THE EXPECTED ADVANCES OF THE TECHNOLOGIES FOR WAVE ENERGY EXTRACTION AND THE EUROPEAN GREEN DEAL

Rusu Eugen*, Onea Florin, Rusu Liliana, Department of Mechanical Engineering, "Dunarea de Jos" University of Galati, 111 Domneasca St., 80008 Galati, Romania,
*correspondence e-mail: erusu@ugal.ro

Wave energy is abundant and it has a higher density and predictability than wind or solar energy. Although there are now designed hundreds types of devices for wave energy conversion, working under various principles, there is yet no device or working principle that can be considered the best. As regards the working principles the main concepts are defined at this moment: attenuator, point absorber, oscillating wave surge converter, oscillating water column, overtopping/terminator, submerge pressure differential, bulge wave or rotating mass. The point absorber and oscillating water column devices appear to be more reliable at least from the point of view of their resistance in the harsh marine environment. The first, which is in general of buoy type, benefits of the long operational experience of the buoys, while the second, which is deployed in general at the shoreline level, has no moving parts and can be considered also for the harbour areas.

Together with the tides, the wave energy is currently denoted as ocean energy, and if by the end of 2020 the installed capacity for ocean energy in the European Union (without UK) was around 13MW, the European Green Deal https://ec.europa.eu/info/publications/communication-european-green-deal_en, communicated publically in December 2019, establishes very ambitious targets. Thus, more than 1GW is expected by 2030 going to about 40GW by 2050. This implies a growth of more than 3000 times in only 30 years and represents indeed a spectacular expectation, and the greatest part of this expectation is related to the wave energy. Together with a high technological development and an increase of the life of the devices in the marine environment, an important issue is represented by a rapid and significant decrease of the LCOE (Levelised Cost of Energy). Thus, the Strategic Energy Technology Plan designed by the EU assumes for tide 15ct€/kWh by 2025 and 10ct€/kWh by 2030 while the wave technologies are assumed to be five years latter from the point of view of the LCOE projections (15ct€/kWh by 2030 and 10ct€/kWh by 2035).

An important direction to maximise the use of the offshore resources and increase the system resilience is represented by the Power-to-X concept. Various projects include for example a power-to-H2 system, using hydrogen as an energy vector and increasing energy network flexibility by enabling an alternative to deliver the energy from offshore locations where electricity evacuation is too expensive. Considering in general the proton exchange technology, such projects aim to demonstrate the feasibility of offshore hydrogen generation on the marine structures. In island environment, or in the nearshore areas where potable water is missing, systems for water desalinization can be also implemented together with the marine energy farms. Besides these power-to-X technologies, innovative offshore storage or battery are as well planned to be designed.

In this context, the research group of the DREAM project performed up to now various studies concerning the efficiency of different types of wave energy converters in various coastal environments, especially focused on the European nearshore, as reflected by the works given bellow in the section of references. An important observation would be that the spectacular increase of the offshore wind should provide also momentum to the ocean energy extraction, either through collocation or hybrid approaches. As regards the wave energy converters, there is still place for significant improvements, this implying in special new materials to reduce the device's weight and biofouling effects, specific PTO systems to increase the overall efficiency, new mooring systems for floating devices adapted to the wave energy needs, underwater power connectors that allow easy underwater operability, optimization, operation, and control systems of arrays, etc.

Keywords: marine renewable energy, wave energy converters, hybrid approaches, efficiency, LCOE

Acknowledgment: This work was carried out in the framework of the research project DREAM (Dynamics of the REsources and technological Advance in harvesting Marine renewable energy), supported by the Romanian Executive Agency for Higher Education, Research, Development and Innovation Funding – UEFISCDI, grant number PN-III-P4-ID-PCE-2020-0008.

References

Aleix Maria-Arenas , Aitor J. Garrido , Eugen Rusu and Izaskun GarridoAddendum: Maria-Arenas, A. et al. 2019, Control Strategies Applied to Wave Energy Converters: State of the Art. *Energies 2019, 12, 3115*, *Energies* 2020, *13*(7), 1665; https://doi.org/10.3390/en13071665

Ganea, D., Amorţilă, V., Mereuţă, E., Rusu, E., 2017, A Joint Evaluation of the Wind and Wave Energy Resources Close to the Greek Islands, Sustainability Journal, Special Issue Wind Energy, Load and Price Forecasting towards Sustainability, 2017, 9(6), 1025; doi:10.3390/su9061025,, http://www.mdpi.com/2071-1050/9/6/1025

Onea, F., Ciortan, S., Rusu, E., 2017, Assessment of the potential for developing combined wind-wave projects in the European nearshore, SAGE Journals, Energy & Environment, 2017, 010 http://journals.sagepub.com/doi/abs/10.1177/0958305X17716947

Onea, F., Ciortan, S., Rusu, E., 2017, Assessment of the potential for developing combined wind-wave projects in the European nearshore, SAGE Journals, *Energy & Environment*, 2017, 010.

Rusu, E. and Guedes Soares C., 2008: Wave Energy Assessments in the Coastal Environment of Portugal Continental, the *27th International Conference on* **Offshore Mechanics and Arctic Engineering -** OMAE2008, June 15-20, 2008, Estoril, Portugal, Vol. 6, 761-772. http://dx.doi.org/10.1115/OMAE2008-57820

Rusu, E., 2014. Evaluation of the Wave Energy Conversion Eiciency in Various Coastal Environments, *Energies* 2014, Special Issue Selected Papers from the 1st International e-Conference on Energies, 7(6) 4002-4018; http://www.mdpi.com/1996-1073/7/6/4002

Rusu, E., Onea, F, 2016, Estimation of the wave energy conversion efficiency in the Atlantic Ocean close to the European islands, *Renewable Energy* 85, 687-703, http://dx.doi.org/10.1016/j.renene.2015.07.042

Rusu, E., Onea, F., 2017, Joint Evaluation of the Wave and Offshore Wind Energy Resources in the Developing Countries, *Energies* 2017, *10*(11), 1866; http://www.mdpi.com/1996-1073/10/11/1866

Rusu, E., Onea, F., 2017, Hybrid Solutions for Energy Extraction in Coastal Environment, Energy Procedia, DOI: 10.1016/j.egypro.2017.07.

Rusu, E., Onea, F., 2018, A review of the technologies for wave energy extraction, Clean Energy, 2018, 1–10, https://academic.oup.com/ce/advance-article/doi/10.1093/ce/zky003/4924611

Rusu, E., Onea, F., 2019, A parallel evaluation of the wind and wave energy resources along the Latin American and European coastal environments, *Renewable Energy*, Vol. 143, 2019, Pages 1594-1607.

Rusu, E., Onea, F., 2019, An assessment of the wind and wave power potential in the island environment, Energy, Volume 175, 15 May 2019, Pages 830-846, https://doi.org/10.1016/j.energy.2019.03.130

Silva, D., Rusu, E, Guedes Soares, C, 2013, Evaluation of Various Technologies for Wave Energy Conversion in the Portuguese Nearshore, *Energies*, *6*(3), 1344-1364, http://www.mdpi.com/1996-1073/6/3/1344