Decommissioning Wind Turbines In The UK Offshore Zone

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INTRODUCTION

The offshore wind industry is in its infancy in the UK, however, the preparation of plans for the decommissioning of structures placed on the seabed has now become a major consideration in obtaining the necessary consents for offshore developments. It is becoming increasingly apparent that decommissioning plans will become important if not critical during the development of offshore wind farms. This paper therefore attempts to identify the key areas that will need to be addressed in preparing plans for the decommissioning of the facility. Moreover, it highlights ways in which the decommissioning process can be simplified at the outset by identifying both current legislation and offshore techniques as a baseline.

1. THE NEED FOR DECOMMISSIONING

Although there appears to be little regulation specific to the decommissioning lifecycle stage of offshore wind installations, it can be anticipated that offshore regulations will be applied by the DTI in the context of well-developed oil and gas licensing and environmental protection regimes. Moreover, in light of the Crown Estate leasing arrangements presenting a requirement for site reinstatement it is crucial that the offshore wind industry as a whole prepares itself adequately.

In order to understand the obligations placed upon offshore developers it is necessary to review the relative legislation surrounding offshore decommissioning on an international level as well at a UK level. These have derived mainly from two international obligations:

UNCLOS[1] - 1982

[1] United Nations Convention on the Law of the Sea

This convention entered into force in 1994 and was ratified by the UK in 1997. Article 60(3) includes the following: *"Any installations or structures which are abandoned or disused shall be removed to ensure safety of navigation, taking into account any generally accepted international standards established in this regard by the competent international organisation. Such removal shall also have due regard to fishing, the protection of the marine environment and the rights and duties of other States. Appropriate publicity shall be given to the depth, position and dimensions of any installations or structures not entirely removed"*

OSPAR[2] – 1998

In July 1998 at the first ministerial meeting of the OSPAR Commission, a new regime for the decommissioning of disused offshore installations was established. In short, Ministers adopted a binding decision to ban the disposal of offshore installations at sea.

Furthermore, in OSPAR's latest published annual quality review, offshore wind farms are

[2] Oslo and Paris (OSPAR) Decision 98/3

specifically identified as a significant human activity, and the decision will inevitably apply to windfarm structures within jurisdiction of the Convention.

In view of this therefore, if guidance is to be taken from the previous obligations, influence on various UK legislations both within UK territorial waters and the Exclusive Economic Zone*, may take place. These include:

- Electricity Act 1989
- Conservation (Natural Habitats &c) Regulations 1994*
- The Coast Protection Act 1949
- Food and Environment Protection Act 1985
- Dangerous Substances in Harbour Areas Regulations 1987
- Water Resources Act 1991
- Health and Safety at Work Act 1974 (HSWA)*
- The Environmental Protection Act 1990 & Waste Management Licensing Regulations 1994.

Enron Wind is one of the eighteen successful candidates who have pre-qualified and are close to signing lease agreements with the Crown Estate for the Gunfleet Sands project. However, its interest in decommissioning has not stemmed solely from the aforementioned project but from its global interest and involvement in the world wide offshore market, as one of the leading wind turbine manufacturers. The undertaking of a decommissioning study by Enron Wind is seen as a natural approach for any comprehensive offshore development.

2. THE STUDY

The study relates to the ultimate decommissioning of a proposed offshore wind farm assumed to be/have:

- Thirty individual turbines
- Located on a sand bank
- Approximately 7km offshore
- 3.6MW turbines (85m Tower, 100m rotor diameter)
- Two anemometry masts (80m high)
- Buried, under water cabling
- Onshore grid connection

Using these assumptions, analysis of the key elements of the offshore development had to be identified and researched.

3. SITE SPECIFIC DYNAMICS

Geotechnical – The site is assumed to comprise of a variation of stiff clays of about 20-30m overlying dense sands of 20-40m.
Wind – On site wind data correlated with onshore meteorological stations = average 8.8m/sec
Waves – Relatively sheltered = 50 year extreme heights of between 4 and 6 metres.
Current – Estimated maximum 1.0m/sec at spring tide
Sediment movement – Unknown
Maximum water depth - 11m

4. ENVIRONMENTAL CONSIDERATIONS

Environmental Impact Assessment – Desk study, full study incomplete.
Biological Environment – Initial studies demonstrate low bio-diversity none sensitive benthic communities.
Commercial Activities – Active Fisheries, Sailing and general navigation nearby.

5. DESIGN CHARACTERISTICS

In order to investigate the decommissioning aspects of offshore wind turbine foundation, it is at first necessary to consider what preliminary design will be required. The design therefore, will in turn depend on the metocean parameters, that is, the height the turbine tower has to be supported above the highest still water level, and the additional environmental loadings on the structure due to wave, currents etc.

Taking into account all of the above design parameters and the total design height of the foundation superstructure is anticipated to be 18.5m above sea level.

6. SUPERSTRUCTURE DECOMMISSIONING

It is assumed that the superstructure decommissioning process (i.e. removal of turbine components including blades, nacelle, tower and containerised transformer) will largely be a reversal of the installation process, and will be the subject to the same constraints. Using today's technology as a bench mark, dismantling of the turbines themselves will probably require a jack-up to ensure adequate control and to cope with the relatively high lifts and high crane hook loads, especially if any turbine components are to be preserved in relatively good condition.

Whilst the same level of care may not be necessary as is required during installation, any attempt to cut corners on procedures or equipment size during dismantling is likely to compromise safety, and for the purposes of this study it was assumed that decommissioning will be undertaken in an entirely controlled manner, with each component being unbolted and carefully lowered onto a barge for transport away from the site.

Figure 1. demonstrates in series the de-construction process of an offshore wind farm. Utgrunden – Sweden.

7. FOUNDATION DECOMMISSIONING

Foundations can be broken down into three main groups:

- Gravity foundation
- Monopile foundation
- Lattice tower with tension legs

The decommissioning aspects of these foundations were assessed on the criteria as to how practical would they be either re-floated or cut off at seabed or just below seabed level.

For the Gravity foundation refloating was the obvious solution with three separate models analysed. They were, 1) cellular concrete whereby voids would be designed to be filled with seawater, 2) cellular concrete whereby voids would be filled with hydraulic fill and 3) Steel pontoon whereby voids would be filled with hydraulic fill.

The decommissioning of this type of foundation was analysed and conclusions were drawn:

- Expensive heavy lift crane required even if filled with air.
- Unknown scour and build up could distort initial lift calculations due to considerable additional forces required to break suction under the bases.
- Possible solutions could be engineered into this however, would result in extra cost.
- Towing costs once refloated
- Disposal of concrete – Unlikely to have re-sale value, sinking of foundations in conflict with consenting.

A range of monopile solutions were analysed however two were identified as viable they were; 1) Steel monopile – driven into seabed 2) Steel monopile – grouted into precast concrete caissons sunk into seabed.

- Can cut off at or below seabed level
- Jet cutting technique or mechanical cutter can be utilised for either option
- Salvaged steel of approx 18m could be relatively easy to handle with potentially high scrap value
- Unlikely for pile to be pulled out entirely considering overwhelming forces.

The Lattice tower was briefly looked at, however due to the high fabrication costs and installation costs compared to the monopile and similar decommissioning properties to the monopile it was rejected at an early stage.

8. INFRASTRUCTURE DECOMMISSIONING

Infrastructure attributed to a typical offshore wind farm in the UK has been identified as being:

- Scour Protection
- Grid Connection
- Sub Sea Cabling
- Anemometry mast

Scour Protection removal is difficult to analyse at present due to the fact that depending on the nature and extent of scour protection utilised, and on its effectiveness, this may have to be recovered from the seabed and removed from site. Decommissioning will involve removal of the scour protection, either by lifting or by dredging. Such removal may be questionable however at the end of the project life as it will minimise seabed disturbance and release of particulate matter and other contaminates that could have an impact on the ecology of the area.

The Grid Connection Point will be relatively easy to decommission, as it is a simple case of demolition of the grid connect building followed by the reinstatement to the approval of the local planning authority.

Assuming that the sub sea cable is buried and that full removal of the cable is required then the decommissioning costs could well be of a similar magnitude to installation costs. However, if cable ends were to be cut off at similar times to the foundation removal it and the remaining length be allowed to stay in-situ costs would be minimal.

The Anemometry mast is envisaged to be decommissioned by simply involving the reversal of the installation procedure, with the mast being removed with a relatively small crane barge. The monopile will be cut-off below sea-bed level using similar technology to the large foundation monopiles.

9. METHOD

A full programme for the decommissioning of offshore wind farms has also been constructed covering the relative timings, covering all points from full consultation with stakeholders through to, health and safety requirements through to stage by stage dismantling of Anemometer masts. The evaluation of which has enabled us to calculate relative costs.

10. DECOMMISSIONING COSTS

The costs presented below were based on method statements developed from the preliminary foundation designs, and rates provided by two contractors

The following assumptions were made

- Decommissioning is an one-off-cost
- Marine installation technology is expected to become more cost effective.
- An assumed discount rate of 2% was used to calculate future costs from present costs discounted over the lifespan of the project (25 years).
- The electrical cable remains in situ.

	Monopile	Gravity
Total for 30 WTG	£3,544,000	£3,973,000
Total per turbine	£118,000	£132,000
Total per MW	£34,000	£38,000

11. CONCLUSIONS

Decommissioning should not be seen as simply a process of removing structures from the seabed. The study we undertook showed that it is a complicated process that takes into account many legal, geophysical, technical and financial considerations. Developers should be mindful of the associated costs of decommissioning from the outset.

12. REFERENCES

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Contributors

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Figure 1.

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1. Offshore Wind Farm – Utgrunden Sweden, 7 x Enron Wind 1.5o WTG's.
2. Rotor lowering
3. Nacelle removal
4. Soft Tower removal – upper section
5. Soft Tower removal – lower section
6. Transition piece
7. Driven mono-pile

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7