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Programme Area: Offshore Wind

Project: Deep Water

Title: Executive Summary

Abstract:

Offshore Wind has huge potential to reduce carbon emissions and create economic prosperity, as well as increasing energy security of supply. For this potential to be unlocked, significant challenges that need to be overcome: a) Electricity costs need to be competitive with current (2010) onshore wind costs by 2020 and with conventional generation by 2050. This is illustrated in the Offshore Wind roadmap in Appendix D, b) Increased yields: annual offshore farm availability to be increased to 97%-98% or better (currently 80% to 90%), c) Reduce technical uncertainties to allow farms to be financed in a manner, and at costs, equivalent to onshore wind today. Deep Water was one of three ETI Offshore Wind projects looking at new turbine design concepts, which were commissioned in 2009 in support of the aims outlined above. The other two were Helm Wind and NOVA. The focus of all projects was on enabling technologies that would have a significant impact on offshore wind cost of energy from 2020 onwards.

Context:

This project was led by Blue H Technologies. The consortium also included BAE Systems, Romax, Centre for Environment, Fisheries and Agricultural Science, EDF, PAFA Consulting Engineers and Sea & Land Power and Energy Ltd. It delivered an economic and technical feasibility study for a novel floating TLP 5MW offshore wind turbine having a hybrid concrete/steel floater and a concrete counter weight.

ETI Executive Summary

Programme: Offshore Wind

Project Name: Deep Water (completed 2010)

Introduction

Offshore Wind has huge potential to reduce carbon emissions and create economic prosperity, as well as increasing energy security of supply. For this potential to be unlocked, in 2010 the significant challenges that need to be overcome were:

- Electricity costs need to be competitive with current (2010) onshore wind costs by 2020 and with conventional generation by 2050. This is illustrated in the Offshore Wind roadmap in Appendix D
- Increased yields: annual offshore farm availability to be increased to 97%-98% or better (currently 80% to 90%)
- Reduce technical uncertainties to allow farms to be financed in a manner, and at costs, equivalent to onshore wind today (2010).

Deep Water was one of three ETI Offshore Wind projects looking at new turbine design concepts, which were commissioned in 2009 in support of the aims outlined above. The other two were Helm Wind and NOVA. The focus of all projects was on enabling technologies that would have a significant impact on offshore wind cost of energy from 2020 onwards.

The Deep Water project has delivered an economic and technical feasibility study for a novel floating Tension Leg Platform (TLP) offshore 5MW offshore wind turbine having a hybrid concrete/steel floater and a concrete counter weight. It is suitable for depths of 30 – 300 m for Round 3 and later round implementation. The project had two aspects:

1. A TLP design based on a concrete / steel hybrid.
2. A novel, fixed-pitch, yaw-controlled, teetering 2-bladed, 120m diameter, downwind 5MW turbine.

The Deep Water consortium was led by Blue H Technologies BV and included BAE Systems, Romax, ‘Centre for Environment, Fisheries and Aquaculture Science (CEFAS)’, EDF, PAFA Consulting Engineers, ‘Sea & Land Power and Energy ltd’.

The Project started in January 2009 and ended in August 2010.

Key findings

Floating platform

The consortium proposed two different, though related, solutions. For water depths of more than 70m, they will use their Tension Leg Platform (TLP) design. For depths between 30m and 70m they have created a 'fix and float' concept, in which the floating part of the TLP is mounted on the counter-weight, with the counter-weight secured to the seabed through piling. These two solutions give the consortium sufficient water depth range to cover many of the round three sites as well as future developments.

In their original proposal, the consortium expected to build complete turbine and TLP units in port and tow them out to the wind farm; eliminating the need for a barge and specialist installation vessels. They've now established that the completed units would have a water draft of 33m, so they need a harbour with at least a 33m water depth. The nearest port to the UK with this depth would be in Norway. Instead they proposed using a custom build barge to transfer the completed units from a UK production facility to sufficiently deep water to allow the structure to float out normally to the wind farm. In our view this significantly reduces the attractiveness of the concept; one of the key features of the original proposal was the ability to float out the wind turbines and TLPs without the need for barges or specialist vessels.

The consortium does not, yet, have a cost effective solution for the tethers in water depths greater than 100m. Up to 100m they plan to use the largest diameter dyneema cables created so far. We do not think this depth constraint is an issue; the UK has a significant amount of offshore sites with water depths in the 50m to 100m range with high average wind speeds; see drawing in Appendix B.

The floating platform has a large surface area in the wave zone, in contrast to other floating platform concepts which aim to minimise wave zone surface area. In our view there is considerable scope to value engineer the design of the TLP. In particular the counterweight has become both large and heavy. We think a more cost effective solution would be a TLP with a cable and anchor type arrangement; there are some novel ideas around in this area that will be investigated in any follow on work. The consortium also identified that moving to an all reinforced concrete platform structure has the potential to save over £1m CAPEX on each unit. Overall our view is that this project has shown that a TLP is a feasible and sensible floating platform on which to mount an offshore wind turbine. We do not think the counterweight 'anchoring' solution developed by Deepwater is the best way of mooring TLPs; both on cost and construction grounds. This may have been different if the TLP / counterweight combination could have been built onshore and floated out to site without the need for a barge. Unfortunately the final design, at 33m draft, is too deep for this to be practical for UK (and many other) ports. The use of a TLP, combined with a different anchoring system, is a sound starting point for any deep water offshore wind project.

Turbine

The proposed turbine is a novel, fixed-pitch, yaw-controlled, teetering 2-bladed, 120m diameter, downwind 5MW turbine. The review team were not convinced that it would be significantly cheaper than models being developed by established OEMs; the predicted nacelle weight (a rough guide to cost) is similar, or even higher, than that already published by some OEMs for a similar size nacelle. We, therefore, think the highly yawed turbine is unlikely to offer any cost of energy advantage over developments from established OEMs.

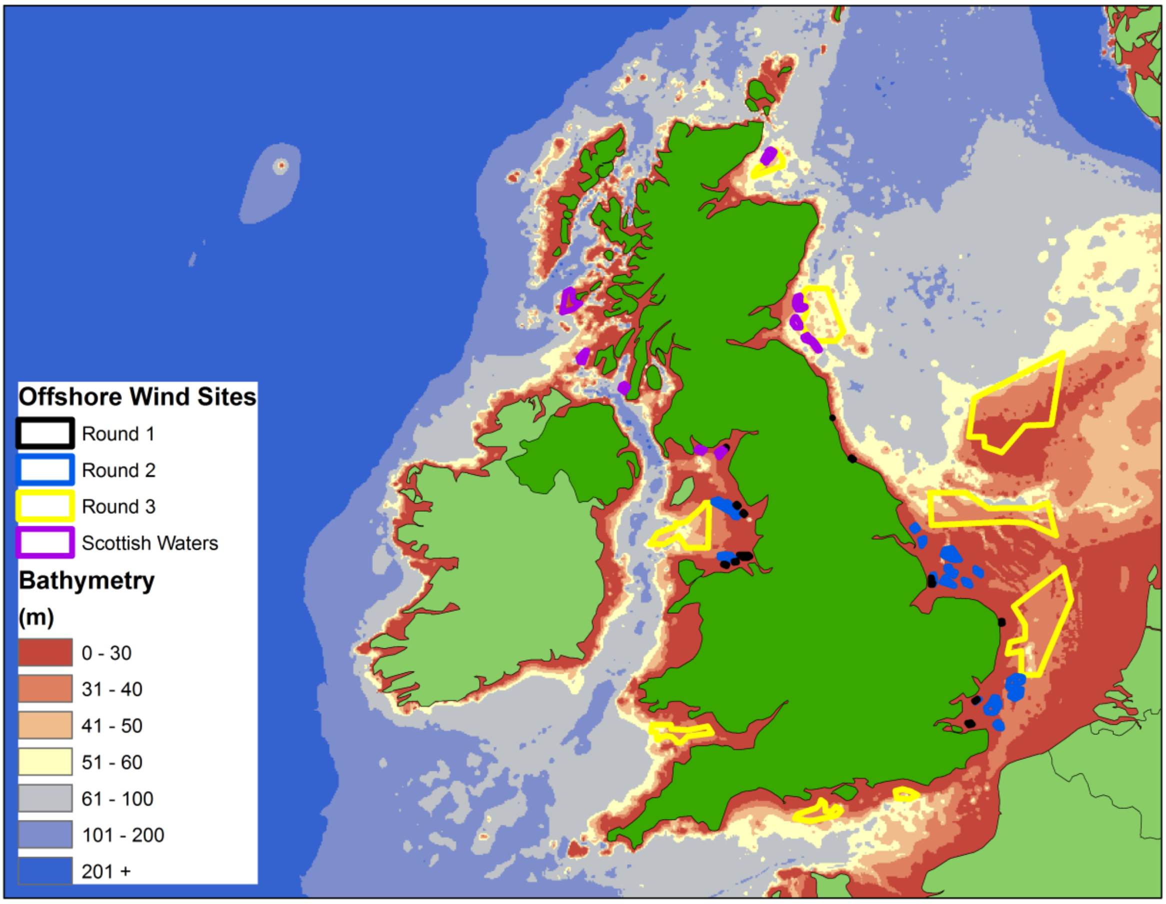
In addition the review team were not convinced that the yaw and teetering hinge approach was robust, with specific concerns over the durability of the teetering hinge and the associated elastomeric bumper.

Conclusions

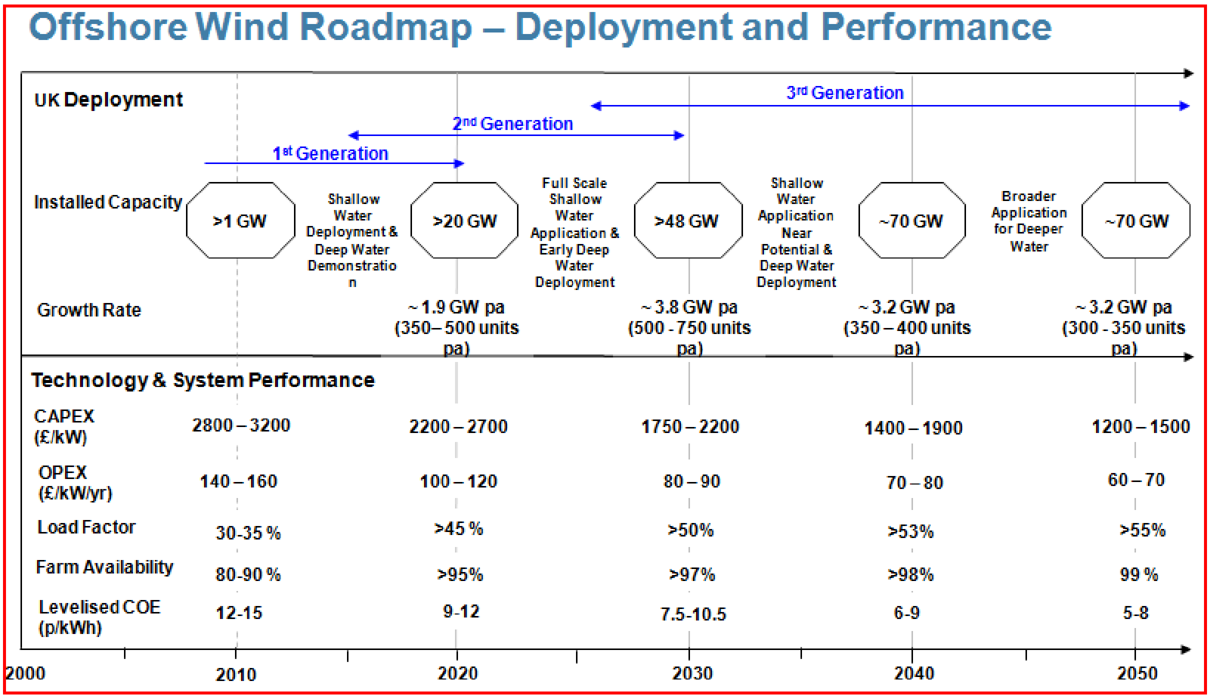
1. This project has provided the ETI with valuable data on TLP floating foundation design and cost to inform the ETI Offshore Wind programme's future work (2010 to 2015):
2. The Turbine and TLP are not a fully integrated system. In the next phase (if taken forward), further work would need to be done on modelling the interactions between waves, TLP, the tower and the nacelle. Existing commercial software will need to be enhanced to meet this need. Current commercial software models support structures fixed to the seabed / ground.

Appendix B

Diagram showing UK water sites with depths 60m to 100m



Appendix D


Offshore Wind Roadmap – Deployment and Performance
UK Deployment
3rd Generation
2nd Generation
1st Generation
Installed Capacity
>1 GW
Shallow Water Deployment & Deep Water Demonstration
>20 GW
Full Scale Shallow Water Application & Early Deep Water Deployment
>48 GW
Shallow Water Application Near Potential & Deep Water Deployment
~70 GW
Broader Application for Deeper Water
~70 GW
Growth Rate
~ 1.9 GW pa (350– 500 units pa)
~ 3.8 GW pa (500 - 750 units pa)
~ 3.2 GW pa (350 – 400 units pa)
~ 3.2 GW pa (300 - 350 units pa)
Technology & System Performance
CAPEX (£/kW)
2800 – 3200
2200 – 2700
1750 – 2200
1400 – 1900
1200 – 1500
OPEX (£/kW/yr)
140 – 160
100 – 120
80 – 90
70 – 80
60 – 70
Load Factor
30-35 %
>45 %
>50%
>53%
>55%
Farm Availability
80-90 %
>95%
>97%
>98%
99 %
Levelised COE (p/kWh)
12-15
9-12
7.5-10.5
6-9
5-8
2000
2010
2020
2030
2040
2050