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Editorial

Special Issue "Advances and Challenges in Harvesting Ocean Energy"

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Climate change has visible effects with growing dynamics in the last decades [1] and it has become quite obvious that more effective measures have to be taken for achieving the transition to a low carbon society [2]. While the global energy demand is growing, an important step in reducing the CO_2 emissions is represented by replacing the traditional sources based on fossil fuels with carbon neutral sources. From this perspective and in order to maintain the target to limit the global warming below 2 °C, established in 2015 by the United Nations Framework Convention for Climate Change, Paris Climate Agreement [3], there is an increased interest to add more renewable energy resources to the energy systems. At this point it must also be noticed that according to a recent study made by the International Renewable Energy Agency (IRENA), based on data provided by previous reports, CO_2 emissions have increased by 1% per year in the last decade [4].

While a drastic reduction of the CO_2 emissions represents an issue of highly increasing importance, marine renewable energy (MRE) sources are abundant, and the amount of energy that can be generated using the existent technologies varies from site-to-site and day-to-day, depending on the location and weather conditions. A correct evaluation of the resources and of their expected future dynamics as well as the technologies currently associated with the extraction of marine renewable energy are highly important for achieving the expected targets in terms of energy efficiency and environmental protection. On the other hand, although significant advances have been noticed in recent years, with regards to extracting ocean energy, there are still important challenges related to the implementation of cost-effective technologies that could survive in the harsh marine environment. From this perspective, the main target of this Special Issue, entitled Advances and Challenges in Harvesting Ocean Energy, was to contribute to the renewable energy agenda through enhanced scientific and multi-disciplinary works, aiming to improve knowledge and performance in harvesting marine renewable energy and to identify some of the main advances and challenges associated. Marine renewable energy includes several forms of energy and the most common and successful offshore technologies developed so far are based on wind, waves, tides, and floating solar panels.

Offshore wind has had in the last decade spectacular dynamics, and Europe is the leading player in this domain with almost sixty wind farms currently operating only in the North and Baltic seas. Furthermore, the European Green Deal adopted in 2019 [5] establishes very ambitious targets in terms of marine renewable energy. Thus, an offshore wind power capacity of 300 GW (without UK) is targeted for 2050, which represents a 25 times growth in relationship with the operating capacity corresponding to 2020 in Europe. As regards the other marine renewable energy resources, the target assumed of 40 GW is much more spectacular and challenging, being more than 3000 times greater than the capacity operating in 2020. Besides Europe, a growing interest in harvesting marine renewable energy is noticed all over the world, with more significant developments in the US, China, Korea, and Japan.

In this context, one important research direction targeted in this special issue is represented by a correct evaluation of the resources as well as of their expected future

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dynamics. Thus, in [6] a new and comprehensive understanding concerning the global wave energy resources is presented based on the most recent results coming from two different databases, ERA5 and the European Space Agency Climate Change Initiative for Sea State. In the study, an analysis was first made based only on the ERA5 data and concerns the 30-year period of 1989–2018. The mean wave power, defined as the energy flux per unit of wave-crest length, was evaluated at that step. Besides the spatial distribution of this parameter, its seasonal, inter, and mean annual variability was also assessed on a global scale. As a second step, the mean wave energy density per unit horizontal area was analyzed across a 27-year period (1992–2018) considering both ERA5 and satellite data from the European Space Agency. The comparison indicates a relatively good concordance between the results provided by the two databases in terms of mean wave energy density, although the satellite data indicate slightly higher energy values. Further on, in [7] the impacts of global climate change on the future ocean wave power potential have been assessed. The study takes as a case study the coastal environment of Sri Lanka from the Northern Indian Ocean. The geographical location of Sri Lanka, which receives long-distance swell waves generated in the Southern Indian Ocean, favors wave energy harvesting. Waves projected by a numerical wave model developed using the SWAN wave model, which is forced by atmospheric forcing generated by an Atmospheric Global Climate Model within two time slices that represent “present” and “future” (end of century) wave climates, are used to evaluate and compare present and future wave power potential around Sri Lanka. The results indicate that there will be a 12–20% reduction in average available wave power along the southwest and southeast coasts of Sri Lanka in the future. This reduction appeared to be due mainly to changes to the tropical southwest monsoon system because of global climate change. The available wave power resource attributed to swell wave component remains largely unchanged. Although a detailed analysis of monthly and annual average wave power under both “present” and “future” climates indicates a strong seasonal and some degree of inter-annual variability of wave power, a notable decadal-scale trend of variability being not visible during the simulated 25-year periods. Finally, the results show that the wave power attributed to swell waves is very stable over the long term.

A very promising geographical area from the point of view of marine renewable energy is the Iberian nearshore. In this coastal environment relatively high wave energy resources are available and the wind, although not so strong as in the North or the Baltic seas, can be considered appropriate for implementing wind farms. Furthermore, significant solar energy is common to this area, so this coastal environment can be considered extremely promising for hybrid wind–wave–solar projects. In this context, three different works from the special issue are focused on this coastal area. Thus, in [8] a comprehensive picture of the wind conditions in the Spanish continental nearshore is provided considering a state-of-the-art wind dataset. In order to do this, the ERA5 wind data, covering the 20-year time interval from 1999 to 2018, was processed and evaluated. In addition to the analysis of the wind resources, the performances of several wind turbines, ranging from 3 to 9.5 MW, were evaluated. From the analysis of the spatial maps, it was observed that the northern part of this region presents significant wind resources, the mean wind speed values exceeding 9 m/s in some locations. On the other hand, regarding the southern sector, more energetic conditions are visible close to the Strait of Gibraltar and to the Gulf of Lion. Nevertheless, from the analysis of the data corresponding to these two southern nearshore points it was observed that the average wind speed was lower than 8 m/s in both summer and winter months. Regarding the considered wind turbines, the capacity factor did in general not exceed 20%; however, some peaks that could reach up to 30% have been noticed. Finally, it can be highlighted that the northern part of the Spanish continental nearshore is significant from the perspective of extracting offshore wind energy, especially considering the technologies based on floating platforms. Furthermore, because of the clear synergy between wind and wave energy, which are characteristic to this coastal environment, an important conclusion of the work is that the implementation of joint wind–wave projects might be effective in the northwestern side of the Iberian nearshore. Going now to the expected future wind climate, in [9] an assessment of the wind resource dynamics along the Spanish coastal environment of the Iberian Peninsula is made. After studying the historical resources for the 20-year period from 1999 to 2018 by analyzing the ERA5 time series of wind speed data, the 10 locations with highest historical wind resources were considered. For these, the study of the future dynamics for the 30-year period from 2021 to 2050 under the climate change scenario RCP 4.5 was carried out. After further selection, mean and maximum values, as well as the seasonal and monthly variability of the wind power density, were obtained for six locations along the Spanish coasts. Furthermore, a performance and economic dynamics assessment is presented for four different wind turbine technologies with rated capacities ranging between 3 and 9.5 MW. A further comparison with other locations in the Baltic, Mediterranean, and Black seas is presented to provide a critical image of the Spanish wind resources' dynamics in the European framework. The results indicate a noticeable gain of wind resources in various locations of the Atlantic and Mediterranean coasts, with others presenting slight losses. Going now from the wind to the waves, in [10] the historical and near future efficiency and energy cost of two WECs (Aqua Buoy and Pelamis) were evaluated. The SWAN model was used to downscale the wave parameters along the NW coast of the Iberian Peninsula, both for a historical period (1979–2005) and the near future (2026–2045) under the RCP 8.5 greenhouse scenario. The past and future efficiency of both WECs were computed in terms of two parameters that capture the relationship between sea states and the WEC power matrices: the load factor and the capture width. The wave power resource and the electric power capacity of both WECs were estimated to decrease in the near future. The load factor for Aqua Buoy will decrease in the entire area, while it will remain unchanged for Pelamis in most of the area, except north of 43.5° N. The capture width and cost of energy is expected to increase for both devices. Furthermore, the methodology applied can be easily extended to any device and coastal domain under different climate change scenarios.

Further on, in the work entitled Mathematical Modelling and Experimental Verification of a New Wave Energy Converter [11], a new wave energy converter is designed, and the water movement in fluid channels is analyzed. The results are used to generate a mathematical model that simulates the water movement. Based on this approach, the water movement state is analyzed, and a formula for calculating the natural frequency of water movement in the power generator is derived. The formula shows that the characteristic length of the water movement in the proposed generator and the backboard tilt angle at the exit point of the fluid channel are two design-related variables that can be used to alter the natural frequency. Furthermore, a regular wave experiment is conducted based on the fluid model, which is designed based on the natural frequency formula, to verify the changes in model torque and speed as well as whether the model can operate under normal wave conditions. The study lays a theoretical foundation for the design of further experiments and engineering prototypes to verify the validity of mathematical models by way of experimental analysis. In another work [12], a novel boundary element method is developed and applied to the investigation of the performance of oscillating water column (OWC) systems, taking into account the interaction of the incident wave field with the bottom topography. The modeling includes the effect of additional up wave walls and barriers used to modify the resonance characteristics of the device and improve its performance as the U-OWC configuration. Numerical results illustrating the effects of depth variation in conjunction with other parameters—such as chamber dimensions as well as the parameters associated with the turbine and power take-off system—on the device performance are presented and discussed. Finally, a case study is presented regarding the potential installation of an OWC in a selected port site in the Black Sea, characterized by a good wave energy potential, on the coast of Romania. Finally, in [13] some numerical simulations of pulsed gravel packing completion in horizontal wells are presented. The gravel packing completion method for horizontal wells has the advantages of maintaining high oil production for a long time, maintaining wellbore stability, and preventing sand production; thus, it has become the preferred completion method for horizontal wells.

The above-mentioned articles constituting this book made various analyses of the ocean energy resources, as well as of their expected dynamics in the context of the climate change. Furthermore, various technologies of marine renewable energy have been critically investigated, including theoretical, numerical, and experimental methodologies of modeling various energy converters and providing systematic solutions for the readers to easily understand the concepts used and outcome produced. Finally, the editor believes that this book is useful for many researchers and industries working on offshore renewable energy. At this final point, it has to be also highlighted that the topic targeting advances and challenges in harvesting ocean energy remains an open one, especially if we take into account the great expectations from ocean energy in the short and medium term, expectations requiring very rapid advances while at the same time requiring that significant challenges must be faced.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Nguyen, K.H.; Kakinaka, M. Renewable energy consumption, carbon emissions, and development stages: Some evidence from panel cointegration analysis. *Renew. Energy* **2019**, *132*, 1049–1057. [CrossRef]
2. Østergaard, P.A.; Duic, N.; Noorollahi, Y.; Mikulcic, H.; Kalogirou, S. Sustainable development using renewable energy technology. *Renew. Energy* **2020**, *146*, 2430–2437. [CrossRef]
3. United Nations Framework Convention on Climate Change. The Paris Agreement. UNFCCC. Available online: https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement (accessed on 22 July 2021).
4. IRENA. Global Renewables Outlook: Energy Transformation 2050. Available online: https://www.irena.org/publications/2020/Apr/Global-Renewables-Outlook-2020/publications/2020/Apr/Global-Renewables-Outlook-2020 (accessed on 22 July 2021).
5. European Commission. The European Green Deal. 2019. Available online: https://ec.europa.eu/info/publications/communication-european-green-deal_en (accessed on 22 July 2021).
6. Rusu, L.; Rusu, E. Evaluation of the Worldwide Wave Energy Distribution Based on ERA5 Data and Altimeter Measurements. *Energies* **2021**, *14*, 394. [CrossRef]
7. Karunarathna, H.; Maduwantha, P.; Kamranzad, B.; Rathnasooriya, H.; De Silva, K. Impacts of Global Climate Change on the Future Ocean Wave Power Potential: A Case Study from the Indian Ocean. *Energies* **2020**, *13*, 3028. [CrossRef]
8. Onea, F.; Ruiz, A.; Rusu, E. An Evaluation of the Wind Energy Resources along the Spanish Continental Nearshore. *Energies* **2020**, *13*, 3986. [CrossRef]
9. Ruiz, A.; Onea, F.; Rusu, E. Study Concerning the Expected Dynamics of the Wind Energy Resources in the Iberian Nearshore. *Energies* **2020**, *13*, 4832. [CrossRef]
10. Ribeiro, A.S.; DeCastro, M.; Rusu, L.; Bernardino, M.; Dias, J.M.; Gomez-Gesteira, M. Evaluating the Future Efficiency of Wave Energy Converters along the NW Coast of the Iberian Peninsula. *Energies* **2020**, *13*, 3563. [CrossRef]
11. Meng, Z.; Liu, Y.; Qin, J.; Chen, Y. Mathematical Modeling and Experimental Verification of a New Wave Energy Converter. *Energies* **2020**, *14*, 177. [CrossRef]
12. Belibassakis, K.; Magkouris, A.; Rusu, E. A BEM for the Hydrodynamic Analysis of Oscillating Water Column Systems in Variable Bathymetry. *Energies* **2020**, *13*, 3403. [CrossRef]
13. Zhang, Z.; Yang, J.; Chen, S.; Ou, Q.; Zhang, Y.; Qu, X.; Guo, Y. Numerical Simulation of Pulsed Gravel Packing Completion in Horizontal Wells. *Energies* **2021**, *14*, 292. [CrossRef]