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Co-located wave-wind farms: A preliminary case study of the shadow effect

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CO-LOCATED WAVE-WIND FARMS

A preliminary case study of the shadow effect

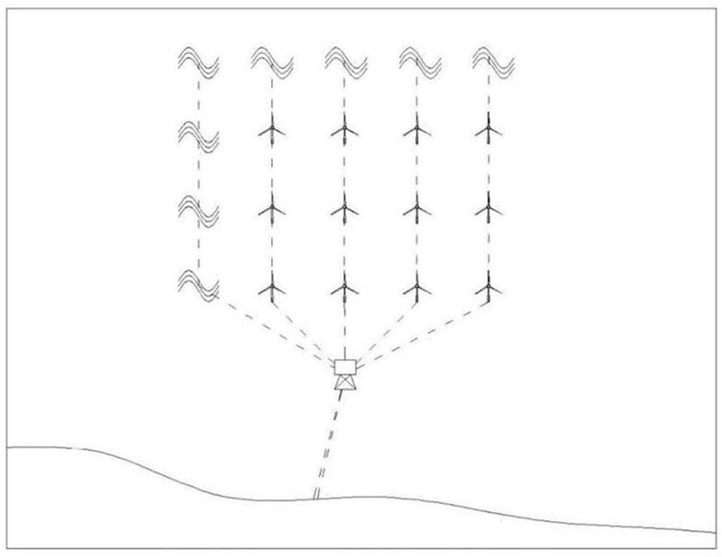
Motivation

The sustainable development of the offshore wind and wave industries requires a proper use of the natural resources, and one that optimizes their exploitation. And it is in relation to this and to the shared challenge for both industries to reduce their costs that the option of integrating offshore wind and wave energy arises. In particular, this research deals with the co-location of Wave Energy Conversion (WEC) technologies into a conventional offshore wind farm.

Combined wave-wind systems

It is clear that strong synergies between wave and offshore wind technologies exist, as defined in these previous works [1, 2], and that the combined harnessing of offshore wind and wave energy presents a great potential of development. Combined wave-wind systems can be classified according to their technology, water depth (shallow, transition or deep water), or location to the shoreline (shoreline, nearshore, offshore). In this work the classification proposed by [2] is considered (see figure below).

- **Co-located systems**
  - Independent arrays
  - Combined arrays
    - Peripherally Distributed Array (PDA)
    - Uniformly Distributed Array (UDA)
    - Non-uniformly Distributed Array (NDA)
- **Hybrid systems**
  - Bottom-fixed: **WaveStar, Wave Treader, WEGA**
  - Floating: **OWWE, W2Power, Poseidon, WindWaveFloat, OOES**
- **Island systems**
  - Artificial Reefs: **Kema energy Island**
  - Floating: **Hexicom, OTEC Energy Island, Hydrogenase**

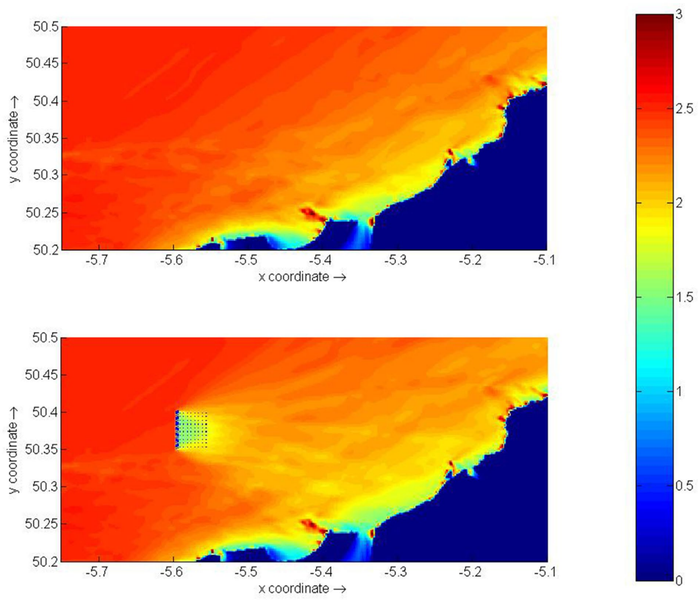


Methodology

An overtopping type of WEC was considered in this work [3] to understand the interaction between the WEC and the offshore wind farm with the wave field, and more in particular the changes of the wave height at the inner part of the co-located farm. This modification of the wave field, the so called shadow effect, is dependent on the relative position between the WECs and the offshore wind turbines. Different array layouts are considered to understand the shield effect.

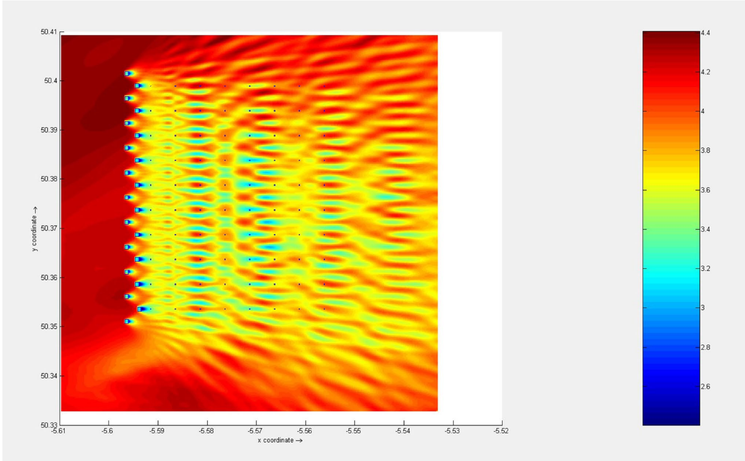
Numerical modelling test tools have been used to study the possible array layouts and the shadow effect. A high-resolution grid was implemented on a wave propagation numerical model to study the interaction between the prospective co-located array configurations and the wave field. A set of possible array configurations for the co-located farm were studied to a preliminary level.

The Wave hub, a wave energy test site located in the South West of England, was considered for this study and, in particular, for selecting the wave conditions. Tests were carried out considering real sea conditions. The Horns Rev I, an offshore wind park located off the west coast of Denmark, was selected to define the spacing between turbines in the offshore wind farm.



Results

A new set of impact indicators was developed to compare the impact of the different co-located farm on the nearshore area. For some rows of wind turbines it has found a considerable reduction on the wave height 20-30%. The relative position between the WEC and the wind turbines affects considerably to the shadow effect at the inner part of the combined farm.



Further steps

The next step in this project is to extend the number of study cases, to understand the relation between the wave-wind farm array disposition and the shadow area.

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[3] H. Fernandez, G. Iglesias, R. Carballo, A. Castro, J. A. Fraguela, F. Taveira-Pinto, et al., "The new wave energy converter WaveCat: Concept and laboratory tests," Marine Structures, vol. 29, pp. 58-70, 2012.