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Tidal range energy: assessment, optimisation and continuous generation options

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Tidal power plant proposals present significant opportunities to deliver a large-scale supply of sustainable energy to the national grid. However, in order to be approved, designs need to demonstrate their competitiveness in comparison to other renewable energy options. They also need to limit or mitigate against hydrodynamic impacts that pose a threat to sensitive estuarine hydro-environmental conditions. As a result, together with a lack of a standardised and proven methodology to benchmark the designs, preceding efforts to harness vast untapped tidal energy resources through barrages were dismissed on the grounds of economic and environmental feasibility uncertainties.

In this work, *Thetis*, a coastal ocean modelling framework based on the finite element engine Firedrake, has been coupled with tidal power plant operation and optimisation algorithms and is applied in a number of case studies towards:

- Quantifying the performance and hydrodynamic impact of tidal range structures including proposals for tidal lagoons and barrages in the UK. Here we consider an adaptive operation over time that aims to maximise the electricity output over variable spring-neap tidal conditions.
- Modelling and assessing the potential of a twin-basin tidal lagoon system that aims to reduce the variability of the tidal energy output, particularly during spring tidal conditions. Twin-basin tidal power systems have been discussed previously but little has been reported in terms of their performance relative to conventional tidal power plants.

In these case studies we will demonstrate how refinements in modern coastal ocean modelling capabilities enable plant operation simulations that yield insights to the energy output and hydro-environmental impacts of conventional as well as alternative tidal range structure options. It will be shown that advanced optimisation techniques can be used to deliver significant increases in energy yield over standard unoptimised operation.