Project 03

Demo Wind Resource and Energy Yield Assessment

A simple demonstration of Wind Resource and Energy Yield Assessment based on Reanalysis Data. You may also refer the short project report.

Objective

To derive the gross annual energy production for a given power curve at an arbitrary set of coordinates and hub height within a rectangular grid. At the corners of the grid ERA5 timeseries at 10 and 100 m are available.

Functions Created

The required functions are stored in the python module: “module_WRA_EYA.py”. It includes functions for loading and processing NetCDF files, calculating wind speed and direction, fitting Weibull distributions, plotting wind roses, and calculating gross annual energy production (AEP).

1. **load_ncs**: Loads and combines multiple NetCDF files from a folder, sorts them by time, and slices the dataset based on optional start and end dates.
2. **get_weights**: Calculates weights for 2D interpolation based on the distance to target latitude and longitude. An exponent of e.g. 1 will imply using simply the distance to the gridpoints to derive the weights, and exponent of 2 in turn, will use the more common square distance approach.
3. **get_ws** and **get_wd**: Calculates wind speed and wind direction from the u and v wind components.
4. **get_uv_interpolated_ws_wd**: Performs weighted interpolation of u and v wind components and calculates wind speed and direction.
5. **get_alpha** and **shear_extrapolation**: Calculates the vertical wind speed shear exponent alpha and extrapolate wind speed to a target height using the power law.
6. **get_veer** and **extrapolate_wd**: Calculates the vertical wind direction veer and extrapolate wind direction to a target height.
7. **get_ws_wd_for_xyz**: Relying on the previously described functions, it gets wind speed and direction for the target latitude, longitude, and hub height.
8. **wbl_fit**: Fits a Weibull distribution to wind speed data and optionally plots the histogram and Weibull fit. The initial guess for the parameters has been chosen as: $k = 2$, works for most Northern Europe, and for A, $\Gamma(1 + 1/2) \approx 0.88$.
9. **plot_wind_rose**: Plots a wind rose using the windrose package.
10. **read_pc**: Reads a power curve from a CSV file. The header must be on row 1, the first column must be the wind speed (m/s), second column, power (kW).

11. **get_power**: Interpolates power from a wind speed time series using a given power curve.

12. **get_gross_aep**: Relies on “read_pc” and “get_power”, calculates the gross annual energy production (AEP) from a wind speed time series and a power curve.

Example Results

For the set of inputs shown in Figure 1 the wind speed distribution and Weibull fit are shown in Figure 2, the wind rose in Figure 3.

```
#%% Inputs
# Wind Resource
input_nc_folder = '../inputs'
lat = 55.625 # 55.5° - 55.75°
lon = 7.875 # 7.75° - 8.0°
start_date='1998-01-01'
end_date='2005-12-31'
# WTG
power_curve = '../inputs/NREL_Reference_5MW_126.csv'
hh = 120 # m
```

Figure 1: Example inputs.

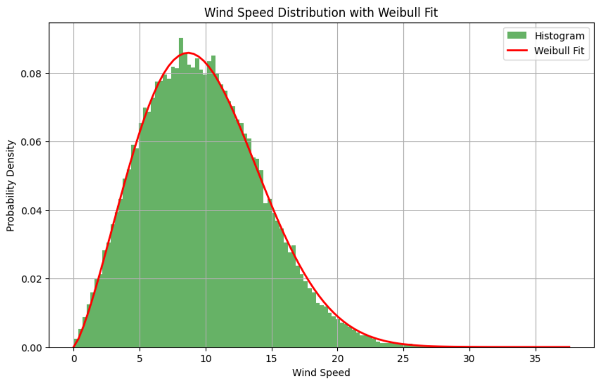

Figure 2: Fitted Weibull Distribution and Wind Speed Histogram.

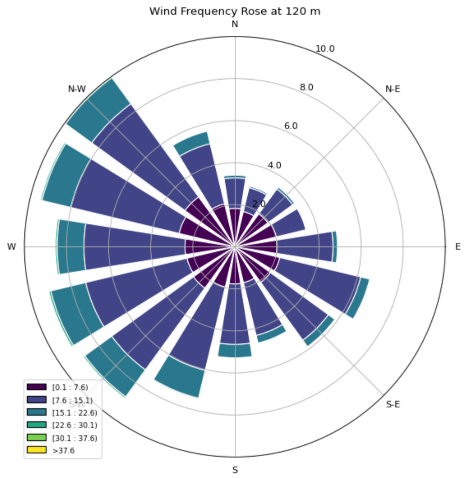

Figure 3: Wind Frequency Rose.

The Weibull parameters found for the fit were: k = 2.3, and A = 11.1 m/s. For the chosen NREL 5 MW machine the gross AEP is 25.1 GWh.

Analysis Case Class

A “class analysis_case” object was created which represents a case for analyzing wind data. Relying on the functions previously described the user is able to estimate the gross AEP and keep the results and traceable inputs in the in the class.