Gravity base foundations for the Blyth Offshore Demonstration wind farm

27th April 2017 | Paul McKeever & Jonathan Hughes
Agenda

- ORE Catapult
- Demowind and the FSFound Project
- The Blyth Offshore Demonstration Wind Farm
- The Project
- Instrumentation in the Marine Environment
The catapult network: A long-term vision for innovation & growth

Catapults

- Established by InnovateUK
- Designed to transform the UK's capability for innovation
- Core grant leveraged with industry and other public funding
ORE Catapult

Our Vision:
Abundant, affordable energy from offshore wind, wave and tide

• Reduce the cost of offshore renewable energy
• Deliver UK economic benefit
• Engineering and research experts with deep sector knowledge
• Independent and trusted partner
• Work with industry and academia to commercialise new technologies

ore.catapult.org.uk
@orecatapult

80+ technical experts
Our impact in 2015/16

50 Companies whose product development we’ve supported through our testing and validation services

151 SMEs we have supported

£1.4bn of world-leading test and demonstration facilities in support of UK innovation

75% Year-on-year uplift in competitive R&D revenue

Global Reach

18 Countries we have worked with to develop opportunities for the UK supply chain

Operating

126 projects with academics

204 industry collaborations

Return on Investment 1:3:21

£4.9m Invested in procuring capital equipment, materials and engineering and consulting services from our supply chain

£6.2m Invested in building team of leading engineering and research specialists

£5.7m Invested in collaborative projects and programmes in 2015/16

World Firsts

First benchmarking platform for offshore wind turbines
Operating largest indoor blade test facility
World’s largest open access offshore wind turbine dedicated to research
First accelerated testing of 50kV cable

For every £1 of core grant invested we have leveraged £3 of additional research funding driving £1.1 of activity
# Who we work with

## Industry Advisory Group
- Senvion
- Dong Energy
- MV
- iFab
- GE Energy
- Ewp Renewables
- Global Offshore Group
- RICARDO
- Atlantis
- SSE
- Edf Energy
- Andritz Hydro
- Scottish Power Renewables

## Research Advisory Group
- Swansea University
- University of Sheffield
- University of Exeter
- Queen’s University Belfast
- Imperial College London
- Loughborough University
- University of Strathclyde
- Institute of Oxford

## Partnerships & strategic alliances
- The Crown Estate
- Edf Energy
- Green Investment Bank
- Wave Hub
- Samsung
- Samsung Heavy Industries
- Carbon Trust
- EMEC

## SMEs
- Tekmar
- Invisotech
- InterReg
- Atlantis
- Innovate
- Gnosys
- Act Blade Ltd
- Nova Innovation Ltd
Blyth Offshore Demonstration Wind Farm

- Consent developed by Narec (now the Offshore Renewable Energy Catapult)
- Consent approved for a 99.9MW demonstrator wind farm in October 2013
- EDF Energy acquired rights in October 2014
- Phase 1 will build:
  - 5x 8.3MW turbines
  - 5.7km off the coast of Blyth
  - 191.5m Tip Height (AOD)
  - 66kV Export and Inter-array cabling
Development and demonstration of float-and-submerged gravity base foundations (GBF) for offshore wind turbines: FSFOUND

Specific project objectives

• To move the FS GBF solution from TRL 6 to TRL 7, thereby verifying the RDI initiative.
• To verify the manufacturing and installation methodology and benefit from the lessons learnt in order to optimise plans for the future transnational exploitation of GBFs;
• To minimise potential delays and cost overruns through the development of multiple installation scenarios against a meteorological model.
• To compare the actual costs and performance with the cost-benefit analysis performed;
• To design and install a condition monitoring system on two GBFs to monitor their behaviour.
• To assess the structural response to extreme and fatigue loads on the GBF and compare theoretical loads with real ones.

Benefits

• Lower installation costs by employing standard tugs and self-buoyancy rather than specialised vessels.
• Lower costs during the operational phase as a result of reduced inspection and maintenance.
• Fabrication and deploy the GBF in physical proximity to the offshore site
• Increased deployment of WTGs in sites where piling is not technically feasible

Project context

To demonstrate the feasibility of the float-and-submerged gravity base foundation solution at all critical stages: design, manufacture and quayside construction, preparation and loadout, seabed preparation, towing, installation, commissioning and operations.

Project Value: £3,636,607
BEIS Contribution: £604,957
Start Date: 20/10/2016
Scheduled Completion Date: 01/02/2019

In collaboration with:
Blyth Offshore Demonstrator Ltd
EDF Energy R&D UK Centre
ORE Catapult Development Services Ltd.
BAM Wind Energy JV
FSFound Project Aims

To validate the FS GBF solution as an alternative solution to energy provision by proving that FS GBF performs as intended and can be installed cost-effectively;

- To conduct a range of simulation and modelling studies to minimise the uncertainties and inefficiencies in the deployment process and in various weather windows;
- To compare the actual costs and performance with the cost-benefit analysis performed;
- To assess structural response to extreme and fatigue loads on the FS GBF and compare theoretical loads with real ones;
- To establish the effect of cyclic loadings on the seabed through monitoring and measurement and verify/calibrate models for differential settlements in the soil;
- To establish the optimal seabed preparation requirements (i.e. minimum preparation depth).
Why instrument these foundations?

1. Validation of the design, including input to verifying simulation models
2. Providing feedback to the design limits of the structure, such that an updated life expectancy can be calculated (if required)
3. Understanding the interaction between:
   - GBF and Seabed (e.g. settlement)
   - GBF and WTG (e.g. modal interaction, load transfer)
   - GBF/WTG combination and the Environment (e.g. wind/wave misalignment loads)
   - Effect of internal divisions on the displacement of the caisson outer walls
4. Provide inputs to the design of a Structural Health Monitoring system for GBF system
5. Provide inputs to the cost model, in the form of estimated O&M OPEX costs
6. Provide a platform for the development of a prognostic methodology for NDT of GBFs
Caisson Pressure Sensors

- Upper sensor mounted near vent (sea reference)
- Lower sensor mounted near top of slipform
- 3 sets of 2 mounted at 120° spacing
- 4Hz sample rate
- Protected against ballast ingress whilst allowing flow of water

- Indirect measurement of depth
- Also can calculate period
- Triangulation may permit direction measurement
- Comparison after calculation with other wave data on site.
- Data corrected for Atmospheric variation
Inclination and Mode Shapes

- High stability servo inclinometers
- Measurement range of +/-14.5°
- Resolution of 0.001°
- Positioned to match ANSYS AQWA modelling nodes
- Positioning is critical to interpretation of data
Load Paths

- Initially aimed to installed SGs into Concrete, however not possible
- Structure can be analysed through load paths rather than direct loads.
- Bending, Compression and Torsion are independently assessed
- Loads measured above and below “Wet Joint” – calculation of loads into caisson roof
- Loads measured at field weld to establish effect of loads from turbine and torsional loads
Corrosion

- Structures are filled ballasted with sand and seawater flooded below LAT
- Water is expected to have slow transit rate through structure, leading to oxygen depletion
- Dissolved Oxygen sensors are installed to monitor
- Water level in shaft is monitored for comparison
- DO Sensors use dynamic luminescence quenching rather than an EC sensor

From AADI 4330 manual
Connection and Protection

- Instruments are useless if they don’t work or give questionable data
- Welding and Bolting were not permitted by the designer
- All instruments are permanently bonded, but need a temporary method of attachment until the adhesive “grabs”
- Protection needed against ballasting force
- Protection against settlement
- Subsea-grade cables and connectors
- Full epoxy fill to instrumentation systems
Installation Challenges

• Vertical installation requires significant additional time and risk management
• Installing delicate sensors; to fine tolerances; in the wet; hanging from a rope...
• Horizontal installation challenging without the ability to roll or traverse
• Location Referencing
• Novel and Evolving design
• Fitting research into a complex and time-critical construction project
## Contact us

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