Floating Tidal – Investigations into Optimal Floater Design

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Project Overview

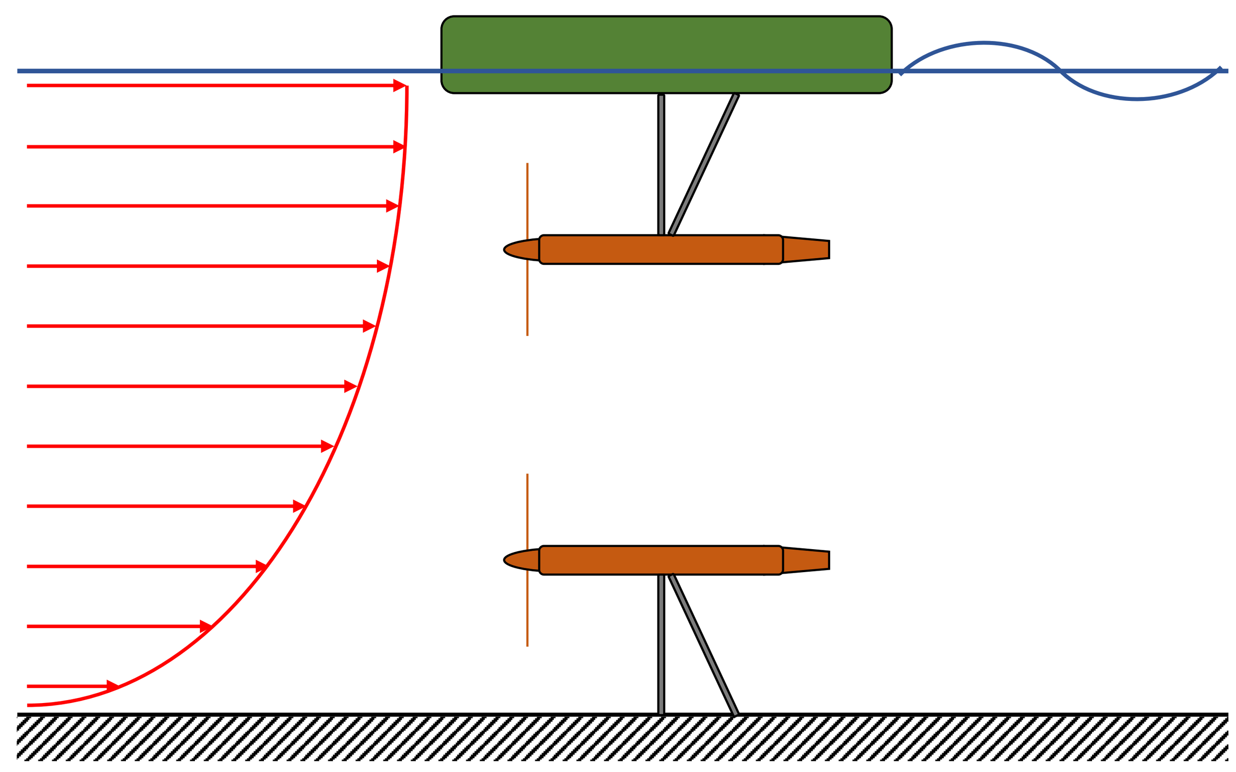
This PhD project will look to assess how the design of floating platforms for tidal turbines can influence dynamic behaviour, responses to wave and currents and interactions with an operating tidal stream turbine (TST) mounted beneath. What is being proposed here is that through the development of a suitable modelling tool, design recommendations can be realised which optimise the performance of the turbine while mitigating excessive loads.

There are complex coupled dynamics involved when considering a floating TST. Both floating structure and rotor dynamics are to be considered, in multiple degrees of freedom, and accounting for elastic structural deformations.

The knowledge contribution of this work will be in the understanding and modelling of these dynamics before making recommendations for optimal floater design. At this stage it is intended that this project produce an open-source modelling tool using a computational fluid dynamics (CFD) approach in conjunction with less computationally expensive models where possible. On completion of the tool a series of investigations will be undertaken to make recommendations on the best performing design characteristics.

Why Floating Tidal?

- By learning from the developments in offshore wind turbines floating TST can be equally beneficial.



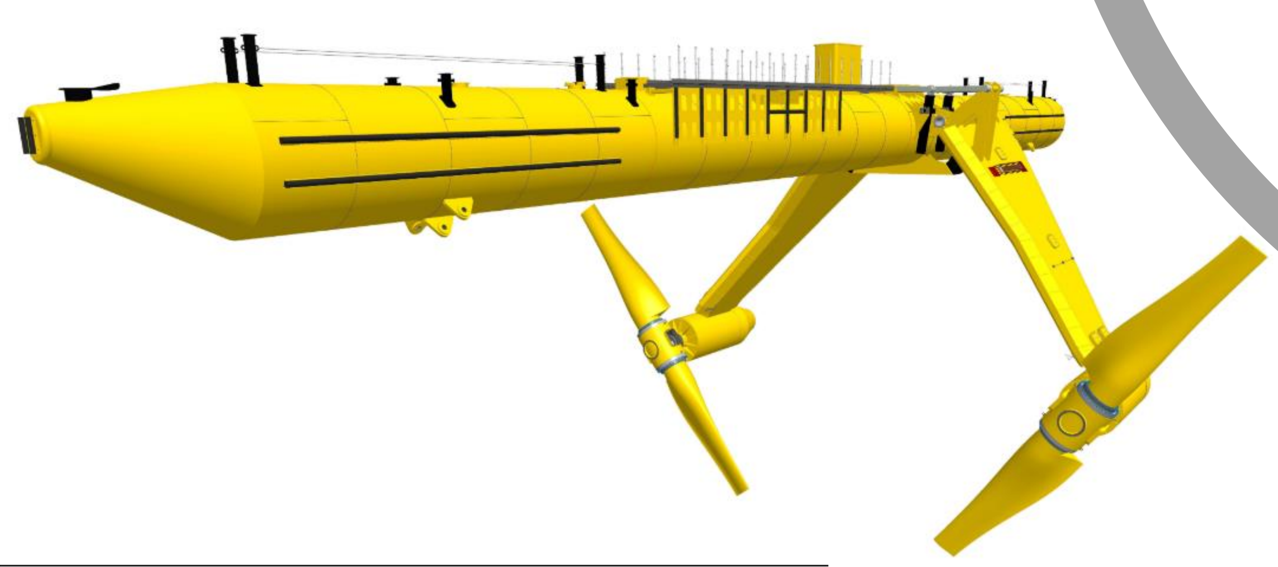
- Floating TST's allow for greater mobility leading to unique maintenance opportunities and improved transportation, as well as access to deeper waters.
- With the increased altitude of the rotor we can take advantage of the more favourable velocities available in the shear, leading to improved energy capture reducing the levelized cost of energy.

What is the optimal floater geometry for future floating tidal turbines?

How does floater geometry impact on turbine performance and loading?

What are the coupling dynamics of rotor and floater, and how can these be controlled to ensure optimal turbine performance?

Modelling



Orbital Floating Tidal Device – image from https://orbitalmarine.com/

- The project intends to adapt the work of NREL's Simulator for Offshore Wind Farm Applications[1] (SOWFA) to produce a TST equivalent with additional features. SOWFA is an open-source tool that couples an LES flow generator with NREL's OpenFAST; creating realistic complex flow fields interacting with state-of-the-art turbine models.
- Taking inspiration from floating wind and floating oil and gas platforms, this project will resolve dynamic responses of the floater and couple them with rotor dynamics modelled using established actuator line theory. Later building in control of the rotor and even structural responses.
- The proposed approach represents potential for expensive computation, and so simplifications will be saught where possible to produce a suitable package that can be utilized commercially.

[1] NWTC Information Portal (SOWFA). https://nwtc.nrel.gov/SOWFA. Last modified 31-March-2015 ; Accessed 30-January-2020

Aims & Challenges

Aims

- To improve the feasibility of tidal stream generation and reduce the levelized cost of energy of the technology.
- To develop a modelling technique and/or tool that allows for interdependence of both floater and rotor dynamics.
- To produce recommendations for optimizing the design of floating structures for the application of tidal stream turbines.

Challenges

- Fully coupling dynamics have been achieved to date in a floating wind application both numerically[2] and more specifically using CFD[3], no such models currently exist for TSTs.
- Moving the rotor below the surface adds a layer of complexity due to the wave-current interaction.
- Surface wave modelling and resolving dynamic responses of floating structures using a CFD approach is extremely expensive computationally.

[2] P. Cheng, Y. Huang, and D. Wan, "A numerical model for fully coupled aero-hydrodynamic analysis of floating offshore wind turbine," Ocean Eng., vol. 173, no. January, pp. 183–196, 2019.

[3] Y. Liu, Q. Xiao, A. Incecik, C. Peyrard, and D. Wan, "Establishing a fully coupled CFD analysis tool for floating offshore wind turbines," Renew. Energy, vol. 112, pp. 280–301, 2017.

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