Circuit Analysis With Solar Energy: Measure the Power Consumed by Various Devices

Activity Summary:

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DESCRIPTION: Students will set up a simple circuit using a solar module and three small loads. They will then use a multimeter to measure the voltage across each load and the current through each circuit. Students will then calculate the power consumption and resistance of each load.

GRADE LEVEL(S): 6, 7, 8, 9, 10, 11, 12

SUBJECT AREA(S): Energy, electricity, power, solar energy, circuit analysis

ACTIVITY LENGTH: 1 hour, 30 minutes

LEARNING GOAL(S):

- Students will understand that voltage is a measure of a difference in electric potential energy and that current is the rate at which charge flows through a circuit.
- Students will understand how to measure and quantify electricity.
- Students will become familiar with the relationships between the fundamental electrical quantities.

STANDARDS MET:

Common Core:

ELA/Literacy:

CCSS.ELA-Literacy.RST.6-8.3	Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
CCSS.ELA-Literacy.RST.9-10.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

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CCSS.ELA-Literacy.RST.9-10.5	Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
CCSS.ELA-Literacy.RST.11-12.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

Mathematics:

CCSS.Math.Content.5.OA.A.2	Write simple expressions that record calculations with numbers, and interpret numerical expressions without evaluating them.
CCSS.Math.Content.6.RP.A.3	Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.
CCSS.Math.Content.7.RP.A.1	Compute unit rates associated with ratios of fractions, including ratios of lengths, areas and other quantities measured in like or different units.
CCSS.Math.Content.7.RP.A.2	Recognize and represent proportional relationships between quantities.
CCSS.Math.Content.7.RP.A.3	Use proportional relationships to solve multistep ratio and percent problems. Examples: simple interest, tax, markups and markdowns, gratuities and commissions, fees, percent increase and decrease, percent error.

Next Generation Science Standards:

4-PS3-2	Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
4-PS3-4	Apply scientific ideas to design, test and refine a device that converts energy from one form to another.
MS-PS2-3	Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.
MS-PS2-5	Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.
HS-PS3-1	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).

HS-PS3-5 Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

SCIENCE KIT MATERIALS LIST:

- One solar module
- One multimeter

OTHER MATERIALS LIST:

- One 250-500W halogen shop light
- One sound board*
- One LED light*
- One mini battery-powered radio*
- Two alligator test leads
- Lab handout
- “How to Use a Multimeter Cheat Sheet” student handout

* Other low power, DC (battery-operated) devices such as calculators, clocks, etc. will work just as well

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Vocabulary:

- Power
- Voltage
- Current
- Resistance
- Electrical Load
- Multimeter

Student Background:

- Students should be familiar with fundamental electricity concepts, including voltage, current, resistance, power and energy
- Students should be familiar with using a multimeter and the basics of electrical circuits

Educator Background:

- It is helpful if teachers have a basic understanding of current, voltage, resistance and power. The background reading provided for students provides some explanation for teachers as well.

- The following mathematical relationships are used in this activity:
  - The power equation: Power = Current x Voltage (P=IV)
  - Ohm's Law: Voltage = Current x Resistance (V=IR)
- Recall the SI units for measuring voltage, current, power and resistance are as follows:
  - Voltage: Volts (V)
  - Current: Amps (A)
  - Power: Watts (W)
  - Resistance: Ohms (Ω)

Lesson Details:

1. Review the basics of using a multimeter with students:
   - Remind students that when they want to measure the voltage across something, they are measuring the difference in electrical potential energy between two separate places in the circuit.
   - If they want to measure the voltage drop across their load, they need to put one lead of the multimter at one side of the load (red wire to red wire or to the positive terminal) and one at the other side of their load (black wire to black wire or to the negative terminal).
   - Remind students that when they want to measure the current through their load, the current needs to travel through the multimeter, meaning that the meter needs to be in the same loop as the load.
   - Sometimes it's helpful to have students trace the possible path(s) through which current can flow with their finger to check how the meter is set up in the circuit.

2. Hand out materials to each student group and explain the goals of the activity.

3. Have students work through the lab.