Comparison of two simplified turbine models for numerical turbine array simulations

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To improve the energy extraction efficiency of hydrokinetic turbine farms, it is necessary to study the performance of different turbine array configurations. However, predicting and analyzing the performance of turbine arrays using high-fidelity blade-resolved simulations is unrealistic due to excessive computational cost. A solution to reduce computational demand while maintaining realistic performance predictions and accurate representation of flow physics is to use simplified turbine models. This work presents a comparison between two simplified modeling approaches developed at Laval University for Cross-Flow Turbines (CFT): the Actuator Line Method (ALM) and the Effective Performance Turbine Model (EPTM). Both approaches consist of representing the real rotor by equivalent volumetric forces, thus bypassing the resolution of the blades and their boundary layers. The ALM is an unsteady method that allows to compute, at each time step, the force distribution to be applied along the span of the turbine's blades. Thus, this method enables to reproduce accurately the local impact of the blade on the flow field and to generate realistic near wake structures. On the other hand, the steady-state EPTM imposes time-averaged blade forces within an annular cylindrical actuating region to reproduce the mean effects of the rotor on the flow, which allows to predict the mean turbine performance and to generate a reasonably accurate mean wake. Compared to the EPTM, the ALM is of higher fidelity, capturing more physical details, but computationally more expensive.

One of the optimal configurations of a triangular three-turbine cluster is simulated using both approaches. In this presentation, the two methods are evaluated and compared in terms of the prediction of key performance metrics (i.e., power and drag coefficients) and in terms of their wake reproduction capability. Recommendations for turbine farm analysis will be formulated.

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