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Editorial

Special Issue "Offshore Renewable Energy: Ocean Waves, Tides and Offshore Wind"

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Offshore renewable energy includes several forms of energy extraction from oceans and seas, and the most common and successful offshore technologies developed so far are based on wind, wave and tides. In addition to other resources, wind, waves and tides are considered to be abundant, inexhaustible, and harvestable zero-carbon resources which benefit the human race in tackling energy-related problems, mitigating climate change, and other environmental issues.

Energy production from offshore wind turbines is leading other ocean renewable energy technologies with significant growth since the first installation in Denmark in 1991. According to the Global Wind Energy Council [1], the installed offshore wind capacity at the end of 2017 in 17 countries across the globe (UK, Germany, PR China, Denmark, Netherlands, Belgium, Sweden, Vietnam, Finland, Japan, South Korea, United States, Ireland, Taiwan, Spain, Norway, and France) accounts for 18,814 MW. The UK leads the offshore wind market with over 36% of installed capacity, with Germany in second place with 28.5%. About 84% (15,780 MW) of all offshore installations at the end of 2017 were located in the waters off the coasts of the above-mentioned 11 European countries, and the remaining 16% is located largely in China, Vietnam, Japan, South Korea, the United States and Taiwan.

With wave and tidal energy technologies, although various studies report differing numbers in quantifying resources, the theoretical wave energy potential is estimated to be 32 PWh/year [2], within which the Asian region shares the highest resource of 6200 TWh/year. Only in Europe, a large number of technological advancements has been undertaken, including both research and prototype testing. Similar to wave resources, the quantification of a reliable estimate of global tidal stream energy potential also appears to have variable numbers which are estimated from numerical models; however, the estimated global resource of 3 TW, which includes both tidal ranges and tidal streams [3], indicates its significance. Nevertheless, only a fraction of this could be harvestable, due to several constraints. Unlike the offshore wind sector, only a handful of commercial wave and tidal energy projects have been undertaken globally, which demonstrates in many cases the industry's immaturity, the costs of energy production using these technologies, the lack of investor confidence, political and other market challenges within this particular sector.

The above information illustrates that the Earth is blessed with enormous resources of offshore wind, wave and tidal energy, and an expansion in technologies to harvest them. The research interest in harvesting marine energy is ever-growing, and hence the outcome of these research materials must be widely shared with the research community to increase awareness and enable knowledge transfer activities in relation to new methodologies, modelling techniques, software tools, optimization methods, and the laboratory testing of technologies etc. used in offshore renewables. The editors of this special issue on "Offshore Renewable Energy: Ocean Waves, Tides and Offshore Wind" have made an attempt to publish a book containing original research articles addressing various elements of wind, wave and tidal energies. This book contains research articles written by authors from various countries (Belgium, China, France, Greece, Japan, Malaysia, Netherlands, Romania, Portugal, Spain, Sweden, Tunisia, United Kingdom) which elaborated several aspects of offshore renewable energy. It covers, through its 18 articles, a broad range of topics including the resource modeling of waves, tides and offshore wind, technologies for energy conversion, numerical and physical modelling of marine energy converters, hybrid energy converters, the shape optimization of energy converters, the modelling of arrays of energy converters; electrical power generation, the control of energy converters, and a macro-economic and cost–benefit analysis.

Regarding offshore wind, the articles discuss the evaluation of state-of-the-art wind technologies suitable for specific locations based on data analysis, the cost of energy evaluated, and longer-term resources estimated for specific areas. Nearshore wind resources in the Black Sea area produced from the European Centre for Medium Weather Forecast (ECMWF) ERA-Interim and AVISO (Archiving, Validation and Interpretation of Satellite Oceanographic data) satellite measurements were used to estimate what type of wind turbines and wind farm configurations would be more suitable for coastal environments [4]. The results indicated that the Crimea Peninsula has the best wind resources; however, considering the geopolitical situation, the western part of this basin (Romania and Bulgaria) was found to be a viable location for developing offshore wind projects. A method was proposed in [5] to minimize the cost of energy (COE) of offshore wind turbines, in which two design parameters, the rated wind speed and rotor radius, are optimally designed, and the relation between the COE and the two design parameters is explored. The recent-past and near-future wind power potential in the Black Sea basin was explored in [6]. An analysis of the wind climate was also undertaken, and the wind-power potential from the recent past was assessed based on two different sources each covering the 30-year period 1981–2010.

In coastal areas, seawater can be desalinated through reverse osmosis (RO) and transformed into freshwater for human use; however, this requires a large reliable electricity supply. An analysis of wave power resource availability in Kilifi-Kenya and an evaluation of the possible use of a wave power converter (WEC) to power desalination plants was described in [7]. Wave energy propagation patterns in the western side of the Iberian nearshore was evaluated in [8]. Several data assimilation techniques were implemented for the model validation. A novel hybrid wind–wave system that integrates an oscillating water column wave energy converter with an offshore wind turbine on a jacket-frame substructure was detailed in [9], in which a scale model of 1:50 was tested under regular and irregular waves to characterise the hydrodynamic response of the WEC sub-system. This study appeared to have led to a proof of concept of this novel hybrid system. Another novel method of estimating wave energy converter performance in variable bathymetry regions was presented in [10], which takes into the account of the interaction of the floating units with the bottom topography. The proposed method used a coupled model which was able to resolve the 3D wave field for the propagation of the waves over the general bottom topography, in combination with a boundary element method (BEM) for the treatment of the diffraction/radiation problems and the evaluation of the flow details on the local scale of the energy absorbers.

A numerical model was proposed in [11], considering not only the interference effect in the multiple floating structures, but also the controlling force of each linear electrical generator. The copper losses in the electrical generator are taken into account when the electrical power is computed. This paper established a relationship between the interference effect and electric powers from wave energy converters. A sliding mode control scheme aimed at oscillating water column (OWC) generation plants using Wells turbines and DFIGs (Doubly Fed Induction Generators) was proposed in [12]. The papers discussed an adaptive sliding mode control scheme that does not require calculating the bounds of the system uncertainties, a Lyapunov analysis of stability for the control algorithm against system uncertainties and disturbances, and a validation of the proposed control scheme through numerical simulations. A generic coupling methodology which allows the modelling of both near-field and far-field effects was presented in [13]. The methodology was exemplified using the mild slope wave propagation model MILDwave and the open source boundary-element method (BEM) code called

NEMOH. This paper [14] focused on one of the point absorber wave energy converters (PAWs) of the hybrid platform W2POWER. Two of the model predictive controllers (MPCs) have been designed with the addition of an embedded integrator. In order to analyze and compare the MPCs with a conventional PI type control, a study was carried out to assess the performance and robustness through computer simulations, in which uncertainties in the WEC dynamics were discussed.

A coupled techno–macro-economic model which was used to assess the macro-economic benefit of installing a 5.25 MW farm of oscillating water column wave energy devices at two locations, Orkney in Scotland and Leixoes in Portugal, was presented in [15]. Through an input–output analysis, the wide-reaching macro-economic benefit of the prospective projects was highlighted. The results presented in this paper demonstrated the merit of macro-economic analysis for understanding the wider economic benefit of wave energy projects, while providing an understanding of key physical factors which will dominate the estimated effects. A shape optimization method of a truncated conical point absorber wave energy converter is presented in [16]. This method converts the wave energy absorption efficiency into the matching problem between the wave spectrum of the South China Sea and the buoy's absorption power spectrum. An objective function which combines these two spectra is established to reflect the energy absorbing efficiency. Through a frequency domain hydrodynamic analysis and the response surface method (RSM), the radius, cone angle and draft of the buoy are optimized.

An electrical model of a vertical axis tidal current turbine in Simulink is coupled with a hydrodynamic vortex-model, and its validation is carried out by a comparison with experimental data in [17]. The current turbine was connected to a permanent magnet synchronous generator in a direct drive configuration. The fuzzy gain scheduling (FGS) technique was used in [18] to control the blade pitch angle of a tidal turbine, to protect it from a strong tidal range. Rotational speed control was investigated by means of back-to-back power converters. The optimal speed was provided by using the maximum power point tracking (MPPT) strategy to harness maximum power from the tidal speed. A methodology was presented in [19] to implement an actuator disc approach to model tidal turbines using the Reynolds-averaged Navier–Stokes (RANS) momentum source term for a 20-m diameter turbine in an idealized channel. The model was tuned to match the known coefficient of thrust and operational profiles for a set of validation cases based on published experimental data. Predictions of velocity deficit and turbulent intensity as a function of grid size/mesh resolution used in modelling the turbine were discussed. The results demonstrated that the accuracy of the actuator disc method was highly influenced by the vertical resolutions, as well as the grid density of the disc enclosure.

An up-to-date review of hybrid systems based on marine renewable energies is proposed in [20]. Main characteristics of the different sources, such as solar, wind, tidal, and wave energies, which can provide electrical energy in remote maritime areas are included in the review. A review of multi-source systems based on marine energies was also presented. Offshore locations at the west of Crete shows a wind availability of about 80%; combining this with the installation of large-scale modern wind turbines is expected to result in higher annual benefits. The spatio-temporal correlation of wind and wave energy production shows that wind and wave hybrid stations can contribute significant amounts of clean energy, while at the same time reducing spatial constraints and public acceptance issues. The analysis reported in [21] discussed the benefits of co-located wind–wave technology for Crete.

The above-mentioned articles which constitute this book critically reviewed various technologies of marine energy, investigated the theoretical, numerical and experimental methodologies of modelling various energy converters and their control systems and provided systematic solutions for the readers to easily understand the concepts used and outcomes produced. The editors believe that this book will be useful to many researchers and industries working on offshore renewable energy.

Conflicts of Interest: The authors declare no conflict of interest.

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