Simulation Methodology of Floating Offshore Wind Turbine (FOWT) Platforms with porous outer Layers with OpenFOAM

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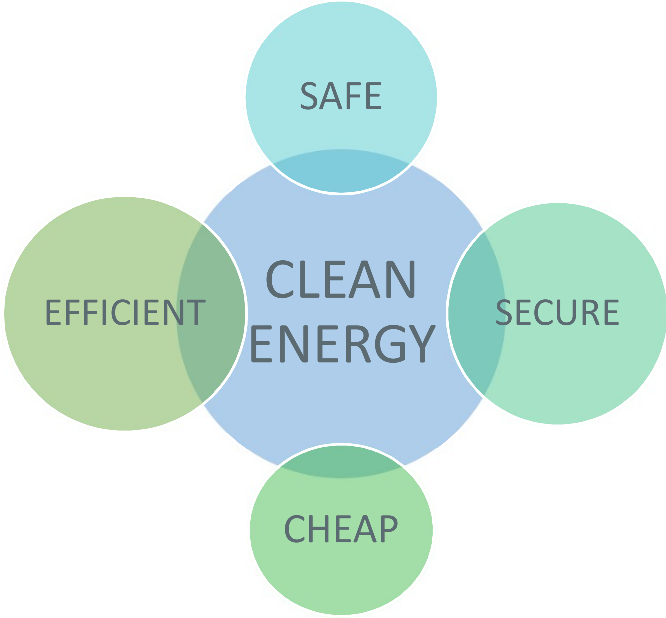
Presentation Overview

1. Project Description: ORE and ResIn
2. Floating Offshore Wind Turbines
3. Aims and Objectives of Work
4. Key Elements and Simulation Cases

1. Project Description: **ORE** and ResIn

Offshore Renewable Energy (ORE) programme:

- aims to develop the next ORE technologies



taken from [a],[b]

- funded by ORE UK-China Newton Fund

1. Project Description: **ORE** and ResIn

5 ORE projects:

FENGBO-WIND

Farming the Environment into the Grid: **Big data** in Offshore Wind

Led by:

- Prof Mike Graham, Imperial College London
- Prof Yonghua Song, Zhejian Uni

Extreme wind and wave **loads**

… on the next generation of offshore wind turbines

Led by:

- Prof Thomas Adcock, Uni of Oxford
- Prof Ye Li, Shanghai Jiao Tong Uni

INNO-MPP

Investigation of the novel challenges of an integrated **offshore Multi-Purpose Platform**

Led by:

- Dr Maurizio Collu, Cranfield Uni
- Liang Zhang, Harbin Engineering Uni

MOD-CORE

Modelling, **Optimisation and Design** of Conversion for Offshore Renewable Energy

Led by:

- Dr Alasdair McDonald, Uni of Strathclyde
- Prof Li Ran, Chonqing Uni

ResIn

Resilient Integrated -Coupled FOW platform design methodology

Led by:

- **Prof Lars Johanning, Uni of Exeter**
- **Prof Bing Chen, Dalian Uni of Technology**

1. Project Description: ORE and **ResIn**

Resilient **In**tegrated-Coupled FOW platform design methodology

- Stable platform / optimum motion response characteristics
- Load reduction through a **porous shroud**
- Operational and extreme conditions

System resilience | robustness

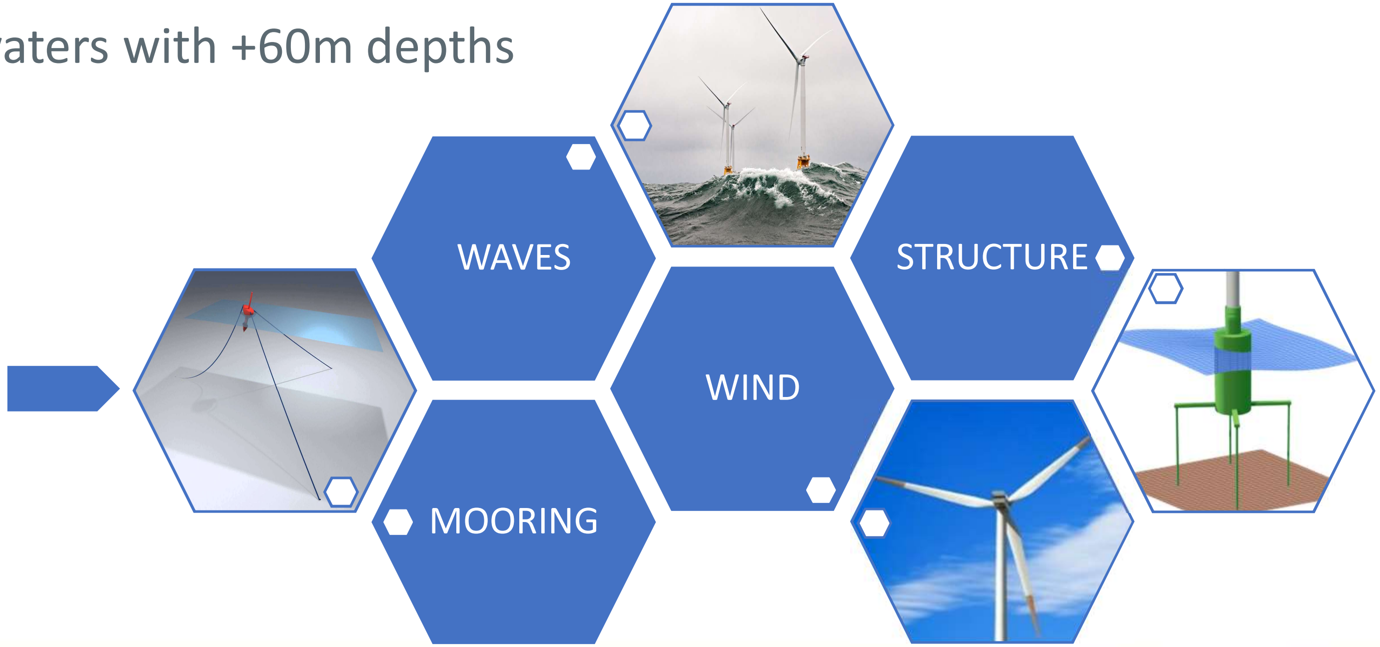
2. Floating Offshore Wind Turbines (FOWTs)

Advantages

- Renewable energy source
- Stronger and less intermittent winds
- Avoid NIMBY criticism
- Access waters with +60m depths

Challenges

- Complex coupled system



Pictures taken from [c],[d],[e],[f]

2. Floating Offshore Wind Turbines (FOWTs)

Coupled Computational Fluid Dynamics (CFD) Simulations of FOWTs:

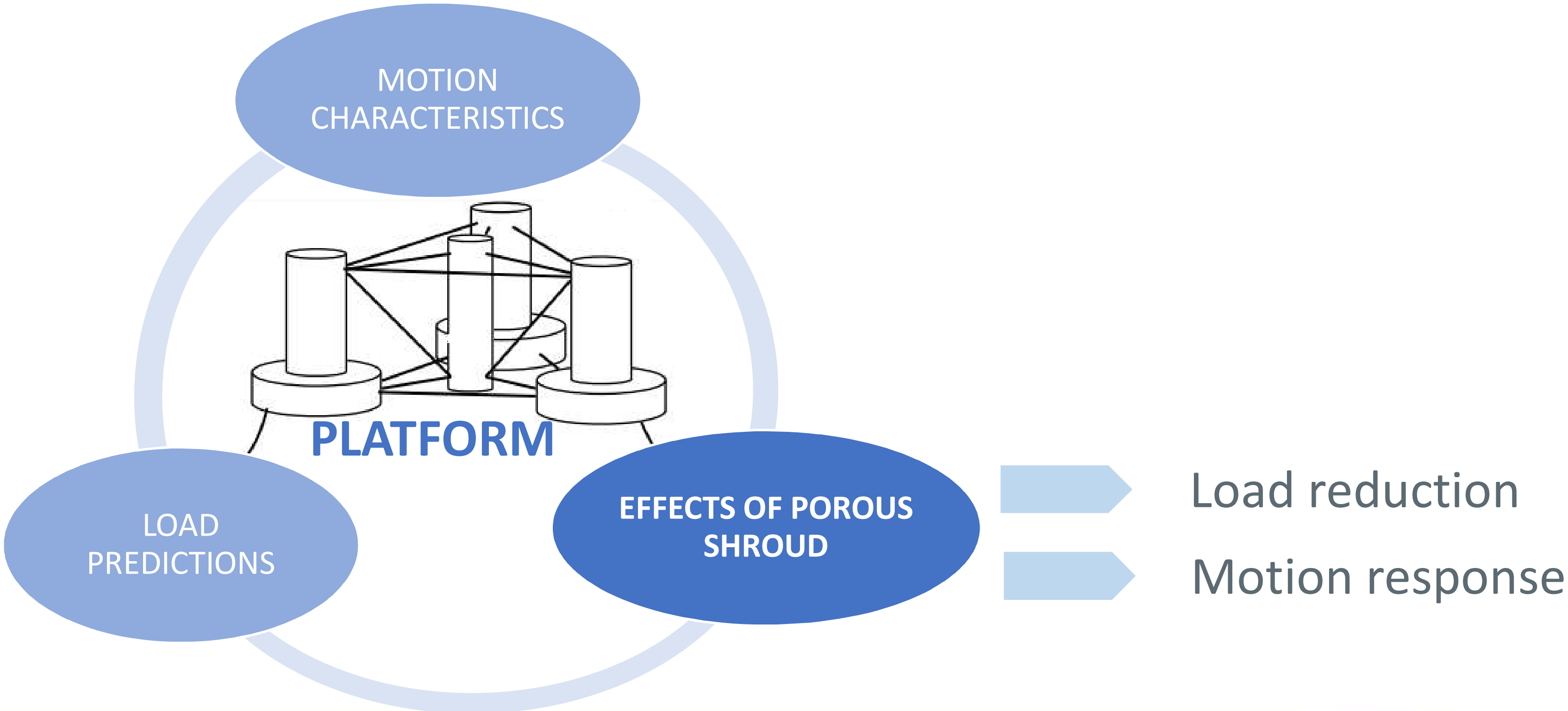
- Prime focus
  - Platform
  - Turbine
- Simplifications
  - Mooring lines
  - Rotor
  - Turbulence
  - Platform motion
  - Rigid structures

- Wave modelling
  - Regular, irregular
  - Focused, extreme
  - Active/passive absorption
- Validation
  - Experiments
  - Potential-flow theory
  - Morison's equation

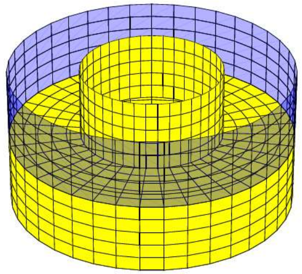
Picture taken from [e]; Nematbakhsh (2013), Nematbakhsh et al. (2015), Quallen et al. (2014, 2016), Ren et al. (2015), Rivera-Arreba (2017), Tran et al. (2014, 2015, 2016, 2017) and others...

3. Aims and Objectives of the Work

CFD simulations with OpenFOAM :

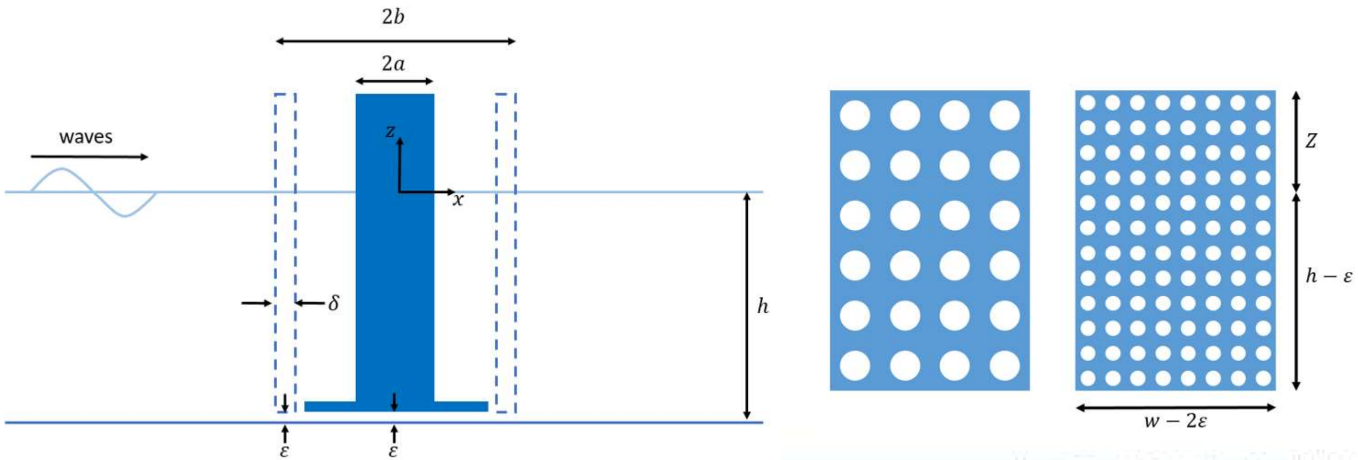


3. Aims and Objectives of the Work



Validation and Verification:

- WAMIT and in-house BEM-code (by Dr Ed Mackay)
- Tank test results
  - State Key Laboratory of Costal and Offshore Engineering, DUT, Dalian, China
  - FloWave, Edinburgh, UK



4. Key Elements and Simulation Cases

CFD simulations with OpenFOAM :

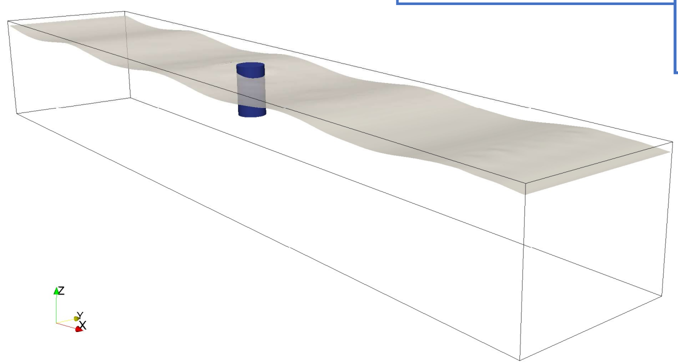
WAVE MODELLING
- Generation and absorption
- Empty domain
- Fixed structures (cylinder)
- WSI
- Mesh resolution

POROSITY IMPLEMENTATION
- Macroscopic vs. microscopic
- Simple fixed structures (wall) → complex structures

FLOATING STRUCTURE
- 6 DOF
- Meshing method (overset)
- Solid structures → porous structures

EXTREME CONDITIONS
- Extension from operational to extreme waves

COUPLING
- Incl. mooring interactions
- Incl. aerodynamic interactions



Thank you for your attention ☺

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Picture References:

[a] https://en.wikipedia.org/wiki/United_Kingdom

[b] https://en.wikipedia.org/wiki/Flag_of_China

[c] https://www.sciencefriday.com/segments/how-wind-farms-affect-the-world-beneath-the-waves/

[d] https://www.youtube.com/watch?v=NfX6_Pbzv3I

[e] http://www.shawnmakes.com/project/floatingturbine/

[f] https://sciencetrends.com/wind-energy-pros-cons-true-advantage-wind-power/

[g] M. Hall, A. Goupee, and J. Jonkman, “Development of performance specifications for hybrid modeling of floating wind turbines in wave basin tests,” *J. Ocean Eng. Mar. Energy*, vol. 4, no. 1, pp. 1–23, 2017.

[h] https://www.esi-group.com/company/events/2016/openfoam-x-plexus-cae