**Title:** Power Up: Exploring renewable energy generation

**Type:** Energy

**Provided by:** Hathaway Brown School, Shaker Heights, OH

**Grade Levels:** 4-5

**Lesson Topic:** Renewable electricity generation

**Learning Standards Addressed:** Hathaway Brown does not align curriculum to State standards.

**Performance Objectives:**

* Students will become familiar with a variety of mechanisms for producing renewable power.
* Students will practice measuring power output and recording and interpreting data.
* Students will discuss the pros and cons of the different power generation methods.

**Required Materials:**

* 1 Window Solar, modified for measuring power output
* 1 nPowerPEG, modified for measuring power output
* 1 PocketSocket by K-Tor
* 1 Sunlinq Folding Solar Power Panel
* 1 C-clamp large enough to clamp the pocket socket to a table
* 4 Digital Voltmeters or Digital Multimeters

**Anticipatory Activity:**

* Begin with a class discussion asking students to list things that they use in their lives that use electricity.
	+ Where does the electricity come from?
		- Students will likely say electricity comes from outlets in the wall. Help them trace the source of the electricity backwards to the power plant, and ultimately to the fuel for the power plant.
		- Discuss concept of renewable and non-renewable power sources. Make list on board.
* How can we generate our own electricity here at school or at home? (Look back at list of ways generating electricity and ask which you might be able to do at a smaller scale.)

**Lesson Activities and Procedures:**

* Explain to students that they are going to rotate through four stations, each with a different portable electricity generator. Students will be recording data about how much energy is generated by each device under different conditions, and then will discuss the pros and cons of the different options for generating power.
* Demonstrate to students how to measure the power output of the devices using the digital voltmeters or multimeters.
* Students will move through the stations in the following manner, spending approximately 10 minutes per station (Alternatively, assign each group to work with just one of the devices, and have each group report back to the class):

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **nPowerPEG** | **Pocket Socket** | **Window Solar** | **Sunlinq Solar** |
| **Rotation 1** | Group A | Group B | Group C | Group D |
| **Rotation 2** | Group B | Group A | Group D | Group C |
| **Rotation 3** | Group C | Group D | Group A | Group B |
| **Rotation 4** | Group D | Group C | Group B | Group A |

* Have the students create bar graphs of the average power generated by each device under the different conditions. (Again, this can either be done by everyone in the whole class, or each group can graph the data for one of the stations.)

**Plans for Independent Practice:**

**Closure:**

* Discuss the graphs as a class. What conclusions can they draw from the data? Some prompting questions might include:
	+ Which generator produced the most power? The least?
	+ What happened when you moved the solar generators inside near a window? Was anything different? If so, why do you think this happened?
	+ What happened whey you placed the solar panel generators in the shade? When you covered them partially and completely? Why do you think this happened?
	+ What happened when you shook the nPowerPEG harder? Cranked the Socket Rocket faster? Why do you think this happened?
	+ How are the devices similar? How are they different?

**Assessment and Follow-up:**

* Students should turn in their data sheets and graphs for review by the teacher.
* Have each student write one paragraph responding to the prompt: If you were stuck without power, which of these devices would you want to have in your emergency kit? Why? Be sure to use data to support your answer.

**Adaptations and Accommodations:**

* Make sure the groups are of mixed ability levels.
* Instead of taking multiple readings for each “treatment” with the devices and averaging them for the graphs, take only one reading from the voltmeter/multimeter for each treatment. Use these individual measurements for the graphs and discussion.

**Enrichment Activities:**

* Before beginning the work at stations, have the students write down hypotheses for the different “treatments” for each device. Follow-up by having them write short lab reports.
* Connect the ideas for power generation represented by these devices to residential scale and commercial scale renewable power generation. Solar power captures the sun’s energy. We can do this at a small scale (like the little solar panels they worked with), at a medium scale (HB’s solar charging station), or at a large scale (solar farms). Solar thermal water heating is another way we directly capture the sun’s energy. The nPowerPEG and Pocket Socket both capture kinetic energy to make electricity. Like solar power, this can also be done at a medium and large scale. Hydropower and wind power both work using the same principle of capturing kinetic energy and converting it to electrical energy.
* Show the students the boxes from each device. Ask them if there was a way to know ahead of time (without using the devices) which one would generate the most power. Have them practice reading the boxes, looking particularly for information on output of Watts, Volts and amps.
	+ Pocket Socket – 10 W, 120 V DC
	+ Window Solar – 0.6W, 5 V/1A max output, battery capacity 2600-6000mAh
	+ Sunlinq Folding Solar Power Panel – 6.5 W, 12V, 433 mA
	+ nPowerPEG – no info on W or V, 2000mAh battery (from website: 2.5 W, 5V DC output, 500mA output)

**Measuring Electricity Generation**

**nPowerPEG**

1. Describe the device. What does it look like? What is the source of power?
2. Connect the voltmeter or multimeter to the nPowerPEG. Hang the nPowerPEG over your shoulder and walk around the room at a regular walking pace. On your data sheet, record the highest reading for the volts generated that you get on the voltmeter/multimeter. Have each person in your group do this, recording the highest reading each time.

1. Holding the nPowerPEG in your hands, gently shake it for about 10 seconds. You should feel the weight inside it moving up and down on the springs. Try to sense what the natural rhythm of the weight is on the springs. Record the volts of electricity generated on the data sheet. Have each person in the group do this.
2. Again holding the nPowerPEG, shake it as hard as you can for about 10 seconds. Record the highest volts generated. Have each person in the group do this.
3. Record any observations you make about using this device.

**Measuring Electricity Generation**

**Pocket Socket**

1. Describe the device. What does it look like? What is the source of power?

1. Connect the voltmeter/multimeter to the Pocket Socket. Crank the Pocket Socket gently, completing 1 rotation of the crank every 2 seconds. Try to keep your motion even and speed consistent throughout. Keep cranking for 15 seconds. Record your highest volts generated. Have each person in the group do this.

1. Crank the Pocket Socket a bit harder, completing 1 rotation every 1 second. Again, try to keep your motion eve and consistent throughout. Keep cranking for 15 seconds. Record your highest volts generated. Have each person in the group do this.

1. Crank the Pocket Socket even harder, completing 2 rotations every 1 second. Again, try to keep your motion eve and consistent throughout. Keep cranking for 15 seconds. Record your highest volts generated. Have each person in the group do this.
2. Record any observations you make about using this device.

**Measuring Electricity Generation**

**Window Solar**

1. Describe the device. What does it look like? What is the source of power?

1. Connect the voltmeter/multimeter to the Window Solar device. Place the device in full sun outside, holding the panel so that it is vertical. Leave it there for 15 seconds. Record the highest volts generated during this 15 second period. Do this 3 times.

1. Repeat the process in step 2, but this time lay the panel horizontal on the ground.
2. Find a place outside that is in the shade of a tree or of the building. Place the panel horizontally on the ground. Record the highest volt reading on the voltmeter/multimeter over a 15 second period. Do this 3 times.

1. Bring the device back inside next to a window that has full sun coming through it. Repeat steps 2 and 3 in the sun coming through the window.
2. Cover the panel completely with a folder or notebook. Record the highest volt reading on the voltmeter/multimeter over a 15 second period. Do this 3 times.
3. Record any observations you make about using this device.

**Measuring Electricity Generation**

**Sunlinq Folding Solar Panel**

1. Describe the device. What does it look like? What is the source of power?

1. Connect the voltmeter/multimeter to the Sunlinq Folding Solar Panel. Place the device in full sun outside, laying it horizontally flat on the groud. Leave it there for 15 seconds. Record the highest volts generated during this 15 second period. Do this 3 times.

1. Move the panels so that half of the solar cells are in the shade and half are in full sun. Leave it there for 15 seconds. Record the highest volts generated during this 15 second period. Do this 3 times.
2. Repeat the process for in step 3, but this time move the whole device into the shade.

1. Move the device back into full sun. Cover two of the cells with a notebook or folder, leaving 2 cells in full sun. Leave it there for 15 seconds. Record the highest volts generated during this 15 second period. Do this 3 times.
2. Cover the panel completely with a folder or notebook. Record the highest volt reading on the voltmeter/multimeter over a 15 second period. Do this 3 times.
3. Record any observations you make about using this device.

**Data Sheet**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Trial 1** | **Trial 2** | **Trial 3** | **Trial 4** | **Trial 5** | **Mean** |
| **nPowerPEG** |  |  |  |  |  |  |
| **Walking** |  |  |  |  |  |  |
| **Shaking gently** |  |  |  |  |  |  |
| **Shaking hard** |  |  |  |  |  |  |
| **Pocket Socket** |  |  |  |  |  |  |
| **Cranking 1 rotation/2 seconds** |  |  |  |  |  |  |
| **Cranking 1 rotation/1** **second** |  |  |  |  |  |  |
| **Cranking 2 rotations/1 second** |  |  |  |  |  |  |
| **Window Solar**  |  |  |  |  |  |  |
| **Full sun, outside,****vertical** |  |  |  |  |  |  |
| **Full sun, outside,****horizontal** |  |  |  |  |  |  |
| **Full sun, inside,****vertical** |  |  |  |  |  |  |
| **Full sun, inside,** **horizontal** |  |  |  |  |  |  |
| **Shaded sun** |  |  |  |  |  |  |
| **Fully covered (no sun)** |  |  |  |  |  |  |
| **Sunlinq Solar**  |  |  |  |  |  |  |
| **Full sun** |  |  |  |  |  |  |
| **2 cells partial sun,** **2 full sun** |  |  |  |  |  |  |
| **All cells partial sun** |  |  |  |  |  |  |
| **2 cells covered (no sun)****2 cells full sun** |  |  |  |  |  |  |
| **All cells fully covered****(no sun)** |  |  |  |  |  |  |