ORE SuperGen Marine Challenge Workshop

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Our **Turbine Division** sells tidal turbine generation equipment into our projects and to third party project developers.

Atlantis can provide drive train, nacelle fixation, subsea connection and power export equipment to the highest specification, capable of withstanding the harshest environments.

Our **Power Generation Division** takes greenfield sites from concept through to commissioning.

The Atlantis project portfolio currently under development is truly global, inclusive of activities in Scotland, China, Canada, India, Indonesia, South Korea, the Phillipines and Australia.

At 398MW, **MeyGen** is the world’s largest tidal power project. Located in the inner sound of the Pentland Firth in Scotland.

Atlantis owns 86.5% of the MeyGen project, alongside the Scottish Investment Bank, The Crown Estate, BEIS and HIE.
Tidal power

Tidal power is a predictable source of clean energy generation, making use of mature technologies developed by the oil & gas and wind industries over the past two decades.

1. The turbine is mounted on a foundation structure and set on the seabed. No drilling is necessary as its weight secures it in place.
2. Tidal currents cause the blades to rotate, powering a generator that produces electricity. The output varies with the tides and is predictable.
3. Underwater cables carry the electricity to an onshore substation.
4. The substation is connected to the national grid, which distributes the electricity.

Why underwater?

- Space saving, no visual pollution
  An underwater turbine with 9 metre blades can generate the same power as an onshore wind turbine with 30 metre blades. Low environmental impact with slow rotor speeds.
- Steel turbine nacelle with composite rotor blades
- Total weight (incl. foundation) ~ 1,000T
- Each turbine can generate enough electricity to power around 1,400 homes
- Each nacelle takes approximately 50 minutes to install onto a pre-installed foundation, offshore

More predictable

Unlike wind and solar energy, tidal energy is predictable as tidal currents can be accurately forecast years in advance. This makes for a more reliable source of electricity generation.

Large untapped resources

Water covers about 70% of the world’s surface and every continent has potential sites for harnessing the power of tidal currents.
Theme of this talk is “Perspective from the tidal industry”

System wide R&D challenges for the transformation of offshore renewable energy
Build on past research

“To deliver a portfolio of prioritised ORE R&D challenges which facilitate transformation of the ORE system through addressing the needs of business and policy whilst delivering measurable progress and impact”
MeyGen Project
World’s largest consented tidal array

- Crown Estate licence for 398MW
- First phase consents for 86MW September 2013
- Phase 1a £51m funding package August 2014: debt, equity, grants
- 4 x 1.5MW turbines installed 2016-17
- Further build out 2018-19
Policy Issues for Tidal
Why we need to reduce the cost of generation (at least in the UK)

BEIS announced CfD2 allocation results on 11/9/17:
• Offshore wind for delivery
  • 2021-22 £74.75/MWh 860MW,
  • 2022-23 £57.5/MWh 2336MW,
  • Total 3196MW
• Projects are Hornsea 2, Triton Knoll, Moray (+ 2 biomass/CHP & 6 EfW/ACT).
• CfD2 auction took no account of the early stage of marine energy, wave and tidal, and did not include barrage/lagoon.

When a strike prices of £305/MWh was announced for Auction 1 in December 2013, there was a 100MW reserved ‘minima’ for wave and tidal. This reserved capacity was not continued into Auction 2. Tidal was allowed to bid up to a strike price of £300/MWh (30p/kWh) for 2021-22 delivery (£295/MWh for 2022-23), but was bidding against offshore wind with a limit of £105/MWh.

CfD2 auction strike price for wave and tidal was a fiction, with no prospect of support being given. If such CfD auctions remain the only means of awarding a Power Purchase Agreement, there is no market in UK. (Yet the government is funding research - SuperGen.)

Atlantis submitted a bid in CfD2 at well below £300/MWh, but was unsuccessful. Now approaching UK government for bilateral negotiations for a 15-year CfD to complete Phase 1 of MeyGen, up to 86MW, at around £150/MWh. This would use ~30% of remaining unallocated CfD2 budget. But in competition with barrages, lagoons, biomass and other renewables.
Where to Concentrate
Approximate Cost Proportions of a Tidal Array Project

Reducing LCoE means working first on the areas that give the most benefits:

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<th>CAPEX</th>
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<tr>
<td>Turbines</td>
<td>40%</td>
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<tr>
<td>Installation</td>
<td>30%</td>
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<tr>
<td>Foundations</td>
<td>5%</td>
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<td>Cable</td>
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<td>Onshore works</td>
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OPEX as % of CAPEX/year

| or over 25 year life of project (depending on discount rate) | ~30-50% |

OPEX is strongly affected by reliability (how often you have to retrieve the turbines), as well as the costs of retrieval/deployment.

Also important to increase energy production ≡ income. Almost anything that increases output is cost effective.
Research Topics

Major issues

From LCoE perspective, main areas requiring work are:
• Financing
• Energy output
• Installation vessels
• Foundations and installation methodology
• Cabling
• Reliability

... not immediately obvious areas for academic research

However...
SITE DATA ANALYSIS
• Wake effects
• Validation of load modelling
• Condition monitoring
Considerable data available from MeyGen

TURBULENCE
• Turbulence measurement (with ADCPs?)
• Translation of ADCP measurements into realistic flow fields for modelling.

WAVES
• Interactions between waves and current
• Waves and turbulence modelling.
HYDROFOIL DESIGN
• Specialist foils for tidal (from 15% to 60% thickness/chord)
• Validated by measurement

CAVITATION
• Cavitation limits
• Transient effects
• Effects of cavitation on blades
• Cavitation protection

CONTROL
• Reducing loads, increasing output.
• Predictive control using flow measurement

RELIABILITY
• Reliability development methods for early stage technology without historical data. Digital twins?
GRID COMPATIBILITY
• Electrical issues for tidal.
• Power quality, power variation, flicker, LVRT
• Operating on weak grids.

ENVIRONMENTAL IMPACTS
• Mammal impacts, active sonar for near field behavior, passive acoustic monitoring, automatic detection and data processing
• Robust equipment
Real conditions

Waves at the MeyGen site
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