Energy Uncertainties and Variability of MRE

Variability

The MRE like other renewable sources is variable and impossible to predict precisely. This increases the risk of setting up an energy farm in the ocean. As the initial costs of MRE devices and marine transmission infrastructure is high, it is necessary to estimate the expected yield from these energy farms, the variability in power production, and confidence bounds on these estimates.

Uncertainty

The uncertainty in total power produced by MRE devices can be categorized as

1. Uncertainty in sensors and measuring instruments.
2. Uncertainty in future resources and ocean climate.
3. Uncertainty in the MRE device availability.
4. Uncertainty in MRE device performance and losses (Energy conversion).

Wave Energy Uncertainties and Variability

Wave energy is considered an intermittent energy source. This is because power produced by waves is uncontrollable and varies in time. Some other examples of variability include sampling variability from wave to wave, synoptic or weather systems affecting available power output, seasonal variations, interannual, and climatic differences.

From the historical data (Sep 2019 - Aug 2020) collected from the Diamond Shoals buoy, the total energy flux which is equal to 93.86 MWh/m/year. The average wave energy flux is found to be 10.69 kWh/m. Figure 1 shows the available wave energy flux and here there are some outliers (sudden increase in flux energy) that can be easily observed. These outliers are caused by storms

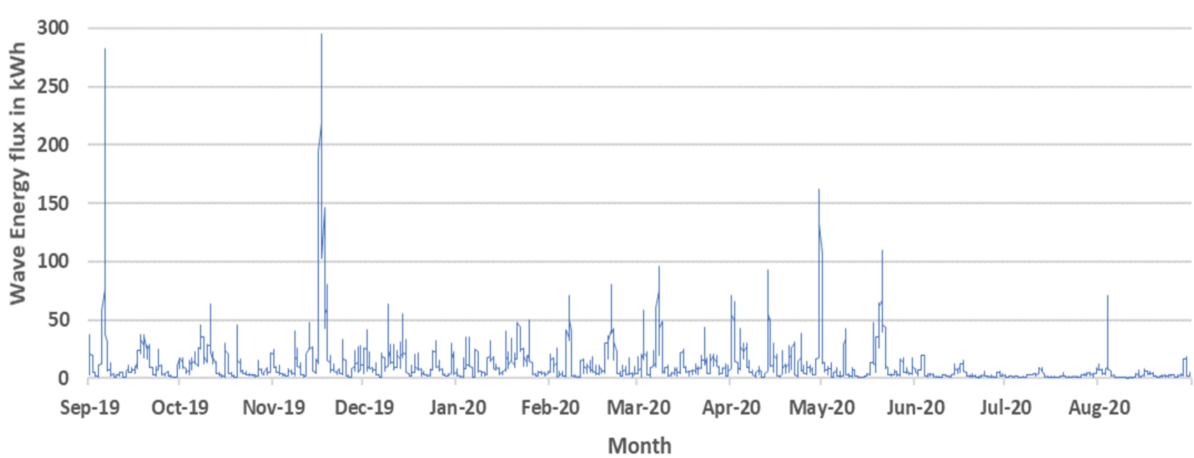

Fig.1 Wave Energy Flux in kWh For Sep 2019- Aug 2020

which increase the average significant wave height and average wave period by approximately 10 times. So, while modeling the device output, we must include the constraints to make the device accept only wave parameters within set limits (availability constraints).

Ocean Current Energy Uncertainties and Variability

Deep ocean current energy is considered to be stable when compared to other marine energy sources due to the continuous flow. Driving forces for large scale ocean currents include the earth's rotation, gravity, wind stresses, and density differences. Besides these, tides, river discharge, surface pressure gradients, and bottom friction can also play roles in shaping the current. The uncertainties of the ocean current energy are more related to the efficiency of the device, the device performance and losses, and the techniques used to install these devices.

From available historical data (Apr 2009 - Aug 2009) collected from the Diamond Shoals buoy, the ocean current energy flux is calculated and tabulated as shown in table 1. Figure 2 shows the ocean current flow direction, and it can be observed that the current flows predominantly in the North-East direction. Also, from figure 3 it can be observed that the current speed reduces as depth increase. Hence, depth and direction of energy conversion device play a major role in power production.

Table 1: Total Ocean Current Energy Flux from April 2009 to August 2009

Depth	Total Energy Flux (kWh)	Depth	Total Energy Flux (kWh)
6.2	228.89	34.2	123.02
10.2	223.86	38.2	99.31
14.2	207.27	42.2	73.50
18.2	196.22	46.2	61.41
22.2	186.71	50.2	52.60
26.2	170.02	54.2	42.32
30.2	147.53	58.2	29.27

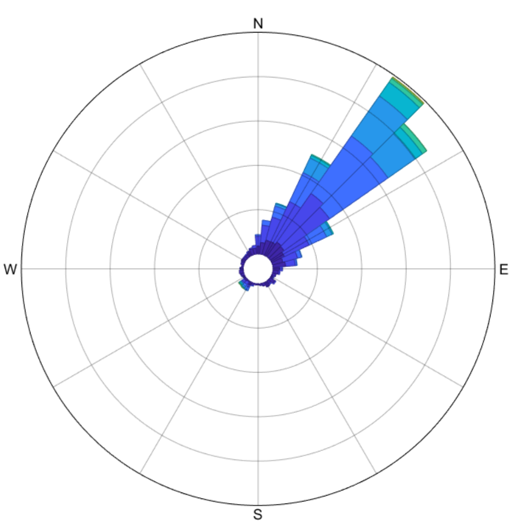

Fig.2 Ocean current flow direction

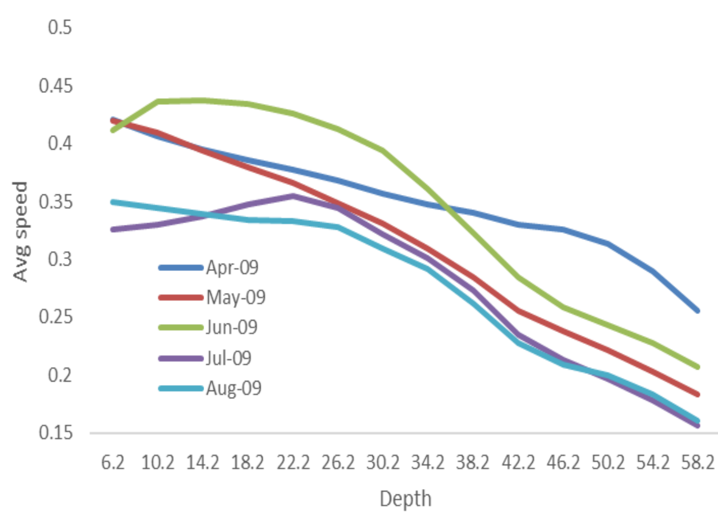

Fig.3 Ocean current flow vs Depth

References:

1. US DOC/NOAA/NWS/NDBC > National Data Buoy Center (1971). Meteorological and oceanographic data collected from the National Data Buoy Center Coastal-Marine Automated Network (C-MAN) and moored (weather) buoys. NOAA National Centers for Environmental Information. Dataset. https://www.ndbc.noaa.gov/station_history.php?station=41025 Accessed [09/25/2020].