ABSTRACT

Large-scale offshore floating wind turbines represent one of the most significant engineering challenges in wind energy at present. Since current fixed-bottom technology can support deployment up to water depths of about 30 m (shallow waters), the technology is now moving towards deeper waters, where the wind resource is extremely abundant. In this regard, single and multi-turbine floating platforms are now being actively investigated.

This paper presents the results of a wind tunnel experimental campaign conducted with the scaled model of a square-shaped floating platform equipped with four wind turbine models located at its corners. The scaled wind turbines feature pitch, torque and yaw control, and are equipped with sensors measuring all main operational parameters, including rotor and tower loads. The models also provide a realistic energy conversion process, due to similar rotor aerodynamic performance, loads, and wake characteristics between the scaled and full scale machines. The pitch floating motion of the scaled platform is obtained by a custom-designed one degree-of-freedom actuator, capable of performing specific motion laws simulating different wave conditions.

Measurements are taken to characterize the wake, including the quantification of wake interference on downstream machines. The potential effect of yawing and derating the upstream wind turbines is then investigated in terms of overall power production.

INTRODUCTION

Energy from wind is the source that has seen the largest increase in capacity over the last years, and this trend is likely to continue. The development of offshore wind turbines has enabled the exploitation of the wind potential available on the sea, while at the same time it offers a solution to the problem of scarcity of vacant good quality sites, which mainly exists in Europe. The concept of Floating Offshore Wind Turbines (FOWT) has gained considerable attention, as it may allow for the exploitation of the stronger and more consistent wind speeds available in waters deeper than 50 m, while reducing the impacts of onshore or near-offshore solutions.

Much research has been done to improve the design of individual FOWTs, and in fact some prototypes have already been produced and tested in the open sea (Liu et al., 2015). Interest is also emerging towards multi-turbine floating wind power platforms (Ayotte, 2015) and hybrid wave&wind multi-turbine floating platforms (Kim et al., 2015).

A distinguishing characteristic of these systems is that there is not only a complex interaction between the atmospheric flow and the wind turbines, but also among the wind turbines themselves. Indeed, the wakes shed by the upwind wind turbines affect the power and loads of downstream machines. In this sense, wakes represent a major form of coupling within the power plant. In addition, the platform dynamics will affect the wind turbine response, modifying performance and loads. It should however be remarked that such large floating platforms will have a ratio between platform and wind turbine inertia that is significantly larger than the one for other semi-submersible systems. It is therefore expected that the floating platform dynamics will not be signif-