Worksheet: using the Anemometer Loan Program data to understand more about wind resources.

Wind speed is a crucial element in determining whether it is worth installing a wind turbine at a specific location, because it determines how much electricity can be produced. Anemometers are devices which record the wind speed and other data. Data collected by the anemometer loan program is run through a software program that estimates the all-important bottom line -- how many kilowatt hours various wind turbines will produce at that site.

All of the sites from the anemometer loan program are mapped on to the wind resource map of Colorado. The wind resource is color coded - (white = poor (1), brown = marginal (2); yellow= fair (3); pink = good (4); purple = excellent (5), red= outstanding (6), blue = superb (7) While the data for that map was collected from towers at 50 meters and the data from the anemometer loan program is at 20 or 30 meters, they correlate well (wind speed does increase with height).

To understand how much electricity can be generated from various wind turbines with different wind resources, it's helpful to compare the data from a variety of sites.

1. Use the anemometer loan website(http://www.engr.colostate.edu/ALP/ALP_Sites.htm) **map to select 4 sites – one from a poor wind resource area (white color -i.e. site #58 in Palisade) a good resource area (pink color, i.e. site #51 in Stonington), an excellent or better site (purple, red, or blue; i.e. site #5 Pawnee Buttes), and the site nearest you.** Fill in the table below with the data requested. The Average net energy and capacity factor can be found in the table at the very bottom of the data set for each site.

Wind resource at sites	Poor	Good	Excellent or better	Site nearest you
Site #/ Location				
Mean wind speed (mph)				
Median wind speed				
Min wind speed				
Max wind speed				
Mean power density				
Power Density at 50m **(**W/m²)[1]				
Wind power class				
Average Net Energy Output *kWh/yr* [3] for a Southwest Skystream 3.7 [4]				
Capacity factor [2] for the Skystream at site				
Average Net Energy Output *kWh/yr* for a Northern Power NW 100/20[5]				
Capacity factor for Northern Power NW 100/20 at site				

[1] Power density indicates how much energy is in the wind at the site for a wind turbine to convert to electricy. PD **=** ½ * ρ *** V**3 (ρ= density of the air, a v= the wind speed) (for more information on this, go to: http://www.seic.okstate.edu/owpi_old/EducOut/default.htm)

[2]The capacity factor compares the turbine's actual production over a given period of time with the amount of power the turbine would have produced if it had run at full capacity for the same amount of time. A higher number is better – it means the turbine is running closer to its full capacity. A capacity factor of 25% to 40% is common, although higher capacity factors may be achieved during windy weeks or months.

[3]Electricity production and consumption are usually measured in kilowatt-hours (kWh). A kilowatt-hour means one kilowatt (1,000 watts) of electricity produced or consumed for one hour. One 50-watt light bulb left on for 20 hours consumes one kilowatt-hour of electricity (50 watts x 20 hours = 1,000 watt-hours = 1 kilowatt-hour). How much electricity you use over a year is expressed as kWh/yr. A typical house uses 8,000-10,000 kWh/yr.

[4]The Southwest Skystream 3.7 is here used as an example of a readily available residential-scale turbine.

[5] The Northern Power NW 110/20 is here used as an example of a readily available turbine for a larger building or farm/ranch.

2. How much electricity do you use in a year in kWh/yr? _________________
(check a year's worth of utility bills to determine your annual usage, or develop an estimate if you are off-grid)

3. Would the energy produced by the turbines at the site nearest you meet your energy needs? (Use the residential size turbine results if you are intending to power your home, and the larger one if you are planning on powering larger buildings. It would never be cost effective to use a larger turbine than you need).

4. The economics of a wind system are very sensitive to the average wind speed in the area, and to a lesser extent, the cost of purchasing electricity. The cost of an installed grid-tied residential wind energy system typically ranges from $12,000 to $55,000 for a 2 to 10 kW wind turbine.
Take your electricity costs times the estimated output of your sample turbine to determine the value of the electricity produced
$_________ per kWh X ___________kWh = $_______ (i.e. if your electricity is $0.10 per kWh x 5700 kWh/yr generated, then it produces $570 worth of electricity per year.) If it costs $13,000 installed, it would take 22.8 years to "pay back" the price. This does NOT take into account Federal tax incentives, or any local incentives. Rechargecolorado.com and www.**dsire**usa.org are good resources for tax credits and rebates. This also doesn't take into account increases in the cost of electricity over the payback period. The above example assumes a grid-tied system – in a remote off-grid system, the economics would be more favorable, given the cost of bringing in electricity.

Take home lessons:

1. The power produced by wind is a factor of the wind speed *cubed!* So a small increase in average wind speed can make a huge difference in electrical generation.

2. Average wind speed does not necessarily give a complete picture. For example in a gusty site, the wind speed may average 32 mph, but could consist of strong 60 mph gusts and 4 mph winds. This would give a low wind power density, and would not produce much electricity. Compare two sites (i.e. 51and 26). They both have similar average wind speeds, yet one is classified as good, and the other as fair. Even though the averages are the same, the wind speeds that comprise them are not the same (i.e, one site could have a constant wind speed of 1, and the other could have a wind speed of 2mph and 0 mph). Since the power of the wind is based on the cube of the velocity, the site that has some higher winds will produce more power.

3. You can use the capacity factor data to help you choose a turbine that would be best suited to your wind resource. Ideally, you'd choose the one with the highest capacity factor for your site. If there are no turbines with at least a 10% capacity factor, you may want to reconsider whether wind is a good choice for your site.