Helping Hands in Rough Waters

The offshore installation of wind turbines requires the development of dedicated foundation systems. Erection and maintenance of the maritime wind farms, furthermore, is only to be accomplished with special installation vessels and experienced offshore logistics enterprises. In the meantime, an international competence network has evolved.

Bladt Industries produced the platform for the 132 kV transformer station of the Nysted offshore wind farm.
Photo: Bladt Industries

Extensive experience has been gained in the erection of offshore wind turbines (offshore WT) and measuring platforms in Europe in recent years. Project-specific consortiums and networks have been formed, and are currently preparing themselves for the extreme demands of future offshore wind energy projects. The erection of WT giants of the 5 MW class is an exceptional logistic challenge: wind turbine nacelles weighting up to 400 tonnes have to be raised to up to 100 metres above water level for mounting.

In the coming years, one can also expect to see installations with tripod foundations, as several projects are planned in water depths well in excess of 20 metres. Conventional structures such as gravity foundations or monopiles will then probably no longer be suitable, both for technical and economic reasons.

Following successful commissioning of the Scroby Sands wind farm off the English North Sea coast in the coming weeks, a total of 16 offshore wind farms with a nominal output of some 600 MW will be on line. The offshore wind energy branch will then be able to count 325 offshore wind turbines successfully erected (see table).

[1] *www.fascination-offshore.com*
[2] *www.aarsleff.com*

Offshore foundations

To date, only gravity foundations and monopiles have been used for the anchoring of offshore turbines. A total of 211 maritime WT stand on monopiles, which accounts for some two-thirds of the turbines in place. Gravity foundations have only been used for four Danish projects with together 113 wind turbines. A single experimental installation in Frederikshavn, Denmark, moreover, has been designed with a so-called »bucket foundation« – a large »upturned bucket«, which is »scoured« into the silt with the aid of a vacuum[1].

From a technical and economic viewpoint, it is the water depth which determines the foundation type suitable for a particular location. In spring 2002, for example, the Danish company **Per Aarsleff A/S**[2] received a commission to develop and manufacture 73 gravity foundations for the Nysted offshore wind farm[3]. The water depth at the planned site varies between 7.5 and 12.5 metres and is thus just still suitable for this type of foundation.

The foundations were to support 72 Bonus 2.3 MW wind turbines and the offshore substation. The concrete foundations came from Swinoujsce (Poland). The structures were produced directly on big pontoon barges and then towed across the Baltic Sea to the wind farm site. Floating cranes brought the 1,300-tonne foundations into their correct positions, where they were finally secured with a ballast weight of 500 tonnes.

Bladt Industries A/S[4] was also involved in the Nysted offshore project. The Danish steel construction specialists produced the platform for the 132 kV transformer station of the offshore wind farm. Bladt had already supplied ten steel monopiles for the wind farm at Samsø[5], Denmark, in 2002, in this case in partnership with a consortium comprising Dredging International NV, Hydro Soil Services NV and ABB New Ventures GmbH. The order specified the delivery of the up to 48-metre long monopiles together with transition pieces with ice cones – the transition piece standing proud of the water is widened in the form of a mushroom, which serves to break up advancing ice. The piles were produced in Aalborg in the third quarter of 2002 and transported to the site between September and October of the same year.

In the future, it is most probable that tripod foundations will also be used. Current planning for North Sea installations, namely, will require structures for water depths up to 40 metres. When it comes to designing and manufacturing of the steel giants, the company **Weserwind**[6] from Bremer-

[3] *www.nystedhavmoellepark.dk*
[4] *www.bladt.dk*
[5] *www.samsohavvind.dk*
[6] *www.weserwind.de*

haven has been able to secure a good position on the market. Weserwind was founded in July 2002 by the Georgsmarienhütte Holding and the Stahl-Service-Center Group. The company is able to bundle the competence of its two manufacturing partners for the wind energy branch. Experience has already been gained in many fields: The list of reference products ranges from wind turbine towers and cast machine supports, rotor hubs and drive shafts, to flanges, gear elements and foundation buckets.

Special installation vessels

The Danish company **A2SEA**[7] takes a special approach in solving its logistics tasks. At the beginning of 2002, two freighters were overhauled at the Ørskov shipyard in Frederikshavn and made ready for the installation of offshore wind turbines. The »Ocean Ady« and the »Ocean Hanne« were fitted with cranes and four jack-ups each. The ships can transport wind turbine components and also possess the necessary equipment for system erection.

Both vessels offer a top speed of around 8.5 knots and can handle significant wave heights up to 1.5 m and wind speeds up to 12 m/s. The main cranes (450 t, hook height 60 m) are mounted on lateral braces. These cranes are used to assemble and erect the turbines. In addition, the ships each possess two auxiliary cranes (40 t, hook height 12 m), which are needed when setting up the tower segments and for pre-assembly of the rotor blades on board.

As one of the first companies to provide special solutions for the commercial installation of offshore wind farms, A2SEA is able to present an impressive list of references after just three years of active operations. With more than 180 offshore WTG systems, the logistics pioneers have cornered a market share of over 50 %. A2SEA also erected the measuring mast for the Arklow Bank farm. The commission covered full installation of the mast, including monopile, transition piece, pylon and measuring instruments, on behalf of GE Energy.

The first experimental wind farms were already installed in the early 1990s. One of the pioneers in the offshore wind turbine branch was the Hamburg company **Bugsier**,- Reederei- und Bergungs-Gesellschaft mbH & Co. KG[8]. The self-propelled ocean salvaging crane »Roland« was already used in 1995 at the installation of the Danish experimental offshore wind farm Tunø Knob. In summer 2003, the Bugsier crane vessel »Enak« transported the jacket construction and the platform deck for the German FINO project to its location in the North Sea.

F+Z Baugesellschaft[9] from Hamburg, a subsidiary of Bilfinger Berger, has gathered comprehensive experience in the offshore wind energy sector: In 2002, F+Z installed the measuring mast at the

In summer 2003, the Bugsier crane vessel »Enak« transported the jacket construction for the German FINO project to its location in the North Sea.
Photo: F+Z Baugesellschaft

The jack-up barge »Annegret« on her way to the North Hoyle offshore location
Photo: F+Z Baugesellschaft

Sky 2000 location[10] in the Baltic Sea on behalf of Gesellschaft für Energie und Ökologie mbH (GEO). One year later, a further commission was received from Germanischer Lloyd to erect the FINO 1 research platform in the North Sea[11]. For the latter project, the Hamburg offices were responsible for the planning, building and installation of the measuring platform. Only shortly afterwards, F+Z joined forces with Muhibbah Marine Engineering (Germany) GmbH and the British offshore company Seacore (see below) to install foundations for the North Hoyle project[12] off the North Wales coast.

During this work, the jack-up barge »Annegret«, which was built by F+Z in 2001, was able to play an important role. The »Annegret« is equipped with four hydraulic jack-ups, enabling the platform to be raised up to 52 metres above the sea bed. The barge measures 40 by 20 metres.

The final »test of proficiency« for F+Z, however, still lies ahead: In 2006, installation work is scheduled to begin at the Butendiek wind farm[13], approx. 34 km west of the German island of Sylt. Eighty Vestas V90 turbines are earmarked for the project, and the wind farm is planned for an overall nominal output of 240 MW. Here, too – as was the case for FINO 1 – F+Z will be acting as general contractor. A new platform is being developed and built to enable installation of the Butendiek turbines and is expected to be double the size of the »Annegret«.

The jack-up barge »Jumping Jack« was designed by **Mammoet van Oord**[14] specifically for logistics tasks in connection with offshore wind turbines, and was taken into service in June 2002. The barge is 91 m long, 33 m wide and 7 m high. Four jack-ups, each 40 m long, stabilise the barge during the installation work. The loading area accommodates WT components or equipment weighing up to 4,000 tonnes. The deck crane is able to lift 1,200 tonnes to a height of up to 150 metres. The »Jumping Jack« was used for the first time between August and September 2003 for the Arklow Bank offshore wind farm in Ireland, where seven GE 3.6s wind turbines

[7] *www.a2sea.dk*
[8] *www.schuchmann.com*
[9] *www.fz-bau.de*
[10] *www.sky2000.info*
[11] *www.fino-offshore.com*
[12] *www.northhoyle.co.uk*
[13] *www.butendiek.de*
[14] *www.mammoetvanoord.com*

The »Annegret« barge and the Seacore jack-up installed nearly the whole North Hoyle offshore wind farm.

Photo: F+Z Baugesellschaft

were to be installed. Mammoet van Oord was also charged with the installation of 30 monopiles and with the laying of submarine cables for the Scroby Sands offshore wind farm. This British project near Great Yarmouth was tackled directly after completion of the work at the Arklow Bank site. All 30 monopiles were set in place between October 2003 and January 2004. Subsequently, the jack-ups were extended by a further seven metres, enabling the »Jumping Jack« to be used in deeper waters and at locations with unfavorable sea-bed conditions.

Similarly in attendance in North Hoyle was the jack-up barge »MEB-JB1« from **Muhibbah Marine**[15]. The company was founded in 1994, specifically to market the services of the MEB-JB1, and has its offices in Buchholz near Hamburg. Parent company is the Malaysian Muhibbah Engineering Group, which embraces not only hydraulic engineering companies and shipyards, but also the well-known crane companies Favelle Favco and Kroll. The barge measures some 50 by 30 metres and possesses a 300-tonne deck crane. Eight jack-ups can be actuated pneumatically and can raise the platform to some 45 metres above the sea bed. The installation of 20 Bonus turbines at the Danish Middelgrunden wind farm[16] in 2000 marked the company's successful entry into the offshore wind energy market. Shortly afterwards, Muhibbah also erected the five turbines of the Swedish Yttre Stengrunden wind farm, and was involved in the geotechnical investigations for a whole range of further projects.

Year	Country	Location	WT	MW	Foundation
1991	DK	Vindeby	11	4.95	Gravity
1994	NL	Lely	4	2.00	Monopile
1995	DK	Tunø Knob	10	5.00	Gravity
1996	NL	Dronten	28	16.80	Monopile
1998	S	Bockstigen	5	2.75	Monopile
2000	UK	Blyth	2	4.00	Monopile
2000	S	Utgrunden	7	10.08	Monopile
2001	DK	Middelgrunden	20	40.00	Gravity
2001	S	Yttre Stengrund	5	10.00	Monopile
2002	DK	Horns Rev	80	160.00	Monopile
2003	DK	Frederikshavn	4	10.60	*
2003	DK	Nysted	72	165.60	Gravity
2003	DK	Samsø	10	23.00	Monopile
2003	IRL	Arklow Bank	7	25.20	Monopile
2003	UK	North Hoyle	30	60.00	Monopile
2004	UK	Scroby Sands	30	60.00	Monopile

Offshore wind farms in operation

*** Frederikshavn: 1 x Bucket, 3 x Monopiles**

The »Annegret« and the »MEB-JB1« were deployed in North Hoyle on behalf of the British Mayflower group, as the group's own barge – the »Resolution« – was not ready for service on time. On this basis, the Hamburg contractors and Seacore installed practically the whole wind farm, with the exception of just three turbines. The »Resolution« – 130 metres long and 38 metres wide – is in the meantime available for offshore installation work. With a draught of approx. 3 metres, it can be used in waters up to 35 metres deep and is stabilised by six jack-ups. Assembly of the wind turbine components is handled by a 300-tonne deck crane (hook height approx. 80 m). In the meantime, the Mayflower group has ceased trading. The subsidiary Mayflower Energy was subject of a management buy-out and now operates under the name **Marine Projects International**[17]. Currently, the MPI-ship installs 30 Vestas V90 turbines at the British offshore site »Kentish Flats«[18].

Drilling and ramming

The Belgian DEME group is similarly able to point to expertise in »wet« wind energy utilisation: Its subsidiary **Hydro Soil Services (HSS)**[19], for example, erected the Utgrunden wind farm in Sweden in 2000. The scope of services covered installation of the monopiles, as well as transportation and erection of the seven wind turbines with nominal outputs of 1.425 MW each[20]. In 2002/2003, ten Bonus 2.3 MW turbines were installed at Samsø.

One contributor to the ramming work for both projects was the company **Menck**[21] from Kaltenkirchen near Hamburg. The company's hydraulic hammers were later in use once more for the British North Hoyle project. At this site, the monopiles were first of all rammed into a 20-metre thick sediment layer. A subsequent rock layer, however, required drilling of the next six to eight metres, before the final monopile depth was achieved with a second round of ramming. Menck thus possesses what is still unique experience in respect of this combined »ram-drill-ram technology«. The Menck technology is currently being promoted actively as an option for further offshore projects throughout Europe. Since the British UWG Group[22] acquired the German ramming specialists in September 2003, follow-up projects in British waters are more than likely.

The English offshore specialist **Seacore**[23] concentrates its attention on offshore drilling. Founded in 1976, the company counts some 150 employees and is active worldwide. Already in 1998, Seacore completed five rock borings for the Swedish Bockstigen project. And in 2000, together with AMEC Civil Engineering, the foundations were set for the 4 MW offshore wind farm near Blyth in Northeast England. Seacore had conducted comprehensive geological investigations at the site two years earlier. Similarly in 2000, drilling was performed for the measuring mast of the Arklow Bank project south of Dublin. One year later, Seacore drilled five more holes for the foundations of the Yttre Stengrunden offshore wind farm in Sweden. A measuring mast at Gunfleet Sands followed in January 2002, and in 2003, Seacore assisted the installation of 30 monopiles for the North Hoyle offshore wind farm with the jack-up platform »Excalibur«.

Klaus-Peter Lehmann

[15] *www.muhibbah.de*
[16] *www.middelgrunden.dk*
[17] *www.marineprojectsint.com*
[18] *www.kentishflats.co.uk*
[19] *www.hss.be*
[20] *www.deme.be/projects/sweden_utgrunden.html*
[21] *www.menck.com*
[22] *www.uwggroup.com*
[23] *www.seacore.co.uk*