XI International Conference on Computational Methods in Marine Engineering

Wake interaction for different tandem vertical axis wind turbine types

I. Marinić-Kragić[1,*], D. Vučina[1], I. Pehnec[1]

[1] Department of Mechanical Engineering, FESB,
University of Split, 21000 Split, Croatia.

[*] Corresponding author email: imarinic@fesb.hr

ABSTRACT

The aerodynamic interactions among offshore vertical axis wind turbines (VAWTs) located close together can significantly enhance their power performance, and understanding the wake dynamics in offshore hybrid VAWT configurations presents opportunities for improvement [1]. The wake of a single VAWT is shown in the figure 1, using a hybrid RANS-LES turbulence model.

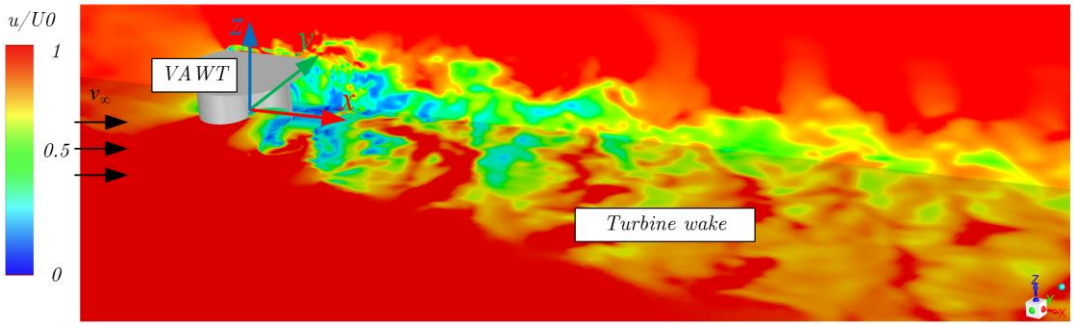

Figure 1. Wake of a vertical axis wind turbine using hybrid RANS-LES turbulence model.

This study explores the wake interactions between two VAWTs arranged in tandem, focusing on three rotor types: Savonius (drag-based), Darrieus (lift-based), and a hybrid design that combines both [2]. Three-dimensional computational fluid dynamics (CFD) simulations utilizing a hybrid RANS-LES turbulence model were conducted to resolve the transient wake structures and quantify the power coefficients of both upwind and downwind turbines. The hybrid model leverages the precision of LES in wake regions and the computational efficiency of RANS near the rotor surfaces. Results indicate that the upwind turbine's rotational direction critically affects the downstream turbine's performance. For the Darrieus and hybrid configurations, a counter-rotating arrangement (relative to the incoming wind vorticity) enhances the downwind turbine's power coefficient by up to 15% compared to co-rotating setups. This improvement results from reduced wake turbulence and favourable vortex shedding patterns that accelerate flow recovery for the downstream rotor. Conversely, the Savonius turbine shows slightly less sensitivity to rotational direction by 8–12%. The RANS model [3] results were also given, and they give about 10-20% lower power coefficient predictions. This work offers valuable insights for optimizing VAWT array designs to capitalize on synergistic wake interactions.

References

[1] B. Belabes and M. Paraschivoiu, "CFD modeling of vertical-axis wind turbine wake interaction," *Trans. Can. Soc. Mech. Eng.*, vol. 47, no. 4, pp. 449–458, Dec. 2023, doi: 10.1139/tcsme-2022-0149.

[2] J. Pan, C. Ferreira, and A. van Zuijlen, "A numerical study on the blade–vortex interaction of a two-dimensional Darrieus–Savonius combined vertical axis wind turbine," *Phys. Fluids*, vol. 35, no. 12, Dec. 2023, doi: 10.1063/5.0174394.

[3] A. Barnes, D. Marshall-Cross, and B. R. Hughes, "Validation and comparison of turbulence models for predicting wakes of vertical axis wind turbines," *J. Ocean Eng. Mar. Energy*, vol. 7, no. 4, pp. 339–362, Nov. 2021, doi: 10.1007/s40722-021-00204-z.