UTAH OFFICE OF
ENERGY DEVELOPMENT

Harnessing the Sun's Energy

Grade/Subject: 7th Integrated Science

Strand/Standard SEEd 7.1.4 Collect and analyze data to determine the factors that affect the strength of electric and magnetic forces. Examples could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or of increasing the number or strength of magnets on the speed of an electric motor. (PS2.B)

Lesson Performance Expectations:

- Students will investigate solar panels' ability to produce volts and amps by collecting data with series vs parallel circuits and angles of light collection.

Materials:

Each group will require:

- Voltmeter
- 2-3 Photoelectric panels
- Motor (or other devices to attach to the panels)
- Protractor
- 2 Alligator clips

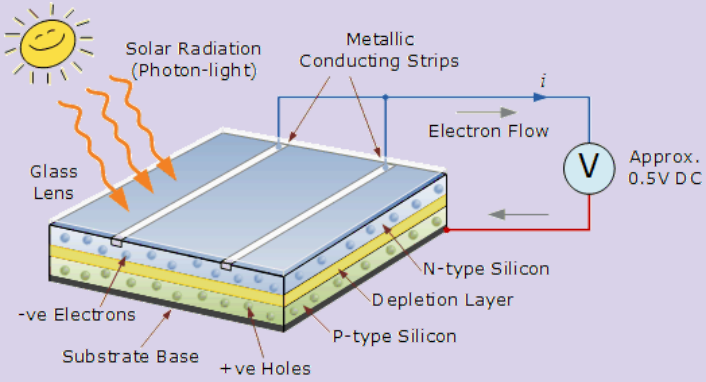
Time: One class period of 50 minutes.

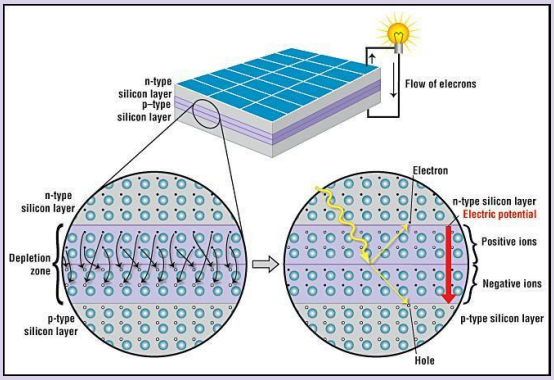
Teacher Background Information:

- Electromagnetic radiation is produced by fusion reactions in the sun's core. Some solar radiation is absorbed by the atmosphere as heat, while some fall on the Earth's surface as light and heat.
- Solar cells called photovoltaic cells (PV cells), convert the visible light in solar radiation directly into electricity. Solar cells produce direct current, just as a battery does, and can be used anywhere a battery can run things directly or charge the batteries. Many solar cells make up a solar panel. When a large amount of electricity is needed, many solar panels are connected to make a solar photovoltaic array. The Utah Red Hills Renewable Energy Park in Parowan, Utah, comprises a vast photovoltaic array that will provide electricity to 18,500 PacifiCorp customers. This plant expects to eliminate more than 145,000 tons of carbon dioxide emissions per year.
- The potential of photovoltaic (PV) cells as a renewable electricity source from the direct conversion of sunlight is enormous. Understanding the PV effect and the history of solar cells can provide a helpful perspective on research and development in energy technology.

- PV cells are made of a semiconductor, a material that conducts electricity (but not as well as a metal)—in PV cells, it's most commonly silicon. Pure silicon is nearly an insulator—very little electricity will flow through it. When light particles, called photons, hit the cell, their energy frees electron-hole pairs. Each photon with enough energy will usually free precisely one electron and result in a free hole as well. If this happens close enough to the junction, or if a free electron and free hole wander into its range of influence, the field will send the electron back to the N side and the hole to the P side.

- If an external current path—like wires attached to each side of the silicon—is provided, electrons will flow through the path to their original side (the P side) to unite with holes that the junction sent there. This electron flow provides the current, and the cell's junction causes a voltage. The electricity produced by a PV cell is direct current, like that produced by batteries. An inverter is often used to convert the direct current into alternating currents, like that obtained from a standard outlet.





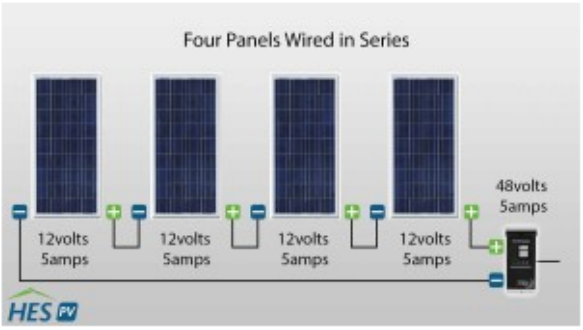
- Electricity produced by a solar PV system has low total life cycle emissions. (Source: National Renewable Energy Laboratory). However, the production of solar panels requires the use of the earth's natural resources such as copper, iron ore, selenium, and silica. To discover more about resources used to create solar panels, see [Minerals Education Coalition.]

Solar panels in a Series Circuit

Wiring Solar Panels in a Series Circuit

Connect the positive terminal of the first solar panel to the negative terminal of the next one.

eg. If you had 4 solar panels in a series and each was rated at 12 volts and 5 amps, the entire array would be 48 volts at 5 amps.

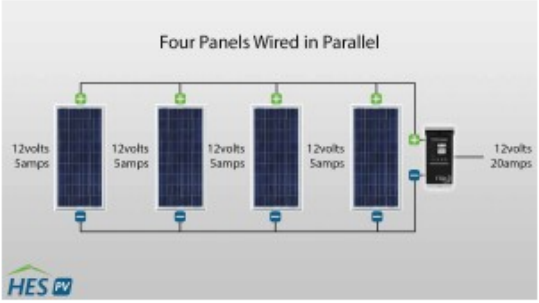


Solar panels in a Parallel Circuit

Wiring Solar Panels in a Parallel Circuit

Connect *all* the positive terminals of *all* the solar panels together, and *all* the negative terminals of *all* the panels together.

eg. If you had 4 solar panels in parallel and each was rated at 12 volts and 5 amps, the entire array would be 12 volts at 20 amps.



Student Background Knowledge:

- Students need to know how to work a multimeter here. (4:35 min)
- Students need to be familiar with what parallel and series circuits look like.
- Students need to understand how to use a protractor to measure angles.

Teacher Step by Step: A 3-d lesson should insist students do the thinking. Provide time and space for the students to experience phenomenon and ask questions. The student sheet provided below provides guidance but is only an example of how students might respond.

1. **Introduce *Phenomenon:*** Show the solar panel pictures. Find ones that the students may be familiar with in your area, like the solar array at the Rio Tinto Soccer stadium. This link has more pictures.

2. Ask the students to write down 3 observations and then ask 3 questions. Have them ask most of their questions without providing answers.

3. The students then answer the questions on the student worksheet.
4. Demonstrate the use of the voltmeter. Use 20 mv for most solar panels.
5. Students should experiment with 3 different ways to increase the electric output from the solar panels. One test should establish the best angle for the solar panel, and the other two should be some combination of the panels.

Assessment of Student Learning.
The summary should include a claim that the angle of the panel should be as direct to the sun as possible and that the panels should be connected in a series. Evidence should include the number of volts created by each experiment. Students should reason that the most direct angle to the sun captures the most energy and that more solar panels will collect more energy. A series circuit will allow the energy from each panel to be additive.

Standardized Test Preparation:

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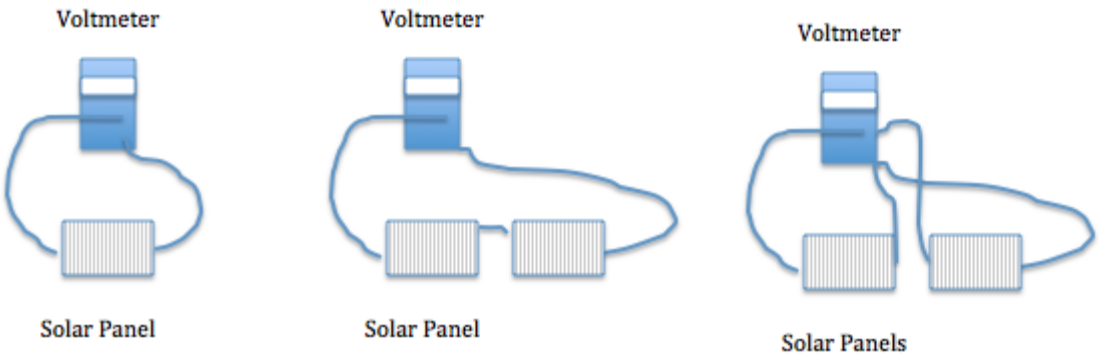
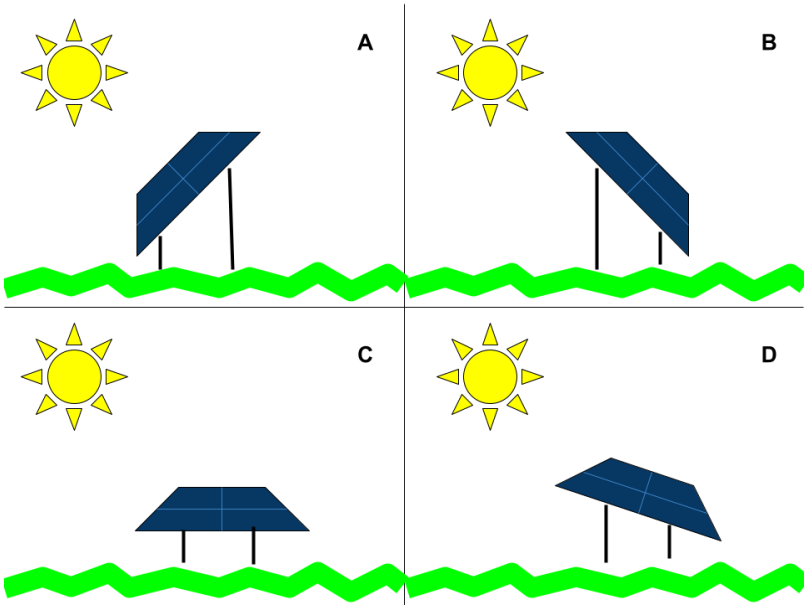
1. What are the first two steps when building a solar array with panels linked together?
   a. Measuring the energy output.
   b. Link the solar panels in a series circuit.
   c. Determine the angle they should be placed relative to the sun.*
   d. Find a location that is large and receives abundant sunlight.*

2. Which circuit would generate the most electricity, assuming the panels were all exposed to the same amount of sunlight?



A B* C

3. Which solar panel is getting the most energy from the sun?
A*



4. What advantages does solar energy have? Choose all that apply.

    a. The energy source is mostly free.*
    b. Solar energy produces low emissions.*
    c. Current energy sources produce emissions.*
    d. Solar energy costs are declining.

Extension of lesson:

- Have students explore how the production of solar panels requires the use of Earth's natural resources such as copper, iron ore, selenium, and silica. To discover more about resources used to create solar panels, see Minerals Education Coalition. Arrange a field trip to Rio Tinto Stadium or Bingham Copper Mine. The students could do the same experiment and measure amps instead of volts.
- Look into how temperature affects the efficiency of panels and brainstorm possible solutions. Agrivoltaics is an interesting idea that could lead to some class discussions.

Career Connections: Potential careers related to this activity: Physicist, Solar Technician, Materials Scientist

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Name_____

Phenomenon: Look at the phenomenon pictures. What are 3 observations? Now ask three questions about what you see.

Observations:

1.
2.
3.

Questions:

1.
2.
3.

Predict five things that Rio Tinto does with this energy from its solar panels.

1.
2.
3.
4.
5.

Where do you think the energy comes from? In your own words, explain the process.

How can you get the most energy from the solar panels you have? List 3 variables you could test.

1.
2.
3.

Use a voltmeter to measure the volts produced by the solar panels. Choose one of your variables and test it. Do the same with two other variables. You will need to take multiple readings for each of your variables.

Variable tested:	**Volts**	**Draw your design.**

Summarize your experiments by writing a claim statement about how you can strengthen the electrical strength of solar panels.

Claim

Evidence

Reasoning