ME 4470/ESE 4470/ME 5475-02
Wind and Tidal Energy

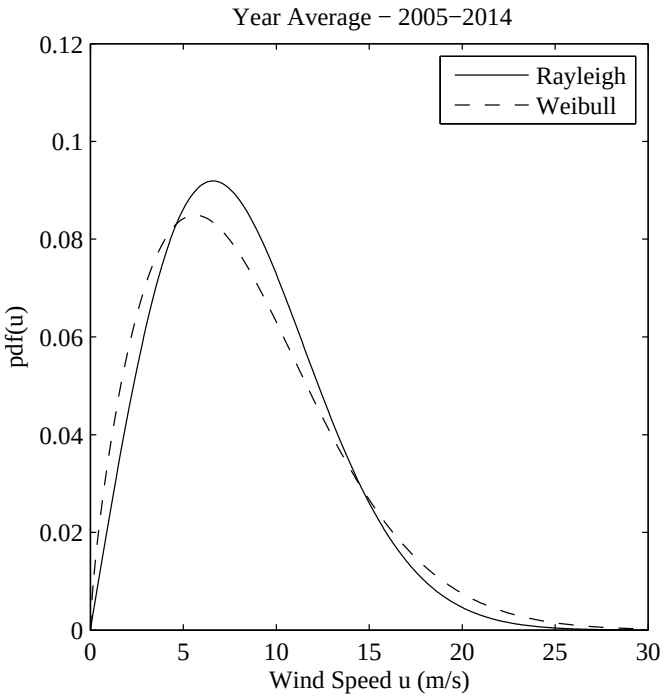
Problem: Use Weibull and Rayleigh distributions with constants determined from data to estimate power production from a turbine

Given: Rayleigh and Weibull distributions with constants determined from data and a turbine power curve

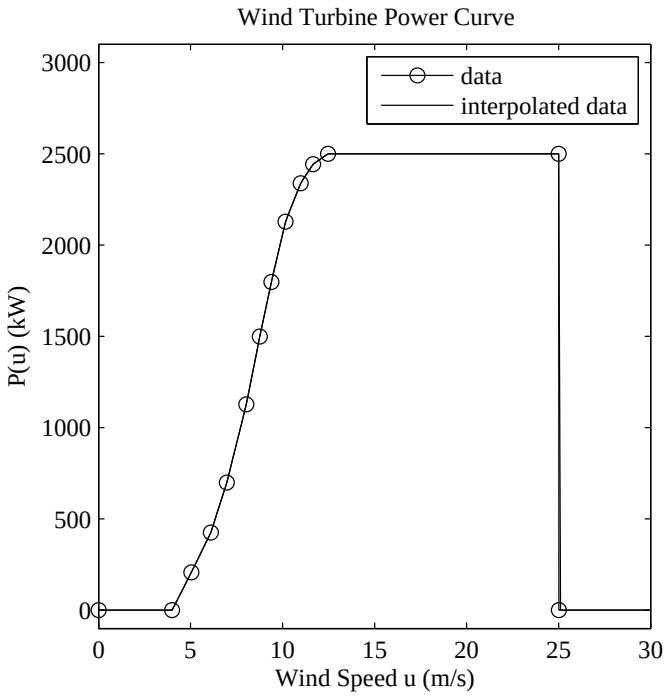
Find: Estimate the power production for the months of January, April, July, October as well as an pdf for the the year.

Solution: Constants for the the Rayleigh and Weibull distributions previously determined are used with the turbine power curve to determine the average power and energy produced over a given period using the following steps.

1. A vector of velocities u_i was created with relatively fine spacing (<0.5 m/s).
2. The probability density functions were determined at each of these velocities using the Weibull and Rayleigh distributions along with the constants previously determined for different time periods. The figure below shows the pdfs determined for the year.



3. The turbine power curve data was then used to determine the power output by the turbine at each of these velocities using interpolation. The interp1 function in Matlab is an example of this. The figure below shows the original data and the interplolated values.



4. The average power $\bar{P}$ was then determined using the probability density function (pdf(u_i)) and the turbine power curve ($P(u_i)$)

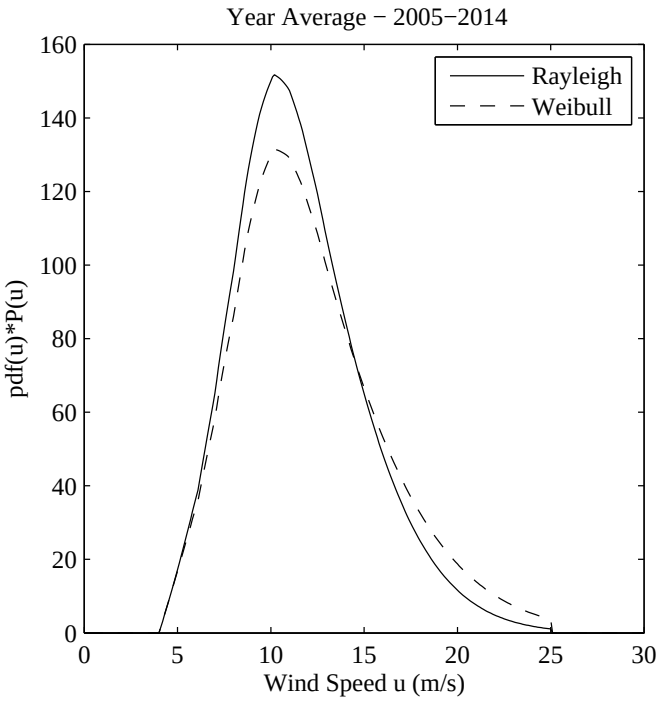
$$\bar{P} = \sum_{i=1}^{M} pdf(u_i) P(u_i) \Delta u$$

where M is the number of bins. This sum is the area under the curve in the figure below, where the product of the pdf and the turbine power curve is plotted. As can be seen, the importance of the differences in the pdfs are affected by how the power turbine curve weights them when calculating average power.

5. The energy produced during the period of interest is determined by multiplying the average power by the number of hours in the period.

The values determined for the average power and energy are tabulated in the table below.

	Rayleigh		Weibull	
Interval	Power	Energy	Power	Energy
Interval	MW	GW-hrs	MW	GW-hrs
Jan	1364.1	1014.9	1275.5	949.0
Apr	1356.6	976.7	1331.0	958.3
Jul	804.1	598.3	804.6	598.6
Oct	1145.6	852.3	1131.5	841.9
Year	1192.0	10442.2	1145.9	10037.8


Year Average − 2005−2014
Rayleigh
Weibull
pdf(u)*P(u)
Wind Speed u (m/s)
0
20
40
60
80
100
120
140
160
0
5
10
15
20
25
30