7 YEARS METEOMAST AMRUMBANK WEST

Joerg Bendfeld(1), Jens Krieger(2)
(1) University of Paderborn, Kompetenzzentrum für nachhaltige Energietechnik KET,
Pohlweg 55, 33098 Paderborn, Germany,
(2) airwerk GmbH, Lohne, Germany

1. Summary
Renewable Energy can satisfy a big part of the energy demand without any restrictions for the following generations. In these concepts the wind energy is an important source. Projects of using wind energy at offshore sites in the German Bight are now starting to build those windfarms. For the estimation of the average annual wind speed distribution and thus the energy production of offshore windfarms it is very important to know the exact wind conditions at each project site. Suitable prognosis methods are missing so far. The methods used at onshore wind locations cannot be transferred to offshore sites. The prognosis errors would be too large. The only possibility to achieve exact information about the wind conditions is a metmast. In spring 2005 the German offshore-research platform Amrumbank West started the operation in the German Bight, 45 km north of the island of Helgoland. One of the main targets is the acquisition of new knowledge about the marine atmospheric boundary layer as well as a better understanding of the meteorological and hydrographical conditions in the offshore area. Meteorological measurements are focused on capturing the wind conditions and the vertical temperature characteristics.

Fig. 1: Metmast Amrumbank West

2. Introduction

Offshore construction costs are extremely high due to the limited accessibility of the locations. Large distances to the coast or to the next port and the extremely expensive logistics are important factors. Almost all potential wind plant operators rely on bank credits.
In order to assess, judge and avoid those risks the Meteorological Measuring Mast “Amrumbank West” was erected. In April 2005 the metmast “Amrumbank West” was constructed (Fig. 1). The measuring platform is situated at a distance of 36 km from Amrum and 35 km north of Helgoland, within the AWZ. The water depth is about 24 m (26.25 yd). The metmast captures meteorological data on seven measuring levels and oceanographic data at seabed. The maximum measuring height is 90 m (98.42 yd) above sea level.

3. The Mast

The Mast can be divided into three major sections:

- The Monopile (Fig. 2) of approximately 60 m (65.62 yd) of length and about 290 metric tons of weight measures a maximum diameter of approximately 3.50 m (3.83 yd).
- The transition piece with the measuring container has a weight of about 50 metric tons and a height of 8 m.
- The lattice mast of about 68 m (74.36 yd) of length and 40 metric tons of weight narrows from 4.50 m * 4.50 m (4.92 yd) to 1 m * 1 m (1.09 yd).

3.1 Data handling

The data storage is carried out by two data loggers. The main data logger collects the data of the anemometers, the wind vanes and all other measuring equipment. This data logger is able to send the data via digital shortwave and a satellite connection will serve as a redundant way of transmission. The second data logger collects only the most significant data from the anemometers, wind vanes, thermometer and hygrometer. As for the data registration, a real data doubling (for the most important data) is performed – that is, two data loggers store the data parallel. The data loggers offer sufficient store capacity also in the event of inaccessibility for a longer period of time. The energy supply is ensured by solar panels and four wind generators. For exceptional cases there is an emergency generator on the platform. The conception of the measuring devices and the data handling worked very satisfactorily.

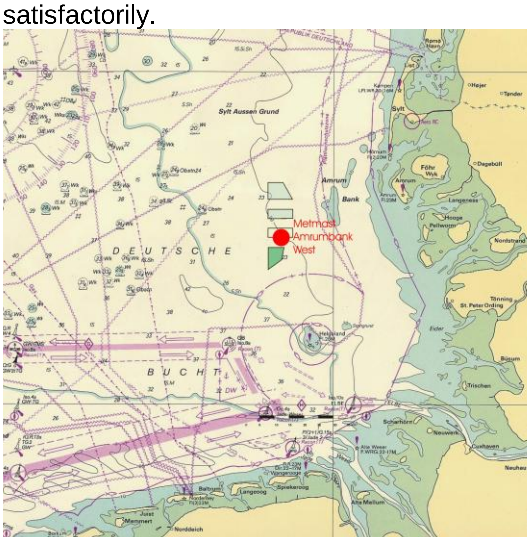


Fig. 2: Location of Amrumbank West

Fig. 3: The monopile

4. Lessons learned

4.1 Lighthing protection

Due to their exposed location offshore metmasts are subject to a high strike probability. There are no reliable statistics concerning the risk of locations on the high seas. Attention has to be paid to the wind metering equipment as well as to the data logger connections and the measuring container located on the tower base since these components control the operation. Furthermore, the proctection of the aviation lights are a prerequisite for the secure operation of the metmast.

4.2 Measuring devices

Due to the limited access to the Amrumbank West Plattform one of the highest priorities was the reliability of all measuring devices. Especially the anemometers should be robust and precise. A series of identical conventional and reliable cup anemometers has been arranged on the north-west side facing away from the platform. The anemometers measure the wind-speed at seven different height levels. The lowest level is at 35 m, the highest level is at 90 m. The measurement of the wind direction is carried out by conventional wind vanes. Furthermore, the wind is measured three-dimensionally by an ultrasonic anemometer. Data concerning atmospheric humidity, air temperature and air pressure complete this figure. The availability of the different measuring instruments at the different heights is very high. For the cup anemometers it is close to 100% at all heights. The sonic anemometers show a lower availability.

4.3 The Tower influence

The lattice Tower of the “Amrumbank West” platform has a strong influence on the wind sensors which are installed on rather long booms. The boom length is at least 2.5 times the diameter of the lattice mast. The influence is stronger than onshore.

4.4 Oceanographic measurements

The focus of these measurements was the acquisition of current and wave data. These data include parameters that are required as basic input for calculations of the load conditions and forces on offshore foundations. Visual estimates of sea and swell height, period and direction are sometimes included in meteorological reports. But those estimates are influenced by the skills of the observer and by subjective impressions.

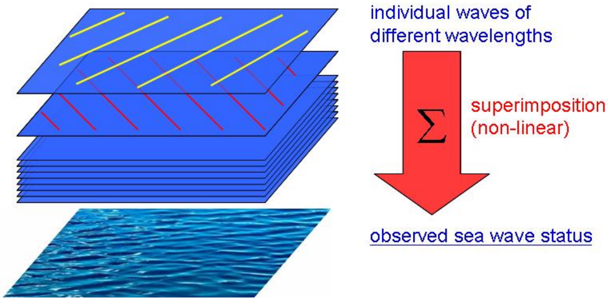


Fig. 3: Simulation of the observable sea waves by non-linear superimposition

Fig. 4: Difficult real wave situation

It is important to know the desired parameter and their importance:

- Swell Direction is the direction that the swells are coming from.
- Swell Height is the estimated average height of the highest one-third of the swells.
- Swell Period is the peak period in seconds of the swells
- Wind-Wave Direction is the direction that the wind-waves are coming from.
- Wind-Wave Height is the average height of the highest one-third of the wind-waves.
- Wind-Wave Period is the peak period in seconds of the wind-waves.
- Significant Wave Height (SWH) and Period is the significant wave height and dominant wave period that has been traditionally available.
- Steepness: For a given wave height, steep waves represent a more serious threat to capsizing vessels or damaging marine structures than broad swell.

Because of the resulting physical effects which may influence the wave measurement, it is important to know how the applied device works.

Buoys:
Direct measurements with movable devices such as a buoy are affected by unwanted acceleration signals as a result of the movement of the water surface. Buoys provide accurate wave information at a specific location. However, the buoys must be moored and can be lost due to bad weather and collisions with other ships. Furthermore, due to its mooring, the wave information is valid for one location only. Buoys are divided in to non-directional and directional buoys.

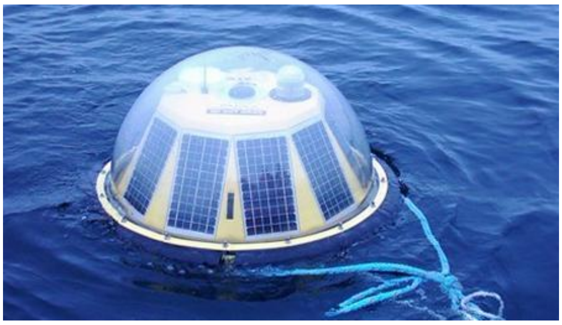
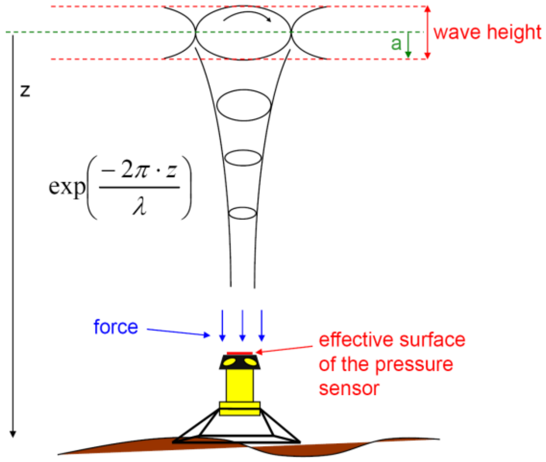


Fig.5: Directional Wave Buoy

Non-directional buoys measure significant wave height, the average zero-upcrossing wave period and other spectral parameters. Significant wave steepness can be estimated. A directional waverider provides wave height, period (peak and zero-upcross) and direction, as well as omni-direction spectra and tabulated directional information.

Underwater Acoustic Devices

Underwater ultrasonic acoustic transducers are frequently used in ocean wave measurements as they measure surface level using acoustic waves. However, their effectiveness can be severely affected in rough sea conditions, when bubbles generated by breaking waves interfere with their acoustic signals. When the seas are rough, one therefore often has to rely on a pressure transducer, which is generally used as a back-up for the acoustic wave gauge. A pressure transfer function is then used to obtain the surface wave information



The availability of the different measuring instruments on the seabed is limited to the connection to the metmast. If the connection is broken the device stops working after a while due to power loss.

5. Results

The conception of the measuring devices and the data handling worked very satisfactorily. The data availability is in nearly every case higher than 95% and for the most important data the availability is higher than 98%.

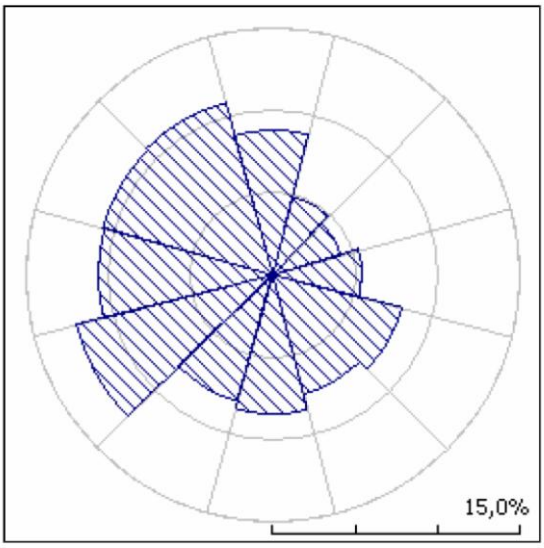


Figure 4: A wind rose for Amrumbank West

Figure 5 shows a wind rose for the location Amrumbank West. Figure 13 and 6 show Wind and Wave conditions in different time scales. The buoy measurement was carried out by the Bundesamt für Seeschifffahrt und Hydrographie.

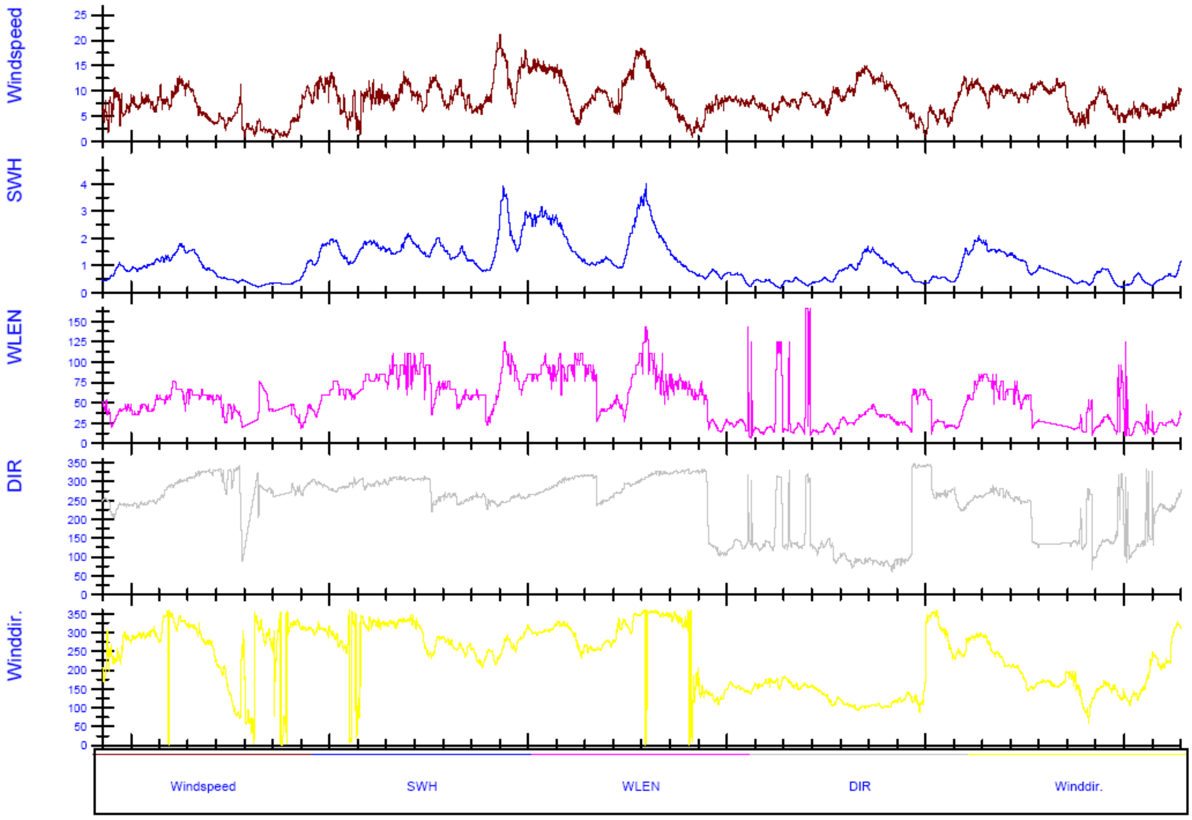


Figure 5: Wind and wave conditions

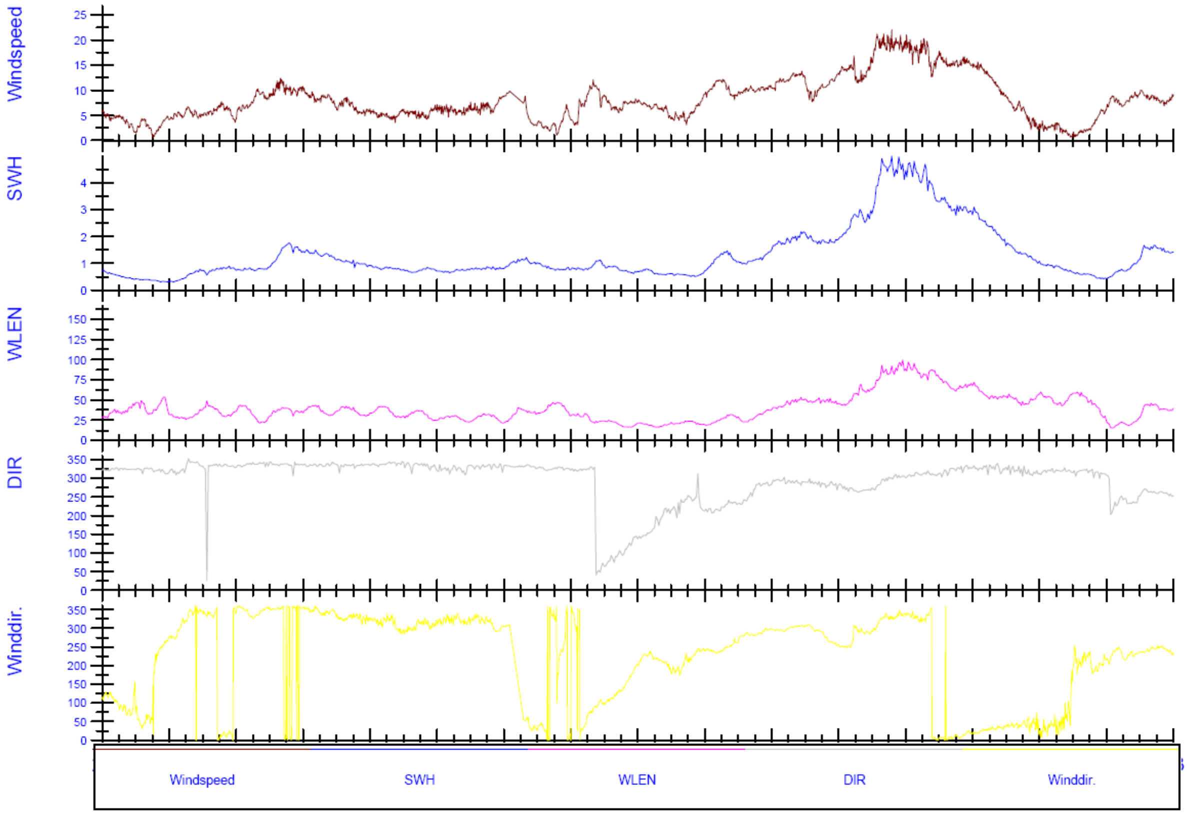


Figure 6: Wind and wave conditions