Homework #2
ME 4470/ESE 4470/ME 5475-02
Wind and Tidal Energy

J. W. Naughton **Assigned: 09/25/15** **Due: 10/05/15**

This homework is worth 33 points

1. (5) Provide a short answer to the questions below, and provide a reference from reading the the 2014 Wind Technologies Market Report Summary (page number and line number).

   (a) Which country has the largest installed capacity of wind turbines? Who produces the most energy from their installed capacity?

   (b) Based on your reading, what would the range of cost for a 2 MW turbine have been in 2014 based on recent price data?

   (c) What is the capacity capability for building wind turbine components in the U.S.?

   (d) Although wind represents the a significant amount of the electrical generating added capacity in the U.S., in which regions of the country did wind have the highest percentage of installed capacity?

   (e) Provide significant evidence that the ability to transport wind generated electricity from where it is made to where it is needed is increasing.

2. (5) Provide a short answer to the questions below, and provide a reference from reading the Executive Summary section ES.3 (Cost, Benefits and Other Impacts of the Study Scenario) from Wind Vision to support your claims (page number and line number).

   (a) Depending on the improvements of wind energy technology, what range of installed wind capacity is anticipated to reach the 35% goal in 2050?

   (b) What are some means of addressing increased variability on the electrical grid as wind penetration increases?

   (c) To reach the goal of 35% in 2050, how much transmission would need to be add per year? Is this reasonable?

   (d) What is the effect of adding wind generation to retail prices in the Central Study Scenario?

   (e) What are the estimated monetary benefit of reduced CO2 production under the central study scenario?

3. (13) You will continue to analyze the 10 year data record of wind at the Laramie Airport used in the previous homework.

   (a) Using the 10 years of wind data provided on the web site, determine the probability density function (pdf) for the wind velocity for each month as well as for a year. Plot your results for January, April, July, October and for the year.

   (b) Using the probability density function, determine the mean wind velocity and the velocity variance for all periods given above. Provide table of these values. How did these compare with the values you calculated in last week's homework?

   (c) Overlay the Weibull and Rayleigh distributions on the pdfs determined for the five different time periods. Determine and tabulate the parameters that provide the best fit and discuss how you obtained them (don't just guess, see the book for a starting value). Conclude whether each of these distributions is a good approximation to the actual wind distribution or not.

   As with the last homework, convert wind speeds to an 80 m tower height before analyzing. Use a power law estimation with a roughness coefficient of a=0.19 for this purpose.

4. (5) The wind turbine power curve for a commercial wind turbine is provided in tabular form on the web site. Assume that the wind turbine will be installed at 80 m.

   (a) Using the Weibull fit to the probability density function (pdf) for the wind velocity for five different time periods (annual, January, April, July, and October) that you determined in the problem above, determine and tabulate the average power and energy produced by the wind turbine for each of these periods. For the purpose of this exercise, assume that the power curve has been adjusted for the density of Laramie.

5. (5) A commercial wind turbine has the turbine power curve given in the file available on the homework web site. In another file, the rotation rate of the wind turbine is also given at different wind speeds. The wind turbine has a rotor disk diameter of 52 m.

   (a) Determine the coefficient of performance for this wind turbine at the velocity values listed in the data file. Assume that the data provided was acquired at sea level.

   (b) Most often, the coefficient of performance is plotted versus the tip speed ratio (blade tip velocity divided by the incoming wind velocity). Using the rotation rate information given, re-plot the coefficient of performance as a function of tip speed. Plot the Betz and Glauert limits on this second plot. A file with the Glauert limit tabulated is provided.

(c) Comment on the result.

Issues:

- You may use whatever software you want for performing these calculations.
- When determining bin spacing, remember to use the spacing consistent with the data given in the file (which you convert to m/s and then further convert to 80 meter height) or you can get noisy results.

Follow a presentation of your work identifying what is given, what you are asked to find, the data provided, assumptions, etc. Include plots and tables as requested above, but e-mail your programs to me rather than including the printed version. Please spend time discussing your approach (complete with equations and how they were implemented) and discussing the results - just don't hand in plots with no explanation. A simple rule for the level of detail requires is that you should be able to understand completely what you did if you picked this assignment up 3 years from now.