Case Study: The Incorporation of Real-Sea Buoy Data and Environmental Impact into Wave Energy Converter Array Optimization

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Topic: How will real, sea-state data (including varying wave direction) influence the configuration of optimized wave energy converter layouts?

Background:

Currently, ocean wave energy is a novel means of electricity generation that is projected to potentially serve as a primary energy source in coastal areas. However, for wave energy converters (WECs) to be applicable on a scale that allows for grid implementation, the devices will need to be placed in close relative proximity to each other. From what's been learned in the wind industry of the U.S., the placement of these devices will require optimization considering both cost and power. However, current research regarding optimized WEC layouts only considers the power produced.

Our ongoing work explores the development of a real-coded genetic algorithm (GA) that generates optimized WEC layouts with an objective function that considers both the economics involved in the array's development as well as the power produced. The WEC optimization algorithm enables the user to either constrain the number of WECs to be included in the array, or allow the algorithm to define this number. To evaluate the objective function, potential arrays are evaluated using cost information from Sandia National Labs Reference Model Project, and power development is calculated such that WEC interaction effects are considered.

In addition to the power and cost, we would also like to include environmental impact as an influencing factor. At this stage, the primary quantifiable impact that an array may have on its local environment is sediment transport based on how an array affects the wave field in the far field. There are models currently being developed that can hopefully be incorporated into our optimization algorithm in the near future.

It has been found that the sea state experienced by an array will greatly influence the the optimal layout. At this point in the research, a representative random sea state (using a Bretschneider Spectrum) has been used to demonstrate the capability of the created algorithm, but for location-specific, realistic results, real sea data needs to be utilized as an input to the algorithm.

The ultimate goal of this research is to reduce the risk of offshore renewable energy systems to encourage stakeholder support of such systems. In the proposed research, we will develop an open-source tool that will provide optimal configuration suggestions to developers such that location, device type(s) and number of devices is considered. With the framework of a functional, novel optimization algorithm established, the next steps are to incorporate environmental impact as an influencer and to include directional sea states from real wave data.

Existing Data:

- Spectral Wave Density Data (From NOAA buoy)
- Spectral Wave (alpha1) Direction Data (From NOAA buoy)
- Spectral Wave (alpha2) Direction Data (From NOAA buoy)
- Spectral Wave (r1) Direction Data (From NOAA buoy)

- Spectral Wave (r1) Direction Data (From NOAA buoy)

Data Needs:

The above data is available online from buoys, owned and maintained by National Data Buoy Center, that are located around the world. In order to determine the power production of a WEC array that relatively accurately describes the generated power over a predicted lifetime, there is a plethora of data that must be managed.

Desired Area(s) of Expertise for Students:

This project would benefit from experience/expertise in oceanography, coastal and ocean engineering, marine policy, social science, computer science, mathematics and statistics.