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# Modelling of hydrokinetic turbine farms using simplified numerical approaches

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ABSTRACT

Hydrokinetic turbines extract energy directly from the free stream of tidal currents or river flows to generate electricity, which is referred to as hydrokinetic energy. Though hydrokinetic energy technologies are analogous to those of wind energy which have been well studied over a longer time, the two sectors differ on some fundamental aspects such as the intrinsic flow confinement in water applications, the presence of a deformable free surface on top, and the higher predictability and regularity of water currents. For the sake of harnessing energy on the regional scale and maximizing energy production, hydrokinetic turbines may be deployed in large arrays at proper sites in rivers or tidal channels. However, the interactions among the turbines and their wakes as well as the impact of the deployment on the water resource itself make the study of turbine arrays much more than a simple superposition of multiple isolated turbines. It is thus essential to understand the dynamics in turbine farms and to optimize the array layouts in such a way as to avoid detrimental impacts on turbine performance and on the environment.

To this end, the *Effective Performance Turbine Model* ("EPTM", see Bourget, Gauvin-Tremblay, Dumas in Trans. CSME 42, 2018), as a steady-state actuator-type simplified model implemented in Reynolds-Averaged Navier-Stokes simulations, has been proved to be a promising tool for this purpose (Gauvin-Tremblay & Dumas, Ren. Energy 181, 2022). The EPTM approach is adaptable and is able to reproduce the time-averaged performance and wake characteristics for all kinds of hydrokinetic turbines by applying specific, technology-dependent, non-uniform momentum source terms in the fluid domain. Since the performances are scaled with a local velocity, the EPTM responds intrinsically to the local inflow and blockage conditions associated to the bathymetry of the site and the presence of the other neighboring turbines. In this way, the EPTM allows rapid reliable predictions for array performance in realistic flow conditions, taking into account the aforementioned complex interactions. Comparison among several array configuration tests shows that optimal array layout varies according to the specific turbine technology considered which underlines the necessity for the accuracy and fidelity of the simplified turbine representation in the analysis of hydrokinetic turbine farm deployments. Arrays of axial-flow turbines and of cross-flow turbines (deployed vertically and horizontally) will be illustrated and discussed in the presentation.