Title  Harnessing the Wind for Electricity

Subject Area(s)  GEOMETRY
Associated Unit  Area
Lesson Title  Area Application

Intro Creative ideas: (song . . . running with the wind by Eddie Rabbitt) Band: Electric Light Orchestra, video clip of sailboat on ocean(CS&N)
Contrasts of Electricity usage
  Bad  Hurricane Katrina, electricity accident
  Good: sailboat, TV, A/C, food

Grade Level  9
Lesson Dependency  None
Time Required  90 minutes

Summary
Wind can be harnessed to spin a turbine blade. The blade is connected to an electrical generator sending electricity to the local power grid and then to our homes. This lesson investigates topics needed to be considered in this task.

Engineering Connection
Power of Wind, Blade Design, Energy Conversion: mechanical- electrical, Rotating Machinery

Engineering Category
Electricity Generation

Keywords
Fossil fuel  Linear
Pollution  Maximum
Turbine  Degrees in a circle
Generator  Interpret graphs
Circle  Area
Educational Standards

TEKS

(G.2.A) use constructions to explore attributes of geometric figures and to make conjectures about geometric relationships

(G.8.A) find areas of regular polygons, circles, and composite figures

Pre-Requisite Knowledge

Area of common shapes
The whole is = to sum of its parts

Learning Objectives

- Area and Energy of flow thru a 100 meter diameter turbine blade in a 10 meter/second wind

Area of circular path the blades trace out = $\pi r^2$

So for a 100 meter diameter turbine blade . . .
radius = 50 meters

Area = $\pi 50^2 = 7854 \text{ meters}^2$

Energy($v$) = $\frac{1}{2}$ (air density) (A) ($v^2$) =
(1/2) (1.2256) (7854) (10^2) =

493,074 joules = 137 watt-hours

Units
energy($v$) (joules) = $1/2 \ (kg/m^3) \ (m^2) \ (m/sec)^2$

1 watt-hour = 3600 joules
-59% of this energy is the MAXIMUM that can be captured, per Betz’s formula

**Introduction / Motivation**
Ways we use electricity and why
How did people do without it
When did it start . . . Thomas Edison 1882  Pearl Station, NY 1 square mile

**Lesson Background & Concepts for Teachers**
Reducing our dependence on fossil fuel is good for our country because we are more energy independent from foreign governments and we pollute our environment less.

**Rationale:**
(Evaluation thinking skill)

Why wind : Good for earth verses:
- **Nuclear**: waste, danger
- **Fossil fuels** like coal, oil, natural gas pollute effluents & increase global warming

(Analysis)
Compare and contrast 3 versus 4 bladed pinwheel design discussing critical attributes

**Vocabulary / Definitions (student homework from google search)**

<table>
<thead>
<tr>
<th>Word</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>Turbine</td>
<td>rotary device in which the kinetic energy of a moving fluid is converted into mechanical energy by a bladed hub</td>
</tr>
<tr>
<td>Electrical Generator</td>
<td>a rotating device that converts mechanical energy to electrical energy</td>
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<tr>
<td>Maximum</td>
<td>largest of a quantity</td>
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<tr>
<td>Fossil fuel</td>
<td>fuel derived from hydrocarbon deposits such as coal, petroleum, natural gas</td>
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**MODELS:**

Pinwheel pattern to be assembled by each student
Fan and Strobe Tachometer to allow observation of an individual fan blade in motion

OTHER:

In the words of Jamie Escalante, (who I had the pleasure off seeing speak at UTA this summer as honored guest of Hispanic Engineers)
“Mathematics is the world’s equalizer,” i.e., it can be learned and practiced by anyone from any culture/race/gender. A solution to a problem is a solution without regard for who did it. Anyone can learn to be proficient at engineering as long as they are willing to be dedicated enough to rise to the level of the required work.

Windmills have been used for centuries to pump water for irrigation purposes. The Nile would annually flood. What an improvement in people’s lives to be able to move the water to where they wanted it.

My project moves this enhancement of life to a level higher . . . electrical power. Electricity from the wind for whoever has the inclination and is willing to do the work to design/build/install the equipment. These do involve a substantial financial investment. Is this something the World Bank should consider supporting for third world countries aspiring to modernize? The following countries are the most advanced with their efforts to harness the wind for the purpose of electrical power. It is clear that many cultures are using technology to harness the wind for electrical power generation.

1. The United States

Power from wind turbines are used very efficiently in the United States, and this equipment is being placed in greater numbers here to further benefit the population, and break away from the dependence on foreign oil and fossil fuels which pollute the air and environment. Wind energy is a clean and renewable source of power, and this country is utilizing it in greater amounts than ever before.

2. Germany

Germany is one of the top countries when it comes to going green concerning energy, and around ten percent or more of the energy used by the population of this country is supplied by wind turbines. This power is harnessed very efficiently here, and helps to reduce the carbon footprint that the residents of Germany are leaving on the earth.

3. India

India may be considered a developing or third world country, but when it comes to wind energy this country is one of the top ten. Five percent or less of the power needed for the country is supplied by the
wind, but this percentage increases steadily each year. In the near future India may surpass larger and more developed countries where alternative energy sources are involved.

4. France

France has a history of energy efficiency, and this is also true when it comes to using wind turbines to generate electricity which is environmentally friendly. This country generates around one percent of the energy used by the population from this alternative source, and other renewable sources like ocean power and nuclear generation are used as well.

5. The United Kingdom

The United Kingdom has a significant number of wind turbines in use, to harness this natural energy source and provide much needed power. This country has many areas which see high wind averages all year long, and this makes this power source extremely efficient when the equipment is placed in the right locations. Between one and two percent of the annual consumption of this country is provided using this alternative source.

6. Spain

Spain is one of the top ten countries when it comes to efficient use of wind energy. More than eleven percent of the power used in this country is supplied thanks to these turbines, which harness the wind energy. Spain has always shown an inclination towards environmental protection and green power sources, and the high use of this equipment just reaffirms this commitment to green power for the future.

7. China

China is considered by many to be very environmentally unfriendly, but this is changing quickly. Wind turbines installed here work very efficiently to provide the energy needed by the billions of residents, and their use is being increased at a very rapid pace. The high population means finding alternative power sources which are renewable and inexpensive, and this technology meets these needs in an efficient manner.

8. Italy

Italy is a beautiful place to visit or live, and it is very eco-friendly as well. Wind turbines generate energy very efficiently here, providing a portion of the electricity used in homes and businesses while keeping the beauty and landscape undamaged.

9. Denmark

Denmark has always been known as a place where the environment is important, and this is one of the most efficient when it comes to alternative energy and using wind turbines as well. Around one fifth of the power that is used by the residents here is provided from this equipment, and this country does not suffer from the pollution, smog, and other problems which are evident in other places around the world.

10. Portugal

Portugal may be a small nation, but it has a big impact when it comes to alternative renewable energy sources, and this includes wind. More than eleven percent of the electricity supplied here comes from this one source being harnessed efficiently.
Lesson Closure
While wind has significant energy to provide a portion of our electrical needs and to move our current use from 1% to our government’s hope for 20% by 2030, the cost of the equipment and wind speed as a variable must be considered. We can alter our uses of electricity as an additional component to lesson our dependence on foreign energy and/ or pollute less.

Assessment
-Internet Google search of electricity generation from Wind Turbines
-Why do you think your parents do not have a wind generator in your backyard?

Lesson Extension

Major uses of electricity in our homes?
- 
-
-
-

Minor uses of electricity in our homes?
- 
-
-
-

Ways to reduce Electrical Consumption

-use less
-insulate

Photos of geometric shapes essential to deal with when insulating my attic (my summer 2009 project)

-Trapezoid
-Triangle
-Rectangle
Costs (cents per kw-hr) of Electricity Generation by:
- nuclear
- fossil fuel (coal, natural gas, oil)
- water
- wind

**Multimedia Support Attachments:**
1) Geographic wind data
2) Power as function of wind speed
3) Wind as function of time and electrical use as function of time
4) photos of geometric shapes in attic

**Contributors**
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**Sponsor**
National Science Foundation under Grant No. EEC-0808687
North and South Korea satellite photo taken at night. Do you notice any difference?