Proposed metocean buoys around Tetraspar

Information for the permit application

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Summary

This document describes information required for the permit application for the proposed deployment of four metocean buoys around the TetraSpar floating wind turbine demonstrator. One metocean buoy will measure wave and current conditions for an expected period of four years. Three smaller metocean buoys will measure wave conditions for a period of 1 year. All four buoys will be installed in close proximity to the Tetraspar demonstrator.

Contents

1. Background

The TetraSpar Demonstration Project [TSD] began in the second half of 2018 with Shell BV, RWE AG and Stiesdal Offshore Technologies A/S as the investors and sponsors. Within an 18-month period the project completed the first phase covering design and manufacturing of the TetraSpar floating foundation, as well as contracting for the later phases. After COVID related delays, TEPCO Renewable Power joined TSD as an additional partner at the beginning of 2021 and the second phase (covering onshore assembly, launch, installation and commissioning) was completed by December 2021.

The TSD floating offshore wind foundation is unique in that it is designed to make use of the existing offshore wind supply chain and to easily enable industrialized fabrication, assembly and installation. The design is therefore anticipated to enable cost reductions for future commercial scale floating wind development in Norway and other international markets. One of the key criteria of TSD is to provide the investors and wider industry partners with important learnings applicable to commercial scale projects.

The wave heights and wave periods are currently being measured by a novel wave radar located on the TSD floating foundation. It is the first time that that a wave radar is being used on a floating wind turbine that is also able to measure the directionality of waves. To effectively validate the wave measurements by the wave radar, metocean buoys in close proximity to TSD will be required.

In addition, the TSD structure reflects incoming waves and the structure creates waves when it moves in the water. These reflected and newly created waves are also measured by the wave radar. To validate the hydrodynamic models that predict the motions of the floating foundation, it is required to measure the undisturbed incoming wave. Because the wave radar also measures reflected and newly created waves from the Structure, the undisturbed incoming wave is not known. By installing at least three small wave buoys around the TSD project at close proximity it would be possible to derive the undisturbed incoming wave also at the specific TSD location.

Currents are currently not measured at the TSD location, however initial hydrodynamic analyses shows that currents have a large effect on the motions of the floating foundation. To better understand these motions, and to validate the hydrodynamic models that predict these motions, measurements of current velocities and current direction is ideally also required.

In addition, strong currents and large variations in current velocity were observed during the first year of operations of the TSD project. When currents are strong, it is particularly difficult to operate a Remotely Operated Vehicle (ROV) during subsea inspections of the floating foundation. Offshore inspection and maintenance activities at TSD could be more efficiently planned and safety could be further enhanced if current measurements would be measured prior and during these offshore activities.

2. Proposal and objective

The proposal is to install four metocean buoys around the TSD project: one Midi wave/current buoy and three Spotter wave buoys.

One midi buoy will measure the wave and currents in close proximity of TSD. The midi buoy is an advanced buoy that has been extensively validated and will serve to validate the measurements of the wave radar at the TetraSpar. These wave measurements will also help to improve the development of the wave radar, from which the wider offshore industry will benefit.

The midi buoy will be equipped with a current measurement device that can measure currents up to a depth of 60 meters. This depth corresponds to the draft of the TSD foundation keel and therefore can be used to validate hydrodynamic models and support inspection and maintenance activities at TSD.

Three Spotter buoys will measure the waves in close proximity of the TetraSpar. These measurements will be used to derive the directionality of the waves. Besides wave measurements, these buoys will be used to calculate the undisturbed incoming wave at reaching the TSD floating foundation, which is required to validate the hydrodynamic models and to validate wave spreading measurements by the wave radar.

3. Proposed locations of metocean buoys

Figure 1 shows an illustration of the TSD floating foundation, the three mooring lines, the electrical cable and the proposed four metocean buoys surrounding TetraSpar. A detailed drawing at scale is included in the Appendices.

Figure 1: Location of the metocean buoys around the TetraSpar demonstrator

The spotter buoys are marked in green and identified by numbers 1-3 in Figure 1. The midi buoy is marked in red with number 4.

During high wave and current conditions, the buoys are expected to have a maximum excursion of 400 m as shown by the yellow circles in Figure 1. The center of each circle marks the location of the anchor, which is a ballast weight deployed at the seabed. Technical information of the mooring and anchor are described in the next section of this report. The coordinates of the anchor locations are presented in Table 1.

Table 1: Coordinates of anchor locations of metocean buoys

ID	Description	Easting	Northing
1	wave buoy, i.e. Spotter bouy	615106.6315	6559180.147
2	wave buoy, i.e. Spotter bouy	614632.2198	6558735.293
3	wave buoy, i.e. Spotter bouy	615937.2216	6558769.285
4	Wave/current buoy, i.e. midi buoy	614988.3981	6558055.451

4. Technical specifications of metocean buoys

This section describes the technical specification of the Midi wave/current buoy and the three Spotter wave buoys respectively.

4.1. Midi wave/current buoy

The Midi buoy is equipped with sensors to measure waves and currents. A picture of the Midi buoy is shown in Figure 2. The dimensions of the buoy are presented in Table 2.

The Midi buoy will be kept in place by a mooring line that is connected to an anchor at the seabed. The anchor is basically a concrete bottom weight with sufficient mass to ensure that the buoy will stay at its intended location in severe storms that statistically occur only once in a period of 10 years. The expected mass of the bottom weight is 2,000 kg. The proposed mooring design is shown in Figure 3.

Annually the Midi buoy will be serviced and equipped with a new battery. The proposal is to install the Midi buoy at its location for a period of approximately 4 years [until maximum 31 December 2026].

Figure 2: Midi wave/current buoy

Table 2: Dimensions of Midi wave/current buoys

Buoy Dimensions	
Weight (approx.)	600 kg
Height (hull)	1.18 m
Overall height	3.4 m
Diameter	1.85 m
Net Buoyancy	800 kg
Mast height (above water)	2.5 m

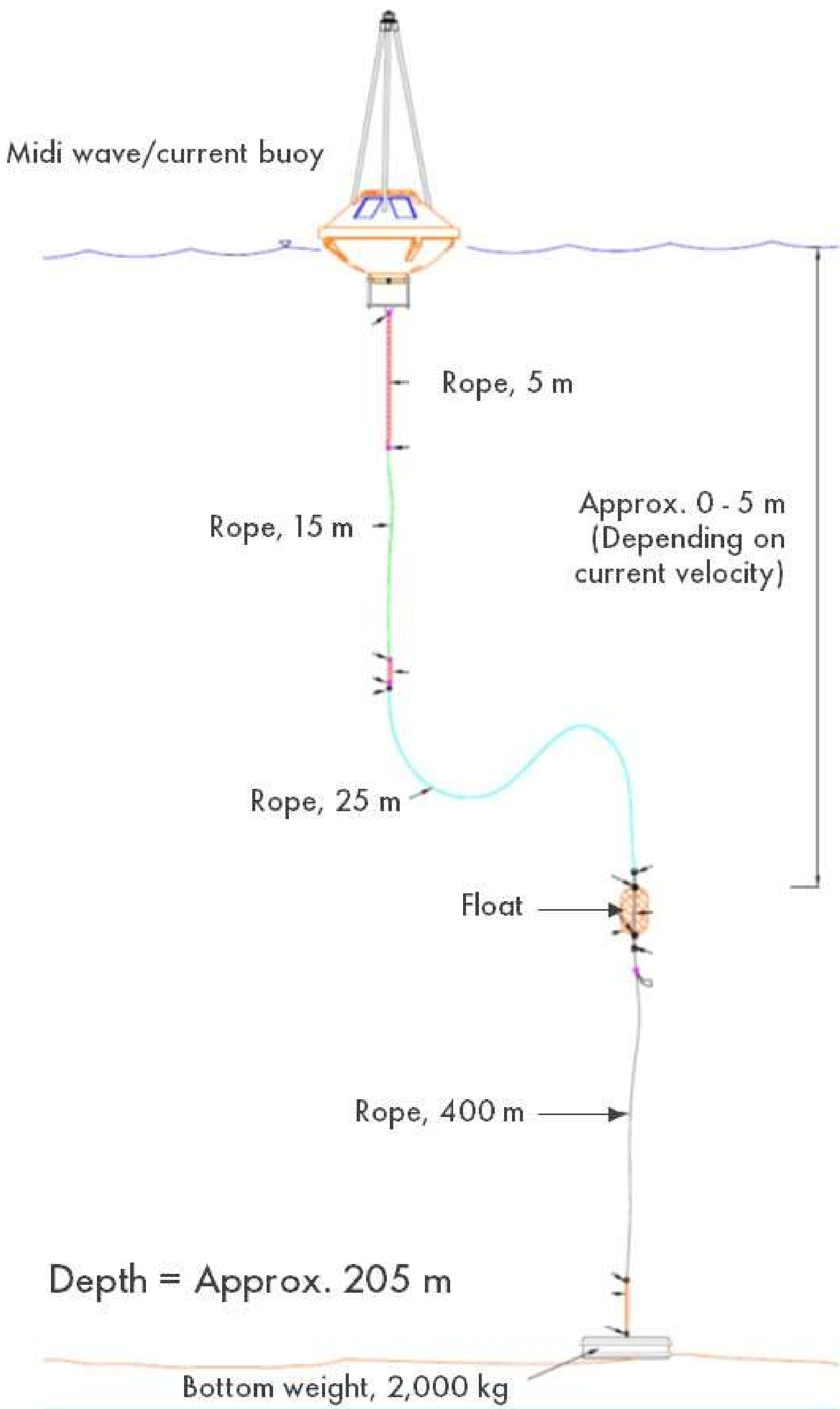

Figure 3: Mooring design of Midi buoy for wave/current measurements

4.2. Spotter wave buoy

The Spotter buoy is equipped with sensors to measure waves and currents. A picture of the Spotter buoy is shown in Figure 4. The dimensions of the buoy are presented in Table 3.

The Spotter buoy will be kept in place by a mooring line that is connected to an anchor at the seabed. The anchor is basically a concrete bottom weight with sufficient mass to ensure that the buoy will stay at its intended location in severe storms that statistically occur only once in a period of 10 years. The expected mass of the bottom weight is 1,000 kg. The proposed mooring design is shown in Figure 5.

The Spotter buoy will be deployed in the water for a period of approximately 1 year and removed from the water before 31 December 2023.

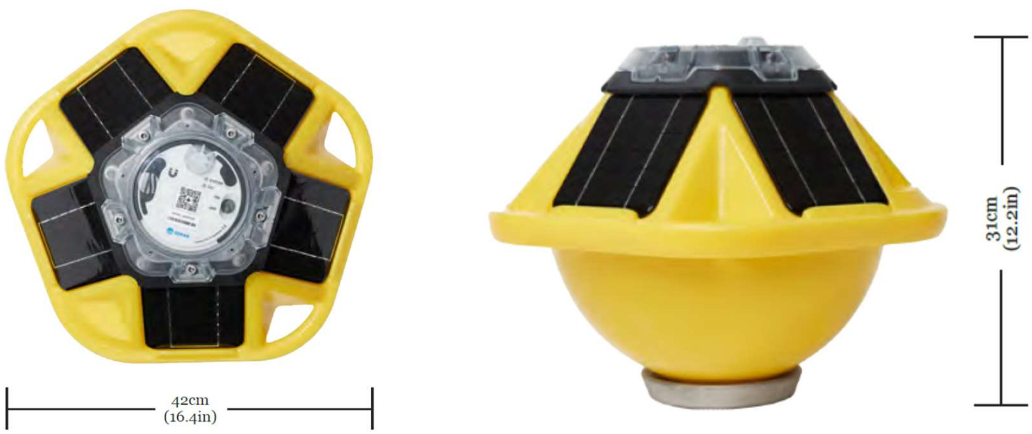

Figure 4: Spotter wave buoy

Table 3: Dimensions of Spotter wave buoys

Buoy Dimensions	
Weight (approx)	7.45 kg
Overall height	31 cm
Diameter	42 cm

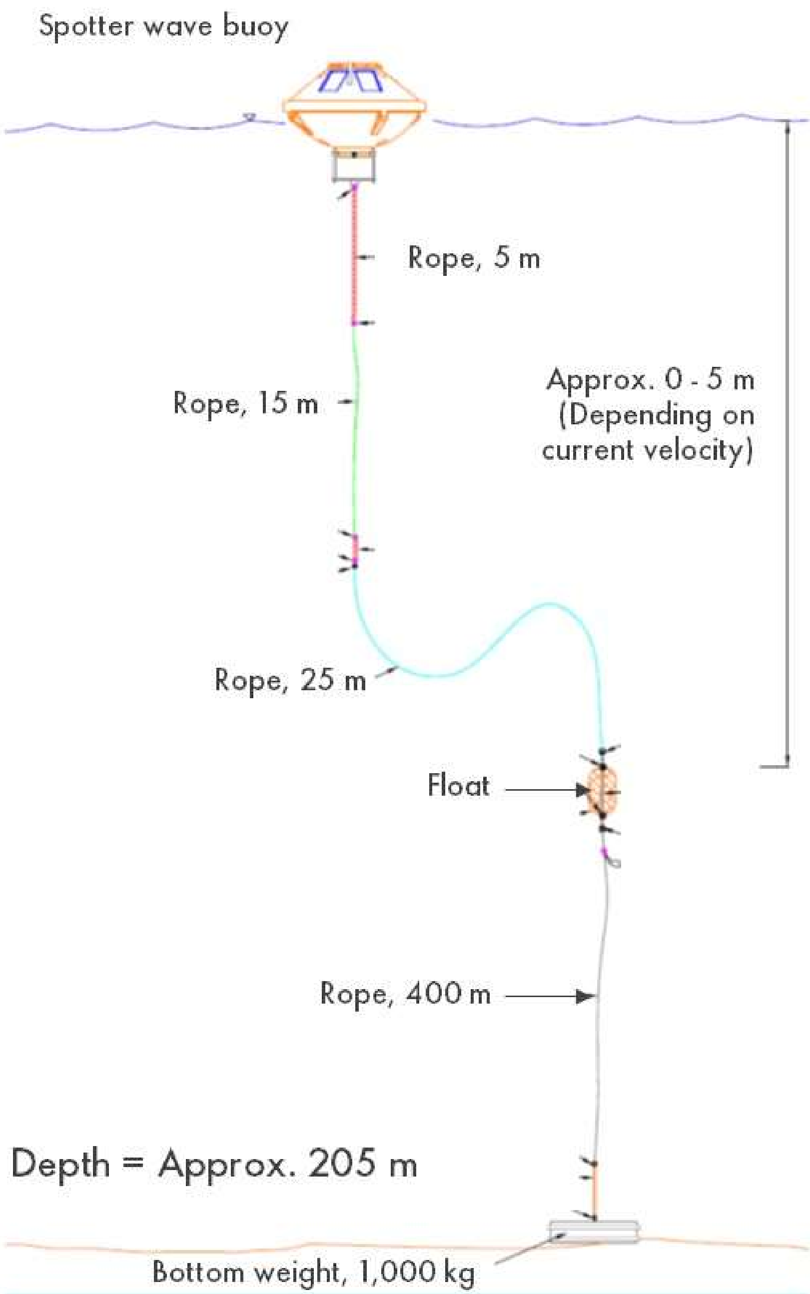

Figure 5: Mooring design of Spotter wave buoys

5. Schedule

The schedules for the Midi wave/current buoy and the three Spotter wave buoys are presented in Table 4 and Table 5 respectively.

The plan is to remove the metocean buoys during the summer period when the weather is favorable. However, conservatively the end date of the decommissioning of the buoys is set at the last day of the calendar year in Table 4 and Table 5 .

Table 4: Schedule for one Midi wave/current buoy

Activity	Start	End	
Installation	26/Sep/22	15/Oct/22	Subject to suitable weather conditions.
Data collection / testing	01/Oct/22	01/Jul/26	Four years data collection next to TetraSpar
Decommissioning	01/Jul/26	31/Dec/26	Plan is to remove it during summer

Table 5: Schedule for three Spotter wave buoys

Activity	Start	End	
Installation	26/Sep/22	15/Oct/22	Subject to suitable weather conditions.
Data collection / testing	01/Oct/22	01/Jul/23	One year of data collection next to TetraSpar
Decommissioning	01/Jul/23	31/Dec/23	Plan is to remove it during summer

6. Appendices

The following appendices are attached to this document:

- Data sheet of Fugro Midi buoy
- Data sheet of spotters
- Map of Tetraspar with proposed locations for metocean buoys at scale 1:8,000
- Map of Tetraspar with proposed locations for metocean buoys at scale 1:50,000