Site Assessment of the floating wind turbine Hywind

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Abstract

In order to predict the environmental conditions at a wind turbine site it is essential to perform a Site Assessment at the specific site. In this work, 2 years of data from a Seawatch buoy at the Hywind site have been evaluated and results for wind, waves and ocean currents are presented and evaluated. A long term extrapolation of wind data has been performed to ensure that results are not based on inter-annual trends. Seasonal variations with maximum values for wind, waves and ocean current occurring during winter are found, with the prevailing flow directions parallel to the coastline.

The site

In 2009 Statoil installed the world's first full-scale floating wind turbine off the coast of Karmøy in the North Sea. This work is based on data from 2009 to 2011 measured by a Seawatch buoy located 200 m west of the floating turbine, Hywind. The depth at the site is 210 m.

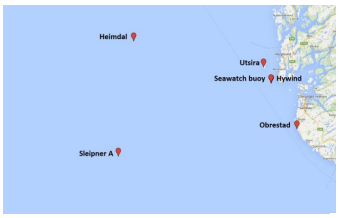
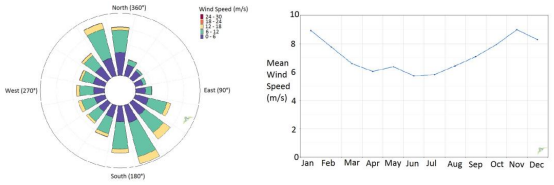


Figure 1 : **Map of positions of Seawatch buoy, Hywind turbine and meteorological stations from Google Maps**

Wind

Wind data are measured at 3.5 m height as 10-minute means. The buoy data are long term extrapolated (LTE) utilizing the Matrix Time Series method with the data from Utsira as reference data, see Figure 1 . Figure 2 displays the results for the LTE data, Figure 2 a showing the direction of the approaching wind. The LTE data display

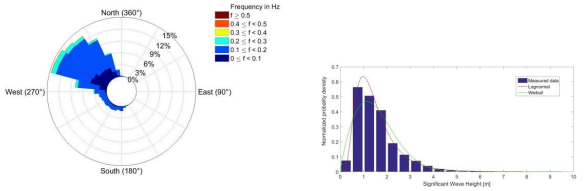
- A near constant diurnal wind speed profile
- Seasonal variations with stronger wind speeds during winter
- A mean wind speed of 10.0 m/s at hub height, vertically extrapolated using the power law with $\alpha = 0.11$



(a) Wind direction distribution for the LTE data **(b) Monthly Wind Speed Profile for the LTE data**

Figure 2 : **Wind results for the LTE data at the Hywind site.**

Wave



(a) Distribution of frequency vs direction **(b) Normalized distribution of significant wave height**

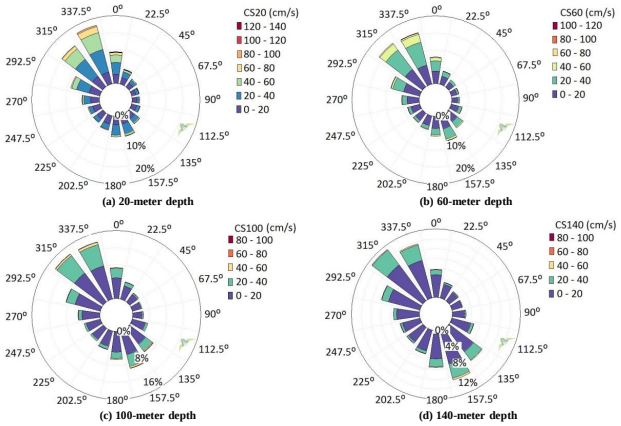
Figure 3 : **Results for estimated significant wave height.**

The time series from the Seawatch buoy contains several parameters, among them are the estimated significant wave height, the period and the flow direction, these are represented by Figure 3 . Direction is in degree measured clockwise from True North and describes the direction the wave comes from. Most of the waves have

- Frequency between 0.05 and 0.30 Hz
- Direction between 250° and 350°

Ocean current

As depth increases the flow direction of the ocean current gets more evenly distributed as Figure 4 shows. 0° represent north and the direction describes where the ocean current flows towards.



(a) 20-meter depth **(b) 60-meter depth**
(c) 100-meter depth **(d) 140-meter depth**

Figure 4 : **The frequency vs direction at different depths.**

The ocean current are measured with 10 m intervals down to 180 m, the mean speed at these depths in addition to the no-slip condition at the bottom result in the velocity profile in Figure 5 .

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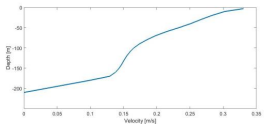

Figure 5 : **Velocity profile for the ocean current**

Conclusions

- Constant mean diurnal wind speed profile
- Seasonal trends. Higher wind during winter and extremes of both waves and current observed in late winter as result of sudden increases in wind speed.
- Vertical extrapolation using the power law with α=0.11 results in a mean wind speed of 10 m/s at hub height.
- Combination of lognormal and Weibull distributions are preferable to describe waves.
- Weibull distribution gives a good description of the ocean current.

References

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