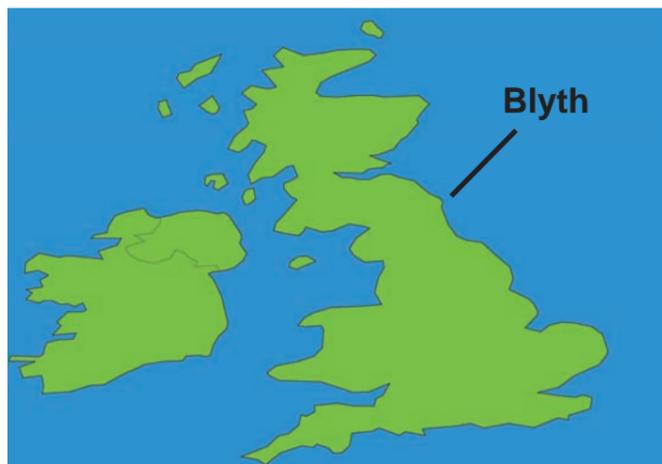




## The Blyth Wind Farm comprises 2 Vestas V 66 1.8 MW turbines.

Type of structure:	Wind turbines, 1.75 MW. Vestas type.
Location:	North Sea off Blyth, N of Newcastle.
Maximum water depth:	8-9 m
Pile diameter at seabed:	3.5 m
Soil conditions:	Underwater rock outcrop (sandstone, mud stone, coal)
Installed:	2000
Installation method:	Core drilling and grouting.
Number of foundations:	2
Maximum pile penetration:	12 m and 15 m
LICengineering tasks:	Detailed design. Specifications. Engineering follow-up. Special Supervision.



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## MONOPILE FOUNDATIONS



### Introduction

The Blyth wind farm is situated on the East coast of England in Northumberland. The windfarm comprises the first two British offshore wind turbines in the 2 MW class placed in an unsheltered offshore environment. The installation works were completed in the summer of year 2000. LICengineering A/S carried out design of the mono pile foundations including tower flange for the Vestas wind turbine, access and cable pull-in arrangements, as well as internal bulkheads in the piles.

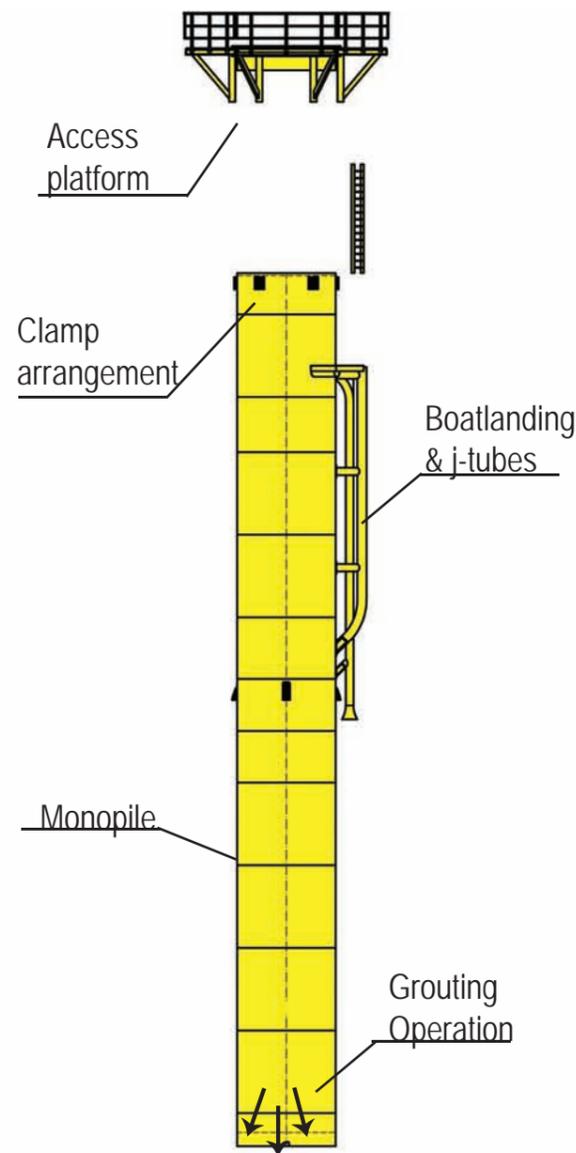
### Project Details

The wind farm is developed by Blyth Offshore Wind Ltd. consisting of Powergen Renewables, Shell Renewables, NV Nuon and Amec. Vestas supplied the turbines and towers. LICengineering A/S carried out design of the monopile foundations and associated structures as well as various follow-on engineering. The installation of the piles, tower and turbines was undertaken by Seacore using a four-legged jack-up rig. The wind farm is operated by Amec Border Wind.

### Foundation Layout

The foundation is a 3.5m diameter steel monopile installed through a short steel casing shoe into a predrilled rock socket and subsequently grouted in place. The monopile is prefitted on the outside with welded access and J-tube arrangements. The access platform is a separate bolted item. The pile has an internal bulkhead at the lower base and one internal platform near the upper pile end. The monopile is fitted with a weld-on internal flange for connecting to the tower structural flange.





## Installation

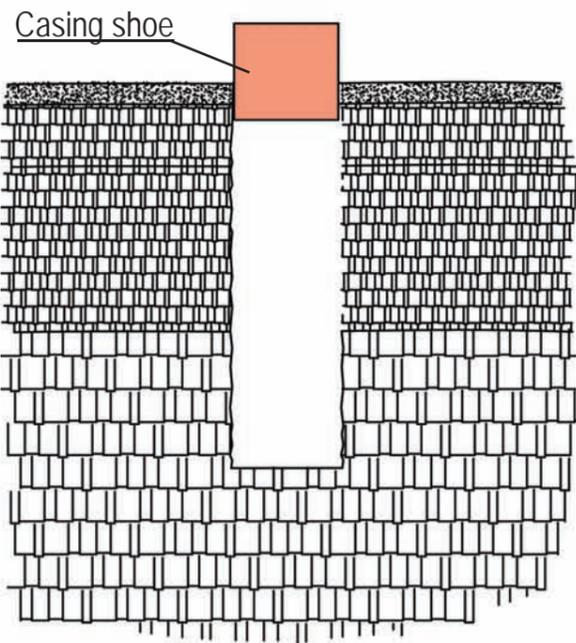
The offshore installation was undertaken in several steps. Two 20 m survey bore holes were drilled in 1998 and later selected as the final locations for the two foundations. The foundation installation took place in year 2000. A pilot hole was drilled through the upper layers at each location. This hole was used for initial centralisation during the following drilling of the full bore hole, using a large coring drill bit guided by full size conductor casing. After completion of the slightly oversize hole, the conductor and drilling equipment was retracted but a casing shoe was left in the top of the hole in order to avoid collapse of the hole in the top section and provide guidance for the pile. The 150 T pile was loaded out on a barge, lifted by the rig crane and lowered through the casing shoe into the rock socket. Grouting was then carried out from the rig using the grout system which was built into the pile. After completion of the grouting operation the access platform was landed onto the bolted clamp arrangement at the top end of the pile. This completed the foundation installation. Tower and turbine were installed, cable pull-in and hook-up was then finally carried out.

## Geotechnical Conditions

The two foundations are placed in rock sockets drilled in a 400 m long Southeast-Northwest oriented bedrock formation. This seabed high is lying about 1 km from the shoreline. The feature is primarily sandstone with rock-like properties. At one of the two foundation positions there is an intermediate coal/weathered mudstone layer.

## Design Analysis

The design analyses were carried out to determine the required wall thickness and penetration depth for the monopiles. Dynamic analysis including the vibrational behaviour of the pile and tower subjected to combined wave and wind loads were carried out. The piles were designed to resist ultimate storm loads and fatigue loads in a 20-years operational lifetime. The integrated boatlanding and J-tube arrangements were analysed for the extreme breaking waves on the location.



## Tower flange

The weld-on flange for connection to the wind turbine tower was part of the LICEngineering design. The flange was designed for ultimate and fatigue loads using dynamic analysis and structural FEM programmes.

## Access and J-Tube Arrangement

The access and J-tube arrangements are designed as welded appurtenances. The access arrangement is situated on the predominantly leeward side towards shore and allows access from a 180-degree approach corridor on the inshore pile side. A small intermediate platform is placed at the top of the boatlanding arrangement. Two J-tubes are included and integrated in the boatlanding vertical fender arrangement. The J-tubes have vertical subsea terminations approximately placed 2 m above seabed.

## Hydrographics

The wind turbines are placed approximately 1 km from the Blyth Harbour shoreline on a bedrock formation with a water depth of approximately 8 m. The seabed at the location has a pronounced slope towards the ocean. Therefore, breaking waves had to be considered in the design of pile and access/J-tube arrangements.

