Use of a wave energy converter as a motion suppression device for floating wind turbines

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Michael Borg,
Cranfield University
Outline

• Introduction
• System Description
• Methodology
• WEC Parameters
• Numerical Model
• Results
• Conclusions
Introduction

- Floating platforms subject to large-amplitude motion
  → Increased fatigue loads
  → Reduced aerodynamic performance

Increased cost of electricity
Introduction

• Use of passive damping devices to reduce motion

• Propose that this energy is captured using a WEC
  → Increased system energy yield
  → Shared infrastructure and reduced costs
Methodology

• Hypothetical WEC is considered.
  • No characteristic constraints
  • No geometry considered → No hydrodynamic forces
• Assumed to move only in heave
• Connected to FOWT with spring-damper system
• Identify spring-damper characteristics for two cases:
  1. Maximum Motion Reduction
  2. Maximum Energy Extraction
System Description

• 5MW Vertical Axis Wind Turbine mounted on Trifloater

• Dogger Bank site, North Sea
  → JONSWAP spectrum
  → $H_s = 4.9$ m ; $T_z = 10$ s

• Hypothetical WEC: additional degree of freedom in heave
  → Connected through PTO spring-damper coupling
WEC Parameters

• Mass → 3 cases: 2.5%, 5% and 10% of FOWT mass
  → based on Refs. [1], [2]

• Damping → Damping ratio (ζ) varied from 0.17 to 7.7
  → 5 cases

• Stiffness → 3 cases: WEC nat. freq. (ω_n) = FOWT ω_n
  1 cases: Varied 25% to 200% FOWT ω_n
  → constant damping

\[ m\ddot{x} + 2ζω_n\dot{x} + ω_n^2 x = F_{exc} \]
Numerical Model

- Cummins Eqn. used with radiation-force approximation
- Aerodynamics modelled with Double Multiple Streamtube model with modifications [4]
- Gyroscopic forces also included [5]
Results

Maximum Energy Extraction

- Found to occur with largest mass and lowest PTO damping
- Shifting WEC $\omega_n$ reduces power absorbed

Absorbed Power vs. Supply Reliability

![Graph showing absorbed power vs. supply reliability for different cases.](image-url)
Results
Effect of WEC Damping

- Increase in PTO damping led to smaller motion reduction
- Damping ratio > 1  →  RAO deteriorates
Results
Maximum Motion Reduction

- Occurs when WEC $\omega_n$ is lower than FOWT $\omega_n$

- 15% reduction in heave mean amplitude
- 29% reduction in RAO peak response
Conclusions

• Proposed concept of using a WEC to reducing FOWT motion and increase cost-effectiveness.

• Maximum energy extraction from the WEC is achieved by matching the WEC $\omega_n$ to the FOWT $\omega_n$ and using low damping ratios.

• Maximum motion reduction of the FOWT is achieved by shifting the WEC to a lower frequency than the FOWT $\omega_n$.

• Importance of maximising energy yield per unit area of ocean utilised.
Thank you for your attention

References