FLOATGEN

Compilation of Environmental Comparison Criteria

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1. EXECUTIVE SUMMARY

This report provides a summary of the types of impact which can be caused by the subsea elements of offshore wind turbines during their installation and operational phases.

The report includes an outline of the criteria which could be used to differentiate between any different types of moored foundations and fixed foundations. Further development of these criteria will be necessary such that a scoring system can be determined.

In addition to outlining the criteria, a draft questionnaire has also been compiled which will enable comparative information to be collected for fixed and moored foundations, such that a scoring exercise can be carried out.

2. ACRONYMS

To be completed

3. INTRODUCTION

One of the objectives of Work Package 7 is to distil the differences in environmental impact associated with fixed foundations and floating mooring systems for use with offshore wind turbines. In order to compare the environmental impacts associated with the methods available to support offshore turbines, a set of environmental criteria have been developed. It is assumed that the turbines themselves have the same impacts whether they are supported on fixed or floating foundations, hence the potential environmental impacts of the above water, turbine, elements of offshore wind have not been considered in the comparison.

Section 4 provides an outline of the types of impact which can be caused by the installation and operation of offshore wind turbine foundations. Section 5 of this report presents a range of questions which will be used to further determine the criteria which will be used when comparing between fixed and floating foundations.

4. ENVIRONMENTAL ASPECTS CONSIDERED

The environmental features considered within the criteria assessment are:

- Physical environment
- Ecology
- Navigation
- Water quality
- Underwater noise and vibration
- Fishing
- Greenhouse Gas emissions
- Waste
- Archaeology

These features have been considered in terms of construction, operation and decommissioning phases. A section has also been included which covers the management of emergency scenarios.

An overview of how each of the above features can be affected by the installation and operation of offshore wind turbines is included below. For the SEMREV site, a summary of the environmental features present is provided in deliverable D7.1 provides more information.

4.1 PHYSICAL ENVIRONMENT

The physical environment includes bathymetry, shallow geology, seafloor sediments, and oceanography.

The predicted impacts of an offshore wind farm installation to the physical environment include:

- Disturbance and changes to seabed morphology from foundation installation, or rock placement/ mattressing around the foundations;
- Increase in suspended sediment levels and re-deposition from installation of turbine foundations;
- Change to the pattern of erosion and deposition around turbines from scour effects; and
- Changes to the current/ tidal pattern from the installation of the turbine.

The type of foundation used will determine the scale of the impacts both in terms of extent and duration.

Geophysical and geotechnical surveys carried out by the developer to determine baseline conditions at an offshore array site are used to select the most appropriate foundation type.

4.2 ECOLOGY

4.2.1 BENTHIC

Effects on benthic communities tend to arise from loss of seabed area (under the footprint of foundations), physical displacement during the installation process, and smothering from the re-deposition of suspended sediment. When assessing the impact to benthic habitats and species, consideration has to be given to the following criteria:

- Magnitude/ extent: the size or amount of impact – such as the area of the seabed directly or indirectly impacted
- Duration: the length of time before recovery is complete. The duration of the activity causing the impact may be much less than the duration of the impact itself for example if the benthic community is sensitive and takes a long time to recover;
- Reversibility: whether the impact is irreversible (permanent) or reversible (temporary);
- Timing and frequency: e.g. whether the impact occurs once, or is repeated, or only occurs in a certain season.

The sensitivity of different benthic habitats also has to be considered. Sensitivity is based on two aspects:

- The importance of the habitat in terms of its nature conservation value, i.e. whether it has a protected status; and
- The expert assessment from the Marine Life Information Network (MarLIN, 2010) which classifies biotopes and habitats according to their tolerance to, and recoverability from, certain impacts.

4.2.2 FISH AND SHELLFISH

When assessing the impact to fish and shellfish (such as impacts to habitat, or normal distribution and behaviour), consideration has to be given to the following criteria:

- Magnitude/ extent: the size or amount of impact – such as the area of the sea impacted by subsea noise or change in area of seabed habitat available to shellfish;
- Duration: the length of time before recovery is complete. The duration of the activity causing the impact may be much less that the duration of the impact itself for example the immediate avoidance reaction of certain fish in response to subsea noise, compared to the time taken to return to the area affected;
- Reversibility: whether irreversible (permanent) or reversible (temporary);
- Timing and frequency: e.g. whether the impact occurs once, or is repeated, or only occurs in a certain season.

4.2.3 MARINE MAMMALS

Underwater noise and vibration during installation has the potential to impact on marine fauna including seals, cetaceans and basking sharks. There is also the potential for cumulative impacts from multiple noise sources audible to marine mammals and fish during installation and increased vessel disturbance.

Detailed modelling is required to predict the impact of underwater noise on fish and marine mammals. There are different types of model available, with the emphasis being on the frequency range within which the species hears, and the typical noise threshold level at which the species hears sound at any of the frequencies (the dBht, or decibel hearing threshold). Based on measured and anticipated noise levels from the likely source (for instance percussion piling) assumptions can be made about the noise levels above the dBht at which disturbance, physical injury and lethality could ensue.

It is generally understood that lethal effects may occur where peak to peak noise levels exceed 240dB re 1µPa. In addition, physical injury (e.g. rupturing of swim bladders) may occur where peak-to-peak noise levels exceed 220dB re 1µPa. Such physical injury may indirectly lead to death, for example through reduced ability to swim or control buoyancy.

Marine mammals are at risk of entanglement with mooring ropes and cables. Mammals can become caught in the cabling which may cause the animal to drown or it may injure itself whilst trying to free itself from the entanglement. Such injuries may impair its ability to swim.

4.3 NAVIGATION

The assessment of effects on navigation needs to consider the impact on other maritime vessels in the vicinity of the wind farm development. This includes search and rescue vessels including coastguards and lifeboats, recreational users. The impact could also lead to a reduction in the safety of navigation and increase in the risk of collision by other marine users with turbine structures and installation/ maintenance vehicles. The magnitude of the impact is dependent upon how busy the area is for shipping.

The effects upon navigation within the area are reversible upon decommissioning.

4.4 WATER QUALITY

The water quality of the local environment may be impacted, dependent on the materials used during the construction process. Materials required during the operation and decommissioning phases will also need to be taken into account. This may be in the form of:

- Drilling muds;
- Construction of foundations;
- Sediment disruption;
- Chemicals and oils e.g. grouting and maintenance; and
- Ballast water.

During the construction process disturbance to contaminated sediments could also affect the water quality e.g. if the foundations were constructed in an area which had previously been used as a disposal site (dredge spoil or munitions dumps). Some foundation types can also create high levels of suspended sediment during installation, which also affects water quality.

4.5 FISHING

The impact on commercial fishing will be determined by understanding if the construction, operation and decommissioning of the wind farm will lead to:

- A complete loss or restricted access to traditional fishing ground;

- Safety issues for fishing vessels;
- Increased steaming times to fishing grounds;
- Interference with fishing activities;
- Presence of seabed obstacles post construction; and
- Adverse impacts on commercially exploited species.

Within the comparison of potential effects, consideration will be given to the importance and sensitivity of the receptor; geographic extent and the duration of the impact.

4.6 GREENHOUSE GAS EMISSIONS

The emissions to atmosphere from the vessels that will be used to construct, operate, maintain, inspect and decommission the offshore elements of a wind farm are governed by the International Maritime Organization's International Convention for the Prevention of Pollution from Ships 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78). In particular, Annex VI sets limits on emissions of nitrogen oxides and sulphur dioxide that have been tightened via revisions as technology has improved. In July 2011, measures were adopted that added a new Chapter 4 to MARPOL Annex VI entitled "Regulations on energy efficiency for ships", making mandatory the Energy Efficiency Design Index (EEDI) for new ships and the Ship Energy Efficiency Management Plan (SEEMP) for all ships. These regulations, which aim to reduce the carbon intensity of transport by sea, will apply to all ships over 400 gross tonnage entered into force on 1 January 2013.

Consideration also needs to be given to the embodied carbon of the materials used in the construction of the foundations. This includes the energy required to manufacture the raw materials in the foundations as well as the energy associated with the manufacture of the foundation units.

4.7 WASTE

Wastes will be generated during the fabrication, installation, operation and decommissioning process. The scale and type of waste will be dependent on the type of foundation and installation methodology used - will foundations be pre fabricated onshore? How and where will dredged material be deposited? Will there be any waste generated as a consequence of the maintenance programme, and if so, how will it be disposed of? Consideration of the waste generated from the decommissioning process will also be required.

4.8 ARCHAEOLOGY

The marine heritage value of the wind farm site would be assessed before any construction work progressed. The value of the site would be assessed in terms of:

- Records of wrecks and obstructions, known wrecks, documented losses and archaeological finds;
- Records of Protected wrecks;
- Historic records held by onshore and offshore agencies, e.g. coastguard; and
- Geophysical survey records

The potential impact of the windfarm foundation on the heritage assets assessment would consider the area of the seabed required for development and the location and importance of the known marine heritage assets. Very often adverse effects on known archaeological features can be avoided through careful siting of seabed equipment.

4.9 EMERGENCY RESPONSE

In the event of the construction, operation and decommissioning processes not going to plan, emergency response processes need to be in place to manage and minimise the environmental impact of such an event.

This will include details of how any predicted incidents will be managed, responsibility for managing the incident response, communicating accurate information to the regulatory authorities and emergency services. The comparison between fixed and moored foundations will consider whether the impact and response associated with an emergency situation is altered based on the foundation type.

4.10 DECOMMISSIONING

The environmental impact of decommissioning will be across all environmental aspects. The degree of the impact to each receptor will be dependent on the foundation design and the way in which it is installed and subsequently decommissioned.

5. ENVIRONMENTAL COMPARISON CRITERIA

The following questions will be used to help collect the information that will be used to define the differences between floating and fixed offshore wind turbine foundations in terms of their environmental impacts.

A. Physical environment	
Construction	
A1. Will extensive pre-construction surveys (such as geotechnical survey) be required?	
Choose an item.	If yes please add details: Click here to enter text.
A2. Will the installation of the foundation require a jack-up barge or other equipment that needs to be in contact with the seabed?	
Choose an item.	If yes please add details: Click here to enter text.
A3. What area of seabed will be affected during construction? (What is the overall footprint of the jack-up feet?)	
Area in m^2: Click here to enter text.	
A4. Will the seabed require preparation (e.g. levelling) prior to installation?	
Choose an item.	
A5. If yes, how would seabed preparation be undertaken?	
Click here to enter text.	
A6. Where would dredged materials be deposited?	
Choose an item.	Please provide details? Click here to enter text.
A7. What will be the direct footprint of the foundation on the seabed?	
Please insert area in m^2: Click here to enter text.	
Operation	
A8. How much of the foundation will protrude above the seabed?	
Please insert height in metres: Click here to enter text.	
A9. How much rock armouring will be required per foundation?	
Click here to enter text.	
A10. Will there be movement of the foundation type that could result in disturbance of the seabed (e.g. anchors and chains) during operation? If so, what area of seabed would be	

affected?	
Choose an item.	If yes please insert area in m^2: Click here to enter text.
A11. Is scour likely? How will this be avoided, or otherwise mitigated?	
Choose an item.	If yes please add details: Click here to enter text.
A12. What are the likely effects of the foundation on sediment movement? will there be general accretion or erosion?	
Click here to enter text.	
Decommissioning	
A13. What is the approximate duration of the decommissioning period?	
Please insert time frame in months Click here to enter text.	
A14. Would the entire foundation be removed from the seabed during decommissioning?	
Click here to enter text.	
B. Ecology	
Construction	
B1. What area of seabed will be directly affected during construction?	
Insert area in m^2 Click here to enter text.	
B2. Will it be possible to commence noisy installation operations in a "slow start" mode to enable mobile species to avoid the area?	
Click here to enter text.	
B3. Are specialist construction vessels from distant locations required (that could introduce risk of alien species)?	
Choose an item.	If yes please add details: Click here to enter text.
B4. How will the foundations be constructed and attached to the seabed?	
Click here to enter text.	
B5. Will piling or drilling be required, and if so by what method?	
Choose an item.	If yes please add details: Click here to enter text.
B6. For piling, what is the maximum blow energy?	
Click here to enter text.	

B7. For piling, what is the maximum duration of a single piling event?	
Click here to enter text.	
B8. For piling, what is the maximum number of events per turbine?	
Click here to enter text.	
B9. For piling, what is the total piling time per turbine?	
Click here to enter text.	
B10. For drilling, what is the maximum sound pressure level?	
Click here to enter text.	
B11. For drilling, what is the maximum drilling time per turbine?	
Click here to enter text.	
Operation	
B12. What area of seabed will be taken up by the foundation?	
Insert area in m^2 Click here to enter text.	
B13. How will the option be anti-fouled? (Will it use cathodic protection?)	
Click here to enter text.	
B14. Could the foundation act as a nursery ground or act as an artificial reef or fish aggregation device?	
Choose an item.	
B15. Will the option create an acoustic signal during operation? If so, how is this likely to manifest itself in the water column?	
Choose an item.	If yes please add details: Click here to enter text.
B16. Is marine mammal/ species entanglement a known issue for the foundation type i.e. mooring cables?	
Choose an item.	If yes please add details: Click here to enter text.
B17. Do you utilise any specific management practices to reduce the risk of marine species entanglement?	
Choose an item.	If yes please add details: Click here to enter text.
Decommissioning	
B16. Would surveys be undertaken to determine the extent of species using the structure?	

Choose an item.	If yes please add details: Click here to enter text.
B17. How will the foundations be decommissioned and removed from the seabed?	
Click here to enter text.	
B18. Will the decommissioning methodology require operations likely to generate underwater noise and vibration?	
Click here to enter text.	
B19. If yes, How long will each event last for?	
Click here to enter text.	
C. Navigation	
Construction	
C1. What size of exclusion area will be required during the construction phase?	
Insert area in m^2 Click here to enter text.	
C2. What is the size of a typical construction vessel for this option? How many support vessels would be required?	
Insert size in metres Click here to enter text. Insert number of vesselsClick here to enter text.	
C3. How many construction vessel movements will be required per installed foundation?	
Insert number of vessel movements Click here to enter text.	
Operation	
C4. Will the foundation designs require restricted navigation in their vicinity?	
Choose an item.	
C5. How often will general maintenance operations be required, and how many vessel movements will be required?	
Click here to enter text.	
Decommissioning	
C6. What size of exclusion area will be required during decommissioning?	
Insert area in m^2 Click here to enter text.	
C7.How many vessel movements are predicted to be required for the decommissioning per installed foundation?	
Insert number of vessels Click here to enter text.	
D. Water quality	

Construction	
D1. Will the foundations be pre-fabricated onshore or assembled on-site? If on-site, what activities will be involved?	
Choose an item.	If onshore please provide details? Click here to enter text.
D2. Will installation of the foundation create sediment disturbance? What sized area would be affected?	
Choose an item.	If yes please provide area: Click here to enter text.
D3. Will drilling muds be required?	
Choose an item.	If yes please add details: Click here to enter text.
D4. How will drilling muds be controlled?	
Click here to enter text.	
D5. How long will the installation of each foundation take?	
Please insert time frame Click here to enter text.	
D6. Will chemicals be required (e.g. grouting chemicals)	
Choose an item.	If yes please add details: Click here to enter text.
D7. Will construction require the discharge of ballast water?	
Choose an item.	If yes please add details: Click here to enter text.
Operation	
D8. How will the foundation be protected against corrosion? Will sacrificial anodes be required as part of a cathodic protection system?	
Click here to enter text.	
Decommissioning	
D8.Will decommissioning of the foundation create sediment disturbance? What sized area would be affected?	
Choose an item.	If yes please add details: Click here to enter text.
D9. How long will the installation of each foundation take?	
Click here to enter text.	

D10. Will chemicals be required?	
Choose an item.	If yes please add details: Click here to enter text.
D11. Will decommissioning require the discharge of ballast water?	
Choose an item.	If yes please add details: Click here to enter text.
E. Fishing	
Construction	
E1. How long will any exclusion apply to the area of construction?	
Click here to enter text.	
E2. What area would be required for exclusion for each foundation?	
Insert area in m^2 Click here to enter text.	
Operation	
E3. From what seabed area would fishing be excluded for each foundation?	
Insert area in m^2 Click here to enter text.	
E4. Can trawling still take place between foundations?	
Choose an item.	
E5. Will the new hard substrate created by the foundation be suitable for local colonization by commercial species (i.e. scallops)?	
Choose an item.	If yes please add details: Click here to enter text.
Decommissioning	
E1. How long will any exclusion apply to the area of decommissioning?	
Click here to enter text.	
E2. What area would be required for exclusion for each foundation?	
Click here to enter text.	
F. Greenhouse gas emissions	
Construction	
F1. From what materials will the foundation type be manufactured?	
Click here to enter text.	

F2. Please provide quantities of the main components used in the manufacture of the foundations?	
Click here to enter text.	
F3. Has an assessment of the energy used in the manufacture of the foundations been undertaken?	
Choose an item.	If yes please add details: Click here to enter text.
F4. How will the foundations be transported to site and how long will an individual installation take?	
Click here to enter text.	
F5. What type of vessel(s) will be required?	
Click here to enter text.	
F6. Can this type of vessel be sourced locally to the site (is a specialist vessel required)?	
Choose an item.	
Operation	
F7. How frequently are maintenance vessels planned to visit the site?	
Click here to enter text.	
F7.What type of vessel(s) will be required?	
Click here to enter text.	
F8. Can this type of vessel be sourced locally to the site (is a specialist vessel required)?	
Choose an item.	
Decommissioning	
F9.How will foundations and any associated structures be removed from the site?	
Click here to enter text.	
F10.What type of vessel(s) will be required?	
Click here to enter text.	
F11. Can this type of vessel be sourced locally to the site (is a specialist vessel required)?	
Click here to enter text.	
Is the number of vessel movements to complete the decommissioning process known?	

Choose an item.	If yes please add details: Click here to enter text.
G. Waste	
Construction	
G1. Will a Site Waste Management Plan be developed for the construction phase?	
Choose an item.	
G2. Have the waste types expected to be generated been identified in terms of waste types (EWC Code) and estimated quantity?	
Choose an item.	If yes please add details of waste types: Click here to enter text.
G3. Have waste management options been identified for the above waste types?	
Choose an item.	
OPERATION	
G4. Have the waste types expected to be generated during operation been identified in terms of waste types (EWC Code) and estimated quantity?	
Choose an item.	If yes please add details of waste types: Click here to enter text.
G5. Have waste management options been identified for the above waste types?	
Choose an item.	
DECOMMISSIONING	
G6. Have the waste types expected to be generated been identified in terms of waste types (EWC Code) and estimated quantity?	
Choose an item.	If yes please add details of waste types: Click here to enter text.
G7. Have waste management options been identified for the above waste types?	
Choose an item.	
H. Archaeology	
Construction	
H1. Has a marine heritage asset study been undertaken?	
Choose an item.	If yes please add details: Click here to enter text.
H2. What is the seabed footprint of the foundation (including areas disturbed by jack-up	

vessel feet during the installation or decommissioning phases)	
Choose an item.	
I. Emergency Response	
I1. Have emergency response plans been developed to cover the construction, operation and decommissioning processes?	
Choose an item.	If yes please add details: Click here to enter text.
I2. What are the key environmental risks associated with the foundation design?	
Choose an item.	
J. Decommissioning	
J1. Has consideration been given at the design stage of the materials used to ensure that at decommissioning they are potentially suitable for reuse or can be managed as a waste?	
Choose an item.	If yes please add details: Click here to enter text.
J2. Is there a Decommissioning Management Plan?	
Choose an item.	If yes please add details: Click here to enter text.