Assessment of Tidal Stream Energy Resources in the UK Using a Discontinuous Galerkin Finite Element Scheme

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The scope of this research is to accurately evaluate the potential energy resource of tidal stream energy. The starting point for this is to develop and validate a model of the naturally occurring tidal dynamics. Once the undisturbed basin has been modelled, it is necessary to extract energy from the basin to represent the effect of tidal turbines. Thus, changes to the tidal dynamics may be evaluated and an accurate estimate of the available energy may be made.

One approach to modelling this energy dissipation is to include an additional bed-shear stress into the problem [1]. This has the effect of smearing out the thrust applied by the turbine over the area of an element and thus may require very refine mesh which can lead to numerical stability problems. An alternative approach is to represent the turbine by a line discontinuity where the upstream and downstream heads are related by an appropriate theory [2]. A suitable candidate is Linear Momentum Actuator Disc Theory (LMADT), which gives the change in head across the turbine in terms of the upstream Froude number, blockage ratio and wake induction factor [3].

The present paper deals with the implementation of such a scheme into a discontinuous Galerkin model (DG-ADCIRC), which has been undertaken as part of the PerAWaT project commissioned by the Energy Technologies Institute. Numerical flux calculation has been altered using a momentum sink defined by LMADT for the selected internal edges that represent the tidal turbines. The scheme is validated against analytical solutions and existing numerical solutions for various idealized geometries. Comparisons are made between results derived using an enhanced bed friction model and line sink of momentum to extract energy, both for near-field and far-field changes to the tidal dynamics. The Anglesey Skerries region has been selected as a candidate headland area to apply the line sink of momentum model in order to evaluate the potential power that can be extracted by conceptual tidal turbines and to investigate the change in the flow characteristics.

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