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Assessment of the hydrodynamic impacts and the performance of a commercial scale tidal farm in the Strait of Larantuka, Indonesia

Kadir Orhan (1) and Roberto Mayerle (2)

(1) Research and Technology Centre, University of Kiel, Kiel, Germany (korhan@corelab.uni-kiel.de), (2) Research and Technology Centre, University of Kiel, Kiel, Germany (rmayerle@corelab.uni-kiel.de)

Anthropogenic climate change requires an effective and appropriate response, with a view to accelerating the reduction of global greenhouse gas emissions. The ocean provides a vast source of potential energy resources, which can be utilized without inflicting any considerable damage to the global ecosystem. To this end, the conversion of tidal current power is recently growing up to a crucial sector of the ocean renewable energy. Previously, tidal stream resources of several straits between the Indian Ocean and inner Indonesian seas have been investigated, and results have revealed that tidal current power potential of Indonesia is likely to exceed 5,000MW (Orhan et al., 2016). In this study, a methodology for evaluation of the hydrodynamic impacts and the performance of a commercial scale tidal farm is described, and results of an application carried out at the Strait of Larantuka, Indonesia are summarized. Current speeds in the Strait of Larantuka reach about 3-4m/s and total extractable power from tidal currents is around 300MW (Orhan & Mayerle, 2017). A high-resolution, three-dimensional flow model providing sufficient spatiotemporal coverage has been developed for predictions. Much attention has been given to the meteorological forcing and conditions at the open sea boundaries to adequately capture density gradients and flow fields in the computational domain. The model has been verified using tidal records. The energy of the tidal currents in the strait is assumed to be removed by 65 horizontal-axis tidal turbines with rotor diameters of ca. 15m, positioned on 10 sequential rows and in an alternating downstream arrangement. An additional drag force dissipating 40% of the pre-existing kinetic power within a flow cross-section is introduced to account for the drag of the devices. A second-order turbulence closure model (k-ε) is selected to involve the effects of the turbulent kinetic energy and turbulent kinetic energy dissipation. Spatial variation of the average kinetic power density within and around the farm area and average extractable electric power by each device are determined. In particular, characteristics, recovery and interactions of the turbine wakes are resolved in detail. Results show temporary energy dissipations in the downstream of the turbines, which seem to recover after each row in a distance equal to approximately ten times the rotor diameter. It is also seen that in a narrow channel such as the Strait of Larantuka, installation of the devices mid-channel can cause increased current velocities over the slopes on both sides, which can result in erosion of the seabed and increasingly turbulent flow conditions affecting the power generation. In light of the findings and considering the physical constraints, a suitability ratio is proposed to optimize the locations for the installation of tidal stream turbines.