Large-scale deployment of marine energy technologies – what could be the benefits of a strong national market in the UK?

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Motivation and objective

The role of energy technology innovation

- **Accelerated technological change** is required to enable an affordable low-carbon energy transition.
- **The time-scales are getting shorter**: low-carbon technologies need to be commercially available soon to play a relevant part in this transition.

From the Carbon Plan

"In the 2020s, we will run a technology race, with the least-cost technologies winning the largest market share. Before then, our aim is to help a range of technologies bring down their costs so they are ready to compete when the starting gun is fired."

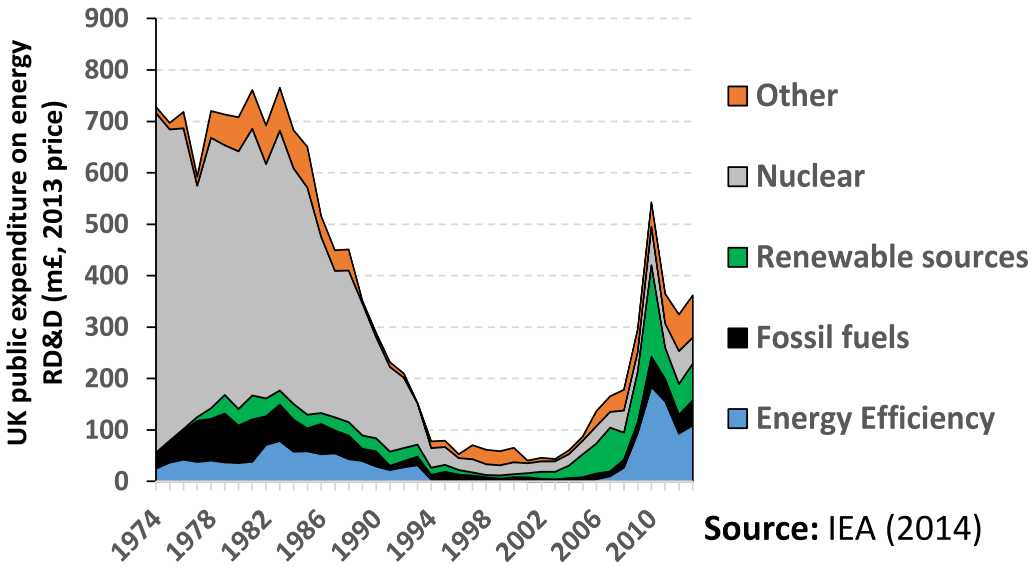
Here: case study on marine technologies in the UK

- Under which conditions could marine technologies make a significant contribution to the UK energy system by 2050?
- Could the UK benefit from the strategic development of a national market for wave and tidal technologies?

The UK energy innovation system

Public RD&D expenditure is picking up again, but is still comparatively low with 0.02 % of total GDP (OECD average of ~0.06 %)

Only limited success in establishing competitive UK industries (“**laggard rather than leader**” strategy)



Source: IEA (2014)

For marine technologies – strong ongoing government commitment

- **Wide range of public funding mechanisms and bodies** for basic and applied research & demonstration projects (RCUK, ETI, Innovate UK (ORE Catapult), DECC MEAD, etc.)
- Leading in terms of **sea testing facilities** (EMEC, WaveHub, FaBTest)
- **Strong deployment incentives** with highest strike price (£305/MWh) under Contracts for Difference scheme

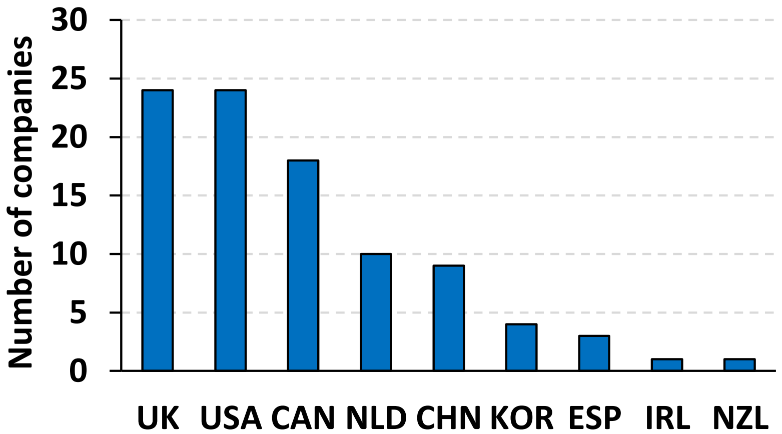
Market for marine technologies

The UK is currently one of the major players in the market for marine technologies.

Current ocean power projects [MW]

	Installed capacity	Consented projects
UK	**9.3**	**136.0**
Canada	20.0	20.5
China	4.4	7.6
US	-	2.7
Rest of the world	4.3	37.8
TOTAL	**38.1**	**204.5**

Major industry players in the marine market



Source: OES Annual Report (2014)

The UK has a considerable potential for marine energy

Practical resource potential

Tidal	**21 TWh**
Wave	**50 TWh**

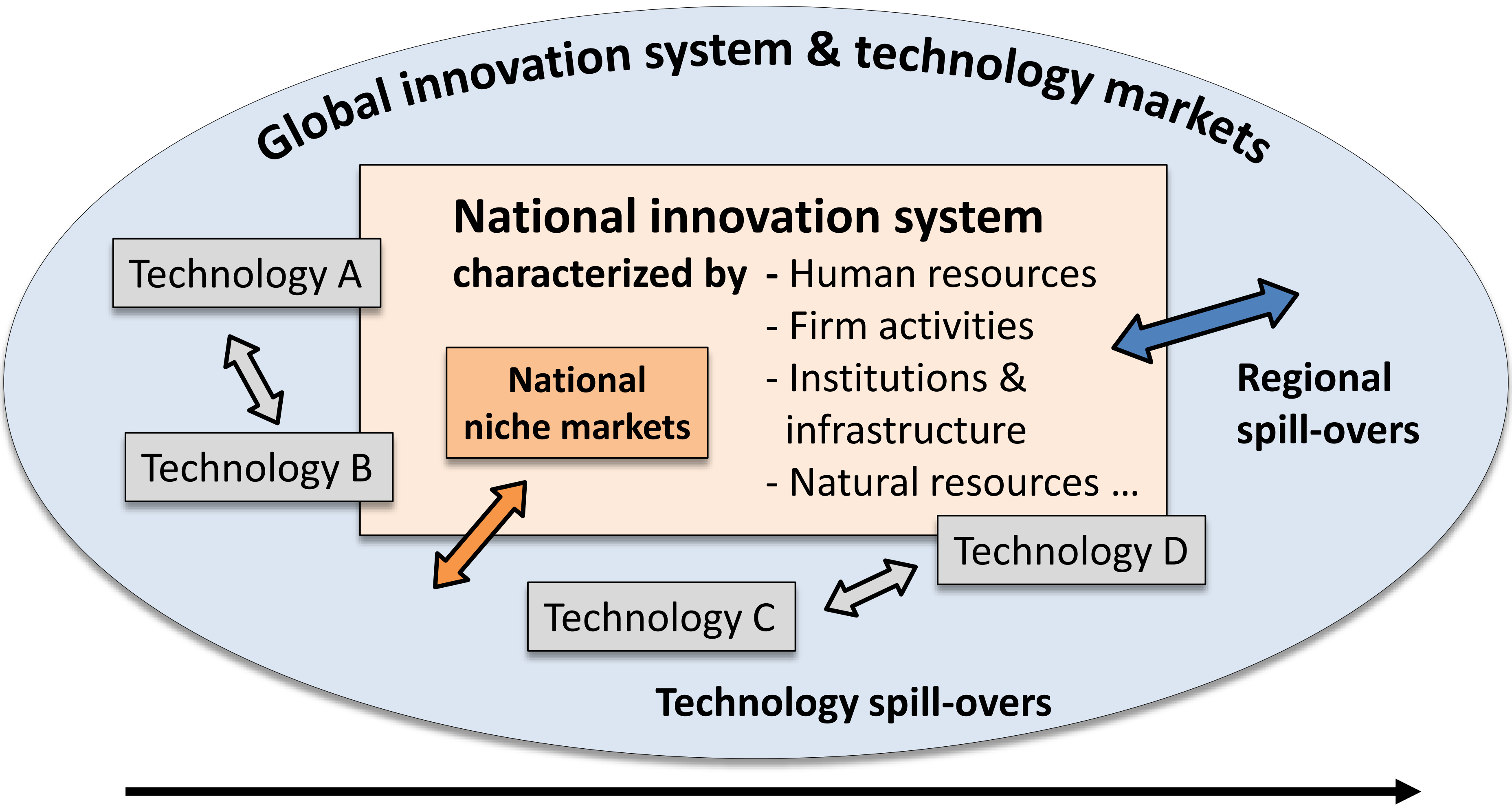
Source: Carbon Trust (2011)

BUT: Marine energy systems are still at an early stage of technology development and demonstration, with significant uncertainty about future costs and deployment risks.

→ **Strategic investments required**

Innovation research

What factors need to be taken into account when analysing energy innovations?



Intertemporal trade-offs, path dependencies **Time**

Methodology - overview

Objective: **from an energy systems analysis perspective**

→ analyse the potential benefits and costs of the strategic development of a national market for marine technologies in the UK

→ focusing on learning-by-doing effects

→ conduct a sensitivity analysis on relevant parameters

Assumptions:

1. The UK undertakes a strategic development of the national marine energy market until 2030.

   → **Model implementation:**
   - Force in marine capacity (0.5 GW in 2020, 2 GW in 2025, 4 GW in 2030)
   - Learning based on national capacity

2. After 2030, a global marine energy market is established and marine technologies receive no further preferential treatment in the UK.

   → **Model implementation:**
   - Optimization approach decides on further marine investments
   - Learning based on global capacity (full regional spill-overs)

UKTM – The UK TIMES Model

- ***Overview***
  Integrated energy systems model - Least cost optimization - Partial equilibrium - Technology rich - sensitivity and uncertainty analysis
  Successor of UK MARKAL

- ***New functionality of UKTM***
  - Higher temporal flexibility; storage
  - All GHG emissions & non-energy mitigation options;
  - Industrial & residential sector disaggregation;

- ***Open source modelling***
  - Transparency at the forefront of development
  - Full open source release in summer 2015
  - Strong policy engagement

- ***Ongoing research development***
  - Behaviour & fuel poverty
  - Land-Energy-Water nexus
  - Macro-economic impacts;
  - Spatial & temporal detail
  - Technology learning

Sensitivity analysis

Key parameters that affect the competitiveness of marine technologies are varied

Learning rate	5%; 10%; 15%; 20% (both national and global)
Global deployment after 2030	- **High scenario:** 178 GW in 2050 (based on 2° scenario, ETP 2015) - **Low scenario:** 37 GW in 2050 (based on 6° scenario, ETP 2015)
Learning spill-overs	Partial spill-over from increases in **offshore wind capacity** (esp. installation, connection, O&M): Conservative learing rate of 7%; learning in 20% of total capital cost and 50% of O&M costs
Failure in other technologies	- No CCS - Low Nuclear (restricted to 16 GW) - Low Renewables (offshore wind ≤ 14 GW, solar PV ≤ to 20 GW)

Other assumptions

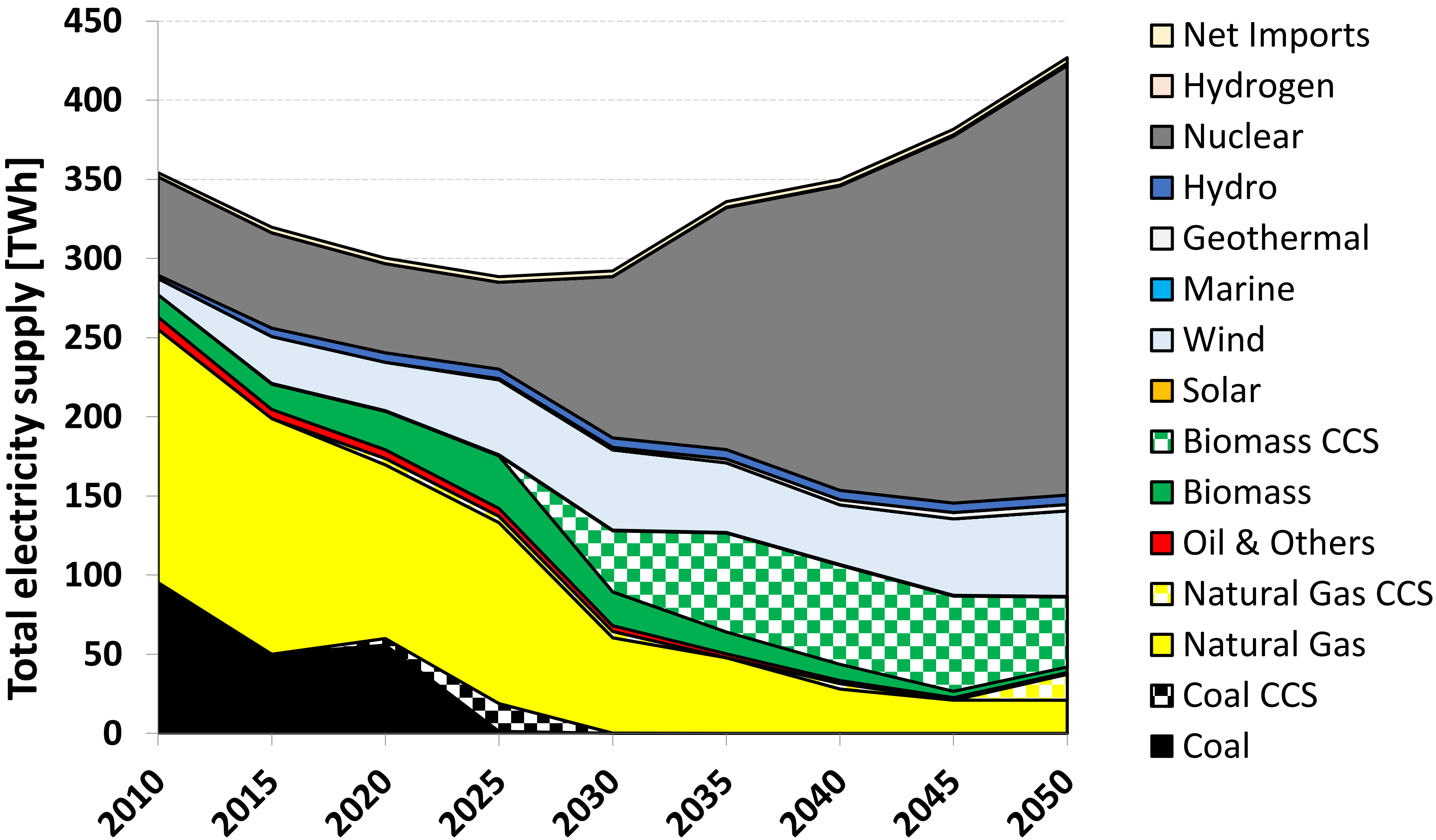
Marine technology:
- starting CAPEX: **6000 £/kW** (cf. ETI Marine Roadmap 2014)
- learning begins at cumulative capacity of **500 MW**

Other technologies:
- **exogenous learning** based on cost assumptions from DECC's Dynamic Dispatch Model (DDM)
- **growth constraints** for all technologies

GHG reduction target: -80% until 2050 in all scenarios

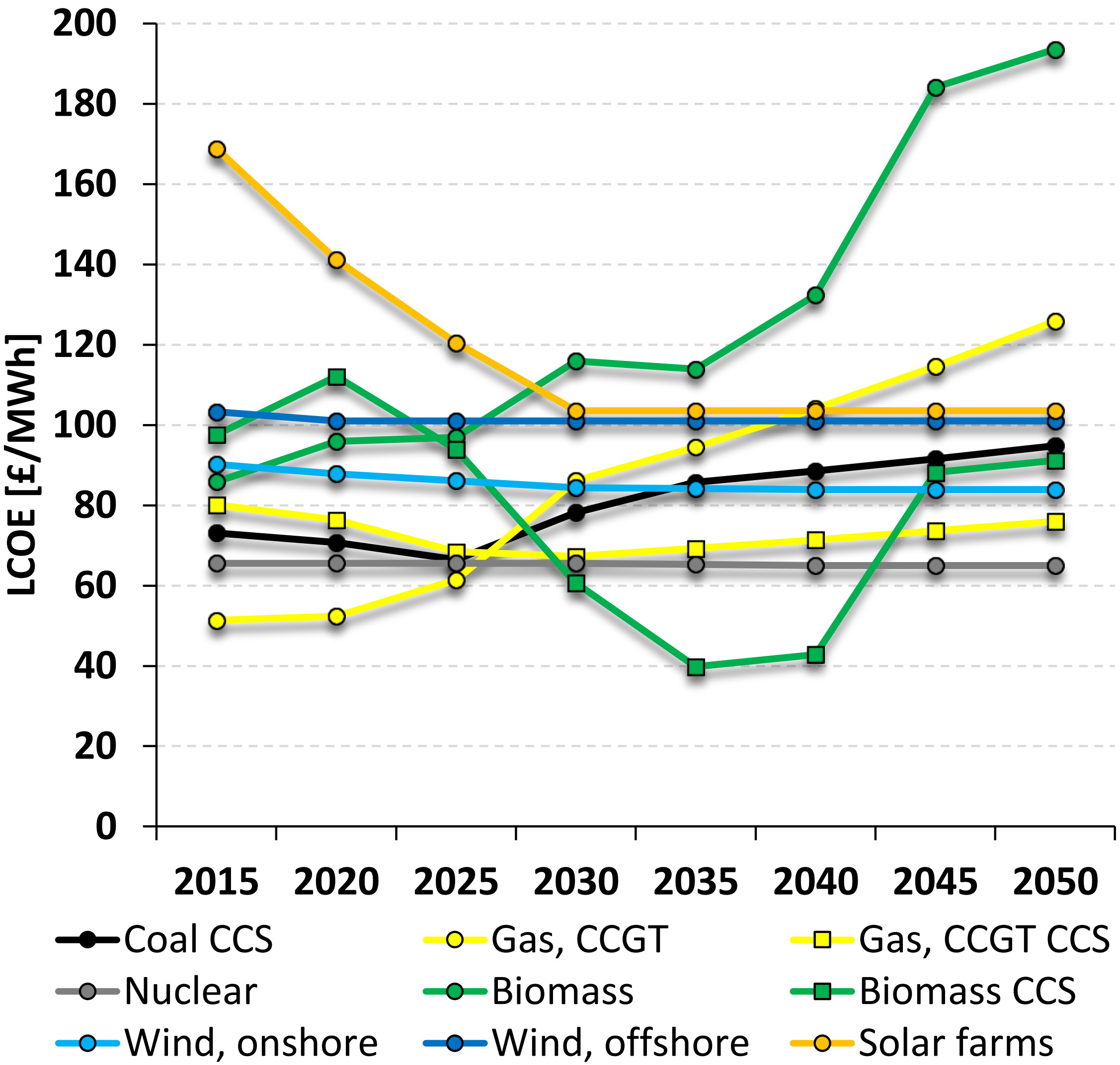
Reference case (1)

What would the transition to a low-carbon electricity system in the UK look like if no learning in marine technologies took place?



Reference case (2)

Levelised costs of electricity generation



Current LCOE of marine technology:

326 £/MWh

Marine technologies would have to reach LCOE below 100 £/MWh before 2050 to be competitive with other renewable options.

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Sensitivity analysis

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Marine capacity in 2050

	GC	LOW				HIGH			
SO	TR \ LR	5%	10%	15%	20%	5%	10%	15%	20%
NO	-	0.0	0.0	0.3	13.9	0.0	0.0	13.9	24.5
NO	No CCS	0.0	5.2	13.2	18.1	0.0	9.1	14.3	24.5
NO	Low NUC	0.0	0.0	1.7	14.3	0.0	0.0	13.9	24.5
NO	Low RE	0.0	0.0	0.3	13.9	0.0	0.0	13.9	24.5
NO	Combined	14.3	24.5	24.5	24.5	14.3	24.5	24.5	24.5
YES	-	0.0	0.0	0.9	13.9	0.0	0.0	13.9	24.5
YES	No CCS	0.0	5.4	13.9	23.9	0.0	10.7	14.3	24.5
YES	Low NUC	0.0	0.0	5.2	14.3	0.0	0.0	13.9	24.5
YES	Low RE	0.0	0.0	0.9	13.9	0.0	0.0	13.9	24.5
YES	Combined	14.3	24.5	24.5	24.5	15.7	24.5	24.5	24.5

Global capacity

Learning rate

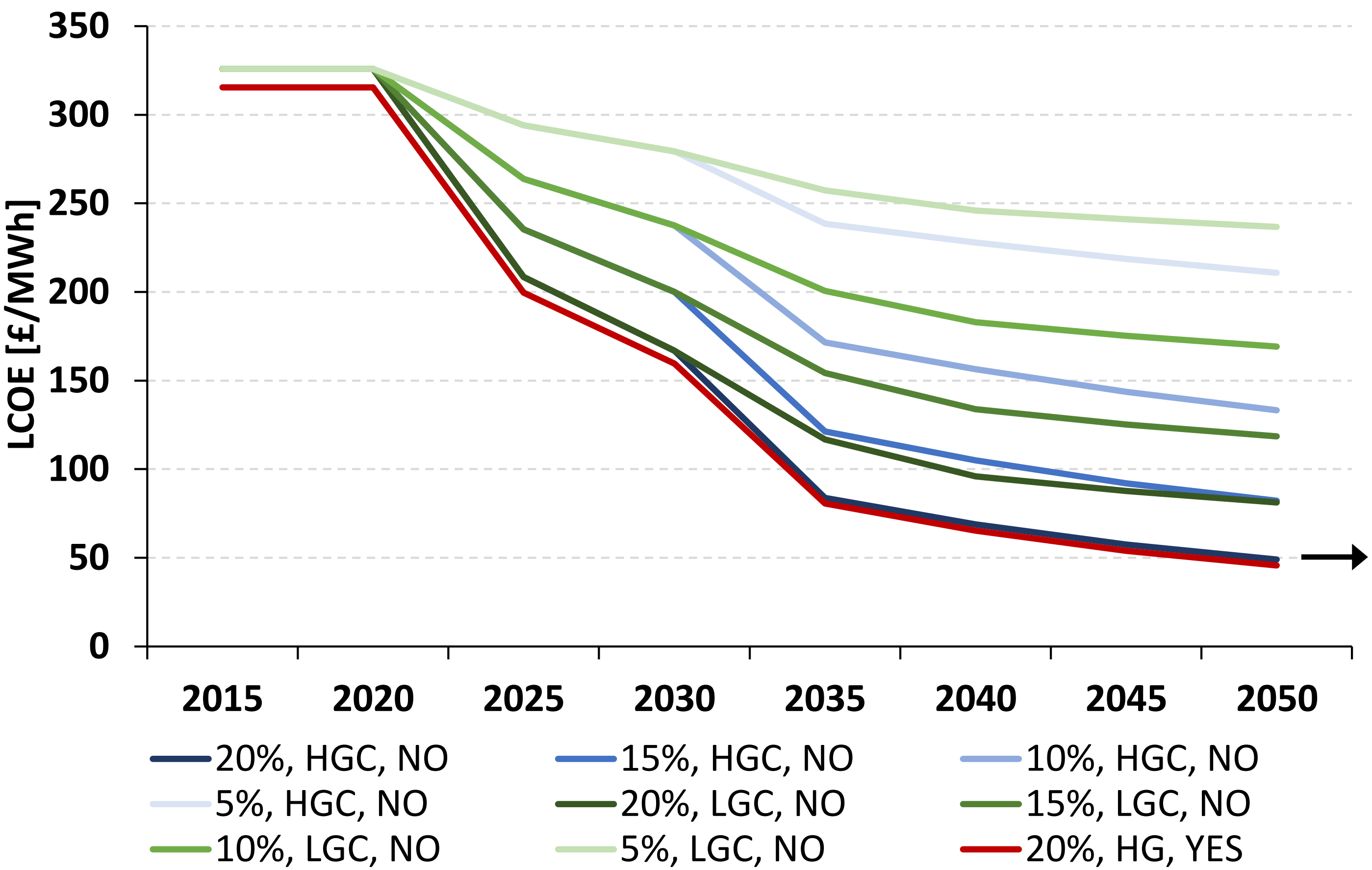
- > 20 GW
- 10-20 GW
- 5-10 GW
- 0-5 GW
- 0 GW

↳ Technology restrictions

↳ Spill-overs from offshore wind

Learning in marine technology

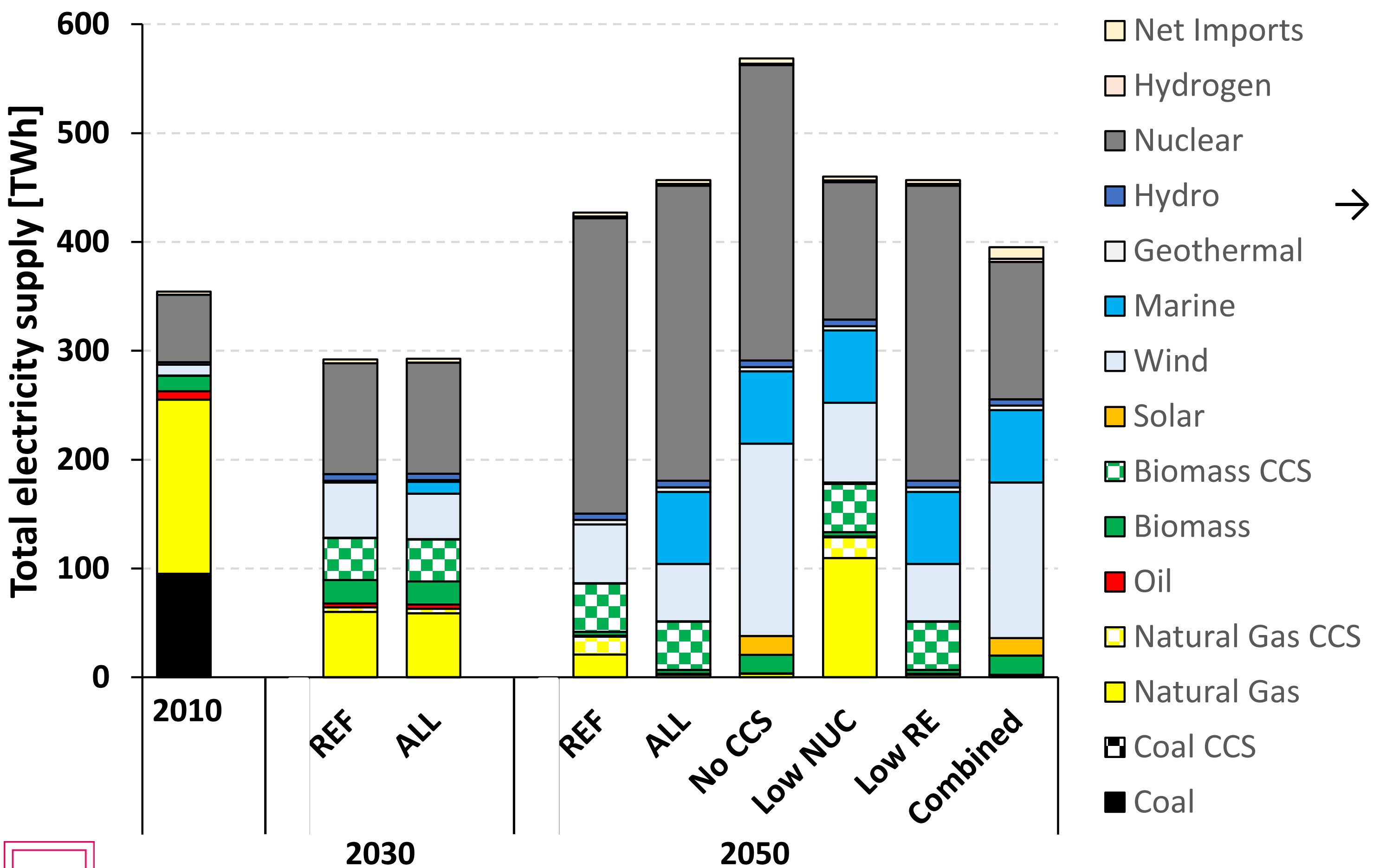
LCOE of marine technology in the sensitivity analysis



CAPEX: 905 £/kW

Marine scenarios

What would a low-carbon electricity system with high shares of marine energy look like?



→ Under the most optimistic scenario assumptions, marine energy covers between **13% and 17%** of total electricity demand in 2050

Cost implications

	GC	LOW				HIGH			
SO	TR \ LR	5%	10%	15%	20%	5%	10%	15%	20%
NO	-	greater	greater	greater	greater	greater	greater	greater	greater
	No CCS	greater	greater	greater	lower	greater	greater	lower	lower
	Low NUC	greater	greater	greater	greater	greater	greater	greater	lower
	Low RE	greater	greater	greater	greater	greater	greater	greater	greater
	Combined	lower	lower	lower	lower	lower	lower	lower	lower
YES	-	greater	greater	greater	greater	greater	greater	greater	greater
	No CCS	greater	greater	lower	lower	greater	greater	lower	lower
	Low NUC	greater	greater	greater	greater	greater	greater	greater	lower
	Low RE	greater	greater	greater	greater	greater	greater	greater	greater
	Combined	lower	lower	lower	lower	lower	lower	lower	lower

Difference in energy system costs (cumulated 2010-2050)

- lower
- greater

… than the respective reference case

The strategic support for a national marine energy market could increase cum. energy system costs by up to 1% (up to £80 bn), but in case of failure in other technologies could also lower cum. energy system costs by up to 10% (£900 bn)

Further benefits

Are there further benefits from marine technologies and/or a strong national lead market that could justify the high strategic investments?

1. **Benefits of marine technologies for the electricity system**
   - Further diversification of the generation portfolio
   - Mitigating intermittency of other renewable sources (predictability of tidal power; counter-correlation of wave and wind power)

2. **Economic benefits**
   - **Value added / job creation**: potential value of the UK marine industry estimated between £1.4 - £50 bn + up to 68,000 jobs (by 2050)
   - **Export opportunities**: First-mover advantages comparable to the Danish wind or the German solar PV industry?
   - **Regional development**: marine energy industry would particularly benefit coastal communities (where other sources of income are declining)

Conclusions

- The UK is currently in a good position to develop a lead market for marine energy. However, there are huge uncertainties regarding the long-term viability of marine technologies.
- The energy system analysis allows to
  - assess under which conditions marine technologies can provide a significant contribution to the decarbonisation of the UK electricity system;
  - consistently evaluate the system-wide cost implications of strategic investments into the marine industry.
- There is a strong risk that the early investments into the development of a national lead market will not directly pay off in the long term.
- The additional potential benefits of marine technologies on the UK economy need to be quantified.

Thank you for your attention!

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