Germanischer Lloyd

Germanischer Lloyd Industrial Services GmbH • Wind Energy • Steinhoeft 9 • 20459 Hamburg/Germany

Global Wind Support GmbH
Frau Dr. Susanne Schorcht
Domshof 21
28195 Bremen

Wind Energy

Steinhoeft 9
20459 Hamburg/Germany

Phone +49 40 36149-707
Fax +49 40 36149-1720
glwind@gl-group.com
www.gl-group.com/glwind

Your reference	*Your letter of*	*Our reference*	*Extension*	*Date*
	25.01.2007	13355/07/Laa	+49 40 36149-7729	2007-03-20

To whom it may concern

Plausibility Certificate

for the Offshore Wind Turbine Support Structure including the BARD VM – 5 MW (incl. tower)

for the Offshore Wind Farm GWS Offshore NL1

Germanischer Lloyd Industrial Services GmbH, Business Segment Wind Energy (GL) has performed a plausibility check for the wind turbine BARD VM – 5 MW and a tripile offshore support structure on behalf of Global Wind Support GmbH. The following normative references have been applied:

"Guideline for the Certification of Offshore Wind Turbines" Ed. 2005 of Germanischer Lloyd".

"Offshore Standard DNV-OS-J101, Design of Offshore Wind Turbine Structures, June 2004".

The plausibility assessment is based on the design documentation listed as follows:

- Plausibility Evaluation Report for the support structure
  report no. 73200, dated 19.03.2007 issued by GL.
- Statement of Compliance / C-design assessment for the BARD VM – 5 MW
  Statement No.: DAC-GL-001-2006, dated 2006-12-05 issued by GL
  (incl. tower)

The design methods described are appropriate and in accordance with the above mentioned standards. The general design concept was assessed to be feasible. Parallel calculations to verify the correctness of measures and structural integrity are to be executed in the final design assessment as part of a type- and project certification.

Further detailed information is given in the above mentioned reports of GL.

Yours faithfully,

Germanischer Lloyd Industrial Services GmbH

i.V. Peter Dalhoff　　　　i.A. Matthias Laatsch

Plausibility Evaluation Report

Tripile Support Structures designated for the Windfarms: BARD Offshore NL1 GWS Offshore NL1 EP Offshore NL1

Report No. 73200 **Date 19.03.2007**

Germanischer Lloyd Industrial Services GmbH

Manufacturer	Bard Engineering GmbH Domshof 21 28195 Bremen Germany
Documentation for Foundation by	The Manufacturer and CDB ME "Rubin" St. Petersburg Russia
GL Wind Order-No.	4800/07/02917/255
Location	SE Northsea ,The Netherlands for the Windfarms: BARD Offshore NL1 GWS Offshore NL1 EP Offshore NL1
Experts in Charge	Andreas Manjock Matthias Laatsch
Address	Germanischer Lloyd Industrial Services GmbH Business Segment Wind Energy Steinhoeft 9 20459 Hamburg Germany

Germanischer Lloyd

1 Documentation

1.1 Documentation examined

1.1.1 "Offshore Wind Turbine Support for Offshore Wind Farms in the Netherlands", BARD Engineering GmbH 2006

1.2 Documentation noted

1.2.1 "Offshore Substructures for Wind Turbine with tower, Design Basis, Detail Design", BARD Engineering GmbH, Revision 1, dated July 2006

1.2.2 "WEC Bard VM, Load Calculation, GL2005 TC1C, 90m hh, Bard61", aerodyn document No. C-98.2-GP.00.00.04-A Revision A, dated 22-12-2006

1.3 Drawings

1.3.1 Drawing No. NL-WTOS-1000-003, Sheet 1, "Offshore Support for Wind Turbine Column Pile, Primary Structure", by CDB ME "Rubin"

1.3.2 Drawing No. NL-WTOS-1000-001, Sheet 2, "Offshore Support for Wind Turbine General View", by CDB ME „Rubin"

1.3.3 Drawing No. NL-WTOS-1000-001, Sheet 3, "Offshore Support for Wind Turbine General View", by CDB ME "Rubin"

1.3.4 Drawing No. NL-WTOS-1000-002, Sheet 3, "Offshore Support for Wind Turbine Intermediate Support (Transition Piece) Primary Structure", by CDB ME "Rubin"

1.3.5 Drawing No. NL-WTOS-1000-002, Sheet 4, "Offshore Support for Wind Turbine Intermediate Support (Transition Piece) Primary Structure, by CDB ME "Rubin"

1.3.6 Drawing No. NL-WTOS-1000-002, Sheet 5, "Offshore Support for Wind Turbine Intermediate Support (Transition Piece) Primary Structure, by CDB ME "Rubin"

1.3.7 Drawing No. NL-WTOS-1000-002, Sheet 6, "Offshore Support for Wind Turbine Intermediate Support (Transition Piece) primary Structure", by CDB ME "Rubin"

1.3.8 Drawing No. NL-WTOS-1000-002, Sheet 1, "Offshore Support for Wind Turbine Intermediate Support (Transition Piece) Primary Structure", by CDB ME "Rubin"

1.3.9 Drawing No. NL-WTOS-1000-002, Sheet 2, "Offshore Support for Wind Turbine Intermediate Support (Transition Piece) Primary Structure", by CDB ME "Rubin

1.3.10 Drawing No. NL-WTOS-1000-002, Sheet 7, "Offshore Support for Wind Turbine Intermediate Support (Transition Piece) Primary Structure", by CDB ME "Rubin

1.3.11 Drawing No. NL-WTOS-1000-002, Sheet 8, "Offshore Support for Wind Turbine Intermediate Support (Transition Piece) Primary Structure", by CDB ME "Rubin

1.3.12 Drawing No. NL-WTOS-1000-002, Sheet 9, "Offshore Support for Wind Turbine Intermediate Support (Transition Piece) Primary Structure", by CDB ME "Rubin

1.3.13 Drawing No. NL-WTOS-1000-003, Sheet 2, "Offshore Support for Wind Turbine Column Pile Primary Structure", by CDB ME "Rubin"

1.3.14 Drawing No. NL-WTOS-1000-004, Sheet 1, "Offshore Support for Wind Turbine Grouted Connection", by CDB ME "Rubin"

1.3.15 Drawing No. NL-WTOS-1000-004, Sheet 2, "Offshore Support for Wind Turbine Grouted Connection", by CDB ME "Rubin"

1.3.16 Drawing No. NL-WTOS-1000-004, Sheet 3, "Offshore Support for Wind Turbine Grouted Connection, by CDB ME "Rubin"

1.3.17 Drawing No. NL-WTOS-1000-004, Sheet 4, "Offshore Support for Wind Turbine Grouted Connection, by CDB ME "Rubin"

1.3.18 Drawing No. NL-WTOS-1000-004, Sheet 5, "Offshore Support for Wind Turbine Grouted Connection, by CDB ME "Rubin"

1.3.19 Drawing No. NL-WTOS-1000-005, Sheet 1, "Offshore Support for Wind Turbine Secondary Structures Personnel Embarkation Platform", by CDB ME "Rubin"

1.3.20 Drawing No. NL-WTOS-1000-005, Sheet 2, "Offshore Support for Wind Turbine Secondary Structures Service Platform", by CDB ME "Rubin"

1.3.21 Drawing No. NL-WTOS-1000-005, Sheet 3, "Offshore Support for Wind Turbine Secondary Structures Laydown Platform", by CDB ME "Rubin"

1.3.22 Drawing No. NL-WTOS-1000-005, Sheet 4, "Offshore Support for Wind Turbine Secondary Structures Erection Platform and Foundation for Module E", by CDB ME "Rubin"

1.3.23 Drawing No. NL-WTOS-1000-005, Sheet 5, "Offshore Support for Wind Turbine Secondary Structures Internal Access Platforms", by CDB ME "Rubin"

1.3.24 Drawing No. NL-WTOS-1000-006, Sheet 5, "Offshore Support for Wind Turbine Cable Layout Foundations & Fixing Details", by CDB ME "Rubin"

2 Applied Standards

The examination of the support structure concept is based on the following standards:

- Det Norske Veritas (DNV), Offshore Standard DNV-OS-J101, Design of Offshore Wind Turbine Structures, June 2004
- Det Norske Veritas (DNV), Offshore Standard DNV-OS-C101, Design of Offshore Structures, 2000
- Det Norske Veritas (DNV), Classification Notes No. 30.5, Environmental Conditions and Environmental Loads, March 1991

- Germanischer Lloyd (GL) "Guideline for the Certification of Offshore Wind Turbines", Edition 2005

Extent of Examination

Germanischer Lloyd Industrial Services GmbH, Business Segment Wind Energy (GL) has performed a plausibility check on behalf of Bard-Engineering GmbH. The design documentation of the tripile support structure including the pile foundation was reviewed for plausibility. Site conditions, load assumptions, application of standards and design methods used were reviewed for plausibility.

The documentation presented under item 1.1.1 (see above) covers the following 3 Windfarms, located in the SE part of the Dutch North Sea inside the Exclusive Economical Zone (EEZ) adjacent to the border of the German EEZ:

BARD Offshore NL1

EP Offshore NL1

GWS Offshore NL1

4 Remarks on examination

4.1 Description of the support structure design

The support structure is of a tripile type, which is a welded steel structure. It is connected to the soil by means of three steel piles. The three columns are placed at the corners of a 20 m equilateral triangle. The piles are connected to the central transition piece by grouted connections. The central part has a clearance of 20 m from LAT. The height of the support structure to tower connection flange is 24 m from LAT. The three piles are flooded with water. The foundation is designed for a water depth between 28 and 35 m (LAT).

4.2 External Conditions and Load Assumptions

The load assumptions for the tripile support structure were generally carried out according to the conditions given as per item 1.2.2. According to the specifications generic loads for a wind turbine acting at the transition piece top flange intersection located at 24 m above LAT were used. For the extreme loading of the tripile support structure an extreme external event with a reoccurrence period of 50 years was considered, the fatigue loading was calculated for a lifetime of at least 20 years.

The site conditions taken into account for the load calculation are based on the assumptions made in the document as per item 1.1.1. The site conditions for turbine locations are summarised in the following table:

Water depths related to lowest astronomical tide (LAT)	28 to 35 m
Mean sea level (MSL)	+1.90 m LAT
Highest Astronomical Tide (HAT)	+5.30 m LAT
50-year extreme wave height	15.2 m
50-year tidal current speed	1.20 m/s
Annual mean wind speed (10-min-mean) at hub hight	10.2 m/s
Weibull exponent of wind speed distribution	2.24 -
10-year-extreme wind speed (3 s gust) at 10 m height	41.6 m/s
50-year-extreme wind speed (3 s gust) at 10 m height	45.5 m/s

Table 1: External condition applied for load calculation

Further environmental conditions applied for the calculations in document 1.1.1 have been taken from the Design Basis documentation of the site "Bard 1", located in the western German Bight, see document as per item 1.2.1. This site is close to the area of the three wind farms evaluated within this report, see chapter 3, so that an adaptation of environmental conditions is reasonable. For the final design evaluation the environmental conditions of the three wind farms have to be analysed in detail and for each site separately.

The pile length for the three wind farms varying between 80.3 and 85.3 m to assure a clearance of 20 m from LAT to the central part of the transition piece. The piles` outer diameter is constantly 3.0 m for all pile versions. A distribution of the pile wall thickness is given in drawing 1.3.1. The three square pylons of the transition piece have an inclination of 30° and change-over to the vertical, cylindrical piles at about 15.4 m from LAT, see drawing 1.3.5. If extreme design waves exceed this elevation the height of the transition pieces should be lifted with respect to the results of an extreme wave analysis to achieve sufficient clearance against extreme wave heights. Otherwise, additional hydrodynamic forces by the affected pylon areas have to be considered within the load calculation.

The load assumptions for the tripile support structure yield to a range of the structure`s Eigenfrequency from 0.341 Hz to 0,358 Hz for the complete structure, respecting the wind turbine, tower, sub structure, foundation and soil stiffness.

4.3 Geotechnical Design

The geotechnical data assumed in the calculations are defined in section 8.4.4 of the documentation. All assumptions were examined by a plausibility check. The results given through the documentation are based on these general and preliminary soil parameters.

Detailed calculations to verify the correctness of measures and structural integrity have to be executed in the final design evaluation under consideration of the appropriate soil parameters at the individual wind turbine locations. The natural frequency of the support structure including tower, sub-structure and foundation are to be calculated assuming a minimum and a maximum spring constant for soil and foundation.

The derivation of the scour depth is given with S = 1,3 x D (D = pile diameter). This assumption has to be verified by periodical monitoring during the operational phase and directly after bad weather occurred.

4.4 Structural Design

The design methods described are appropriate and basically in accordance with the standards mentioned under item 2.

The calculating methods for the entire structural design considers a static and fatigue analysis. The calculation is performed on an ANSYS-3D- Finite Element model. For the final design it is required to hand in calculations done with a FE-model, where discontinuity region may be meshed with solid elements. The element order number (solidXX) shall exceed 100. Nodal- and Element-Solutions shall lead to comparable results. For interpretation of stresses at hot spot locations reference is made to GL`s Wind Guideline for the Certification of Offshore Wind Turbines or IIW recommendations.

The fatigue occurring from pile driving has to be reflected regarding the pile design within the further planning stages.

The intended method of installation must be an integral part of the future detailed design study, as the installation procedure will affect the design of the tripiles`s Transition piece (TP). Elastic deflection of the TP during the installation procedure has to be respected for the development of the installation procedure in order to guarantee the perfect fit of the TP onto the piles. The given maximum inclination of the piles presented on page 17 of the documentation (max 0,2°) should be verified in a detailed geometrical investigation.

In order to assure a load transmission from the TP into the piles by means of the grouting, the intermediate supports between TP and pile has to be removed after grouting to achieve an appropriate clearance.

4.5 *Corrosion Protection*

Regarding corrosion protection a coating system has been presented for the structures above sea level (incl. splash zone). The submerged structures will be protected by cathodic protection using impressed current.

The coating system should be designed according to DIN EN ISO 12944 by choosing category C5-M. All coating must be compatible with the cathodic protection.

5 Summary

The design methods described are appropriate and in accordance with the standards mentioned under 2. The general design concept was assessed to be feasible. Parallel calculations to verify the correctness of measures and structural integrity are to be executed in the final design evaluation. A description of the installation of the three piles offshore and the connection with the central transition piece by means of inserts to the three piles was not provided. The installation process with required tolerances shall be evaluated in a later stage.

Manj/Laa

Germanischer Lloyd Industrial Services GmbH
Business Segment Wind Energy

Andreas Manjock
Expert in Charge

Matthias Laatsch
Expert in Charge