Marine Renewable Energy Center

MREC

Ocean Energy for New England

Marine Energy - Technology Status

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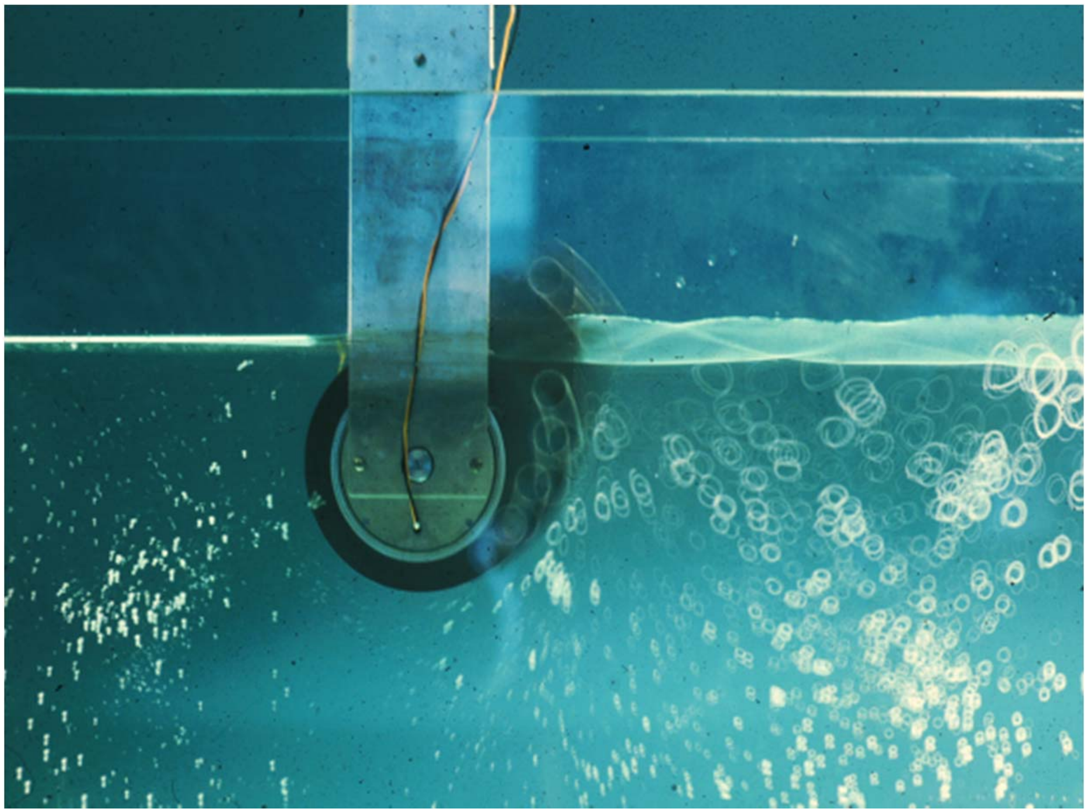
Technology Status

- Device development
- UK marine energy infrastructure
- R&D base - SuperGen
- Remaining challenges and opportunities for collaboration

Device Development - Wave

Salter’s nodding duck in tank in 1970s



Device Development - Wave

Shoreline OWC Limpet – Islay – UK

2 x 250 kW rated

Device Development - Wave

Point Absorber – Wavebob – Ireland

Prototype

Device Development - Wave

Point Absorber – OPT Powerbuoy – UK

50 kW

Device Development - Wave

Overtopper – WaveDragon - Denmark

25 kW

Device Development - Wave

Surface Float – WaveStar - Denmark

6 kW

Device Development - Wave

Surface Float – Olsen device - Norway

Protoype kW

Device Development - Wave

Submerged Float AWS - NL

2 MW

Device Development - Wave

Articulated Attenuator – Pelamis - UK

750 kW

Device Development - Tidal

Floating vertical rotor – Enermar Kobold - Italy

15 kW

Device Development - Tidal

SeaSnail – Self securing test bed - RGU - UK

100 kW

Device Development - Tidal

Open Hydro – 250 kW

Device Development - Tidal

Monopile single propeller – Hammerfest Strom - Norway

300 kW

Device Development - Tidal

Monopile propeller – MCT SeaFlow - UK

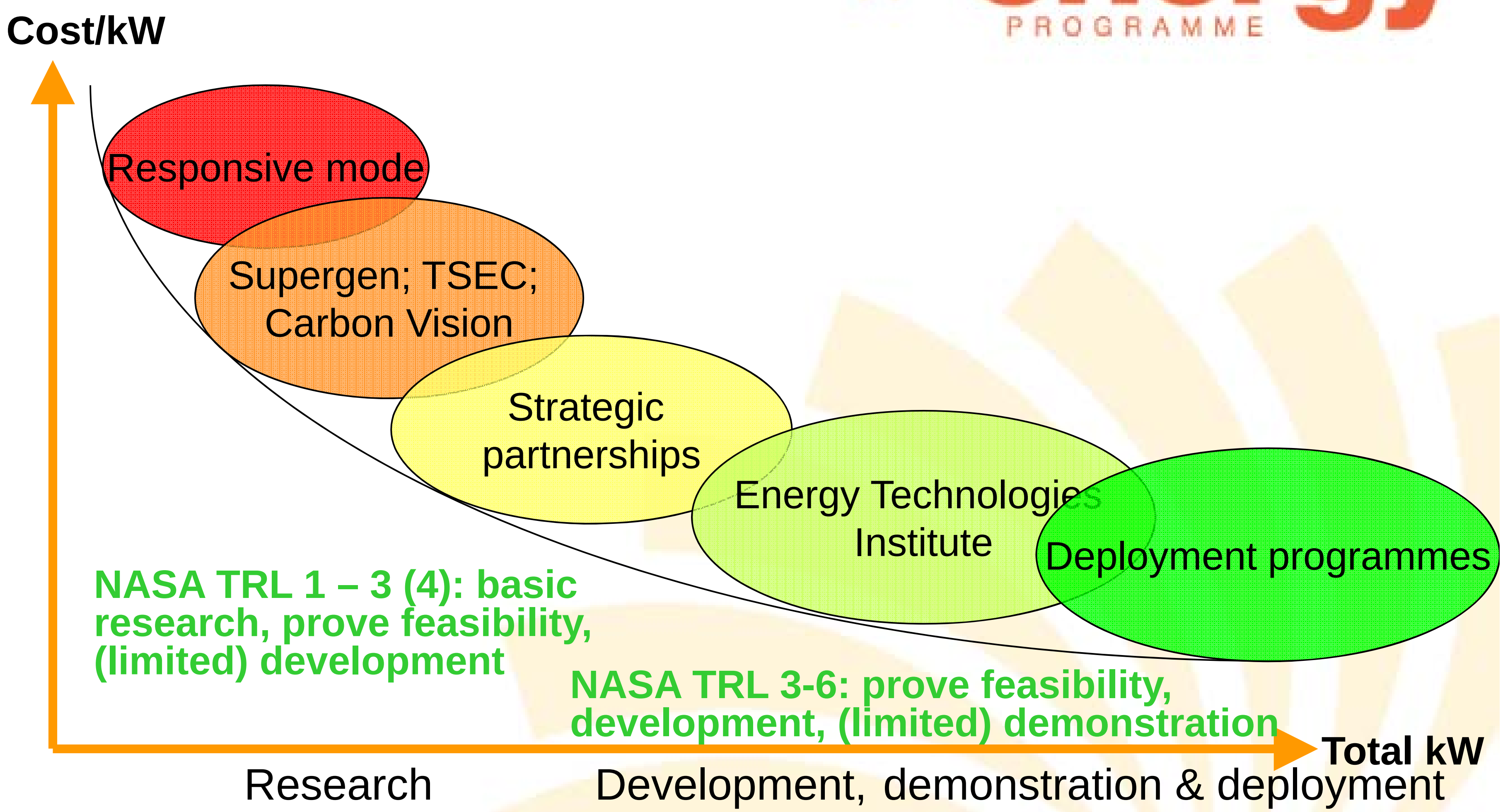
300 kW

Device Development - Tidal

Multi-pin pile Dual Propeller – MCT SeaGen - UK

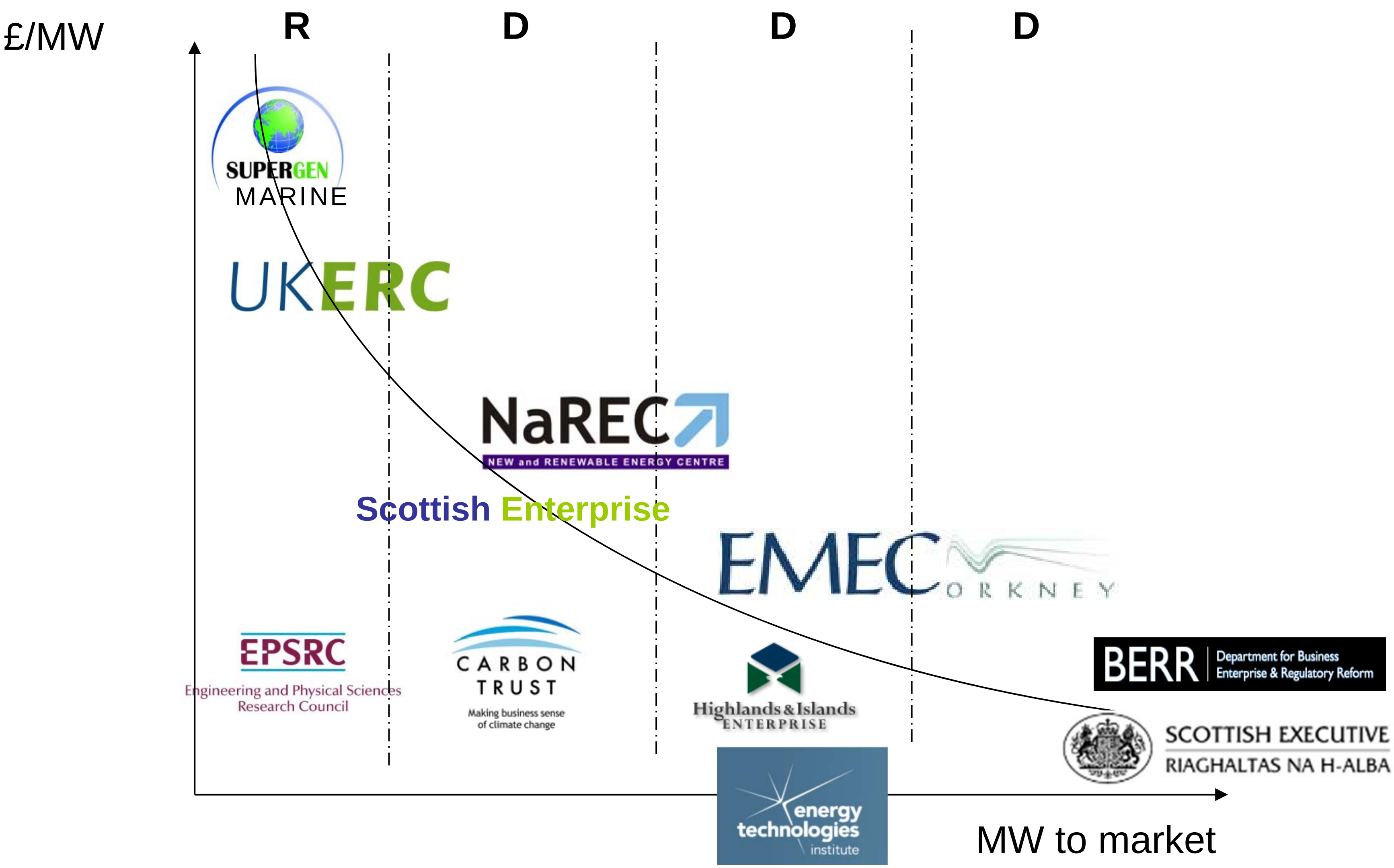
1500 kW

UK marine energy infrastructure



Fundamental underpinning	Generic targeted	Applied pre-competitive	Technology Pull-through	Deployment

UK marine energy infrastructure

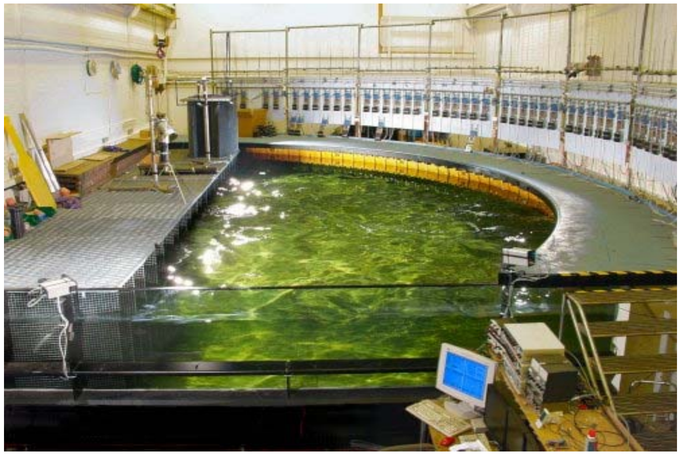


UKERC

UK marine energy infrastructure

Queen’s Belfast, Durham, Edinburgh, Exeter, Heriot-Watt, Hull, Imperial, Lancaster, Liverpool, Manchester, Newcastle, Robert Gordons, Southampton, Strathclyde, St Andrews, Swansea…………..

- estimated 50-60 academics and RAs
- all have in excess of 20 person years of experience
- 12 have wave tanks, most have wave flumes
- 16 towing or pumped tidal current tanks
- 6-10 other specialised, dedicated labs
- all have numerical modelling suites
- 7 have devices under development
- £50-75M of prior investment
- £20-25M of research funding



UK marine energy infrastructure

NaREC

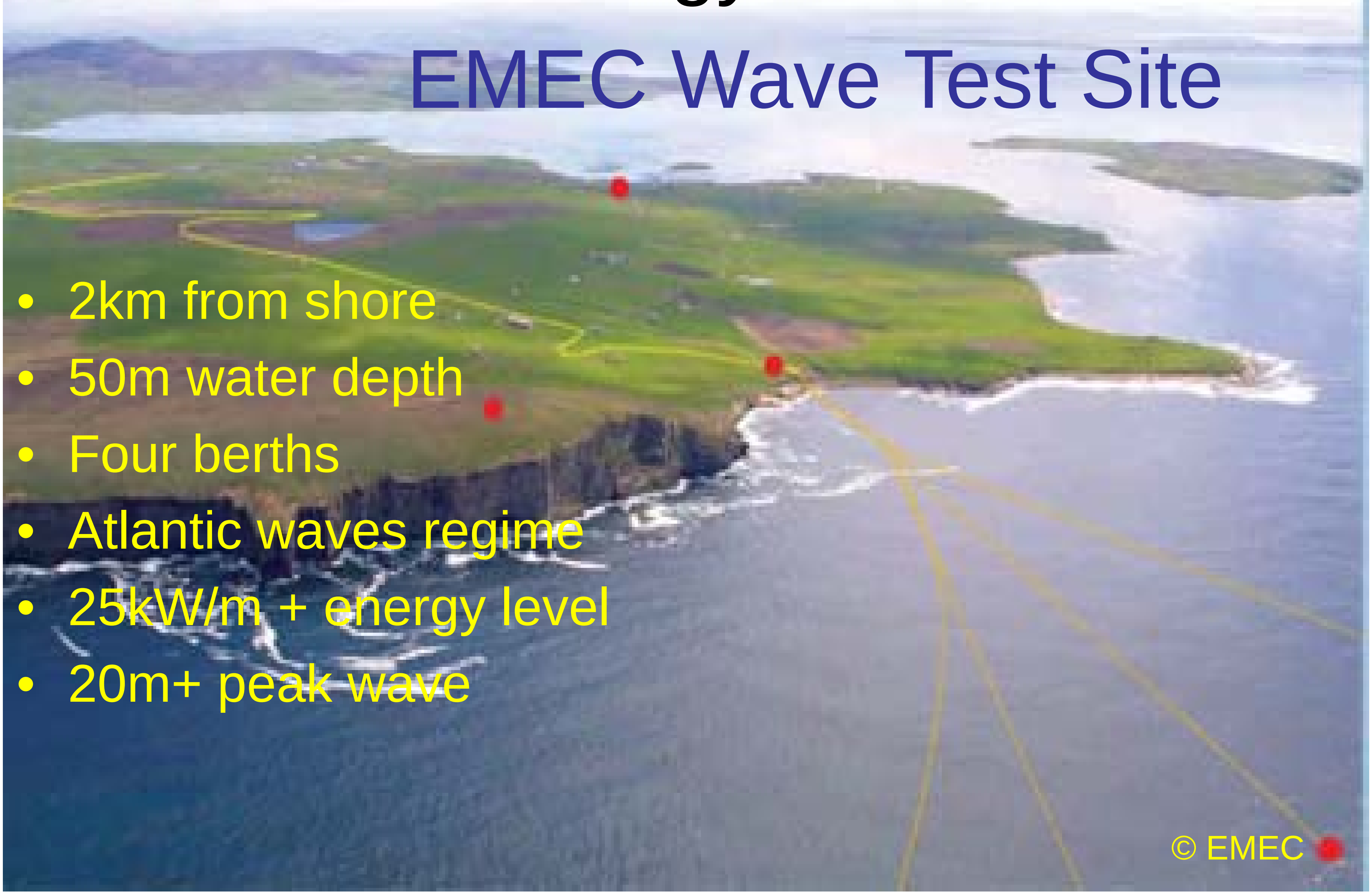
- Wave
- Tidal Current
- Oil & Gas

NaREC
NEW and RENEWABLE ENERGY CENTRE

UK marine energy infrastructure

EMEC Wave Test Site

- 2km from shore
- 50m water depth
- Four berths
- Atlantic waves regime
- 25kW/m + energy level
- 20m+ peak wave



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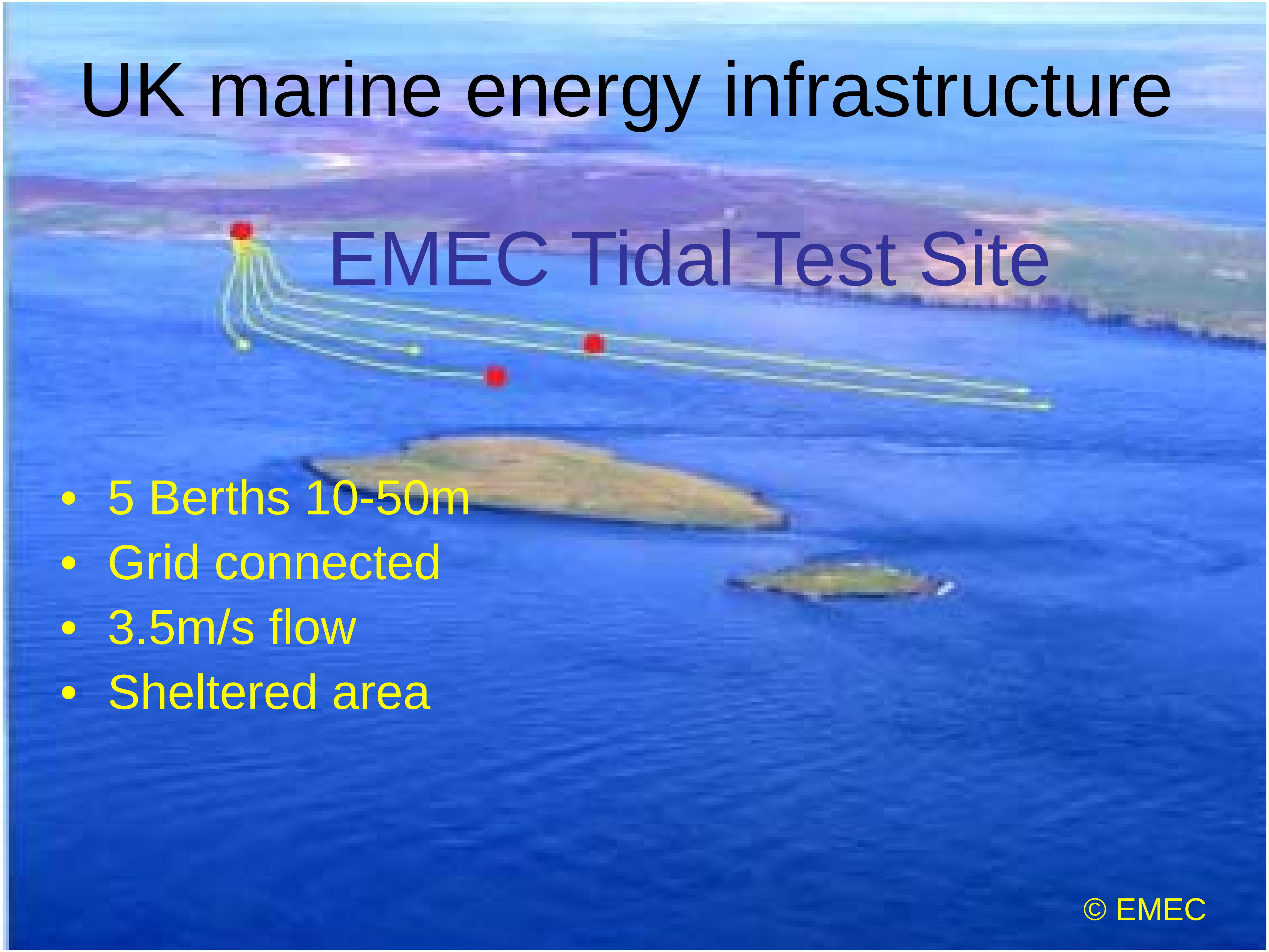
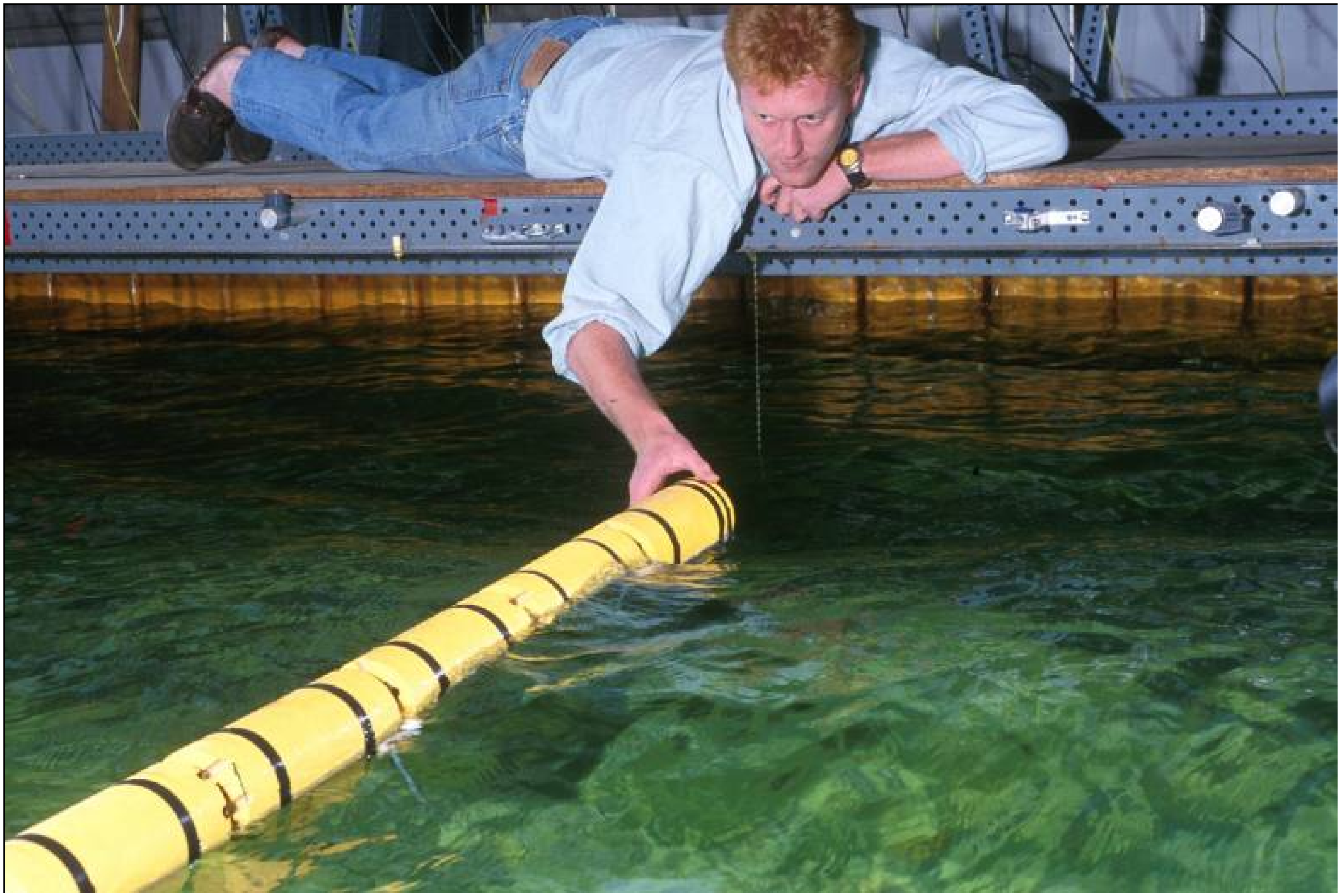
UK marine energy infrastructure



- 5 Berths 10-50m
- Grid connected
- 3.5m/s flow
- Sheltered area

Development route from model to full-scale

Pelamis at 1/100 scale with inventor Richard Yemm (full scale)



Development route from model to full-scale

Pelamis 1/7 scale

Development route from model to full-scale

Pelamis full-scale – 750 kW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UK marine energy infrastructure

UKERC's European Marine R&D Road Map

For each of Wave and Tidal Technologies, UKERC has mapped

- Short term needs (2-3 years)
  - Showstoppers, enablers, make-feasibles
- Medium term progress (3-10 years)
  - Essential, desirable, ideally available
- Long term drivers (10-15 years)
  - Drivers down cost curves

UKERC

UK marine energy infrastructure

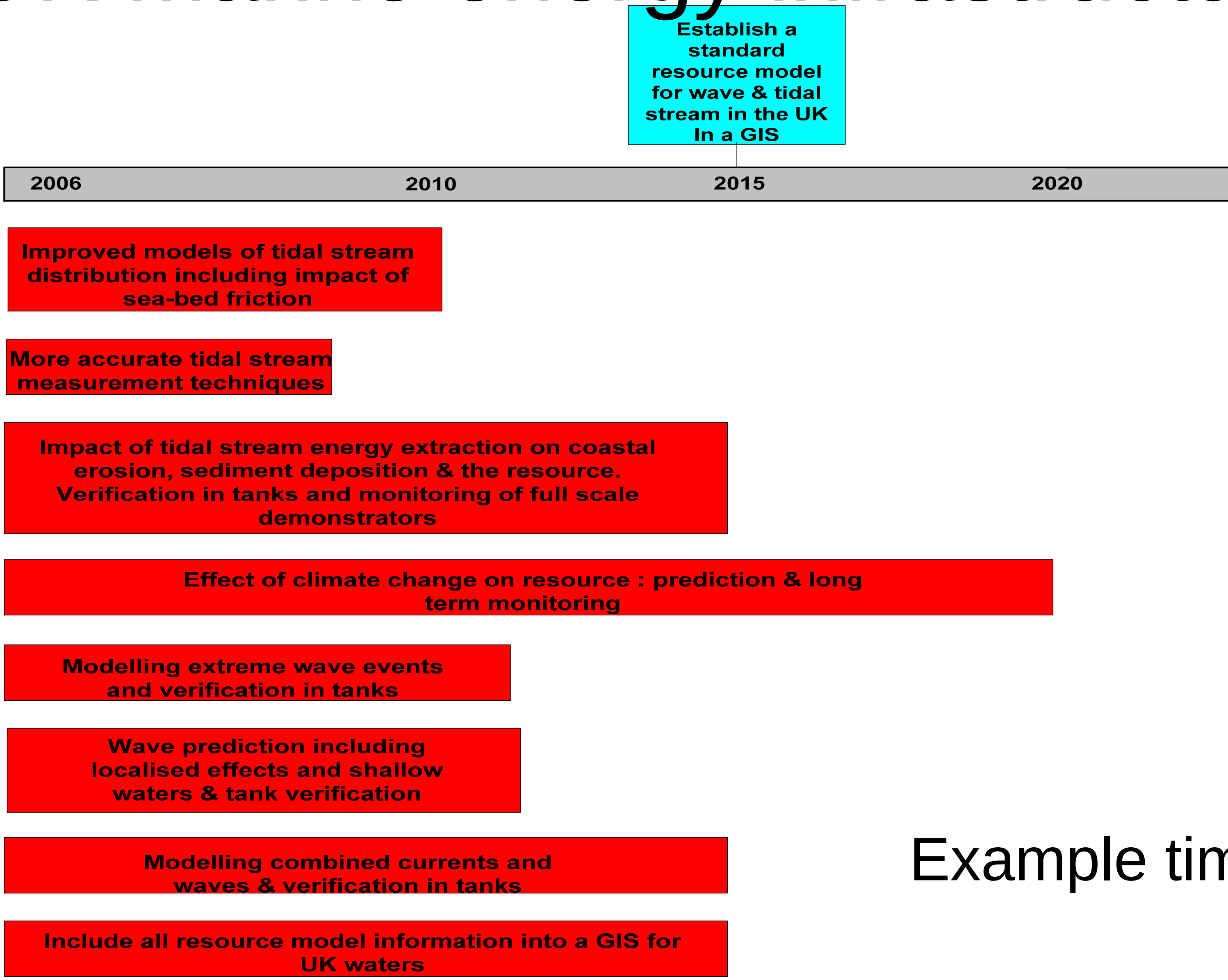
Initial outcomes of Roadmap

Term	Wave	Tidal
Short	67	
Medium	53	60
Long	16	

Items of generic, component or method research – not device specific. Device development needs to focus.

Vary from 3 -36 months in duration depending on needs, and will be addressed where appropriate in collaboration. Will advise RCUK planning.

UK marine energy infrastructure



Example timeline

Resource modelling

The SuperGen Marine Energy Research Consortium

Phase 2 Oct 2007 – Sep 2011

Phase 2 Aims and objectives

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Generic research with long-term objectives to:

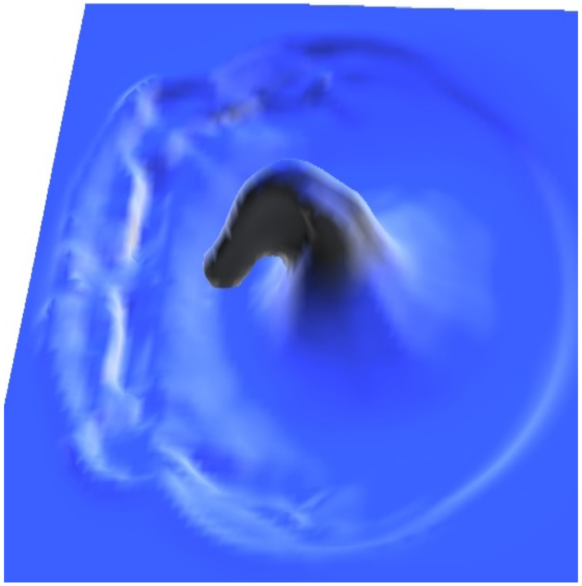
1. To increase knowledge and understanding of device-sea interactions of energy converters from model-scale in the laboratory to full size in the open sea.
2. Reduce risk and uncertainty for stakeholders in the development and deployment of technology;
3. Enable progression of marine technology and energy into true positions in future energy portfolios.

Phase 2 Work Streams

WS1 Numerical and physical convergence
WS2 Optimisation of collector form and response
WS3 Combined wave and tidal effects
WS4 Arrays, wakes and near field effects
WS5 Power take-off and conditioning
WS6 Moorings and positioning
WS7 Advanced control of devices and network integration
WS8 Reliability
WS9 Economic analysis of variability and penetration
WS10 Ecological consequences of tidal & wave Energy conversion
WS11 Doctoral Training Programme
WS12 Dissemination and Outreach

WS1: Numerical & physical convergence

There has been a revolutionary increase in the power of numerical modelling for analysis of waves, tidal currents and marine technologies. Numerical modelling, scale-testing and full-scale testing will be advanced to more confidently predict working performance.



WS1: Numerical & physical convergence

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Numerical modelling, tank testing, part- and full-scale testing will be aligned to provide consistent and confident predictions of performance

WS2: Optimisation of collector form

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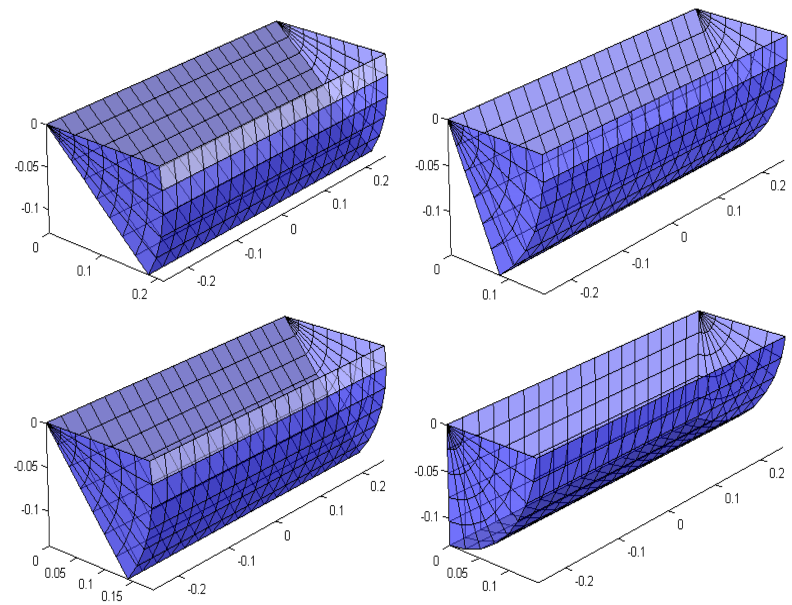
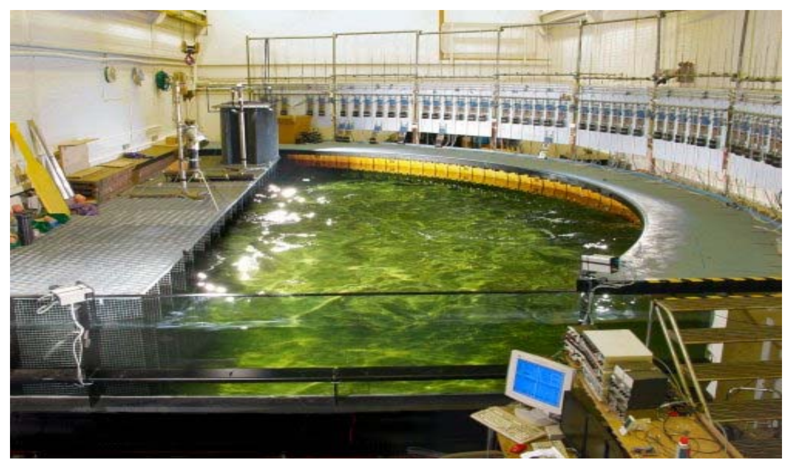
Genetic algorithms, numerical modelling and tank testing is being used to evolve better, even optimal, designs of wave energy converters.





WS3: Combined wave and tidal effects

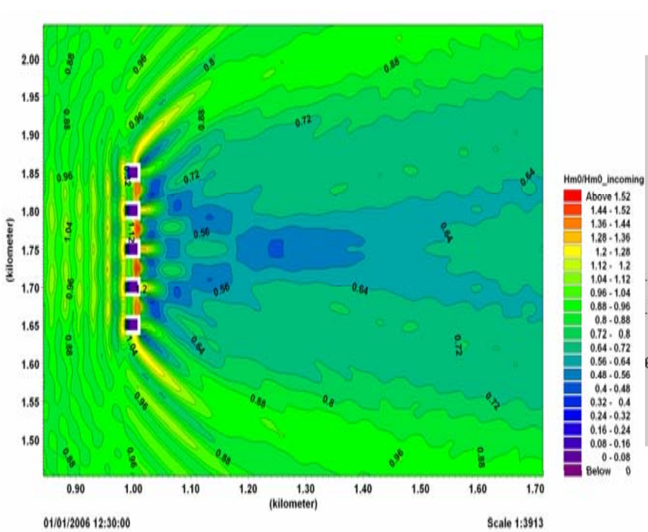
Tidal current converters are installed and operate in seas with wave action. Wave converters are influenced by currents and water level changes. This work is advancing design, prediction and test procedures to recognise this.

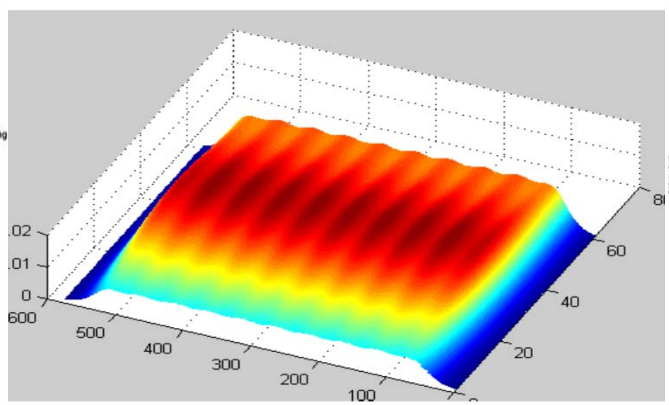
Tests will be conducted at Queens, Edinburgh and a new dedicated 1/10th scale facility at Portaferry and at EMEC

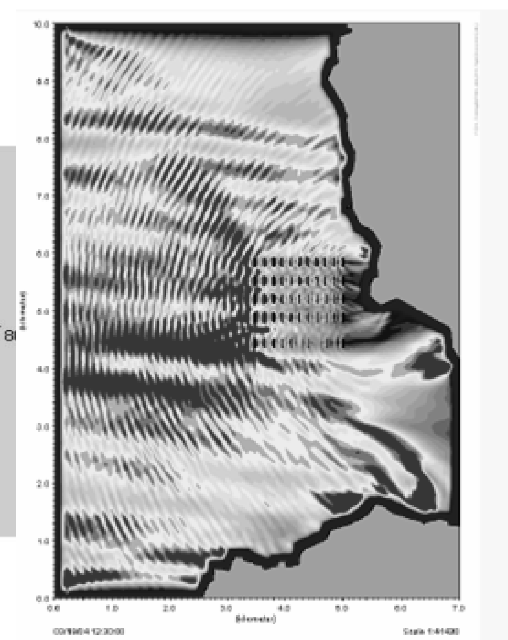
WS4: Arrays, wakes and near field effect

Array interactions will affect the design and performance of both tidal current and wave converters – individually and collectively.

This work is determining the local impact of multiple devices on the energy flux environment and on each other to identify optimal configurations and control strategies for arrays.





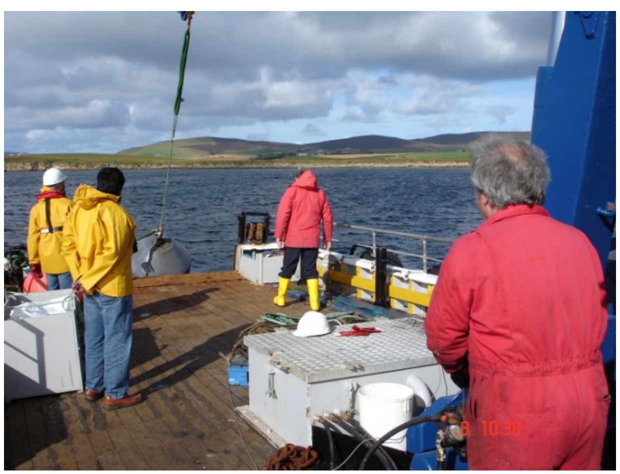


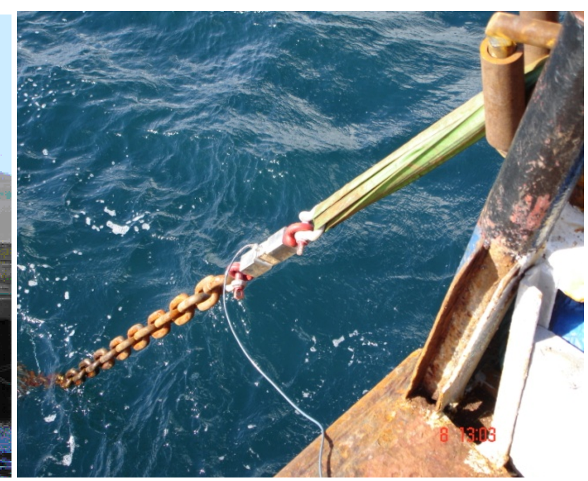
WS5: Power take-off and conditioning

The prime-mover, drive-train, generator and power converter must be designed from the outset in an integrated manner, fit for the purpose in the working environment. This work is integrating structural, magnetic, thermal and electrical designs to optimise performance:cost ratio.

WS6: Moorings and positioning

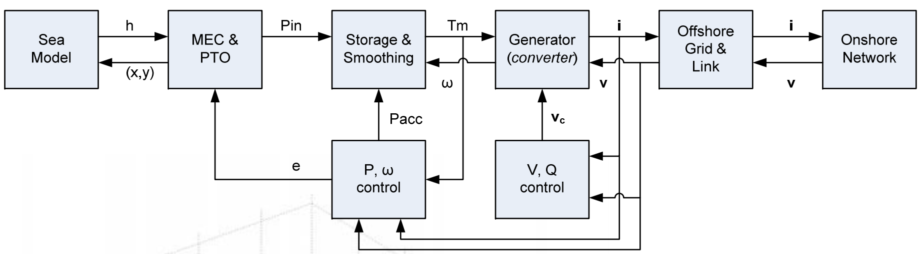
Moorings for arrays of wave or tidal energy converters must be designed to ensure safe and economic operation. This work is establishing design methods for the safe, economic station keeping of arrays taking account of short and long term loading in combined wave, current and winds to predict coupled response from combined device and mooring loads.

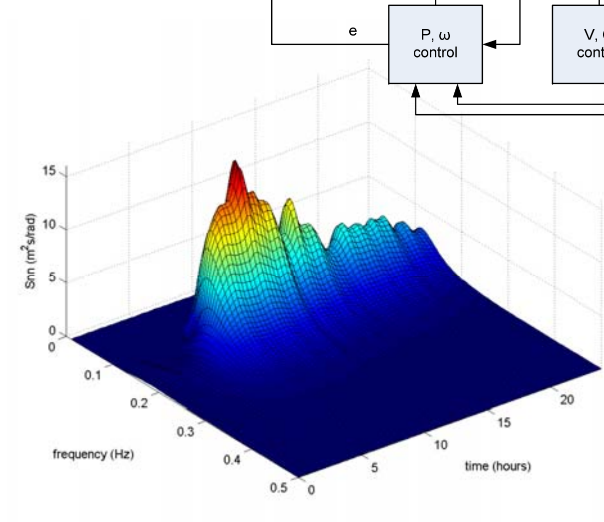


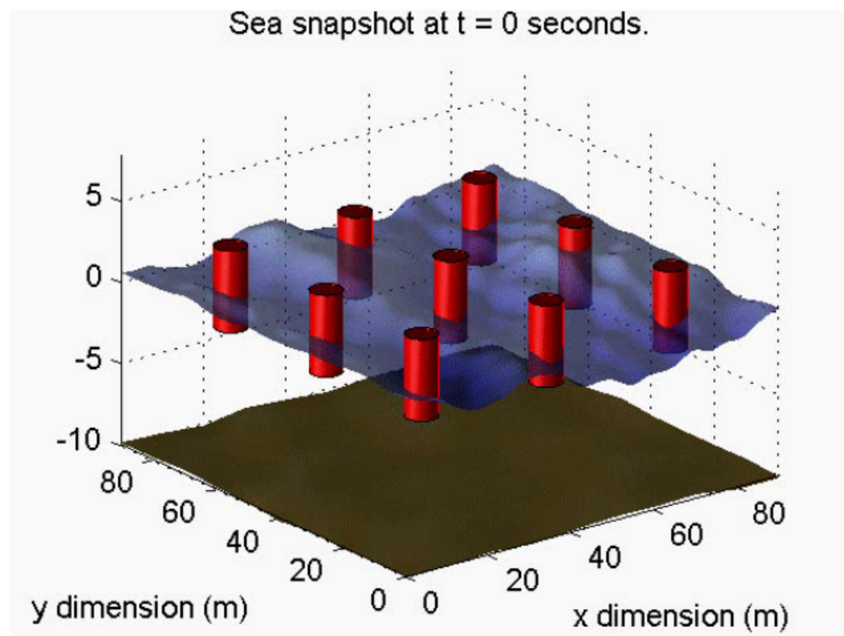


WS7: Advanced control/network integrati

The sea is a non-linear non-stationary environment. This work is developing continuously adapting control techniques to optimise energy extraction and survivability. Interaction of arrays of devices with actively controlled distribution networks assesses impact.





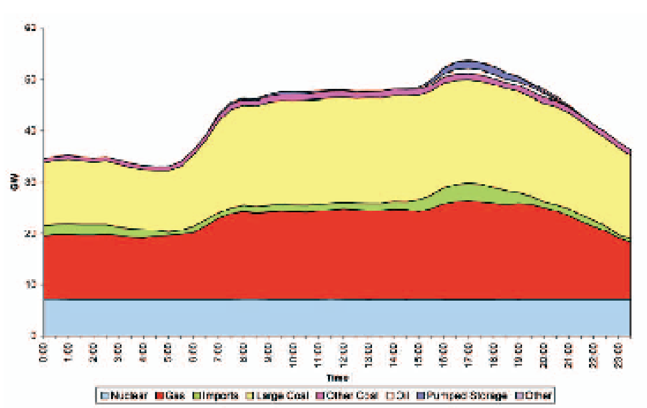


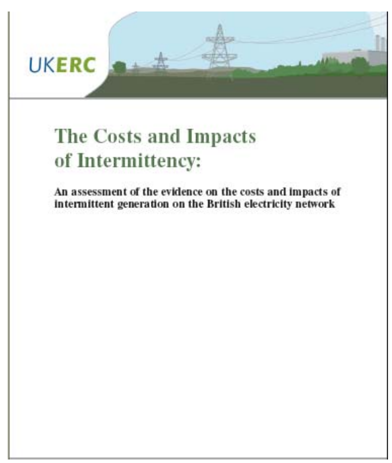
WS8: Reliability

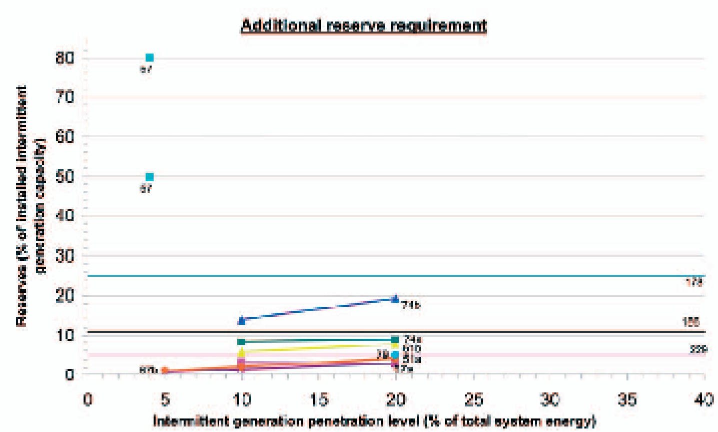
This work will establish an effective method to quantify the reliability of marine energy converters even in the scarcity of industry-specific component failure rates and environmental data. It will explore the effect of changing maintenance strategy on availability in arrays.

WS9: Economic analysis of variability and penetration

This work is predicting the pattern and timing of future uptake of marine energy by the market, recognising its nature and location recognising the variability of generation and peripherality of sites.







WS10 - Ecological Consequences of Tidal and Wave Energy Conversion

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This work is establishing the principal ecological consequences of the extraction of tidal and wave energy in coastal and offshore zones. It is exploring the extent to which such changes be predicted from forecasts of change in the ambient flow field, energy and associated particulate regimes, and whether these are observable in the field or amenable to compliance monitoring for statutory purposes.

WS11 - Doctoral Training Programme

SUPERGEN MARINE

This is attracting, sponsoring and training 24 doctoral students to re-vitalise the supply of trained scientists and engineers for the academic, industrial and infrastructure sectors of marine energy. It operates across core and affiliate universities.

Remaining challenges and Opportunities for Collaboration

Road Map identified research priorities as

- Test facilities
- Moorings and Foundations
- Resource modelling
- Device modelling
- PTO and control
- Installation and O&M
- Survivability
- Engineering Design
- Environmental and Marine Users
- Electrical Power infrastructure and technology
- Economics & Policy
- Standards & Life cycle analysis

Remaining challenges and Opportunities for Collaboration

- Design for manufacturability, survival, performance and cost-efficiency;
- Realistic dual wave & tidal current test facilities/practices;
- Novel installation, maintenance and recovery technologies;
- Analysis, modelling and validation of array deployment;
- Mitigation of combined wave and tidal interactions devices;
- Integrated design and manufacture of generators;
- Environmental impact assessment and mitigation.

Keen to identify US collaboration and exchange to secure and accelerate progress

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