AN ARTIFICIAL ISLAND FOR THE WIND POWER INDUSTRY 80 KM OFFSHORE IN THE NORTH-SEA

Hans-Dieter Clasmeier
Niedersachsen-Ports GmbH & Co. KG, Port Planning, Emden

Abstract:

Worldwide several man made islands have been building in the last decades or are under construction today. Nearly all of them have been created in calm waters. Hitherto never was erected an artificial island in the roughness of the North-Sea. Perhaps the offshore wind power park operators will ascertain that an island in their neighbourhood can be very helpful for the maintenance of the generators. How to plan and to construct this “WIND POWER ISLAND”?

I. INTRODUCTION

The German government and especially the two coastal riparian counties of Niedersachsen and Schleswig-Holstein have made the development of large wind-power-parks in the German Sea more than 60 or 80 km offshore as a target in their energy policy. A several thousands of wind power towers with a capacity of 5 MW and more for each one shall be installed in the next 15 years (Fig.2). In 2009 the first 5 MW generators will go into operation. A total yield of energy of 2,000 MW each year shall be added [1].

Today it doesn’t exists any plan, how to supply in future more than 3- or 4,000 generators founded in a depth up to 40 m below the sea-level (Fig.1).

II. MAN-MADE-ISLANDS AT THE NORTH-SEA COAST IN GERMANY

Rising sea water levels one thousand years ago brought the idea to the people, living at the shore line is more safety if they build wharfs by filling up semi protected areas with sand and clay and settle on these “Islands” (Fig.3).
Higher storm surges were not able to overflow the settlements. But several very high tides were able to damage the wharfs; dykes need to be build and a new culture of dyke construction starts. Today this process has not finished.

More and more people brought a settlement pressure to the shore line, industry followed and so it needed to go back into the sea and to built new islands. In the first time these islands were only up-fillings of sand, most times behind a wooden wall.

Increasing of the high water level and increasing engineering techniques let built the people, after the discovery of the concrete and the techniques for rolling steel plates and steel sheet piling walls, new harbours in front of the shoreline. New dyking techniques due to increasing hopper dredgers capacity allowed filling up the sea bottom by 10, 15 or 20 m and more. Dewatering systems today are able to diminuend the pore water pressure in the subsoil very quick.

But also ship building techniques were used to built huge flowing elements as islands on piles (jack up platforms), as flowing storages or as anchored systems with demy-divers, using it for the exploration of oil and gas. Fig. 4 gives an example of the 6 different general-systems of artificial islands.

III. TECHNIQUES TO BUILD ARTIFICIAL ISLANDS

The construction of artificial islands is not a new technology. Old Japanese, Chinese and Phoenician projects are known, but these islands were built near-shore, only some 100 m before the shoreline [2].

Creating the Airports of Kansai in the Osaka-Bay, Chep-Lap-Kok nearby Hong Kong or Palm- and World Island before the Dubai coastline [3] were a great challenge to the dredging companies, but how to built an island in the North Sea by a water depth of 30 m and more, by a wave height of 20 m and more and by a medium temperature of 10° and less in summer and a cold and stormy wintertime. Site working is possible only at the summer decade of less than 5 months, but later working on the isle is necessary the total time over the year.

For building an artificial island in the North Sea in a first step a surrounding wall is to create. It needs a lot of investigation to the underground observation.

Most time the subsoil must be compacted by high specialized pontoons, equipped with five to ten vibrators.

If the underground is stable to take off high loads, large floating concrete caissons are to build by using a ship lift or in a dry dock or by using of another technology circular steel sheet pile cells are to be set up on a pontoon and to float them to the site.

Another way is to drive steel sheet piles into the sea bottom and anchor them with ultra long piles.
The next step is to fill in some million m³ of sand. Modern hopper dredgers are able to bring each time more than 30,000 m³ of sand (Fig.7).

This filling also is to be compacted and most times the subsoil needs a drainage system to enlarge the pore water pressure which will increase by the high load of up fill in the clay layers of the subsoil (Fig. 8).

In the last step the surrounding of the man made island is to protect it against waves and erosion. Big concrete elements like tetra pods, dolosses or others must be positioned at the sea-bottom and on the slopes. The banks need a very heavy asphalt layer to withstand the load of the waves and to guarantee a long life of the island.

IV. GEO-MORPHOLOGICAL SITUATION IN THE GERMAN BIGHT

An artificial island needs a sea-bottom, which is able to withstand the high load of dedicated coastal constructions. The North-Sea level had rise up in the last 20,000 years of more than 40 m.

The rivers of the Rhine, the Weser and the Elbe found together in the centre of the North-Sea nearby today’s Doggerbank (Fig.9).

It needs a lot of investigation works to find out the best area to build an island in the German Bight to take up supply elements for the wind power industry. This first study only looks to today’s surface of the bottom found in the nautical maps. There are three mainly demands:

- to look for any place, were the water is not too deep and the waves and the currents are not too high
- to calculate an optimal distance to all some thousands of wind power towers that shall be installed in the so called Duck’s beak (Fig.10)
- to not obstruct the sea traffic too much
But there are also a lot of questions to be answered, before the construction works of an artificial island can starts:

- What’s about the density of the sea bottom?
- An artificial island needs several million of cubic meters graded graining sand. Where can be extracted this sand?
- What technical solutions exist to improve the subsoil?
- Are new technical solutions available for breakwaters, quay walls and subsoil improvement?
- At what place at the German, Dutch or Danish coastline can works of preparation for the first intensive step of starting the project be done? See figures 11, 12.

**V. DEMANDS TO “WIND POWER ISLAND”**

The total area of the island should be more than 100 ha wide, this means a length of 1.5 to 2.0 km and a width between 500 m to 1,000 m. So the extension including the breakwaters, slopes and buoyages to secure the fairway will be more than 5,000 m long.

The first demands to such a man made island should be:

- the water depth at the site is between 20 and 25 m,
- the working level must be more than 8.00 m higher than the sea level
- it must be necessary to fill up the sea bottom with 35 to 70 million m³ of sand.
- a protection against waves must be made out of floatable caissons and heavy wave breakwater stones, cellular cofferdam elements and steel sheet piles
- the possibility of the installation of hangars and harbour facilities
- the installation of workshops, offices and barracks for the crews a construction time less than four or max. five years.
- total costs less than 4 billion €.

A general layout of the island, which is heavy protected from south-west to north-west directions and is open for vessels navigation in south-east is given in figure 13, next side.
tetrapodes or dolosses are to position in front of the caissons to stable them.

Figure 13. Max. wave height in 50 years mean value
(The North Sea Environmental Guide, Ledbury)

Figure 14. General layout of "Wind Power Island"
The life cycle of an artificial island, in this case for the support of wind power parks is calculated for a time of eighty to hundred years. What will happen with the sea water level? The water level perhaps will rise in this time more than 1 m. The tidal range at the recommended location is nearly 2 m and due to storm surges it will be 60 km offshore not more than 2 m higher than the mean high water level. To have an absolutely safety against overflowing means, to bring the level of the new island more than 8.00 m higher than the mean sea water level. It needs no higher working level, because there cannot be any water level rising due to storm surges.

The different steps to do for the creation of “Wind Power Island” – WPI are:

1. In the first two years are to build in a coastal supported dock site nearly 30 or 40 concrete floating caissons with a length of 50 m and a width of 30 m. The draft of these caissons must be less than 10 m to bring them from the dock site to the offshore site. The total height will be nearly 35 m or 40 m because overtopping of waves should not be possible due to the breakwater in front of the caisson (fig. 15).

2. Parallel to caisson works are the subsoil improvement works to do at the offshore site. The caissons are to float to site in the month between Aprils an August. In September the work must be protected against the following winter-storms.

3. In the third year the first circular cofferdam cells must be put up on large barges to bring them to the site in springtime and to set them down to the sea bottom, for filling and stabilizing (fig. 16).

4. Also in springtime the construction work for the quay walls (fig. 17) needs to start to guarantee filling up the islands with the first millions of m³ sand. Therefore very heavy and busy equipment is needed. Dredgers with a capacity of more than 35,000 m³ will be on the side.

5. Having already in the fourth year a reclaimed area 60 km offshore it is possible to put up the second part of the cellular cofferdams at the site. Vessels can arrive at this island and are able to bring all things for the construction works like cement, sand and gravel for concrete, steel sheet piles for the quays and steel girders and others for the hangars.

6. The late fourth year will bring the first inhabitants and labours to WPI and they can start their maintenance work on the wind power station in the neighbourhood.

7. In the last year of construction works will be finished the harbour, the hangars and offices and WPI will be a new settlement in the stormy North-Sea.

VII. OUTLOOK

This paper is a vision of the author. Nobody knows if that, what is describing here will be reality. But the paper shows that it is possible to build an artificial island 60 km offshore for such of interests however, for the wind power industry or the exploration of any kind of raw material. Coastal and offshore engineering experts are standing by to realize WPI or any other island in the North-Sea or everywhere.
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