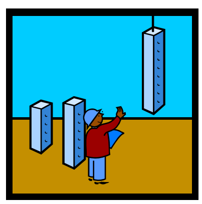
# Topic 2 Student Activities

# Wind Basics

# Topic 2: Wind Basics

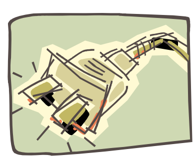
These activities will help students understand the basics of wind. The students will be able to understand how wind is formed and how it is measured. Students will get hands on experience with a model turbine to see how it works and watch it produce electricity right before their eyes. Finally the students should be able to calculate the wind power output and understand how wind power contributes to the electricity portfolio.











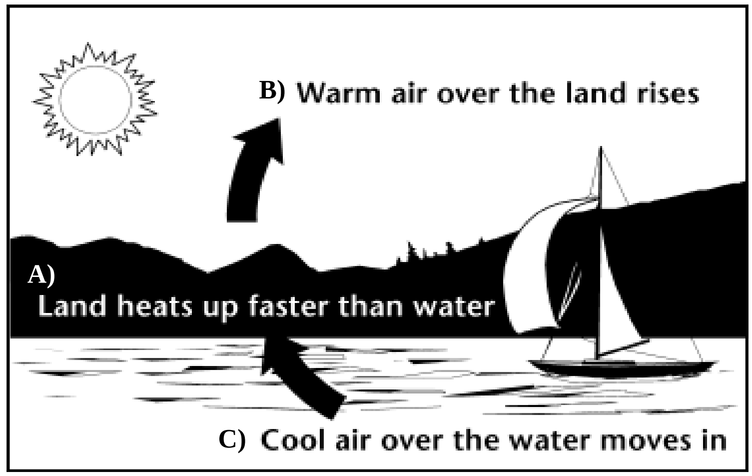




# Topic 2: Wind Basics

**Teacher Answer Key**

## Wind Flow




1.) Have students label diagram and in a brief paragraph describe how wind is produced and answer the following questions.
  a. Why does the warm air rise and the cooler air stay near the ground?
  b. Would the direction of the air current change at night and why?

## Model Wind Turbine Activities

1.) Have students hook the bulb and voltmeter to the turbine, please see page 7 of the KidWind wind turbine manual.
2.) Next have the students write down a hypothesis for what will happen to the power output when the wind speed on the fan is changed and when the pitch of the blades are changed. Students can fill in the chart below by noting the brightness of the bulb and recording the voltmeter reading.
3.) Blade Pitch (see example below)

| Blade Pitch | Visual Example |
|---|---|
| 0 degree | |
| 45 degree | |
| 90 degree | |

| Wind Turbine Activities | | |
|---|---|---|
| **Wind Speed** | **Bulb** | **Voltmeter** |
| 1 (Low Setting) | | |
| 2 (Med. Setting) | | |
| 3 (High Setting) | | |
| **Blade Pitch** | **Bulb** | **Voltmeter** |
| 0 degree | | |
| 45 degree | | |
| 90 degree | | |

# Topic 2: Wind Basics

**Wind Power Output**

Have the students calculate the power output from a turbine model below. Also have the students calculate how many homes different turbine models can power. Remember this is a simplified version of the wind power density equation, the purpose is to give students an idea of wind power output.

| GE Energy | www.gepower.com, | | | |
|---|---|---|---|---|
| **Model** | **Rotor Diameter** m | **Swept Area** $m^2$ | **Cut In Speed** m/s | **Cut Out Speed** m/s |
| **1.5 MW** | 70.5 | 3,904 | 4 | 25 |
| **2.5 MW** | 100 | 7,854 | 3.5 | 25 |
| **3.6 MW** | 111 | 9,677 | 3.5 | 27 |
| | | | | |
| **Vestas** | www.vestas.com | | | |
| **Model** | **Rotor Diameter** m | **Swept Area** $m^2$ | **Cut In Speed** m/s | **Cut Out Speed** m/s |
| **V80-1.8 MW** | 80 | 5,027 | 4 | 25 |
| **V82-1.65 MW** | 82 | 5,281 | 3.5 | 20 |
| **V90-3.0 MW** | 90 | 6,362 | 4 | 25 |

1.) Using the power output equation (below), chose a turbine model (above), use the swept area and chose a wind velocity between the cut in and cut out speeds.

$$P = \frac{1}{2}\rho A V^3$$

$\rho$ = Density of Air

A = Area of the Turbine Blades ($m^2$)

V = Wind Velocity (m/s)

P = Power output in watts (w)

The density of air is about 1 kg/$m^3$

**Example**

GE 1.5 MW turbine, 3904 $m^2$ swept area, wind speed of 8 m/s.

$$P = 1/2 * 1\text{kg/m}^3 * 3904\ \text{m}^2 * (15\ \text{m/s})^3$$

$$\mathbf{P = 6{,}588{,}000\ watts\ (w)}$$

2.) Using the power output from the turbine above that was calculated, have the students now calculate how many homes the turbine can power.

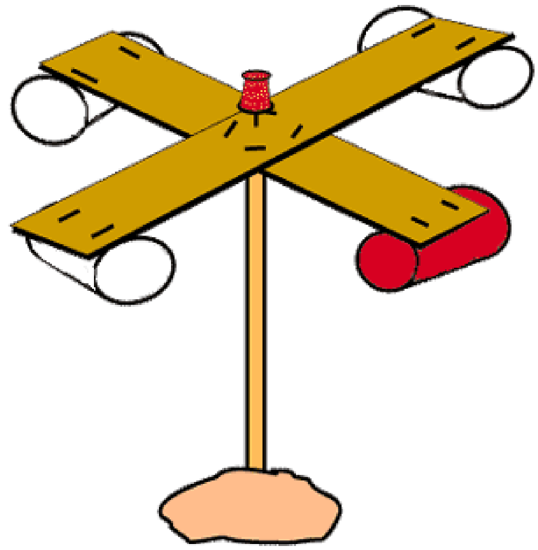
6,588,000 W * 1 MW/1,000,000 W = 6.58 MW

6.58 MW * 300 homes/1 MW = 2055 homes

**Power units:**
1KW = 1,000 W
1 MW = 1,000,000 W
1 MW can power 300 homes.

# Measuring the Wind - Constructing an Anemometer

**Group Activity**



**Materials Needed:**

1. Scissors
2. 4 small paper cups (like drinking cups)
3. A marking pen (any color)
4. 2 strips of stiff, corrugated cardboard, the same length
5. Ruler
6. Stapler
7. Push pin
8. Sharpened pencil with eraser on the end
9. Modeling clay
10. A watch that shows seconds

**Directions:**

1.) Cut off the rolled edges of the paper cups to make them lighter.

2.) Color the outside of one cup with the marking pen.

3.) Cross the cardboard strips so they make a plus (+) sign. Staple them together.

4.) Take the ruler and pencil and draw lines from the outside corners of where the cardboard strips come together to the opposite corners. Where the pencil lines cross will be the exact middle of the cross.

5.) Staple the cups to the ends of the cardboard strips; make sure the cups all face the same direction.

6.) Push the pin through the center of the cardboard (where the pencil lines cross) and attach the cardboard cross with the cups on it to the eraser point of the pencil. Blow on the cups to make sure the cardboard spins around freely on the pin.

7.) Place the modeling clay on a surface outside, such as a porch railing, wooden fence rail, a wall or a rock. Stick the sharpened end of the pencil into the clay so it stands up straight.

8.) Use the watch, to count the number of times the colored cup spins around in one minute. The anemometer will measure the wind speed in revolutions (turns) per minute.

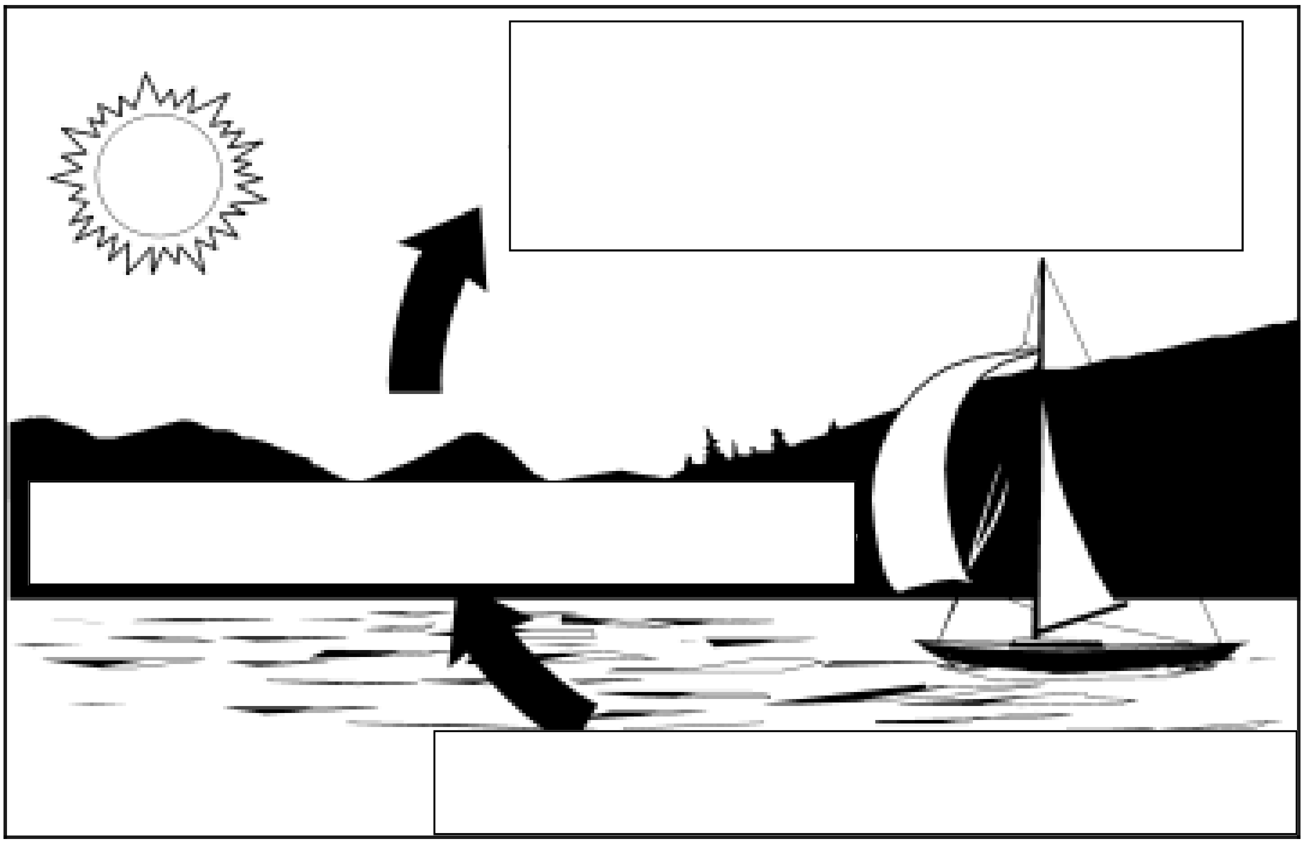
**Have the students measure the wind speed at different times of day (morning & afternoon) and different locations around the school and note the differences in wind speed and discuss reasons why.

# Wind Flow Patterns

Name:____________________________________

**Directions:** Label the diagram and write a brief paragraph that describes how wind is produced and in the paragraph answer the questions below.

a. Why does the warm air rise and the cooler air stay near the ground?
b. Would the direction of the air current change at night and why?



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# Wind Power Output

Name:________________________________

Calculate the power output from the different turbine models below as well as calculate how many homes different turbine models can power.

| **GE Energy** | www.gepower.com, | | | |
|---|---|---|---|---|
| **Model** | **Rotor Diameter** m | **Swept Area** $m^2$ | **Cut In Speed** m/s | **Cut Out Speed** m/s |
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| **V82-1.65 MW** | 82 | 5,281 | 3.5 | 20 |
| **V90-3.0 MW** | 90 | 6,362 | 4 | 25 |

1.) Using the power output equation below, chose a turbine model, use the swept area and chose a wind velocity between the cut in and cut out speeds.

Turbine Model:____________________

Swept Area:_______________________

Wind Speed (m/s):_________________

Power Output:_____________________

$$P = \frac{1}{2}\rho A V^3$$

$\rho$ = Density of Air

A = Area of the Turbine Blades ($m^2$)

V = Wind Velocity (m/s)

P = Power output in watts (w)

The density of air is about 1 kg/$m^3$

2.) Calculate how many homes your turbine can power.

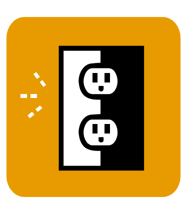
Turbine Model:____________________

Power Output:_____________________

Number of MW:____________________

Number of Homes:_________________

**Power units:**
1 kilowatt (kW) = 1,000 watts (w)
1 megawatt (MW) = 1,000,000 (w)
1 MW = Electricity for 300 homes

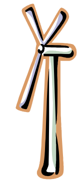


# Get to Know Your Turbine

Name:______________________________

1.) Hook up the bulb and voltmeter to the turbine. (Please see page 7 of the Kidwind wind turbine manual)

2.) Write down a hypothesis for what will happen to the power output when the wind speed on the fan is changed and when the pitch of the blades are changed. Use the chart below to record your findings.



**Hypothesis**

______________________________

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| Wind Turbine Activities | | |
|---|---|---|
| **Wind Speed** | **Bulb** | **Voltmeter** |
| 1 (Low Setting) | | |
| 2 (Med. Setting) | | |
| 3 (High Setting) | | |
| **Blade Pitch** | **Bulb** | **Voltmeter** |
| 0 degree | | |
| 45 degree | | |
| 90 degree | | |

# Get to Know Your Turbine con't...

Now that you have had a chance to interact with the turbine, answer the following questions below:

1.) Did the voltmeter readings and bulb brightness correspond?________________________

2.) On what fan setting and blade pitch were the voltmeter readings highest and the bulb the brightest?________________________

3.) Describe what happened when the blade pitches were at 0 degrees, 45 degrees and 90 degrees.________________________

4.) Using knowledge from previous discussions and from the turbine activity, explain the process of how a turbine works.________________________

# Parts of a Turbine

Name:__________________________________

**Label parts of the wind turbine using the terms below:**

Rotor
Tower
Nacelle
Hub
Blade