The Aerodyn model & wind ressource assessement

Background

- The main driver file `Ex1.dvr`.
- The main input file `Ex1_input.dat`.
- A folder `airfoil_NREL_5MW` containing information on the aerodynamics of airfoils used.
- The Rotor/Blade dimensions file called `NRELOffshrBsline5MW_AeroDyn_blade.dat`.

The excercise is organised as follows: First the power coefficients C_p , thrust coefficients Ct and torque coefficients Cq are computed using the Aerodyn model. Then, the influence of the pitch control system on the power production and thrust force on the rotor is explored. Finally, using the C_p value calculated, the capacity factor of an offshore wind turbine is investigated. To answer the questions, you are welcome to use the Aerodyn user's manual[1] and other documentation found on the internet.

Question 1

The airfoil_NREL_5MW contains multiple airfoil profiles. Why? Using a hand-made sketch, illustrate how the airfoil profiles are connected to the blade geometry. Tip: Check the keyword `BlAFID` in the user's manual and the file `NRELOffshrBsline5MW_AeroDyn_blade.dat`.

Question 2

The file Ex1.dvr can be read with Notepad++. This file contains the different simulation scenarios (lines 22-106). Plot in a figure the variation of the pitch angle and blade rotation speed with the mean wind speed. This figure reflects the active control system of the wind turbine. Using your own words, describe this control system and how it influences the power output of the wind turbine.

Question 3

Run the script `RUN_ME.py` or `RUN_ME.m` in Python or MATLAB, respectively. This script uses the driver `Ex1.dvr` as input, which contains 85 simulation scenarios. Based on the simulations, display the variation of the power coefficient C_p, thrust coefficient C_t and torque coefficient C_q as a function of the mean wind speed

[1] https://www.nrel.gov/wind/nwtc/assets/pdfs/aerodyn-manual.pdf

$\overline{u}$. Why do C_t and C_q decreases sharply after the rated wind speed is achieved? Display in another figure the variation of the power output P and thrust T as a function of the mean wind speed $\overline{u}$. What is the maximal value achieved by C_p ? How does it compare with Betz's limit?

Question 4

The file data_SNII.mat contains five years of hourly wind speed data collected using a wind atlas[2]. These data are located at hub height, in the future Norwegian offshore wind park Sørlig Nordsjø II. The C_p values estimated in Question 3 have been interpolated to match the data from the wind atlas. According to the Matlab file data_SNII.mat, what are the values of C_p for $\overline{u} < 4$ m/s and $\overline{u} > 25$ m/s? What does it imply for the power production of the wind turbine?

Question 5

The power production of a wind turbine is given by the equation:

$$P = \frac{1}{2}\pi\rho R^2 C_p \overline{u}^3 \tag{1}$$

where $\overline{u}$ is the mean wind speed, ρ is the air density, Cp is the power coefficient and R the radius of the wind turbine blades. Assuming a radius R = 62.575 m and $\rho = 1.225$ kg m^{-1} , calculate the capacity factor of the NREL 5MW wind turbine at Sørlig Nordsjø II over the five year period. Wake effects are neglected. How does this capacity factor compare to onshore wind turbines?

[2]You can download the code here: https://github.com/ECheynet/read_matFile_with_python