EIEN10 - Assignment 1
Project : Kriegers Flak, Swe (wind data B)

Group 1402
Morgan Ask, François Boveroux, Martin Nilson, Michael Nilsson

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1 Introduction

To analyse the wind conditions at Kriegers Flak, a potential offshore wind farm area outside of Sweden, the wind data B was used.

2 Results

2.1 Wind rose

Include : Wind rose directions + energy (which height ?)

2.2 Wind calculation at 100 m

The wind data we received is measured at 65 m above the ground. In order to compute the wind speeds at 100 m, the following formula has been used:

$$U(z) = U(z_0)\frac{ln(z/z_0)}{ln(z_r/z_0)}$$

where $z_0 = 0.0005\ m$ is the surface roughness length for blown sea, $z_r = 65\ m$ the height at which wind is measured, $z = 100\ m$ the height at which wind is computed and U the different speeds in m/s.

2.3 Mean and standard deviation

In order to calculate the mean and standard deviation for the speeds at 65 and 100 m, the following formulas have been used :

$$\overline{U} = \frac{1}{N-1}\sum_{i=1}^{n} U_i$$

$$\sigma_u = \sqrt{\frac{1}{N-1}\sum_{i=1}^{n}(U_i - \overline{U})^2}$$

At 65 m, we have :

$$\overline{U} = 9.113\ m/s \qquad \sigma_u = 5.127\ m/s$$

At 100 m, we have :

$$\overline{U} = 9.446\ m/s \qquad \sigma_u = 5.345\ m/s$$

2.4 Number of occurencies

The number of occurrences have been computed and the sample histogram could be made (see figures 1 and 2).

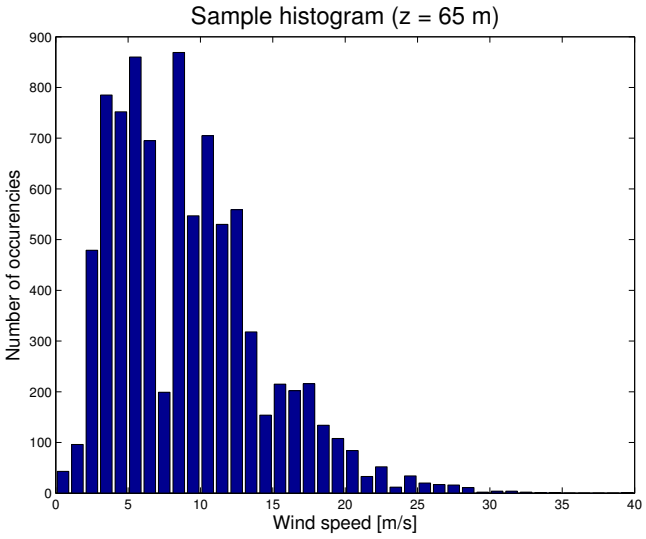

Figure 1: Sample histogram for z = 65 m

2.5 Weibull distribution

To compute Weibull parameters, we used the approximation presented in the book (equations 2.65 and 2.67).

$$k = \left(\frac{\sigma_u}{\overline{U}}\right)^{-1.086} \qquad c = \overline{U}(0.568 + 0.433/k)^{-1/k}$$

Here are our results : At 65 m, we have :

$$k = 1.868 \qquad c = 10.27$$

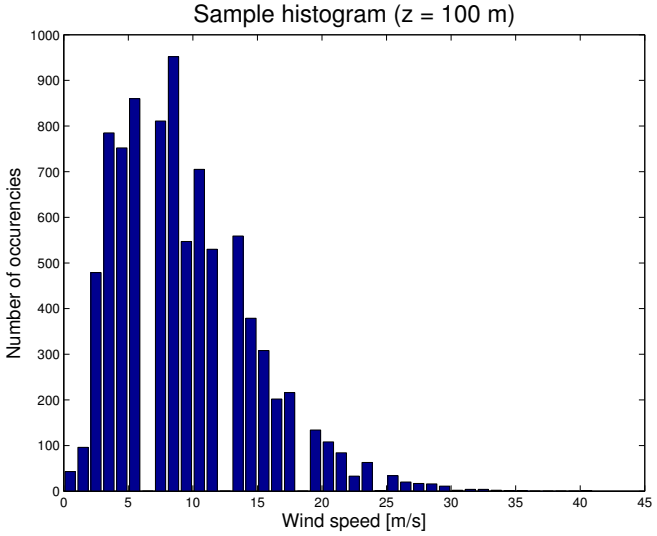

Figure 2: Sample histogram for z = 100 m

At 100 m, we have :

$$k = 1.868 \qquad\qquad c = 10.646$$

2.6 Selected wind turbine

We chose the Siemens SWT-3.6 107 for this exercise. It has a rated power of 3.6 MW and a rotor diameter of 100 m. The output power versus wind speed is shown on figure 3.

Thanks to the wind-power curve and the wind data, we can calculate the energy produced during one year and the capacity factor CF.

$$E_{WT} = \sum_{i=1}^{8760} P(U_i) \cdot 1 \ [kWh] = 15.17 \ GWh$$

$$CP = \frac{E}{3.6 \cdot 10^6 \cdot 8760} = 0.48$$

2.7 200 MW wind power plant

If we consider a 200 MW wind power plant, we need $200/3.6 \simeq 139$ wind turbines. Different efficiencies need to be taken into account. The wake effect efficiency η_{wake} is estimated at 0.85. Other efficiencies (availability turbines, availability of grid, dirt, insects, icings, high wind hysteresis, internal electrical losses, external electrical losses) could be approximated to $\eta_{others} = 0.9$.

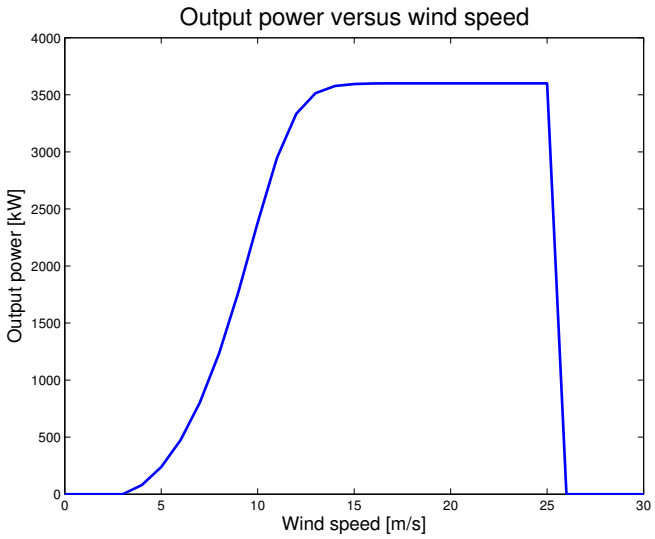

Figure 3: Output power versus wind speed

$$E_{WPP} = E_{WT} \cdot 139 \cdot \eta_{wake} \cdot \eta_{others} = 1.613\ TWh$$

3 Conclusion