Numerical simulations of the wind-loaded floating solar photovoltaic array systems with different layout patterns

MARINE 2023

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ABSTRACT

The floating photovoltaic system is a promising application of solar photovoltaic. However, wind loading is a significant concern for floating solar photovoltaic array systems, especially those that are subject to great drag and lift under severe typhoon weather, which may cause a drag-driven or lift-driven instability for the floating photovoltaic system. Thus, it is necessary to evaluate the wind resistance of the upper photovoltaic structure under wind load. In this study, computational fluid dynamics (CFD) is performed to examine the flow characteristics over solar photovoltaic arrays mounted on a floating structure for six different configurations. Firstly, the mean and peak values of drag and lift coefficients obtained from numerical simulation and wind tunnel experiments are compared to validate the accuracy of numerical simulation. Then the unsteady flow fields over solar photovoltaic arrays are discussed to explain the difference in wind resistance for different arrangement structures, including velocity distribution, pressure distribution, vorticity, lift resistance coefficient, and lift torque. It is found that the wake vortex of the array photovoltaic panel consists of two patterns of vortex structure, which affects the pressure distribution around the photovoltaic panel. Regardless of the arrangement, the first photovoltaic panel always experiences higher wind loads than other photovoltaic panels. Furthermore, the lift direction is sensitive to the layout of the photovoltaic panels. Considering a single wind direction, the arrangement of array c is recommended, otherwise array b due to its symmetry, which can be used as guidelines for the design of a floating photovoltaic array system layout.

Key words: Floating solar photovoltaic array, Computational fluid dynamics, Numerical simulation, Wind pressure coefficient, Wind force coefficient.