EE4-50 | EE9-FPN1-10: Coursework 1

Submission deadline: 4 pm on 25 February 2019

Use MATLAB to do the exercises below. You need to submit the MATLAB code (.m file) and generated wind speed samples (in a .mat file) separately and also include the MATLAB code as an Appendix within the coursework report.

Coursework Problem

The hourly wind speed data at a particular location follows Weibull probability distribution with a form factor $k = 1.9$ and a scaling factor $A = 8.5$ The air density is 1.225 kg/m^3.

A wind turbine (WT) installed at this particular location has the following parameters:

Maximum power coefficient	Blade diameter (m)	Cut-in speed (m/s)	Cut-out speed (m/s)
0.496	150	4	25

Part 1:

A direct drive variable-speed generator with a maximum power capacity of 6.0 MW is used with the above-mentioned wind turbine. Assume the efficiency of the generator to be 0.9 for any power output.

1. Obtain the characteristic curve of the 6 MW wind turbine generator (WTG) showing the power output (in MW) against wind speed (in m/s). Determine the rated speed of this WTG.

   [3+1 marks]

2. Generate hourly samples of wind speed (in m/s) over a year for the above-mentioned location and plot a histogram of wind speed with 23 bins. Use the default binning option in MATLAB. Calculate the annual average wind speed (in m/s) for this location.

   [4+1 marks]

3. For the different range of wind speeds shown in the histogram in Q2, plot the following (in MWh) on a single bar graph:

   a. energy available for extraction by the WT across the year
   b. energy available over a year after applying the Betz limit
   c. energy extracted by the 6 MW WTG over a year

   [3+3+3 marks]

4. What percentage of the total annual energy available for extraction by the WT was actually produced by the 6 MW WTG? How different would this percentage figure be if the energy calculations were based on the annual average wind speed?

   [3+2 marks]

Part 2:

A bigger generator (of same type having the same efficiency as in Part 1) with a maximum power capacity of 12 MW could be used to increase the energy extracted from the same WT as in Part 1.

1. Obtain the characteristic curve of the 12 MW WTG (12 MW generator with the same WT as in Part 1) showing the power output (in MW) against wind speed (in m/s). Determine the rated speed of the 12 MW WTG.

[2+1 marks]

2. Considering the same wind speed distribution used in Part 1, plot the energy (in MWh) extracted by the 6 MW and 12 MW WTG for the same range of wind speeds shown in the histogram in Q2 of Part 1.

[4 marks]

3. What percentage of the total annual energy available for extraction by the WT was actually produced by the 12 MW WTG? How does this compare with the case in Q4 in Part 1?

[2+1 marks]

4. Determine the percentage increase in annual energy yield by using the 12 MW WTG compared to the 6 MW WTG (in Part 1).

[2 marks]

[15 marks for MATLAB code with necessary comments]

Coursework submission:

- In the main body of your coursework report, you should present the results of the above exercises and provide concise comments or explanations where necessary. This part should **be limited to 4 A4 size pages**. The cover page and appendix would not count towards the 4-page limit.
- The MATLAB script (.m file) with proper documentation (comments) should be submitted separately and also included within the coursework report as an Appendix. Mark each section of the MATLAB code with the relevant part and question number.
- Submit the following on **Blackboard before 4 pm on 25th February 2019**.
  - Coursework report as a PDF file.
  - A zipped file containing:
    - MATLAB code as a self-contained .m file which can be run by the marker.
    - Generated wind speed samples (in Q2 of Part 1) stored in a variable ‘vw’ and saved in a .mat file.

All four files should be named as your ‘Firstname_Surname’