the CEED

THE CENTER FOR ENERGY EFFICIENT DESIGN

Renewable Energy Conversions and Comparisons

Grade Level	Middle School-8th	**Subject**	Physical Science

Objective(s):

Compare electrical energy output of windmills and solar cells.

Design windmill blades to determine most efficient shapes and pitch.

SOL Addressed:

PS.6 The student will investigate and understand forms of energy and how energy is transferred and transformed. Key concepts include

a) potential and kinetic energy; and
b) mechanical, chemical, electrical, thermal, radiant, and nuclear energy.

PS.10 The student will investigate and understand the scientific principles of work, force, and motion. Key concepts include

c) work, force, mechanical advantage, efficiency, and power;

PS.11 The student will investigate and understand basic principles of electricity and magnetism. Key concepts include

c) electromagnets, motors, and generators and their uses.

Next Generation Science Standards:

MS-PS2-2, Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

MS-PS3-5Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object**.**

Materials Needed Per Class of 30 **and** **Prior Knowledge**	There are several options. Kits from Pasco are available, called Renewable Energy Kits, that have windmills and blade options that students will put together and compare with each other. There is also a solar cell in this kit along with a generator, an LED light, and radio to illustrate energy has been generated. KidWind also has kits that can be borrowed (through James Madison University for Virginia Teachers) with supplies. Some can create their own windmills from PVC pipe and rotors that connect to small generators. The students make blades out of poster board. Per group: 1 multimeter or voltage meter, small 1.5 volt electrical engine, LED light with a propeller.

<table>
<tr><td>Ways to differentiate this lesson plan</td><td colspan="2">EXTENSION: Observe changes in the voltage when wind blows at different speeds, or with a solar cell, change the amount of sunlight that hits the surface. (change angle, place plastic over the surface, etc)
MODIFICATIONS: Windmills can already be built for comparison with solar cells.</td></tr>
<tr><td>Introduction/ Anticipatory Set</td><td>Anticipatory Set:
Observe at least two examples of windmills and compare their movement, speed, wobbling,

Questions to ask students:
Where are windmills installed and why?
How many blades should you include?
How should the blades be pitched (tilted)?</td><td>Introduction:
Students should be familiar with the ways energy is converted-kinetic (wind) and solar can be converted to electrical. How windmills are the turbines connected to the generator.

Challenge students to create windmill blades that produce the most voltage. Test windmills with a fan. Will it cause the light to come on (music to play)?</td></tr>
<tr><td>Guided Practice</td><td colspan="2">Allow time for research online if possible to find out what companies are using and why. What is pitch? How are most blades shaped? Why? Does spin speed matter? What about weight (which can be a problem with poster board).

Sample Facilitator Questions for the Activity:
Does weight have an effect?
Why does the windmill wobble? How can that be alleviated?</td></tr>
<tr><td>Independent Practice</td><td colspan="2">Once students start to build or compare blades, they should analyze ways to change the blade and make it better. This is a trial and error activity.

For another day, set up solar cells in different areas/angles and measure voltage. Compare with windmills. Identify advantages and disadvantages to both wind and solar.</td></tr>
<tr><td>Closure (Summary of Lesson)</td><td colspan="2">What worked best for both types of renewable energy? Have students discuss the process they went through to come to their conclusions. What would you do differently if you have better materials?</td></tr>
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CEED Building Application/ Sensor Data	Collect data that shows the amount of wind power produced with the measured wind speed. Collect data of solar power produced on sunny and cloudy days. Students can create their own graphs and compare data.
Assessment	Graphs of CEED data should be labeled with proper units and spacing. http://dashboard.intellergy.us/ceed/index.php