University of Oldenburg
Python Programming in Energy Science, WiSe 2023-2024
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Assignment 5

Allowed library imports: `os`, `numpy`, `matplotlib`, `plotly`, `pandas`, `scipy`

In the main taskes of this exercise, we are going to create a small application for wind resource assessment. This application should compute the Annual Power Production (APP) using four methods, namely timeseries (E1), average velocity (E2), binned wind speed (E3) data and fitted Weibull distribution (E4). Such basic evaluation should give a general idea about the potential of a specific site.

In this assignment, we are going to use a real wind farm data as case study. So please use the following data:

- Timeseries: `timeseries_la_haute_borne_2017.csv` (attached).
- Power curve: `Senvion_MM82.csv` (attached).
- Density $\rho = 1.225 kg/m^3$, rotor diameter $D = 82m$, Total hours/year $T = 8760h$

E1. APP based on the entire timeseries, which has N the total number of time steps.

$$APP = \frac{1}{T}\sum_{i=0}^{i=N}\frac{1}{2}\rho c_p A U_i^3 \Delta t_i, \qquad U_{\text{cut-in}} < U < U_{\text{cut-out}}$$

E2. APP based on the average wind speed $\bar{U}$ and $cp = cp(\bar{U})$, with respect to the entire timeseries.

$$APP = \frac{1}{2}\rho c_p A \bar{U}^3, \qquad U_{\text{cut-in}} < U < U_{\text{cut-out}}$$

E3. APP based on binned timeseries wind speed data ($\Delta u = 0.5$ m/s bin width, total number of bins N, normalized frequency P_i for bin i such that $\sum_i P_i = 1$).

$$APP = \sum_{i=0}^{i=N}\frac{1}{2}P_i \rho c_p A U_i^3, \qquad U_{\text{cut-in}} < U < U_{\text{cut-out}}$$

E4. Fit a Weibull curve (use Python of course, search the internet) to the given timeseries and calculate the APP from the fitted curve. Include a plot shows the histogram and the fitted Weibull distribution.

$$APP = \int_{U_{\text{cut-in}}}^{U_{\text{cut-out}}} \frac{1}{2} P\, \rho c_p A U^3 \mathrm{d}U$$

where U is the wind speed and A is the rotor area of the turbine. Here P is the fitted Weibull probability density function with $\int P\, \mathrm{d}U = 1$. Note that both c_p and P are functions of U.

Here are the general rules and some hints

- Using Object-oriented paradigm is encouraged but not essential. However, the application should be divided into functions. One large procedure script is not accepted.
- The code has to be clean and easy to read (For humans).
- Documentation is essential for each unit of the code.
- Hint1: you may need to use, `scipy.interpolate.interp1d` for interpolation of c_p
- Hint2: the time-series has some NaN values, so the data is not for exactly one year.
- Hint3: the cut-in and cut-out are the min and max operating velocity of the turbine, check the power curve.
- Hint4: The annual power value should be in order of 300kW++.

E5. Drainage of a large water tank
It is not related to the above problem!

In a hydrogen production station, assume that you have a large cylindrical tank with diameter D, with initial water level h_0. The tank is connected to an electrolyzer by a pipe of diameter d. Under the gravity only g, the height of the water in the tank is governed by

$$\frac{dh(t)}{dt} = -\sqrt{(2g)}(\frac{d^2}{D^2})\sqrt{h(t)}$$

Solve the above initial value problem and plot the variation of h up to one hour. Use $D = 20m, d = 0.5, g = 9.8m/s^2, h_0 = 25m$. Compare your answer with the analytical solution

$$h(t) = \left[-\sqrt{\frac{g}{2}}\frac{D^2}{d^2}t + \sqrt{h_0}\right]^2$$