GEOG 455 Exercise Three
WIND POWER
15 points

Name:_______________________
Student#:_______________________

Purpose: You are to determine the power needs of a family of four in Goodland, KS and the percentage of those needs that can be met by a commercial wind-power system.

Background (*from Oliver J. E., 1981, Climatology: Selected Applications, V. H. Winston and Sons, pages 100-102*)

Power in a uniform flow of air is determined by:

$$\mathbf{P = \tfrac{1}{2}\, \rho v^3}$$

where: **ρ** is the density of air which can be taken for a constant of 1.29 Kg/m^3
v is the wind speed in m/s
P is the available power in w/m^2

Winds on the Earth's surface are not steady constant flows, so they must be provided in a form that is meaningful for a wind design project. To obtain the best results, the analysis of the wind is highly specialized and the technology and data collection systems quite sophisticated. Unfortunately, such data are quite sparse and it is necessary to use alternative methods drawing upon conventional data availability. One such approach is to divide wind speed into a small set of ranges and then identify the percent of time spent in each category on a monthly basis (Table 1). Then, calculating the monthly available wind power merely involves substituting values into the formula (above) and multiplying the result by the fraction of time during the month that the wind falls within the defined range. An evaluation of the power available given by this or similar methods is an important piece of background research that is necessary in determining the feasibility of wind-energy use at a particular site.

Exercise Procedure

Step 1--determine the amount of power required--This is a critical part of the design process. Load demand varies diurnally and seasonally; actual use should be determined from a fairly close examination of use patterns in a client's home. We will assume that the family living in the dwelling follows typical usage characteristics (Table 2).

Step 2--site correction factors--The height at which wind speed measurements are taken has an influence on the values. You intend to install your chosen system on a 60 foot tower; wind speeds at the airport are measured at 30 feet. A site (location) correction factor was estimated by determining the ratio between airport measurements and measurements on site that you have taken for one year (also at 30 feet). The site winds averaged 12.7 mph. The average wind speed at the airport is 12.3 mph, so the location correction factor is 12.7 / 12.3 = _________________.

The height correction factor is 1.10 (taken from tables showing wind variation with height). Location and height factors are combined by multiplying the two together yielding ___________________. This factor was then *multiplied by the values of each wind speed class from the airport to get the actual wind speeds at your site*. Table 1 represents the corrected wind characteristics for your site, broken down by the percentage in each category for all twelve months.

Step 3--calculate the power (Kw-hours) produced on a monthly basis by a conventional system--You decide to use a Dakota BC4 wind generator with a fourteen foot rotor. In order to determine the monthly power produced by this system, you have to figure out how many kilowatts are available at specific wind speeds; such data are supplied by the manufacturer. The BC4 starts generating power after the wind speed reaches 8 mph (the cut-in speed of the rotor), power increases until the wind reaches 25 mph, and then flattens out to 40 mph, when the rotor cuts out to prevent damage to the mechanism. (Power curves are determined from mounting the system on a large flat bed truck, a railroad car, or by putting the system next to one with know characteristics. Rocky Flats outside Denver serves as a test site for many companies.)
The power generation by the BC4 for the mid-points of each wind class in Table 1 are:
3.5 mph-0 Kw, 10 mph-0.4 Kw, 15 mph-1.2 Kw, 20 mph-2.2 Kw, and 25+mph-4.2 Kw.
The wind speed category percentages in Table 1 can now be used to calculate Kw-hours/month for each month.

a. determine the number of hours in the month (31, 30, or 28 times 24)
b. multiply the power generation by the number of hours and the percentage for each class during every month
c. add up the values in each class for each month for the total power available (Kw-hours/month)

Step 4--final monthly calculation based on efficiency of conversion--The power coefficient of the Dakota is 0.419. Multiply your results from step 3 by this figure to determine power output of the wind generator (We will ignore line losses between the generator, storage batteries, inverter and house, and losses in the batteries and inverter. These would also reduce the available power.)

Step 5--estimate of the percentage of needs that can be met per month--Using the results from #4, determine the percentage of needs met by your chosen system throughout the year.

TABLE 1

PERCENTAGE TIME IN EACH WIND SPEED BAND

(Data in Miles per Hour: Monthly Percentages)

	0-7	8-12	13-17	18-22	23-27	28-32	33 mph
January	10	42	30	13	2	1	2
February	7	38	31	17	4	1	2
March	8	35	31	19	1	1	5
April	1	26	30	21	10	2	10
May	8	35	31	19	1	1	5
June	7	38	31	17	4	1	2
July	12	40	32	11	1	1	3
August	13	39	31	10	2	2	3
September	11	41	29	14	1	1	3
October	10	42	30	13	2	1	2
November	10	40	31	15	1	1	2
December	9	43	29	14	1	2	2

TABLE 2
ENERGY AND POWER REQUIREMENTS FOR A TYPICAL HOUSEHOLD

Appliance	Hours Used (Hrs./month)	Rated Power (watts)	Energy Use (Kwh/month)
Refrigerator	500	360	180
Kitchen light	120	100	12
Bedroom light	100	100	10
Porch light	100	40	4
Living room light	120	100	12
Bathroom light	100	75	8
Television	120	350	42
Microwave oven	15	1500	22
Slow cooker	40	75	3
Misc. Kitchen devices	8	250	2
Blow dryer	8	500	4
Misc. Bath. devices	20	50	1
TOTALS		3500	300

Month	Hours	Total Power	Adjusted Power	% of needs
January				
February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				