ORE Supergen Conference
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ORE Challenge Workshop

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Carnegie
CLEAN ENERGY

European Union
European Regional
Development Fund

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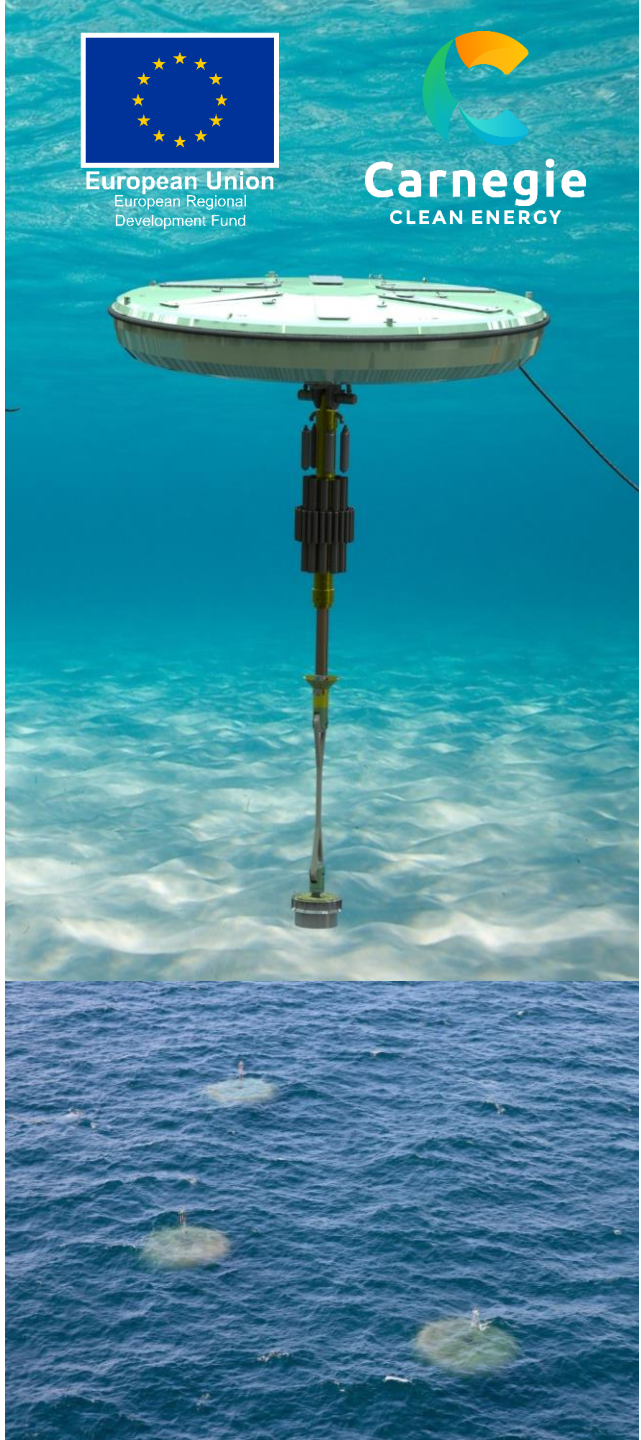
Carnegie Wave Power

- >£80m invested to date through to 6th generation
- One of the leaders in wave energy technology. CETO 5: grid-connected wave energy project over four seasons, with thousands of in-ocean operating hours
- Last 18 months and £5m invested in designing and then disrupting our CETO 6 design
- Deep engagement with global supply chain and WEC and subsystem developers
- Three deployment sites for CETO 6 currently under development:
  - Garden Island, Western Australia supported by £7m ARENA grant
  - Wave Hub in Cornwall, UK with £10m EU grant
  - Albany, Western Australia supported by £11m WA State Government grant



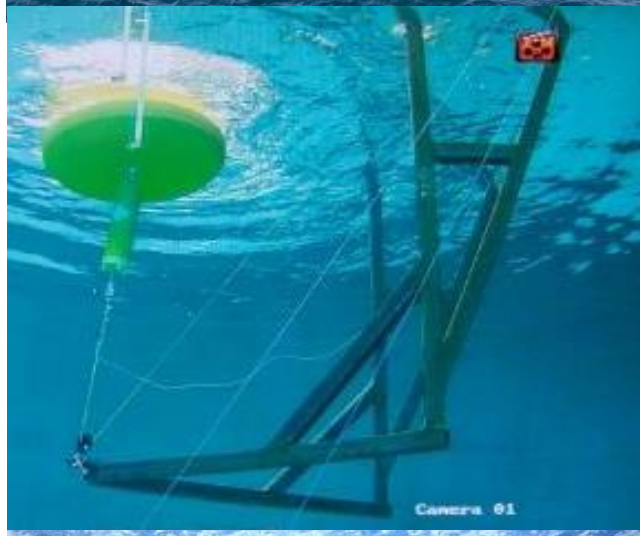
Carnegie's Open Innovation R&D Portfolio

- €7.5m portfolio of collaborative R&D
- Wave Energy Scotland (WES) funded projects:
  - C-Gen PTO, University of Edinburgh
  - Reinforced Polymers for Wave Energy (RePower) project with DNV GL and the National Composites Centre
  - RotoHybrid scheme with University of Edinburgh & Queen's University Belfast
- University of Western Australia (UWA) projects focussed on cost and performance optimisation:
- University of Western Australia (UWA) ARC Linkage project on foundation design for extreme conditions
- University of Adelaide development of control strategies to increase efficiency of CETO
- Partner in the SUPEGEN funded "E-Drive" linear generator project with University of Edinburgh applied to CETO
- Atlantis Resources collaboration agreement focused on electrical architecture.

wave energy SCOTLAND

DISCOVER WITH PLYMOUTH UNIVERSITY

THE UNIVERSITY OF EDINBURGH



Main Challenge for Wave

- Cost Reduction
- Make wave energy attractive to investors

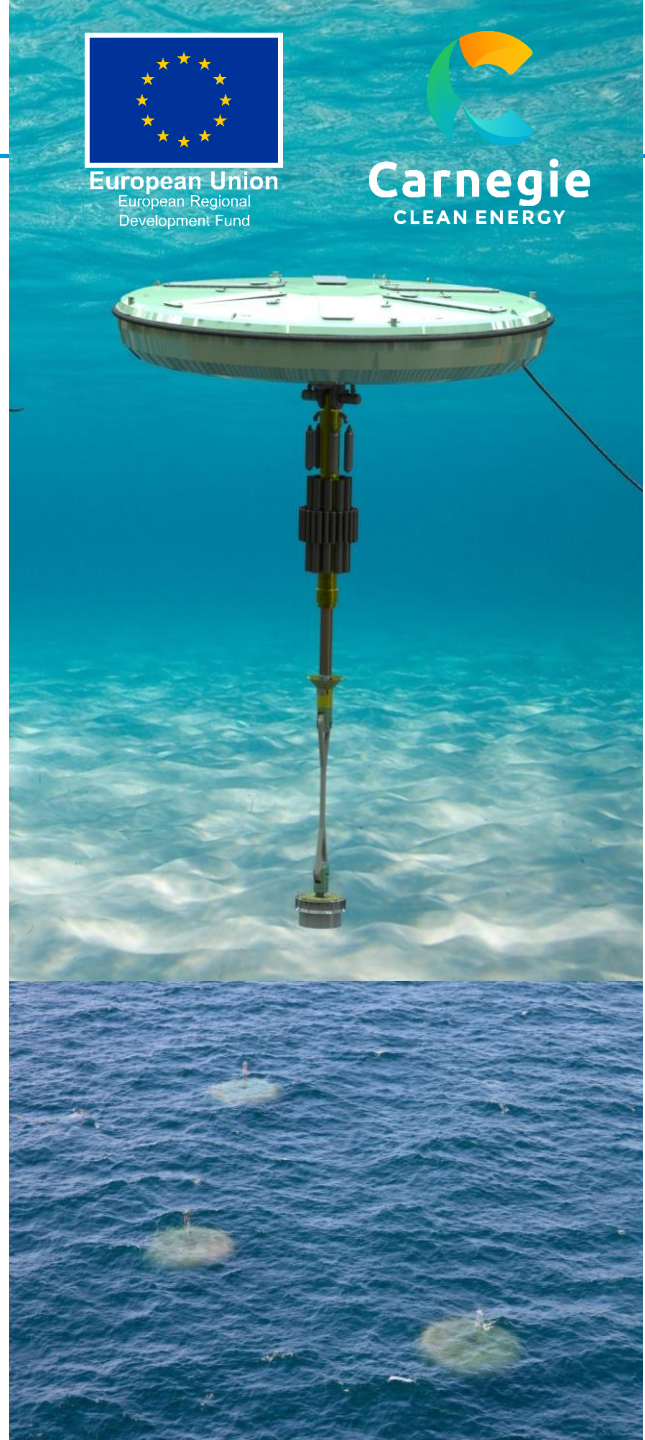
- Policy Vacuum

- At a very simplistic level, wave energy costs are forecast to come down due to:

- Design & Innovation
- Scale/Volume Manufacturing & Supply Chain Development

- Reducing LCOE

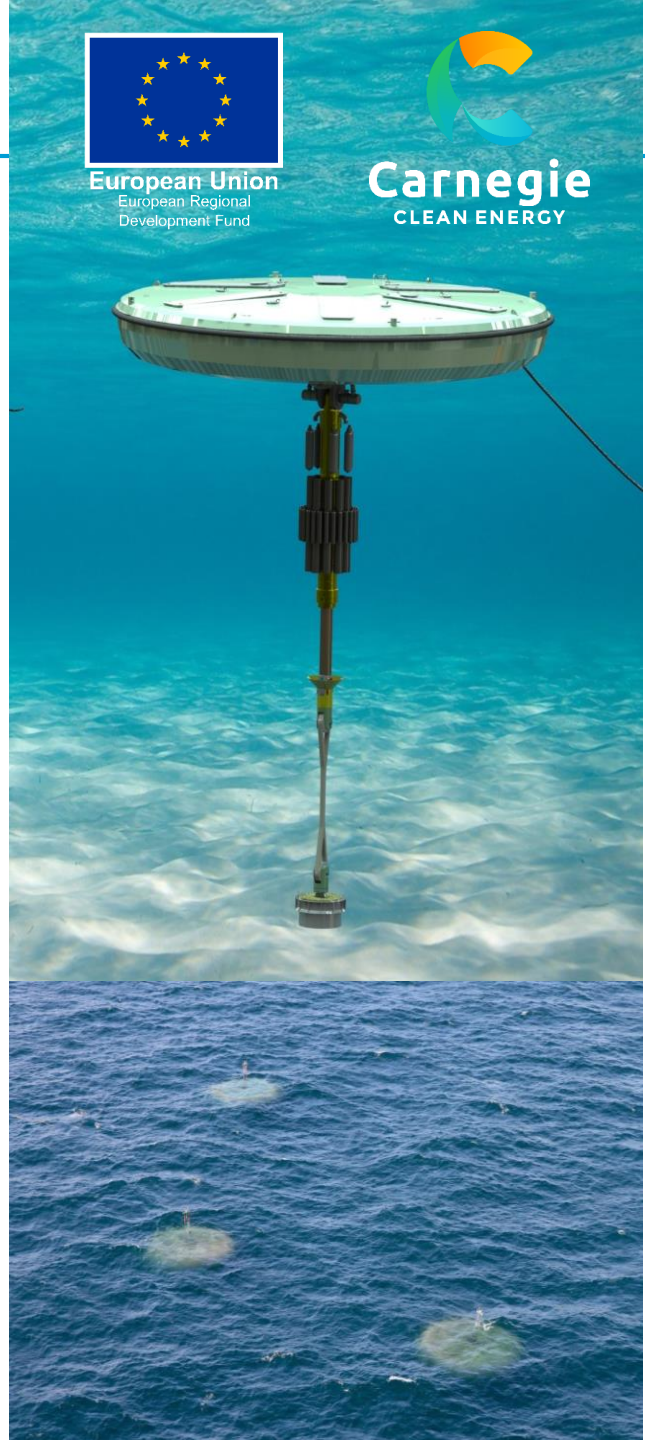
- UK Govt The Clean Growth Strategy
- “More nascent technologies such as wave, tidal stream and tidal range, could also have a role in the long-term decarbonisation of the UK, but they will need to demonstrate how they can compete with other forms of generation”



Research Opportunities

3 Research Areas

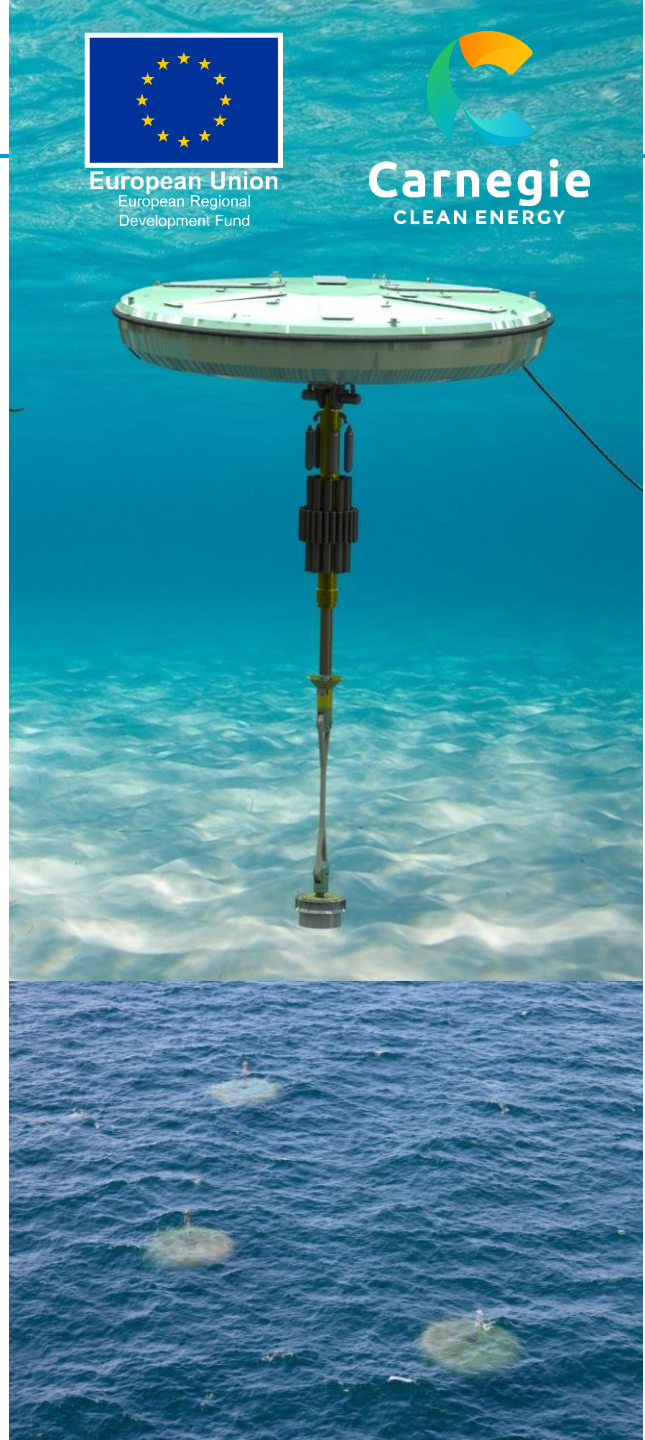
- Project specific R&D needing to be managed in-house with short / critical deliverables
- R&D to support next stage mini array deployment, hence 2-4 year timeframes but applied
- Blue sky R&D to support commercial role out leading to GW of cumulative deployment



Research Challenges

- Applied Research

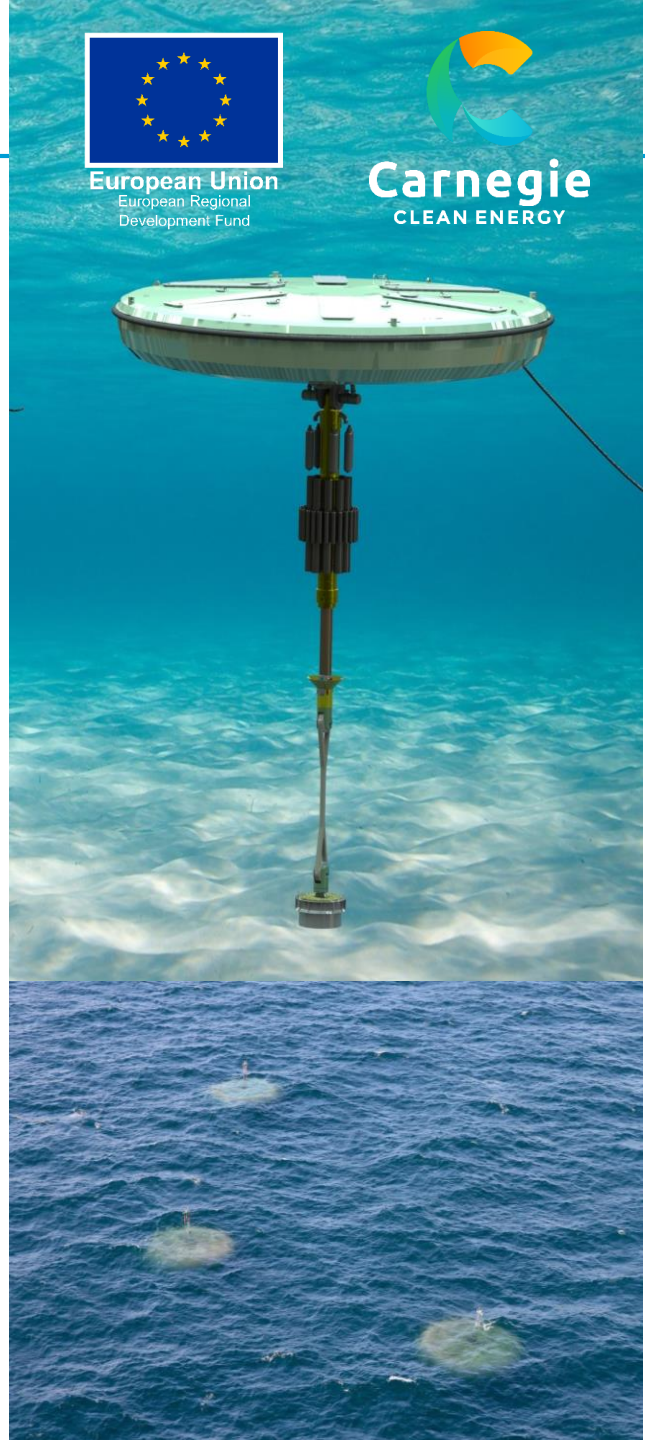
- Analytical tools to speed yield and survival load modelling and resource assessment – Reducing the need and cost to tank test, speeding up CFD testing and leveraging linear models as appropriate - New extreme wave load method developed
- Novel Hydraulic, electric and control designs for PTO
- Auto latching and release mooring connectors
- Reducing cost of subsea foundations
- Active buoyancy variation?
- Active surface area variation?



Research Challenges

- Applied Research

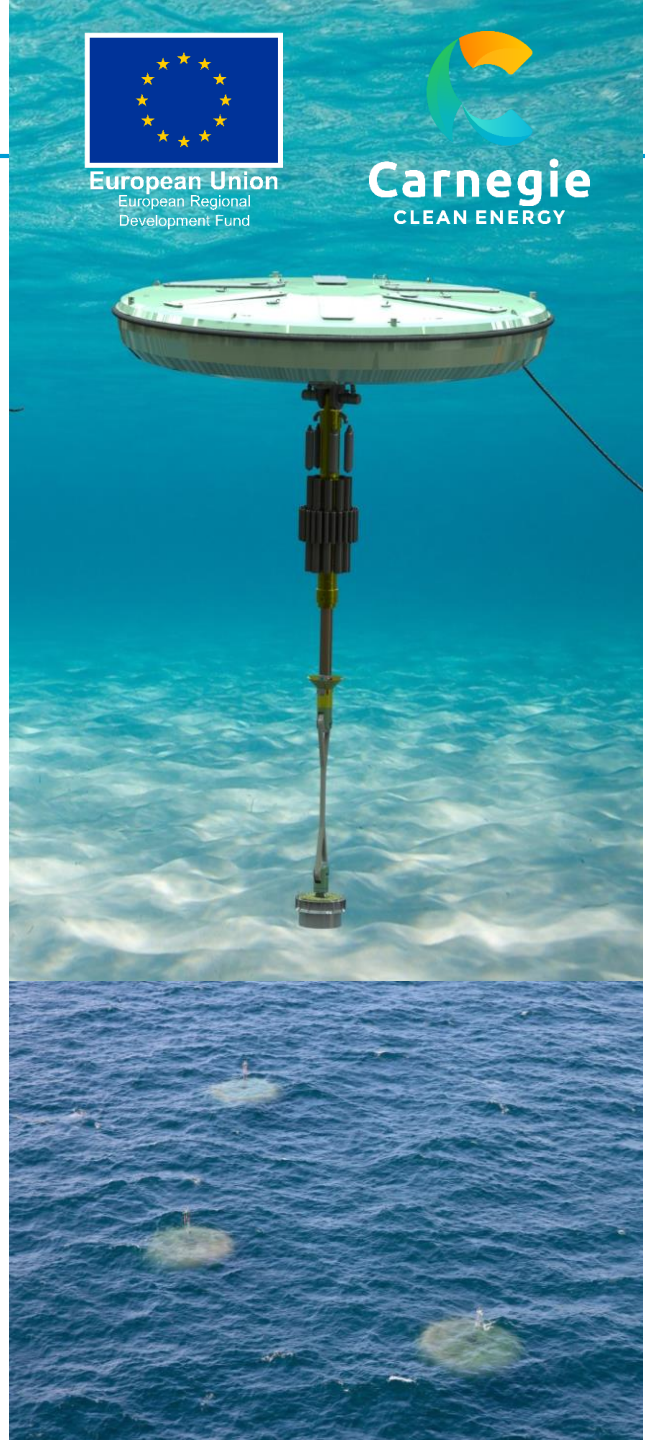
- Cost and weight of structures
- Application of new materials to CETO WEC (composites, 3d printed components)
- Use of new materials for mooring lines
- Composite mechanical springs – can they be applied to WECs?
- Cyclic bending over sheave of ropes – what is the optimum material for very high cycle, high force WEC application?
- Development of very high efficiency hydraulic machines
- Electrical connectors – wet mate connectors in particular.



Research Challenges

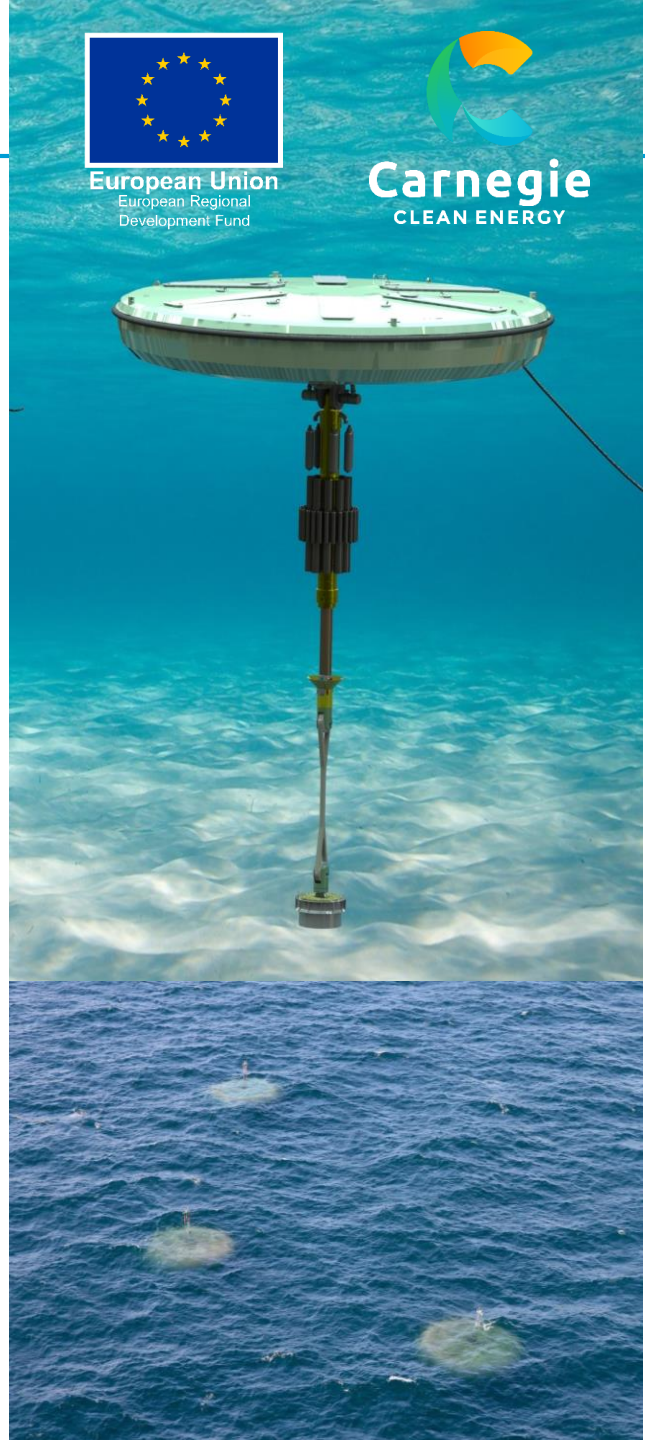
- Operations

- Reducing site development costs – novel approaches to geophysical and geotechnical site investigation, energy forecasting and environmental monitoring
- Analysing cost of performance vs. survivability
- Do advanced control methods (and increased yield) actually pay-off when considering cost of equipment?
- Can survival be achieved by the wave energy equivalent of ‘blade pitching’? What is that equivalent?
- Array level planning and cost reductions
- Accurately estimating Maintenance and reliability
- Array planning



Way Ahead

- Moving past TRL to CRL - Commercial Readiness
- Project Planning – Understanding project cost and risk
- Make it easier to get in the water beyond test sites – developing standardised legislation and templates for permitting and approval in absence of existing legislative framework
- Standards for WEC’s – Investor confidence, Insurance
- Fostering Industry Collaboration to reduce development costs and share knowledge
- Applied Industry lead Research



THANK YOU

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Carnegie Overview

- Carnegie is an Australian Stock Exchange listed developer of utility scale renewable energy projects. It's a global leader in the delivery of solar, battery, wave and hybrid energy solutions
- Team of over 100 across engineering, analysis, corporate, commercial, offshore, operations, maintenance, electrical, mechanical
- >£80m+ market capitalisation, £13m cash and £26m in undrawn grants
- Business model across the full value chain of design, development, finance, construction, operation and maintenance
- Diversified into solar and battery systems