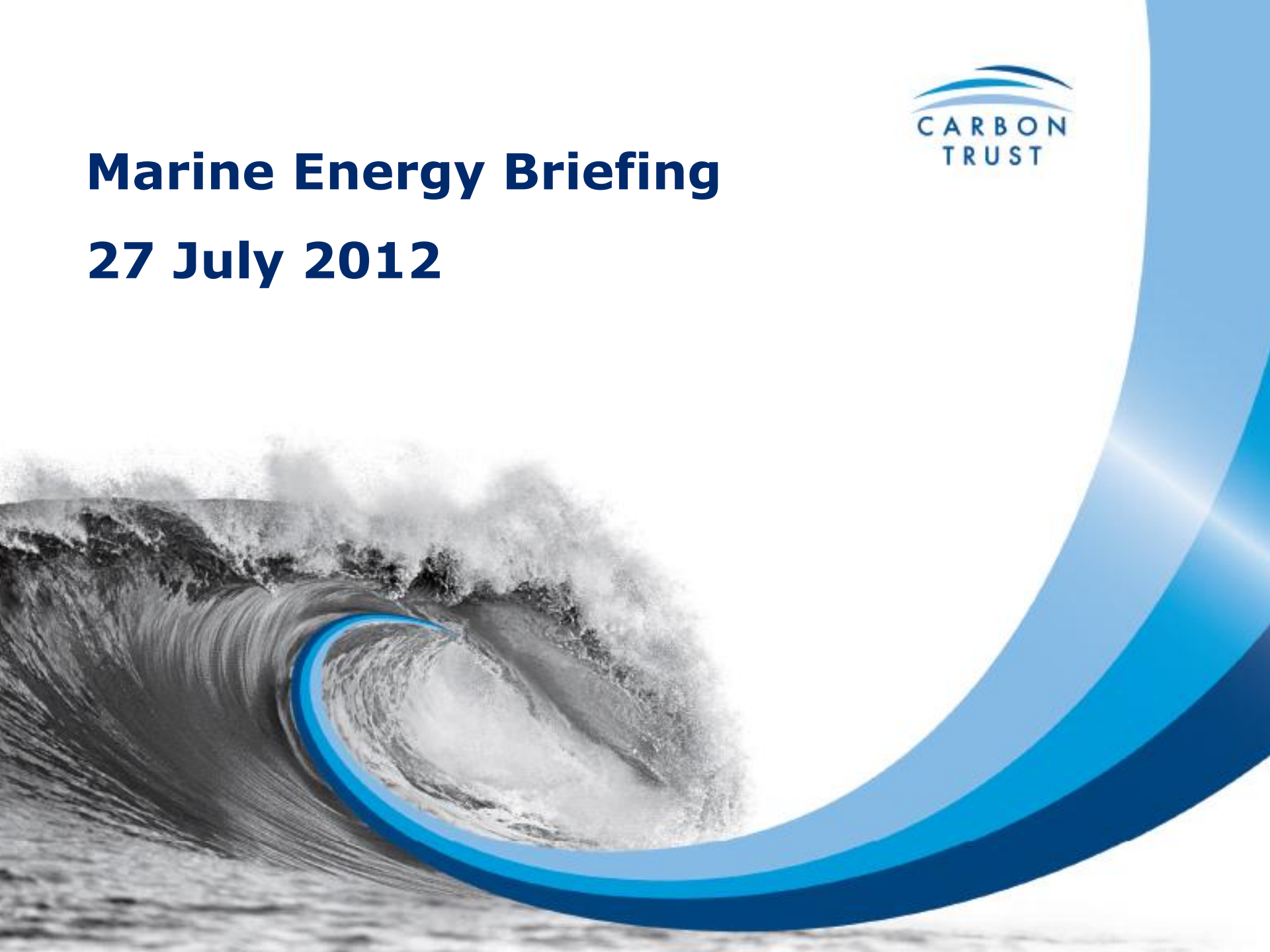
Marine Energy Briefing

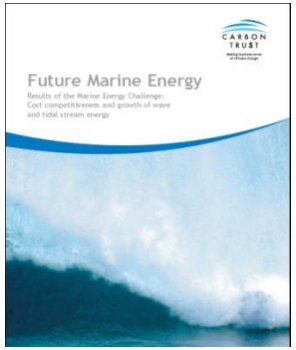
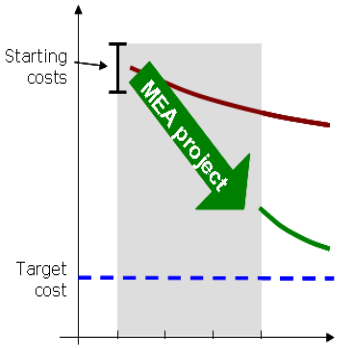
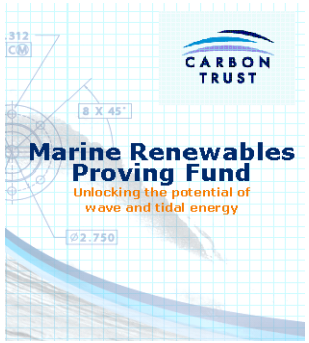
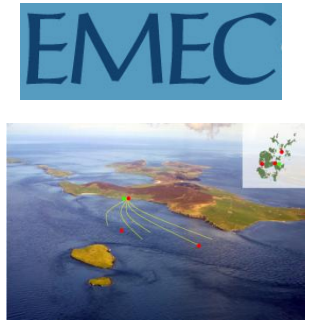
27 July 2012



Agenda

- Overview of wave and tidal
- Potential for marine energy in the UK
- Technology status and challenges
- Unlocking the potential for marine energy

Carbon Trust have delivered, or are delivering £50m of marine energy innovation

Understanding the challenge	Accelerating cost reduction	Proving the technology	Demonstrating at scale	Facilitating development
				
Marine Energy Challenge 2003-2006	Marine Energy Accelerator 2007-2010	Marine Renewables Proving Fund 2009-2011	MRCF 2012	Founding Funder since 2005

- CT have been working with the marine energy industry since 2003
- Current focus is on full scale demonstration and cost reduction
- EMEC test centre is vital to the industry, and provides cost-effective open-access infrastructure
  - Capital funded by a consortia of key public sector stakeholders
  - Running cost covered by berthing fees

Marine Energy technologies

Tidal Stream power

The blades are around 16m Dia. Typically in 25m of water.

Sufficient power for ~800 homes.

Wave power

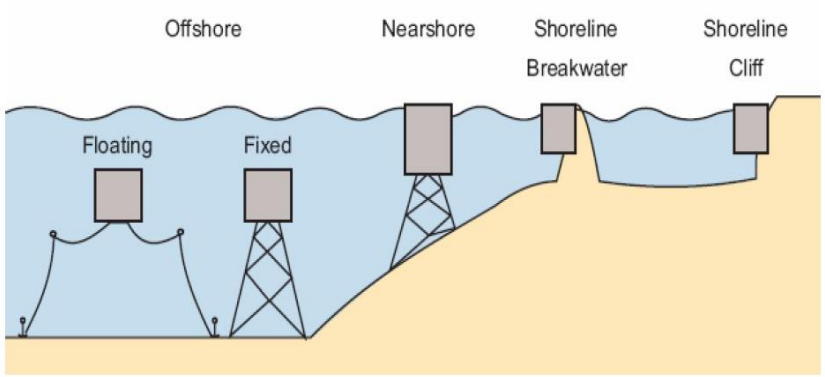
About the same size as a London tube. Sufficient power for ~500 homes.

Background: Within "Wave" and "Tidal stream" there are a number of variants being developed

Wave Energy

- Occurs in the movements of water near the surface of the sea. Waves are formed by winds blowing over the sea surface and the water acts as a carrier for the energy.
- The amount of energy in waves depends on height and period (the time between successive peaks).
- Systems to convert wave energy to electricity are categorised by their location in the sea, which has a bearing on the amount of energy they can capture.
- Offshore wave energy converters are designed for sites that are deep and many km offshore, while near-shore & shoreline systems are intended for shallower water on shoreline positions.

Wave energy systems

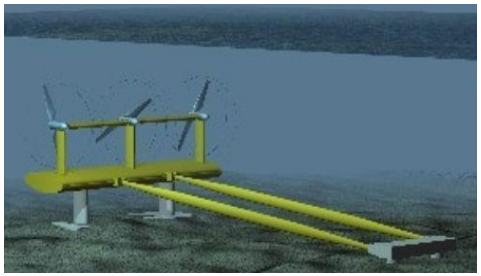


Tidal energy

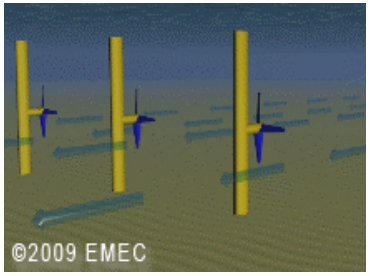
Tidal Streams are driven by the gravitational pull of the moon causing large bodies of water to move in the world oceans. Where these movements are constricted high velocity tidal flows occur. It is these tidal flows which hold the greatest potential for energy extraction. This is similar to wind power extraction on a very basic level, but because water is much denser than air, an equivalent amount of power can be extracted over smaller areas and at slower velocities.

Tidal stream energy systems

Deep



Shallow



Source: MEC Future Marine Energy, CT 2006, IEA OES Ocean Energy Global Technology Status 2009; IEA OES Annual Report 2008; EMEC

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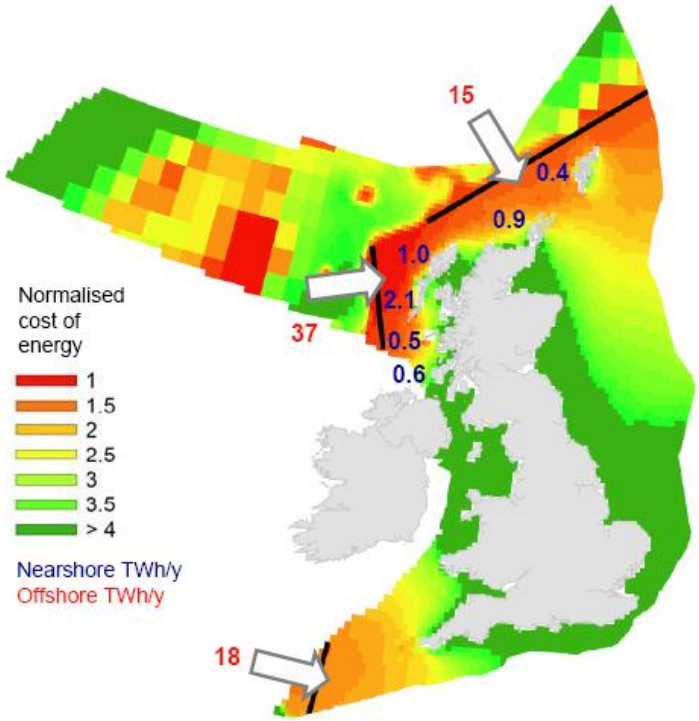
Marine Energy Resource in the UK - together wave and tidal could provide 20% of the UK's electricity if fully developed

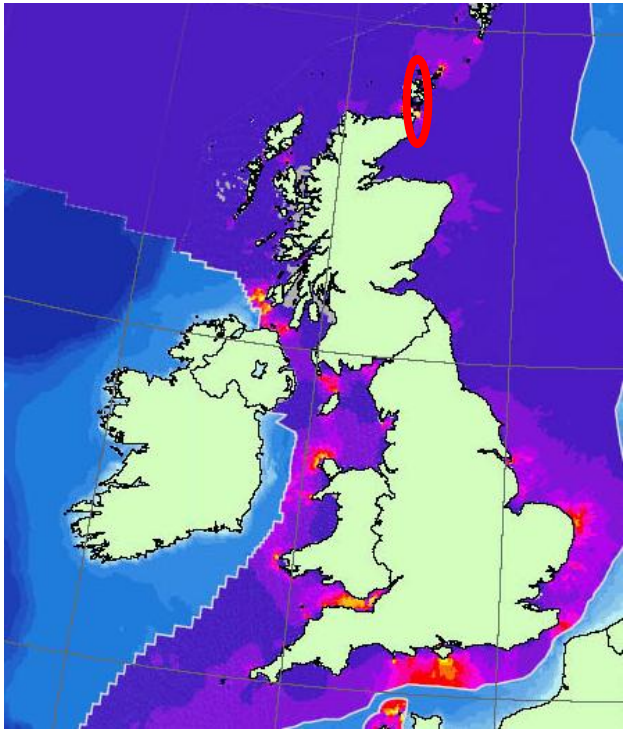
Wave energy



Distribution of wave energy around UK

- Highly energetic seas (warm colours) are off NW Scotland and SW England
- Estimate of UK practical offshore wave energy resource: 70 TWh/year

Tidal stream energy



Distribution of tidal stream energy around UK

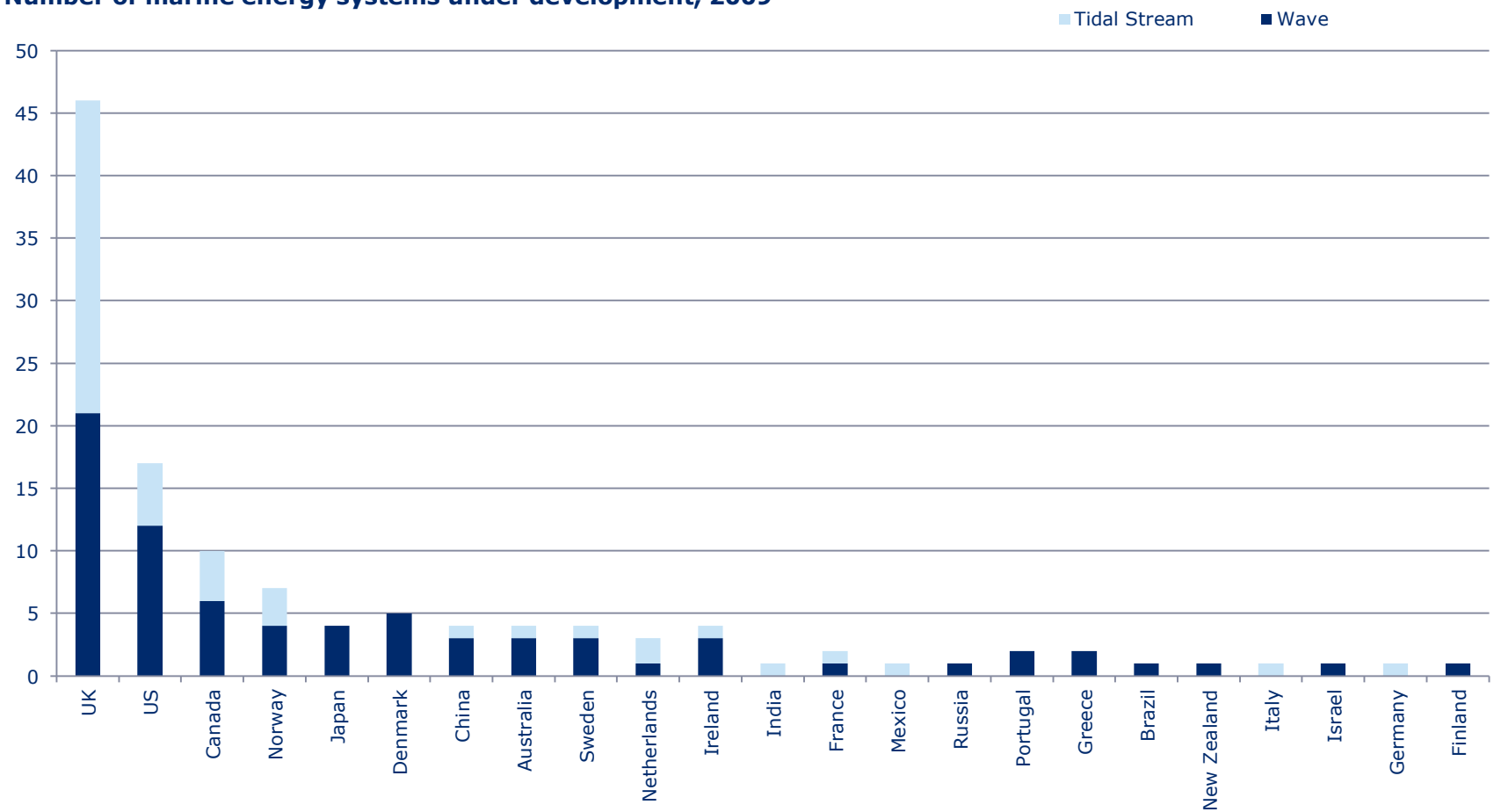
- Energetic sites (warm colours) are scattered around UK
- Estimate of UK resource: 29 TWh/year.

Marine Energy has the potential to provide up to 20% of the UK's electricity

Potential to meet energy demands	Max: 15-20% UK electricity demand Worldwide: 2000-4000 TWh/year In the UK a realistic scenario is 13.2 GW by 2050 (~11%)
Potential to make carbon savings	UK: 50-100 $MtCO_2$ Worldwide: 200-700 $MtCO_2$
Security of supply	Large indigenous energy resources
Potential to create economic benefits	UK: Significant export opportunities. Job creation through design manufacturing, as well as deployment and servicing. Est. 16,000 from wave, and c.10,000 from tidal. Value add to UK economy £3bn / year. Global market size est. £8 bn.
UK advantages over other countries	Strong academic R&D capacity Concentration of technology development companies Ability to exploit knowledge/skills in traditional maritime/offshore industries

Overall the UK has a strong competitive position and leads global marine device development

Number of marine energy systems under development, 2009



Source: EMEC, IEA OES Ocean Energy Global Technology Status 2009, Company websites

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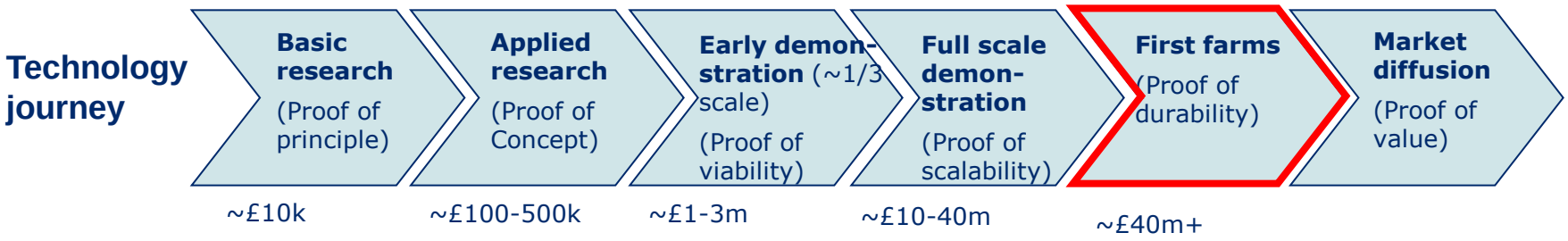
There are essentially 2 challenges for marine energy; performance and cost

	Challenge	Requirement
	Performance	
1	We know it can work (in principle) but can we generate significant power from wave and tidal energy devices?	Demonstration of current best in class concepts to understand what we can do with todays technology.
	Cost	
2	We know current cost are prohibitively high but is it possible to make significant cost reductions?	Explore the potential for cost reduction, and accelerate most promising options.

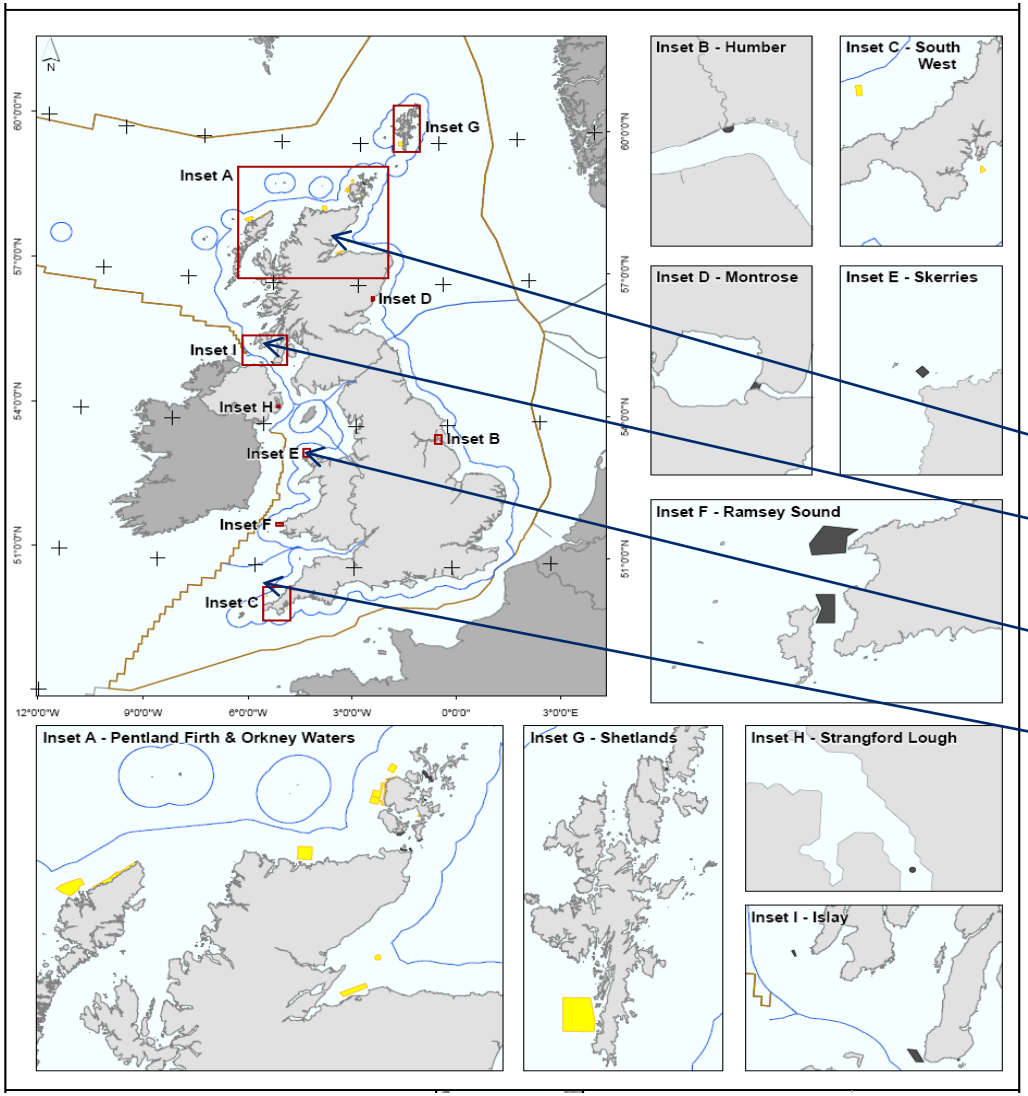
Both wave and tidal have been demonstrated at full-scale, but costs to move along the technology journey are high



No. of UK devices			
Wave	**c.10-15**	**c.5-7**	**c.3**
Tidal	**c.15-20**	**c.5-10**	**c.5**

- The marine market has a number of devices which are being demonstrated at full scale. However, costs to move to full demonstration are high, and development can represent an unacceptable risk for private investment - the public sector has needed to take on some of this risk.
- Hence, significant progress in wave and tidal generation still depends on public sector intervention to share the risk of progressing to full-scale demonstration and beyond.

We are now moving towards the first commercial projects - 36 wave and tidal sites leased for wave and tidal, the majority is in the Pentland Firth



- First array projects are focused on Pentland first and Orkney waters, with a few other potential projects in England and wales.

Pentland first and Orkney waters

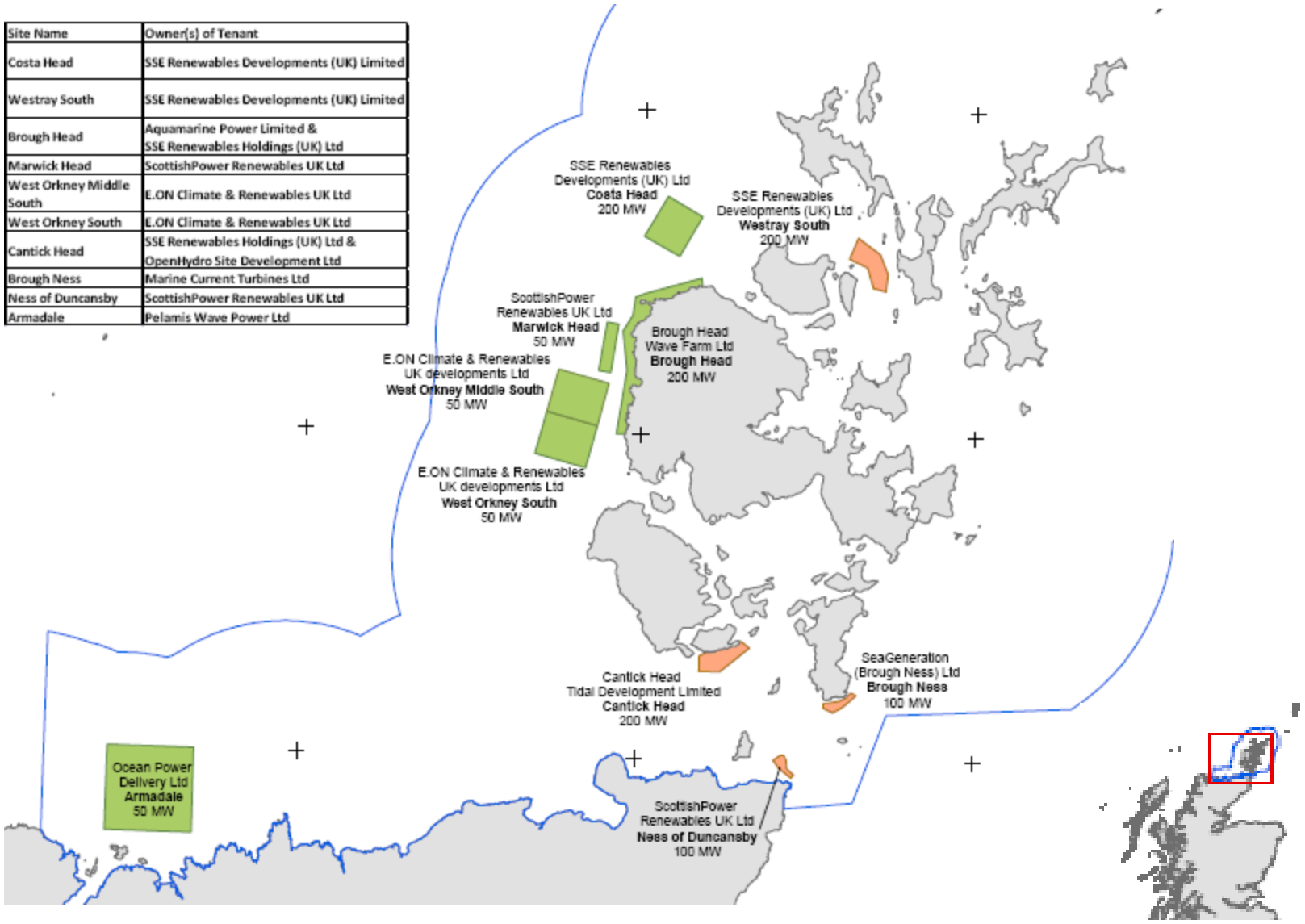
Sound of Islay

Anglesey skerries

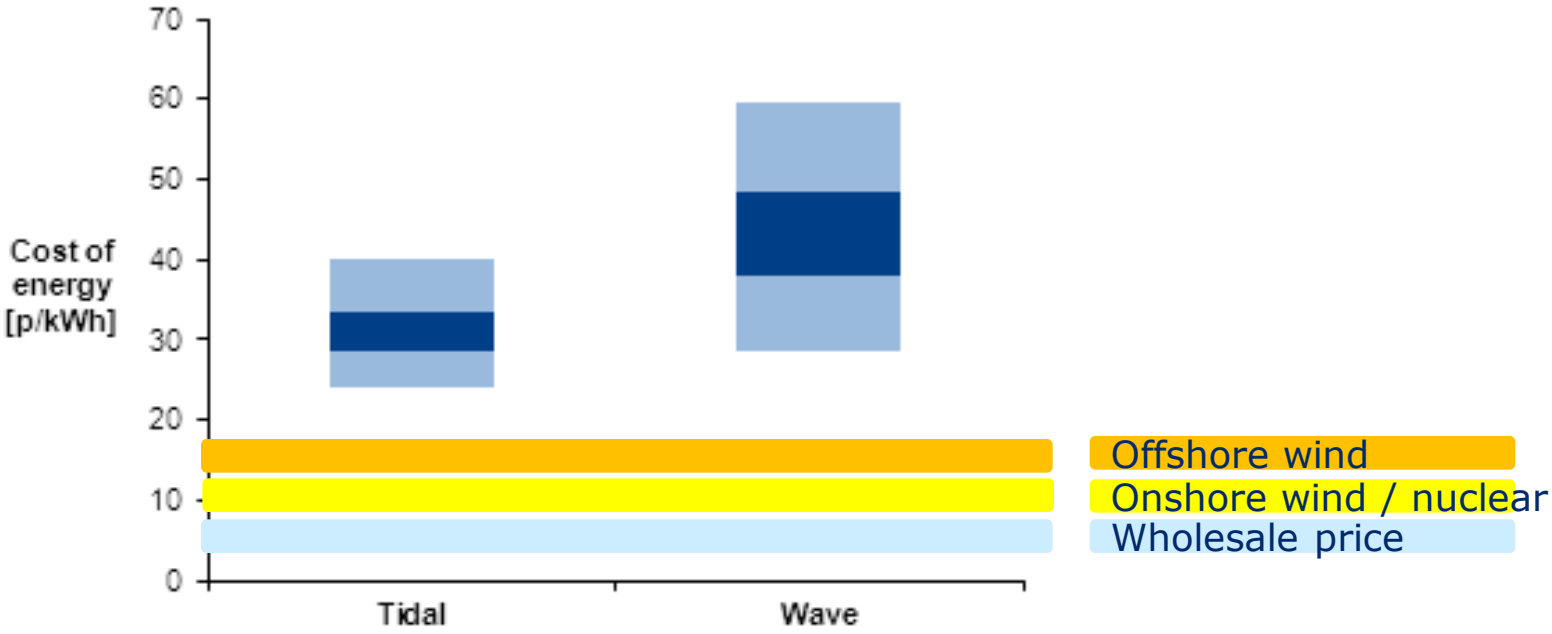
Wave hub

The first commercial leasing round was in the Pentland firth and Orkney waters, total licenses are 1.6GW

Site Name	Owner(s) of Tenant
Costa Head	SSE Renewables Developments (UK) Limited
Westray South	SSE Renewables Developments (UK) Limited
Brough Head	Aquamarine Power Limited & SSE Renewables Holdings (UK) Ltd
Marwick Head	ScottishPower Renewables UK Ltd
West Orkney Middle South	E.ON Climate & Renewables UK Ltd
West Orkney South	E.ON Climate & Renewables UK Ltd
Cantick Head	SSE Renewables Holdings (UK) Ltd & OpenHydro Site Development Ltd
Brough Ness	Marine Current Turbines Ltd
Ness of Duncansby	ScottishPower Renewables UK Ltd
Armadale	Pelamis Wave Power Ltd



The MEA has established new benchmarks for the costs of wave and tidal energy which are based on real cost and performance data



Updated MEA estimates of 'first farm' levelised cost of energy

Dark blue – base case, resource variation
Light blue – optimistic/pessimistic case, plus resource variation

Deployments of todays leading concepts in 10MW arrays, after 10MW of previous installations, using a 15% discount rate and 25 year lifetime.

Agenda

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- Potential for marine energy in the UK, (GDP, GWH, Jobs)
- Technology status and challenges
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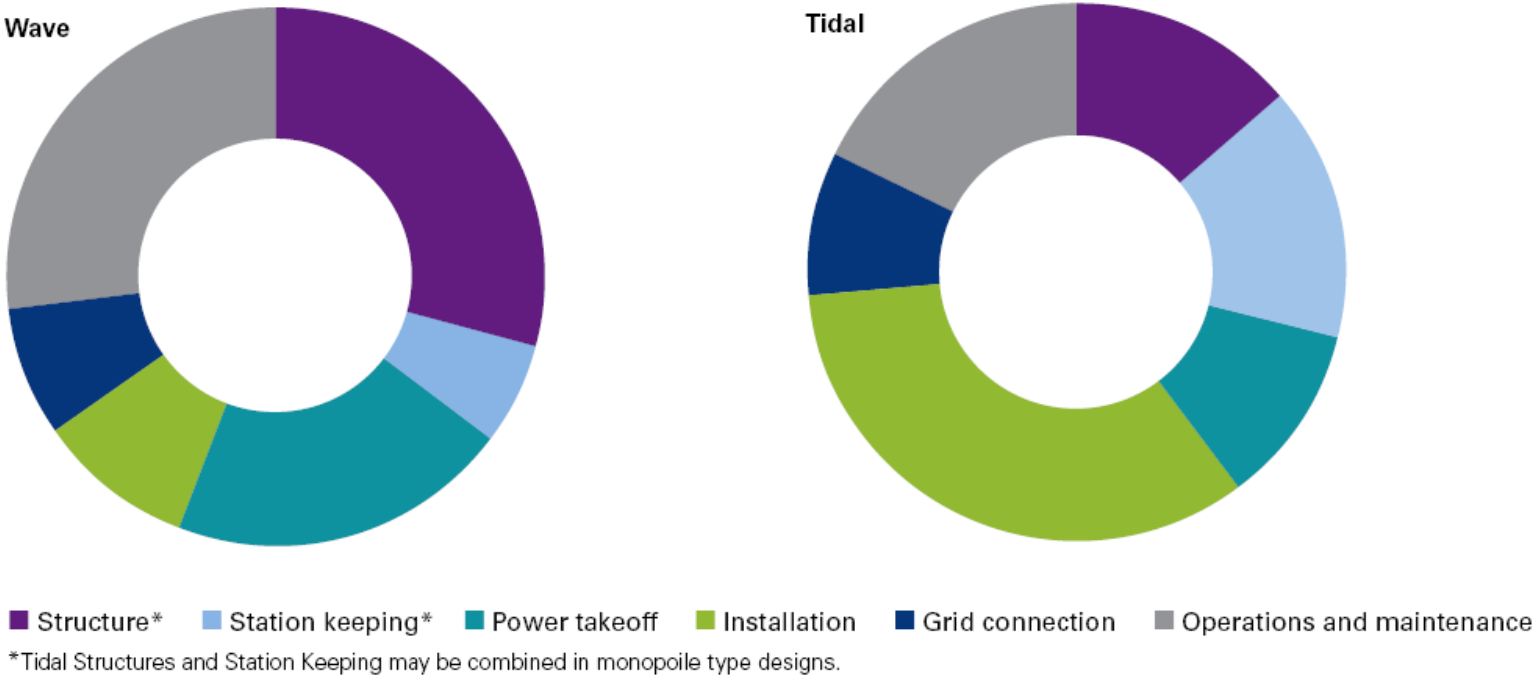
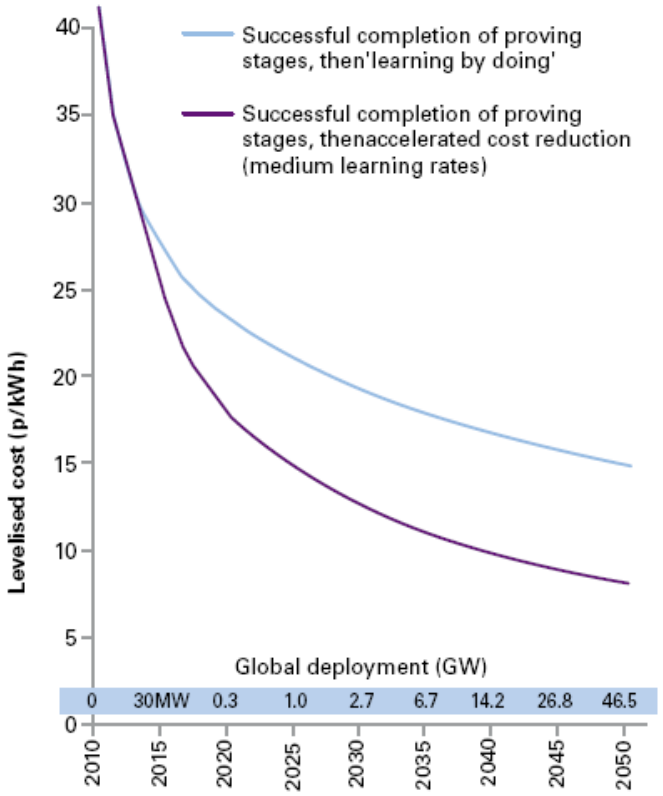
Priorities for cost reduction R&D point strongly to offshore engineering such as installation and O&M

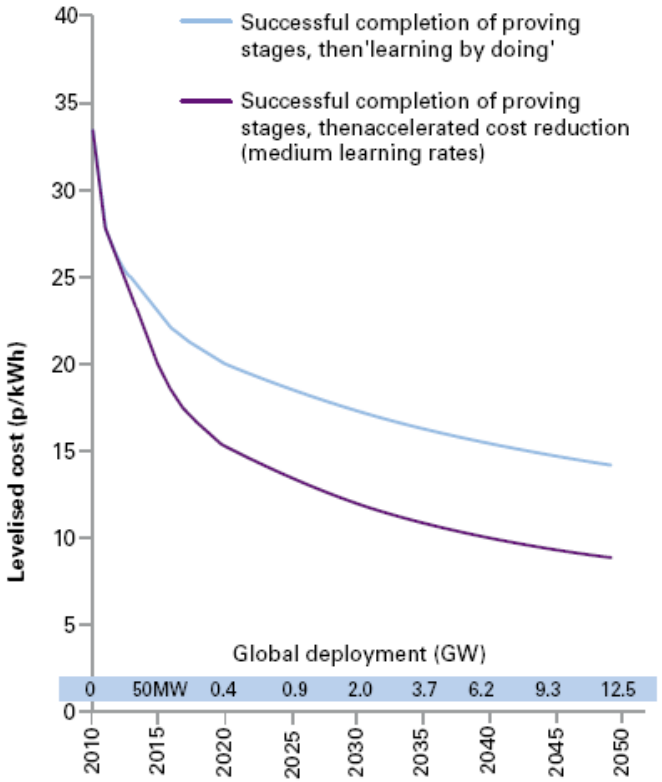


Source: CT Analysis: Accelerating Marine Energy 20011

In a medium deployment and cost reduction scenario, the levelised costs of tidal stream energy are calculated to reach c.6p/kWh

Figures 23a and 23b Possible cost reduction pathways for wave (left) and tidal stream energy under a 'business as usual' and innovation scenario



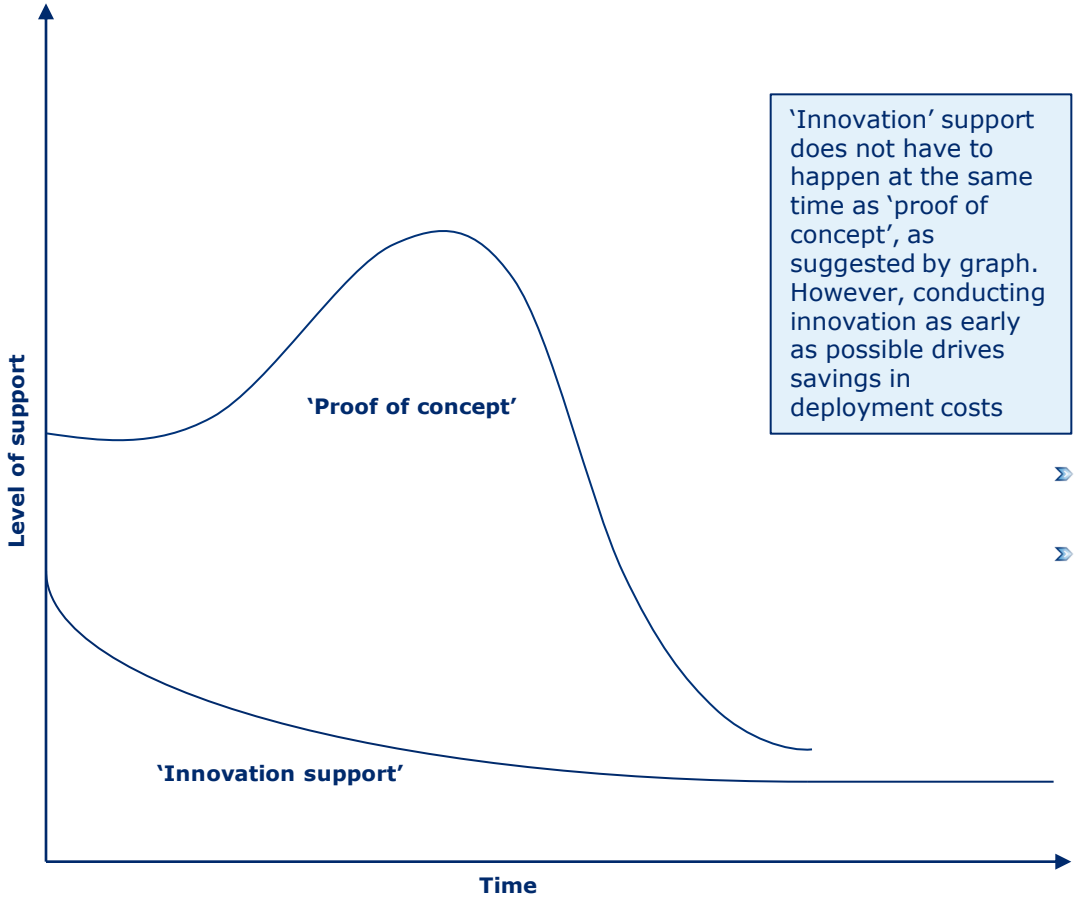


Note: [1] 'Proof of value' point based on time at which a critical mass of devices have been deployed , and reached a potential subsidy level of approximately 2-3 ROCs (depending on electricity prices)
[2] Division between learning by research and learning by doing based on Jamasb, Tooraj (2007). "Technical Change Theory and Learning Curves", The Energy Journal 28(3)

Source: Cost reduction profiles based on results from CT Marine Energy Accelerator studies, 2010, CT analysis

In order to reach full scale commercialisation, marine energy is likely to need support for 'proof of concept' and component innovation

Illustrative view of support profile required for Marine Technologies



'Innovation' support does not have to happen at the same time as 'proof of concept', as suggested by graph. However, conducting innovation as early as possible drives savings in deployment costs

- Marine technology is still very much in it's infancy, and as such two areas of support are identified
  - 'Proof of concept' support is required to drive the technology to a stage where its long-term viability as a power generation solution is proven, and notable deployment takes place. It is at this stage that the technology is considered to have reached the stage where it can start to reduce costs as 'learning' happens through deployment
  - 'Innovation' support is required to drive research in specific technology areas to identify new designs, materials and methods of manufacture that will reduce the cost of the technology
- 'Proof of concept' support is essential in order to envisage any notable technology deployment
- 'Innovation support' is not essential to drive deployment of the technology. It will nevertheless drive cost reductions in components such that the overall cost of deployment is reduced; and as is shown in this study, the value of support required is likely to be notably inferior to the deployment cost savings that it generates

Source: CT analysis, Engagement with stakeholders

Marine Energy can be a strategic asset for the UK; helping meet CC targets, aiding security of supply and generating green growth

- Potential to generate 11% supply (13GW) by 2050
- Potential to create a new industry and some 26,000 jobs
- Opportunity to create £3bn a year of value to the UK economy
- Potential (through learning by doing and innovation) to reduce costs some 5 fold to reach £60/MWh by 2050
- Proof of concept support and continued support for innovation critical to drive cost reduction
- The cost of creating this industry is hundreds of millions, and requires revenue subsidy and R&D funding.

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