

Tidal Stream Energy Resource Assessment of the Pentland Firth: Practical and Accessible Constraints

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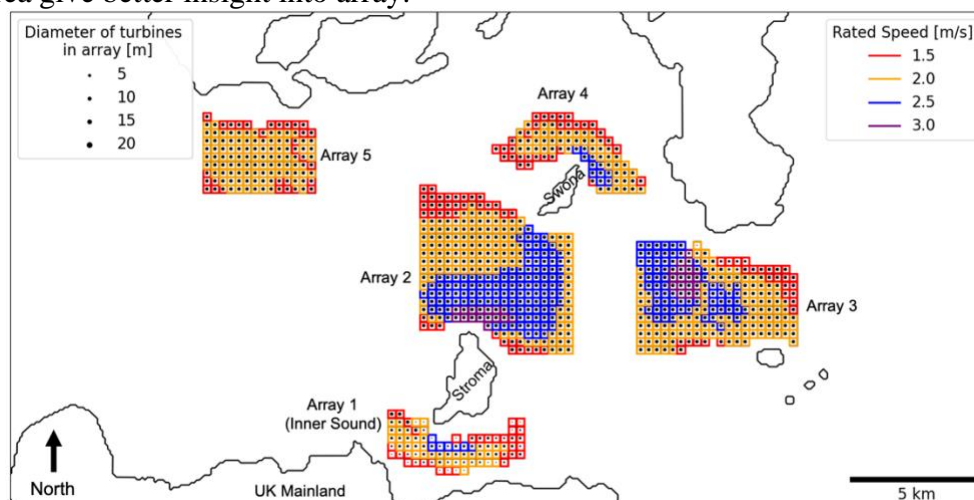
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Abstract: With limited areas suitable for tidal stream energy development, it is important to consider the interactions between distinct arrays in close proximity. There is a risk of negative interactions between independent arrays located nearby if they are not developed successively or collaboratively, which can lead to an overall reduction in their power potential. The Pentland Firth is a major site of interest for tidal stream energy development and in 2010 four lease sties were agreed by the Crown Estates and leased to four developers. Three leases were withdrawn by 2015, leaving the Inner Sound as the only site being actively developed by Meygen, with Phase 1 already operational. One lease has been reinstated but is in pre-planning stages. The lease sites have the potential to be updated as seabed usage is re-prioritised.

In this work, a resource assessment is conducted of the Pentland Firth, considering additional arrays in high resource areas to the development in the Inner Sound. The arrays are deployed sequentially with the assumption that the Inner Sound is the first development, considering its preeminent status. A heterogeneous array design framework is implemented to consider practical limitations on the resource, such as bathymetry and spatially variable velocity across the site. The framework defines the diameter and rated speed of the turbines based on bathymetry and flow field data. Successive arrays are defined using the flow field of the previous deployment strategy to account for effects of the increasing scale of developments.

Deploying turbines beyond the Inner Sound leads to constructive effects for Array 1 and up to 15% increase in power averaged over the Spring-Neap cycle. The average capacity factor of the arrays is between 40-50%, depending on the number of independent arrays deployed. The incremental average power with each additional array decreases. However, with varying numbers of turbines and installed capacity in each array the average power per turbine and per swept area give better insight into array.



Heterogeneous arrays across the Pentland Firth. The maximum diameter of turbines allowable in each array indicated by the size of inner the black circle and the rated speed indicated by the edge colour.