CFD ANALYSIS AND OPTIMISATION OF TIDAL TURBINE ARRAYS USING OPENFOAM

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Tidal energy has the potential to make a signicant contribution to renewable energy generation resources in many countries. Because of the regularity of tides coupled with the high energy density of water currents, tidal stream generation presents signicant advantages over more intermittent resources such as wind, and lower energy density resources such as wave power. The UK is particularly well placed to exploit tidal energy with an estimated 95TWh/yr tidal stream resource concentrated in about 10 locations, including the Severn estuary and Solway firth. Esturine sites such as these offer a combination of high resource and relatively benign environment (compared with marine installations), but the shallow water environment indicates that GW-scale exploitation is likely to involve the installation of arrays of 100s of small scale turbines. Such arrays will require optimisation to maximise energy extraction through the tidal cycle and maximise the important return on investment (ROI).
Computational Fluid Dynamics (CFD) provides a valuable tool for investigating the hydrodynamics of in-dividual turbines at all levels of detail from full moving blade modelling to simpler actuator disk modelling. We present simulations of a novel cross-flow turbine known as the Lift-Drag turbine using OpenFOAM, simulating the full blade motion using GGI. Based on this and on experimental data we derive a lower cost empirical model; the Immersed Body Force (IBF) model and implement this in OpenFOAM[1, 2]. The latter enables us to compute small arrays of 7-15 interacting turbines [3]. For larger arrays, we apply surrogate modelling, using Kriging to create a low cost model of an innite array, which can then be used within a Genetic Algorithm to optimise the power generated and array cost, based on proxies such as array area. The same methodology is also applied to an array of HAWT turbines using Actuator Disk modelling.

References

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