Fully Coupled Dynamic Analysis of a Floating Wind Turbine System

by
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Abstract

The use of wind power is in a period of rapid growth worldwide and wind energy systems have emerged as a promising technology for utilizing offshore wind resources for the large scale generation of electricity. Drawing upon the maturity of wind turbine and floater technologies developed by the wind energy and oil and gas industries, respectively, large offshore wind energy systems have been developed and are being proposed for operation in offshore areas where environmental restrictions are less restrictive, large wind resources exist, and open sea areas are available for wind farm development.

A fully coupled dynamic analysis technique was developed to predict the response of a floating wind turbine system in a stochastic wind and wave environment. This technique incorporated both non-linear wave loading on the submerged floater and the aerodynamic loading on the wind turbine. A tension leg spar buoy was designed to support the wind turbine. This design was chosen due to its relatively small size and hence lower potential cost per wind turbine. The system's tethers were attached to the ends of spokes which radiated out from the spar cylinder. This arrangement of lines and spokes promised to be very stiff in the roll and pitch modes of motion.

The fully coupled analysis technique was used to evaluate the feasibility of the chosen floater design. Damping properties of the combined floater / wind turbine system were determined by conducting simulated free decay tests for the different modes of motion and wind turbine operating conditions. Numerical simulations for operational conditions were also carried out. The response of the floating wind turbine to three different sets of environmental conditions was determined and compared to a fixed base system. Additional simulations were conducted to determine extreme wind and wave event response. Stiffness of the floating system in roll and pitch was found to be a desirable attribute. The results of the analysis demonstrated that the tension leg spar buoy has the potential to support a wind turbine in an offshore environment without adversely affecting the loading on the system components.

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