Supergen

Offshore Renewable Energy

Metamaterials for Wave Energy Harvesting

Metamaterials Network Conference June 2023

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University of Plymouth

UKRI Engineering and Physical Sciences Research Council

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Offshore Renewable Energy

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- Research that **supports and accelerates** the development of ORE technologies for society
- **Whole systems approach**: allowing transfer of fundamental knowledge, shared learning and use of resources for inter-disciplinary research
- **Clustering**: Marine (wave and tidal) and offshore wind sharing of expertise, strategies and best practice
- **Networking:** building UK and international collaboration
- **Flexible Funding**
  - Seedcorn funding for projects aligned with the hub.
- **Impact**
  - Early Career Researcher Support
  - Equality, Diversity and Inclusivity Support
  - Industry Partnership
  - Policy Engagement

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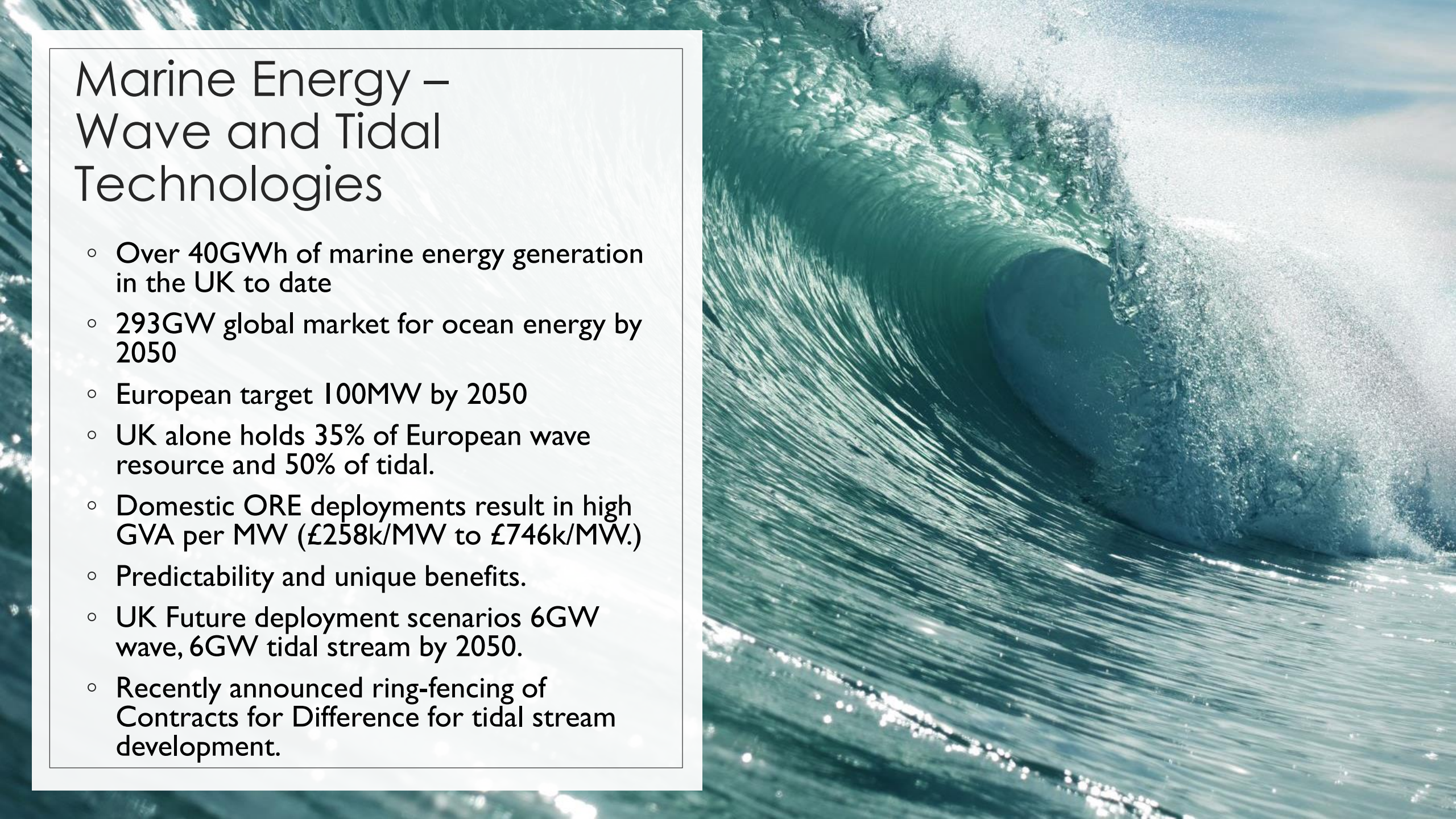
Marine Energy – Wave and Tidal Technologies

- Over 40GWh of marine energy generation in the UK to date
- 293GW global market for ocean energy by 2050
- European target 100MW by 2050
- UK alone holds 35% of European wave resource and 50% of tidal.
- Domestic ORE deployments result in high GVA per MW (£258k/MW to £746k/MW.)
- Predictability and unique benefits.
- UK Future deployment scenarios 6GW wave, 6GW tidal stream by 2050.
- Recently announced ring-fencing of Contracts for Difference for tidal stream development.



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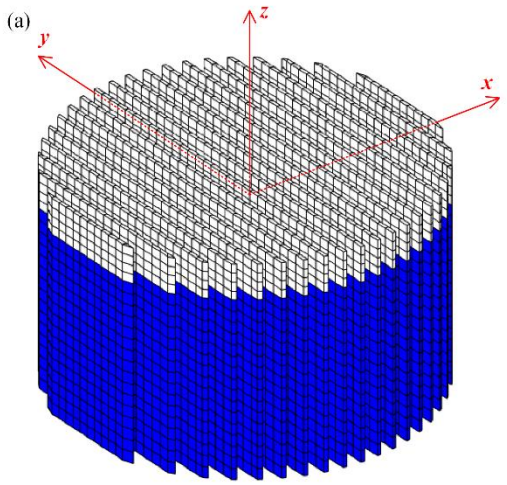
Wave Energy Innovation Paper
Wave Energy Road Map
May 2020

UKRI Engineering and Physical Sciences Research Council

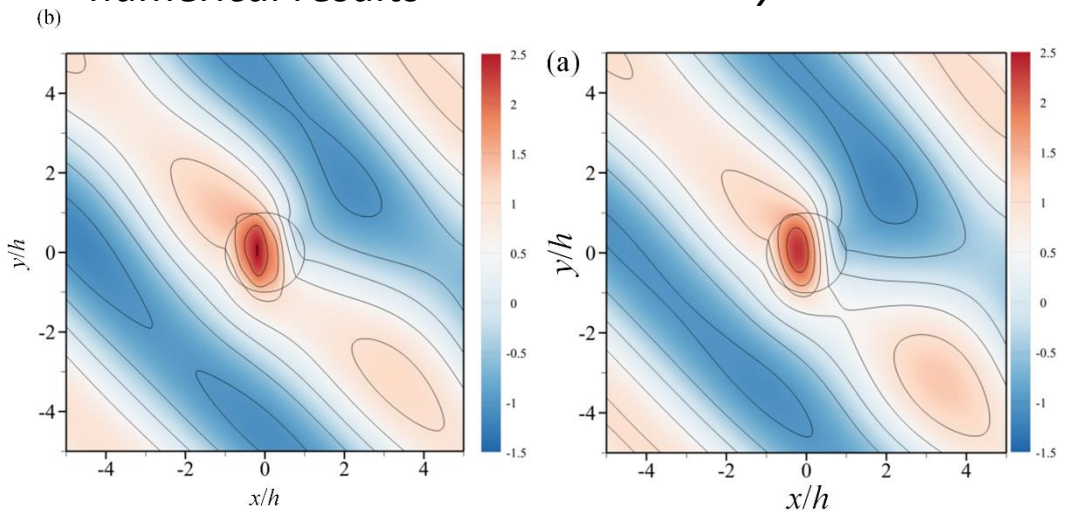
Access the papers at www.supergen-ore.net/impact

Wave Energy and Metamaterials?

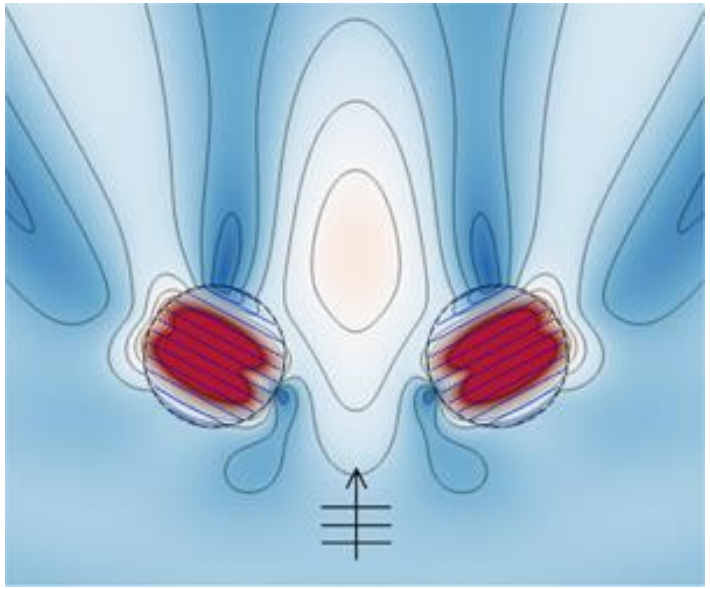
single metamaterial cylinder



numerical results semi-*analytical results*

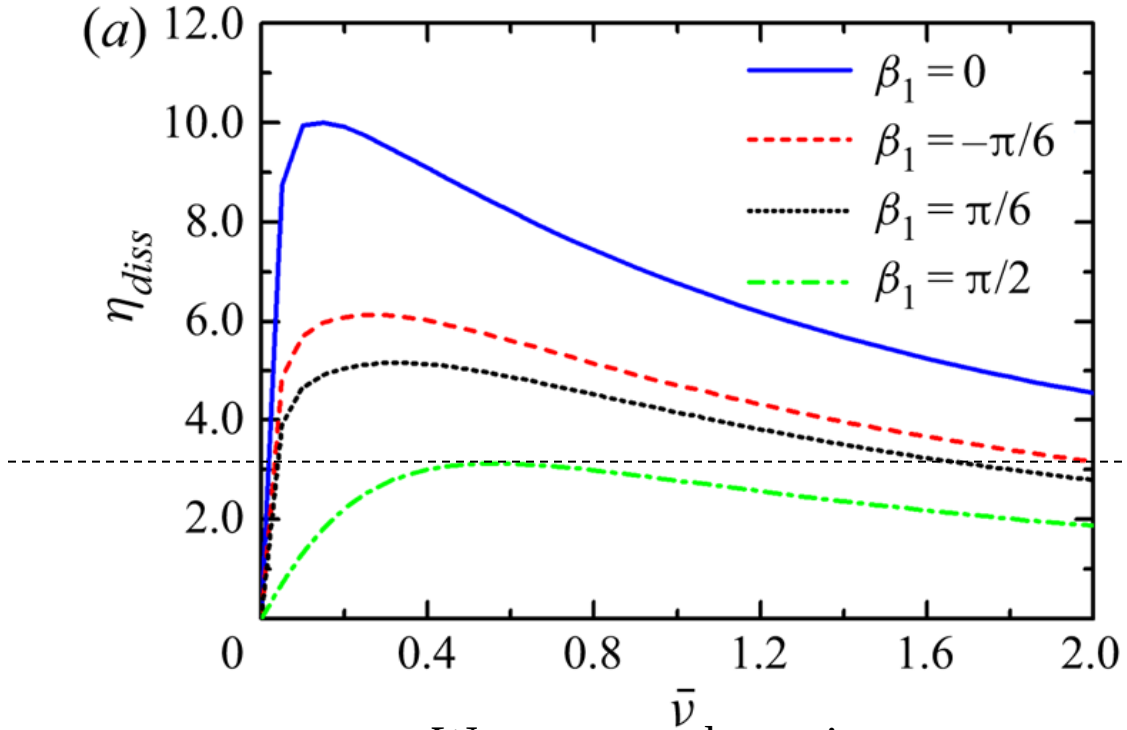


A pair of metacylinders



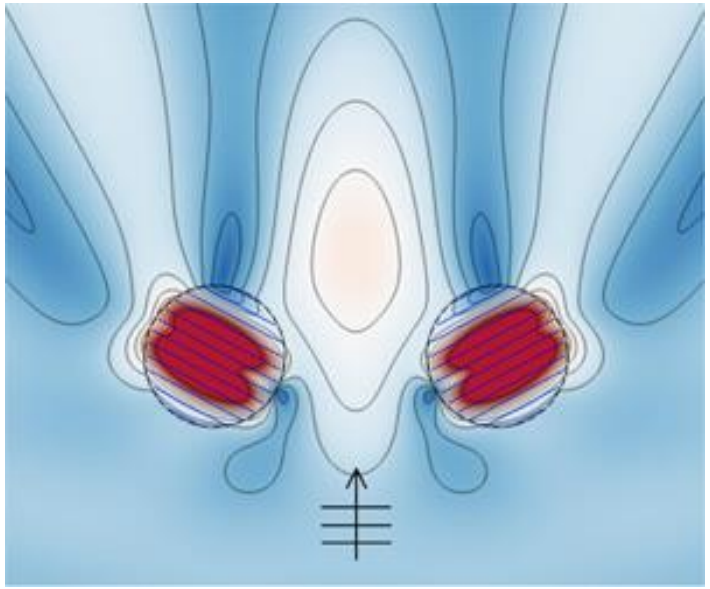
- Good agreement between the semi-analytical results with BEM numerical simulations.
- For a pair of metamaterial cylinders without any damping, wave focusing/blocking can be achieved by rotating the cylinder orientation to direct wave energy in the desired manner.

Wave Energy and Metamaterials?



Wave power absorption

two non-interacting heaving cylinders



The structured cylinders hold profound potential for wave power extraction

metamaterial cylinder outperforms the theoretical maximum values for rigid cylinders operating in rigid body modes.

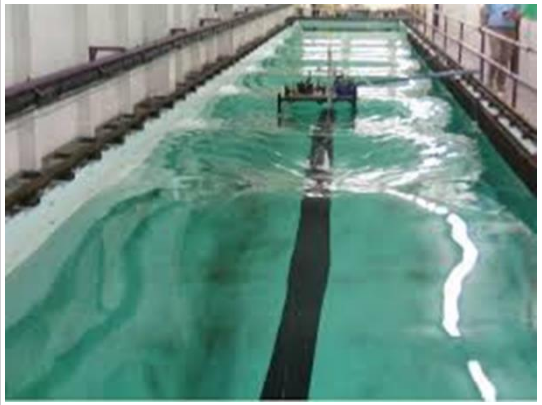
R. Porter, Plate arrays as a water wave metamaterial, in 33rd International Workshop on Water Waves and Floating Bodies, 2018.

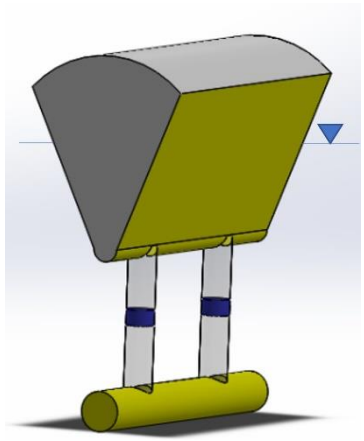
S. Zheng, R. Porter, and D. Greaves, Wave scattering by an array of metamaterial cylinders, J. Fluid Mech. 903, A50 (2020).

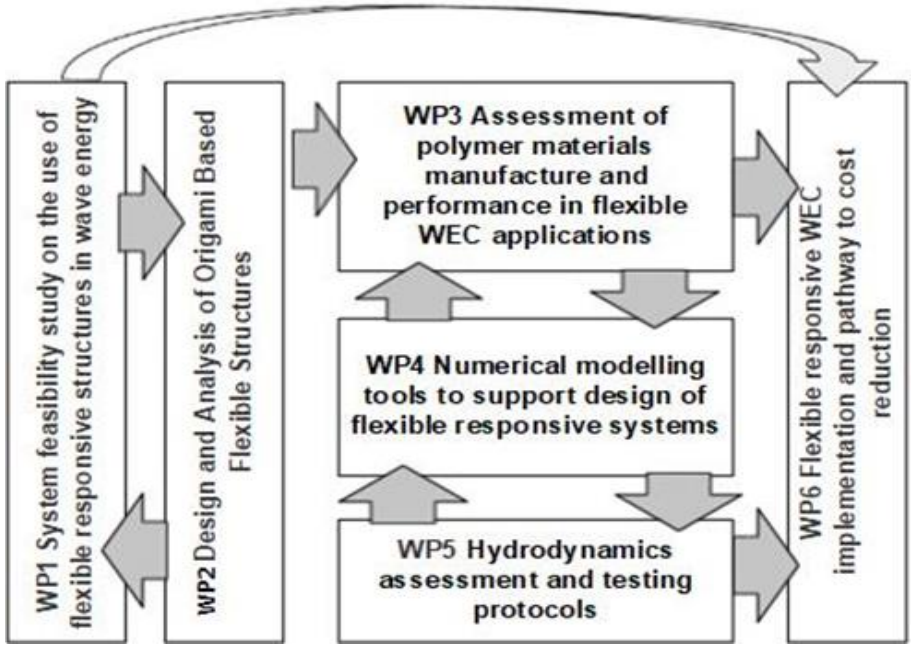
R. Porter, S. Zheng, and H. Liang, Scattering of surface waves by a vertical truncated structured cylinder, Proc. R. Soc. A: Math. Phys. Eng. Sci. 478, 2258 (2021).

Flexible Responsive Systems in Wave Energy: FlexWave

Professor Deborah Greaves, Dr Martyn Hann, Professor Zhong You, Professor John Chaplin, Dr Shanshan Cheng, Dr Maozhou Meng, Professor Alistair Borthwick, Dr Robert Rawlinson-Smith, Dr Edward Ransley, Dr Siming Zheng 2021 – 2024 £1,000,000







Demonstrate step change reduction in cost of energy and pathway to utility scale and niche application WEC designs through the use of Flexible Responsive Systems in Wave Energy.

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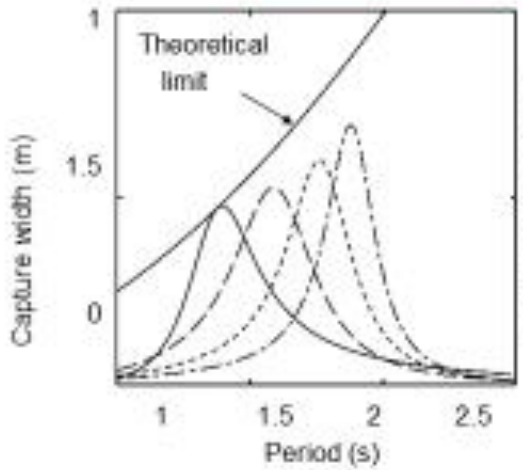
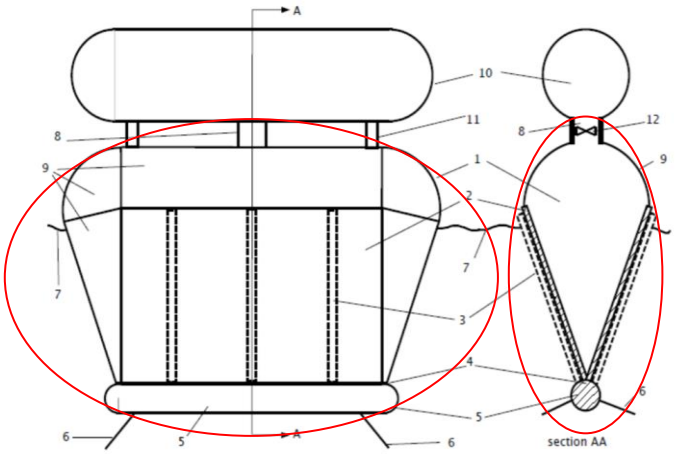
Why FlexWave?

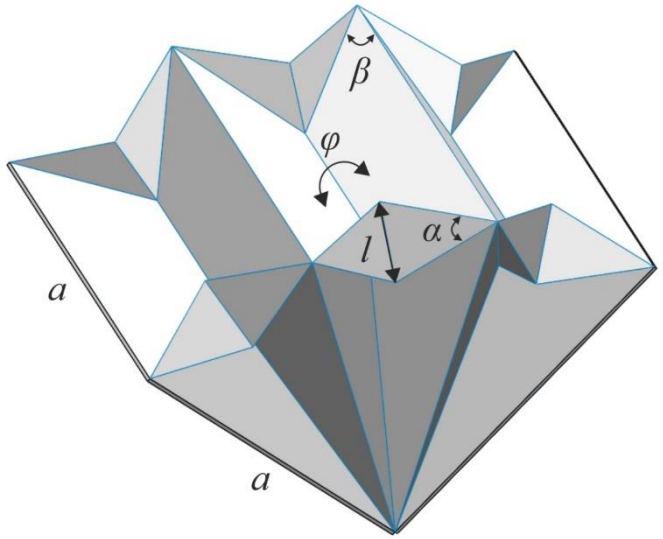
- Flexible fabric WECs can be smaller and lighter than rigid counterparts.
- May be tuned to suit incident wave conditions by controlling internal fluid pressure.
- Controlled non-linear deformation can accommodate or shed high loads without reaching critical stress concentrations, improving survivability and reducing installation and lifetime costs.
- A range of PTO types could be utilised, such as air turbine, electro active polymers or novel distributed embedded energy converters.
- Lightweight flexible structure is unlikely to cause collision damage, so a low risk option for co-location with offshore wind.

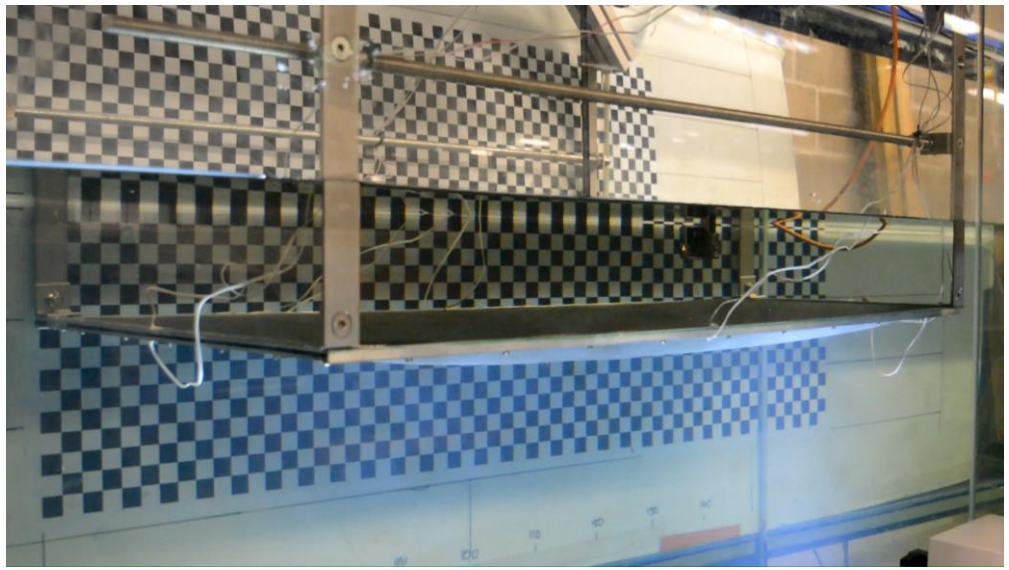


Kurniawan A, Chaplin J, Greaves D, Hann M., and Farley, F. Wave energy absorption by a floating air bag, Journal of Fluid Mechanics 812:294-320 2017.

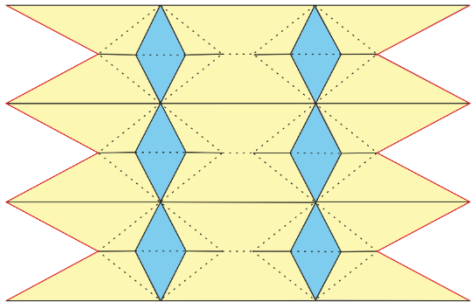
Flexible Responsive Systems in Wave Energy: FlexWave

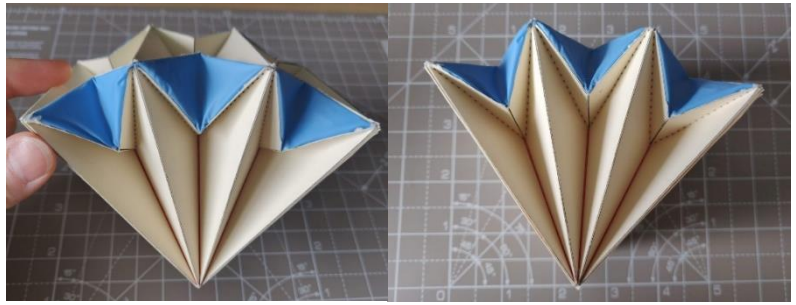


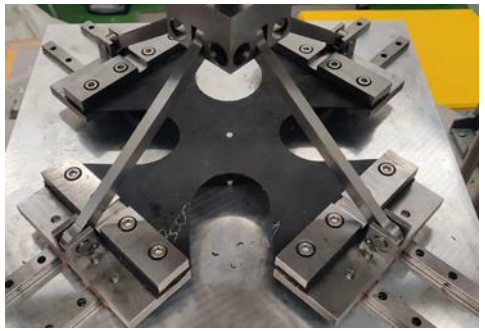




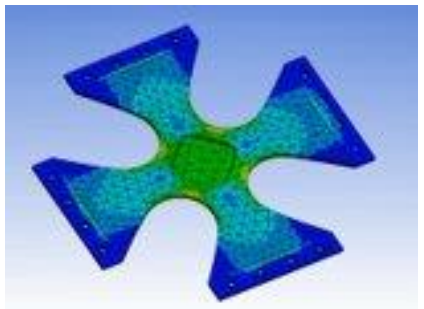
Neoprene rubber fixed at four edges







Biaxial Fatigue testing setup



FEA modelling of the Biaxial test

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Next Generation wave technology

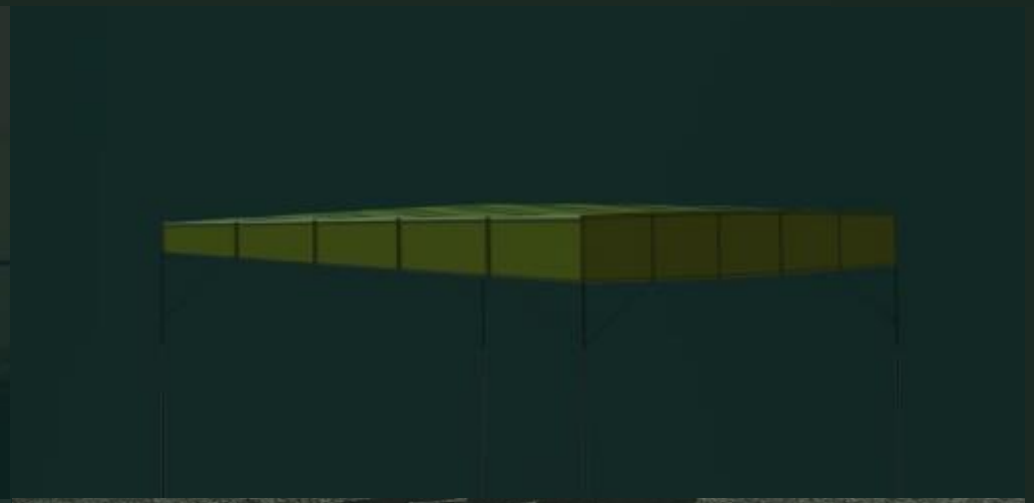
- WES is seeking to support the development of a next generation of technology, that can
  - deliver even greater cost reduction
  - enable a completely new class of wave energy converters
  - utilise direct, distributed, flexible generation

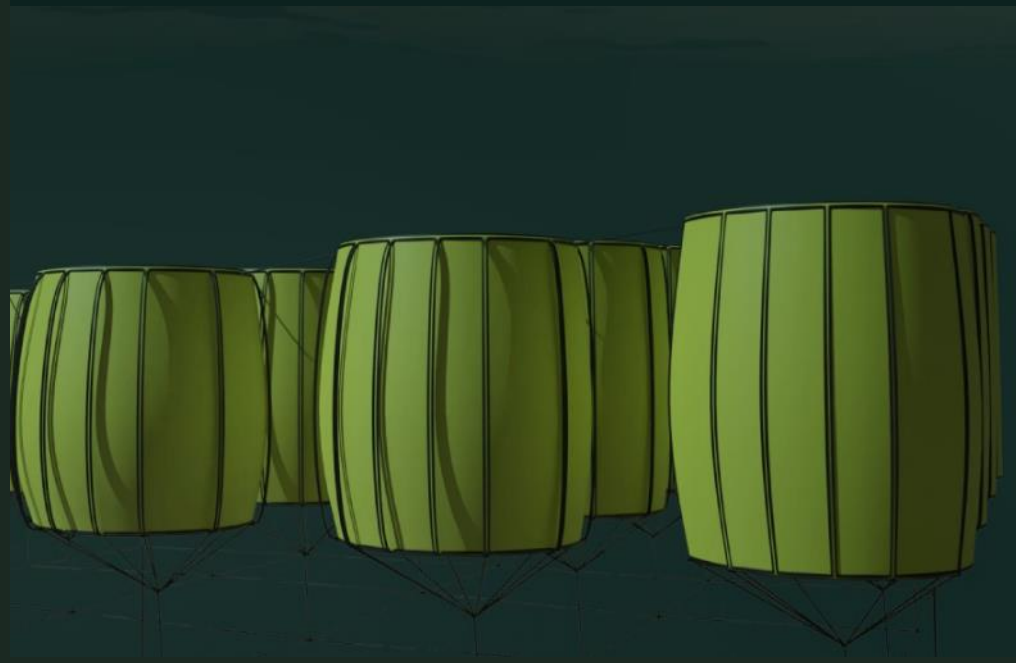
- Electrostatic generation technologies
  - Flexible properties of polymers, elastomers, and dielectric fluids

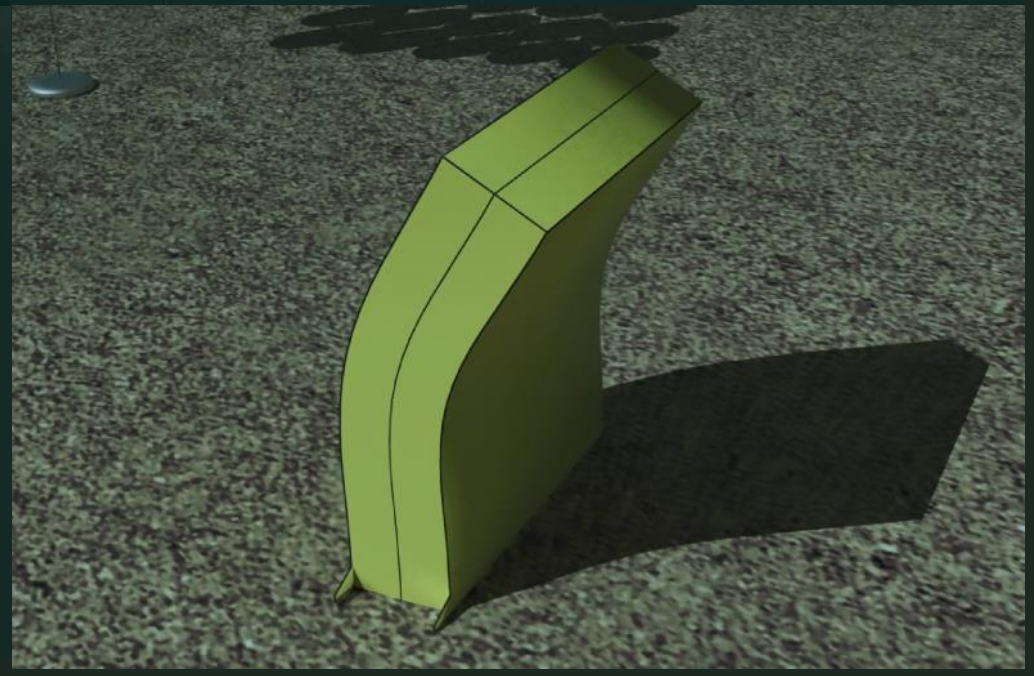
- Variable capacitance **metamaterials,** prioritising**:**
  - Dielectric Elastomer Generators
  - Dielectric Fluid Generators

A new class of wave energy converters

wave energy SCOTLAND







A new class of wave energy converters

Please contact us:

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Updates on WES support:

www.waveenergyscotland.co.uk

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Supergen ORE Hub Assembly and ECR Forum

11 and 12 July 2023
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