The FUTURES Channel®

MOVIE GUIDE

MOVIES NUMBER 1019-21

# Making Sparks PARTS 1, 2 & 3

## The Movies:

**Part 1: Where Energy Comes From—**When you turn on your lights, you are plugging into a power grid which is fed by fossil fuel, nuclear and hydro-electric power plants. *(Movie length: 3:23)*

**Part 2: Photovoltaics**—Sunlight can be converted directly into electricity with a device made of one of Earth's most plentiful elements. *(Movie length: 2:50)*

**Part 3: How it Works—**Solar panels are a practical source of electricity for an individual or a nation. *(Movie length: 4:55)*

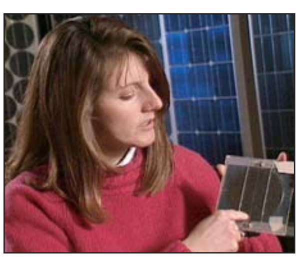
Featured: Beth Richards, engineer, Sandia Laboratories; Miguel Contreras, research scientist, National Renewable Energy Laboratory.

## Background:

Silicon is one of the most abundant and common elements on Earth, found in every rock and grain of sand. So it was all the more marvelous that in the middle of the 20th century silicon was found to have extremely useful properties in relationship to the control of electrical currents. These properties led scientists first to the invention of transistors and ultimately to the development of ultra-powerful microprocessors found in today's computers.

But silicon has another very remarkable property. When "salted" with the right amounts of other elements in the right places, a piece of silicon can transform the energy of an incoming light wave directly into the energy of an electrical flow. To put it another way, silicon converts sunlight into electricity. Which means that someday, perhaps, silicon will help us to convert fossil fuel dependence into abundant and clean energy independence.

## Curriculum Connections:



**Percents** 1

1. If you have a solar panel that produces an average of about 250 watt-hours of energy on a sunny day, and you live in an area that is cloudy 40% of the time, how much energy would your panel produce in a year?

**Measurement (area)** 2

2. Determine the area of your classroom floor in square meters. Suppose you have solar panels that can produce 100 watts of peak power for each square meter. How much peak power could you produce if an area the size of your classroom floor were covered with those panels?

**Measurement (area)** 3

3. If you can produce 100 watts of peak power per square meter, how much peak power could you produce from one acre of panels?

**Percents** 4

Suppose that your electricity bill for the month of April was $45.75, and your billing rate is 15 cents per kilowatt-hour.

a) How many kilowatt-hours were used?

b) If you used 60 kilowatt-hours in April to run your refrigerator, what percentage of the total bill is due to the refrigerator?

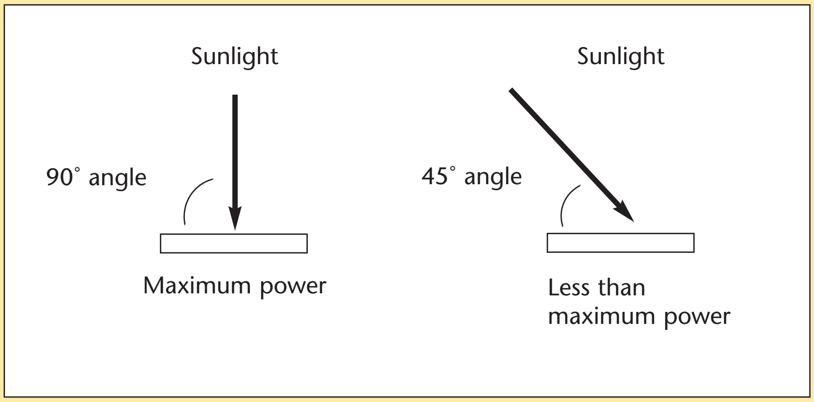
c) If 15% of the electricity for April was used to power the lights in your home, how many kilowatt-hours were used for lights?

**Percents** 5

Suppose you could sell electricity produced from your solar panels for 10 cents per kilowatt-hour. You have a standard solar panel with an efficiency of 10% that produces 250 watt-hours a day. If you could buy a replacement panel with an efficiency of 20% for $25.00, how many more watt-hours could you produce each day? How long would it be before you produced and sold enough kilowatt-hours to pay for the replacement panel?

**Geometry (angles)** 6

As shown in the diagram, a solar panel produces the most power when sunlight strikes it at a right angle.




This chart indicates how much power is produced by the same solar panel when sunlight strikes it at different angles. Note that the panel has a peak power of 50 watts.

| **Angle** | 90° | 80° | 70° | 60° | 50° | 40° | 30° | 20° | 10° | 0° |
|---|---|---|---|---|---|---|---|---|---|---|
| **Power output (watts)** | 50 | 49.2 | 47.0 | 43.3 | 38.3 | 32.1 | 25 | 17.1 | 8.7 | 0 |
| **Percent of Maximum Power** | 100% | | | | | | | | | |

A. Fill in the table. Then use the data to draw a graph with “Power” on the vertical axis and “Angle Size” on the horizontal axis. Use the table and the graph to answer questions B, C, and D.

B. For what angle is the power exactly 1/2 of the peak power?

C. By what percent does the power drop as the angle changes from 90° to 80°? From 20° to 10°?

D. Suppose you installed one of the solar panels on a roof slanted at a 45° angle. What would the power output be when the sun is directly overhead?

To: Consultants
From: Beth Richards/Sandia National Laboratories
Subject: Testing of solar panels

Miguel Contreras has just sent us several new panels. These panels have the same dimensions as our standard panels, but are better at converting sunlight into electricity.

A. The efficiency of a solar panel is a percentage that compares the electrical power you get out of the panel (output) with the amount of sunlight that the panel receives (input). The efficiency of our current panels is 10%, which means that 10% of the power of the sunlight is changed to electricity. When our standard panel is producing 50 watts, how much energy from the sun is being captured by that panel?

B. I've made some measurements on the peak power of Miguel's new panels. With the same amount of sunlight you determined in question 1, the panels produced the following peak power ratings. Please figure out the efficiency of each new panel.

Panel A: 60 watts Panel B: 75 watts Panel C: 80 watts Panel D: 100 watts

C. The solar cells used in the new panels cost more than the ones we have been using. However, since the new cells are more efficient, we can still produce the same amount of power using fewer or smaller panels. Fill out the following table to help me make the best decision. Use the top row of the table as a model to help you decide which calculations you need to make.

| Incoming Peak Sunlight Power (watts) | Efficiency of Panel | Percent of Full Size | Peak Output Power (watts) |
|---|---|---|---|
| 500 | 10% | 100% | 50 |
| 500 | 12% | 90% | |
| 500 | | 80% | 50 |
| 500 | 15% | | 45 |
| 500 | 16% | 70% | |
| 500 | 18% | | 45 |
| 500 | | 50% | 40 |

Now work out three more "Efficiency" and "Percent of Full Size" combinations that result in a peak power output of 50 watts when the peak sunlight power is 500 watts. For example, a panel with an efficiency rating of 20% that is 50% of full size produces a peak power of 50 watts. Find three other combinations that are not already listed in the table.

**Teaching Guidelines: Testing of Solar Panels**
**Math Topic: Percents**

A. Students should translate the problem into the mathematical statement 10% of ? = 50 watts. This can be solved in several ways. Perhaps the simplest is to realize that 10% is 1/10, so that the incoming sunlight must be 10 times the output, or 500 watts.

B. Efficiency equals output divided by input.
Panel A: 60 W/500 W = 12%
Panel B: 75 W/500 W = 15%
Panel C: 80 W/500 W = 16%
Panel D: 100 W/500 W = 20%

C.

| Incoming Peak Sunlight Power (watts) | Efficiency of Panel | Percent of Full Size | Peak Output Power (watts) |
|---|---|---|---|
| 500 | 10% | 100% | 50 |
| 500 | 12% | 90% | *54* |
| 500 | ***12.5%*** | 80% | 50 |
| 500 | 15% | ***60%*** | 45 |
| 500 | 16% | 70% | *56* |
| 500 | 18% | ***50%*** | 45 |
| 500 | ***16%*** | 50% | 40 |

Working out three other combinations means finding percents to fill in the blank in this relationship: 500 x ___% x ___% = 50. Students won't find this too difficult if they realize that the product of the two percentages must equal 1/10, since 50 is 1/10 of 500. Here are some examples of solutions:

Efficiency: 20%, size: 50%
Efficiency: 15%, size: 66 2/3%
Efficiency: 25%, size 40%

**If you enjoyed this Futures Channel Movie, you will probably also like these:**

| | |
|---|---|
| *Electricity from the Wind, #1010* | The natural force of the wind is harnessed by mathematics and physics to generate clean electricity. |
| *Off the Grid Series, #1022-1024* | For people in remote locations without access to a power grid, solar panels can provide a solution to their energy problems. |
| *Solar Powered Cars, #1001* | Using the energy it takes to run a hair dryer, this solar-powered car travels 200 miles at speeds of 50 to 65 mph. |