Generating Energy from the Sea

The potential of UK Marine Energy Resources

GENERATING ENERGY FROM THE SEA
THE POTENTIAL OF UK MARINE ENERGY RESOURCES

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Saturday, 7 May 2022

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WHAT IS MARINE ENERGY?

- Marine energy is also referred to as ocean energy and ocean power.
  - Sometimes called 'Blue energy'
- There are various types of marine energy;
  - Wave energy (mainly floating structures with generation by small rotation)
  - Tidal stream energy (mainly turbines both floating and sea bed)
  - Tidal range energy (Barrages and tidal lagoons with turbines)
  - Ocean thermal energy (uses the ocean thermal gradient between cooler deep and warmer shallow or surface waters to run a heat engine usually producing electricity)
  - Ocean current energy (Strong currents are generated from a combination of temperature, wind, salinity, bathymetry (sea bed depth and shape), and the rotation of the earth)
  - Run-of-river energy (generate energy from turbines in flowing streams and rivers)
  - Salinity (Ocean Salinity and Temperature Energy Conversion (OSTEC). Uses up-welling currents where two water bodies at different salinity and temperature are mixed)
- The UK Government published the British Energy Security Strategy (BESS) on 7 April 2022.
  - It omits any mention of marine energy, instead promoting offshore wind energy and nuclear energy
- I only intend to talk about tidal stream energy

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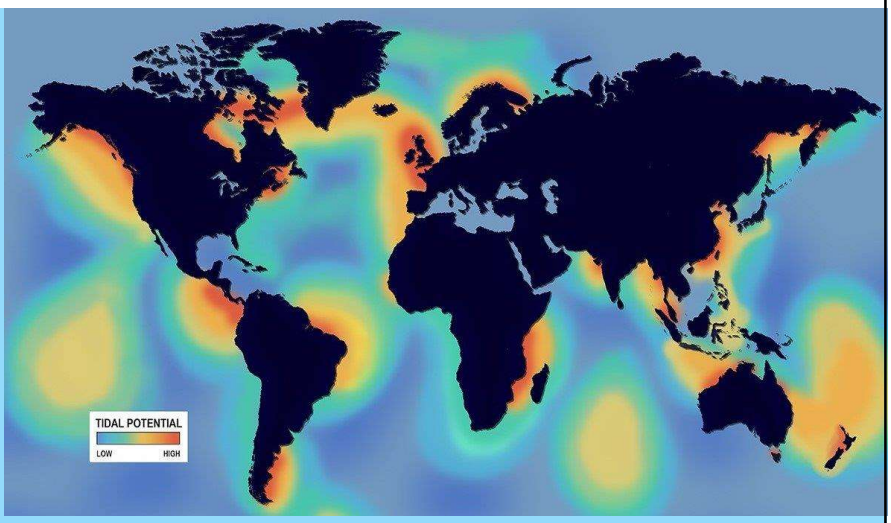
WHAT ARE TIDAL STREAMS?

- The earth has large volumes of water mainly in oceans
- Tidal streams are water movements caused by forces of gravity between the earth, the moon and the sun
- The UK is particularly fortunate in having strong tidal currents around its long coastline



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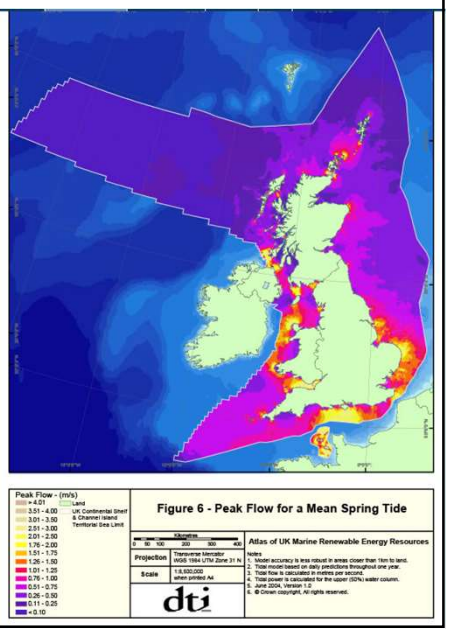
WHAT ARE TIDAL STREAMS?

The UK is particularly fortunate in having strong tidal currents around its long coastline

- The best locations are Pentland Firth, St Georges Channel, Anglesey and Isle of White
- (Yellow on map)

- The outline on the map is the UK marine resources area
  - This area is divided up into concession areas



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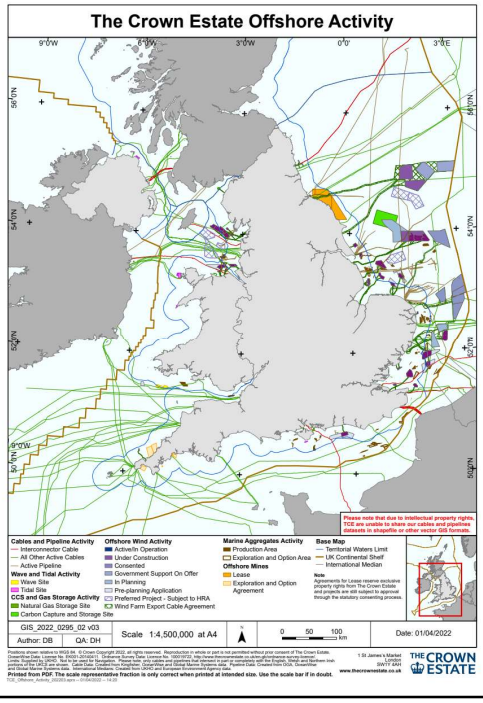
LICENSING OF THE SEA BED

- The UK territorial waters are divided into licencing areas
- These are licenced by the Crown Estate
- The licences cover pipelines, dredging, gas and oil platforms, offshore wind arrays and marine energy sites
- The map shows the activities in the UK marine resources areas of England, Wales & NI excluding Scotland
- Marine licences in Scotland are issued by the Marine Scotland - Licensing Operations Team (MS-LOT). MS-LOT is the regulator on behalf of Scottish Ministers



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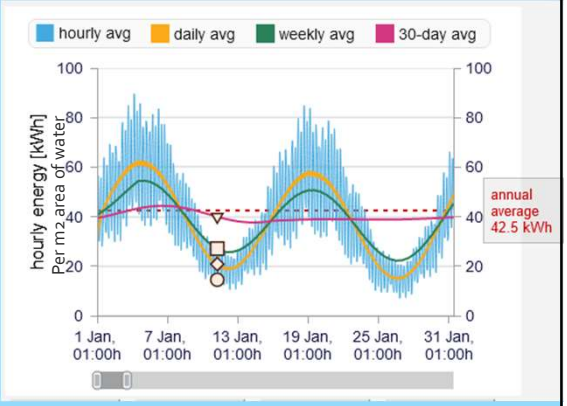
TIDAL STREAM ENERGY

- In the UK there is potential for 5 - 16GW or up to 15% of the UK's electricity.
- The tidal streams are very predictable
  - This makes useful base load energy.
- The stream varies with the tides around the British Isles so that at any time there is a peak tidal stream flowing strongly somewhere
- Tides are caused by gravitational interaction of the sun and moon and results in two high tides and two low tides.
- Maximum currents are at mid-tide every 6 hours



- The seasonal tilt of the Earth is responsible for maximum peaks around the equinoxes and minimal during solstices
- Tides are also influenced by the Moon and these follow the lunar cycle of 24h 50' 24". Due to the differences in mass and distance of Sun and Moon, the power of lunar tides outweighs the solar tides by around 7:3 with the dominant tidal pattern following the 6h 12' 24" cycle.

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HISTORY OF ENERGY FROM TIDES

- The earliest recorded evidence of the use of the oceans' tides for power generation dates back to about 900 A.D.
- Early tidal power plants utilized naturally-occurring tidal basins by building a barrage (dam) across the opening of the basin and allowing the basin to fill on the rising tide, impounding the water as the tide fell, and then releasing the impounded water through a waterwheel
- The power was typically used for grinding grains into flour. Power was available for about two to three hours, usually twice a day

Woodbridge Tide Mill

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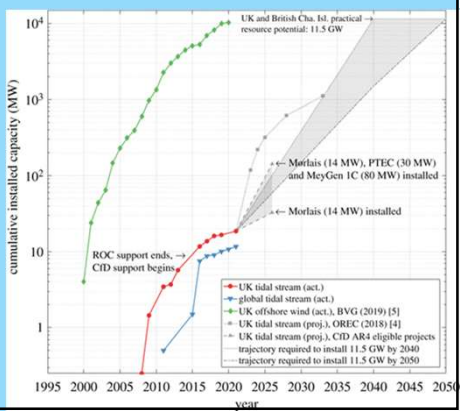
RECENT HISTORY OF ENERGY FROM TIDES

- Since about 2000 UK Governments have invested heavily in offshore wind energy
- In 2020 offshore wind capacity was about 10GW (10,000MW)
- Investment in tidal stream energy started in about 2007
- The European Marine Energy Centre (EMEC) Ltd was set up in 2003 in Orkney to demonstrate and test wave and tidal energy converters
- During the Labour Government interest and investment slowly grew.
- The 2015 Tory Government abandoned Renewable Obligation Certificates (ROCs) and introduced Contracts for Difference.
- After this investment in tidal stream energy reduced considerably as the Government transferred its support mainly to wind turbines and nuclear energy



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RECENT GOVERNMENT ACTION ON MARINE ENERGY

- The present Government put out a call for evidence on innovative marine energy technologies between 28 August 2020 and 30 September 2020
  - This is an extremely short one month period for realistic consultation as it required of a 12 questions each with evidence
  - It followed consultation on changes to the Contracts for Difference in March/May 2020 (3 months)
- They are still analysing feedback!
- But the consultation controversially broadened the definition of marine energy to include floating offshore wind energy as well as tidal stream, tidal lagoons and barrages and wave energy.
- The then Secretary of State for Business and Energy, Alok Sharma said in 2020:
  - As an island nation we are perfectly placed to capitalise on clean marine energy, building on our world-leading position in offshore wind.
  - (We are) examining how to make the most of our natural resources and support marine technologies that are cost-effective for the consumer will be crucial as we build back better, creating green jobs and reaching net zero emissions by 2050.

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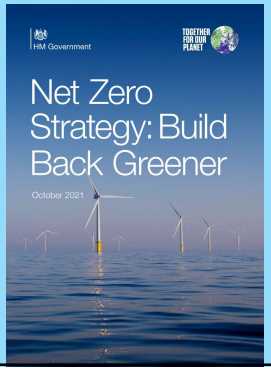
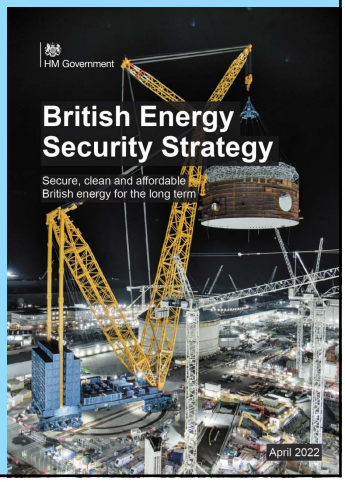
RECENT GOVERNMENT ACTION ON MARINE ENERGY

- In September 2021 the Government published 'Climate Change Strategy 2021-2024'
- In October 2021 they published 'Net Zero Strategy: Build Back Greener'
  - This refers to building insulation and electric vehicles
- Then in April 2022 they published 'British Energy Security Strategy'
  - This only refers to onshore and offshore wind, solar and nuclear energy
- What happened to marine energy?





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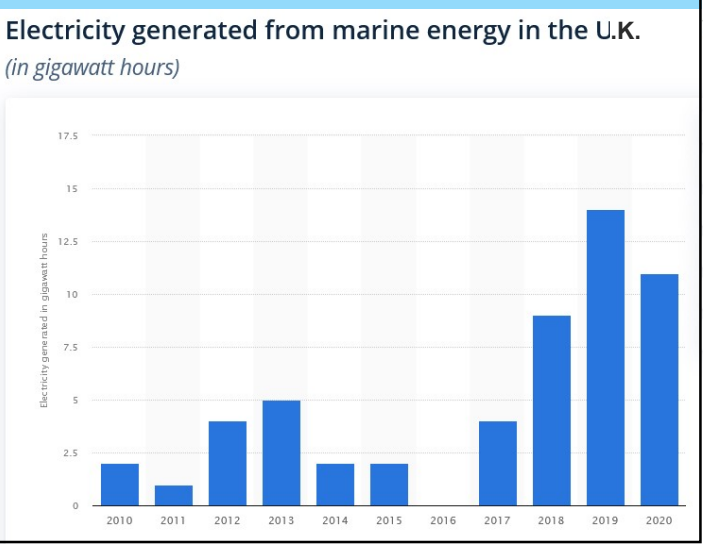
GENERATING ENERGY FROM THE SEA

- This graph shows the total electricity generated from marine energy in the UK
- It includes wave energy and tidal stream energy



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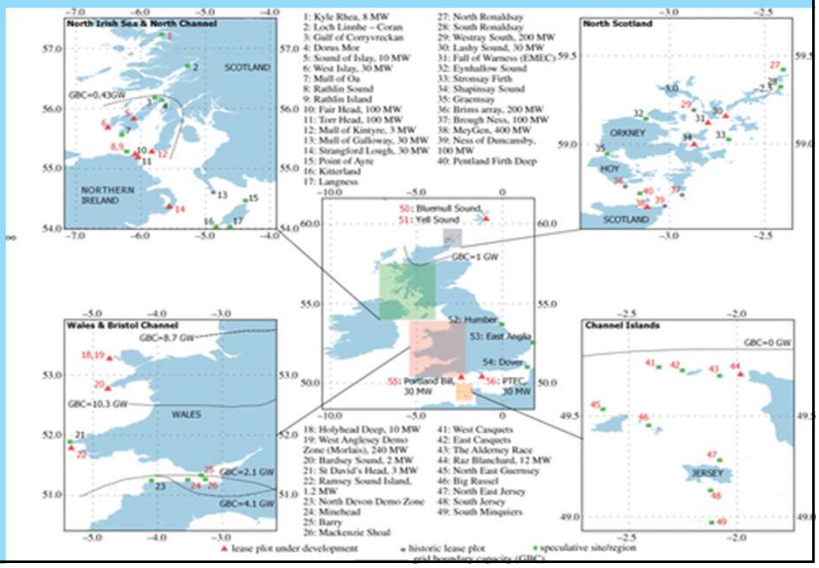
CURRENT TIDAL STREAM PROJECTS

- A review of the UK and British Channel Islands practical tidal stream energy resource



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CURRENT TIDAL STREAM CAPACITY

Table 1. Tidal stream installed capacity in the UK and globally.

developer	project/site	turbine model(s)	rotors	start of operation	installed capacity	active	energy yield	inc. capacity factor
UK projects								
Orbital Marine Power*	EMEC testing	O2	2	2021	2.00 MW	yes	n.a.	n.a.
Minesto	Holyhead Deep Phase 1	DG500	1	2019	0.50 MW	yes	n.a.	n.a.
Magallanes	EMEC testing	ATIR	2	2018	2.00 MW	yes	n.a.	n.a.
Nova Innovation	Shetland Tidal Array	M100-D	4	2018	0.40 MW	yes	n.a.	n.a.
Orbital Marine Power*	EMEC testing	SR2000	2	2017	2.00 MW	no	3.3 GWh	0.10 ‖
MeyGen	MeyGen 1A	HS1500, AR1500	4	2016	6.00 MW	yes	37.0 GWh	0.16 ‡
Tidal Energy Ltd	Ramsey Sound	Deltastream	1	2015	0.40 MW	no	n.a.	n.a.
Alstom	EMEC testing	Deepgen	1	2013	1.00 MW	no	1.2 GWh	0.07 ⊥
Voith Hydro	EMEC testing	HyTide 1000	1	2013	1.00 MW	no	n.a.	n.a.
Orbital Marine Power*	EMEC testing	SR250	2	2012	0.25 MW	no	n.a.	n.a.
SIMEC Atlantis Energy	EMEC testing	AR1000	1	2011	1.00 MW	no	n.a.	n.a.
Andritz Hydro Hammerfest	EMEC testing	HS1000	1	2011	1.00 MW	no	n.a.	n.a.
Marine Current Turbines (MCT)	Strangford Lough testing	SeaGen	2	2009	1.20 MW	no	11.6 GWh	0.10 ‡

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CURRENT TIDAL STREAM PROJECTS - MEYGEN

- MeyGen tidal stream energy project is owned by SIMEC Atlantis Energy Ltd
- MeyGen 1A has an installed capacity of 6MW in an array with;
  - 1 x Atlantis Resources Limited AR1500: with a rated capacity of 1.5MW at 3.0 m/s, a rotor diameter of 18 m
  - 3 x Andritz Hydro Hammerfest HS1500: consisting of a horizontal axis 18m diameter rotor, pitched blades and yaw with rated power at current speeds of 3 m/s

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CURRENT TIDAL STREAM PROJECTS - ATIR

- Magallanes Renovables ATIR
- The ATIR has an installed capacity of 2MW;
  - It has 2 rotors
  - Deployed at EMEC site in Orkney

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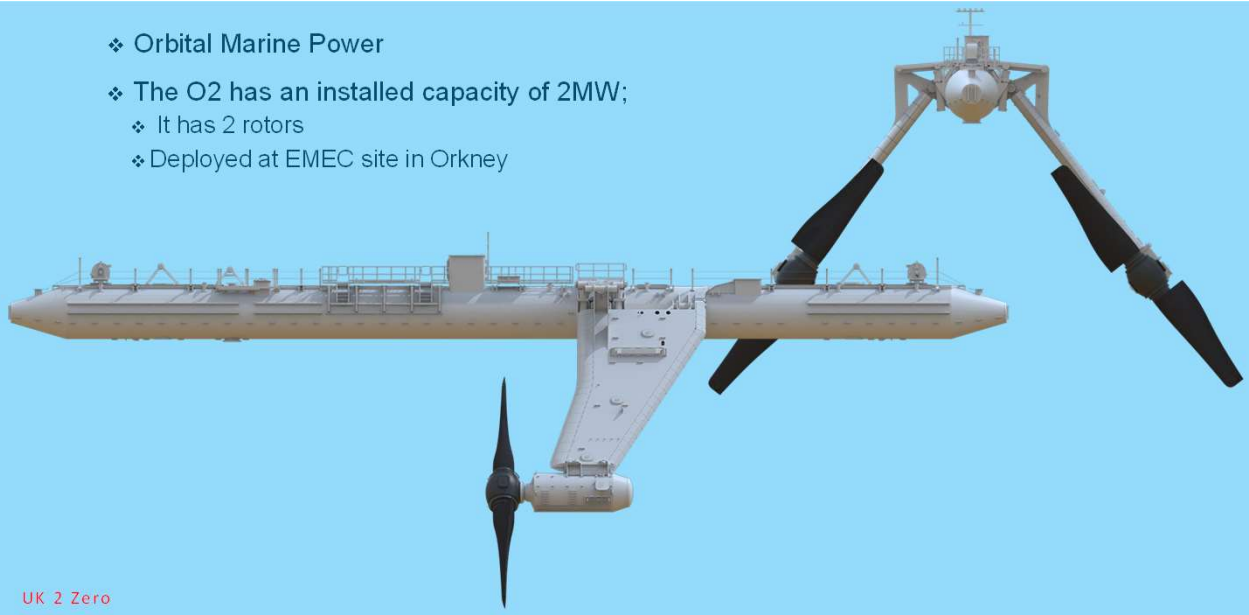
CURRENT TIDAL STREAM PROJECTS – O2

- Orbital Marine Power
- The O2 has an installed capacity of 2MW;
  - It has 2 rotors
  - Deployed at EMEC site in Orkney



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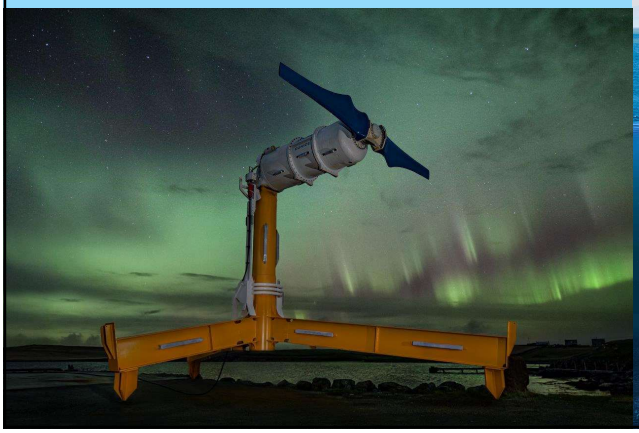
CURRENT TIDAL STREAM PROJECTS – NOVA M100-D

- Nova Innovation
- The M100-D has an installed capacity of 0.4MW;
  - It has 4 rotors
  - Deployed at Shetland Tidal Array



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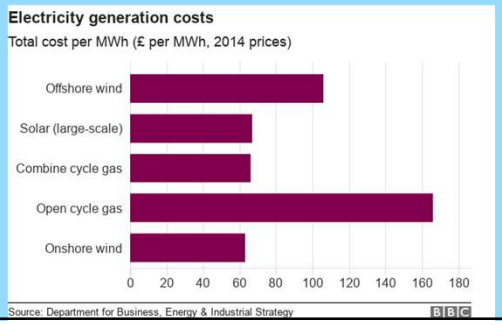
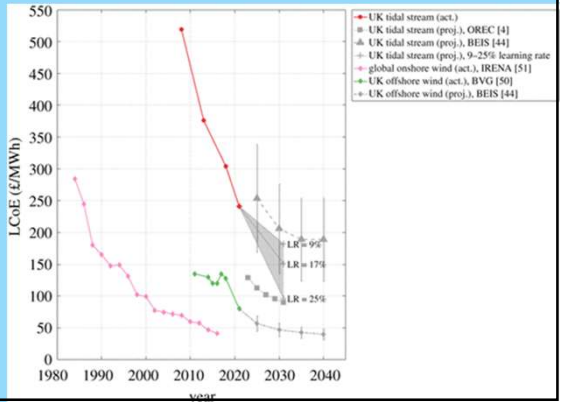
COSTS OF TIDAL STREAM ENERGY

- Over the years there has been a steady decrease in the cost of energy from tidal stream energy
- Future projections show further reductions to between £200 and £100/MWh
- For comparison Offshore wind costs were about £100/MWh at 2014 prices.
  - Costs have subsequently reduce further
- Economies of scale and higher unit production will further reduce costs in the future



A review of the UK and British Channel Islands practical tidal stream energy resource, Volume: 477, Issue: 2255, DOI: (10.1098/rspa.2021.0469)



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COSTS OF TIDAL STREAM ENERGY

- Economies of scale and higher unit production will further reduce costs in the future
- This is illustrated by a 2021 study
- So a major increase in tidal stream capacity will reduce costs to about the level of offshore wind
- A comprehensive 'Economic analysis of tidal stream turbine arrays: a review' was carried out in 2021

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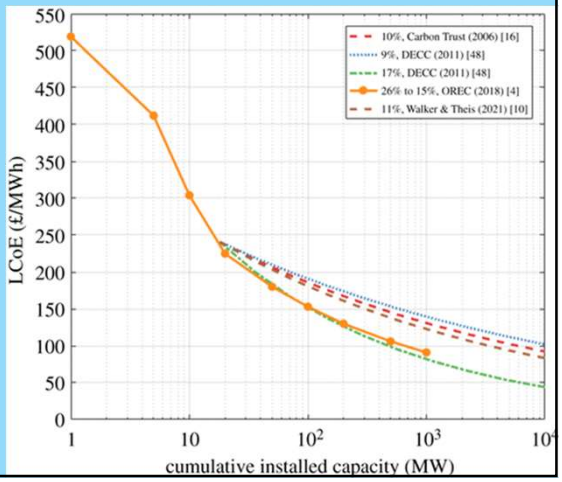

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OPERATIONAL FACTORS FOR TIDAL STREAM ENERGY

- Tidal stream installations require periodic maintenance
- Sea bed based units would have to be lifted for major maintenance although minor work could be carried out by divers
- Lifting and reinstalling sea bed based units is a daunting task
- Hence some developers have opted for floating and tethered units
- Major maintenance can then be carried out by releasing the moorings and towing the unit back to a base
- As a civil engineer with offshore engineering experience I think that moored and tethered floating structures are a higher risk than sea bed fixed structures
- This comment applies to tidal stream units, wave energy units and floating offshore wind turbines

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ENVIRONMENTAL ASSESSMENTS OF TIDAL STREAM ENERGY

- Tidal stream projects have been criticised for damaging the seabed environment
- However at the optimum locations for tidal stream installations the tidal currents are very strong and therefore the seabed is usually scoured clean
- There has also been the fear the fish and other marine animals would be injured or killed by the rotors
- However so far the evidence is that fish, seals, dolphin and whales avoid the rotors as they do with ship propellers
- The Sustainable Development Commission published a comprehensive report 'Turning the Tide Tidal Power in the UK' in October 2007 with a section on Tidal Stream and its environmental impacts

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CONCLUSIONS

- Tidal stream energy potential is huge and underdeveloped
- The energy production is reliable and **predictable** unlike wave and wind generated energy
- This makes it very useful as a baseline source of electrical energy that can replace coal, gas and nuclear
- The peak energy is produced at mid-tide current flows but as the times of the tides vary around the UK coastline a continuous source of energy is available
- Currently there are few productive installations (even though the UK leads the world) and the development costs and lack of economy of scale result in high energy costs
- Even a small proportion of the current billions invested in nuclear energy would develop tidal stream energy to provide the proposed 24GW by 2050
- The costs of tidal stream energy will reduce as units are installed at scale in large arrays

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Thank you

The end

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