

Simplified Turbine Modeling Approach for Array Optimization

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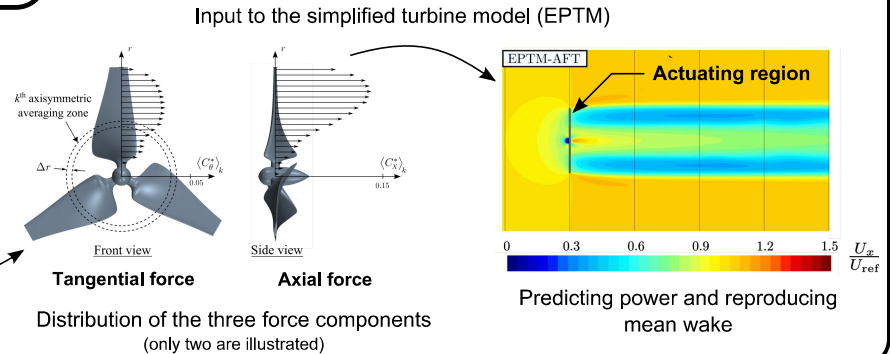
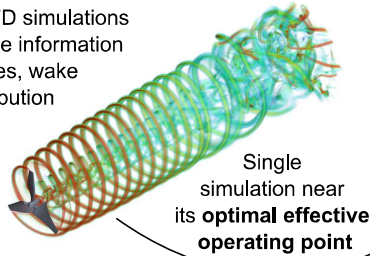
Context

In order to maximize the energy extraction from tidal and river currents at specific sites, it is considered to deploy hydrokinetic turbines in array. In doing so, turbines may experience different types of interaction, changing the local flow conditions and thus their performances. Since high fidelity CFD of the whole array with all its turbines is out of reach, a simplified turbine modeling approach allowing array optimization at an affordable cost has been developed.

EPTM : Effective Performance Turbine Model

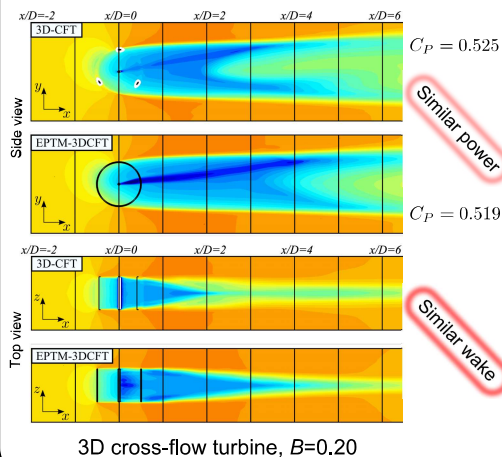
High fidelity CFD simulations provide valuable information on performances, wake and force distribution at different tip speed (TSR) and blockage ratios B .

$$B = \frac{A_{\text{turbine}}}{A_{\text{channel}}}$$



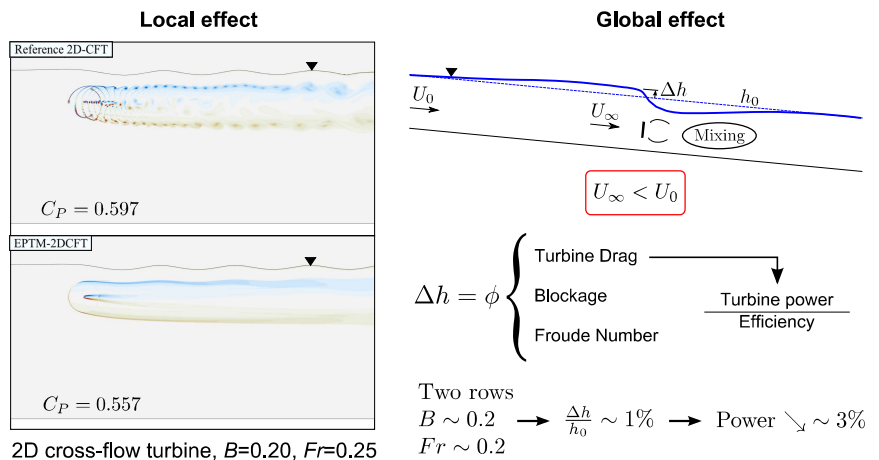
Different technologies

Adaptable to **any type of turbine**: axial-flow or cross-flow turbine.



Free-surface effects

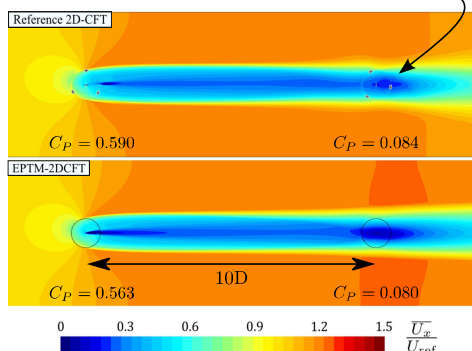
The EPTM captures the effects of the free surface on the turbine.



Perturbed flow

EPTM reproduces turbine-wake interaction.

Perturbation level to avoid (in 2D flow)!



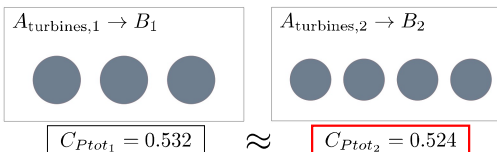
Turbine array simulations

Axial-flow turbines with **equivalent frontal areas**

$$A_{\text{turbines},1} = A_{\text{turbines},2}$$

$$B_1 = B_2 = \frac{A_{\text{turbines}}}{A_{\text{channel}}} = 0.20$$

Front view



Financial support from the Natural Sciences and Engineering Research Council of Canada (NSERC) and computing resources provided by Compute Canada are gratefully acknowledged.

Key points

- EPTM: simplified modeling approach to reproduce turbine behavior at low cost
- Adaptable to any type of turbine technology
- Single set of force distributions for any blockage conditions
- Good power prediction as well as wake reproduction
- Captures local and global free-surface effects
- Allow to develop guidelines for turbine placement and to optimize array configurations