Review of international environmental best practice for floating wind turbine systems

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Review of international environmental best practice for floating wind turbine systems

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Written by: Rebecca Heath

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1. EXECUTIVE SUMMARY

The FloatGen project's objective is to demonstrate the technical and economic viability of floating wind turbines, in order to expand the development potential of offshore renewable energy into windier and deeper waters that are not currently considered commercially viable.

This document aims to summarise international environmental best practice requirements associated with floating wind turbines.

Owing to the lack of specific floating-turbine environmental guidance, the approach for this deliverable has been to consider potential impacts associated with floating wind turbine construction, operation and decommissioning and relate these to best practice guidance for the conventional wind turbine industry and other offshore industries, e.g. oil and gas industry, shipping, etc.

A summary of international environmental best practice is provided in Section 4 of this document with respect to

- impacts on water quality from use of anti-fouling products
- introduction of invasive species from ballast water exchange
- seabed scour from wind turbine mooring structures
- impacts of anchoring on seabed communities
- impacts of underwater noise on marine mammals
- impacts of mooring structures on large marine animals (entanglement)
- routine discharges and emissions from associated vessels
- socio-economic impacts on fisheries
- impacts on navigation (collision risk) and associated requirements for emergency response
- decommissioning impacts.

2. ACRONYMS

AFS Convention	International Convention of Harmful Anti-fouling Systems on Ships 2001
AIS	alien invasive species
COWRIE	Collaborative Offshore Wind Research into the Environment
EIA	environmental impact assessment
EMEC	European Marine Energy Centre
ERP	emergency response plan
FEPA	Food and Environment Protection Act
FLOWW	Fishing Liaison with Offshore Wind and Wet Renewables Group
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
ICES	International Council for Exploration of the Sea
IMO	International Maritime Organization
IPIECA	global oil and gas industry association for environmental and social issues
MEPC	Marine Environment Protection Committee
MMO	marine mammal observer
MRE	marine renewable energy (devices)
OGP	International Association of Oil & Gas Producers
OREI	offshore renewable energy installation
PAM	passive acoustic monitoring
ROV	remotely operated vehicle
SNH	Scottish Natural Heritage
TBT	tributyltin

3. INTRODUCTION

The FloatGen project's objective is to demonstrate the technical and economic viability of floating wind turbines, in order to expand the development potential of offshore renewable energy into windier and deeper waters that are not currently considered commercially viable.

This document aims to summarise international environmental best practice requirements associated with floating wind turbines. Several guidance documents have been compiled on this subject[1], although they tend to focus solely on technical requirements with no reference to environmental considerations.

The approach for this deliverable has therefore been to consider potential impacts associated with floating wind turbine construction, operation and decommissioning and relate these to best practice guidance for the conventional wind turbine industry and other offshore industries, e.g. oil and gas industry, shipping, etc.

Key potential impacts are listed below:

- impacts on water quality from use of anti-fouling products
- introduction of invasive species from ballast water exchange
- seabed scour from wind turbine mooring structures
- impacts of anchoring on seabed communities
- impacts of underwater noise on marine mammals
- impacts of mooring structures on large marine animals (entanglement)
- routine discharges and emissions from associated vessels
- socio-economic impacts on fisheries
- impacts on navigation (collision risk) and associated requirements for emergency response
- decommissioning impacts.

Section 4 summarises international environmental best practice associated with the above impacts.

[1] For example:
MERIFIC. 2013. Best Practice Report – Mooring of Floating Marine Renewable Devices.
DNV. 2013. Design of Floating Wind Turbine Structures. DNV-OS-S103.rock dump, geotextile fabric, concrete block mattress, etc.)
EMEC, 2009. Guidelines for Design Basis of Marine Energy Conversion Systems. Marine Renewable Energy Guidelines.

It is assumed that the aerial parts of the turbines (including the tower above the water line, the nacelle and the turbine blades) would have the same impacts whether they are supported on fixed or floating foundations, hence information has not been included in this report for above-water elements. Similarly, impacts associated with the electrical export power cable to shore are outside the scope of this report.

4. SUMMARY OF RELEVANT INTERNATIONAL BEST PRACTICE

Document title	Requirements
Impacts on water quality from use of anti-fouling products	
Alien invasive species and the oil and gas industry - guidance for prevention and management. IPIECA/ OGP, 2010.	Organotin biocides (including tributyltin, or TBT) are of considerable concern owing to their harmful environmental effects, and their use has been banned since September 2008. Use anti-fouling paints that comply with the International Convention of Harmful Anti-fouling Systems on Ships 2001 (AFS Convention) and national legislation. Ensure that the selected paint is suitable for the specific application required. Undertake maintenance to ensure integrity of paint coverage. In all cases, the anti-fouling paint manufacturer should be consulted, particularly for advice on surface preparation, coating thickness and number of coats required, to ensure that optimal results are achieved. Maintain a biofouling management plan and log to include the following items. **Anti-fouling paint details** • Location(s) of applications, e.g. port name • Product used (brand and type) • Surface preparation work undertaken • Date(s) of applications • Documentation of application, e.g. contractor receipts • Estimated expiry date of effective life of antifouling paints • Conditions required for effective operation of anti-fouling paints • Coverage, including areas not painted, e.g. sea-chests, areas covered by support blocks while ashore **Inspection details** • Type of inspection, e.g. hull, internal seawater systems

Document title	Requirements
	• Date/location/coverage of visual inspections on land/dry dock • Date/location/coverage of underwater (diver or remotely operated vehicle, ROV) inspections • Documentation of correspondence on required inspections, e.g. by local quarantine authorities • Copies of inspection reports • Record of main fouling species/groups and types encountered, e.g. sea-squirts, green algae, tube worms, particularly of any apparently new, unusual, abundant or dominant species **Biofouling removal details** • Location (e.g. port/harbour name; position if offshore) • Method used (e.g. scraping, blasting, wrapping) • Underwater or above water removal **Waste management details** • Disposal method (e.g. landfill, incineration) • Associated documentation (e.g. waste transfer receipts) As the removal of biofouling may remove quantities of toxic anti-fouling paints, in-water cleaning is not recommended. Instead, slipping and/or dry-docking of vessels provide the best opportunity for effective large-scale removal of biofouling. Dispose of removal residues appropriately to prevent environmental harm. Residue disposal should encompass the following: • All paint residues, biofouling and related materials (for example, grit used in blasting) should be treated as contaminated waste and disposed of in land-based facilities in accordance with local regulations. • Records of waste disposal should be retained in the biofouling management plan. • Suitably licensed contractors should be used.

Document title	Requirements
	• Residue should not be allowed to enter adjacent waterways (dry-dock facilities should be able to contain residues safely) and waste should be kept in sealed containers.
Guidelines for Survey and Certification of Anti-fouling Systems on Ships. MEPC, 2010.	For the purpose of compliance with the International Convention on the Control of Harmful Anti-fouling Systems on Ships, 2001, small quantities of organotin compounds acting as a chemical catalyst (such as mono- and di- substituted organotin compounds) are allowed, provided they are present at a level that does not provide a biocidal effect to the coating. On a practical level, when used as a catalyst, an organotin compound should not be present above 2,500 mg total tin per kilogram of dry paint.
Introduction of invasive species from ballast water exchange	
Alien invasive species and the oil and gas industry - guidance for prevention and management. IPIECA/ OGP, 2010.	Ballast **uptake** should be in a 'low alien invasive species (AIS) potential' area, i.e. • deep: 200 m or deeper • offshore: 200 nautical miles, or where this is not possible, 50 nautical miles; failing this, as far as possible from the nearest land mass. Taking on ballast water in deep, nutrient-poor mid-ocean waters, distant from inshore AIS sources, is widely agreed to represent best practice (although it is not completely effective) owing to the lower abundance of eggs, larvae and other organisms of oceanic species and their much lower potential to become AIS in inshore environments. Ballast **discharge** should take into account the following: • manage ballast to minimise or remove the need for discharge • use appropriate onshore discharge, where possible • discharge only 'low AIS potential' ballast water in port/inshore waters. Ballast **exchange** should, as far as practicable, be conducted in deep water (at least 200 m) and as far as possible from land. Three methods of effective ballast water exchange are recognised by the IMO (sequential discharge, flow through and dilution)

Document title	Requirements
	and all involve discharge of high AIS potential (coastal) ballast water at sea and refill with clean low AIS potential oceanic water before arriving at the next port. The following measures may be undertaken to minimise AIS pathway potential while a vessel is being prepared for disposal/ decommissioning/abandonment: • upon retrieval, smaller elements, such as anchor arrays and spud cans, may be washed down with high-pressure seawater at source to remove mud and other substrate • removal from water (if feasible) • blanking off of niche areas not required, e.g. sea chests • either maintaining (e.g. using biocides) or completely shutting down internal seawater systems (shutting down will kill biofouling organisms through removal of oxygen).
Seabed scour risk from wind turbine mooring structures	
Coastal Process Modelling for Offshore Wind Farm EIA: Best Practice Guide. COWRIE, September 2009.	There are two aspects to environmental impact: 1) Ecological receptors sensitive to changing seabed morphology (sediment around seabed mooring foundations can be removed due to the effect of the object on local flow patterns and velocities) 2) If scour protection is introduced (e.g. rock dump, geotextile fabric, concrete mattress), ecological receptors can be sensitive to the introduction of new substrate. It is considered good practice that, during the design process of the wind turbine foundation, an appropriate assessment be made of local scour arising from the influence of waves and currents. The assessment should take into account spring and neap conditions and the influence of storm events, as well as the relative magnitude of waves and currents that will vary from location

Document title	Requirements
	to location. The potential for scour interaction between adjacent foundations also needs to be assessed. Finally, the influence of variation in seabed level over the design life of the wind turbine needs to be considered (may arise from regional changes or local changes due to migration of banks, sand waves or channels). Studies following the installation of scour protection indicate that this mitigation is effective in preventing lowering of the seabed adjacent to the foundations. However, a secondary scour response then often occurs around the scour protection materials that are proud of the seabed. UK marine licences (previously FEPA licences) now require the development of a site-specific scour protection plan to ensure that materials and methods are appropriate for the site conditions. In terms of post-construction monitoring, best practice is to undertake monitoring with a greater degree of consistency, with development of a recommended standard methodology. When trying to maintain a consistent horizontal and vertical datum, sites far offshore have additional problems achieving accurate tidal correction, where there are limited local reference stations for this purpose. Best practice in this case would be to use RTK/PPK GPS techniques, possibly in combination with dedicated and surveyed on-site tide gauges.
Recommendation O-139 On The Marking of Man-Made Offshore Structures Edition 1. IALA, December 2008.	There is some evidence that scouring at the bases of wind generators in areas of strong tides or currents has resulted in significant deposits of material in other locations. Some authorities have insisted on fitting depth monitoring devices to wind generators to measure scour.
Impacts of anchoring on seabed communities	
Oil & Gas Drilling in	An anchor and mooring analysis should be conducted that considers protected habitats when planning for positioning and

Document title	Requirements
Sensitive areas A guideline for "best practices" keeping focus on the seabed environment. DNV GL, 2014.	handling of anchor, anchor chains, pennant wires etc.
Impacts of underwater noise on marine mammals	
OSPAR inventory of measures to mitigate the emission and environmental impact of underwater noise. Biodiversity Series, Ospar Commission, 2014.	Since floating wind turbines allow for a high level of pre-fabrication onshore, the underwater noise during installation is limited to transport and the mooring process. Noise emissions during mooring depend on the technique employed. The installation of suction anchors and bucket foundations have relatively low noise emission levels, whereas micropiling of the foundations would have higher noise emission levels. Best practice measures to prevent death, injury or physical damage of marine mammals from **high level** under water noise include • displacing animals from the area of harmful underwater noise with the aid of acoustic deterrent devices and/or acoustic harassment devices such as pingers or seal scarers • employing so-called soft-start or ramp-up procedures if appropriate to allow animals to escape the area affected detrimentally by the noise • ensuring the absence of marine mammals from the impact zone by visual or acoustic monitoring (preferably real time) with the aid of marine mammal observer (MMO) and passive acoustic monitoring (PAM) respectively during the construction phase.

Document title	Requirements
Assessment of the marine renewables industry in relation to marine mammals. ICES Working Group on Marine Mammal Ecology, 2014.	The best approach to reducing impact from construction of renewable energy devices is to avoid pile driving noise altogether, such as through developing alternative methods for pile driving or the use of alternative types of foundation. In the case of offshore wind farms this includes, but is not limited to, use of gravitational foundations or suction piles, installation by water jet or by drilling, and in deeper waters use of floating platforms tethered to the seabed. Secondary solutions involve limiting the energy radiated from the pile driving into the water, for example by using bubble curtains or pile sleeves (if feasible and efficient).
Underwater Acoustic Monitoring at Wave and Tidal Energy Sites: Guidance Notes for Regulators. EMEC, February 2014.	Document provides basic guidance for the consistent measuring of noise from marine energy converters. Measurements should include consideration of the frequency range of the equipment and procedures used. Specifically this should be in relation to the hearing ranges of the marine species present. Methods of measurement are presented including boat-based systems, static systems (moored and bottom-mounted hydrophones) and drifting systems.
Impacts of mooring structures on large marine animals	
Report 791: Understanding the potential for marine megafauna entanglement risk from renewable marine	Based on an extensive literature review, it was concluded that moorings such as those proposed for marine renewable energy (MRE) devices will likely pose a relatively modest risk in terms of entanglement for most marine megafauna, particularly when compared to risk posed by fisheries. Nevertheless, some circumstances were identified where moorings associated with MRE devices could potentially pose a risk, particularly (1) in cases involving large baleen whales and (2) if derelict fishing gears become attached to the mooring, thereby posing an entanglement risk for a wide range of species. Study provides a series of recommendations for the industry to reduce risks to animals. These include relative risk assessments,

Document title	Requirements
energy developments. SNH, 2014.	routine inspections of moorings and for developers to report to regulators any significant changes to mooring and installations. It also recommends an official process for developers to report any marine animal entanglement and an associated formal accident investigation procedure.
Routine discharges and emissions from associated vessels	
Ships and cargoes guidance – prevent pollution and reduce harmful emissions at sea. UK Maritime & Coastguard Agency, 2012.	Most international regulations on marine pollution come from the 1973 International Convention for the Prevention of Pollution from Ships (MARPOL), which was updated in 1978. MARPOL was developed by the International Maritime Organization (IMO) and is aimed at preventing and minimising pollution from ships, both accidental and from routine operations. There have been several amendments to the Convention since it was first produced, and MARPOL now has six technical annexes covering marine pollution by • oil (Annex I) • noxious liquid substances carried in bulk (Annex II) • harmful substances carried in packaged form (Annex III) • sewage from ships (Annex IV) • garbage from ships (Annex V) • air pollution from ships (Annex VI). In addition, there are requirements for ship survey and certification for pollution prevention in the marine environment. All vessels involved in the construction, operation, maintenance, inspection and decommissioning of wind turbines to operate in accordance with MAPROL 73/78.

Document title	Requirements
Socio-economic impacts on fisheries	
Best Practice Guidance for Offshore Renewables Developments: Recommendations for Fisheries Liaison. FLOWW, January 2014.	Document provides guidance on • setting up of an effective liaison structure during all phases of an offshore renewable energy installation (OREI), assisted by the appointment of key liaison roles • formal and informal consultation during the planning and consenting phase, and includes suggestions for the data collection and the information that developers would need to obtain from the fishing community in order to fully appreciate potential impacts and mitigation • fishing liaison activities that may be applicable during the construction and operational phases of an OREI • considerations for identifying mitigation and co-existence opportunities and the development of a mitigation and co-existence plan • the process for developers to apply for safety zones around an OREI for construction and operation, and the factors that a developer should consider in applying for a safety zone, including discussions with the fishing community. In 2007, Safety Zone Regulations were introduced to provide a formal mechanism for putting in place restrictions on vessel movements within certain distances of OREIs. Subject to an acceptable and demonstrable safety case, safety zones can be established for any phase in the life of an OREI, i.e. construction, operation, extension, major maintenance and decommissioning. Current safety regimes for OREIs are shown below:

<table>
<tr><th>Document title</th><th>Requirements</th></tr>
<tr><td></td><td>
<table>
<tr><th>TYPE OF SAFETY ZONE</th><th>AREA COVERED</th></tr>
<tr><td>CONSTRUCTION 1</td><td>Typically up to 500m around single offshore renewable energy installations under construction. This is usually evidenced by the presence of a jack-up rig or other large vessels. Other large construction vessels, such as a cable-lay vessel, will also typically be surrounded by a mobile 500m safety zone.</td></tr>
<tr><td>CONSTRUCTION 2 (pre-commissioning)</td><td>Typically up to 50m around offshore renewable energy installations where construction has finished but some work is on-going e.g. turbine incomplete or in the process of being commissioned.</td></tr>
<tr><td>OPERATION</td><td>Where this can be justified up to 50m where an offshore renewable energy installation is in operation.</td></tr>
<tr><td>MAJOR MAINTENANCE</td><td>Typically up to 500m when major maintenance is in progress. This is usually evidenced by the presence of a jack-up rig or other large vessel.</td></tr>
<tr><td>DECOMISSIONING</td><td>Typically up to 500m at the end of the working life of an offshore renewable energy installation when it is being decommissioned. This is usually evidenced by the presence of a jack-up rig or other large vessel.</td></tr>
</table>
</td></tr>
<tr><td colspan="2">Impacts on navigation (collision risk)</td></tr>
<tr><td>Recommendation O-139 On The Marking of Man-Made Offshore Structures, Edition 1. IALA, December 2008.</td><td>In general, development of offshore energy structures or wind farms should not prejudice the safe use of traffic separation schemes, inshore traffic zones, recognised sea lanes and safe access to anchorages, harbours and places of refuge.
During the construction of an offshore wind farm, working areas should be established and marked in accordance with the IALA maritime buoyage system. National authorities should also consider the use of guard ships in areas of high traffic density. Notices to mariners, radio navigational warnings and notices to airmen must be promulgated in advance of and during any offshore wind farm construction.
Lighting and marking of turbine towers outside the scope of this document (see Section 3).</td></tr>
<tr><td colspan="2">Emergency response</td></tr>
<tr><td>Working the wind</td><td>An emergency response plan (ERP) covering all activities at the workplace needs to be in place prior to the start of activities.</td></tr>
</table>

Document title	Requirements
safely. Guidelines on emergency arrangements including first aid. European Wind Energy Association, December 2013.	Interfaces with all parties working at the same site and between activities that are being carried out at the same time shall be covered. One ERP will be created and maintained for the entire site. In case of multiple parties working at a site with each party having its own ERP, a site ERP bringing together the individual ERPs of the different contractors will be created as a bridging document for the entire site. Requirements for an ERP may consist of, but are not limited to • measures and resources for an emergency response • scenarios that may occur at the workplace • the tasks, responsibilities and authorities of all key personnel involved in the emergency response • communication lines and numbers of all internal or external parties during emergencies • contact numbers of all third party emergency services • potential hazards • locations of the site's most significant hazards. Apart from the ERP for the offshore wind farm itself, each vessel used at an offshore wind farm needs to have an ERP in accordance with IMO regulations. An emergency response cooperation plan should be communicated to and agreed with the coastguard. Points to be considered for the ERP offshore may include • turbine abandonment • the relevant emergency procedures • medical evacuation (Medevac) procedure • man overboard procedure

Document title	Requirements
	• responsibilities during an emergency, such as first aid • escape routes on board • vessel collision or grounding • vessels not under command • pollution • extreme weather • emergency equipment on board • overview of all chemicals and fuel • diving emergencies (if applicable) • crew/personnel stranding.
Decommissioning impacts	
Decommissioning of offshore renewable energy installations under the UK Energy Act 2004. Guidance notes for industry. Department of Energy & Climate Change, January 2011.	Guidance developed to assist businesses to understand their obligations under the decommissioning scheme for offshore wind and marine energy installations. Guidance can be used to • decide whether or not an installation is included within the scope of the decommissioning scheme • understand the process that must be followed for submission, approval and review of decommissioning programmes • understand what must be included in a decommissioning programme submitted under the scheme. Suggested contents of decommissioning programme: 1) Introduction 2) Executive summary

Document title	Requirements
	3) Background information 4) Description of items to be decommissioned 5) Description of proposed decommissioning measures (including waste management solutions, and details of any items left in situ following decommissioning) 6) EIA (including in particular any use of explosives) 7) Consultation with interested parties 8) Costs 9) Financial security 10) Schedule 11) Project management and verification 12) Seabed clearance 13) Restoration of site 14) Post-decommissioning monitoring, maintenance and management of the site 15) Supporting studies