Experimental Investigation of Heterogeneous Wave Energy Converter Arrays: Open-Source Data and Performance Comparisons

Comprehensive, open-source, experimental data for wave energy converter (WEC) arrays is scarce throughout the marine energy industry. Few datasets exist, and those that do are missing crucial data for model validation, such as the complete radiation force interaction matrix. Additionally, most array studies consider farms made up of WECs of a single design. Some studies numerically investigate WECs with varying dimensions or geometries within the same array, but none have examined the integration of WECs operating in different degrees of freedom within the same array. This work investigates heterogeneous arrays consisting of heaving point absorbers (PAs) and oscillating surge WECs (OSWECs). Eight machines were constructed and transported to the O.H. Hinsdale Directional Wave Basin at Oregon State University (OSU). Preliminary numerical models guided the investigated array configurations, finding heterogeneous designs that should outperform their homogeneous counterparts. A 4-body array consisting of two OSWECs and two PAs was chosen for testing. They will undergo wave excitation, forced oscillation, regular wave (with and without power take-off engaged), and random wave tests over a slew of wave frequencies, headings, and amplitudes–totalling to 80 tests. The homogeneous counterparts (4-body arrays of all PAs or all OSWECs) will undergo the regular and random wave tests to compare mechanical and electrical power production.

Details of the mechanical build and electronics configuration will also be detailed. For mechanical, this includes Froude scaling analysis, material selection, designing for resonance, viscous drag modeling, and minimizing failure modes (bearing and gear force analyses). For the onboard electrical system, the developed software (controls, data logging, etc.) and specific hardware selections will be included, with links to the open-source GitHub repository. In addition to the onboard electrical system data acquisition, which will collect motor current, voltage, and position and static torque in the powertrain, OSU will provide data from their Qualysis Motion Capture system for device motion in 6 degrees of freedom. OSU will also provide 20 wave gauges to obtain free surface wave elevation measurements throughout the basin.

The prototypes are a 1:50 scale, and operating conditions were carefully selected such that deep water wave regime assumptions hold in the basin. Targeted results are the wave excitation force on each device, the full radiation force matrix (obtained through forced oscillation tests), mechanical power production (regular waves, PTO disengaged), electrical power production (regular and random waves, PTO engaged), the total free surface elevation, and the isolated diffracted, radiated, and incident wave fields. The experiments are in progress and will complete on April 9th, 2025. The data will be post-processed, available on PRIMRE, and presented at UMERC 2025. This work was funded through the TEAMER program RFTS 12.