vessel with ROV 1 day duration for each
Unforeseen visits	10 per WTG per year for corrective actions 25 to 100 days per year
WTG Units	Un-hooked and removed

Due to the small size of the Hywind development it will not be constructed in phases. However, it provides a useful case study due to the application of the SDM Policy to an offshore wind farm and the potential that future developments using the Hywind technology may be constructed in phases (the application of the SDM Policy to the Hywind Project is discussed in the next section). Whether this is the case remains to be seen and will depend on how future developments using the Hywind technology proceed.

The Hywind ES stated that it is anticipated that the mooring system consisting of suction anchors and mooring chains will be installed first. The mooring system will be pre-installed prior to inter-array cable installation and towing of the preassembled WTG Units to the site. The suction anchors are to be lowered into the water, together with the lower mooring chain, from an offshore construction vessel onto the seabed using a crane. Suction pumps will be activated to create a minor vacuum within the anchors and force them into their installed positions. Once the anchors are installed the lower mooring system comprising between 150 m and 600 m of mooring line will be laid and later lowered to the seabed. For installation purposes, a retrieval system will be deployed consisting of either a buoy floating approximately 10 m above the seabed or a pennant wire that can be retrieved using a grapple.

The inter-array cables and export cable will be installed before the WTG units are moored on site. Inter-array cables will be installed from an installation vessel with a cable carousel and will be stored on the seabed with a retrieval system prior to connection to the moored WTG Units. The export cable will, most likely, be laid from the landfall to the turbine deployment area. The end of the cable will be stored on the seabed and retrieved before connection to the inter-array cables.

Within 4 weeks to 18 months of installation of the moorings the WTG units will start to arrive on site to be installed. The installation vessel will retrieve the pre-laid mooring line from the seabed using an ROV and, connect the upper mooring line with the pre-laid lower mooring system. The connection will be made on the deck of the installation vessel with the two lines secured in shark jaws. This sequence will be repeated for each pre-installed mooring line.

The cable landfall at Peterhead will either be installed using Horizontal Directional Drilling (HDD) under the inter-tidal area to a point landward of MHWS or there will be a surface laid landfall involving the installation of the cable across the foreshore in a surface laid duct weighted down with clump weights and concrete mattresses.

The indicative constructive program of the Hywind Pilot Park (from the ES (Statoil, 2015)) is presented in Figure C-3.

Figure C-3. Outline of the Construction Program for the Hywind Scotland Pilot Park (Statoil, 2015)

SDM Policy Application

As with the other floating offshore wind project to which the policy has been applied (Kincardine Offshore Wind Farm), the SDM Policy was used in the case of Hywind to reduce the requirements for pre-application surveys from 2 years' worth of seabird survey data to 1 year of pre-application survey data. Having assessed the project using the risk assessment methodology in the SDM Policy guidance (Marine Scotland, 2016), the project was deemed to be of low risk / low uncertainty due to the small size of the development, its location and the available knowledge on potential impacts from offshore wind developments.

Thus, only a single years' worth of survey data was required to be collected prior to the application being submitted. However, following review of the survey results it was noted that large numbers of razorbills (*Alca torda*) were observed rafting in the area during winter and Marine Scotland required further analysis to be undertaken over a further 6 months (R. May, pers. comm. 2016). While this did increase the timeframe of the surveys and the overall determination of the project, it was much shorter than the usual 2 years of data required for most wind farm developments. Had the SDM policy not been applied to the Hywind project from the start then the project may have been delayed by the need to collect 2 years' worth of data prior to submitting their application.

In terms of the deployment of the project in phases this was not required due to the low risk considered for the development and the low number of WTGs. The SDM policy was also not used to develop the monitoring strategy for the development as once the application has been submitted and was in the determination process, the project was treated as a traditional wind farm application.

The same process was applied to the Kincardine Offshore Wind Farm (R. May, pers. comm. 2016).

Benefits / Risks of SDM Approach

For the Hywind project it should be noted that construction will be completed in a single phase, mainly due to the size of the development (five 6MW turbines, total of 30MW). Based on the risk assessment undertaken by Marine Scotland for the project the risk was not considered high enough to require construction to be split into phases. In addition, the monitoring requirements were also not as stringent as they might be for a much larger higher risk project and in general the PDE was relatively narrow (i.e. few variables presented for each variable) although significant detail was provided for each parameter. According to the ES (Statoil, 2015) this was mainly due to significant work having already been undertaken to design the project. Thus, it is clear that the SDM Policy did not affect whether the project undertook a phased approach to development and the PDE was unaffected by the application of the SDM Policy to the project. However, the Hywind project serves as the best example of the application of SDM to an offshore wind project as the development has been awarded consent (i.e., Kincardine Offshore Wind Farm is currently in determination).

The following tables (Table C-8, Table C-9, Table C-10) provide analysis of the risks and benefits of the application of the SDM Policy to the Hywind Scotland Pilot Park. Table C-8 presents the risk / benefit analysis of the SDM approach for the developer.

Table C-8. Risk Benefit Analysis of the SDM Approach for the Developer

Benefit	Risk
• Reduction in the required length of the pre-application survey data collection • Reduction in timescale for application to be submitted. Had the SDM Policy not been applied to the Hywind project, then 2 years' worth of survey data would have been required to be collected instead of 1 year prior to submission of the application. • SDM clearly sets out how the regulator plans to manage risk which allows the developer to predict and manage project development risk more efficiently, even if this has negative consequences. • SDM also gives comfort in knowing that there is a plan for how offshore renewable energy development and associated impacts are being adaptively managed. • Monitoring data, although potentially onerous, may provide data that will inform future applications, smoothing the process for larger future applications.	• The agreed timeline is not guaranteed. • Further data collection may be required once the first year's data has been analyzed and reported. • If further data collection required may delay determination of the consent. • Monitoring required post consent may be more onerous than if pre-application data collection period was longer.

Table C-9 presents the risk / benefit analysis of the SDM approach for the regulator (MS-LOT) in relation to the Hywind Scotland Pilot Park.

Table C-9. Risk Benefit Analysis of the SDM Approach for the Regulator

Benefit	Risk
• Providing flexibility in the approach to data collection prior to determination allowing for further data collection should it be required. • Provides an early opportunity to assess the project and provide guidance to the developer that would hopefully result in a smoother transition through the consenting process. • Potential to reduce administration and resource requirements for supporting the developer during the pre-application and determination periods by providing clear and early guidance. • Provides auditable trail of decision making in relation to advice given to the developer and a framework for undertaking a risk based approach.	• Additional resources may be required to analyze any new data presented by the developer • Further resources may be required to work with the developer in the early stages to ensure the data collection methodology is adequate. • Potential to negatively impact the consenting process for other projects if the results of monitoring are worse than predicted in the ES. • If additional survey requirements indicated by pre-application data collection risk of criticism of the use of the SDM approach. • If monitoring identifies long term trends that were not identified pre-application there is the risk that the use of the SDM approach is criticized.

Table C-10 presents the risk / benefit analysis of the SDM approach for the environment in relation to the Hywind Scotland Pilot Park.

Table C-10. Risk Benefit Analysis of the SDM Approach for the Environment

Benefit	Risk
• Adequate risk assessment of the potential risk posed by the project at an early stage in the life cycle of the project. • Subsequent data collection designed based on the results of the risk assessment. • Adequately management and characterization of the baseline environment based on risk assessment. • Approach allows for additional data collection if data collection identifies an unexpected result that requires further investigation • Pre-application survey is designed with post-construction monitoring in mind. • Pre-application and post-construction monitoring data can be analyzed to inform future, larger Hywind developments.	• Long term trends may not be identified in the 12 to 18-month dataset collected • Potential to miss population declines and / or key inter-annual variation in populations. • A large risk is the potential negative effects to the environment and its constituent components especially if the impacts of the project are worse than predicted in the project application and ES. • SDM is a move away from the previous precautionary approach and poses a risk of increased likelihood of negative effects occurring.

C.3. Application of the SDM Policy

This section provides a review of how principles of the SDM Policy could be applied to a hypothetical offshore wind farm by examining how the process applied to previous offshore wind examples (e.g., Hywind) and to the marine renewables sector might be applied to an offshore wind application. Using the hypothetical example from Appendix D.2, this section examines how such a development might take place, monitoring requirements and the elements of the SDM Policy that might be applied to such a project.

C.3.1. Introduction

The initial aim of this task was to review the application of the SDM Policy and how a phased approach using the principles of SDM could be applied to an offshore wind development. The aim was to examine how the different phases might be delineated in practice and how monitoring could be utilized to inform the deployment of each subsequent phase. However, one of the main conclusions drawn from examining the SDM Policy is that it is likely to be too restrictive for much larger offshore wind developments if it were implemented in its entirety.

To date, Marine Scotland has only implemented some aspects of the SDM Policy for three offshore wind developments all using novel floating offshore wind turbines. For larger developments using fixed turbines where potential impacts are relatively well understood, this type of phasing is likely to be unattractive to investors and is unnecessarily precautionary. If implemented it is likely to result in much slower progress of development, particularly if phases need to be separated by considerable amounts of time to allow monitoring to be implemented fully.

The risk management process and the early examination of risks associated with a project are useful tools in examining the project and understanding its potential risk to the environment at an early stage of development. The process can be used to identify the level of baseline characterization required and provide a framework for collaborative approaches to addressing key issues at a strategic level. It is that process that will form the major part of the review of the application of the SDM Policy.

C.3.2. Methodology

In order to undertake the risk assessment process utilized in the SDM Policy, the methodology developed by Marine Scotland (2016) has been used to examine the potential risk of an example project. Some changes have been made to make the methodology more applicable to offshore wind in terms of the capacity (MW) categories used to determine the scale of development and the type of environmental hazards. The environmental hazards used are based on knowledge of the key issues in the U.K. offshore wind sector.

We have adapted the SDM Policy risk assessment methodology form Marine Scotland (2016) to illustrate how such a risk assessment might be applied. **It is for illustrative purposes only.**

C.3.2.1. Environmental Risk

Under the SDM Policy, Marine Scotland use data on the proposed location of the development was considered to determine environmental sensitivity based on the presence of protected areas, protected species, and protected habitats and other relevant environmental factors. They also undertook an assessment of relative environmental sensitivity based on the environmental sensitivity maps provided in the SDM Policy (Marine Scotland, 2016). For this exercise, we have assessed the projects against Low, Medium and High sensitivity locations.

C.3.2.2. Scale of Development

As per the methodology of Marine Scotland (2016), the relevant measures for the scale of a development was based on the proposed total installed generating capacity in megawatts (MW) of the development. The scale of the development is assessed on a three-point scale, as shown in Table C-11, with associated assessment as Low, Medium, or High. However, in order to make the criteria more applicable to the development of offshore wind in the U.K., the criteria are based on the size of development currently within the U.K. and the current understanding of potentially environmental issues related to the size of the development.

Table C-11. Scale of Development Criteria

	Criteria	Assessment
Small scale	Up to 100MW	L
Medium scale	100 to 500 MW	M
Large scale	More than 500 MW	H

C.3.2.3. Development Risk

Development Risk (device / technology risk in Marine Scotland (2016)) is an expression of how the offshore wind farm is installed and interacts with the surrounding environment. It is a broad assessment of the potential effects of the offshore wind farm on the environment.

Table C-12 contains a selection of key environmental hazards which will be considered. It has been derived from our knowledge of the U.K. offshore wind industry and key issues that are assessed within the EIA but does not represent a definitive or comprehensive list of potential impacts or those considered to be the most important / highest risk. The list has purely been developed for this exercise and any list developed for a real project would have to consider the key potential risks relevant for that project.

Please note that the hazards identified in Table C-12 are not necessarily an exhaustive list and have been selected here for the purposes of this exercise. In reality, a longer list is likely to be used which assess risks against a whole host of other factors and will provide a more even spread of human, biological and physical factors.

Table C-12. Environmental Hazards Related to Offshore Wind.

No.	Potential Environmental Hazards
1	Potential for harmful collision between seabirds / migrating birds and offshore wind turbine generators
2	The potential effects on marine mammals and fish species from underwater noise generated by installation of wind turbine generator foundations (e.g., piling)
3	Direct loss of protected or sensitive sub-littoral seabed communities due to the presence of offshore wind turbine generators and associated moorings/support structures on the seabed. The potential wider/secondary effects on protected or sensitive sub-littoral seabed due to installation and operation of wind turbine generators and associated moorings/support structures.
4	Potential barrier to movement for seabird / migrating birds due to physical presence of wind turbine generators / wind turbine array.
5	Potential displacement of essential activities of seabirds due to the presence of wind turbine generators and associated moorings/support structures.
6	Potential displacement of essential activities of marine mammals/fish due to the presence of wind turbine generators and associated moorings/support structures.
7	The potential for cetaceans / basking sharks to become entangled in mooring lines.

No.	Potential Environmental Hazards
8	Loss of fishing grounds for key commercial / local fishing communities.
9	The potential for release of polluting substances to the sea.
10	Potential impacts from EMF on migratory fish species.

The individual assessments of each key impact in Table C-12 for the two project examples are then used to calculate an overall risk score expressed as Low, Medium, or High using the methodology described below. The final overall risk assessment will be assigned on the basis of the considerations outlined above.

Derivation of Development Risk

According to the methodology of Marine Scotland (2016) it is necessary to summarize the series of individual assessments of the list of environmental hazards in Table C-12 into a single development risk assessment.

The procedure to undertake this is as follows:

1. Each individual assessment against the key impacts in Table C-12 is scored one, two or three for Low, Medium and High assessments respectively.
2. The geometric mean of the scores from the key impacts in Table C-12 is calculated by multiplying the scores together and taking the *N* root of the product.
   i.e., Geometric Mean = $\left((X_1)(X_2)(X_3)\ \ldots\ (X_N)\right)^{1/N}$
   where
   X = Individual score
   N = Number of scores
3. The overall development risk is expressed as High, Medium or Low according to the geometric mean, as shown in Table C-13.

Table C-13. Development Risk Criteria (Marine Scotland, 2016)

Geometric mean score	Overall risk
1 – 1.60	Low
1.61 – 2.20	Medium
2.21 – 3.0	High

C.3.2.4. Overall Project Risk

The assessment of overall project risk is based on the geometric mean derived from the three scores derived from the assessment of environmental risk (Section C.3.2.1), development scale (Section C.3.2.2) and development risk (Section C.3.2.3). The procedure to undertake overall project risk is as follows:

1. Each individual assessment (environmental risk and scale of development) is scored one, two or three for Low, Medium and High assessments, respectively, with the score form the derivation of development risk being taken directly from the calculation of the geometric mean in Section C.3.2.3.

2. The geometric mean of the scores is calculated by multiplying the scores and taking the square root of the product.

   i.e., Geometric Mean = $\left((X_1)(X_2)(X_3)\right)^{1/3}$
3. The overall project risk is expressed as High, Medium or Low according to the geometric mean as shown in Table C-14.

Table C-14. Project Risk Criteria (Marine Scotland, 2016)

Geometric mean score	Overall risk
1 – 1.60	Low
1.61 – 2.20	Medium
2.21 – 3.0	High

According to the methodology of Marine Scotland (2016) this final project environmental risk will be expressed as Low, Medium or High and will be used to guide the requirements for pre-application site characterization and assessment of the environmental interactions of the development. The following summarizes what the outcome of the assessment may mean for a development in terms of site characterization and the consideration of overall project risk according to the SDM Policy (Marine Scotland, 2016).

- **High Risk or Uncertainty**. A large development proposed for an area of higher environmental sensitivity and development risk could have an overall project environmental risk assessment of High. In such a case, there would be little benefit to applying a fast-tracked approach to consenting. Under the SDM Policy, a minimum of 2 years of site characterization data would be necessary to support an application. Under the SDM Policy it is the High-risk projects that are likely to be phased, with monitoring requirements developed for between each of the phases (Marine Scotland, 2016).
- **Medium Risk or Uncertainty**. An overall project environmental risk assessment as Medium would require an approach intermediate to that of High and Low risk schemes. The initial presumption would be that 2 years of site characterization data would be required. However, if it is considered that after one year the environmental risk is less than anticipated, or that the data gathered to date have been adequate to inform the licensing processes, then there may be scope to discuss relaxation of the requirements for further site characterization, on receptor-specific or hazard-specific bases. This is known as a 2 minus 1 approach.
- **Low Risk or Uncertainty**. A small development proposed for an area of low environmental sensitivity with low development risk would have an overall project environmental risk assessment of Low. In such a case, if the environmental risk information was considered robust or underpinned by strategic survey information fast tracking of an application or permit might be considered. In such situations, up to 1 year of site characterization data (or equivalent) may be required to inform a license application/permit. It is possible that this survey data may alert the regulator that further data collection is required (e.g., because of unexpectedly high numbers of a protected species). Should that be the case, the EIA and license

application may go forward in parallel with the additional survey work but consent will not be determined until the additional data have been collected and analyzed.

C.3.2.4. Application to the Hypothetical PDE

To review the use of the risk assessment process, two different projects which could be constructed based on the parameters in Table D.3 in Appendix D.2 were assessed using the methodology presented in Sections C.3.2.1 to C.3.2.4. These projects were very different in their design and size to show how the risk assessment might differentiate between projects and determine the level of site characterization required.

To reduce the length of the task, only basic offshore parameters have been used as would be available at an early stage of a project. These are presented in Table C-15.

Table C-15. Example Projects taken from the Hypothetical PDE in Table D-3 in Appendix D.2.

Parameter	Project A	Project B
Offshore		
Array Area		
Turbine Capacity	6 MW	15 MW
Number of Turbines	50	160
Maximum Capacity	300 MW	2400 MW
Maximum Blade Tip Height	236 m	325 m
Minimum Blade Tip Height	22 m (relative to LAT)	26 m
Maximum Rotor Diameter	167 m	265 m
Foundation Types	Floating - Spar buoy, semi-submersible, tensioned-leg platform (TLP)	Fixed - Monopile, jacket, suction buckets, gravity base, floating
Anchor type	Suction caisson, drag embedment anchor (fluke anchor), torpedo anchors, gravity based anchor,	N/A
Mooring line material	Chain, steel wire, polyester	
Floating foundation sea surface area per turbine	31,050 m^2	
Seabed area occupied by moorings, anchors and WTG units	7.5 km^2	
Number of mooring lines and anchors per turbine	3 to 12	
Mooring cable radius	Up to 100 m	

Parameter	Project A	Project B
Total spoil volume per turbine (depends on anchor type)	0 to 26,000 m^3	
Offshore Electrical Infrastructure		
Distance from turbine where cable hits the seafloor	Maximum of 250m from substructure	N/A
Cable burial depth	1 to 3 m	
Cable installation methodology	Trenching, dredging, jetting, plowing, vertical injection, rock cutting, horizontal directional drilling (HDD)	
Cable protection options	Rock or gravel burial, concrete mattresses, frond mattresses, grout bags or similar	
Width of seabed affected by installation per cable	3 to 10 m	

C.4. Results

The following provides the results of the analysis of the Hypothetical PDE (Table D-3 in Appendix D.2) using the methodology provided in Section C.3.2.

C.4.1. Environmental Sensitivity

For the purposes of this exercise, a hypothetical site that is of Low sensitivity is given a score of one, a site of Medium sensitivity a score of two and a site of High sensitivity a score of three. All three site examples are considered within the assessment to examine how the sensitivity of a site affects the overall risk assessment.

C.4.2. Scale of Development

Based on the scale provided in Table C-11, Project A is considered to be a Medium scale project (a score of two) and Project B is considered a Large-scale project (a score of three).

C.4.3. Development Risk

The result of the development risk assessment is presented below in Table C-16.

Table C-16. Environmental Hazard scores.

No.	Potential Environmental Hazards	Project A	Project B
1	Bird collisions with turbines	3	3
2	Underwater noise effects on marine mammals and fish	1	3
3	Direct loss of protected or sensitive sub-littoral seabed communities The potential wider/secondary effects on protected or sensitive sub-littoral seabed	2	3
4	Barrier to movement for birds	2	3
5	Displacement of essential activities of seabirds.	2	3
6	Potential displacement of essential activities of marine mammals/fish.	1	1
7	Marine mammal entanglement in mooring lines.	2	1
8	Loss of fishing grounds.	3	2
9	Release of polluting substances.	1	1
10	EMF impacts on migratory fish.	3	2
Development risk		**1.83 (Medium)**	**1.99 (Medium)**

C.4.4. Overall Project Risk

Table C-17 presents the overall project risk for the two projects examined for this exercise against Low, Medium and High environmental sensitivity.

Table C-17. Overall Project Risk.

Environmental Sensitivity	Project A	Project B
Low	$((1)(2)(1.83))^{1/3} = 1.54$ **Low**	$((1)(3)(1.99))^{1/3} = 1.81$ **Medium**
Medium	$((2)(2)(1.83))^{1/3} = 1.94$ **Medium**	$((2)(3)(1.99))^{1/3} = 2.29$ **High**
High	$((3)(2)(1.83))^{1/3} = 2.22$ **High**	$((3)(3)(1.99))^{1/3} = 2.61$ **High**

Based on the results from Table C-17, Project A is the only project that has Low overall potential risk. As a result, if this project were to be deployed at a site with Low environmental risk, then there would be the potential to reduce the level of site characterization to inform the license application. Instead of the full level of data collection required for high risk projects, there is the potential that less collection of data would be required. However, if the regulator after an initial period (i.e. the first year) identified the need for further data collection (i.e., because of high numbers of protected species), then the developer may be required to collect further data as their application progresses, which will feed into the process at a later date.

Project A located within a Medium sensitivity environment and Project B located in a Low sensitivity environment would both result in overall risk of Medium. As a result, an intermediate approach may be applied. In this instance the full level of data collection would be undertaken but reviewed after an interim period (i.e. after the first year). If after this initial period, it is considered that the environmental risk is lower than expected or the data collected is adequate to inform a licensing application, then further site characterization may not be required. However, this will very much depend on the receptors and hazards that may be present. In the instance of Project B, it is likely that there would still need to be full data collection due to the size of the development and that there are no 15 MW turbines deployed to date. As a result, the potential impacts are less likely to be well understood and the potential uncertainty is likely to result in further data collection.

Project A located in a High sensitivity environment and Project B located in Medium and High sensitivity environments would result in an overall risk of High. As a result, the license application will require a minimum of 2 years' worth of characterization data. Due to the high risk, there would be no scope for fast tracking an application by reducing the time period over which surveying would be undertaken.

C.5. Appendix C References

Aqautera. 2012. A review of the potential impacts of wave and tidal energy development on Scotland's marine environment. A Report to Marine Scotland. P324 – March 2012.

MeyGen. 2012. MeyGen Tidal Energy Project Phase 1. Environmental Statement.

Marine Scotland. 2016. Survey, Deploy and Monitor Licensing Policy Guidance. Version 2. Available online at: http://www.gov.scot/Resource/0049/00498694.doc.

Statoil. 2015. Hywind Scotland Pilot Park. Environmental Statement. April 2015

Appendix D: Development of the Hypothetical PDE and Implementation into Phased Approach

This appendix presents the development of a hypothetical Project Design Envelope (PDE), a tool to translate (or implement) phasing into an environmental assessment. The intention is to consider how phased and PDE approaches can be implemented for environmental reviews of offshore wind facility Construction and Operations Plans (COPs) in the U.S., thus reducing the need for further reviews later in the development lifecycle.

D.1. Methodology

This section provides the methodology used in the development of a hypothetical PDE to be used in examining how it could be applied to an offshore wind farm. The section describes the process undertaken to develop the hypothetical PDE using information publicly available from U.K. and U.S. wind farms and how the projects used to inform the PDE were selected.

D.1.1. Developing the PDE

To develop a hypothetical example of a project design envelope, the most recent projects in the U.K. were reviewed, including projects that have been awarded consent, those still in determination, and one project still at the early planning stage. Using publicly available information (from the Project Description chapter of the Environmental Statement (ES) or Scoping Report) the review examined the common parameters included in each PDE and the range of values that were included for each parameter. The projects that were reviewed included the largest project to be consented to date (Hornsea Project Two) and some of the largest examples of offshore wind farms currently consented. In addition, the Hornsea Project Three scoping report was reviewed as this represents the most up-to-date thinking in terms of the range of values included within the PDE. Data from floating technologies was also included as this represents the next phase of development in the offshore wind industry and floating foundations are now being considered more by developers within the U.K. Finally, publicly available information from U.S. developers' websites and the National Renewable Energy Laboratory (NREL, 2015) was used to check the feasibility of the values from the U.K. in the context of projects being developed within the U.S.

Table D-1 provides a list of the U.K. projects reviewed to develop the hypothetical PDE.

It should be noted at this point that the Hypothetical PDE in Table D-3 was developed for demonstration purposes only and should not be used as an example of likely parameter values outside of the context of this report. The parameters and their values contained within Table D-3 are for example purposes only. Therefore, any project that uses a PDE would have its own project-specific PDE and should not be based on the parameters or values provided in the example in Table D-3. It should also be noted that the PDE for projects are not usually presented in a single table as in Table D-3 but as a series of envelopes for each relevant design parameter (i.e. the foundation envelope, turbine envelope, substation envelope, etc.) and the parameters have only been placed in a single table to aid interpretation for the purposes of this study.

Table D-1. U.K. Developments Reviewed to Develop the Hypothetical PDE.

Wind Farm	Location	Status	Capacity	Maximum Number of Turbines	Developer	Reason for selection
Hornsea Project Three	Southern North Sea	Development (pre-consent)	2400 MW	400	DONG Energy	Scoping report available which provides some PDE parameters. Represents the most up-to-date project details in the industry
Hornsea Project Two	Southern North Sea	Pre-construction	1800 MW	300	DONG Energy	The most recently consented and currently largest individual project in the U.K.
East Anglia Three	Southern North Sea	Determination	1200 MW	Up to 172 depending on capacity (7 to 12 MW)	Scottish Power Renewables / Vattenfall	Chosen as another example of the latest thinking in the U.K. in relation to project design.
Dogger Bank Teesside A and B	Southern North Sea	Consented	2400 MW (1200 MW each)	Up to 200 each depending on capacity (6 to 10 MW)	Forewind	One of the most recent examples consented in the UK and within the largest Round 3 development zone. A good example of current thinking in the U.K. industry in relation to project design.
Dogger Bank Creyke Beck A and B	Southern North Sea	Consented	2400 MW (1200 MW each)	Up to 300 each depending on capacity (4 to 10 MW)	Forewind	One of the most recent examples consented in the UK and within the largest Round 3 development zone. A good example of current thinking in the U.K. industry in relation to project design.
Hywind Scotland Pilot Park	East coast of Scotland	Pre-construction	30 MW	6	Statoil	Representative of a floating wind technology
Dounreay Trì Floating Wind Demonstration Project	North coast of Scotland	Determination	12MW	2	Dounreay Trì Limited	Representative of a floating wind technology
Kincardine Offshore Windfarm	East coast of Scotland	Determination	48MW	8	Kincardine Offshore Windfarm Limited	Representative of a floating wind technology

D.1.2. Parameter Review

Before selecting the parameters that would be used in the hypothetical PDE, all the PDE for the projects in Table D-1 were examined to identify the most typical and common parameters presented within each PDE. A long list of parameters that could be part of a typical project was then developed which would cover all potential variations between different projects. The PDEs for each project were then systematically compared to the parameters to develop a realistic range of values for each parameter.

Once all the U.K. projects had been reviewed, the values were further refined by reviewing the NREL (2015) report and by reviewing information available on each of the proposed projects in the U.S., either from their website or from online offshore wind databases such as 4C Offshore. A check was then made to ensure the parameters from the U.K. would be reasonable in the context of projects proposed within the U.S.

The review identified some of the broad scale project design parameters that are common to projects in the U.K. and potentially the U.S. The results encapsulate a range of construction strategies, including different foundation types (e.g., gravity base, monopiles, suction buckets and jacket foundations), turbines sizes (6 MW to 15 MW capacity), and maximum hammer energy for piled foundations (up to 5,000 kJ) to demonstrate that various technologies are proposed within the PDE based on those that have been used within the offshore wind industry as it stands today. The resulting table in Section D.2 is based on a realistic hypothetical wind farm scenario that could potentially be submitted to the regulator to apply for consent in offshore U.K. waters.

D.1.3. Data Sources

All information that has been reviewed and analyzed as part of this report has been derived from publicly available sources. The main project information has been drawn from the ES and supporting documentation for the relevant case study projects. The following documents were reviewed for this analysis:

- Dong Energy (2016). Hornsea Project Three Offshore Wind Farm. Environmental Impact Assessment: Scoping Report.
- Kincardine Offshore Wind Limited (2016). Kincardine Offshore Wind Farm, Environmental Statement.
- Dounreay Trì Limited (2016). Environmental Statement. Dounreay Trì Floating Wind Demonstration Project.
- SmartWind (2015). Hornsea Offshore Wind Farm Project Two. Environmental Statement. Volume 1, Chapter 3, Project Description.
- East Anglia Three Limited (2015). East Anglia Three Offshore Wind Farm. Environmental Statement. Volume 1, Chapter 5, Description of the Development.
- Statoil (2015). Hywind Scotland Pilot Park. Environmental Statement. April 2015.
- Forewind (2014). Dogger Bank Teesside A & B. Environmental Statement. Chapter 5, Project Description.
- Forewind (2013). Dogger Bank Creyke Beck. Environmental Statement. Chapter 5, Project Description.

Additional information has been obtained through consultation with developers in the U.S. (see Section D.1.4).

D.1.4. Consultations with U.S. Developers

Consultation was undertaken to further refine the parameters in the hypothetical PDE to ensure they were relevant to the U.S. offshore wind industry and the regulatory context of the U.S. legislative regime. E-mails with the draft hypothetical PDE were sent to U.S. developers to allow them to provide comment on the parameters within the PDE and their relevance to the U.S. system. Developers were invited to provide comment and input based on their knowledge of the industry and their own projects. This allowed for further refinement of the hypothetical PDE originally based on the most recent U.K. projects to one more relevant to the U.S. industry and the developments that have the potential to be developed. The developers were also invited to provide comments on the concept of a phased approach to development for offshore wind energy facilities in general.

Table D-2 presents the main comments of the key offshore wind developers currently engaged in the permitting process for offshore wind energy development in the U.S.

Following review of the received comments, the hypothetical PDE was refined and finalized, presented in Table D-3 and discussed further in Section D.2.

Table D-2. Consultation Responses from U.S. Developers.

Comment	Response and Relevant Section
The onshore side of the design envelope is contingent on the state and municipalities that the line goes through. BOEM has no jurisdiction or permitting for the landside transmission piece as it is not federal. Each state already has their own cable and electricity transmission permitting methods in place (e.g., NY is Article VII). So, is it relevant to include the onshore elements in this study? It seems this would then lead to a review of all the different states current practices and what development envelopes each state would go along with. For the offshore export cable, this will straddle both state and federal waters, but it makes sense that the state would adapt BOEMs BMPs because it could be considered a connected action.	Following discussion with BOEM during the Task 1C Workshop, it was determined that the onshore elements should be included in the PDE. Though they may not have jurisdiction over all of these elements, the onshore elements are required in the PDE to have a holistic understanding of the proposed project. BOEM needs this information to coordinate with the other regulatory agencies on all aspects of the project. It should also be noted that the inclusion of the onshore elements is not just for the purpose of coordination with other agencies, but that any connected action or activity - whether on the OCS (i.e. federal waters), in state waters, or onshore – is considered part of BOEMs undertaking and considered under the NEPA analyses, NHPA, and other consultations. It was also determined that a full review of current practices with different states was not within the scope of this current project. **Section D.2 and Table D-3**
One developer stated that they were not currently advanced enough in their commercial wind development to provide detailed input on the information provided in the hypothetical PDE. However, upon further description provided on the project, they stated that they would prefer to perform the permitting in incremental phases and not consider the entire project at one time.	N/A
BOEM should define the relevant parameters required within the PDE for the COP. There also needs to be a clear definition of what is allowed under phasing. The leasing process (the schedule of the lease) might need to be reviewed for the implementation of phasing as there is the potential for phasing to affect the timeline provided within the leases issued to developers. It needs to be examined whether phasing is legal under the current U.S. laws and regulations and whether it might be construed as segmentation (i.e., attempting to consent everything at once to reduce the finding of significant impacts at each phase).	**Section D.3**
For the Gravity Bases, the understanding is that they are filled with seawater for ballast and then towed out to location, then filled with sand and/or gravel to sink them. The volume of material needed is dependent	No changes have been made to the PDE. The total spoil volume refers to the amount of seabed material removed / disturbed due to the installation of each turbine foundation type. For instance, spoil could be

Comment	Response and Relevant Section
on the specs of the base; therefore, that amount is subject to a design envelope as well. Thus, the question is whether “total spoil volume per turbine” in the PMP refers to this or whether it is a different parameter to be considered?	created through preparation of the seabed prior to placing a gravity based foundation or due to the action of a drill bit on the seabed for drilled monopiles. Thus, the ‘total spoil volume per turbine’ is a different parameter to the ballast within the gravity base. However, we have not provided details of the gravity base ballast within the PDE as it is not normally included in the PDE as it does not affect any particular impact.
What about if an offshore substation is co-located on a WTG foundation? This option should be included, if not already.	This option has not been included as currently it is not a parameter that has been considered in any of the PDE that have been submitted within the U.K. We are also not aware of such a solution being implemented anywhere else. Thus, and for this exercise, it was not thought to be a parameter of relevance.
The only items that stand out as being different than some of one developer’s estimates are the piling driving and scour details for a jacket foundation. They estimated an 800kJ hammer with a time of 8 hours per pile (though this is likely in line with what is currently in the hypothetical PDE with a max of 1900-2300kJ for less time). The PDE shows 5x diameter scour protection, and this developer’s envelope would have 1.5x diameter as the low side.	At this point, this is being used as a hypothetical PDE to help explain the concept of PDE’s and how they would fit into a phased approach to development. Therefore, if BOEM decides to implement this strategy, a separate PDE would be created based on the specifics for each individual project and these details would be considered then.

D.2. Hypothetical PDE

Table D-3 provides a summary of the key parameters selected for the hypothetical Project Design Envelope (PDE). The PDE approach (i.e., Rochdale Envelope) is an approach that the industry, regulators, and consultants within the U.K. apply, allowing for the development of a range of different development scenarios within the parameters that have been assessed.

Table D-3 provides an indicative PDE. Note that this table has been developed for the purposes of this study only and should not be used as an example of likely parameter values outside of the context of this report.

Table D-3 encapsulates a range of construction strategies, including different foundation types (e.g., gravity base, monopiles, suction buckets and jacket foundations), turbines sizes (6 MW to 15 MW capacity turbines), and maximum hammer energy for piled foundations (up to 3,000 kJ) to demonstrate that the approach accommodates various technologies. The broad scale design parameters in

Table D-3 was developed following the review of the key project parameters from relevant ES and Scoping Reports publicly available for various developments from the U.K., written between 2013 and 2016. The documents are available on the Planning Inspectorate (PINS) portal or the Marine Scotland pages of the Scottish Government website.

The parameters and values included in Table D-3 are based on the most recently available information within the U.K. and are therefore considered current and appropriate at the time of this review. However, as the industry in the U.K. evolves, these parameters are also likely to change. This is illustrated most clearly by considering turbine capacities. Early Round 1 projects in the U.K. were generally constructed with 3.6 MW turbines, so this capacity turbine would have been assessed in the PDE; however, a typical project description at the current time considers turbines capacities in the range of 6 to 15 MW. This evolution is also reflected in the emergence of new technologies that are now being included in the PDE, such as floating foundation technology (e.g., semi-submersibles and tension-leg platforms).

The PDE is used to illustrate the concept of the 'Envelope' and its application to the consenting process and to provide an idea of the range of possible values under a certain parameter as opposed to providing actual design parameters.

Table D-3 describes the typical broad scale design parameters considered in this study. It does not cover all the parameters used to define an offshore wind farm (OWF) project; rather, it includes those parameters that may influence consenting or permitting, together with the associated program and cost.

The Hypothetical PDE in Table D-3 was developed for demonstration purposes only and should not be used as an example of likely parameter values outside of the context of this report. The parameters and their values contained within Table D-3 are for example purposes only. Therefore, any project that uses a PDE would have its own project-specific PDE and should not be based on the parameters or values provided in the example in Table D-3. It should also be noted that the PDE for projects are not usually presented in a single table as in Table D-3 but as a series of envelopes for each relevant design parameter (i.e. the foundation envelope, turbine envelope, substation envelope etc.) and the parameters have only been placed in a single table to aid interpretation for the purposes of this study.

Table D-3. Typical Project Parameters for a Hypothetical Offshore Wind Farm.

Parameter	Maximum Size
Offshore	
Array Area	
Turbine Capacity	6 MW to 15 MW
Number of Turbines	50 to 400 (depending on the size of the lease area and proposed project area)
Maximum Capacity	In the U.K., typical projects taken forward for consent via the most recent Round 3 leasing round have been between 1.2 and 2.4 GW, whereas extension projects have been between 250 and 700 GW. Sizes may vary in other countries and markets depending on a number of factors, including the size of lease areas, the support mechanisms in place and the characteristics of each development site.
Minimum separation distance	675 to 1,000 m (relative to rotor diameter – approximately 3 to 6 times depending on turbine design)
Maximum Blade Tip Height	236 to 325 m (relative to Lowest Astronomical Tide (LAT))
Minimum Blade Tip Height	22 to 26 m (relative to LAT)
Maximum Rotor Diameter	167 to 265 m
Number of Accommodation Platforms	1 to 3
Foundation Types	Monopile, jacket, suction buckets, gravity base, floating (Foundation types are assumed to be the same for wind turbines and for relevant offshore infrastructure such as HVAC Booster Stations or Accommodation Platforms for example)
Maximum number of foundations per turbine	1
Number of foundations per accommodation platform	1 to 4
Number of foundations per HVAC collector station	4 to 6
Number of foundations per HVDC substation	72
Number of foundations per HVAC booster	4 to 6
Maximum oil per turbine	11,000 to 24,000 l (including grease, hydraulic oil and gear oil
Other hazardous materials within turbine	Water / Glycerol – 7,800 to 13,000 l Silicone Oil - 2,000 to 6,000 kg Sulphur hexafluoride (SF6) gas – 20 to 40 kg Liquid nitrogen – 530 to 80,000 l

Parameter	Maximum Size
Hazardous materials in accommodation platforms and substations	coolant (up to 10,000 l each), oil (up to 200,000 l), helicopter and vessel fuel (up to a maximum of 260,000 l across the windfarm)
Monopiles	
Maximum pile diameter	10 to 15 m
Maximum number of piles per foundation	1
Maximum Hammer Energy to Install Foundations	2,700 to 5,000 kJ
Number of vessels undertaking piling	1 to 2
Piling duration (per pile)	3.5 to 8 hours
Percentage of foundations drilled	0 to 100%
Drilling depth	30 to 75 m
Drill rate	1 to 3 m/hr
Scour protection diameter per monopile (based on 5x pile diameter scour protection)	30 to 50 m
Total spoil volume per turbine (from drilling)	1,382 to 6,220 m^3
Jacket Piles	
Maximum pile diameter	3 to 6 m
Maximum number of piles per foundation	4
Maximum number of piles per HVDC substation foundation	72
Maximum Hammer Energy to Install Foundations	1,900 to 2,300 kJ
Number of vessels undertaking piling	1 to 2
Piling duration (per pile)	3 to 4 hours
Percentage of foundations drilled	0 to 100%
Scour protection diameter per pile (based on 5x pile diameter scour protection)	15 to 30 m
Drilling depth	50 to 66 m
Drill rate	1 to 3 m /hr
Total spoil volume per turbine (from drilling)	960 to 6,220 m^3
Suction Buckets	

Parameter	Maximum Size
Maximum diameter	8 to 10 m
Maximum number per foundation	1 to 4
Scour Protection diameter	40 to 65 m
Total spoil volume per foundation	0 to 13,500 m^3
Gravity Base	
Gravity based foundation diameter	40 to 60 m
Seabed preparation area per gravity base	50 to 70 m
Scour protection per gravity base diameter	75 to 98 m
Total spoil volume per turbine	3,169 to 26,000 m^3
Floating Foundations	
Floating foundation types	Spar buoy, semi-submersible, tensioned-leg platform (TLP)
Mooring points	3 to 4
Number of anchors per mooring point	1 to 2
Anchor type	Suction caisson, drag embedment anchor (fluke anchor), torpedo anchors, gravity based anchor,
Mooring line material	Chain, steel wire, polyester
Floating foundation sea surface area per turbine	31,050 m^2
Seabed area occupied by moorings, anchors and turbine units	7.5 km^2
Number of mooring lines and anchors per turbine	3 to 12
Mooring cable radius	Up to 1000 m
Distance from turbine where cable hits the seafloor	Maximum of 250m from substructure
Total spoil volume per turbine (depends on anchor type)	0 to 26,000 m^3
Offshore Electrical Infrastructure	
Export cable route length	25 to 261 km
Inter-array cable Length	650 to 950 km
Inter-platform cabling	200 to 320 km
Export Cable Circuits	1 to 2
Cable external diameter	250 to 300 mm
Cable burial depth	0 to 3 m (note: floating turbine cables will hang form the structure and in deep water may not be buried)

Parameter	Maximum Size	
Cable installation methodology	Trenching, dredging, jetting, mass flow excavation, plowing, vertical injection, rock cutting, horizontal directional drilling (HDD)	
Cable installation vessel	Anchor barge or dynamically positioned cable lay vessel	
Cable protection options	Rock or gravel burial, concrete mattresses, frond mattresses, grout bags or similar	
Width of seabed affected by installation per cable	3 to 10 m	
Transmission Options	The PDE would carry two transmission options: High Voltage Alternating Current (HVAC) and Direct Current (HVDC). Each option will have specific associated infrastructure requirements which are outlined below.	
Electrical Infrastructure	HVDC	HVAC
Offshore HVAC Collectors (within the array)	2 to 12	2 to 12
Offshore HVDC Converters (within the array)	1 to 4	N/A
Offshore HVAC Booster stations (on the export cable route or onshore. Boosters are only required for AC infrastructure for cables which are greater than a certain length)	N/A	2 to 4
Offshore Export Cables Comprising the Circuits	4 HVDC cables (up to 2 single core cables per circuit and 1 cable per trench)	8 HVAC cables (single 3 core cable per circuit and 1 cable per trench)
Offshore Export Cable Trenches	2 to 4 (1 offshore HVDC cable per circuit)	3 to 8 (1 offshore HVAC cable per trench)
Length of intertidal portion of export cable	200 to 750 m	200 to 750 m
Landfall installation methodology	HDD or trenched across intertidal zone	HDD or trenched across intertidal zone
Onshore		
Onshore Cable		
Onshore Cable Route Corridor Width	20 to 40 m. The width is determined by the presence of physical obstacles or to accommodate access and haul roads for construction vehicles and storage areas for excavated soil.	
Cable external diameter	120 to 150 mm	
Trench depth	1.2 to 1.5 m	
Trench width	0.8 to 1.5 m	

Parameter	Maximum Size	
Water course crossings	HDD or trenched	
Electrical Infrastructure	HVDC	HVAC
Onshore Corridor Study Area	1km buffer (2km corridor)	1km buffer (2km corridor)
Onshore Export Cables Comprising the Circuits	1 to 4 HVDC cables (up to 2 single core cables per circuit)	9 to 24 HVAC cables (up to 3 core cables per circuit)
Onshore Export Cable Trenches	1 to 4 (1 onshore HVDC cable per trench)	3 to 8 (3 onshore HVAC cables per trench)
Area of construction compounds	Up to 1 ha	
Onshore Substation		
Electrical Infrastructure	HVDC	HVAC
Onshore Substation Equipment	Includes HVDC converter equipment	Includes HVAC equipment only
Onshore Substation/Converter Station Site Area	2 to 6 ha	2 to 6 ha
Number of Main Buildings	1 to 2	1
Onshore Substation / Converter Station Main Building	70 m (w) x 135 m (l) x 40 m (h)	40 m (w) x 82.5 m (l) x 15 m (h)
Vessels		
Total return trips for construction vessels (construction of array, platforms, substations and installation of cable)	Up to 12,000	
Annual return trips to shore for helicopters during construction	Up to 1,000	
Operation and Maintenance (O&M) vessel round trips per year	Up to 700	
Annual return trips for helicopters during O&M	Up to 4,000	
Durations		
Duration of Construction Phase	Minimum of 5 years to a maximum of 13 years for all phases to be constructed and the wind farm to be operational	
Construction Schedule	Project built out either as one project or in phases (between 2 and 4 phases - current maximum is four phases per individual project)	

Parameter	Maximum Size
Phased Approach	• Single phase of construction • Sequential - two or more phases, each one occurring after the previous phase has completed • Simultaneous construction - two or more phases, each with a different undertaker / construction contractor, each constructed at the same time, although not necessarily the same aspect being constructed at the same time (e.g. one may be installing wind turbines and the other the export cable).
Duration of Operation and Maintenance Phase	25 years
Duration of Decommissioning Phase	Maximum of 5 years

D.3. Implementation/Interpretation of Phasing

This section aims to present how the concept of phasing within the PDE is interpreted and/or implemented. To illustrate this point, a number of key impacts are presented (one key impact for each key receptor group / key topic). For each example, the maximum design scenario from the PDE is presented alongside justification of why this represents the maximum design scenario to illustrate how the PDE is interpreted and how the phasing of the developments construction may influence the maximum design scenario.

To demonstrate how phasing within the PDE affects the assessment of a development, it is necessary to identify the maximum design scenario for key impacts. In so doing, it would then be possible to demonstrate how the PDE is interpreted when assessing the potential impacts of the development on the environment and how different phasing strategies might influence the maximum design scenario for different receptors.

D.3.1. Impacts

The impacts identified as part of this exercise have been specifically selected to illustrate how phasing within a project affects the interpretation of the PDE and what constitutes the maximum design scenario. The review focused on construction phase impacts as these will be the only potential impacts affected by phasing of the development. They are by no means a comprehensive list and have been specifically selected to demonstrate how phasing might influence the interpretation of the PDE.

We have attempted to focus on impacts that are either influenced by phasing and / or the key impact to each receptor considered within any assessment. The key receptor groups and impacts examined are as follows:

- Marine physical processes - Increases in suspended sediment concentrations and deposition of disturbed sediment to the seabed due to cable and foundation installation;
- Benthic, subtidal and intertidal ecology – Temporary habitat loss/disturbance due to cable and foundation installation, and
- Marine mammals - Underwater noise from foundation piling and other construction activities.

D.3.2. Maximum Design Scenario

The maximum design scenario considered for each of the impacts outlined in Section D.3.1 is the scenario (i.e., the combination of relevant project parameters) that would give rise to the greatest potential impact. For example, if several turbine types remain possible, then the assessment is based upon the turbine type known to have the greatest impact. This may be the turbine type with the largest footprint, the greatest tip height or the largest area of seabed required during construction, depending upon the topic under consideration.

For each of the impacts presented in Section D.3.1, the parameters in Table D-3 have been examined to identify the maximum design scenario applicable to that impact, with the calculations presented to show how this has been identified. Justification of why this is considered to be the maximum design scenario is also provided based on RPS experience in undertaken impact assessments for offshore wind farms and the identification of the maximum design scenario.

D.3.3 Phasing

To demonstrate how phasing might influence the selection of the maximum design scenario four different phasing strategies were developed. These include:

- Single phase – the wind farm is constructed in a single phase as a single development;
- Sequential (with gap) - two or more phases, each one occurring after the previous phase has completed. May be constructed by a single or multiple undertakers or developers;
- Sequential (overlapping) - two or more phases, construction overlapping but each component (i.e., wind turbines) only occurring after the previous phase has completed. May be constructed by a single or multiple undertakers or developers, and
- Simultaneous - two or more phases, each with a different undertaker / construction contractor, each constructed at the same time, although not necessarily the same aspect being constructed at the same time (e.g., one may be installing wind turbines and the other the export cable). However, maximum design scenario would include the construction of the same elements at the same time.

D.3.4. Interpreting Phasing with the PDE

Table D-4 presents the maximum design scenario for each of the impacts identified in Section D.3.1 and the implications for phasing on each of the identified maximum design scenarios.

Table D-4. Implications of Phased Approaches for the Maximum Design Scenario for Example Impacts (see Section D.3.1)

Receptor	Potential Impact	Maximum Design Scenario	Justification	Phasing
Marine Physical Processes	Increases in suspended sediment concentrations (SSC) and deposition of disturbed sediment to the seabed due to cable installation.	**<u>Inter-array cable installation</u>** Installation method: mass flow excavation Total length = 950 km V-shape trench; width = 10m; depth = 3 m; volume = (950 km x 10 m x 3 m x 0.5) = 14,250,000 m^3 **<u>Substation interconnector cables</u>** Installation method: mass flow excavation Total length = 320 km V-shape trench; width = 10 m; depth = 3 m; volume = (320 km x 10 m x 3 m x 0.5) = 4,800,000 m^3 **<u>Export Cable Route</u>** Up to eight cable trenches; each 261 km in length (2,088 km in total) Installation method: mass flow excavation V-shape trench; width = 10 m; depth = 3 m; volume = (8 x 261 km x 10 m x 3 m x 0.5) = 31,320,000 m^3 Total sediment disturbance = 50,370,000 m^3 Up to three cables may be installed at the same time.	Cable installation may involve ploughing, trenching, jetting, rock-cutting, surface laying with post lay burial, and/or surface laying installation techniques. Of these, jetting and mass flow excavation will most (similarly) energetically disturb the greatest volume of sediment in the trench profile and as such is considered to be the maximum design scenario for sediment dispersion.	**<u>Sequential (overlapping)</u>** By introducing phasing into the project, there is the potential that impact along the cable route will occur up to 3 times (as opposed to once under the single-phase strategy). This is due to each phase installing their cables at different times within the overall schedule. While they may not disturb exactly the same area, the area affected by deposition and increases in SSC is likely to overlap, resulting in repeat disturbance to the same area before recovery has completed following each previous phase.
Benthic, subtidal and intertidal ecology	Temporary habitat loss/disturbance due to cable installation	**<u>Temporary habitat loss</u>** • 9.5 km^2 from burial of up to 950 km of inter-array cables, by trenching, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development (up to 10 m wide corridor) • 3.2 km^2 from burial of up to 320 km of substation interconnector cables, by trenching, jetting, mass flow excavator, ploughing or vertical injection and similar	The maximum design scenario for temporary habitat loss has considered the burial of all subtidal cables, except where the necessary burial depth cannot be achieved. The use of anchor barges to undertake the cable installation is also likely to result in the greatest area	**<u>Sequential (overlapping)</u>** By introducing phasing into the project, there is the potential that temporary habitat loss along the cable route will occur up to 3 times (as opposed to once under the single-phase strategy). This is due to each phase installing their cables at different times within the

Receptor	Potential Impact	Maximum Design Scenario	Justification	Phasing
		tools currently under development (up to 10 m corridor) • 20.82 km^2 from burial of up to 2,082 km of export cable (up to eight trenches of 260.25 km length (261 km - 750 m intertidal length) by trenching, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development augmented by mobile sediment clearance up to 10 m width of seabed) • 1.65 km^2 (1,654,896 m^2) from cable barge anchor placement associated with cable laying for two vessels for all subtidal cables (up to nine anchors per barge repositioned every 500 m). Typical values: ○ 4 x side anchors (13.448 m^2 each, 53.792 m^2 in total) ○ 4 x bow / stern anchors (13.448 m^2 each, 53.792 m^2 in total) ○ 1 x pulling anchor (15.842 m^2) ○ Total habitat loss per anchor placement = 123.426 m^2 ○ Repositioned every 500 m, total number of repositions 950 + 320 + 2,082 km = 3352 /0.5 = 6,704 repositions. Total disturbance - 6,704 x 123.426 = 827,448 m^2 (0.83 km^2) per vessel • 0.06 km^2 from works to bury up to 6 km of export cable in the intertidal corridor (up to eight cables of 0.75 km length) by trenching (assuming habitat loss within the entire corridor width).	of temporary habitat loss.	overall schedule. While they may not disturb exactly the same area, the area will be affected by deposition and increases in SSC and there may be some overlap, resulting in repeat disturbance to the same area before recovery has completed following each previous phase.

Receptor	Potential Impact	Maximum Design Scenario	Justification	Phasing
		• 0.0005 km² (494 m²) due to temporary works in the intertidal including anchor placement (assuming 2 placements required within the 750-m long corridor). Total disturbance - 2 x 123.426 = 247 m² (0.00025 km²) per vessel Total subtidal temporary habitat loss = 35.17 km² (35,170,000 m²). Total intertidal temporary habitat loss = 0.06 km2 (60,494 m²). **Total Temporary Habitat Loss = 35.23 km² (35,230,494 m²)**		
Marine mammals	Underwater noise from foundation piling	**<u>Spatial maximum design scenario</u>** One monopile per foundation Piling of up to 400 monopile WTG foundations of up to 7 m diameter with a maximum hammer energy per strike of 5,000 kJ Piling of 108 monopile foundations, up to 7 m diameter, for substations and platforms with a maximum hammer energy of 5,000 kJ including: • three offshore accommodation platforms (1 foundation each) = 3 x 4 = 12 • 12 offshore HVAC collector substations (6 foundations per platform) = 6 x 12 = 72 • Four offshore HVAC booster stations (on the export cable route (ECR) corridor) (6 foundations per platform) = 6 x 4 = 24 Maximum 8 hours piling duration per monopile Concurrent piling using two vessels located at opposite ends of the site. Total duration of actual piling = (8 x 508) / 2 = 2,032	The maximum adverse spatial design scenario equates to the greatest area of effect from subsea noise at any one time during piling. The area of ensonification for a 15-m diameter pile is smaller than for a 7-m diameter pile (due to higher frequency components of the smaller pile leading to greater propagation (T. McGarry, pers. comm.)). Therefore, the maximum adverse scenario presented here captures all pile diameters up to and including the largest 15 m diameter pile. The HVAC option results in the maximum design scenario spatially due to	**<u>Single phase strategy</u>** Under a single-phase strategy there is potential that simultaneous piling might occur at opposite ends (i.e., furthest apart) of the full array area, causing a much greater spatial impact. **<u>Simultaneous strategy</u>** Under the simultaneous strategy there is the potential that each undertaker may pile two piles simultaneously resulting in 6 piles being undertaken simultaneously so could potentially significantly increase the spatial maximum design scenario. In practice this has not been applied for in an application or has been

Receptor	Potential Impact	Maximum Design Scenario	Justification	Phasing
		hours	piling being undertaken on the export cable route. Two vessels piling concurrently at maximum spacing would result in the largest area of impact at any one time.	undertaken. It is most likely that each undertaker or developer would only be allowed to undertake single piling, which would again see an increase to 3 piling events or the development would be restricted to two piling events simultaneously. As the whole array is being constructed at the same time, this could potentially result in the same spatial extent as the single-phase strategy.
Marine mammals	Underwater noise from foundation piling	**<u>Temporal maximum design scenario</u>** Piling of up to 400 4 m diameter jacket foundations with a maximum hammer energy per strike of 5,000 kJ (four piles per foundation) = 400 x 4 = 1,600 piles in total Piling of up to 624 jacket foundations, up to 4 m diameter, for substations and platforms with a maximum hammer energy of 5,000 kJ including: • three offshore accommodation platforms (four piles per foundation) = 3 x 4 x 4 = 48 piles in total • 12 offshore collector substations (six legs with four piles per leg) = 12 x 24 = 288 piles in total • Four offshore converter substations (HVDC) (72 piles per foundation) = 4 x 72 = 288 piles in total Total number of piles = 1,600 + 48 + 288 + 288 =	The maximum adverse temporal scenario represents the longest duration of effects from subsea noise. This scenario assumes piled jackets as this would result in a longer duration of piling per foundation and in total. The HVDC export cable option results in the maximum design scenario temporally due to the larger number of pin piles in the jacket foundations. Scenario assumes longest duration of piling per pile (8 hrs). A single vessel piling would prolong the	**<u>Sequential (with gap) strategy</u>** Intuitively the maximum design scenario temporally would be the sequential (overlapping) strategy as it would result in the greatest period between the start and completion of piling. However, with a gap there is the potential for the breeding seasons of marine mammals present in the area to be impacted twice. Having left the area during the first phase of piling, they may return once it has ceased only to be disturbed again by the second phase, especially if this takes place

Receptor	Potential Impact	Maximum Design Scenario	Justification	Phasing
		2,302 Single vessel piling only Maximum duration 4 hours piling per pile – 2,302 x 4 = 9,208 hours of piling	total time piling would take (although noting that the piling phase itself has not actually increased under this scenario).	at exactly the same time the following year. If there is no gap, then they are likely to move away from the area until piling has ceased and may breed elsewhere.

D.3. Appendix D References

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Department of the Interior (DOI)

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