Marine Current Turbines
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Presenter
Phil Wilkinson

SeaGen S 2MW Foundations @ Anglesey Skerries

Introduction

Introduction

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Phil Wilkinson

20 years experience in offshore marine construction, large diameter drilling and specialist pile installation. Noteable Projects:-

North Hoyle OWF - 2003

Flamanville EPR Shaft - 2008

Today's Presentation

- MCT & History
- MCT's Tidal Technology
- Anglesey Skerries Tidal Array - Foundation Requirement
- Anglesey Skerries - Ground Investigation
- Discussion & Lessons Learned

MCT

MCT

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Pioneering Bristol based tidal developer

- First device install in Loch Linnhe, Scotland, in 1994-5, 15kW

- Second device “SeaFlow” installed offshore Lynmouth, North Devon in 2003, 300kW test device

- Third device “SeaGen” (full scale, grid compliant) installed in 2008, Strangford Narrows, Northern Ireland, 1.2MW

Now 100% owned by Siemens, since early 2012

First Tidal Turbine Array

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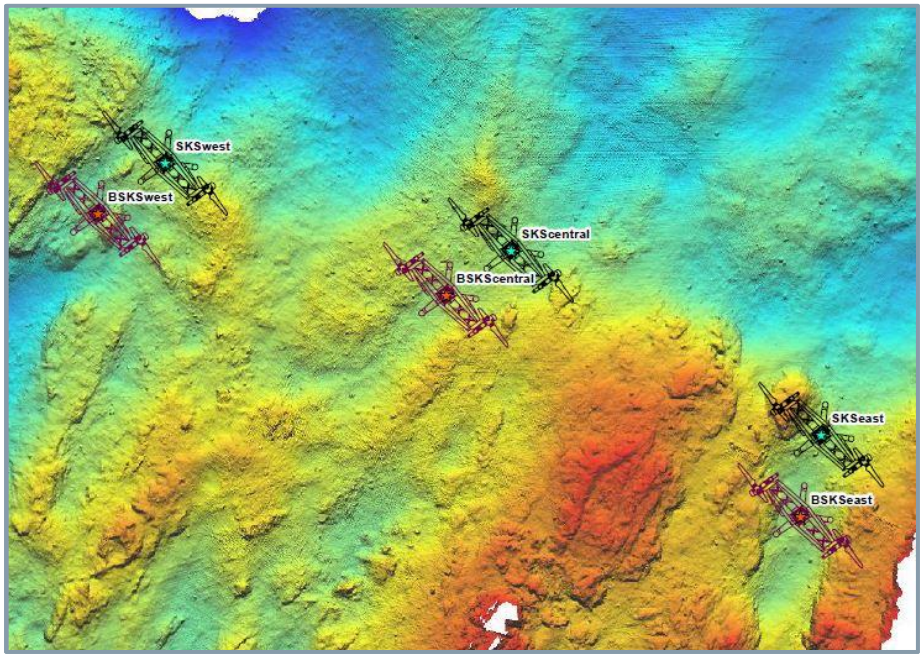
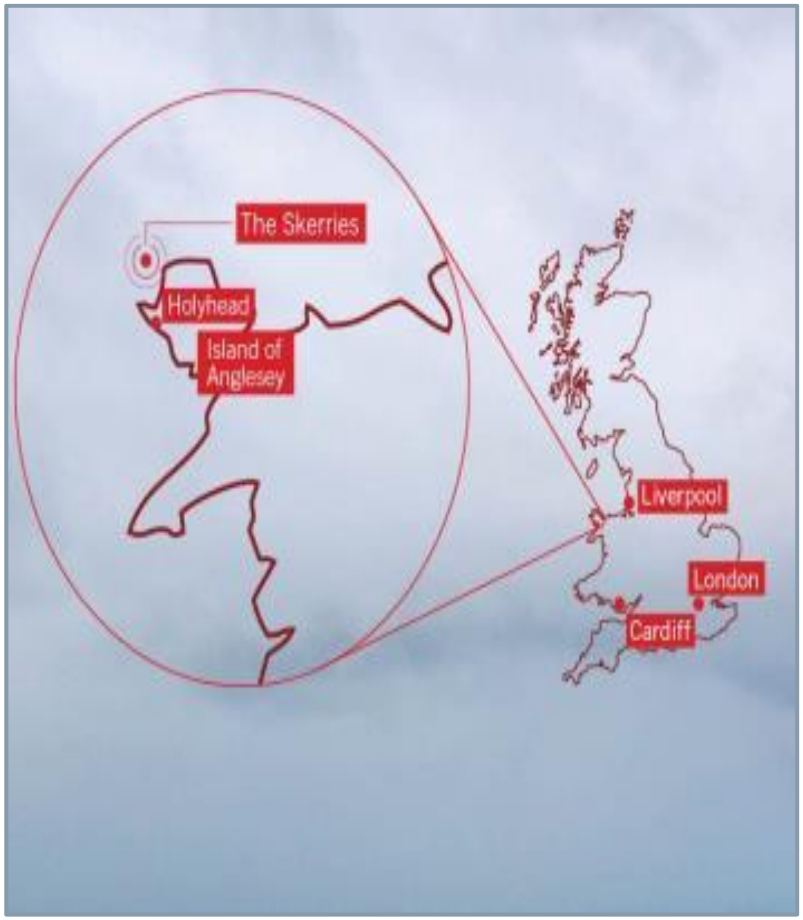
SeaGen S 2MW - Commercial Array

- 2016 (Planned)
- Anglesey Skerries, North Wales
- 3 x SeaGen S 2MW Tidal Current Turbines





The Technology

SeaGen S 2MW

SeaGen S 2MW - Technology

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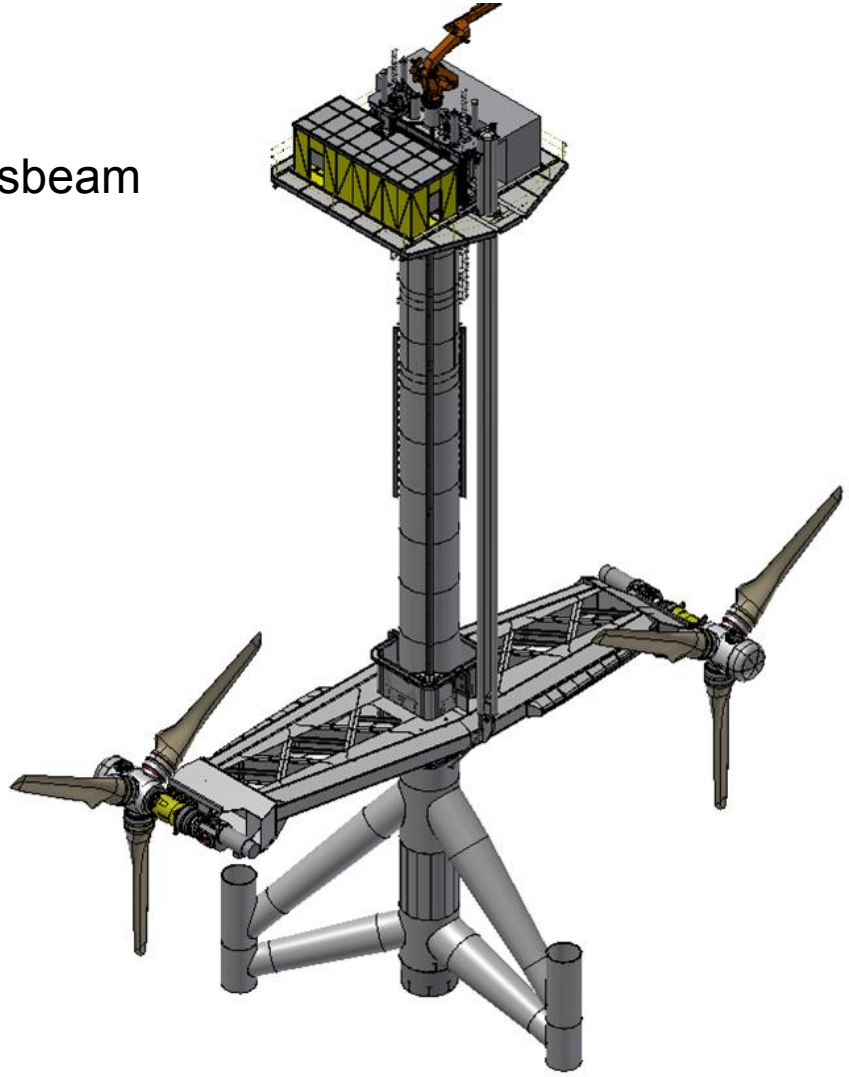
SeaGen S 2MW Tidal Turbine Generator

- Development of the 1.2MW device
- Surface piercing tower with raisable crossbeam
- 2 x 1MW drivetrains
- 3 x variable pitch blades per rotor
- Tripod foundation
- Modular topside with power conditioning, exporting grid compliant electricity



SeaGen S 2MW - Skerries Loads

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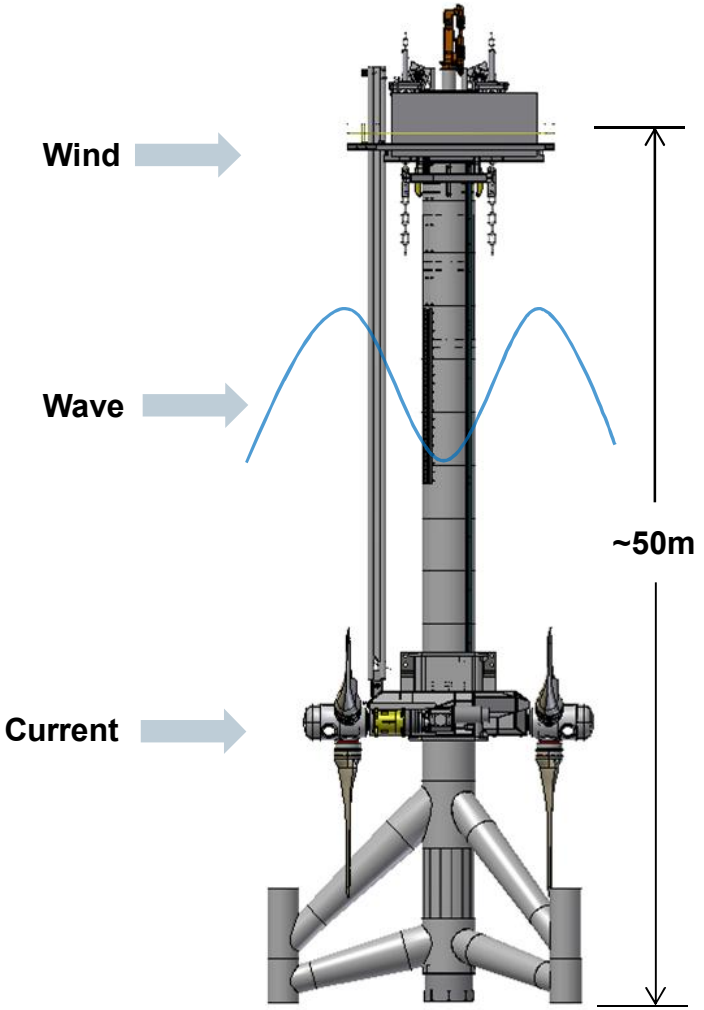
SeaGen S 2MW - Skerries Loads

- Skerries 50 yr wind = **35 m/s**
- Skerries 50 yr wave = **7.1 m Hs**
- Skerries 50 yr current = **4.8 m/s**

+ loads due to tide, turbulence, storm surge, temperature, ice/snow, collision etc



Conclusion = A significant lever arm requiring robust fixity to seabed!

SeaGen S 2MW - Foundations

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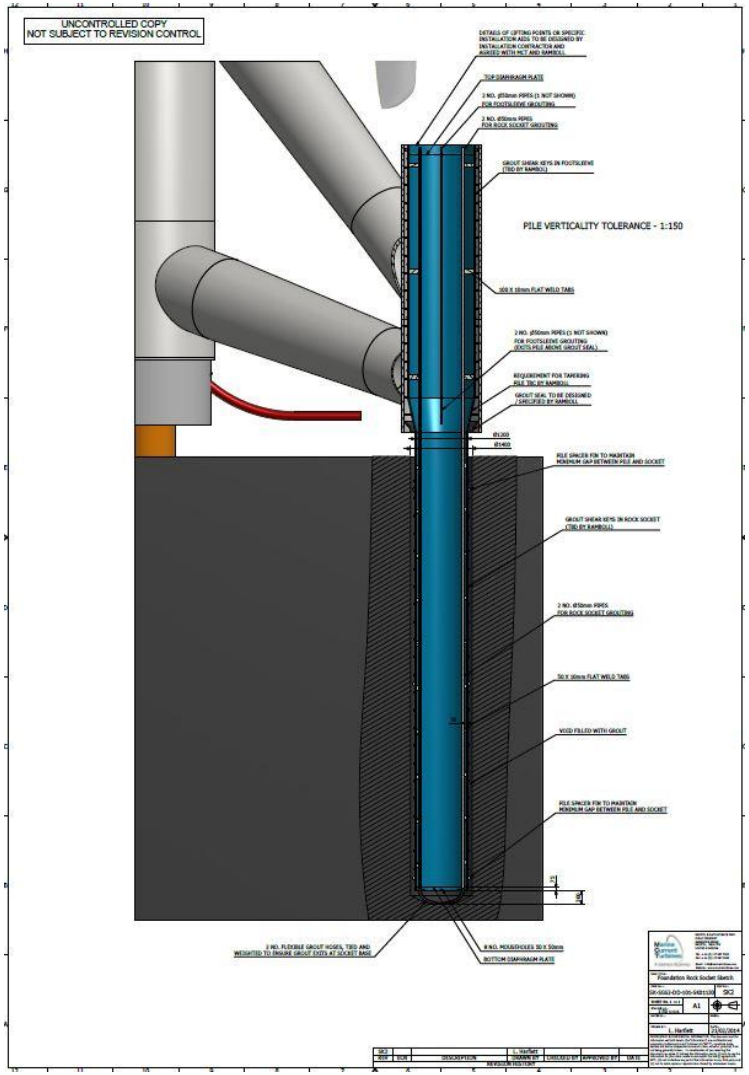
Foundation Piles

- 3 x pin piles per device
- Pile diameter 1.2-1.3m
- Tubular steel pile installed into circa 1.4-1.5m diameter x 10m deep rock socket
- Connection between pile and rock, and pile and foot-sleeve to be grout

Purpose/Design

- To transfer all axial, torsional and moment loads from device to the ground
- To maintain within fatigue (FLS) and ultimate limit state (ULS) design for device lifetime, 20 years



Foundation Design Requirements

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Foundation Design Requirements

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We need to know loads and what it is to be fixed to....

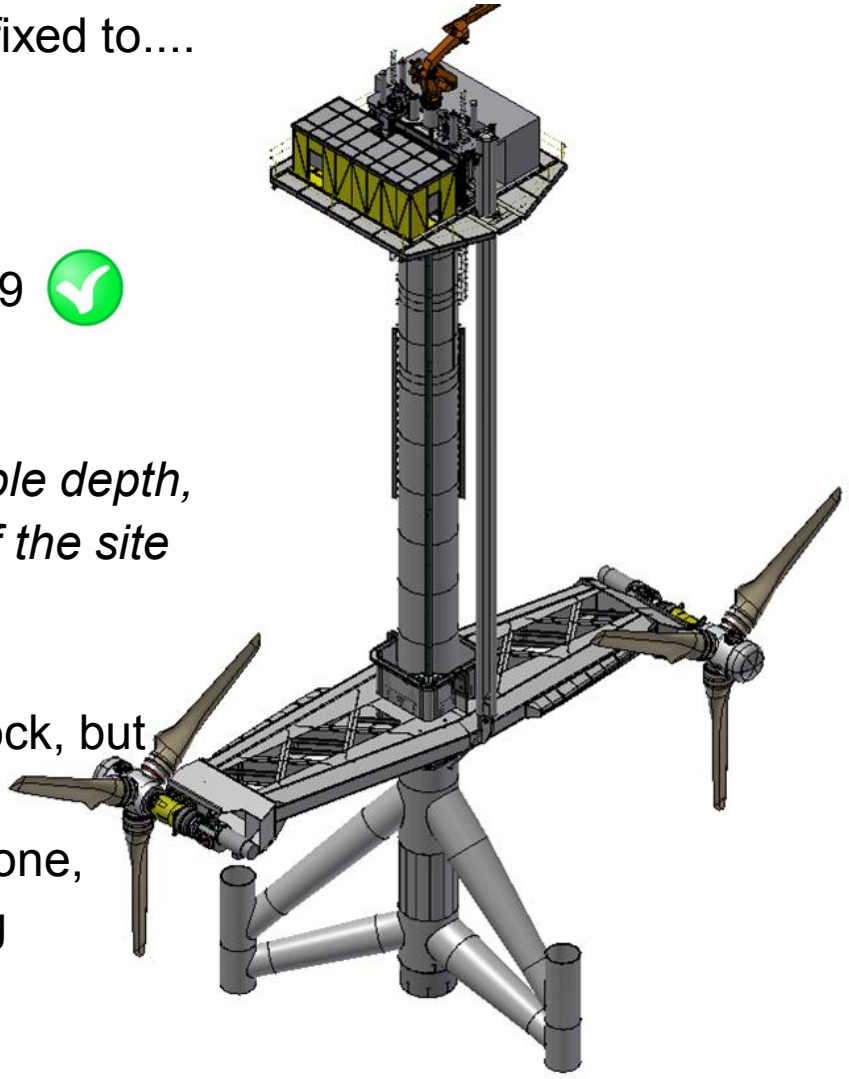
In early 2012, what we knew…..

Environmental loads ✓

Soil & seabed conditions

- Geotechnical Desktop Data - SEtech 2009 ✓
- Geophysical data - EMU 2009 ✓
- Geotechnical data - ?? ✗

Note - foundation design requires 15m sample depth, ideally 3 holes across representative area of the site



Conclusion

We knew the seabed was mainly made of rock, but we could not confirm rock characteristics or overburden details from geophysical data alone, hence geotechnical sampling and lab testing potentially required.

Geotechnical Survey Options

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Geotechnical Survey Options

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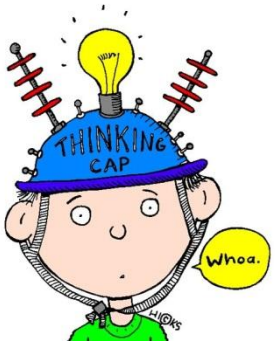
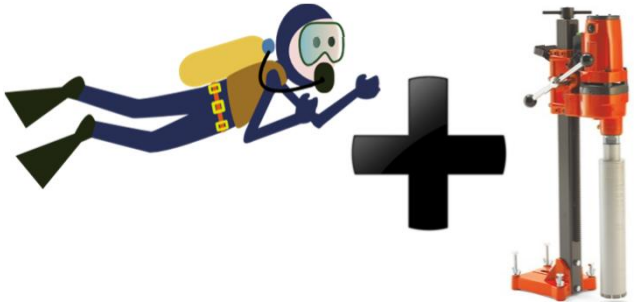
Option 1
Do nothing, estimate rock strength & characteristics from desktop & geophysical data



Comments
Current Foundation design not robust enough to rely on this.

Current geophysical survey equipment gives limited sub-bottom information, unless expensive equipment used.

Option 2
Diver with drill



Comments
Has been done before.

May give cheap solution but small length of core and diver working in tidal regime, so not ideal.

Geotechnical Survey Options

Option 3
Small scale seabed drill

Comments
Single shot up to 5m core sample.

Doesn't meet the sample depth requirement for foundation pile design.

Option 4
Full site investigation works, with jackup or DP vessel

Comments
Meets all technical requirements.

One of the most expensive options and generally a long lead, or potentially opportunistic?

Geotechnical Survey Options

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Option 5
Seabed carousel drill

Comments
Can be deployed from a variety of vessels.

Meets the sample depth requirement for foundation pile design, and can be cheaper than conventional techniques.

Conclusion
The option which satisfied the sample depth requirements and was the most cost effective option (at the time) was Option 5, the remotely operated seabed drill rig.

Geotechnical Site Investigation

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Geotechnical Site Investigation

Skerries Site

Geotechnical Site Investigation

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Plant

Marine Support Vessel

DP2 Multi-use

"Deep Cygnus"

Drill

Subsea Drill "*ROVDrill 2"*

Geotechnical Site Investigation

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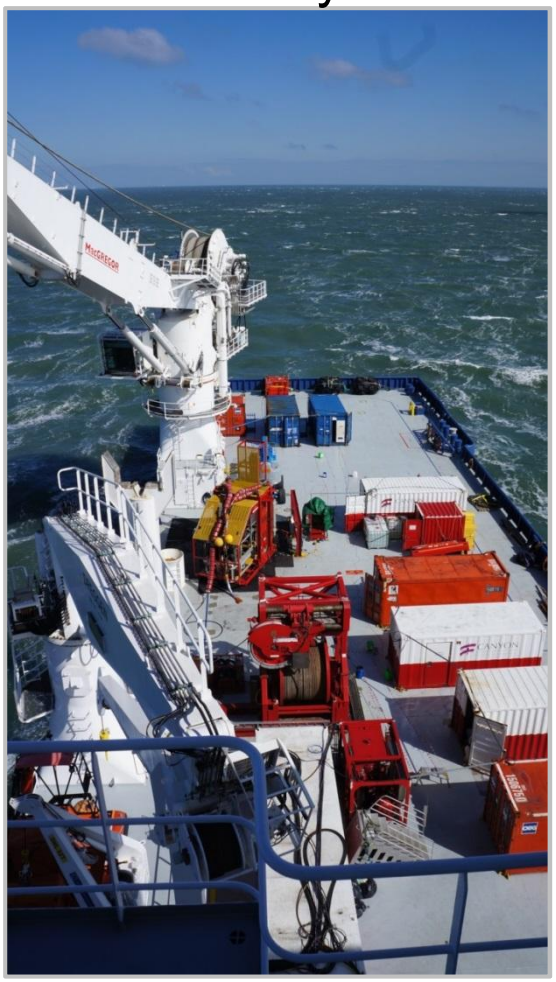
Operations

Deck layout



Deploying Drill

Geotechnical Site Investigation

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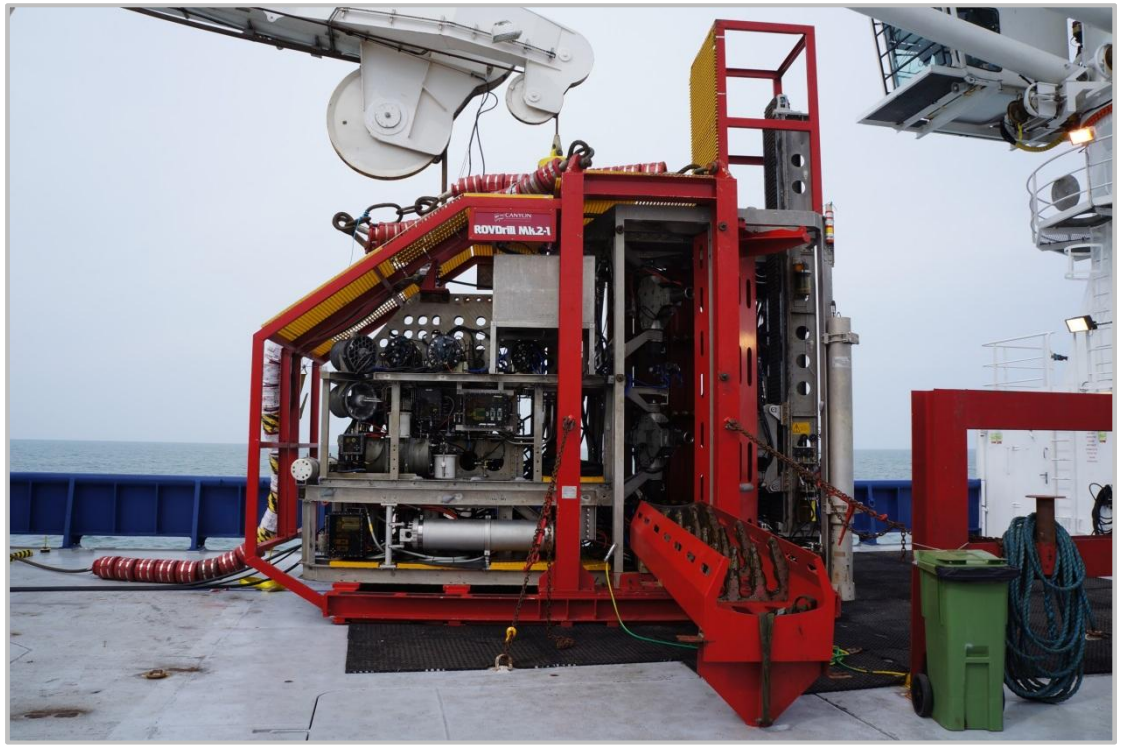
Drill

Carousel showing drill rods

Drill



Geotechnical Site Investigation

Sample Returns

Inspecting core samples

Core samples

Geotechnical Site Investigation

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Temporary Logged Sample

Lessons Learned

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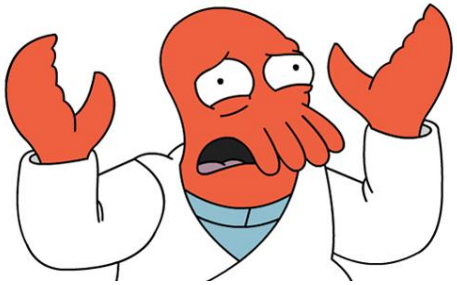
Lessons Learned

Overall
Success!!!!

Samples were recovered to surface and of decent enough quality to test.

However……
The scope of works was for 3 number boreholes to a depth of 15m each. Whereas, only 2 locations were drilled and only one of those was to 15m.....

Why…….



…….and more importantly, what did we learn?

Lessons Learned

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Technical Appraisal

- DP2 vessel proved it could work outside the typical operating tidal current limit.
- ROVDrill 2 experienced problems stabilising itself on seabed, due to boulders & rocky outcrops.
- Learning curve problems were encountered during the first hole, and on such short duration works, on-site “learning” is not viable.
- Visibility was much less than expected at the site adding to difficult working conditions.

Commercial Appraisal

- As is typical in the industry where specialist short duration works are required, the contract was day-works; at the same time performance warranties were limited, hence when the budget for the works was used up further sampling was not possible.

Result

- Inferior core recovery resulted in less than ideal data for foundation design. Therefore foundation design is less efficient, and potentially more expensive, plus further sampling is being considered for project de-risking.

Next Steps & The Future

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Next Steps & The Future

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Next Steps - Skerries

- Additional geophysical data was acquired in 2013, which has been incorporated into the overall geo data set; hence device micro-siting is complete.
- There is enough geotechnical information to design the foundations.

The Future - Questions to answer……..

- For future tidal sites to be viable can we afford to go down the same route as offshore wind and sample on each foundation location? A mitigation for this is to design more robust foundations, which need less soil data. However, maybe we should adopt a more pragmatic approach to foundation design - review guidance?
- Seabed conditions on tidal sites is typically rock with limited overburden, hence the above philosophy lends itself to the solution.
- Are physical boreholes really required to 15m in the rock for a 10m foundation, would a 5m core suffice, and how many cores per device site/project?
- Latest geophysical survey techniques together with quality desktop study, and sampling using cheaper (shorter sample) coring tools may be adequate e.g. BGS rock corer?
- Maybe novel geophysical survey tools that can achieve the required sub-bottom profile information?

Reducing overall project capex is key to future of renewable projects, we should adopt a pragmatic approach to foundation design and geotechnical investigation requirements.

Thanks

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Thank you for listening

Questions?