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## Wave & Tidal Stream Insights

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## About Marine Energy

**Tidal Range**



**Captured tidal  
waters turn  
turbines –  
potential  
energy**

**Tidal Stream**



**Tidal flow turns  
turbines in  
open stream –  
kinetic energy**

**Wave**



**Wave particle  
motion**

**Ocean Thermal  
Energy Converter**



**Temperature  
difference used  
to extract  
thermal energy**

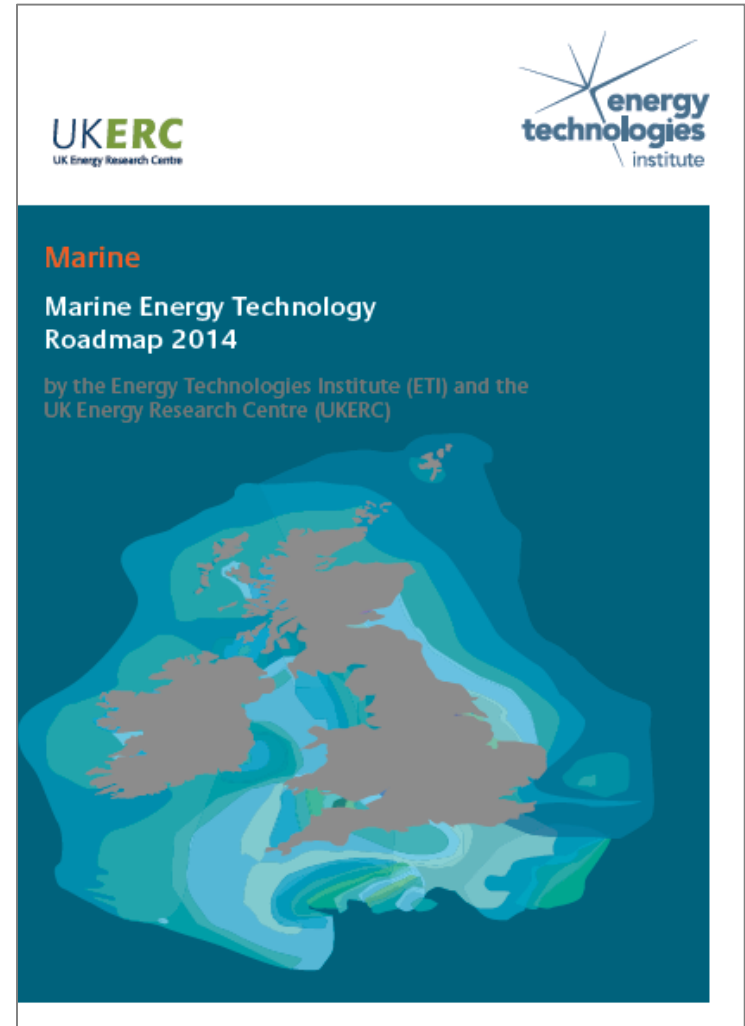


## Context

- TEC & WEC projects completed
- TEC2 StreamTec development project launched
- ReDAPT delivered 1.207GWh of electrical energy, and three months continuous running
- 2014 update to the ETI / UKERC Marine Energy Technology Roadmap

But the external environment for marine energy remains very challenging

- Pelamis and Aquamarine
- Siemens MCT, Voith and Kawasaki

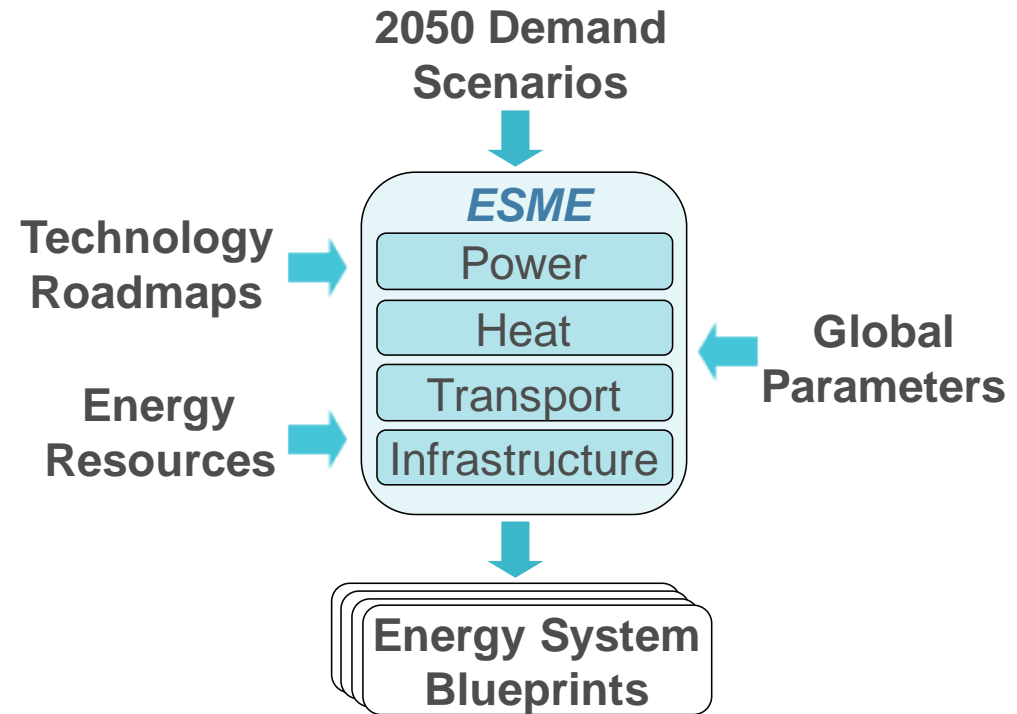




A national energy system design tool  
Integrating power, heat, transport and infrastructure  
Searching for the lowest cost solution

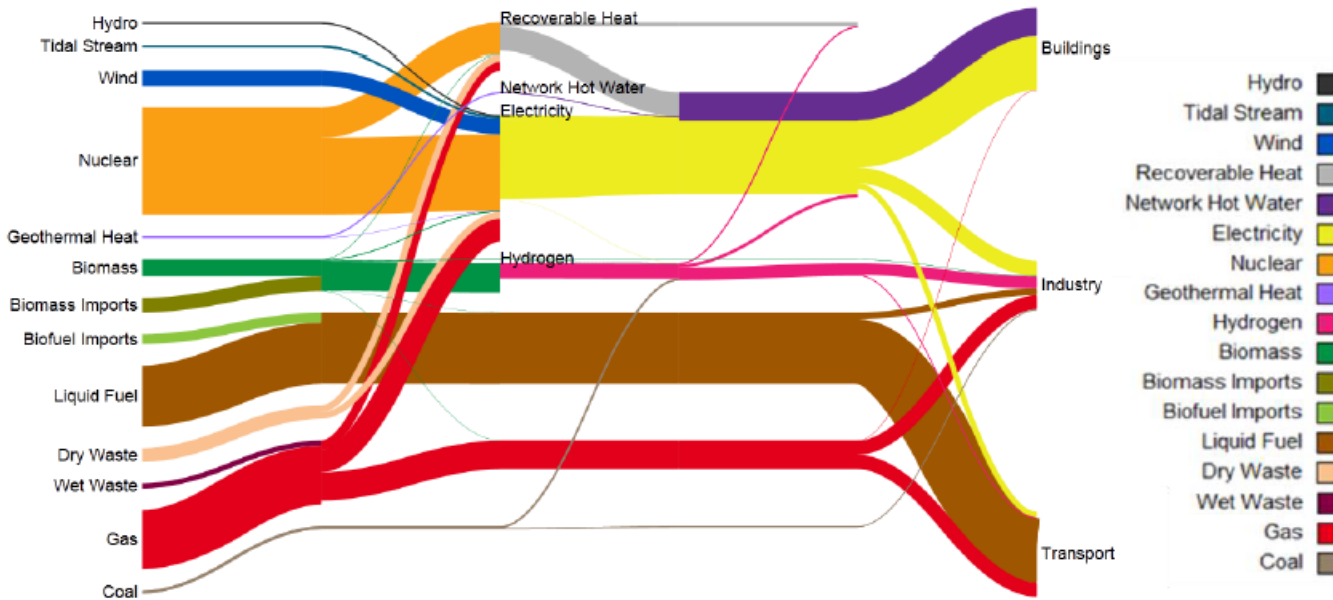


- Least cost optimisation (policy neutral)
- Focus on the destination and on backcasting
- Probabilistic treatment of uncertainties
- Understands geography and time variations





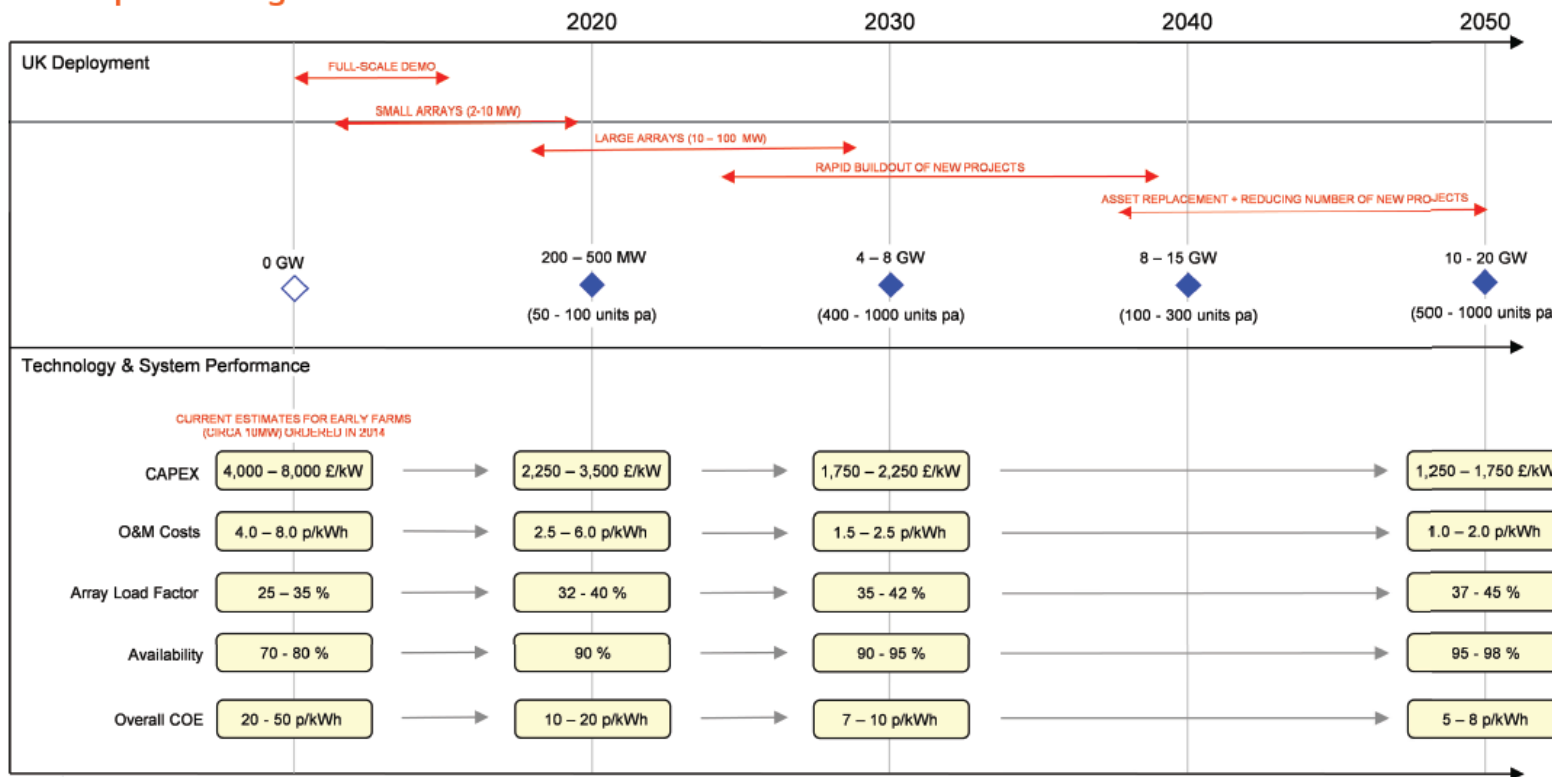
# ESME Reference Case 2050



Tidal Stream, minor contribution  
Wave – not selected



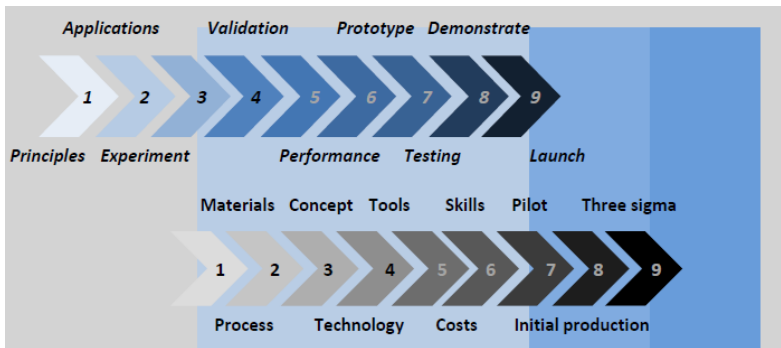
**Figure 1: UK Marine (Wave & Tidal) Energy Deployment Strategy and Technology Development Targets**





# UK Resources

	Tidal Stream	Wave
Potential Capacity – UK electricity demand 360TWh/year	6-27%	14%
Technology Readiness Level	5 - 7	2 - 5
Manufacturing Readiness Level	3 - 5	1 - 4
Capex per power capacity (£/kW) 2014	3800 - 5600	7200 - 18000



Technology Readiness Level (TRL)

Manufacturing Readiness Level (MRL)



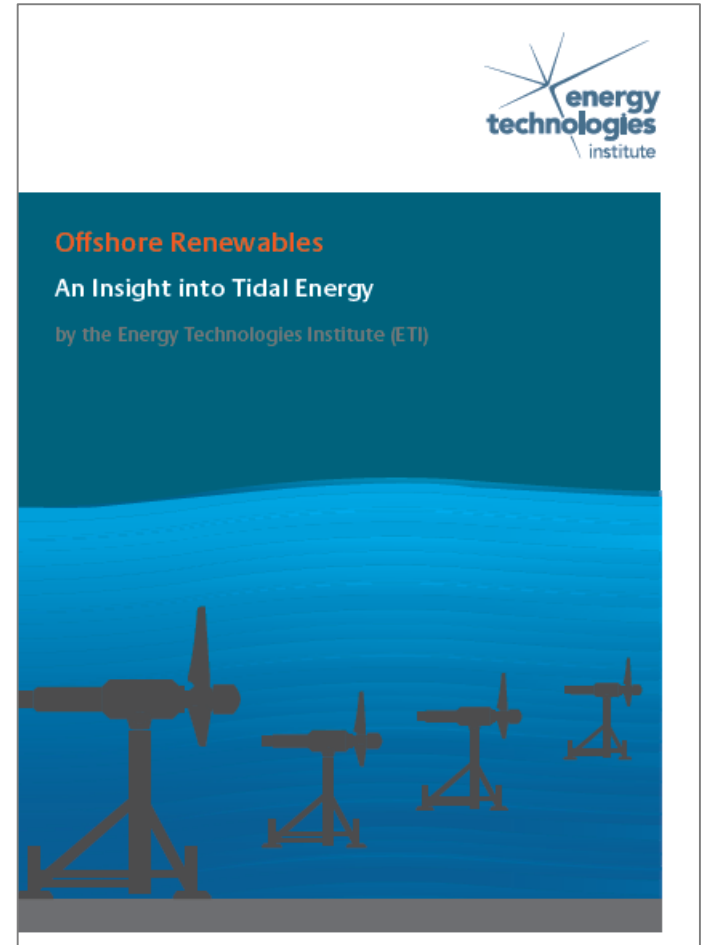


# TIDAL STREAM



## Tidal Stream Energy – Key Insights

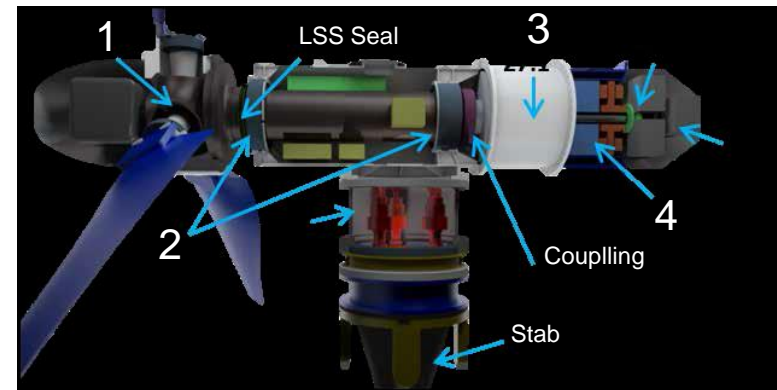
- **There is a demonstrable route to making tidal stream energy competitive with other low carbon technologies;** tidal stream has the potential to be a material part of the future UK energy system
- System-level engineering design coupled with reliability improvements (& testing) is needed to reduce cost; array and device design integration is vital
- Significant cost reduction will require coordinated investment in supply chain innovation, processes and people





## Tidal Energy Converter Project Insights

- Using a systems-engineering approach, £129/MWh is achievable by 2020
  - Foundation structure, with two turbines supported
  - 3 variable-pitch blades (1) per driveline (2)
  - Gear-driven (3) medium-speed permanent magnet generator (4)
  - Subsea power conversion module for collection and conditioning to grid
  - Marine operations optimised vessel using Automated Dynamic-positioning Intervention System
  - 80% of the components needed already exist and are available
  - “Level of Newness” is moderate
- There is a clear route to further cost reduction to meet the longer-term Marine Energy Roadmap targets





# WAVE ENERGY



## Wave Energy – Key Insights

- Even with aggressive cost reduction and innovation activities, **current wave energy technologies are highly unlikely to meet the ETI / UKERC Roadmap targets** and are therefore unlikely to form a material part of the future UK energy system
- There is now a need to **reconsider some of the fundamental wave energy extraction and conversion system approaches** to establish whether alternative methods are plausible to deliver lower cost solutions in the long term





## Wave Energy Converter Project Insights

- Project analysis delivered significant LCOE reduction against the existing Pelamis design at the array scale
  - 57 innovations studied (some radical, some less so)
  - Different variants of Pelamis designs considered (existing, 5 sections, elliptical, concrete, PTO re-design, etc)
  - But LCOE reduction delivered by these innovations (and volume production) are insufficient to meet Marine Energy Roadmap targets
- **Radical** new wave energy concepts are needed to address the deficiencies



Innovative

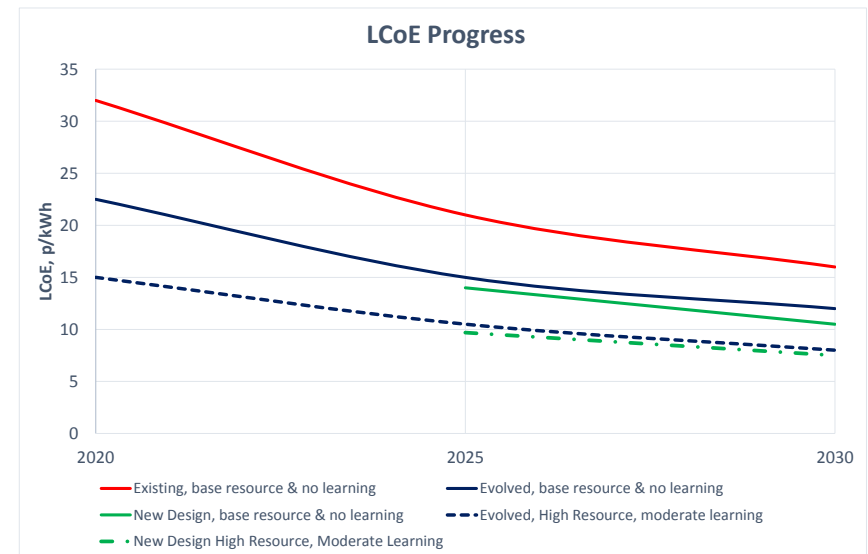
Evolved

Existing



## Why Won't Wave make the Cut?

- CAPEX too high
- Annual Energy Yield too low
- CAPEX
  - 1400 tonnes of material for a nominal 1MW machine
  - Compare against 2000tonnes for a 10MW Floating wind turbine
- Energy Yield
  - Nominal power rating = 1MW
  - Average Design rating = 220kW
  - Achieved average 10,000hrs = 60kW
  - Note: 10MW Wind turbine would give an average of about 5.5MW





## What's Next for Wave?

- Wave Energy Scotland (WES)
  - £1.3m FY2014/15
  - £13m FY2015/16
- Expert input from OREC, CT and University of Edinburgh
- First Call – Power Take Off
  - Note Carbon Trust have already invested in WavePOD with Bosch



WavePOD





# COST OF ENERGY



# LCOE trajectory





# 10 YEARS TO PREPARE for a low carbon transition

UK leads the world in tidal and wave device development



This has created an established supply chain

## Wave Energy

Timescales to make wave energy competitive look longer term



## Wave Energy



The UK has some of the world's best available wave resources

## Wave Energy

Industry needs a radical rethink...



to reconsider approaches to wave energy extraction and conversion for lower cost solutions in the longer term



## Tidal Energy



Innovation needs are known - focus is about putting it together, not having to reinvent



Cost of tidal stream energy has the potential to compete with other low carbon sources in the coming decades

## Expensive



Wave and tidal energy is expensive to extract

## Tidal Energy Reliable & Predictable

it has low visual impact and creates economic impact in specific locations



Tidal stream energy is reliable and predictable



## Wave Energy

Our wave energy converter work shows that design convergence of arrays and device systems is essential



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