Siting Wind Power: Wind Power Curves & Community Considerations (Student Handout)
(Assessing the Feasibility of Wind Power for Pennsylvania)

Name _____

Part 1: Refresh your memory with a question that may be a "breeze" for you…

How is wind created?

Beaufort Scale

Beaufort number	Wind Speed (mph)	Seaman's term		Effects on Land
0	Under 1	Calm		Calm; smoke rises vertically.
1	1-3	Light Air		Smoke drift indicates wind direction; vanes do not move.
2	4-7	Light Breeze		Wind felt on face; leaves rustle; vanes begin to move.
3	8-12	Gentle Breeze		Leaves, small twigs in constant motion; light flags extended.
4	13-18	Moderate Breeze		Dust, leaves and loose paper raised up; small branches move.
5	19-24	Fresh Breeze		Small trees begin to sway.
6	25-31	Strong Breeze		Large branches of trees in motion; whistling heard in wires.
7	32-38	Moderate Gale		Whole trees in motion; resistance felt in walking against the wind.
8	39-46	Fresh Gale		Twigs and small branches broken off trees.
9	47-54	Strong Gale		Slight structural damage occurs; slate blown from roofs.
10	55-63	Whole Gale		Seldom experienced on land; trees broken; structural damage occurs.
11	64-72	Storm		Very rarely experienced on land; usually with widespread damage.
12	73 or higher	Hurricane Force		Violence and destruction.

i. Use the scale above to make an observation about the wind conditions outside of your school today. Record your observations in the box below.

Date: Time: Beaufort number: Land Effects observed:

ii. Even if there is not much wind blowing today, think about a time when a gust blew your hat from your head or rustled leaves in a tree above you. How do you think wind is created?

Many of the materials and photographs included in this section of the handout have been adapted from the lesson, "Wind Power Curves" with written permissions from the Kidwind Project, 2093 Sargent Avenue, Saint Paul, MN 55105
http://www.kidwind.org

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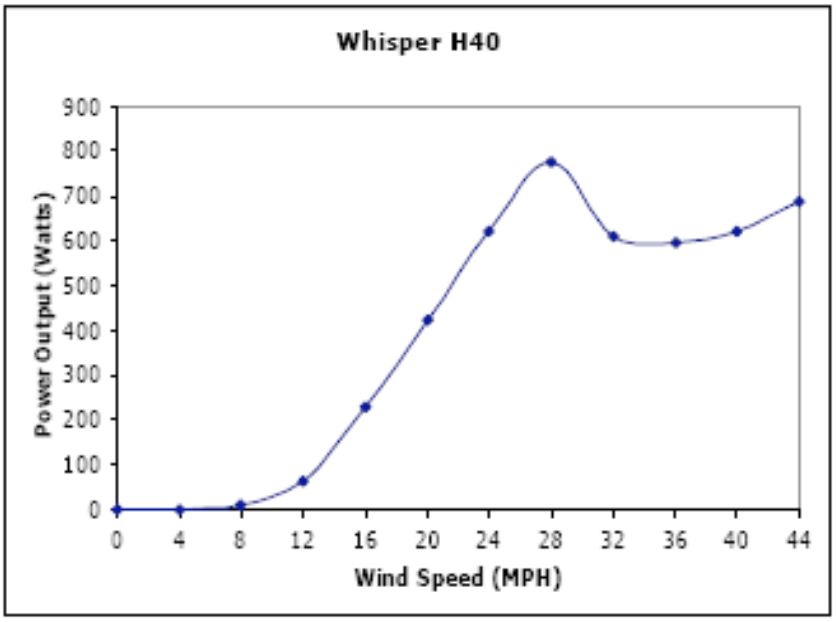
Part 2: Wind Power Curve Analysis

The wind power curve to the right is for a Southwest Wind Whisper H40. The data used to generate this graph were obtained on Paul Gipe's wind energy website. Use the graph above to answer these questions.



1. What is the cut in speed?

   _____

2. At what speed does this turbine have its maximum output?

   _____

3. Why does the output decrease after 28 MPH?

4. Why might it dip at 36 MPH and increase after that?

Wind Speed (MPH)	Power Output (watts)
0	0
4	10
8	400
12	1200
16	1600
20	1900
24	1700
28	1650
32	1640
36	1500
40	1200

To the left is some data that was observed for a KidWind18 Turbine. Use a separate piece of graph paper or and electronic spreadsheet to create a graph of this data and make your own wind power curve.

5. What is the cut in speed of this turbine?

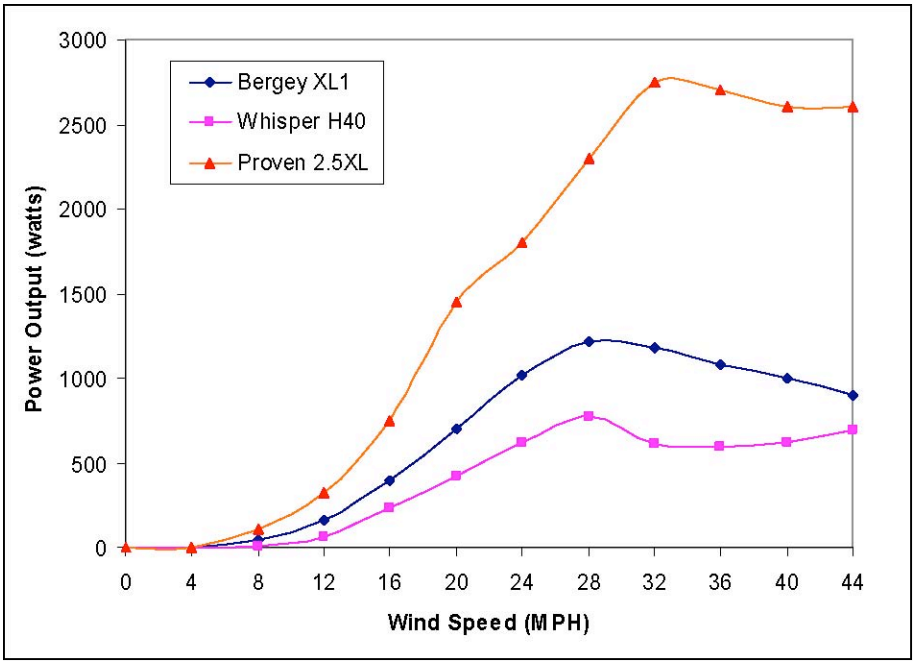
6. What is the maximum output of this turbine?

7. At what wind speed does the turbine start to furl?

8. How many watts does this turbine make at 14 MPH?

9. How many watts does this turbine make at 30 MPH?

10. Compare this to the curve above. Does it look right?



Proven 2.5XL

Bergey XL1

Whisper H40

11. This graph shows power curves for three different turbines. Answer these questions based on the data shown above.

a) Which turbine has the lowest cut-in speed? How can you tell?

b) Which turbine has the highest maximum power output overall?

c) Which one these turbines do you think has the largest diameter blades? Why?

d) Which turbine would have the least amount of power output loss when it started to furl out of the wind or reduces its wind speed?

e) Why do all the curves peak then move downward? *(Doesn't more wind mean more power? hmmm…)*

f) If you had a limited amount of money and needed a turbine that produced a maximum of 1000 – 1200 watts which turbine would you choose?

Part 3: Siting a Wind Farm

Work with your team to use what you have learned. Use the many resources at your fingertips via the Internet and any additional public records that you may find useful in preparing a wind resource site assessment and recommendation for a wind turbine installment to produce electricity for your school. Be prepared to make a statement to your audience that is supported by evidence gathered from answering and investigating the following list of guiding questions.

1. What kinds of things do you need to assess to site a wind turbine?

- **Data Collection & Analysis**
  What data do you need to have to make your decision?
  (Does is matter which way the wind blows? What about wind shear? What does the terrain look like? etc.)

- **Account for Local Population Opinions**
  Whose opinion matters? Is the site you are considering on public or private land?

- **Visual Simulations**
  Should you visualize the wind turbine/farm?

- **Cost/Benefit Analysis & State Incentives**
  Does Pennsylvania offer any incentives to help you install your wind turbine/farm? How close are you to the electrical grid?

- **Turbine Specifications**
  Which turbine is the best choice for your site? Why do you think so?

- **Permitting**
  Is there a permitting process associated with siting your wind turbine(s)? If so, what permits are required?

2. Please do apply what you have learned "close to home." Take a look at some topographic and political boundary maps to find out where wind power would work as a resource for your community. A list of sources of information is included on the next page to help you get started.

Resources to get started…

For a wind resource map for Pennsylvania:

- http://www.eere.energy.gov/windandhydro/windpoweringamerica/maps_template.asp?stateab=pa

The Pennsylvania Department of Environmental Protection's link on Wind Energy

- http://www.dep.state.pa.us/dep/deputate/pollprev/energy/wind/default.htm

The Danish Wind Industry homepage has an amazing number of resources on siting a wind turbine that are searchable by topic. Check it out!

- http://www.windpower.org/composite-85.htm

Turbine Manufacturer Data:

These links have been compiled by the designer at KidWind and will take you to some specification sheets from a variety of small turbine manufacturers. You can examine their output curves and read more about the characteristics of small wind turbines.

Some major manufacturers of small and large wind turbines include:

- Bergey Windpower
  http://www.bergey.com/

- Southwest Windpower
  http://www.windenergy.com/

- Proven Windpower
  http://www.provenenergy.co.uk/

- GE Windpower
  http://www.gepower.com/businesses/ge_wind_energy/en/index.htm

- Vestas
  http://www.vestas.com/uk/Home/index.asp

- Suzlon
  http://www.suzlon.com/

- Gamesa (The turbines featured in the Bear Creek videos are manufactured by this company).
  http://www.gamesa.es/gamesa/index.htm

Mapping Tools:

- TopoZone
  http://www.topozone.com/
- Google Earth
  http://www.googleearth.com