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2D comparative study of Vertical Axis Wind and Tidal Turbines with a *p*-adaptive Hybridizable Discontinuous Galerkin method and ANSYS Fluent

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ABSTRACT

During the last decade, the installed wind-power capacity in Spain has continuously increased and wind energy has become the third source of energy production. Vertical-axis wind turbines (VAWT) are regarded as an alternative to horizontal-axis wind turbines because of two attractive basic properties: they are cheaper in terms of installation and maintenance, the rotor and the generator are installed at the base of the mast, and they are less sensitive to air turbulence and wind direction. In this context, special attention is needed on the analysis of new designs of VAWT with increased performance. Tidal turbines have also seen increasing interest from academia, industry and government bodies, during recent years, as offshore sites present huge energy potential.

For such a demanding technological application, numerical methods with higher accuracy than the standard first or second-order methods are an asset in order to allow a high-fidelity computation of the aerodynamic loads. In this work, several 2D designs of vertical-axis turbines are studied. On one hand, a *p*-adaptive Hybridizable Discontinuous Galerkin (HDG) method is used to solve this incompressible Navier-Stokes problem [1, 2]. The HDG method allows to drastically reduce the coupled degrees of freedom of the computation, seeking for an approximation of the solution that is defined only on the edges of the mesh. The discontinuous character of the solution provides an optimal framework for a *p*-adaptive technique. *P*-adaptivity further reduces the number of degrees of freedom in the HDG computation by means of *p*-refining only where more precision is needed. This method is used along with a coordinate transformation that attaches the coordinate system to the rotating blades [3]. On the other hand, the second-order finite volume method of ANSYS Fluent v13.0 is used to validate and complete the obtained results.

The influence of the number of blades and of the chosen NACA profiles is studied. For each case, the obtained torque and the resulting power are studied as a function of the Tip-Speed Ratio.

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