

Comprehensive Verification and Validation of OpenFAST for Horizontal Axis Marine Hydrokinetic Turbine Modeling

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OpenFAST is a widely utilized legacy tool designed for wind and marine turbine modeling and analysis. This study presents preliminary findings from model verification & validation (V&V) efforts for marine hydrokinetic turbine modeling to ensure user confidence in model predictions for loads, power performance and wake dynamics. Model verification includes assessments of numerical sensitivity, such as the dependence on time-step size, discretization through variations in node and panel counts, and numerical convergence criteria for computational methods within OpenFAST. Additional verification efforts involve code-to-code comparisons between two-dimensional panel method-based predictions and unsteady Reynolds-averaged Navier Stokes (URANS) CFD simulations for hydrofoil polars (lift, drag, minimum pressure, and pitching moment), which are critical components for hydrodynamic load estimation within the OpenFAST model. Validation is conducted by comparing OpenFAST model predictions against published experimental data. This data includes measurements obtained from a water tunnel test of a 1:8.7 scale model of the 5.0-meter-diameter U.S. Department of Energy's Marine Hydrokinetic Family 1 (MHKF1) reference marine turbine rotor, as well as measurements from a 1.6 m diameter turbine tested during the blind prediction stage of the Tidal Turbine Benchmarking Projects conducted by the UK's Engineering and Physical Sciences Research Council (EPSRC) and Supergen Offshore Renewable Energy (ORE) Hub. These dataset encompass rotor loads, power performance, blade bending moments at the blade root and along the blade span, cavitation potential, and wake flow. Although existing experiments provide high-quality measurements, they often require corrections for blockage or flow confinement effects inherent in scaled-model testing setups, introducing further complexity to the validation process. These comprehensive verification and validation strategies serve to enhance confidence in OpenFAST's capability to accurately predict loads, performance characteristics, and wake dynamics for marine hydrokinetic turbine applications.

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