

Comprehensive modelling methodology for a Wells turbine through computational fluid dynamics

Zak Hawthorne, Peter Ryan, Fergal O'Rourke

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The world is increasingly moving toward a more sustainable energy landscape, and a crucial part of that is the decarbonisation of electricity. Typically, this has been achieved through solar or wind; however, ocean energy has been a neglected part of the overall solution. This is of significant importance to the Republic of Ireland, as it holds some of the highest potential for ocean wave energy in the world, as shown in Figure 1. The challenges associated with ocean energy devices arise naturally from the ocean as a domain. The presence of saltwater is a corrosion hazard for many materials commonly used; the deployment of a large-scale device can be costly due to the requirement for lifting barges; and should a device be submerged, maintenance requires either specialised divers or the retrieval of the device from the ocean. Ultimately, these issues and the lack of a single ideal ocean wave energy device suitable for deployment have hindered ocean energy growth. Whilst many solutions exist, one of the most promising devices is the Oscillating Water Column (OWC). The OWC is a novel concept that converts the hydraulic energy of the waves into pneumatic energy that can be extracted for electricity generation using an air turbine. The action of such a device is shown in Figure 2.

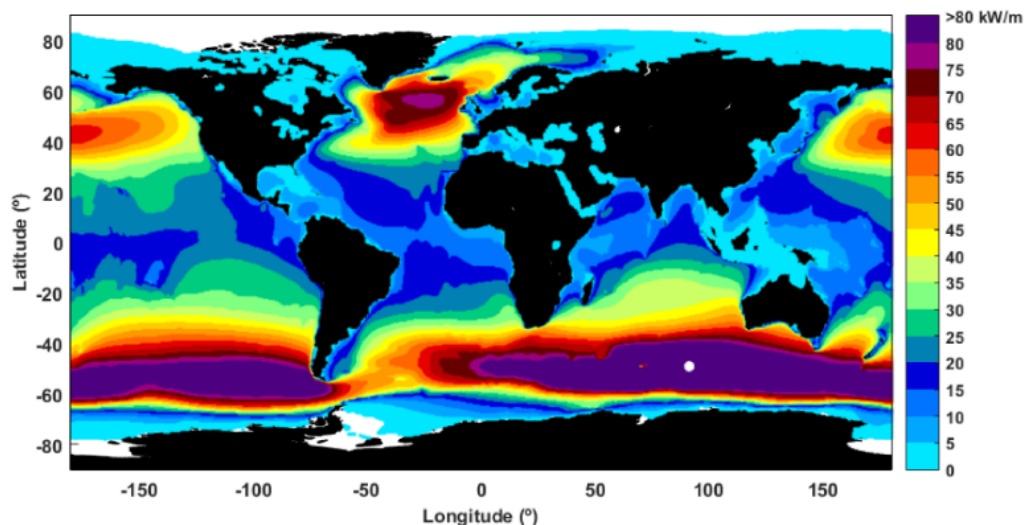


Figure 1: Mean wave power over 30 year time interval (1989-2018) (Rusu and Rusu 2021).

One key technical challenge of this device is the selection of a suitable turbine that can operate under bidirectional flow conditions. Traditional turbines can be used, but only in conjunction with air rectification systems; as such, these are generally unfavourable economically. The two main competitors in this area are the Wells turbine and the air impulse turbine. Neither design requires rectification and instead produces unidirectional rotation from bidirectional flow. These two turbines are shown in Figure 3.

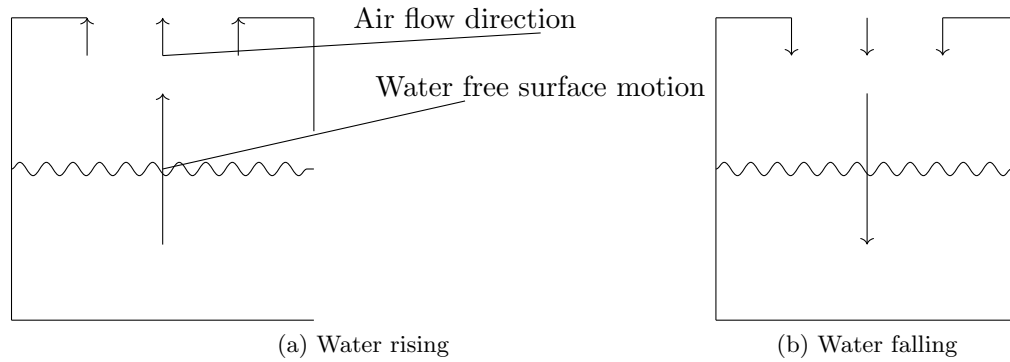


Figure 2: Example of OWC wave/air motion.

To address this, this work is focused on the analysis of the performance of the Wells turbine through computational fluid dynamics (CFD). To date, a consistent CFD methodology from meshing to simulation has been developed, applicable to all Wells turbines, enabling a standardised approach to performance evaluation. Future work will use this standardised methodology for analysis of a number of known performance-enhancing geometric features that, to date, have only been tested in isolation. This will culminate in the integration of several of these features into a single turbine for the purpose of developing a design with superior performance to any existing in the literature.

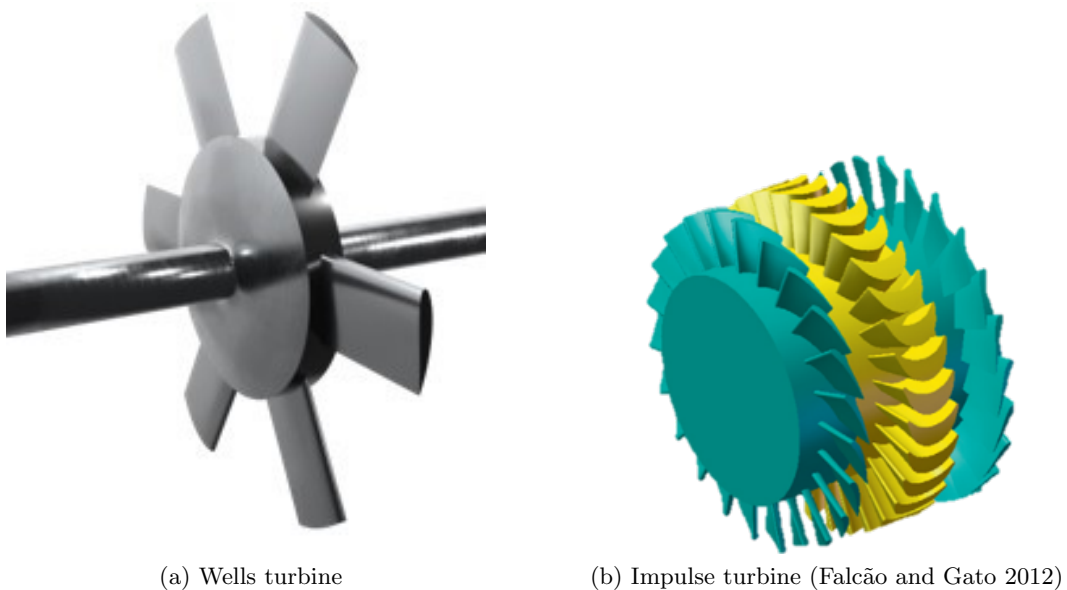


Figure 3: Example of the most competitive turbines for oscillating water columns.

References

- Falcão, A. F.O. and L. M.C. Gato. *Air turbines*. Vol. 8. Publication Title: Comprehensive Renewable Energy Issue: December. 2012. 111-149. ISBN: 978-0-08-087873-7. DOI: 10.1016/B978-0-08-087872-0.00805-2.
- Rusu, Liliana and Eugen Rusu. "Evaluation of the worldwide wave energy distribution based on ERA5 data and altimeter measurements". In: *Energies* 14.2 (2021). ISSN: 19961073. DOI: 10.3390/en14020394.