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Numerical evaluation of wave energy absorption and performance of a selection of wave energy converters in southern sea conditions of Sri Lanka

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Ocean wave energy is undoubtedly the next crucial step in Sri Lanka's energy sector. The abundance of this source of green energy, mainly in the Southern seas of Sri Lanka, has been identified and estimated in a handful of preliminary studies. In the present work, three wave energy converters are numerically modelled with the objective of estimating annual average electrical power and variations in seasonal average electrical power. A 1-body point absorber, 2-body point absorber, and an oscillating surge flap are simulated in sea conditions native to Tangalle, Galle, and Matara generated using measured and re-analysis data. The selection of the devices is mainly based on the depth of the location at which the data is available. The open-source numerical wave energy converter simulating software WEC-Sim is used as the dynamic equation solver, while the open-source Boundary Element Method code NEMOH is used to calculate hydrodynamic parameters. The power take-off is modelled as a linear spring-damper system in all three cases. A damping coefficient optimisation procedure is carried out using samples drawn from each set of data in which a comparative analysis was done to select the damping values that give the maximum power output. Under the optimised damping conditions, mechanical power matrices are generated which are then converted to electrical power matrices using a PTO efficiency conversion factor. Annual and seasonal average power outputs are calculated utilizing both electrical power matrices and joint probability distributions of sea states. The electrical power matrices generated for the 2-body point absorber, and oscillating surge flap are a clear indication that both the devices are naturally tuned to the dominant wave frequencies of tested locations, while the 1-body point absorber is tuned to sea states with lower periods. The highest output power is observed for oscillating surge flap, the second highest for the 2-body point absorber, and the lowest for the 1-body point absorber. The variation of the seasonal average power is significant over the four climatic seasons of Sri Lanka. The highest power observed in South-West monsoon is more than twice the lowest observed in North-East monsoon. The calculated annual average power and seasonal average power outputs are a clear indication of Sri Lanka's potential for wave energy harvesting, although the greater variation in seasonal average power poses a considerable challenge.

Keywords: Damping optimisation, Green energy, Point absorber, Sri Lankan seas, Wave energy