Experimental study of the dynamic response of a TLP Wind Turbine model

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The model studies in this project show that the dynamic response of a floating TLP wind turbine depends very much on the mooring configuration, and shows the necessity of choosing a configuration that is flexible and thus able to absorb loads from wind and waves. It was found that the use of inclined mooring lines reduces the motion of the nacelle dramatically and allows harsher wind and wave conditions before the structure motion becomes critical. Today's offshore wind turbines are mounted on piles that are drilled into the seabed which limits the sites suitable for offshore wind farms to shallow waters. Many places in the world coastal waters are very deep, and in order to install offshore wind turbines here, they must be floating.

This project investigates the dynamic effects of different mooring configurations applied to a floating TLP wind turbine model in various wind and wave climates.

The TLP wind turbine keeps itself buoyant by means of a Tension Leg Platform (TLP) which is comprised of a cylindrical floater and four spokes forming a cross at the bottom of the floater. From each spoke a tendon is drawn to an anchor on the seafloor and given a pre-tension in order to keep the TLP stable. The experimental study is based on a 1:200 scale model of a TLP wind turbine that is equipped with a generator and where the floater and the nacelle are fitted with accelerometers. Data from these devices forms the basis for a dynamic analysis giving accelerations of the wind turbine as well as power and rotational speed of the generator. The waves are generated in a wave flume, while the wind is created by an open wind tunnel that was designed and built as part of the project.

Defining φ as the angle between the upstream spoke and the direction of waves and wind, three different mooring configurations were tested, where all three were tested at $\varphi = 45°$ and only one at $\varphi = 0°$. All configurations were tested in five different irregular wave climates as well as in a range of regular waves. In figure 1 the cumulative probability distribution of the nacelle displacement in the wave direction (surge displacement) is shown for irregular waves generated from a JONSWAP wave spectrum with a significant wave height of 19.43 m and a peak period of 21.90 s. Here it is distinct that the mooring configuration having 4 inclined tendons is by far the most stable configuration. This can be explained by the fact that the surge eigenfrequency of this configuration is low compared to the other mooring configurations and falls below the frequencies in the wave spectrum that contain noticeable energy.

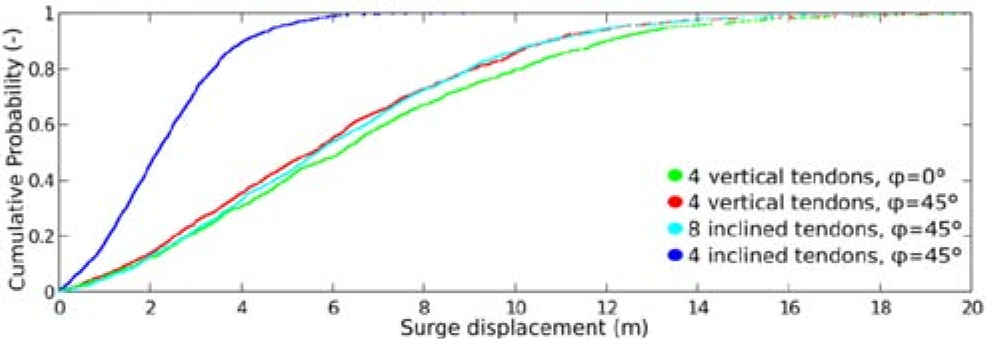

Figure 1: Cumulative probability of full scale surge displacement.