Numerical Investigation of Layout Configurations for Diff Vertical Axis Wind Turbines

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Introduction

Vertical axis wind turbines (VAWTs) are promising for urban and low-wind environments due to their ability to operate under multidirectional flow conditions.

However, turbine performance in wind farms strongly depends on wake interaction and spatial arrangement.

This study aims to investigate the influence of turbine layout and rotor design on aerodynamic performance using CFD simulations.

Methodology

A three-dimensional CFD model was developed in ANSYS Fluent to simulate aerodynamic interactions between vertical-axis wind turbines.

Four rotor configurations were analyzed:

- Three-bladed H-Darrieus
- Four-bladed H-Darrieus
- Asymmetric rotor
- Troposkien Darrieus

Three array layouts were considered:

- Linear
- Staggered
- Diagonal

The turbines were placed in a computational domain with a spacing of 5D between rotors to capture wake interaction effects.

Simulations were performed at a wind velocity of 10 m/s using the SST k–ω turbulence model and a sliding mesh approach.

Aerodynamic performance was evaluated using moment coefficient (Cm) and power coefficient (Cp).

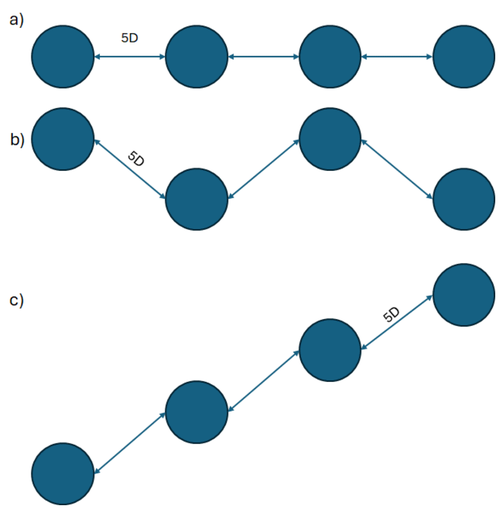

Fig.1. Schematic representation of turbine array configurations: (a) linear, (b) staggered, (c) diagonal arrangement.

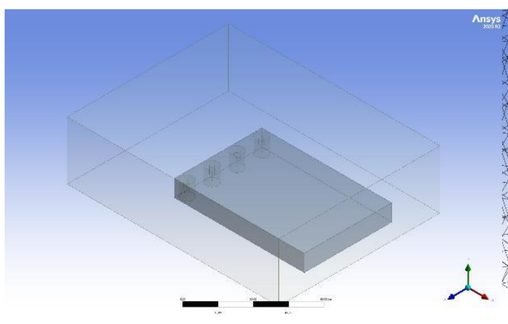

Fig.2. Computational domain and arrangement of vertical-axis wind turbines in the simulation

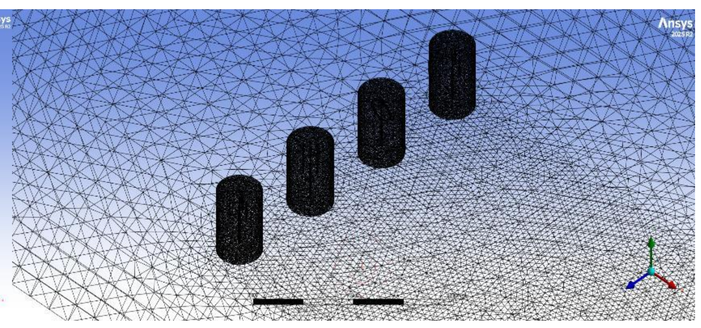

Fig. 3. Computational mesh of the turbine array with local refinement around the rotors

Results

The results show that the influence of turbine layout depends on rotor type.

For three-bladed and troposkien turbines, layout variation has minimal impact, indicating stable aerodynamic performance.

For asymmetric and four-bladed turbines, the staggered configuration reduces performance by up to 12% due to stronger wake interaction.

Flow visualization shows that:

- Linear layout → uniform wake
- Staggered → increased turbulence and wake overlap
- Diagonal → reduced interaction and improved flow distribution

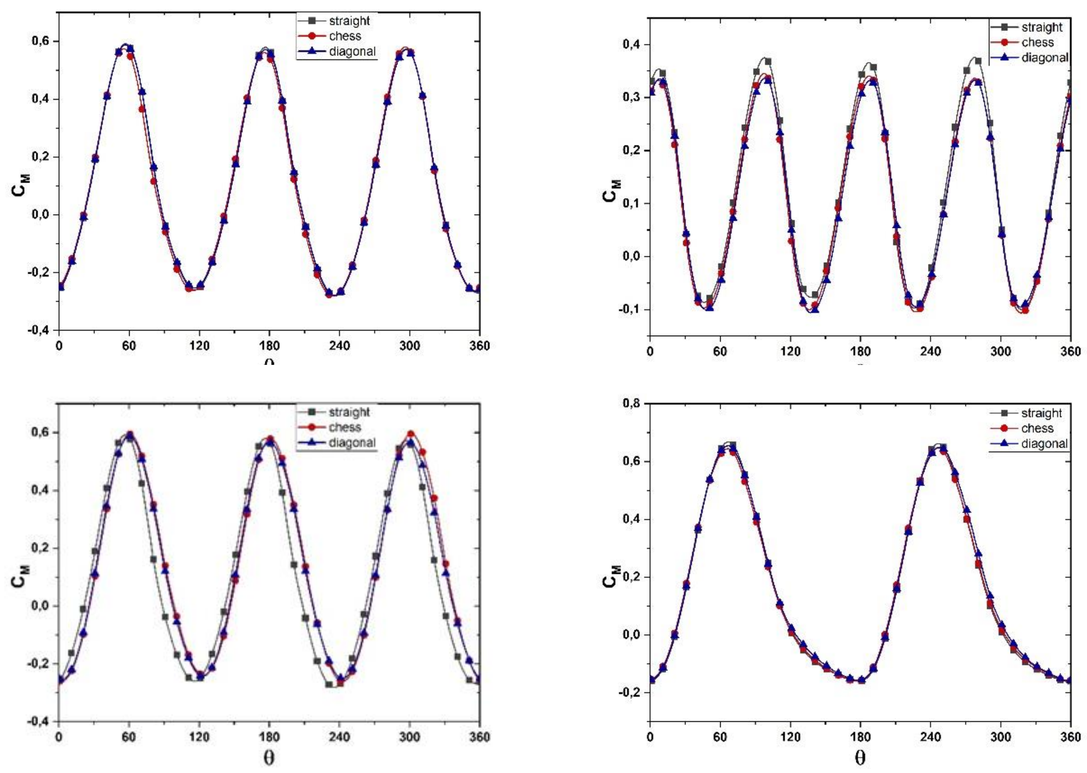

Fig 4. Moment coefficient (Cm) for different VAWT rotor configurations under various array layouts

Conclusion

Both rotor design and array configuration significantly influence the aerodynamic performance of VAWTs.

Troposkien turbines demonstrate the highest efficiency (Cp ≈ 0.31–0.33).

Staggered layouts negatively affect performance due to wake interference, while diagonal configurations provide more favorable operating conditions.

These results are important for optimizing VAWT wind farm layouts.

Acknowledgements

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