Resource Assessment of Tidal Current Energy and Hydrodynamic Impacts of the Energy Extraction in the North Sea

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Abstract

A model study was carried out of the resource assessment of tidal current kinetic energy in the North Sea and the possible hydrodynamic impacts of the energy extraction in the Pentland Firth by a potential tidal turbine array, with the three dimensional baroclinic ocean model HAMSOM simulating from 2010 to 2013. Even though currents in the North Sea are mainly dominated by tidal streams, still the model took the wind-driven and density-driven currents into account. The resource assessment suggests the Pentland Firth possesses the most abundant energy density in the study region, over 12 kW m^{-2} of the averaged power density in 2013, which indicates it is a potential suitable site for tidal current energy extraction. The virtual setting of 900 MW scenario and a massive energy extraction to 9 GW scenario were selected to study the far-field and regional impacts on hydrodynamics under different energy extraction levels. The 900 MW scenario suggests minor effects on sea levels, velocity fields and energy redistribution, while the massive energy extraction scenario suggests significant effects could spread over hundreds of kilometers away from the deployment site, with the maximum changes of up to 0.3 m s^{-1} reduction in current velocity and 25% loss of initial energy. The impact on sea levels is very small, but it could propagate over the whole North Sea, and indicates that the turbine array might have a negative influence on tidal amplitudes. Moreover, the averaged energy extraction efficiencies for both scenarios are approximately 30%, with a little higher for the case when more tidal turbines are included.