UTAH OFFICE OF ENERGY DEVELOPMENT

The Solar Power Challenge

Grade/Subject: 4th Science

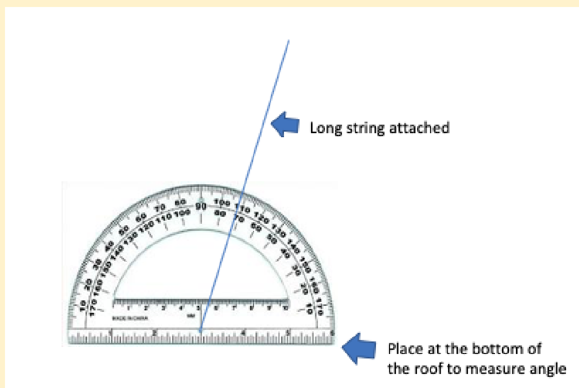
Strand/Standard 4.2.4 Design a device that converts energy from one form to another. *Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data from testing solutions, and propose modifications for optimizing a solution.* Emphasize identifying the initial and final forms of energy. Examples could include solar ovens that convert light energy to heat energy or a simple alarm system that converts motion energy into sound energy. (PS3.B, PS3.D, ETS1.A, ETS1.B, ETS1.C)

Lesson Performance Expectations

- Students will identify photovoltaic solar power as a source of energy.
- Students will explain what happens when a photovoltaic cell is shaded.
- Students will understand why we can't rely solely on this resource for energy.

Materials: Materials listed are enough for one group of 3-4 students.

- Cardboard, poster board, or stiff paper to construct the house
- Optional - Basic house design plan -- Students can change any portion of the plan to fit their needs. Free Paper Design house templates -- 3 different house templates or find more templates at their website https://www.template.net/business/paper-templates/paper-house-template/
- Protractors 2 per group (attach a long string to help the students measure) See picture.
- Small Solar Panel - Example
- 1 voltmeter per group
- Two sunny days to test the prototypes 3 times (Suggestions: 1st part of the day, Lunch, near the end of the school day. Approx 10 mins for the students to gain data).
- Optional-- Students could go out on a cloudy day to see the voltage of the solar panel after their testing.



Time: 4 Class periods of 45 - 60 mins

Day 1 Introduction and research
Day 2 Building the prototype
Day 3 Testing prototype and Redesign
Day 4 Testing of redesign and Interpretation

Teacher Background Information:

- Solar energy is a renewable resource that can be used to create electricity. Photovoltaic solar panels take the sun's energy and turn it into usable electricity through a chemical reaction that occurs in the solar cells.
- Solar cells are made of several layers: the top layer is glass for protection; the next layer is dark so that the glass doesn't reflect the sunlight; underneath those two layers are two thin "wafers" made of silicon and metal wires. The wafers contain chemicals that loosen the bonds of the electrons in the silicon. When a photon from the sun hits the wafers, the electrons in the silicon begin to move around more and flow along the metal wires in the wafers. This movement of the electrons produces an electric current or electricity. Many of these solar cells are joined together to create a photovoltaic panel. How do solar panels work? Ted-Ed Video (4:58 mins)
- Solar power has many advantages. The sun is an endless energy supply, and the source itself costs nothing. The conversion of sunlight to electricity happens silently and instantly with no moving parts to wear out. Using solar power is also an emissions-free process, although there will be costs and emissions to produce the solar panels. Solar power can reduce the cost of a person's energy bill, and they can receive some financial incentives from the government. Solar technology is continually improving. New technologies and practices improve the quality of solar panels while making solar power more affordable for people to install solar on their properties or for large-scale solar plants to be built.
- Solar power also has some challenges. While the sun doesn't cost anything to use, solar panels are costly because of the energy and materials required to build the panels, including copper, steel, and petroleum products. Nitrogen trifluoride and sulfur hexafluoride are all emitted in the production of solar panels. While solar energy has a history of being expensive, the price is decreasing. New technology has been introduced, including batteries to store energy. Sunlight doesn't shine at night or directly onto the solar panels all the time. This impacts the amount of solar power available for use.
- Solar accounts for 5.6% of Utah's energy resources and around 50% of Utah's renewable generation. Challenge students to change these statistics by improving solar technology (Utah Energy Landscape).

Student Background Knowledge:

- Students should know how to read a voltmeter.
  Video on How to read a voltmeter: The Best Multimeter Tutorial (4:35 minutes)
- Students should know that a watt is a measure of power.
  Video on What is a Watt: What is a watt? (2:02 minutes)
- Students will need to know how to work a protractor and measure angles.
  (Standard 4.MD.6- Measure angles in whole-number degrees using a protractor.)

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

Teacher Preparation: Divide the students into groups of 3 - 4. Allow students to be creative. They might want to create their own house template. There is also a template that they can use to make any type of adjustments to the roof. Make sure you have sturdy paper that can hold the solar panel's weight. The students will also need a square base of poster board to place their house on it. This is a time for students to problem-solve. Watch the time of design.

Day one: Introduction and Research

Introduce the Problem to the students on page one. Have students discuss (3-5 mins) their knowledge of solar panels, where they have seen them, and how they work. After the discussion, let the students answer some questions they may need to know before creating a house that will hold a solar panel that will work. Have them write down their questions and draw a model of their knowledge of where the solar panel will look on the roof and how it functions on the inside. As a class, look at the questions the groups came up with but do not answer the questions.

Research: On the student worksheet, there are links that the students can click on and watch to learn how solar panels work and how they create energy. Students will need to take notes and look at the previous model they drew. Have the students work quietly on their notes and designs.

Bring the students together in their groups. Ask; Is there something you would add or change to your model? As a group, determine which house design will provide the best Solar solution? Where should the solar panels go?

Using the student page 3, have the student groups use their research to create a model that will meet the criteria and constraints. Make sure they realize that they only have a limited time to build their prototype. The students will also need to look at what supplies are available for use. (You can make some changes to some of the building supplies.) Groups must make a list of supplies. They will also need to have a detailed model with notes of the height of the house, the angle of the roof, where they are putting the solar panel and their prediction on how many watts of energy they will get.
Note: Some students may want to place their solar panels on the ground. If so, make sure they indicate at what angle the panel will be set.

Day two: Building your Prototype
Students build their original prototype.

Day three: Testing, Analyzing, and Redesign
Teacher prep: Set up an area where the students can test their prototypes. Make sure that each group has access to the voltmeters. The students will need 10 - 15 mins to test their prototype at least 3 times throughout the day. Suggested times would be first thing in the morning, lunchtime, and the day's end. The students will need time to redesign their prototypes and retest them.

Recommend for the teacher to help students understand a voltmeter.
Video on How to read a voltmeter: The Best Multimeter Tutorial (4:35 minutes)

Student groups can test their prototype, writing down the amount of energy they have created using solar energy. They will record the number of volts on the voltmeter. They will also need to record any observations they may see (example: the angle is off, the roof is too steep, the roof is too weak, etc.)

Once the group has tested their prototype, the students need to answer the analysis questions. Students will then get an opportunity to redesign and update their prototypes. Explain that this is not a time to start over from the beginning. This is the time to look at the problems and use different ideas to come up with a solution. Allow time for the students to make the changes to their prototype and test again. Record their data and observations on the Data table.

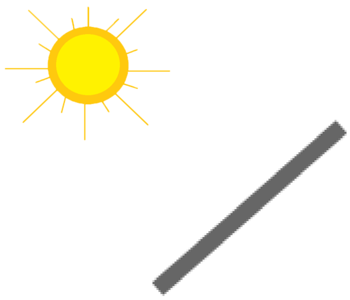
Day four: Testing Redesign and analyzing data
Allow students to test their redesigns and analyze the data. Once the groups have discussed their data, have the students complete the worksheet's interpretation and conclusion portions.

Assessment of Student Learning. Students will complete the Interpretation or Conclusion page. Write a Summary of your experience: The summary should have a clearly stated claim with one identified solution for increasing the total volts (Energy) produced. Two evidence statements should come from the data collected from your design and research. Students should base reasoning on evidence and why it is most compelling.

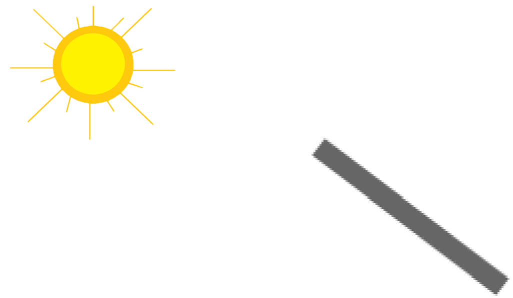
Standardized Test Preparation:

The Solar Power Challenge

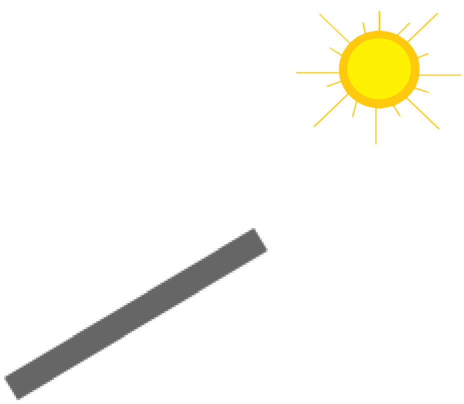
1. What angle of solar panel will work best for the sun at the angle pictured? Choose all that apply.



A.*



B.



C.

D. * 

2. What are the criteria for designing solar homes in Utah at this time?

a. Solar energy must be useful to supplement other energy sources.*
b. Solar energy must be able to run all the household appliances and heating.
c. Solar energy must provide extra energy to sell to the electric companies.
d. Solar energy must replace other forms of energy available to the household.

3. What are constraints to homeowners that wish to use solar energy? Choose all that apply.

e. Cost of solar panels.*
f. Amount of electricity the panels can produce.*
g. Several days of adequate sunlight.*
h. The size of the homeowner's roof or yard area.*

4. Why is solar energy attractive to homeowners and cities in Utah?

a. The energy source is free.*
b. Solar energy produces little or no emissions.*
c. Current energy sources produce emissions.*
d. The solar energy costs less than other sources.

Extension of lesson: At the height of productivity, solar panels in Utah can produce 826,000 kWh (826 gWh) of energy per day. The average home in Utah used 797 kWh of energy per month in 2014 (Source: U.S. Energy Information Administration), so based on the solar energy production information above, how many people (at most) could rely on solar energy to power their homes for a month? (First, you will need to figure out how much electricity can be produced from solar energy in one month.) *826,000 x 30 = 24,780,000 kWh; 24,780,000/797 = 31,091 people Utah's population is almost 3 million people, so Utah's current solar portfolio could provide energy to about 1% of the state.*

1. What makes the state of Utah a good place for solar farms? Utah's cooler temperatures and rural spaces with little interference from buildings.
2. Which areas of Utah would be ideal for these solar farms? Why? The open rural areas of SW Utah. There is enough uninhabited space to have solar farms, and the conditions are ideal for solar energy.
3. What are some current limitations of solar power? Cost, yield, take up large amounts of land space, variability (cloudy days, nights, etc.)
4. The problem that engineers are trying to solve today is how to capture more (and even store) solar energy. What could today's students learn more about to help solve problems like this? Answers Vary
5. What needs to happen for society to be able to depend more on solar energy? More technological advancement, solve the storage/variability problem

Career Connections: Students can research the different types of careers in solar energy. The following website provides information.
DOE Solar Careers
Let's Go Solar

The Solar Power Challenge

Name___________________________________

The mayor of a small town needs your help. The town will be growing quickly in the next few years. The city council would like to see this growing city use renewable energy as an energy source. Your job is to create a prototype using the sun as energy to generate electricity for the town.

The mayor has assigned you and your partners to find the best way to generate the most electricity from one panel efficiently.

Together with your group discuss what 3 main questions that you will need to research before you can start building.

1.

2.

3.

Research: Research is important to the engineering process. Watch the following videos and summarize what you learned in them.

What is Solar Energy? (5:07 min)
Summarize this video

Solar Energy 101 (1:58 min)
Summarize this video

Engineering projects have criteria and constraints. In this activity, they are:

Criteria: Develop a prototype of a house that can gather at least 1.0 volts of solar energy as shown on a voltmeter.

Constraints: Limited supplies-- 1 sheet cardboard or very stiff paper, solar panel, voltmeter, and sun. Time: you will have 1 hour to complete your prototype.

Design: Draw your house design and show where the voltmeter will be placed and the angle it will have. Show where the sunlight will be coming from.

Testing: Take your prototype outside at least 3 times throughout the day to gather data. You must place it in the same location each time. Once outside, give your solar panel time to gather the sun's energy. Then measure the amount of energy the sun generated by using the voltmeter. Record your observations.

Day 1 The angle of the solar panel:	Weather:
Time: Observation:	Volts:
Time: Observation:	Volts:
Time:	Volts:

Observation:

Analysis: Answer the following questions.

1) How did your solar panel perform? Give some evidence from your observations.

2) What changes do you need to make with the solar panel to make it more efficient or fix issues during testing?

Redesign: Redesign your house by making changes to improve or reach the criteria. Is there a new angle? What adjustments did the group make? Redraw your prototype showing the changes made.

Retest your design and record the results in the table below.

Day 2	Weather:
The angle of the solar panel:	
Time:	Volts:
Observation:	
Time:	Volts:
Observation:	
Time:	Volts:
Observation:	

Analysis: Answer the questions below.

1) Did your redesign help meet the criteria? Why or Why not? Describe your observations.

2) What other changes do you need to make to the prototype to make it more efficient or fix issues during testing? Use the space below to show any redesigns.

Interpretation & Summary: Answer the following questions about your project.

1) Did your prototype meet the Criteria? Why or why not? Did your group succeed in creating at least 1.0 volts? What was the highest amount of voltage? How did the redesign changes help your project?

2) Did your group work together successfully? What is your evidence?

3) What did you learn in the process of designing and testing your project?

Assessment

Write a Summary of your experience. The summary should have a clearly stated claim with one solution identified to increase the total volts (Energy) produced. Two evidence statements should come from the data collected from your design and your research. The reasoning should be thoughtful and complete based on which evidence and why you think it is most compelling.