Marine renewable energy production

Climate change is a fact. Summers become warmer and winters tend to be colder but also sea level rise and superstorms are consequences we are facing more often. Governments are changing their policies to address climate change. One measure is to invest in renewable energy resources of which solar and wind energy are widely known. Wind energy has moved from onshore to offshore up to innovative floating wind turbines. Over the last year, coastal and offshore structures became more complex to withstand the increasing wave loading due to climate change. The fact that waves exert a large load on structures triggered the question: can we extract energy from waves to produce electricity? This question initialised the research into wave energy as a part of marine renewable energy production.

Wave energy from waves is absorbed by Wave Energy Converters (WECs). There are numerous device types available and the choice is based on the location, geometry, mooring type and operating method. In this research, we focus on point absorber WECs which are floating devices producing energy by their motion under wave loading. In order to extract a considerable amount of wave power at a location, multiple WECs are arranged in arrays using a particular geometrical configuration. Interactions between the individual WECs affect the overall power production of the array. A WEC responds under incident waves and starts moving in six degrees of freedom. Consequently, the WEC's motion leads to the generation of small waves, called radiated waves. Additionally, the presence of a WEC disturbs the incoming waves and both reflected and diffracted wave fields are present. The total wave field around a WEC is thus a combination of incoming, radiated, reflected and diffracted waves. This results into zones with higher or lower wave elevations compared to the incident wave field. One should thus avoid that one WEC is positioned in the wake region of another WEC. By arranging the individual WECs positioned in zones with higher wave elevations, the energy extraction is significantly higher. In addition to these near field effects, a WEC-array also influences the wave climate further away (far field effects). The wave height reduction behind an entire WEC-array affects other users in the sea, the environment or even the coastline. If such a WEC-array is installed close to the shoreline, it acts as a coastal defence system by reducing the wave loading on beaches for example.

In order to answer fundamental questions on WEC-array design, we use a numerical wave tank (NWT) implemented in the Computational Fluid Dynamics (CFD) toolbox OpenFOAM. CFD solves the most advanced equations representing the physics with a very high accuracy. Over the last three years, we have developed enhanced prediction tools for wave modelling and efficient fluid-structure interaction simulations in a NWT. The methods are validated by using experimental data obtained in a physical wave flume or basin. We not only performed simulations of a single WEC but also, for the first time ever, an array consisting of 2, 5 and up to 9 WECs. With this research, we open up the possibilities for numerical simulations of any kind of floating structure installed in any sea state.

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