System-level Co-design and Control of Large Capacity Wave Energy Converters with Multiple PTOs

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The Consortium

- Queen Mary University of London:
  - Guang Li (Control)
- Exeter University
  - Mike Belmont (Wave prediction)
- University of Manchester
  - Judith Apsley (Test rig design and dry testing)
  - Matteo Iacchetti (Power electronics)
  - Samuel Draycott (Hydrodynamics)
  - Peter Stansby (Device design)
- Industrial partners: Mocean Energy, Eco Wave Power.

Outline of the project

- **The objective:** to develop a unified systematic platform based on whole system optimal control, design and control-operational techniques for WECs to reduce LCOE.
- **The design/control features:**
  1) Multi-objective control: Maximize electricity generation and improve electricity quality (power spikes, peak-to-average power ratio).
  2) System-level Control and Co-design (all stages from waves to wire)
  3) Minimise risk in shutdown operations.
  4) Directional waves considered in modelling and control.
  5) Incorporate wave prediction into control to achieve non-causal optimality.

Targeting Case Study – M4

The advantages of M4:

- Large capacity – comparable to wind turbines.
- Multiple floats and multiple PTOs – lower P2A ratio.
- Linear hydrodynamics – friendly to controller design.
- Reconfigurable – No. of floats/PTOs, float layout.

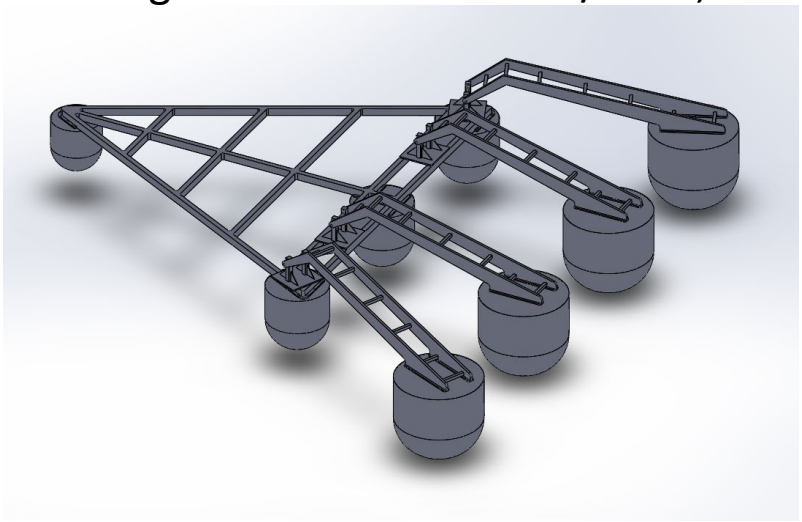


Fig. 1. 3-D view of the 8 floats M4 configuration.

Initial simulation results:

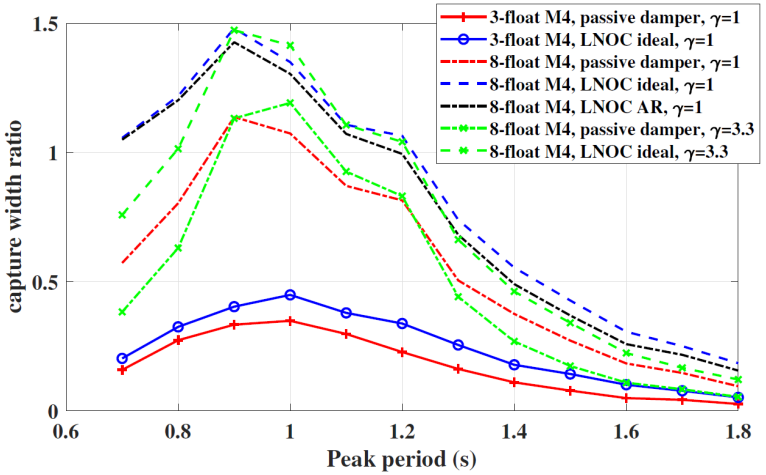
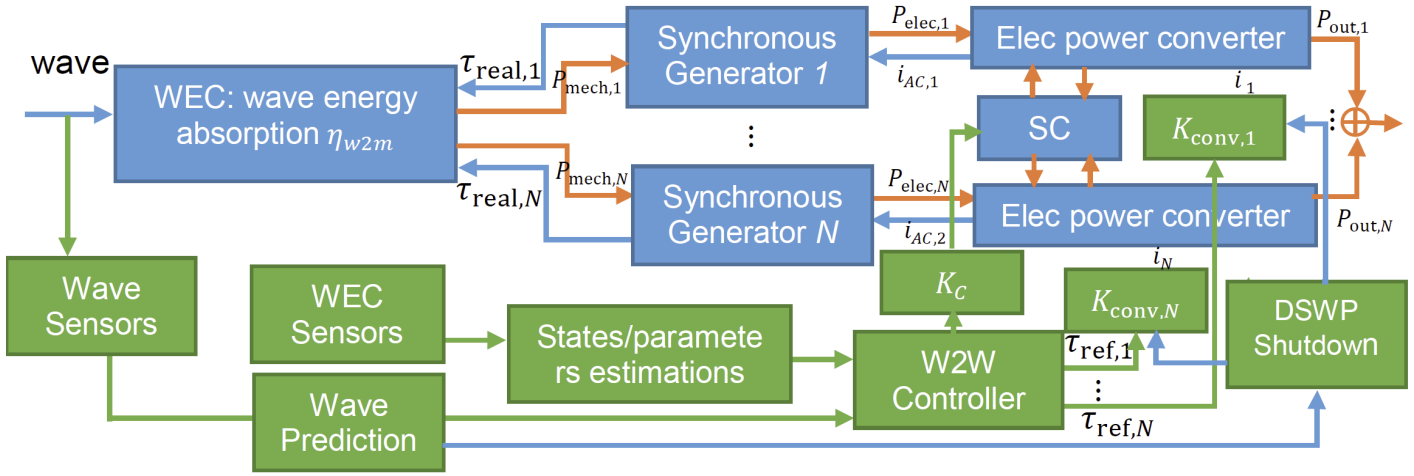


Fig.2. Capture width ratio comparison: 8 floats (4 PTOs vs 3 floats (1 PTO); optimal control vs passive damper.

- 8-float WEC (4 PTOs) can capture 4 times energy compared to 3-float (1 PTO).
- Non-causal control can improve energy output by 30% to 93%.

Z. Liao, P. Stansby, G. Li, High-capacity wave energy conversion by multi-floats, multi-PTO, control and prediction: generalised state-space modelling with linear optimal control and arbitrary headings, accepted by *IEEE Transactions on Sustainable Energy*.

The Work Packages



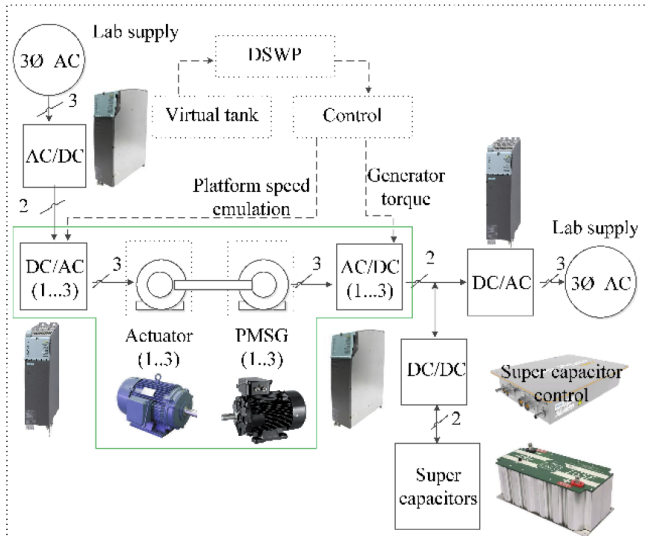


Fig. 4: HIL test rig for M4 control: Components: Gear box, generator, supercapacitor, electronic converters, microcontroller and numerical tank

- WP1: Modelling for all the subsystems: wave-to-wire model.
- WP2: Multi-directional wave prediction and shutdown.
- WP3: Control framework based on the wave-to-wire model.
- WP4: Co-design of the whole system.
- WP5: HIL for validation of control and co-design.

Thank you!