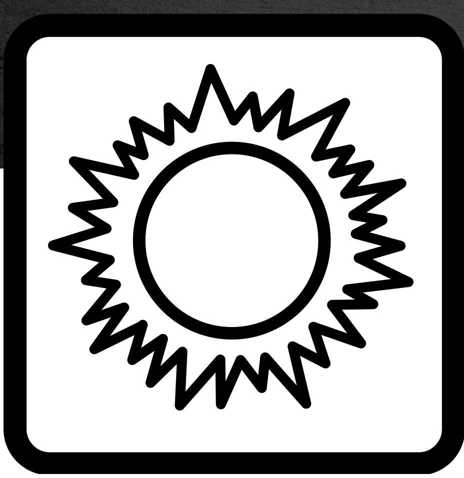
2019-2020

# Energy From the Sun

## Teacher Guide

Hands-on explorations that allow students to investigate solar energy. Students explore radiant energy transforming into thermal energy, chemical energy, and electricity.



**Grade Level:**

Int Intermediate

**Subject Areas:**

Science

Language Arts

Social Studies

Technology

Math

NEED National Energy Education Development Project

Dominion Energy

SOLAR FOR STUDENTS

# Teacher Advisory Board



# NEED Mission Statement

The mission of The NEED Project is to promote an energy conscious and educated society by creating effective networks of students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education programs.

## Permission to Copy



## Teacher Advisory Board

In support of NEED, the national Teacher Advisory Board (TAB) is dedicated to developing and promoting standards-based energy curriculum and training.

## Energy Data Used in NEED Materials

NEED believes in providing teachers and students with the most recently reported, available, and accurate energy data. Most statistics and data contained within this guide are derived from the U.S. Energy Information Administration. Data is compiled and updated annually where available. Where annual updates are not available, the most current, complete data year available at the time of updates is accessed and printed in NEED materials. To further research energy data, visit the EIA website at www.eia.gov.

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# Energy From the Sun
## Teacher Guide

PROUD MEMBER OF

Interstate Renewable Energy Council

### Energy From The Sun Kit

- 1 Package clay
- 6 Concave mirrors
- 6 Flat mirrors
- 5 Radiation can sets
- 1 Solar balloon
- 5 Solar cell kits
- 1 Solar house kit
- 10 Lab thermometers
- 1 Package UV beads
- 1 Oven thermometer
- 24 Ping pong balls
- 30 Student Guides

## Table of Contents

# Standards Correlation Information

www.NEED.org/educators/curriculumcorrelations/

## Next Generation Science Standards

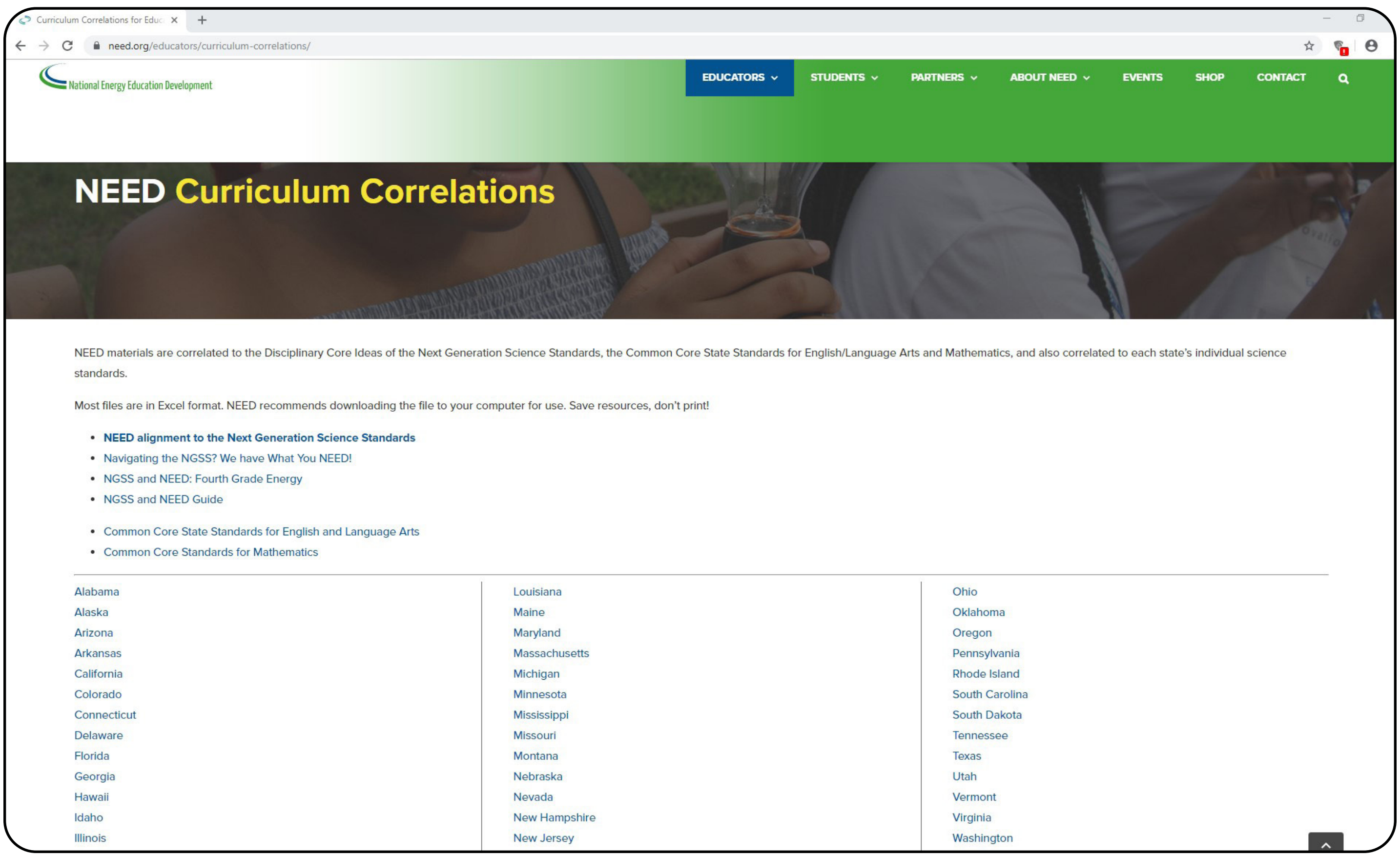
- This guide effectively supports many Next Generation Science Standards. This material can satisfy performance expectations, science and engineering practices, disciplinary core ideas, and cross cutting concepts within your required curriculum. For more details on these correlations, please visit NEED's curriculum correlations website.

## Common Core State Standards

- This guide has been correlated to the Common Core State Standards in both language arts and mathematics. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED curriculum correlations website.

## Individual State Science Standards

- This guide has been correlated to each state's individual science standards. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED website.



# Energy From the Sun Materials

| ACTIVITY | MATERIALS IN KIT | ADDITIONAL MATERIALS NEEDED |
|---|---|---|
| *Radiation Cans—Converting Radiant Energy to Heat* | ▪Radiation cans<br>▪Thermometers | ▪Water<br>▪Light source*<br>▪Timer<br>▪250 mL Beakers |
| *Radiation Cans—Solar Concentration* | ▪Radiation cans<br>▪Clay<br>▪Thermometers<br>▪6 Concave and 6 flat mirrors | ▪Cold water<br>▪Light source*<br>▪Ruler<br>▪250 mL Beakers |
| *Solar Collection with a Solar Distiller* | | ▪Large container<br>▪Small glass beaker or bowl<br>▪Marble<br>▪Clear plastic wrap<br>▪Large rubber band<br>▪Water<br>▪Food coloring<br>▪Light source* |
| *PV Ping Pong Simulation* | ▪24 Ping pong balls | ▪1 Flashlight<br>▪Colored or masking tape<br>▪Sticky name tags |
| *Photovoltaic Cells* | ▪PV module kit | ▪Paper<br>▪Bright light source* |
| *Temperature and UV Beads* | ▪UV beads<br>▪Thermometers | ▪Foam cups<br>▪Ice<br>▪100 mL Beakers<br>▪Permanent marker<br>▪Timer<br>▪Hot water<br>▪Room temperature water<br>▪Cold water<br>▪Sunny day |
| *Solar Balloon* | ▪Solar Balloon | ▪Sunny day |
| *Solar Oven Challenge* | ▪Oven thermometer | ▪Small pizza boxes<br>▪Plastic wrap<br>▪Aluminum foil<br>▪Wooden skewers<br>▪Markers<br>▪Scissors<br>▪Rulers<br>▪Masking tape<br>▪Paper plates<br>▪Black construction paper<br>▪Food to cook<br>▪Additional solar oven materials |
| *Designing a Solar House* | ▪Solar house kit | ▪Cardboard box<br>▪Graph paper<br>▪Research materials<br>▪Presentation materials |

***NOTE:** Consider the bulbs used to complete the activities. For most heat-centered activities, energy efficient bulbs like CFLs and LEDs will not produce the amount of thermal energy needed in the time allotment. Using sunlight or a traditional incandescent bulb will work best. When working with PV cells, sunlight and traditional incandescents are the best option, but energy-saving halogen incandescent bulbs, "work" bulbs, and even heat lamps may work. Call NEED for help with bulbs and troubleshooting concerns.

# Teacher Guide

## Grade Level

- Intermediate, grades 6-8

## Time

- Five 45-minute class periods

## Web Resources

**American Solar Energy Society**
www.ases.org

**Energy Information Administration**
www.eia.gov

**EIA Energy Kids**
www.eia.gov/kids

**International Renewable Energy Council**
www.irecusa.org

**Lawerance Berkely Lab Tracking the Sun**
https:// emp.lbl.gov/tracking-the-sun/

**National Renewable Energy Laboratory**
www.nrel.gov/solar

**National Renewable Energy Laboratory Open PV Project**
http://openpv.nrel.gov/

**U.S. Department of Energy, Solar Energy**
https://energy.gov/science-innovation/energy-sources/renewable-energy/solar

**U.S. Department of Energy, Solar Energy Technologies Office**
https://www.energy.gov/eere/solar/solar-energy-technologies-office

## Background

*Energy From the Sun* is an inquiry-based unit with Teacher and Student Guides containing comprehensive background information on solar energy and how it can generate electricity. Through hands-on inquiry investigations, reading nonfiction text, and critical thinking activities, students will learn about the transformations of energy related to solar or radiant energy. The kit that accompanies this curriculum contains most of the materials necessary to conduct the activities and investigations. Please refer to page 5 for a complete list of materials included in the kit.

## Concepts

- Nuclear fusion within the sun produces enormous amounts of energy, some in the form of radiant energy that travels through space to the Earth.
- Most of the energy on Earth originates from radiant energy emitted by the sun. Only geothermal, nuclear, and tidal energy do not originate from radiant energy emitted by the sun.
- The sun's energy coupled with the greenhouse effect make life possible on Earth.
- We use the sun's energy to produce heat, light, and electricity.
- It is difficult to capture the sun's energy because it is spread out—not much of it is concentrated in any one place. We can capture solar energy with solar collectors that convert radiant energy into heat.
- Photovoltaic cells convert radiant energy directly into electricity.
- Concentrated solar power systems collect radiant energy from the sun and convert it into heat to produce electricity.

## Preparation

- Familiarize yourself with the Teacher and Student Guides, and with the materials in the kit. Select the activities you will complete.
- Collect the materials that are not included in the kit. See the materials list on page 5 for materials that are not in the kit.
- Make sure that the PV module and motor work smoothly. If the motor doesn't spin immediately, lengthen the wires and remove any kinks, or, 'jumpstart' it by touching the leads to the ends of a C, D, or 9-Volt battery.
- If the thermometers have been unused for a long time, or are not reading the same temperature, put them in ice water, then a few minutes later, in boiling water. This should recalibrate the thermometers to the same temperature.
- Prepare a copy of the *Photovoltaic Cell* master on page 21 to project for the class.
- Divide the class into five groups.
- Make copies of handouts, as needed.

## Science Notebooks

Throughout this curriculum, science notebooks are referenced. If you currently use science notebooks or journals, you may have your students continue using them. A rubric to guide assessment of student notebooks can be found on page 14 in the Teacher Guide.

In addition to science notebooks, student worksheets have been included in the Student Guide. Depending on your students' level of independence and familiarity with the scientific process, you may choose to use these instead of science notebooks. Or, as appropriate, you may want to make copies of worksheets and have your students glue or tape the copies into their notebooks.

## Activity 1: Introduction to Solar Energy

### Objectives

- Students will be able to identify basic facts about energy and solar energy.
- Students will be able to read a thermometer using the Fahrenheit and Celsius scales.
- Students will be able to convert between Fahrenheit and Celsius scales.

### Materials

- Copies of *Fahrenenheit/Celsius Conversion* for each student (optional), page 18

### Time

- 45 minutes

### Procedure

1. Distribute the Student Guides or worksheets to the students.
2. Introduce solar energy as the topic of exploration using the *KWL Organizer for Solar Energy* on page 9 in the Student Guide. Have the students make a list of the things they know and questions they have about solar energy.
3. Have students read the informational text, adding to their KWL chart. Discuss the questions they have and have them research specific questions as homework.
4. Play *Solar Energy Bingo* or *Solar Energy in the Round* with the class as an introductory activity. See the instructions on pages 15-17. These activities can be revisited later as formative assessments.

***OPTIONAL:*** Practice Fahrenheit and Celsius conversions using page 18 in the Teacher Guide.

### Answers

1. 122°F
2. 37.8°C

### Extension

- Project or have students study the map on page 8 in the Student Guide, *Solar Resources in the United States*. Direct students to find where they live on the map and analyze their area's solar resources in comparison to other areas. Have students complete a quick-write about the possible reasons for their area's shading on the map and why other areas stack up differently. Direct students to share their ideas with a partner or the class. If desired, you can also download a color version of the map at www.nrel.gov/gis/solar.html.

## Activity 2: Radiation Cans — Converting Radiant Energy to Heat

### Objective

- Students will be able to explain that light can be reflected or absorbed and then converted to thermal energy (heat).

### Materials

- Radiation can sets
- Thermometers
- 250 mL Beakers
- Water
- Light source
- Timer

### Time

- 60 minutes

### Preparation

- Set up centers or stations each with one set of radiation cans, 2 thermometers, a beaker, and water. Make sure the stations are situated in the sunlight or each has a light source.

***CONTINUED ON NEXT PAGE***

## ✔ Procedure

1. Go to pages 10-11 of the Student Guide. Explain the procedure and have the students complete the activity in groups.
2. Review the activity with the students, discussing the following concepts:
    - radiant energy can be reflected or absorbed when it hits objects;
    - absorbed radiant energy can be converted into heat;
    - black objects tend to absorb radiant energy; and
    - shiny objects tend to reflect radiant energy.

# Activity 3: Radiation Cans — Solar Concentration

## Objectives

- Students will be able to describe how light can be concentrated on an object.
- Students will be able to define or describe the term concave, citing an example of a concave item.

## Materials

- Radiation can sets
- Clay
- Thermometers
- Flat mirrors
- Concave mirrors
- Beakers
- Cold water
- Sunny day or lamps
- Ruler
- *Concentrating Solar Energy Assessment*, page 19

## Time

- 45 minutes

## Preparation

- Set up centers or stations each with 2 radiation cans, 2 thermometers, a beaker, cold water, ruler, and mirrors. Make sure the stations are situated in the sunlight or each has a light source.

## ✔ Procedure

1. Go to pages 12-13 of the Student Guide. Place students into groups, and assign each group a label of A-E. Assign each group to a center with the corresponding number of concave or flat mirrors listed below. Explain the procedure and have the students complete the activity. They must obtain data from the other groups to complete the activity.
    - Group A: The control—cans without mirrors.
    - Group B: Position one concave mirror behind each can so that the mirrors focus sunlight onto the cans. The mirrors should be about seven centimeters (7 cm) from the outside edge of the can. Use pieces of clay to hold the mirrors in the correct position.
    - Group C: Position two concave mirrors behind each can as described above.
    - Group D: Position one flat mirror behind each can as described above.
    - Group E: Position two flat mirrors behind each can as described above.
2. Review the activity and discuss the following concepts:
    - a mirror reflects radiant energy; and
    - a concave mirror can concentrate solar radiation onto an object.
3. Hand out and/or project the *Concentrating Solar Energy Assessment* as an assessment of student comprehension of activities and discussion. Or, have students draw pictures and write about their results to indicate what they have learned.

## Activity 4: Solar Collection with a Solar Distiller

### ✪ Objectives

- Students will be able to define the process of distillation.
- Students will be able to compare a solar distiller to the steps in the hydrologic cycle.

### Materials

- Large containers
- Small glass beakers or bowls
- Marbles
- Clear plastic wrap
- Large rubber bands
- Water
- Food coloring
- Sunny day or lamps
- *Water Cycle* master, page 20

### Time

- 10 minutes to set up; distillation may take up to 24 hours to see full results

### Preparation

- Set up stations or centers so that each group has the materials to complete the activity.

### ✔ Procedure

1. Go to page 14 in the Student Guide. Explain the procedure and have the students complete the activity in groups.
2. Review the water cycle. You can project the water cycle master to enhance discussion.
3. Revisit the distiller the next day. Review and discuss the following concepts:
    - radiant energy can pass through transparent materials such as plastic wrap, but thermal energy does not pass through as easily;
    - evaporation and condensation in Earth's natural water cycle; and
    - evaporation and condensation can be replicated and modeled.

## Activity 5: Photovoltaic Cells (PV cells)

### ✪ Objectives

- Students will be able to explain how a PV cell transforms radiant energy directly into electricity.
- Students will be able to explain how a motor transforms electricity into motion.

### Materials

- 24 Ping pong balls
- 1 Flashlight
- Colored or masking tape
- Sticky name tags
- PV module kit with motors and fans
- Paper
- Bright light source
- *Photovoltaic Cell* master, page 21
- *PV Ping Pong Simulation*, page 22
- *Using Solar Energy to Produce Electricity Assessment*, page 24

### Time

- 60-75 minutes

### ✔ Procedure

1. Set up the *PV Ping Pong Simulation* as directed on page 22.
2. Assign students to roles.
3. Re-visit the photoelectric effect after the simulation is concluded to ensure students understand the energy transformation involved.
4. Go to the PV cells activity on page 15 of the Student Guide. Place students into five groups. Explain the procedure and have the students complete the activity in their groups.
5. Review the activity with the students, using the *Photovoltaic Cell* master to review and discuss the following concepts:
    - PV cells transform radiant energy directly into electricity;
    - motors transform electricity into motion; and
    - sunlight and artificial light are both examples of radiant energy.
6. Hand out or project the *Using Solar Energy to Produce Electricity Assessment* to assess student comprehension of activities and discussion.

## Activity 6: Temperature and UV Beads

### Objective

- Students will be able to explain how temperature affects the rate at which UV beads change back to white after UV exposure.

### Materials

- UV beads
- Thermometers
- Foam cups
- Ice
- 100 mL Beakers
- Permanent marker
- Timer
- Hot water
- Room temperature water
- Cold water
- Sunny day

### Time

- 45 minutes

### Preparation

- Each group will need four of the same color UV beads. There are multiple colors. It does not matter which color each group uses. The bag you receive will be mixed so you will need to separate out beads for the groups. Hold them near a window to quickly separate.

### ✔ Procedure

1. Go to pages 16-17 of the Student Guide. Place students in their groups and provide them with the necessary materials.
2. Explain the procedure and have students complete the investigation.
3. Discuss the results of the investigation with the students, and review the forms of energy involved with the class.
4. Ask students to design an experiment to test the UV beads further, incorporating or considering other variables to manipulate, like color of beads, amount of UV radiation, etc.
5. Ask students if all reactions to UV radiation might be affected by temperature. Be sure to discuss as a class that our skin will still react to UV radiation and burn in cold or hot temperatures.

### Technology Extension

- If allowable, it may be easier for students to record detailed data and observations using digital cameras. Have students submit a digital lab report showcasing their hypothesis, data, and conclusions.

## Activity 7: Solar Balloon

### Objective

- Students will be able to describe how radiant energy impacts air molecules.

### Materials

- Solar balloon with fishing line
- Sunny day

### Time

- 30-45 minutes

### ✔ Procedure

1. Review the solar balloon activity on page 18 of the Student Guide.
2. Bring your students outside to an open area. They should bring their science notebooks or Student Guides and a writing utensil with them. Follow the procedure on the student worksheet.
3. Students should record their observations throughout the investigation.
4. Discuss the results with students, highlighting vocabulary they should use in their conclusions.

# Activity 8: Solar Oven Challenge

## ✪ Objectives

- Students will be able to design and test a solar oven.
- Students will be able to describe the transformation of radiant energy to thermal energy.

## Materials

- Small pizza boxes
- Plastic wrap
- Aluminum foil
- Wooden skewers
- Markers
- Scissors
- Rulers
- Masking tape
- Paper plates*
- Black construction paper
- Food to cook
- Oven thermometers
- Additional materials to redesign ovens
- *Solar Oven* instructions, page 25

## Time

- 2 - 45 minute classes, plus time for cooking

***NOTE*:** Dark-colored paper plates work best, if available.

## Preparation

- Make one standard solar oven using the directions on page 25. This solar oven will be used as the "standard" oven.
- Decide what to cook in the solar ovens. Popular choices include cookies, s'mores, English muffin pizzas, and nachos. You can also steam carrots if you put them in a plastic bag inside the oven. Be aware of food allergies in your classroom.
- Gather the prescribed materials and any additional materials students may need.

## ✔ Procedure

1. Show your students the standard solar oven you have made using page 19 of the Student Guide to describe its construction. Discuss with them all of the different variables that could be changed that might affect the oven's ability to cook food.

   Suggested variables to share with students as needed:
   - Color of construction paper
   - Number of reflective panels
   - Side of aluminum foil—shiny side/dull side
   - Use of plastic wrap
   - Seal/unseal air leaks
   - Cover outside of box in different materials
2. In their science notebooks, or using the worksheet on page 20 of the Student Guide, students should individually brainstorm possible oven designs. Put students into groups. As a group they must discuss their designs and decide on one design to construct as a team.
3. Give students the materials they need to build their solar ovens.
4. Before cooking the food you have chosen, discuss with the class how they will know whether or not their solar ovens were effective.
5. Re-visit page 19 of the Student Guide. Ask students to answer the conclusion questions. Review the following concepts with the class:
   - radiant energy can be reflected or absorbed when it hits objects;
   - absorbed radiant energy can be transformed into thermal energy for cooking;
   - black objects tend to absorb radiant energy; and
   - shiny objects tend to reflect radiant energy.

## Activity 9: Designing a Solar House

### ✪ Objectives

- Students will be able to explain the difference between active and passive solar energy.
- Students will design a model house that utilizes both passive and active solar energy.

### Materials

- Solar house kit*
- Cardboard box (for teacher's model)
- Graph paper
- Research materials
- Presentation materials
- *Solar House* instructions, page 26
- *Solar House Rubric*, page 27

### Time

- 45+ minutes

***NOTE:*** As the classroom kit includes only one solar house kit, you will need to remove the implements from the model and have each student group affix the tools to their own house for testing.

### Preparation

- Gather the appropriate materials students may need if designing and building their own models.
- Use the solar house kit and the instructions in this guide to make a model of a solar house for your students.
- Make copies of the *Solar House Rubric*.

### ✔ Procedure

1. Students should read the informational text about solar energy, if they have not yet done so.
2. Show your students the model solar house you made. Ask the students to brainstorm some questions they would have if they were designing a solar house. (Examples: Should the house face in a particular direction? What about trees in the area, should they be considered in the design? What type of materials should I use to build the house? How many windows should I use? Should the windows be on a certain side of the house? What types of solar systems should I use?)
3. Discuss each of the following terms with the students and show them a picture or example of each: passive solar, active solar, photovoltaic, tracking solar systems, stationary solar systems, building-integrated photovoltaic, solar thermal systems. To facilitate the discussion, graphics related to solar energy can be downloaded from NEED's graphics library at https://need-media.smugmug.com/Graphics/Graphics.
4. Allow students to do additional research about solar homes and the design components of a solar home.
5. Put students into groups. Instruct the students to use their knowledge of solar energy and solar technology to design a solar home that would be very efficient. Students should use the following guidelines:
    - Draw your plan on your design sheet (page 21 of the Student Guide) or graph paper. You may want to use scrap paper to sketch out ideas first.
    - Indicate cardinal directions—N, S, E, W—on your drawing.
    - Label all components, including windows, types of solar systems, and any other information that will help explain your design.
    - Write a paragraph describing your house design and explaining the choices you made. Use complete sentences and proper punctuation.
6. Discuss the guidelines and review the rubric with the class before allowing time for design and construction.
7. Allow students time to prepare short presentations about their solar homes using Student Guide page 22. Have students present their designs to their peers.

### Extensions

- Have students create computer assisted drawings or build a model of the home they designed.
- Explain how the change in seasons and the different locations of the sun in the sky would impact the effectiveness of the PV cells where you live. How could you compensate for this?
- Students can make a multimedia presentation to local realtors, energy engineers, or community members.

## Optional Activity 10: Photovoltaic Arrays on the School

### ✪ Objective

- Students will monitor the PV arrays on the school or in the community.

### ✔ Procedure

- Have the school's energy/facility manager or a local expert speak to the students about the PV arrays on the school or in the community and show them how they work. If possible, have the students monitor the electrical output of the arrays and correlate the output to weather conditions. See NEED's *Schools Going Solar* guide for more information. *Schools Going Solar* can be downloaded from shop.NEED.org.

## ☑ Evaluation and Assessments

- There are a variety of assessment opportunities provided in the Teacher Guide. These include:
  - *Rubrics for Assessment* on page 14 to evaluate student and group work.
  - *Concentrating Solar Energy Assessment*, page 19
  - *Using Solar Energy to Produce Electricity Assessment*, page 24
  - *Solar House Rubric*, page 27
  - *Solar Energy Bingo* or *Solar Energy in the Round* as formative or summative assessments for the group, instructions are found on pages 15-17.
- Evaluate the unit with the class using the *Evaluation Form* found on page 35 and return it to NEED.

# Rubrics for Assesment

## Inquiry Explorations Rubric

This is a sample rubric that can be used with inquiry investigations and science notebooks. You may choose to only assess one area at a time, or look at an investigation as a whole. It is suggested that you share this rubric with students and discuss the different components.

| | SCIENTIFIC CONCEPTS | SCIENTIFIC INQUIRY | DATA/OBSERVATIONS | CONCLUSIONS |
|---|---|---|---|---|
| 4 | Written explanations illustrate accurate and thorough understanding of scientific concepts. | The student independently conducts investigations and designs and carries out his or her own investigations. | Comprehensive data is collected and thorough observations are made. Diagrams, charts, tables, and graphs are used appropriately. Data and observations are presented clearly and neatly with appropriate labels. | The student clearly communicates what was learned and uses strong evidence to support reasoning. The conclusion includes application to real life situations. |
| 3 | Written explanations illustrate an accurate understanding of most scientific concepts. | The student follows procedures accurately to conduct given investigations, begins to design his or her own investigations. | Necessary data is collected. Observations are recorded. Diagrams, charts, tables, and graphs are used appropriately most of the time. Data is presented clearly. | The student communicates what was learned and uses some evidence to support reasoning. |
| 2 | Written explanations illustrate a limited understanding of scientific concepts. | The student may not conduct an investigation completely, parts of the inquiry process are missing. | Some data is collected. The student may lean more heavily on observations. Diagrams, charts, tables, and graphs may be used inappropriately or have some missing information. | The student communicates what was learned but is missing evidence to support reasoning. |
| 1 | Written explanations illustrate an inaccurate understanding of scientific concepts. | The student needs significant support to conduct an investigation. | Data and/or observations are missing or inaccurate. | The conclusion is missing or inaccurate. |

## Culminating Project Rubric

This rubric may be used with the *Designing a Solar House* activity or *Solar Oven Challenge*, or for any other group work you ask the students to do.

| | CONTENT | ORGANIZATION | ORIGINALITY | WORKLOAD |
|---|---|---|---|---|
| 4 | Project covers the topic in-depth with many details and examples.<br>Subject knowledge is excellent. | Content is very well organized and presented in a logical sequence. | Project shows much original thought. Ideas are creative and inventive. | The workload is divided and shared equally by all members of the group. |
| 3 | Project includes essential information about the topic.<br>Subject knowledge is good. | Content is logically organized. | Project shows some original thought. Work shows new ideas and insights. | The workload is divided and shared fairly equally by all group members, but workloads may vary. |
| 2 | Project includes essential information about the topic, but there are 1-2 factual errors. | Content is logically organized with a few confusing sections. | Project provides essential information, but there is little evidence of original thinking. | The workload is divided, but one person in the group is viewed as not doing a fair share of the work. |
| 1 | Project includes minimal information or there are several factual errors. | There is no clear organizational structure, just a compilation of facts. | Project provides some essential information, but no original thought. | The workload is not divided, or several members are not doing a fair share of the work. |

# Solar Energy BINGO Instructions

## Get Ready

Duplicate as many *Solar Energy Bingo* sheets (found on page 28) as needed for each person in your group. In addition, decide now if you want to give the winner of your game a prize and what the prize will be.

## Get Set

Pass out one *Solar Energy Bingo* sheet to each member of the group.

## Go

**PART ONE: FILLING IN THE BINGO SHEETS**

Give the group the following instructions to create bingo cards:

- This bingo activity is very similar to regular bingo. However, there are a few things you'll need to know to play this game. First, please take a minute to look at your bingo sheet and read the 16 statements at the top of the page. Shortly, you'll be going around the room trying to find 16 people about whom the statements are true so you can write their names in one of the 16 boxes.
- When I give you the signal, you'll get up and ask a person if a statement at the top of your bingo sheet is true for them. If the person gives what you believe is a correct response, write the person's name in the corresponding box on the lower part of the page. For example, if you ask a person question "D" and he or she gives you what you think is a correct response, then go ahead and write the person's name in box D. A correct response is important because later on, if you get bingo, that person will be asked to answer the question correctly in front of the group. If he or she can't answer the question correctly, then you lose bingo. So, if someone gives you an incorrect answer, ask someone else! Don't use your name for one of the boxes or use the same person's name twice.
- Try to fill all 16 boxes in the next 20 minutes. This will increase your chances of winning. After the 20 minutes are up, please sit down and I will begin asking players to stand up and give their names. Are there any questions? You'll now have 20 minutes. Go!
- During the next 20 minutes, move around the room to assist the players. Every five minutes or so tell the players how many minutes are remaining in the game. Give the players a warning when just a minute or two remains. When the 20 minutes are up, stop the players and ask them to be seated.

**PART TWO: PLAYING BINGO**

Give the class the following instructions to play the game:

- When I point to you, please stand up and in a LOUD and CLEAR voice give us your name. Now, if anyone has the name of the person I call on, put a big "X" in the box with that person's name. When you get four names in a row—across, down, or diagonally—shout "Bingo!" Then I'll ask you to come up front to verify your results.
- Let's start off with you (point to a player in the group). Please stand and give us your name. (Player gives name. Let's say the player's name was "Joe.") Okay, players, if any of you have Joe's name in one of your boxes, go ahead and put an "X" through that box.
- When the first player shouts "Bingo," ask him (or her) to come to the front of the room. Ask him to give his name. Then ask him to tell the group how his bingo run was made, e.g., down from A to M, across from E to H, and so on.

***Solar Energy Bingo* is a great icebreaker for a NEED workshop or conference. As a classroom activity, it also makes a great introduction to a unit on solar energy.**

### Preparation

- 5 minutes

### Time

- 45 minutes

**Bingos are available on several different topics. Check out these resources for more bingo options!**

**Download these titles for free in PDF format by visiting shop.NEED.org.**

- Biomass Bingo—*Energy Stories and More*
- Change a Light Bingo—*Energy Conservation Contract*
- Coal Bingo—Coal guides
- Energy Bingo—*Energy Games and Icebreakers*
- Energy Efficiency Bingo—*School Energy Managers* and *School Energy Experts*
- Hydropower Bingo—Hydropower guides
- Hydrogen Bingo—*$H_2$ Educate*
- Nuclear Energy Bingo—Nuclear guides
- Oil and Natural Gas Bingo—Oil and Natural Gas guides
- Science of Energy Bingo—*Science of Energy* guides
- Wind Energy Bingo—Wind guides

- Now you need to verify the bingo winner's results. Ask the bingo winner to call out the first person's name on his bingo run. That player then stands and the bingo winner asks him the question which he previously answered during the 20-minute session. For example, if the statement was "can name two renewable sources of energy," the player must now name two sources. If he can answer the question correctly, the bingo winner calls out the next person's name on his bingo run. However, if he does not answer the question correctly, the bingo winner does not have bingo after all and must sit down with the rest of the players. You should continue to point to players until another person yells "Bingo."

# SOLAR ENERGY BINGO

## ANSWERS

A. Has used a solar clothes dryer

B. Knows the average conversion efficiency of PV cells

C. Knows the nuclear process in the sun's core

D. Knows how radiant energy travels through space

E. Can explain how solar energy drives the water cycle

F. Has used a photovoltaic cell

G. Rides in a solar collector

H. Can explain how solar energy produces wind

I. Knows how plants convert solar energy into chemical energy

J. Uses passive solar energy at home

K. Has seen a solar water heater

L. Has cooked food in a solar oven

M. Can name two advantages of solar energy

N. Knows the energy conversion that a PV cell performs

O. Can explain why dark clothes make you hotter in the sun

P. Owns solar protection equipment

| | | | |
|---|---|---|---|
| **A** Has hung clothes outside to dry | **B** 13-30% | **C** Fusion | **D** In electromagnetic waves (or transverse waves) |
| **E** Sun evaporates water in lakes and oceans, water vapor rises and becomes clouds, rains to replenish | **F** ask for location/description | **G** Car without tinted windows is a solar collector-like a greenhouse | **H** Sun heats the Earth's surface unevenly-hot air rises and cooler air moves in |
| **I** Photosynthesis | **J** Allows sun to enter through windows for light and heat-has materials that retain het (masonry, tile, etc.) | **K** ask for location/description | **L** ask for description |
| **M** Solar energy systems do not produce air pollutants or carbon dioxide, minimal impact on environment, sun's energy is free | **N** radiant energy to electrical energy | **O** Dark colors absorb more radiant energy and turn it into thermal energy | **P** Sun screen, sunglasses, etc. |

# Solar Energy in the Round

## Get Ready

- Copy the *Solar Energy in the Round* cards on pages 29-31 onto card stock and cut into individual cards.
- Make an additional copy to use as your answer key. These pages do not need to be cut into cards.
- Have copies of the *Energy From the Sun* informational text or *Intermediate Energy Infobooks* available for quick reference.

## Get Set

- Distribute one card to each student. If you have cards left over, give some students two cards so that all of the cards are distributed.
- Have the students look at their bolded words at the top of the cards. Give them five minutes to review the information about their words.

## Go

- Choose a student to begin the round and give the following instructions:
    - Read the question on your card. The student with the correct answer will stand up and read the bolded answer, "I have ______."
    - That student will then read the question on his/her card, and the round will continue until the first student stands up and answers a question, signaling the end of the round.
- If there is a disagreement about the correct answer, have the students listen to the question carefully looking for key words (forms versus sources, for example) and discuss until a consensus is reached about the correct answer.

## Alternative Instructions

- Give each student or pair a set of cards.
- Students will put the cards in order, taping or arranging each card so that the answer is directly under the question.
- Have students connect the cards to fit in a circle or have them arrange them in a column.

***Solar Energy in the Round* is a quick, entertaining game to reinforce vocabulary and information about solar energy.**

### Grades

- 5–12

### Preparation

- 5 minutes

### Time

- 20–30 minutes

**"In the Rounds" are available on several different topics. Check out these guides for more, fun "In the Round" examples!**

**Download these titles for free in PDF format by visiting shop.NEED.org.**

- Coal in the Round—Coal guides
- Conservation in the Round—*School Energy Managers*, *School Energy Experts*
- Energy in the Round—*Energy Games and Icebreakers*
- Forms of Energy in the Round—*Science of Energy* guides
- Hydrogen in the Round—*$H_2$ Educate*
- Oil and Natural Gas Industry in the Round—*Fossil Fuels to Products*, *Exploring Oil and Natural Gas*
- Uranium in the Round—Nuclear guides

# Fahrenheit/Celsius Conversion

On the Fahrenheit scale, the freezing point of water is 32° and the boiling point of water is 212°—a range of 180°.

On the Celsius scale, the freezing point of water is 0° and the boiling point of water is 100°—a range of 100°.

To convert from Celsius to Fahrenheit, multiply the C number by $\frac{180}{100}$ or $\frac{9}{5}$, then add 32, as shown in the formula below.

$$F = (C \times \frac{9}{5}) + 32$$

If C = 5

$F = (5 \times \frac{9}{5}) + 32$

$F = 9 + 32$

$F = 41$

To convert from Fahrenheit to Celsius, subtract 32 from the F number, then multiply by $\frac{100}{180}$ or $\frac{5}{9}$ as shown in the formula below.

$$C = (F - 32) \times \frac{5}{9}$$

If F = 50

$C = (50 - 32) \times \frac{5}{9}$

$C = 18 \times \frac{5}{9}$

$C = 10$

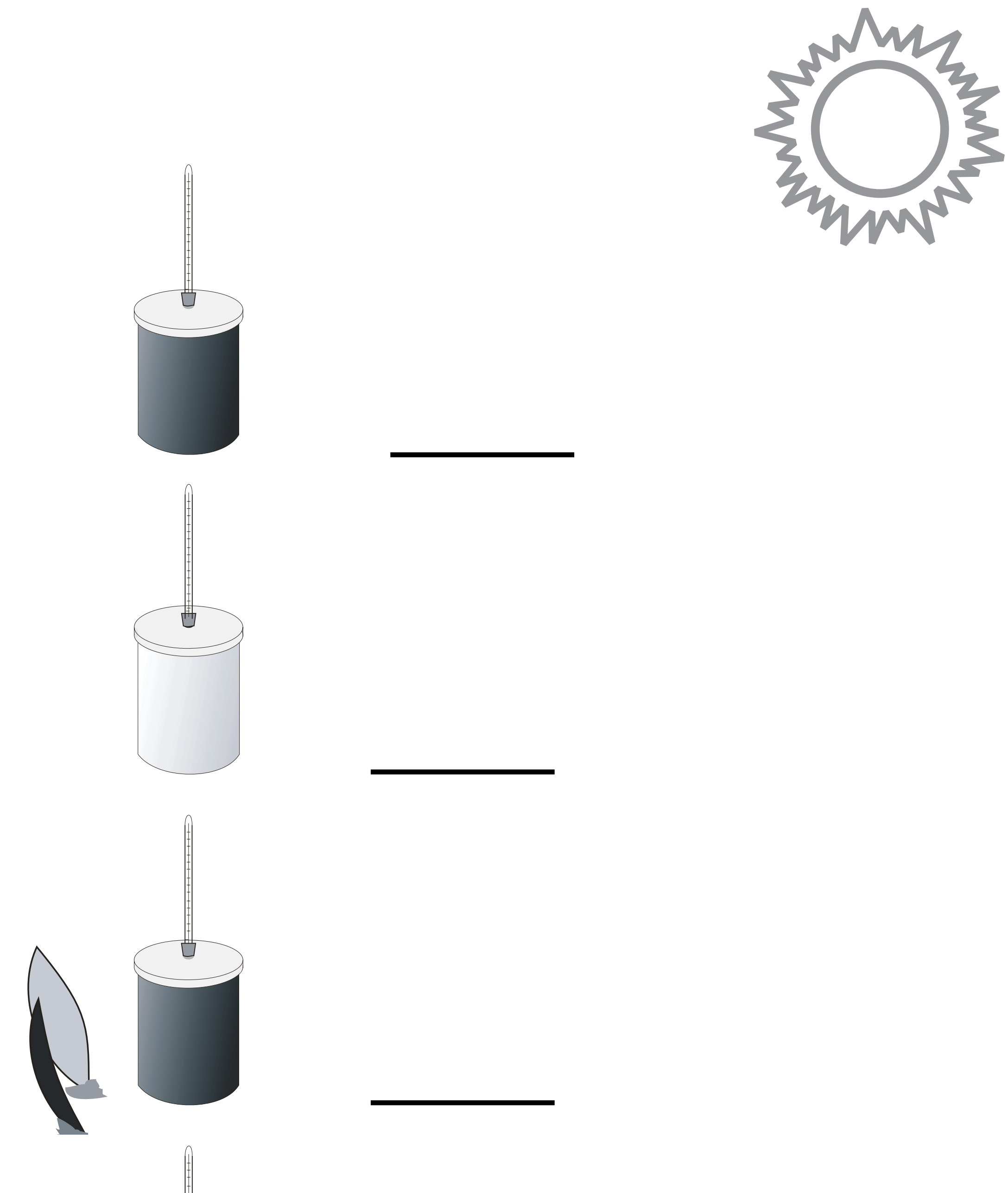
## Answer These Questions

1. If C is 50°, what is the temperature in Fahrenheit?

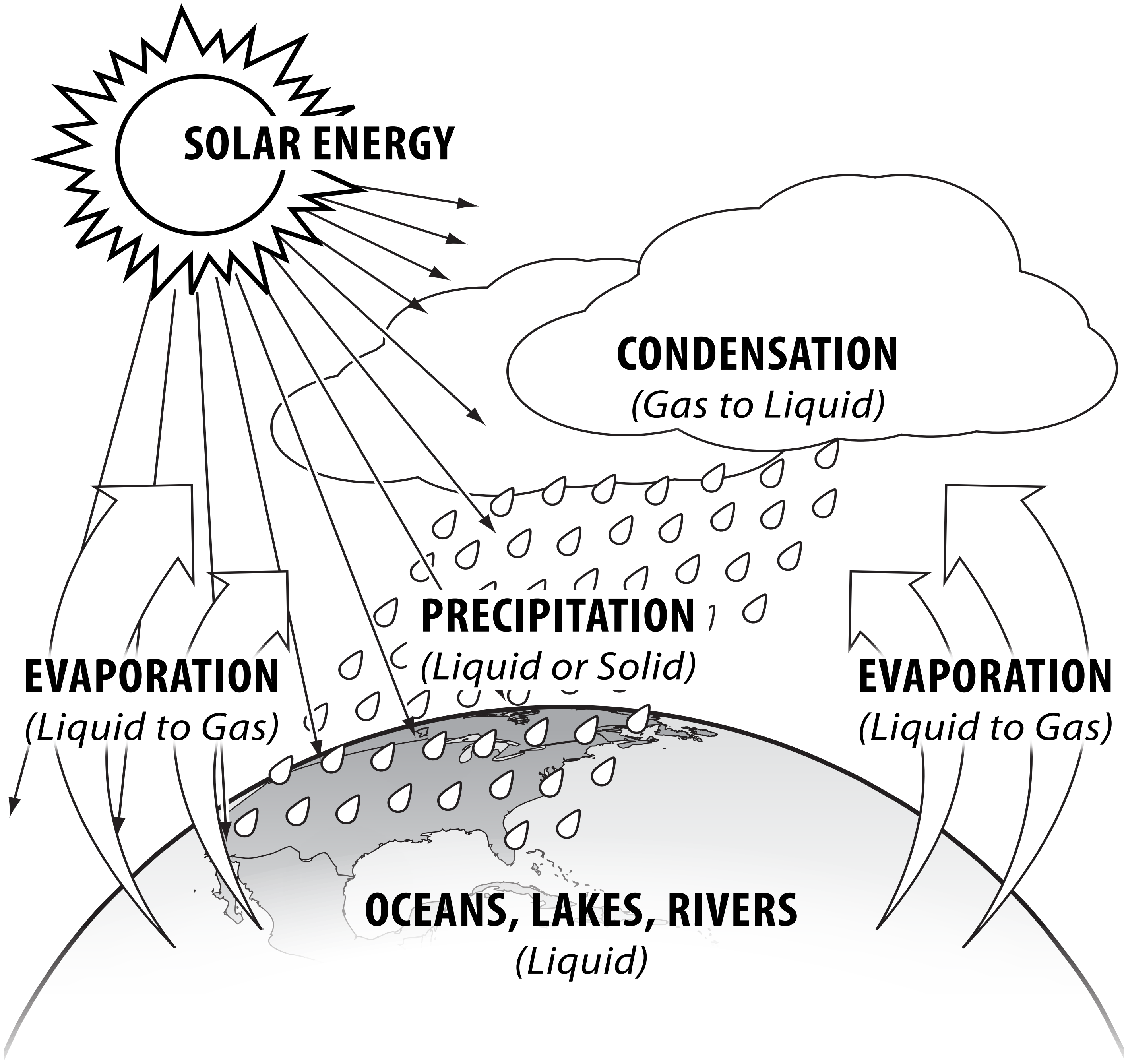
2. If F is 100°, what is the temperature in Celsius?

# Concentrating Solar Energy Assessment

1. Indicate on the drawings below where solar energy is being absorbed and reflected on each can.
2. Indicate the order in which the temperature of the water inside will increase from least to greatest using 1 (least) to 4 (greatest).



# Water Cycle

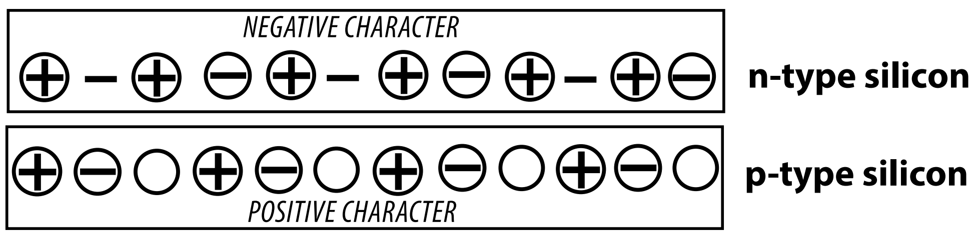

SOLAR ENERGY
CONDENSATION
(Gas to Liquid)
PRECIPITATION
(Liquid or Solid)
EVAPORATION
(Liquid to Gas)
EVAPORATION
(Liquid to Gas)
OCEANS, LAKES, RIVERS
(Liquid)

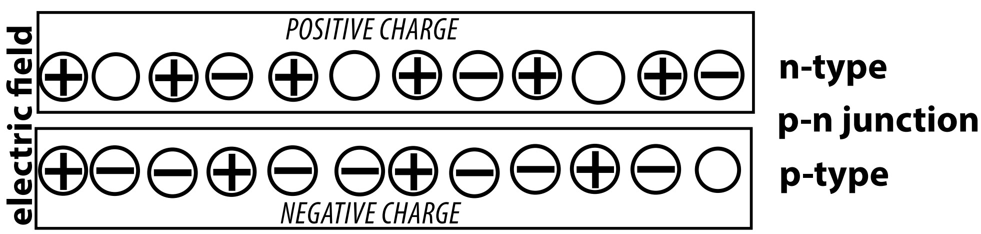
# Photovoltaic Cell

| | |
|---|---|
| ○ | A location that can accept an electron |
| – | Free electron |
| ⊕ | Proton |
| ⊖ | Tightly-held electron |

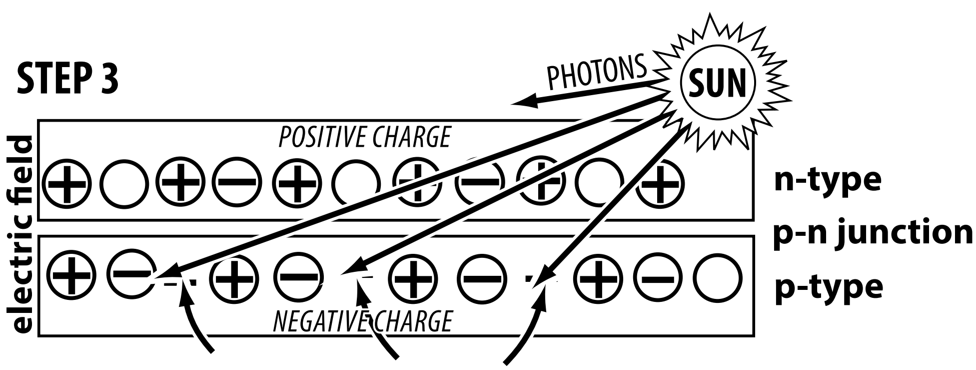
## STEP 1



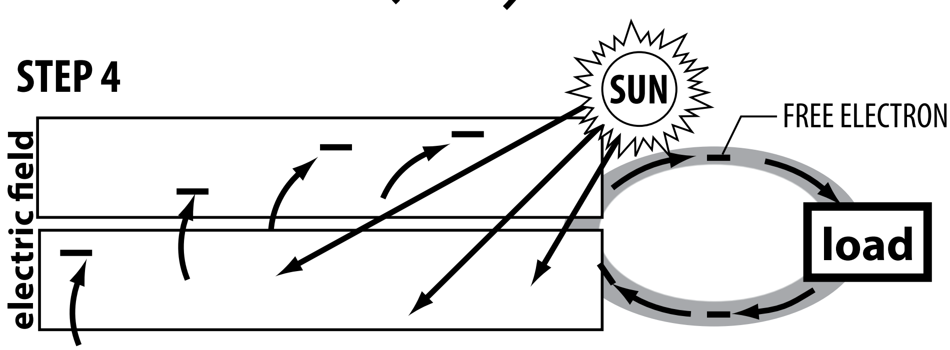

## STEP 2




## STEP 3




## STEP 4



# PV Ping Pong Simulation

## Background

Solar energy can be used to produce electricity without any chemical reaction. This process, known as the photoelectric effect, allows electrons to be ejected or emitted from the surface of a material when photons of light strike the material. Solar panels, or photovoltaic cells, are the devices we use to collect radiant energy from the sun and turn it directly into electricity to power our homes, schools, and businesses. This process, however, can be somewhat mystifying to students. In this simulation, students will act as the layers of a solar cell within a solar panel, photons of light, and electrons on the move.

## Materials

- 24 Ping pong balls
- Flashlight
- Colored or masking tape
- Sticky name tags
- *Photovoltaic Cell* master

## Preparation

- Set up two lines of tape on the floor for students to stand on. The lines should be facing each other with a few feet between them.
- Create a circle behind one of the tape lines. This will be the photon home.
- Write out name tags for each of the roles. This can also be done by the students once roles are assigned. You may choose to get "fancy" giving name tags or props that resemble roles as well (i.e., N-layers=N, photons=light bulbs, etc.).

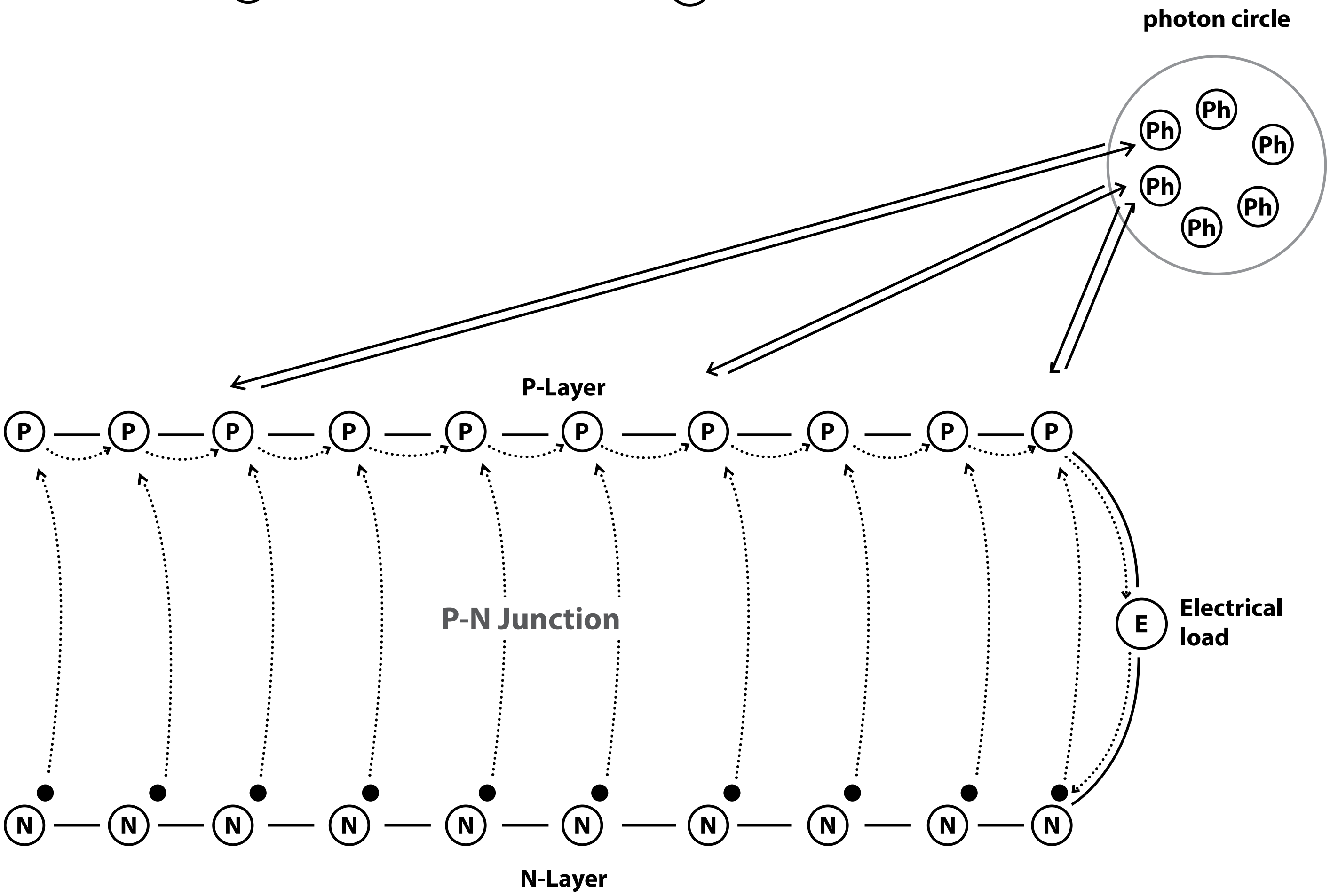
## ✔ Procedure

1. Project the *Photovoltaic Cell* master and discuss how a PV cell works.
2. Show students an overview of PV cells, if desired. Check out Brown University's SciToons YouTube clip for a good example, https://youtu.be/UJ8xW9AgUrW.
3. Assign students to roles.
4. Ask the P-layer students to stand on one line and the N-layer students to stand on the other line so that they are facing each other. Tell them the P-N junction is between them. Have the students on each line hold hands "wiring" themselves together.
5. The electrical load(s) should stand at the end of two lines. Students on the end of each line should hold hands with the electrical load, forming an open loop from P-layer through electrical load and on to N-layer.
6. Ask the photons to congregate in the photon circle, their "light source".
7. Give each N-layer student a ball. Tell students these are electrons. P-layer students should have none but should want to receive them.
8. When you signal, have the N-layer students toss their electrons to P-layer students, who will catch them.
9. When you signal, photons must leave the light source circle and tap a P-layer student (student with a ball) on the shoulder. They should then return to the circle and repeat the process.
10. When a P-layer student with a ball feels a tap, he or she should pass their electron down to the next person in line towards the electrical load to start the flow of current (or balls) toward the electrical load student.
11. When the electrical load student receives an electron, he or she should turn on his or her flashlight and yell "WOOO HOO," and turn it off as they pass the electron to the other side.
12. As electrons come to the N-layer from the load, they should immediately be tossed to the P-layer again.
13. Simulate darkness by having photon students sit in their circle, not moving. P-layer students should stand, holding electrons, ready to receive photons.

## PV Ping Pong Simulation and Roles

N-layer students – 17 (N) Photon students – 10 (Ph) Ball ●

P- layer students – 17 (P) Electrical load students – 1-2 (E)




## Extensions

- Have students determine how they would extend the simulation to include more solar arrays and devices into the circuitry.
- Have students write a description of how PV cells work.
- Have students design a simulation to showcase how a concentrated solar power (CSP) facility operates.

# Using Solar Energy to Produce Electricity Assessment

Use the vocabulary below to explain how electricity is produced by photovoltaic systems and concentrated solar power systems.

| | | | |
|---|---|---|---|
| dish/engine systems | linear Fresnel lens | radiant energy | solar power towers |
| electricity | parabolic troughs | residential | thermal energy |
| electrons | PV system | solar cell | utility scale |

# Solar Oven

## Objective

Students will be able to describe the energy transformation involved when using a solar oven.

## Materials

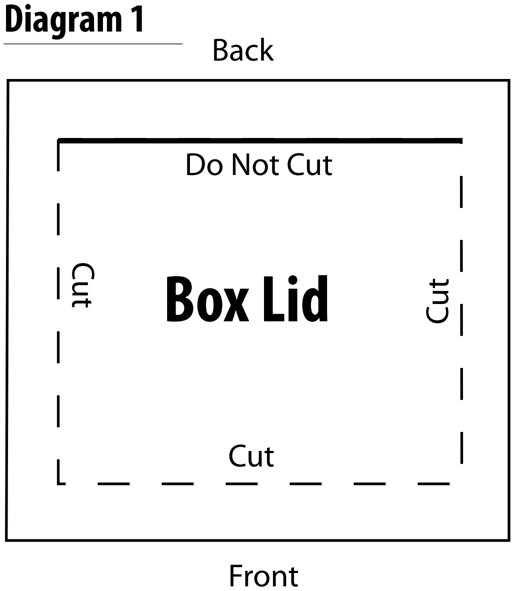
- 1 Small pizza box
- Plastic wrap
- Aluminum foil
- 1 Wooden skewer (12”-18”)
- Marker
- Scissors
- Ruler
- Masking tape
- 1 Paper plate*
- Black construction paper
- Oven thermometer
- Food to cook

***NOTE*:** Dark-colored paper plates work best, if available.

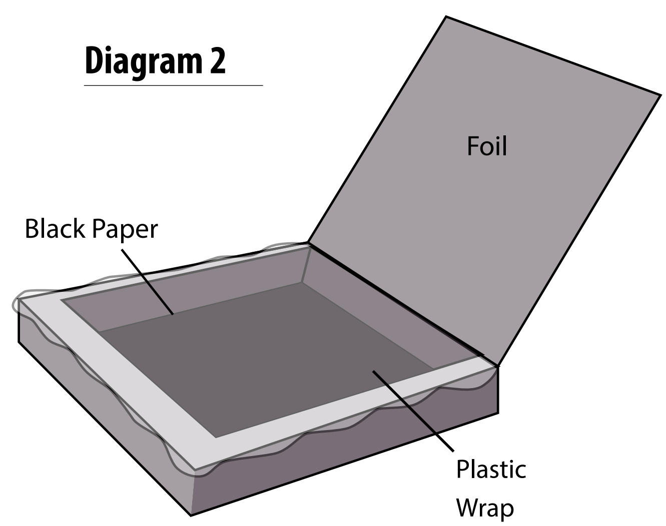
## General Directions to Build a Solar Oven

1. On the top of the pizza box, use your marker to draw a square with edges spaced 1” from all sides of the box.
2. Use scissors to cut along the sides and front edge of the lid, leaving the fourth side along the box’s hinge uncut, as shown in diagram 1.
3. Tape aluminum foil to the inside surface of the new flap you just cut, shiny side visible. This is to reflect sunlight into the box. Smooth out any wrinkles that might occur.
4. Tape plastic wrap to the original box flap so that it covers the hole you cut into the flap. Seal all four of the edges with tape.
5. Tape black construction paper to the bottom inside of the box. This will help absorb the incoming sunlight. See diagram 2 to make sure you have assembled steps 3-5 correctly.
6. Cover any air leaks around the box edges with tape, making sure that the box can still be opened to place food inside or remove it later.
7. Go outside in the sunlight and place the solar oven on a level flat surface.
8. Place food items on a paper plate and place it inside the oven. Put the oven thermometer inside the oven where you will be able to see it without moving the oven.
9. Tape one end of a wooden skewer to the reflector lid, attach the other end to the box to adjust reflector.
10. Let the food cook and periodically check the reflector angle to make sure sunlight is getting inside the oven.

### Diagram 1




### Diagram 2



# Solar House

## ✪ Objective

Students will be able to explain the difference between active and passive solar energy.

## Materials

- Cardboard box
- Scissors
- Clear transparency film
- Black construction paper
- 2 Sheets of white paper
- Clay
- Tape
- Solar house kit

## ✔ Procedure

1. Using the scissors, cut large windows and a door on one side of the box.
2. Tape clear transparency film over the windows.
3. Make a round water storage tank from black construction paper. Attach it to the side of the house with tape.
4. Make two holes 1 cm in diameter in the top of the box.
5. Push the shaft of the motor through one of the holes.
6. From the inside of the house, attach the fan blades to the motor. Make sure there is enough room above the blades for the fan to turn without bumping the ceiling. Use a strip of tape to hold the motor in place.
7. Push the LED through the other hole and tape it in place.
8. Attach the PV cells to the fan and LED.
9. Lay the PV cell with tubing on top of the house with the tubing extending down to the black water storage tank. Tape in place, or use clay to hold in place.
10. Carefully carry the house model into the sun. Observe the speed of the fan and the brightness of the LED. Tilt the PV cells so they are directly facing the sun. How does this affect the speed of the fan? Use a piece of clay under the PV cells to leave them in this position.
11. Simulate a bright, overcast day by placing a single sheet of white paper over the PV cells. Observe the speed of the fan and the brightness of the LED.
12. Simulate a very cloudy day by placing two sheets of white paper over the PV cells. Record your observations of the fan speed and LED brightness.
13. Simulate nighttime by placing a piece of cardboard over the PV cells. Record your observations of the fan speed and LED brightness.

# Solar House Rubric

Your group has been commissioned by The National Energy Education Development Project to design a home using passive and active solar. Your group will be expected to present the solar home design to your peers. You will need to explain what the solar features are, how they work, and why they are beneficial to the energy efficiency of your home. Use this rubric to evaluate your work as a group. Your teacher may also use this rubric to evaluate your group.

| | Meets or exceeds expectations | Needs some work | Back to the drawing board | Comments |
|---|---|---|---|---|
| Thorough explanation is provided for why each material was used in the design | | | | |
| Rationale for placement of solar elements | | | | |
| Design is creative and original | | | | |
| Identifies and explains which elements are active solar and which elements are passive solar | | | | |
| Use of materials | | | | |
| House is designed neatly and soundly | | | | |
| Design is adequately and correctly labeled | | | | |
| Sales pitch is informative and effective, using keywords and concepts from the background materials and activities | | | | |
| Other: | | | | |

# SOLAR ENERGY BINGO

A. Has used a solar clothes dryer

B. Knows the average conversion efficiency of PV cells

C. Knows the nuclear process in the sun's core

D. Knows how radiant energy travels through space

E. Can explain how solar energy drives the water cycle

F. Has used a photovoltaic cell

G. Rides in a solar collector

H. Can explain how solar energy produces wind

I. Knows how plants convert solar energy into chemical energy

J. Uses passive solar energy at home

K. Has seen a solar water heater

L. Has cooked food in a solar oven

M. Can name two advantages of solar energy

N. Knows the energy conversion that a PV cell performs

O. Can explain why dark clothes make you hotter in the sun

P. Owns solar protection equipment

| | | | |
|---|---|---|---|
| **A**<br>NAME | **B**<br>NAME | **C**<br>NAME | **D**<br>NAME |
| **E**<br>NAME | **F**<br>NAME | **G**<br>NAME | **H**<br>NAME |
| **I**<br>NAME | **J**<br>NAME | **K**<br>NAME | **L**<br>NAME |
| **M**<br>NAME | **N**<br>NAME | **O**<br>NAME | **P**<br>NAME |

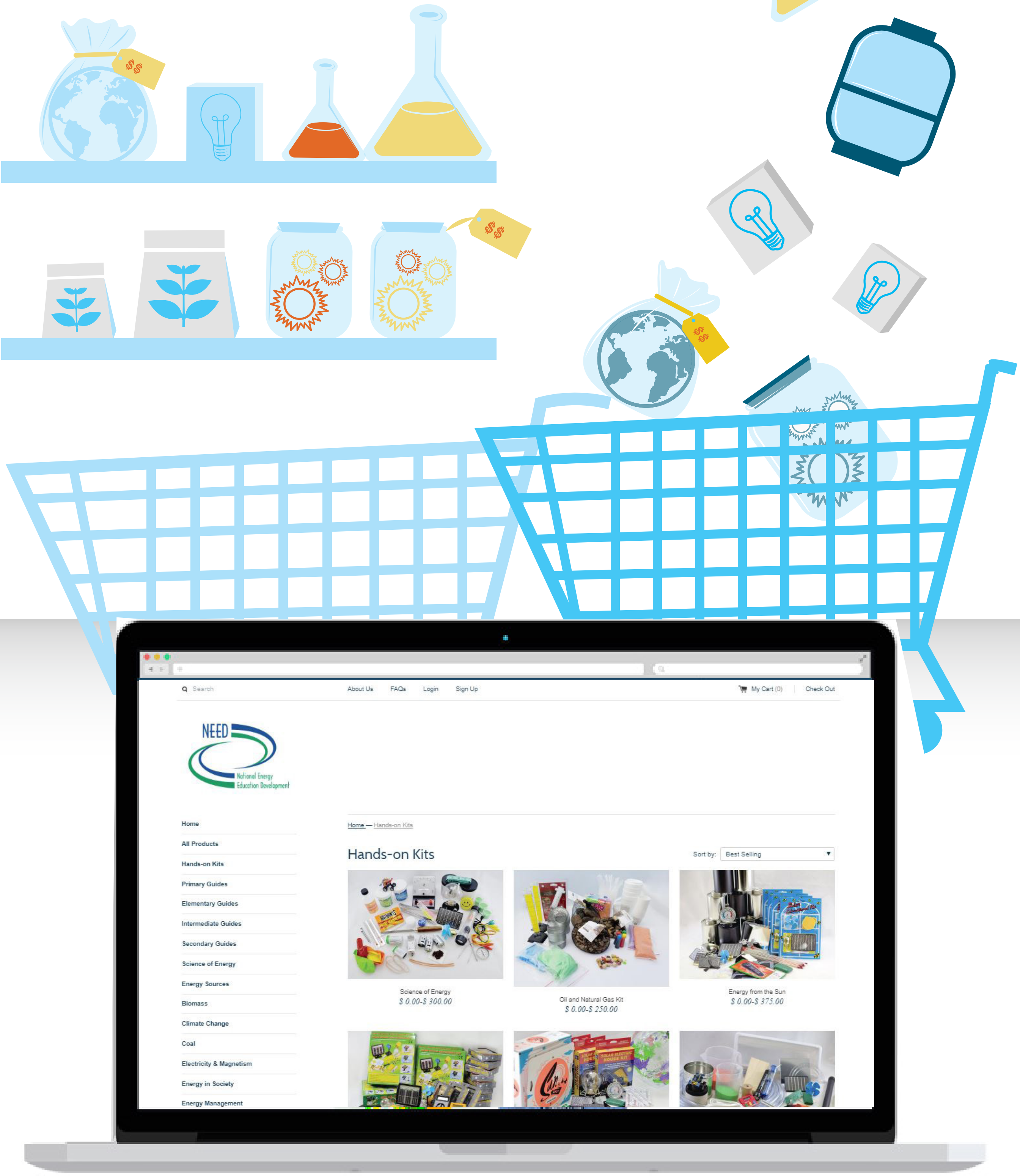
| | |
|---|---|
| **I have energy.**<br>Who has the two major gases that make up the sun? | **I have the speed of light.**<br>Who has the form of energy that sunlight is converted to when it is absorbed by the Earth? |
| **I have hydrogen and helium.**<br>Who has the process in which very small nuclei are combined into larger nuclei? | **I have thermal energy.**<br>Who has the color that absorbs more sunlight than other colors? |
| **I have nuclear fusion.**<br>Who has the form of energy emitted into space by stars and the sun during fusion? | **I have the color black.**<br>Who has a system that captures solar energy and uses it to heat spaces or substances? |
| **I have radiant energy.**<br>Who has the amount of time it takes the sun's energy to reach the Earth? | **I have a solar collector.**<br>Who has the process of using the sun's energy to heat buildings? |
| **I have eight minutes.**<br>Who has 186,000 miles per second? | **I have solar space heating.**<br>Who has a home that relies on orientation and construction materials to capture the sun's energy for heating interior spaces? |

| | |
|---|---|
| **I have a passive solar home.**<br>Who has a home with solar collectors and other solar equipment to heat it? | **I have chemical energy.**<br>Who has the process that traps the sun's energy in the atmosphere and makes life on Earth possible? |
| **I have an active solar home.**<br>Who has the energy source produced by uneven heating of the Earth's surface? | **I have the greenhouse effect.**<br>Who has the process plants use to convert radiant energy into chemical energy? |
| **I have wind.**<br>Who has organic matter that has absorbed energy from the sun? | **I have photosynthesis.**<br>Who has evaporation, condensation, and precipitation driven by energy from the sun? |
| **I have biomass.**<br>Who has the energy sources that can be replenished in a short time? | **I have the water cycle.**<br>Who has an object that can be used to cook food on a sunny day? |
| **I have renewables.**<br>Who has the form of energy that is stored in fossil fuels? | **I have a solar oven.**<br>Who has the system that uses mirrors to capture the sun's energy? |

| | |
|---|---|
| **I have concentrated solar power.**<br>Who has the Greek word that means light? | **I have silicon.**<br>Who has the device that nearly 2 million U.S. homes use to increase the thermal energy in their water? |
| **I have photo.**<br>Who has tiny bundles of energy from the sun? | **I have solar water heater.**<br>Who has the direction solar collectors should face in the U.S.? |
| **I have photons.**<br>Who has the form of energy directly produced by solar cells? | **I have south.**<br>Who has a major reason that capturing sunlight is difficult? |
| **I have electrical energy.**<br>Who has the technical word that is abbreviated as PV ? | **I have solar is spread out.**<br>Who has the only renewable energy source that is NOT produced by the sun's energy? |
| **I have photovoltaic.**<br>Who has the element that is a semi-conductor used to make PV cells? | **I have geothermal.**<br>Who has the ability to do work or cause a change? |

# ORDER MATERIALS AND CURRICULUM ONLINE!

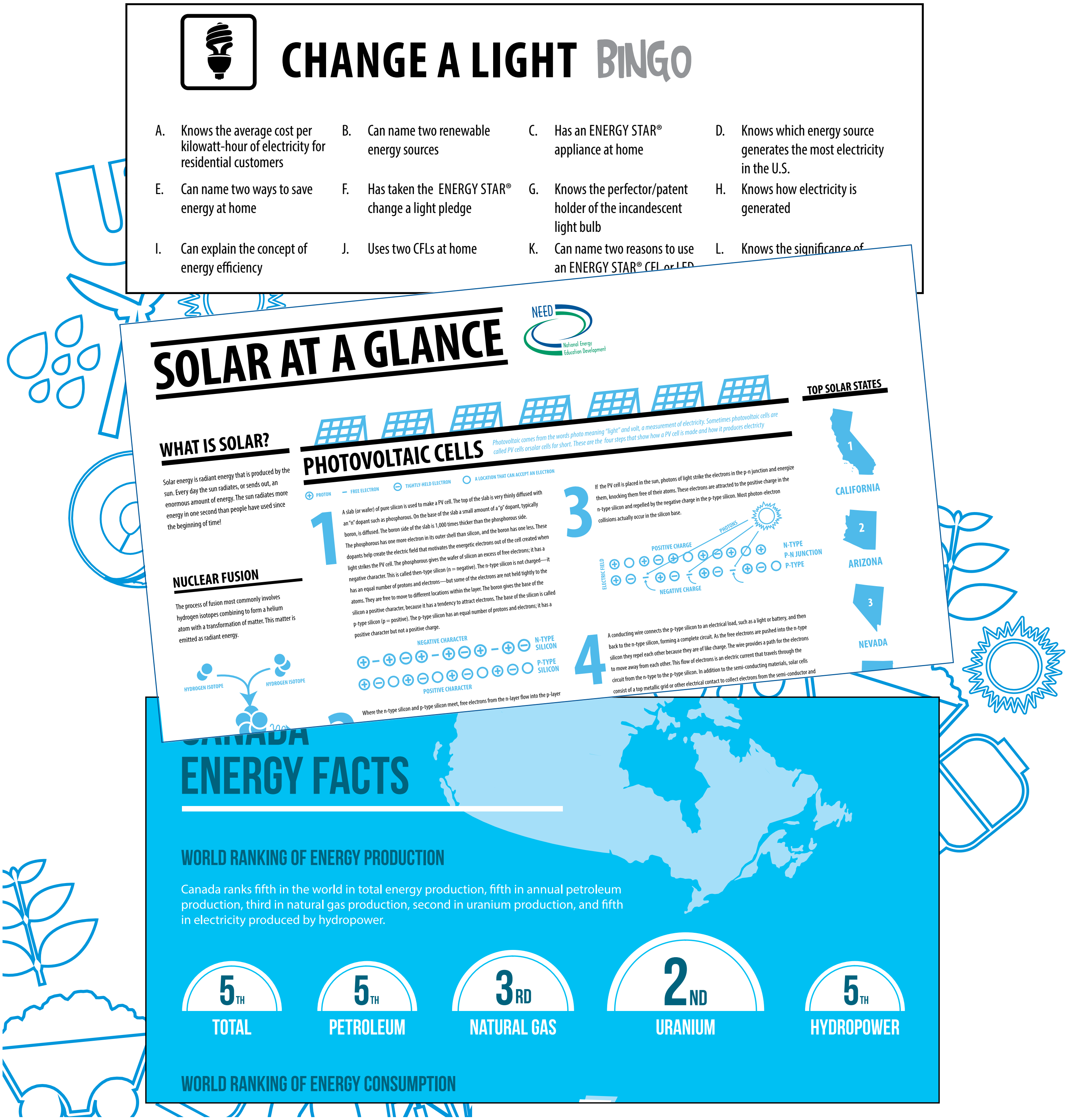
**Anemometers and solar cells and light meters — oh my! Getting your guides and kits (or refills) has never been easier! Check out NEED's official online store at shop.NEED.org.**



# Awesome Extras!

Our Awesome Extras page contains PowerPoints, animations, and other great resources to compliment what you are teaching!

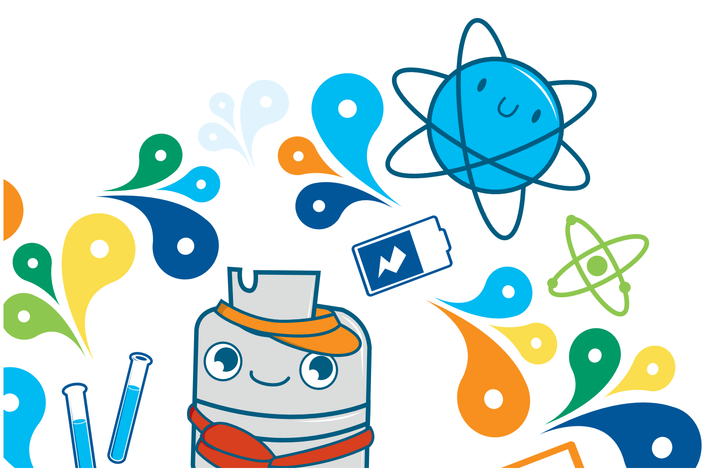
**This page is available at www.NEED.org/educators/awesome-extras/.**




# YOUTH ENERGY CONFERENCE AND AWARDS

The NEED Youth Energy Conference and Awards gives students more opportunities to learn about energy and to explore energy in STEM (science, technology, engineering, and math). The annual June conference has students from across the country working in groups on an Energy Challenge designed to stretch their minds and energy knowledge. The conference culminates with the Youth Awards Ceremony recognizing student work throughout the year and during the conference.

**For More Info: www.youthenergyconference.org**



# YOUTH AWARDS PROGRAM FOR ENERGY ACHIEVEMENT

**All NEED schools have outstanding classroom-based programs in which students learn about energy. Does your school have student leaders who extend these activities into their communities? To recognize outstanding achievement and reward student leadership, The NEED Project conducts the National Youth Awards Program for Energy Achievement.**

**Share Your Energy Outreach with The NEED Network!**
This program combines academic competition with recognition to acknowledge everyone involved in NEED during the year—and to recognize those who achieve excellence in energy education in their schools and communities.

## What's involved?

Students and teachers set goals and objectives and keep a record of their activities. Students create a digital project to submit for judging. In April, digital projects are uploaded to the online submission site.

## Want more info?

Check out **www.NEED.org/event/youth-energy-conference-and-awards/** for more application and program information, previous winners, and photos of past events.

# Energy From the Sun Evaluation Form

**State:** ____________ **Grade Level:** ____________ **Number of Students:** ___________

| | | |
|---|---|---|
| **1. Did you conduct the entire unit?** | ❑ Yes | ❑ No |
| **2. Were the instructions clear and easy to follow?** | ❑ Yes | ❑ No |
| **3. Did the activities meet your academic objectives?** | ❑ Yes | ❑ No |
| **4. Were the activities age appropriate?** | ❑ Yes | ❑ No |
| **5. Were the allotted times sufficient to conduct the activities?** | ❑ Yes | ❑ No |
| **6. Were the activities easy to use?** | ❑ Yes | ❑ No |
| **7. Was the preparation required acceptable for the activities?** | ❑ Yes | ❑ No |
| **8. Were the students interested and motivated?** | ❑ Yes | ❑ No |
| **9. Was the energy knowledge content age appropriate?** | ❑ Yes | ❑ No |
| **10. Would you teach this unit again?**<br>*Please explain any 'no' statement below* | ❑ Yes | ❑ No |

| | | | | |
|---|---|---|---|---|
| **How would you rate the unit overall?** | ❑ excellent | ❑ good | ❑ fair | ❑ poor |
| **How would your students rate the unit overall?** | ❑ excellent | ❑ good | ❑ fair | ❑ poor |

**What would make the unit more useful to you?**

**Other Comments:**

**Please fax or mail to: The NEED Project**
8408 Kao Circle
Manassas, VA 20110
FAX: 1-800-847-1820

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