Homework #6
ME 4470/ESE 4470/ME 5475-02
Wind and Tidal Energy

J. W. Naughton **Assigned: 11/23/15** **Due: 12/07/15**

This homework is worth 22 points.

1. (7) Provide references from reading the Executive Summary of "Beyond Renewable Portfolio Standards" to support your answers below (page number and line number).

   (a) After the RPS requirements expire, what is likely to affect what renewable resources will be developed?

   (b) What is a value proposition? What destinations for power are most likely to be involved in the positive value propositions?

   (c) What prevents good wind resources in Colorado from being attractive for export to other states?

   (d) What is of importance to utilities beyond the cost of renewable energies and associated transmission costs?

   (e) Normally, resources whose output corresponds to demand are the most valuable, and solar often fits this criteria because it peaks during the day. When does solar's value in this sense decline?

   (f) What resource and location had the highest value according to this study?

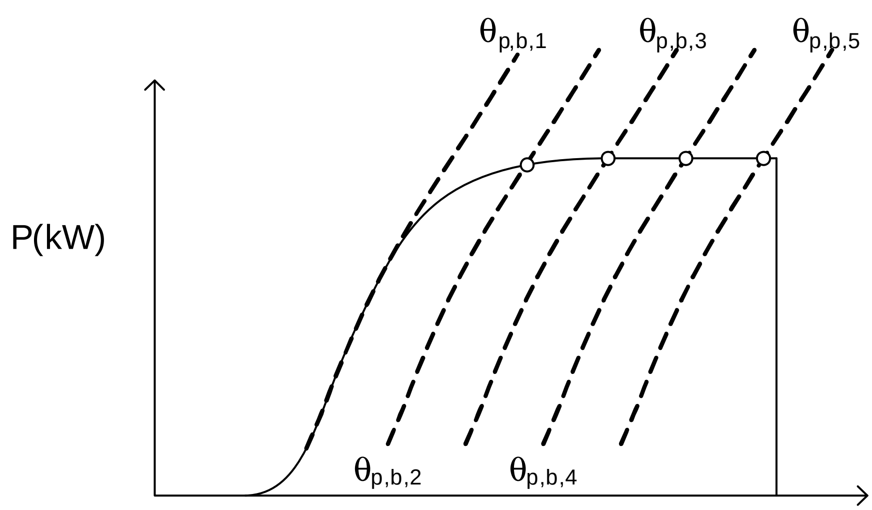
   (g) What renewable resource(s) and location(s) had prices comparable to Combined Cycle Gas Turbines for delivery into the California market after 2025?

2. (15) A pitch controlled, constant rotational velocity wind turbine typically operates using one total blade pitch $\theta_{p,b,1}$ (the blade pitch setting at the root) at velocities that produce less than rated power. A higher wind velocities, the entire blade is pitched to create increased pitch angles (θ_p) along the blade (this decreases the angle of attack) in order to maintain the torque constant such that the generator produces the rated power. The turbine power curve schematic below shows this process as a series of curves for different total blade pitch.

   (a) Reusing the wind turbine blade you designed homework 3 and the generator provided in homework 5, determine the power curve for the portion where power is increasing to rated power (i.e. the leftmost curve in the figure) by running a series of simulations at different inflow velocities using the nominal blade pitch provided (call this a total blade pitch of 0). Note that this is essentially repeating homework 5. Plot the result.

   (b) Now run several velocities for other blade pitches of 8, 12, 16 and 20 degrees that bracket the 425 kW level. Be careful not to run velocities that exceed the 425 kW level by too much as your generator will give bad results there. Plot these points on the same plot as you plotted your 0 total blade pitch results to produce a result like that shown in the figure below.

   (c) For each blade setting, estimate the velocity at which the turbine produces rated power. This is the point where each total blade pitch curve $\theta_{p,b}$ intersect the rated power. Repeating this for each $\theta_{p,b}$ curve yields the circles shown in the figure (plot them on your figure as well). Also generate a new figure that plots these blade pitch values against wind speed.



Note that by completing this exercise, you have developed a control schedule for the turbine and have defined the power curve all by simulation of the blades, generator, and pitch control system - no small task!