Evaluating Proper Wave Measuring Instrument Locations: Ensuring Representative Waves at Wave Energy Converter

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ABSTRACT
In this study, an approach to evaluating wave scatter diagrams and wave power matrices using a spatial wave transfer model and observed ocean wave data was applied to the wave energy converter (WEC) and wave measuring instrument (WMI) installed to the west of Jeju Island, Korea. Wave simulation results showed that waves at WMI location can be represented by waves at the WEC. The results of this study showed that the limitations of the spatial wave transfer model (i.e., an exaggerated response to wave scattering) can be overcome through the application of an advanced wave transfer model and irregular waves. Furthermore, this approach can be used to select optimum install locations for WEC and WMI.

KEY WORDS: Wave energy converter (WEC), Wave measuring instrument (WMI), Wave scatter diagram, Wave power matrix, Spatial wave transfer model

INTRODUCTION
Increasingly, attention has been paid to developing ocean-based renewable energy sources (i.e., wind, wave, current, tidal current, and ocean thermal energy). The main focus has been utilization, industrialization, and securing core technology, which all contribute to the improvement of national energy independence without carbon emissions.

Wave energy converters (WEC), which harness high-density kinetic wave energy near the sea surface, can be installed as either fixed or floating structures. When floating structures with a mooring system are applied to the WEC, there is almost no constraint on the installation water depth; therefore, WEC farms can be constructed in the ocean. The development of marine renewable energy technologies requires device verification through real-sea tests and the construction of test site infrastructure. Representative real-sea test sites include the European Marine Energy Centre Ltd (EMEC) in the United Kingdom and the Biscay Marine Energy Platform (BIMEP) in Spain.

In order to evaluate WEC performance at real-sea test sites, incident waves and data from a WEC should be simultaneously measured using a wave measuring instrument (WMI) and the several sensors installed at a WEC. Observed wave data at the WMI can represent the sea state of the WEC install location; therefore, the install location of the WMI must be selected to minimize the effects of wave deformation from the WEC (e.g., wave reflection, radiation, diffraction, and shadowing). The International Electrotechnical Commission (IEC) recommends that WMI are placed in a location where the average radiated wave energy from the WEC has decayed by 90%, and where wave deformation is effected by seabed topography and the characteristics of the WEC (e.g., hull shape, motion response, and positioning system). With these conditions met, the WMI should measure real-sea wave data, allowing for the best selection of WEC install locations. However, the process of measuring the ocean wave data used to direct the install locations of WMI are inefficient and come with a huge temporal and financial cost. To overcome these difficulties, this study used numerical simulations to analyze wave deformation between WEC and WMI installation locations.

The Korea Research Institute of Ships and Ocean Engineering (KRISO) has been measuring real-sea wave data to the west of Jeju Island since August 2009. Wave measurement is performed using an Acoustic Doppler Current Profiler (ADCP) WMI, located 4 km offshore of Jeju Island (Fig. 1). Five years of observed wave data have shown that wind waves of shorter than 5 seconds are dominant and that the main wave direction is to the NW and generated by winter monsoon (Fig. 2). In this study, this observed wave data were applied to the incident wave condition of the wave simulation.

Fig. 1 Map of the sea to the west of Jeju Island, Korea. The wave measurement instrument (WMI) is located at 33°19.688’N and 126°8.199’E

In order to simulate the wave field of the real-sea test site (including the WEC structure), the large area (6 x 6 km) in which the 5 seconds waves mainly appear was divided into a dense 4-m resolution grid for computational accuracy, which is related with a main wave length.