Solar vs. Wind Energy

Lesson 6: Variables Affecting Solar Power

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GRADE LEVELS: 7-8

LESSON DURATION: 2-3 days

SUBJECT AREA(S): science, electricity, photovoltaic cell, current, voltage, energy, power, hypothesis, variables, investigation

LESSON OVERVIEW:

Students have experimented with different turbine variables to see how the amount of electrical power is affected. After each team completes testing their chosen variable, the highest wind turbine configurations from each team will tested against one another. The turbine that generates the most power from this lesson will then compete with a photovoltaic cell of approximately equivalent cost to see whether wind or solar is the most economical (in the next lesson).

OBJECTIVES:

- Students will be able to identify and explain at least three variables that effect the efficiency of photovoltaic cells
- Students will conduct a scientific investigation to determine which photovoltaic cell configuration will generate the most power.

NEXT GENERATION SCIENCE STANDARDS:

MS-PS3-4: (Science and Engineering Practices)

- Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.

MS-PS3-1 (Science and Engineering Practices)

- Construct and interpret graphical displays of data to identify linear and nonlinear relationships

MS-ETS1-2

- Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

COMMON CORE STANDARDS:

CCSS.ELA-Literacy.RST.6-8.3

- Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

STUDENT BACKGROUND: This lesson assumes some knowledge of circuits and understanding about how electricity can be generated using photovoltaic cells.

EDUCATOR BACKGROUND: It will be helpful if you have a basic understanding about how to generate electricity using photovoltaic cells. Here is a simple video giving the basic idea. https://www.youtube.com/watch?v=KR2cW3lfphQ

KEY VOCABULARY:

- Alligator clips
- Multimeter
- Photovoltaic Cell
- Volts
- Current

MATERIALS NEEDED FOR PHOTOVOLTAIC CELL:

- Computer with internet access and LCD projector connected
- Two wires with alligator clips per group
- 3.0 V photovoltaic cells – 1 per group
- 2.0 V photovoltaic cells – 1 per class (only one group will change the size of the PV cell)
- 1.5 V photovoltaic cells – 1 per class (only one group will change the size of the PV cell)
- Clamp lamp (search Amazon for “clamp lamp”)
- Three sizes of halogen bulb (50 W – approx. 530 lumens , 75 W – approx. 1000 lumens, and 100 W – 1600 lumens). This is just a guide, you can choose to use halogen lights with different wattages/lumens depending on price and availability).
- Different kinds of bulbs (8 W LED, 13 W florescent bulb, 60 W incandescent bulb, and 43 W halogen) that all make roughly an equivalent amount of light even though they use vastly different amounts of electricity
- Protractor

- Multimeter
- Grain of Wheat Light Bulb (http://www.amazon.com/Memotronics-GOWSM-Bulbs-480-5-pack/dp/B00N6HY1FO/ref=pd_rhf_se_p_img_2?ie=UTF8&refRID=0XVNTYFY8CXAWJVT0E47) LEDs may work as well, but try it first as they can burn out easily with too much current.

PREP:

1. Gather materials above
2. Make copies of "Student Sheet 6: Measuring Power Generation in Photovoltaic Cells"
3. Make labeled bins with all of the different types of light bulbs, photovoltaic cells, multimeters, etc. for students to access.

LESSON 6:

Set up Photovoltaic (PV) cell and clamp light (10 minutes)

- Give students some time to set up and play with the photovoltaic cells along with the clamp lamp, alligator clips, and small grain of wheat light. If students struggle, remind students they will need to create a circuit in order for the light to turn on.

Brainstorming Variables (10) minutes)

- Have students work in their groups to come up with as many variables as they can that will affect the amount of amount of electricity produced by the PV cell and write their variables on "Student Sheet 6: Measuring Power Generation Photovoltaic Cells" (examples include: angle, distance from light, number of solar cells, voltage of solar cell, etc.) Assign (or allow each group to choose) which groups will test each variable. Note: Like yesterday's experiment, it is helpful if different groups choose different variables so students are exposed to more factors that influence PV efficiency.

Write Question, Hypothesis, and Procedure for Tested Variable (15-20 minutes)

- Have students work in their groups to fill out Part 2: "Write Question, Hypothesis, and Procedure for Tested Variable" for "Student Sheet 6: Measuring Power Generation Photovoltaic Cells"

  Teacher Note: It is highly advisable to check procedures from groups as they finish and check them off to be sure they are complete and specific. Also, some teachers like to have everyone in a group write the same procedure exactly OR you can have individual students write their own.

Perform Investigation (15 minutes)

- Have students perform the investigation and collect and graph data on "Student Sheet 6: Measuring Power Generation Photovoltaic Cells"

Communicate Data with Others (10-15 minutes)

- Have each group quickly share their question and the results they obtained. Examples of data shared could include: angle, distance from light, number of solar cells, voltage of solar cell, etc.

Which Photovoltaic Cell Configuration Generates the Most Power? (10-15 minutes)

- Choose one clamp light as the test set up. Then, have each group test photovoltaic cell configuration that generated the most power using the test set up (to make sure the test set up is valid for all groups). Keep track of the amount of power generated (or just voltage if you wanted to keep it simple) and write your data on the board.
- **Option #1:** Keep track of which configuration generated the most power. Save this photovoltaic configuration and test this model against the winning wind turbine blade configuration up next.
- **Option #2:** Alternatively, you could also take the best solar cell voltage, distance, angle, etc and combine it all into one configuration and use this set up to compete against the wind turbine.

The Final Contest!!! (10-15 minutes)

- Set up the winning wind turbine and fan configuration against the winning photovoltaic cell configuration to see which one generates the most power (or voltage if you want to keep this simple).
- Calculate the total cost of your wind turbine and the total cost of your photovoltaic cell and divide by the amount of power generated. This will give you the actual cost per Watt (milliWatt) and determine whether the wind turbine or the photovoltaic cell was more economical.

Class Discussion (10-15 minutes)

Questions to Discuss:

1. Was this contest valid (were the conditions close enough to “real life” that the results could be helpful in deciding whether or not to use solar or wind?)? Why or why not?
2. How could we have made this experiment more realistic?
3. What are some disadvantages of wind power?
4. What are some advantages of wind power?
5. What are some disadvantages of solar power?
6. What are some advantages of solar power?
7. Why is it important that multiple types of alternative energy (non-fossil fuels) are pursued simultaneously not just one or two types?
8. How many types of alternative power can you describe?
9. What is something you have learned from our unit “Solar vs. Wind power?”

POSSIBLE EXTENSION:

Have students research the average actual cost of wind turbines and photovoltaic modules per watt capacity installed. Then have students look up the “capacity factor” of both wind and solar plants in different parts of the country. The capacity factor will tell students what percentage of the time the wind turbine or photovoltaic module is producing at its full rated power capacity. So, a 3kW wind turbine with a capacity factor of 0.3 will produce 3kW 30% of the year, meaning that it will produce roughly 7,860 kWh per year (365 days x 24 hours/day x 3kW x 0.3). This will allow them to do some rough calculations on the actual relative cost of wind vs. solar in different parts of the country. Have them compare these numbers to their own observations through the in-class activity.

SOURCES AND WEBSITES USED:

How a PV Cell works
https://www.youtube.com/watch?v=KR2cW3lfphQ

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