Journal of
Marine Science and Engineering

MDPI

Editorial

Offshore and Onshore Wave Energy Converters: Engineering and Environmental Features

Luca Cavallaro [1,*] and Diego Vicinanza [2]

1 Department of Civil Engineering and Architecture, University of Catania, 95123 Catania, Italy
2 Department of Engineering, University of Campania Luigi Vanvitelli, 81100 Caserta, Italy; diego.vicinanza@unicampania.it
* Correspondence: luca.cavallaro@unict.it

check for updates

Citation: Cavallaro, L.; Vicinanza, D. Offshore and Onshore Wave Energy Converters: Engineering and Environmental Features. *J. Mar. Sci. Eng.* **2021**, *9*, 1265. https://doi.org/10.3390/jmse9111265

Received: 8 November 2021
Accepted: 10 November 2021
Published: 12 November 2021

In the last decade, extensive research has been carried out with the aim of designing new prototype devices that allow for the extraction of electricity from renewable energy sources, in order to contribute to a reduction in the use of nonrenewable resources, and thereby mitigate climate change impacts. Among the various renewable energy resources, the energy extracted from sea waves is widely available, although it is currently poorly exploited. Furthermore, several technologies are being developed, but none of them seem to be very promising.

The purpose of this Special Issue has been to publish the most exciting research with respect to the above subjects.

After a careful review process, five papers were included. Their thematic contributions include the evaluation of the performance of a Power Take-Off controlled by the Maximum-Power-Point-Tracking (MPPT) control algorithms; the development of a database on marine biofouling, which could affect the marine energy sector; the development of a model to evaluate the performance of an Overtopping Wave Energy Converter embedded in a port breakwater; the identification of the main methods applied in industry for the Wave Energy Design Process; and the quantification of the environmental impacts of a wave energy converter through the Life Cycle Assessment (LCA) technique.

The contributions are commented upon in order of appearance in this Special Issue.

Although an effort has been made to compile contributions that cover an update in the state-of-the-art of innovative techniques in wave energy converters, by no means should they be limited to the topics presented hereby.

To begin with, the Power Take-Off (PTO) system is an element essential for every wave energy device, used to convert the mechanical motion of the primary wave interface into a smoothed energy output. Xu et al., 2020 [1] proposed the adoption of the Maximum-Power-Point-Tracking (MPPT) control algorithms to improve the power generated by an oscillating buoy Wave Energy Converter (WEC) embedded in an artificial floating breakwater and designed by the authors. At present, most of the MPPT are applied to linear generators and are used in research on generator resistance. Nevertheless, the authors proposed the application of MPPT control to the hydraulic PTO of their WEC in order to identify the optimal motor dumping point associated with different sea conditions, thus improving the power generation. The authors showed the unsuitability to their case study for using the traditional MPPT algorithm. Therefore, they designed an MPPT control algorithm based on the hill-climbing method and supported by a filter method to ensure the operation of the algorithm, and by an interrupt condition to ensure the convergence of the simulation in an effective time. The control flow of the MPPT algorithm was also provided by the authors.

Among the problems affecting the marine sector, biofouling is a major one, and it also concerns Marine Renewable Energy (MRE) with its risks of adding weight and/or thickness/roughness to equipment, as well as of working as a primer/accelerator of erosion. Vinagre et al. [2] pointed out a dispersion of knowledge throughout papers and reports concerning the biofouling affecting MRE, and described a European biofouling database which compiles in one document several pieces of key information useful to support the MRE sector and other marine industries, as well as to solve the inefficient knowledge transfer among developers, regulatory bodies and ecologists. The database encompasses information concerning ecoregions, countries, sites, distance to shore, depth, type of equipment, submersion time, temperature, wave height and detailed biofouling data. The data spans a distance from the shore up to 195 km, a depth range from the surface to 90 m, and a submersion time from 10 days to 39 years. The authors also offered a review of the general biofouling aspects and a description of a general zonation pattern reflecting the literature and reports they reviewed.

Cavallaro et al. [3] proposed a numerical model for the optimization of the performance of an innovative breakwater for wave energy conversion (OBREC). The model was used to identify the main geometrical parameters affecting the output power of the device, as well as to develop a methodology to optimize its geometrical configuration according to the specific wave climate of its working location. A control strategy for the adaptation of the number of working turbines to the current sea state affecting the device was also investigated. The performance of the OBREC, optimized as proposed by the authors, was also tested on the case study of Pantelleria Port (Sicily, Italy), and this allowed assessment of the impact that such device could have on the energy supply of a small Mediterranean island. It was observed that an OBREC extended along the 260 m of the new Pantelleria's breakwater could have satisfied about 5% of the minimum reduction in yearly CO_2 required by the island by 2020.

The unique design challenges for WECs have led to a disjointed progression of research and development. There is currently a great variety of design practices, and a low level of communication, especially between researchers and industrial developers. This inefficiency of communication works against a useful sharing of developing methods and general innovation, and could cause higher development costs and times, if not even the failure of projects. Trueworthy and DuPont [4] recognized the current organizational need, and in their paper they reviewed the process of WEC design; they outlined the design and evaluation methods currently used; they identified 11 specific design requirements and discussed the tools available to fulfill them; and they presented and discussed the results of a survey distributed to 25 WEC designers chosen among developers, academic researchers and national labs. The authors identified the iterative method as the most common design approach to WECs, they highlighted those design techniques and key requirements that could help address the current shortcomings of the design process, and they suggested the areas of WEC design in which further testing and development of new methods is necessary.

The quantification of the environmental impact of a WEC is fundamental, but very few studies have put their focus on it yet. Apolonia and Simas [5] presented a preliminary Life Cycle Assessment (LCA) of a MegaRoller wave energy converter, considering its deployment in Peniche, Portugal. Their LCA encompassed all the life stages of the device, from "cradle-to-grave", and quantified 18 different impacts, breaking their contribution down to each main component and life stage of the WEC. High levels of global warming potential (GWP) and cumulative energy demand (CED) were observed during manufacture due to the high amount of materials used, especially steel, but overall the energy and carbon payback times were found to be slightly below 2.5 years. The LCA allowed better understanding of the environmental impact of wave energy converters and pointed toward the least carbon intensive design option for the MegaRoller. Indeed, some alternative scenarios were drawn for future analysis, concerning the materials used, the recycling rate, the manufacture location and the lifetime of the device.

Closing this editorial, the guest editors consider that this Special Issue will provide benefits to technicians, engineers and researchers in the area of wave energy conversion.

Author Contributions: L.C. and D.V. wrote and reviewed this editorial. All authors have read and agreed to the published version of the manuscript.

Funding: This work has been partly supported by the project "NEWS—Nearshore hazard monitoring and Early Warning System" (code C1-3.2-60) in the framework of the EU programme INTERREG V-A Italia Malta 2014–2020 and by University of Catania-funded projects "Interazione Moto Ondoso—Strutture (IMOS)" and "VAlutazione del Rischio Idraulico in sistemi cOmplessi (VARIO)".

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Acknowledgments: The Guest Editors wish to express their deepest appreciation to the authors for their cooperation, to the anonymous reviewers for their valuable comments.

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

References

1. XU, J.; Yang, Y.; Hu, Y.; Xu, T.; Zhan, Y. MPPT Control of Hydraulic Power Take-Off for Wave Energy Converter on Artificial Breakwater. *J. Mar. Sci. Eng.* **2020**, *8*, 304. [CrossRef]
2. Vinagre, P.A.; Simas, T.; Cruz, E.; Pinori, E.; Sevenson, J. Marine biofouling: A European database for the marine renewable energy sector. *J. Mar. Sci. Eng.* **2020**, *8*, 495. [CrossRef]
3. Cavallaro, L.; Iuppa, C.; Castiglione, F.; Musumeci, R.E.; Foti, E. A Simple Model to Assess the Performance of an Overtopping Wave Energy Converter Embedded in a Port Breakwater. *J. Mar. Sci. Eng.* **2020**, *8*, 858. [CrossRef]
4. Trueworthy, A.; DuPont, B. The Wave Energy Converter Design Process: Methods Applied in Industry and Shortcomings of Current Practices. *J. Mar. Sci. Eng.* **2020**, *8*, 932. [CrossRef]
5. Apolonia, M.; Teresa, S. Life Cycle Assessment of an Oscillating Wave Surge Energy Converter. *J. Mar. Sci. Eng.* **2021**, *9*, 206. [CrossRef]