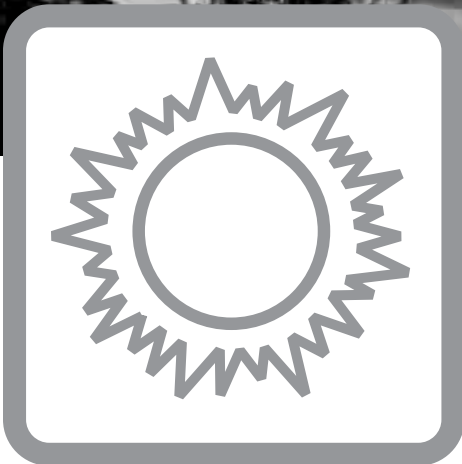


Energy From The Sun

Teacher Guide

Hands-on explorations that introduce scientific concepts of solar energy to elementary students.



Grade Level:

- Elementary



Subject Areas:

- Science
- Social Studies
- Math
- Language Arts



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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.

Teacher Advisory Board Statement

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

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Energy Data Used in NEED Materials

NEED believes in providing the most recently reported energy data available to our teachers and students. Most statistics and data are derived from the U.S. Energy Information Administration's Annual Energy Review that is published in June of each year. Working in partnership with EIA, NEED includes easy to understand data in our curriculum materials. To do further research, visit the EIA website at www.eia.doe.gov. EIA's Energy Kids site has great lessons and activities for students at www.eia.doe.gov/kids.



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Energy From the Sun

Teacher Guide

Materials Needed

- Shallow Pan with Water
- Red, White, & Black Construction Paper
- White Copy Paper
- Tape
- Scissors
- Food to Cook in Solar Oven
- Plastic Wrap
- Cardboard Boxes (12" x 12" x 12")

Materials in Solar Kit

- Class Set of Student Guides
- 12 Student F/C Thermometers*
- 4 Radiometers
- 2 Solar Balloons with String
- 2 Solar Ovens with 1 Oven Thermometer
- 4 Solar House Kits
- Clay
- 40-pack of NaturePrint® Paper

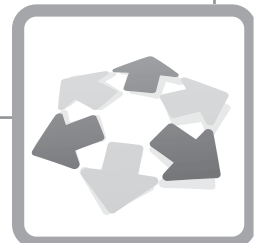
Student thermometers in the kit are safety thermometers containing alcohol, not mercury.

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Correlations to National Science Standards

This book has been correlated to National Science Education Content Standards.
For correlations to individual state standards, visit www.need.org.

Content Standard A | *SCIENCE AS INQUIRY*

▪ Abilities Necessary to do Scientific Inquiry

- Identify questions that can be answered through scientific investigations.
- Design and conduct a scientific investigation.
- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Develop descriptions, explanations, predictions, and models using evidence.
- Think critically and logically to make the relationships between evidence and explanations.
- Recognize and analyze alternative explanations and predictions.
- Communicate scientific procedures and explanations.
- Use mathematics in all aspects of scientific inquiry.

▪ Understandings about Scientific Inquiry

- Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models.
- Mathematics is important in all aspects of scientific inquiry.
- Science advances through legitimate skepticism. Asking questions and querying other scientists' explanations is part of scientific inquiry. Scientists evaluate the explanations proposed by other scientists by examining evidence, comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations.
- Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for an investigation, or develop new technologies to improve the collection of data. All of these results can lead to new investigations.

Content Standard B | *PHYSICAL SCIENCE*

▪ Transfer of Energy

- Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways.
- Heat moves in predictable ways, flowing from warmer objects to cooler ones, until both reach the same temperature.
- Light interacts with matter by transmission (including refraction), absorption, or scattering (including reflection). To see an object, light from that object—emitted by or scattered from it—must enter the eye.
- Electrical circuits provide a means of transferring electrical energy when heat, light, sound, and chemical changes are produced.
- The sun is a major source of energy for changes on the earth's surface. The sun loses energy by emitting light. A tiny fraction of that light reaches the earth, transferring energy from the sun to the earth. The sun's energy arrives as light with a range of wavelengths, consisting of visible light, infrared, and ultraviolet radiation.

Content Standard C | *LIFE SCIENCE*

▪ Populations and Ecosystems

- For ecosystems, the major source of energy is sunlight. Energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis. That energy then passes from organism to organism in food webs.

Content Standard D | *EARTH AND SPACE SCIENCE*

▪ Earth in the Solar System

- The earth is the third planet from the sun in a system that includes the moon, the sun, eight other planets and their moons, and smaller objects, such as asteroids and comets. The sun, an average star, is the central and largest body in the solar system.
- Most objects in the solar system are in regular and predictable motion. Those motions explain such phenomena as the day, the year, phases of the moon, and eclipses.
- The sun is the major source of energy for phenomena on the earth's surface, such as growth of plants, winds, ocean currents, and the water cycle. Seasons result from variations in the amount of the sun's energy hitting the surface, due to the tilt of the earth's rotation on its axis and the length of the day.



Correlations to National Science Standards

Content Standard E | *SCIENCE AND TECHNOLOGY*

▪ **Understandings about Science and Technology**

- Scientific inquiry and technological design have similarities and differences. Scientists propose explanations for questions about the natural world, and engineers propose solutions relating to human problems, needs, and aspirations. Technological solutions are temporary; technologies exist within nature and so they cannot contravene physical or biological principles; technological solutions have side effects; and technologies cost, carry risks, and provide benefits.
- Many different people in different cultures have made and continue to make contributions to science and technology.
- Science and technology are reciprocal. Science helps drive technology, as it addresses questions that demand more sophisticated instruments and provides principles for better instrumentation and technique. Technology is essential to science, because it provides instruments and techniques that enable observations of objects and phenomena that are otherwise unobservable due to factors such as quantity, distance, location, size, and speed. Technology also provides tools for investigations, inquiry, and analysis.
- Perfectly designed solutions do not exist. All technological solutions have trade-offs, such as safety, cost, efficiency, and appearance. Engineers often build in back-up systems to provide safety. Risk is part of living in a highly technological world. Reducing risk often results in new technology.
- Technological designs have constraints. Some constraints are unavoidable, for example, properties of materials, or effects of weather and friction; other constraints limit choices in the design, for example, environmental protection, human safety, and aesthetics.
- Technological solutions have intended benefits and unintended consequences. Some consequences can be predicted, others cannot.

Content Standard F | *SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES*

▪ **Populations, Resources, and Environments**

- When an area becomes overpopulated, the environment will become degraded due to the increased use of resources.
- Causes of environmental degradation and resource depletion vary from region to region and from country to country.

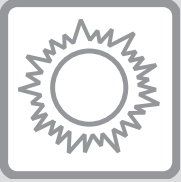
▪ **Science and Technology in Society**

- Societal challenges often inspire questions for scientific research, and social priorities often influence research priorities through the availability of funding for research.
- Technology influences society through its products and processes. Technology influences the quality of life and the ways people act and interact. Technological changes are often accompanied by social, political, and economic changes that can be beneficial or detrimental to individuals and to society. Social needs, attitudes, and values influence the direction of technological development.
- Science and technology have advanced through contributions of many different people, in different cultures, at different times in history. Science and technology have contributed enormously to economic growth and productivity among societies and groups within societies.

Content Standard G | *HISTORY AND NATURE OF SCIENCE*

▪ **Nature of Science**

- Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science, there is much experimental and observational confirmation. Those ideas are not likely to change greatly in the future. Scientists do and have changed their ideas about nature when they encounter new experimental evidence that does not match their existing explanations.
- In areas where active research is being pursued and in which there is not a great deal of experimental or observational evidence and understanding, it is normal for scientists to differ with one another about the interpretation of the evidence or theory being considered. Different scientists might publish conflicting experimental results or might draw different conclusions from the same data. Ideally, scientists acknowledge such conflict and work towards finding evidence that will resolve their disagreement.



Teacher Guide

Hands-on explorations introduce elementary students to the basic concepts of solar energy.

Background

Students use a backgrounder and hands-on explorations to develop a basic understanding of solar energy.

Concepts

- Nuclear reactions within the sun produce enormous amounts of energy, some in the form of radiant energy that travels through space to the earth.
- Most of the energy on Earth came from the sun. Only geothermal, nuclear, and tidal energy do not.
- The sun's energy makes life possible on Earth because of the greenhouse effect.
- We use the sun's energy to see.
- Through the process of photosynthesis, plants convert the sun's energy to chemical energy to provide food for growth and life.
- Fossil fuels and biomass contain chemical energy from plants and animals that we use to produce heat and light.
- Radiant energy from the sun powers the water cycle and produces wind.
- It is difficult to capture the sun's energy because it is spread out—not concentrated in any one area. We can capture solar energy with solar collectors that convert the energy into heat.
- Photovoltaic (PV) cells convert radiant energy directly into electricity.

Time

Eight 30 minute class periods.

Procedure

STEP ONE - PREPARATION

- Familiarize yourself with the Teacher and Student Guides, and with the materials in the kit.
- Make transparencies of the masters you want to use on pages 13-20.
- Collect the materials that are not included in the kit. See the Materials List on page 3 for materials that are not in the kit.

Activity 1: Introduction to Solar Energy

MATERIALS

▪None

TIME

▪60 minutes over two days

OBJECTIVE

To learn about solar energy by reading and completing worksheets.

PROCEDURE

- Introduce solar energy as the topic of exploration and make a list of the things the students know about solar energy. Write their ideas on the board.
- Distribute the Student Guides to the students and have them write their names on the cover.
- Have the students read the backgrounder (pages. 3-10 in the Student Guide) or read the backgrounder with/to them, depending upon grade level. Use the masters to help explain the greenhouse effect, the water cycle, how wind is made, photosynthesis, and fossil fuel formation, as you choose. The graphics in the Student Guide are designed so that younger students can color them.
- Have the students complete the Solar Energy and Wind & Water worksheets (pages 11-12 in the Student Guide) to reinforce new concepts and vocabulary.

Activity 2: Solar Energy To Heat And Motion

MATERIALS

IN KIT: 12 thermometers and four radiometers

TIME

▪30 minutes

NEEDED: White and black construction paper cut in 2" x 2" squares

OBJECTIVE

- To learn how to read a thermometer with Fahrenheit and Celsius scales.
- To learn that radiant energy can be reflected and absorbed by objects. When it is absorbed by objects, some radiant energy is converted into heat.

PROCEDURE

- Go to page 13 of the Student Guide. Use the Thermometer Master 6 to explain how to read a thermometer with Fahrenheit and Celsius scales. Have the students fill in the tube of the thermometers on the worksheet to the level of the Fahrenheit reading, then write the corresponding Celsius reading in the circle of each thermometer. Review with the students.
- Go to page 14 of the Student Guide. Set up four centers in sunny areas, each with three thermometers and pieces of black and white construction paper.
- Explain the procedure and have the students complete the exploration. Review the worksheet with the students to make sure they understand that:
 - white objects tend to reflect radiant energy.
 - black objects tend to absorb radiant energy.
 - when radiant energy is absorbed by objects, some of it is converted into heat.
- Go to page 15 of the Student Guide. Have one radiometer at each center.
- Explain the procedure, emphasizing that the radiometer is made of glass and can break very easily. Have the students complete the exploration.

CONTINUED ON NEXT PAGE

▪ Review the worksheet, using the Radiometer Master 7, to make sure the students understand that:

- the black vanes absorb more energy than the white vanes.
- the radiometer is a partial vacuum with few air molecules.
- the air molecules in the radiometer move around and bounce off the black vanes with more force because the black vanes have more energy.
- the force of the air molecules bouncing off the black vanes pushes the black vanes and makes the radiometer spin in a clockwise direction.

Activity 3: Solar Energy Can Cause Chemical Reactions

MATERIALS

IN KIT: One piece of NaturePrint® paper for each student

NEEDED: White paper, red construction paper, shallow pan of water, scissors for each student

TIME

▪ 30 minutes

OBJECTIVE

To learn that solar energy can cause chemical changes when it is absorbed by objects.

PROCEDURE

- Go to page 16 of the Student Guide.
- Explain the procedure and have the students complete the exploration. Review the worksheet with the students to make sure they understand that:
 - solar energy can cause a chemical reaction when it is absorbed by objects.
 - chemical reactions can produce a change in color.

Activity 4: Solar Energy to Heat and Motion

MATERIALS

IN KIT: Two solar balloons with string

TIME

▪ 30 minutes

OBJECTIVE

- To learn that air expands when it gets hotter—the molecules gain energy and bounce against each other with more force, pushing away from each other.
- To learn that warm air rises because it is less dense—there are fewer molecules per given volume than the surrounding air.

PROCEDURE

- Go to page 17 of the Student Guide. Explain the procedure to the students, go outside and have fun! The balloons should work on any clear, sunny day even if the temperature is cold. Avoid very windy days because it is difficult to tell whether the sun or the wind is lifting the balloons.
- Review the activity with the students, correlating it with the way wind is produced, to make sure they understand that:
 - black objects tend to absorb solar energy.
 - when solar energy is absorbed, some of it turns into heat.
 - warm air is less dense and rises.

Activity 5: Cooking with Solar Energy

MATERIALS

IN KIT: Two solar ovens with one oven thermometer

NEEDED: Food to cook in solar oven—nachos and chocolate chip cookies are good

TIME

▪ 30 minutes

OBJECTIVES

- To learn that shiny materials reflect solar energy.
- To learn to cook with a solar oven.

PROCEDURE

- Go to page 18 of the Student Guide. Explain the procedure to the students, go outside and cook a snack! The ovens will work even in really cold weather if you cover the ovens with clear plastic wrap. Have the students measure the temperature of the solar oven with the thermometer.
- Review the activity with the students to make sure they understand that:
 - the shiny sides of the oven reflect the solar energy onto the food.
 - the food absorbs the solar energy and turns it into heat that cooks the food.

Activity 6: Turning Solar Electricity Into Electricity

MATERIALS

IN KIT: Four Solar House kits, transparency film, clay

NEEDED: Four cardboard boxes, black paper, tape, scissors

TIME

▪ 30 minutes

OBJECTIVE

- To learn that photovoltaic (PV) cells turn solar energy into electricity.
- To learn that electricity can produce light and motion.

PROCEDURE

- Go to page 19 of the Student Guide. Set up four centers, each with one Solar House Kit, a piece of transparency film, a small piece of clay, scissors, and tape. You can also have crayons and markers on hand if you would like the students to decorate the boxes to look like houses. Divide the class into four groups.
- Explain the procedure to the students, emphasizing that all of the students in the groups should have an opportunity to help with the activity. [As an alternative, every student can prepare his/her own box house and take turns installing the PV equipment.] Assign each group of students to a center and have them complete the activity. For younger students, it is recommended that adult helpers at each center assist students with this activity.
- Review the activity with the students to make sure they understand that:
 - a solar collector turns solar energy into heat.
 - a PV cell changes solar energy into electricity.
 - electricity can produce light and motion.

ONLINE REFERENCE

See NEED's *Monitoring and Mentoring Meter Reading* activity, available at www.need.org for more information.

DATA COLLECTION

For real time PV panel data collection activities, see NEED's *Schools Going Solar Guide* available at www.need.org.

Activity 7: Optional PV Cells on the School

MATERIALS

▪None

TIME

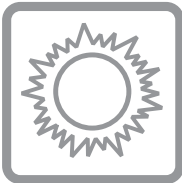
▪30 minutes

OBJECTIVE

To learn about the PV cells in use on the school.

PROCEDURE

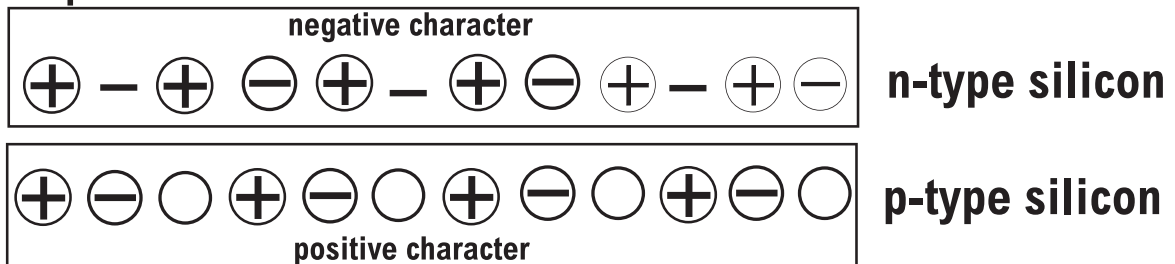
Have the school energy/facility manager or administrator show the students the PV system on the school and explain how the system helps the school reduce its energy costs. If the system is separately metered, older students can monitor the electricity use to determine how much electricity the system is producing, keeping a journal of weather conditions and output each day.



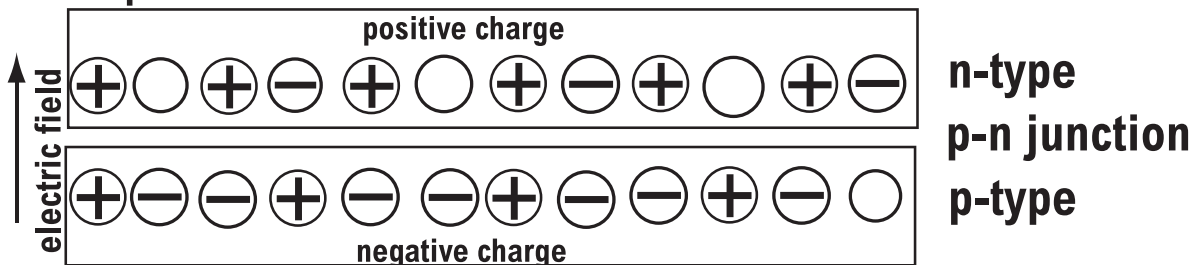
Photovoltaic Cell

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

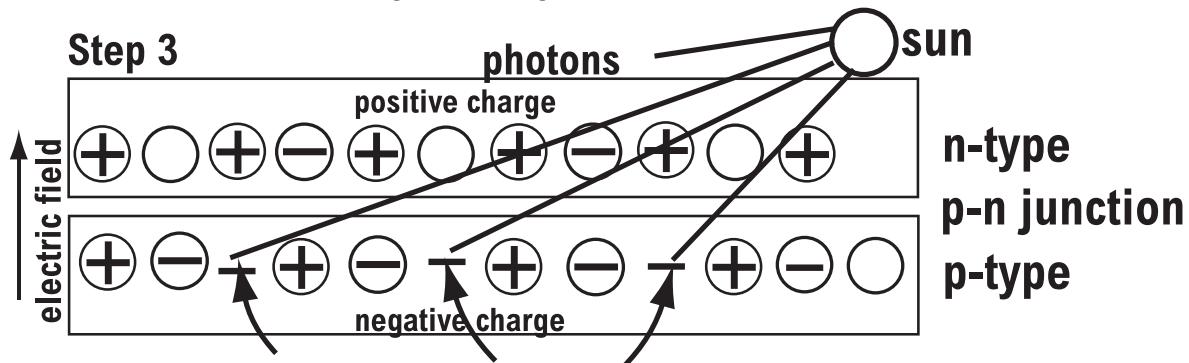
Step 1



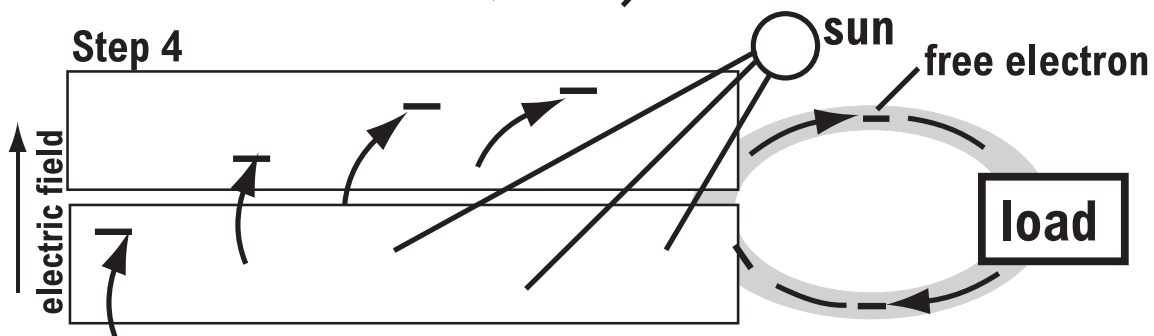
Step 2



Step 3



Step 4





Teacher Information

What is Energy?

Energy is the ability to do work, the ability to make a change. Everything that happens in the world involves a change of some kind, the exchange of energy in some way. The total amount of energy in the universe remains the same. When we use energy, we do not ‘use it up’, we convert one form of energy into other forms. Usually the conversion of energy produces some heat, which is considered the lowest form of energy, since it dissipates into the surroundings and is difficult to capture and use again. Energy is categorized in many ways—by the forms it takes and by what it does—the changes it makes and the effects we can see or feel or measure.

What Energy Does: Energy is recognized in the following ways:

- Energy is light—energy produces light—the movement of energy in transverse waves or rays—radiant energy.
- Energy is heat—energy produces heat—the movement of atoms and molecules within substances—thermal energy.
- Energy is sound—energy produces sound—the back-and-forth vibration of substances in longitudinal waves.
- Energy is motion—energy produces motion—kinetic energy.
- Energy is growth—energy is required for cells to reproduce—chemical energy stored in the bonds of nutrients.
- Energy is electricity to run technology—the movement of electrons from atom to atom.

Forms of Energy: Energy is recognized in many forms, all of which are potential or kinetic:

- Thermal Energy (Heat)
- Mechanical Energy (Motion)
- Chemical Energy (Energy in Wood, Fossil Fuels)
- Electrical Energy (Electricity, Lightning)
- Nuclear Energy (Fission, Fusion)
- Radiant Energy (Light, X-rays)
- Sound (Motion)

Solar Energy

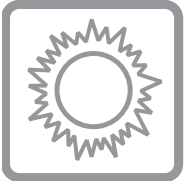
Solar energy is energy from the sun. The sun is a giant ball of hydrogen and helium gas. The enormous heat and pressure in the interior of the sun cause the nuclei of two hydrogen atoms to fuse, producing one helium atom in a process called fusion. During fusion, nuclear energy is converted into thermal (heat) and radiant energy. The radiant energy is emitted from the sun in all directions and some of it reaches Earth. Radiant energy is energy that travels in electromagnetic waves or rays. Radiant energy includes visible light, x-rays, infrared rays, microwaves, gamma rays, and others. These rays have different amounts of energy depending upon their wavelength. The shorter the wavelength, the more energy they contain.

Photovoltaic Cells

Photovoltaic (PV) comes from the words *photo* meaning light and *volt*, a measurement of electricity. PV cells are made of a thin piece of silicon, the substance that makes up sand and the second most common substance on earth. One side of the silicon has a small amount of boron added to it, which gives it a tendency to attract electrons. It is called the p-type because it has a positive tendency. The other side of the silicon has a small amount of phosphorous added to it, giving it an excess of free electrons. This is called the n-type because it has a tendency to give up electrons. After the two sides of silicon have both been chemically modified, some electrons from the n-type flow to the p-type and an electric field forms between the layers. The p-type now has a negative charge and the n-type has a positive charge.

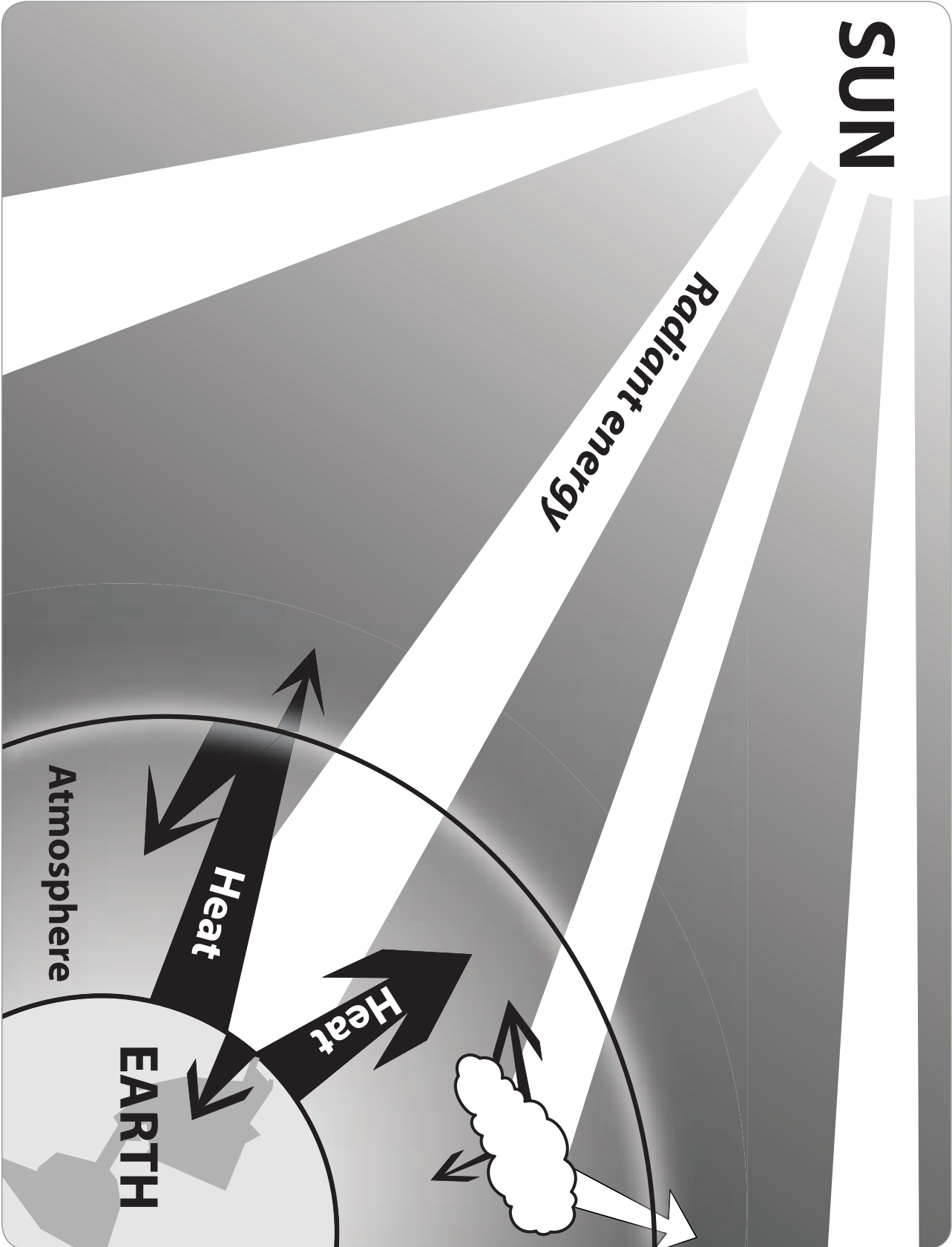
When the PV cell is placed in the sun, the radiant energy energizes the free electrons. If a circuit is made connecting the sides, electrons flow from the n-type through the wire to the p-type. The PV cell is producing electricity—the flow of electrons. If a load such as a lightbulb is placed along the wire, the electricity will do work as it flows. The conversion of sunlight into electricity takes place silently and instantly. There are no mechanical parts to wear out. (See the diagram on the previous page for a graphic explanation of how a PV cell works.)

For more information and activities about Energy Transformations, download *Primary Science of Energy* (grades K-3) or *Science of Energy* (grades 4-5) from www.need.org.



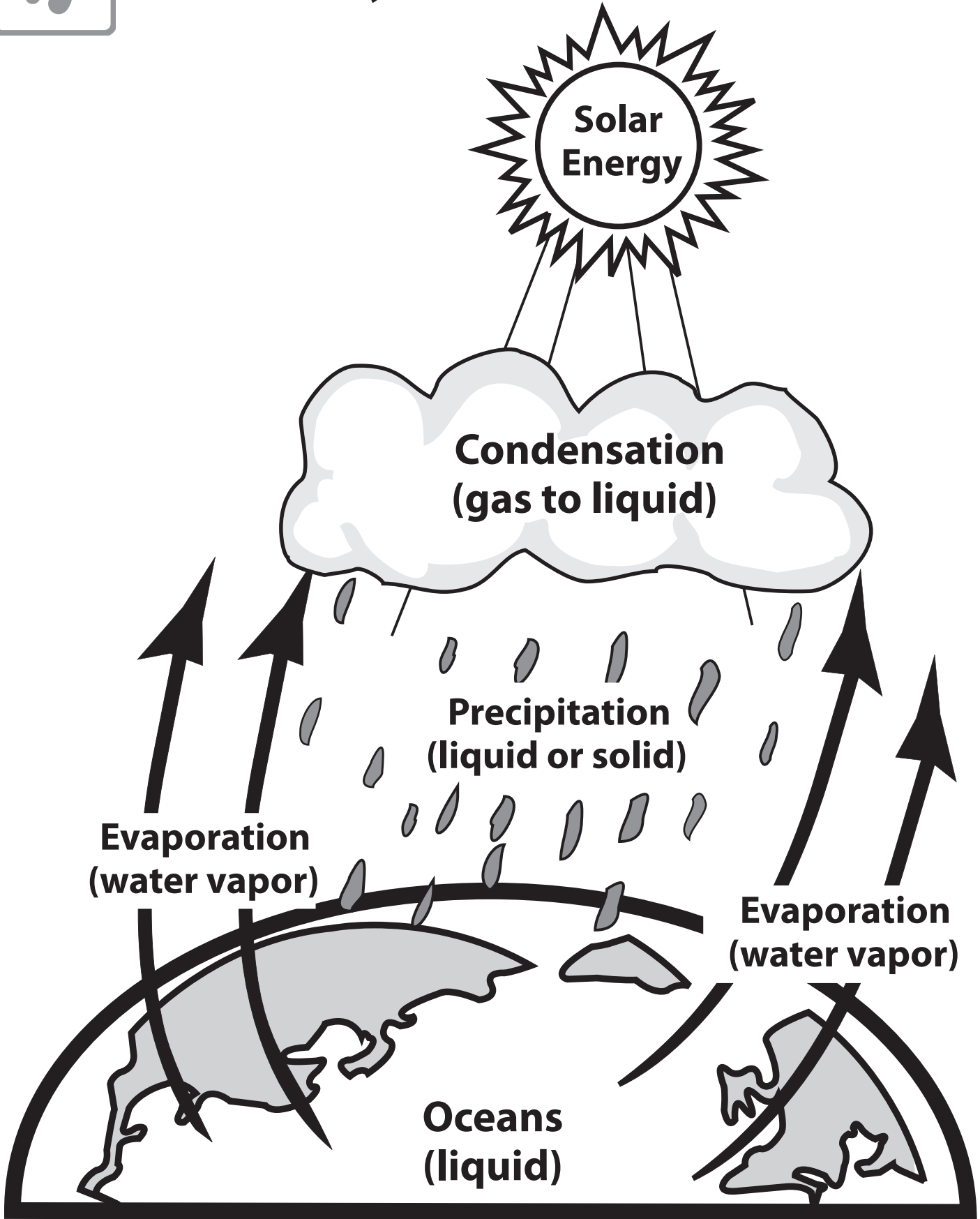
MASTER 1

The Greenhouse Effect



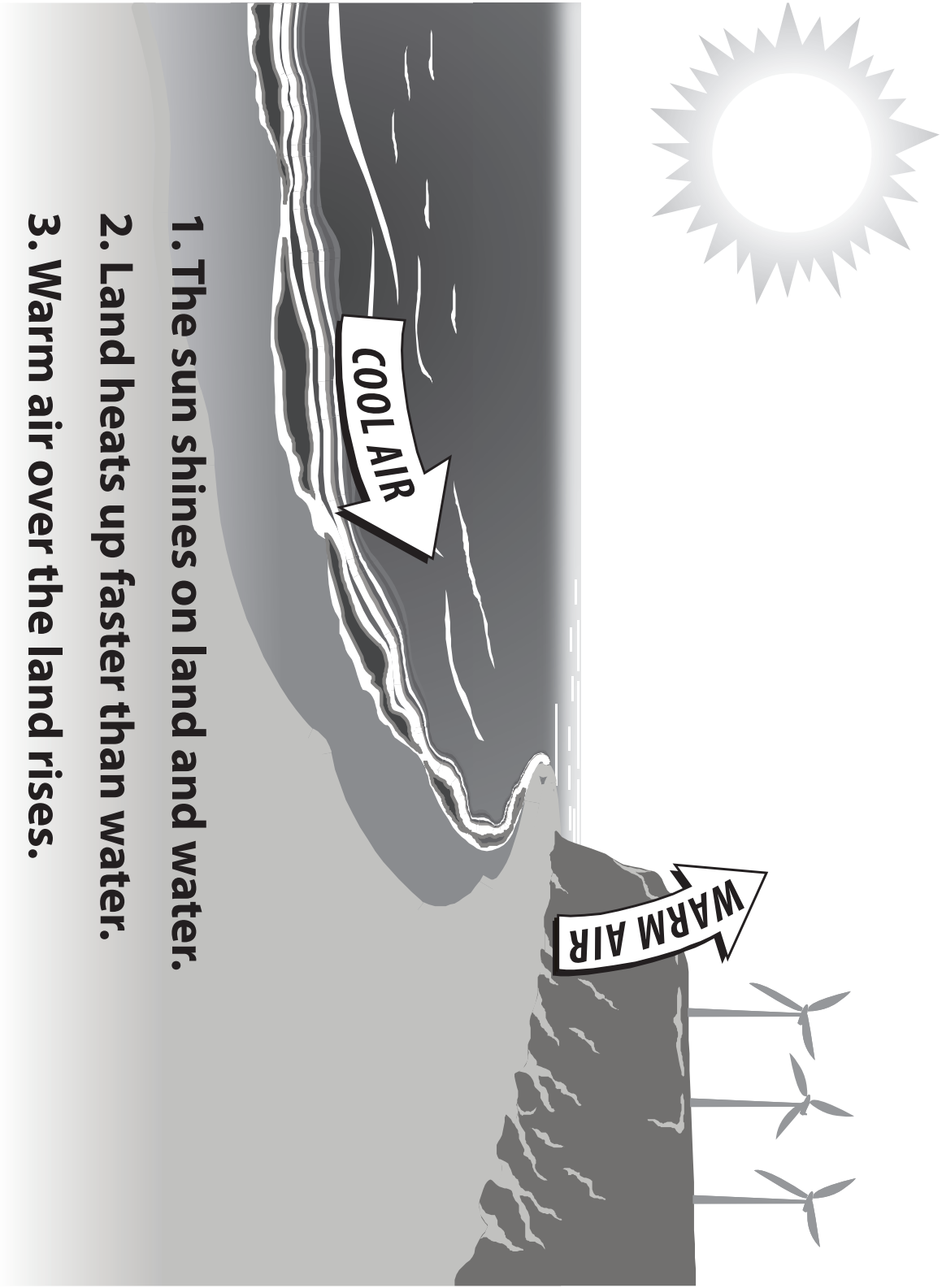


The Water Cycle

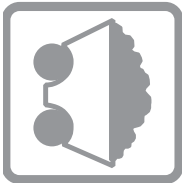




How Wind Forms Where Water Meets Land



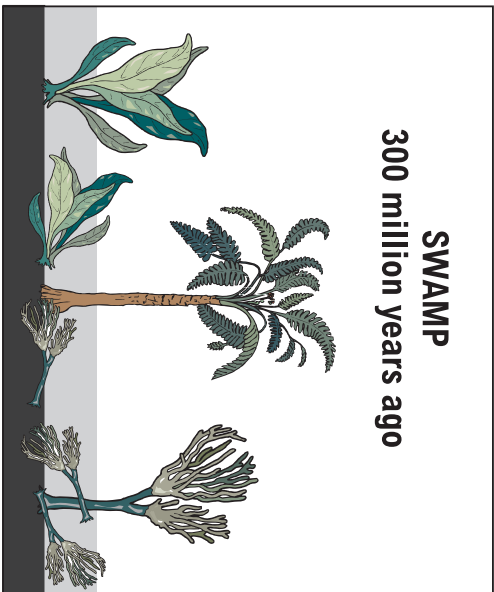
- 1. The sun shines on land and water.**
- 2. Land heats up faster than water.**
- 3. Warm air over the land rises.**
- 4. Cool air over the water moves in.**



MASTER 4

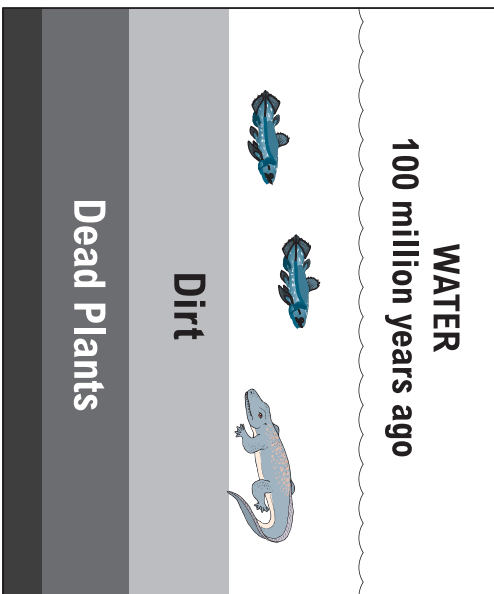
How Coal Was Formed

SWAMP
300 million years ago



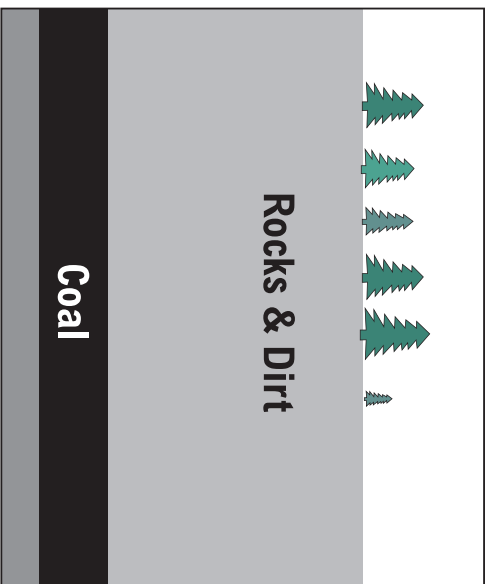
Before the dinosaurs, many giant plants died in swamps.

WATER
100 million years ago

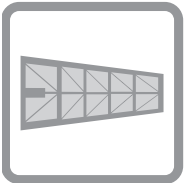


Over millions of years, the plants were buried under water and dirt.

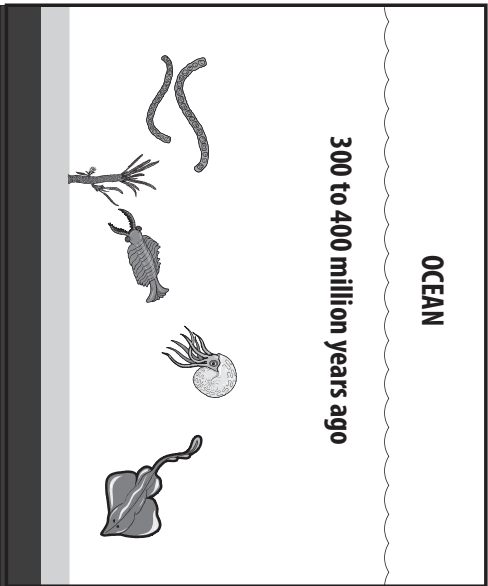
Rocks & Dirt



Heat and pressure turned the dead plants into coal.



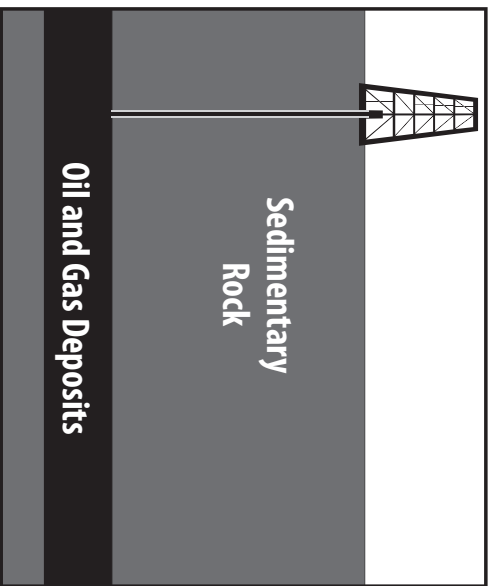
How Oil and Natural Gas Were Formed



Tiny sea plants and animals died and were buried on the ocean floor. Over time, they were covered by layers of sedimentary rock.



Over millions of years, the remains were buried deeper and deeper. The enormous heat and pressure turned them into oil and gas.

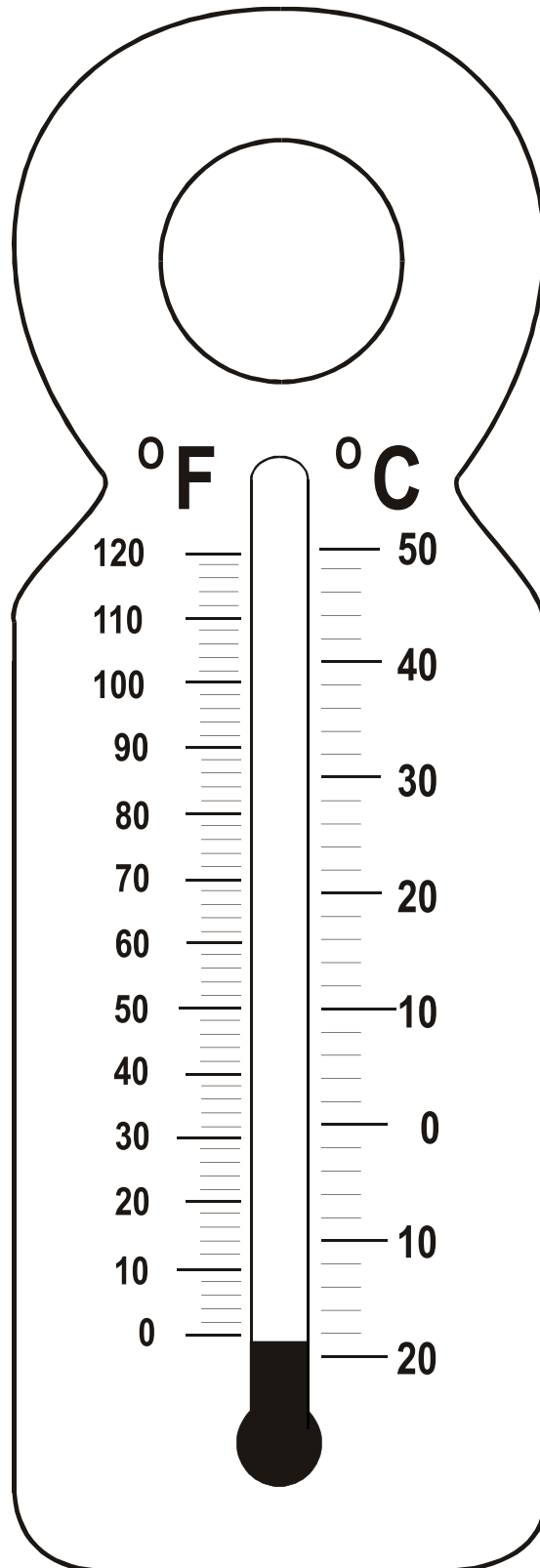


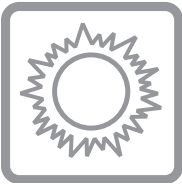
Today, we drill down through layers of sedimentary rock to reach the rock formations that contain oil and gas deposits.



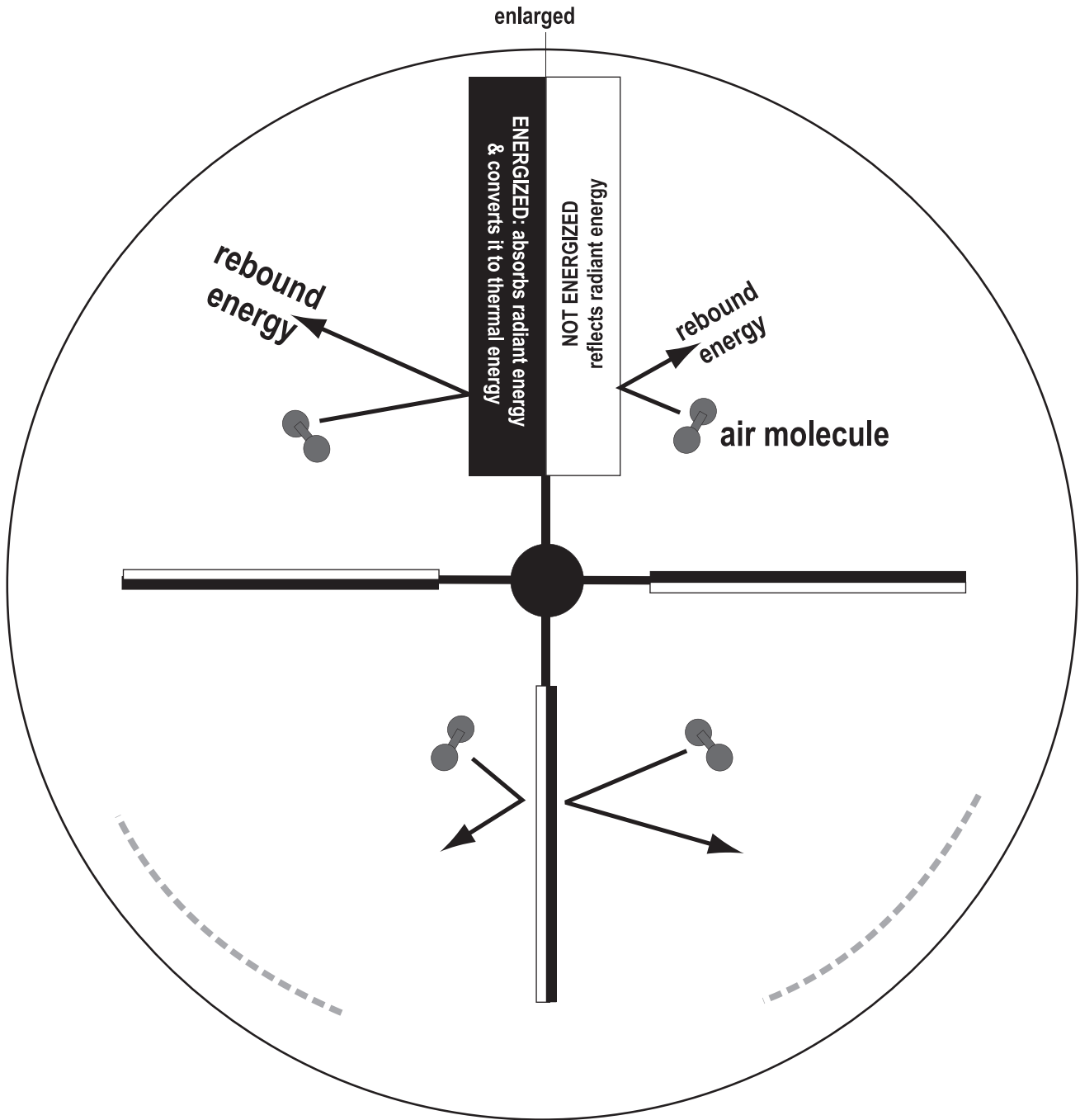
MASTER 6

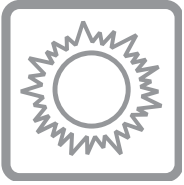
Fahrenheit and Celsius Thermometer





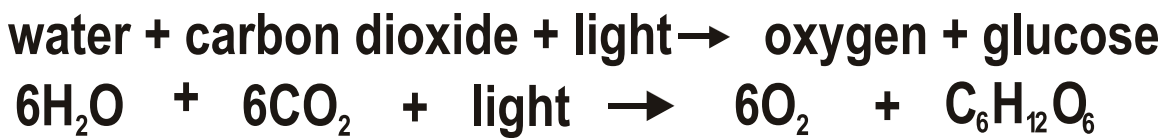
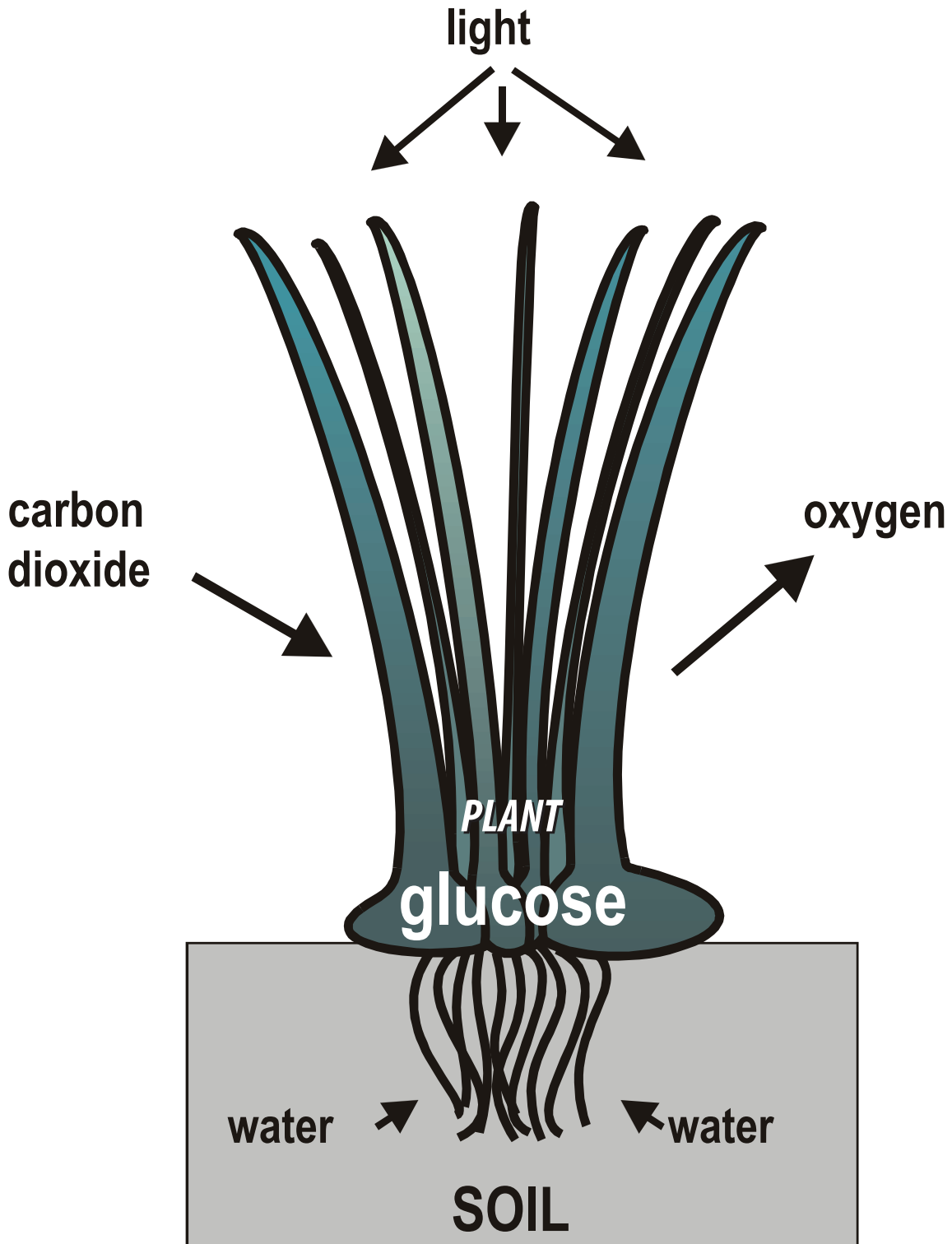
Top View of Radiometer





MASTER 8

Photosynthesis





Solar Energy

Fill in the blanks with the words in the box at the bottom of the page. Use each word only once.

- Solar comes from the word **sol**, which means sun.
- The word **photo** means light.
- volt** is a measure of electricity.
- radiant energy** is energy that travels in rays.
- Plants **absorb**, or take in, radiant energy.
- White and shiny objects **reflect** radiant energy.
- A **solar collector** takes in solar energy and turns it into heat.
- Solar energy is called a **renewable** energy source, because it will always be there.
- A **photovoltaic** cell turns light into electricity.
- Plants take in solar energy and store it in their leaves and roots as **chemical energy**.

reflect absorb chemical energy photo volt sol
renewable photovoltaic solar collector radiant energy

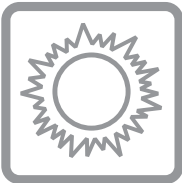


Water and Wind

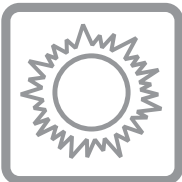
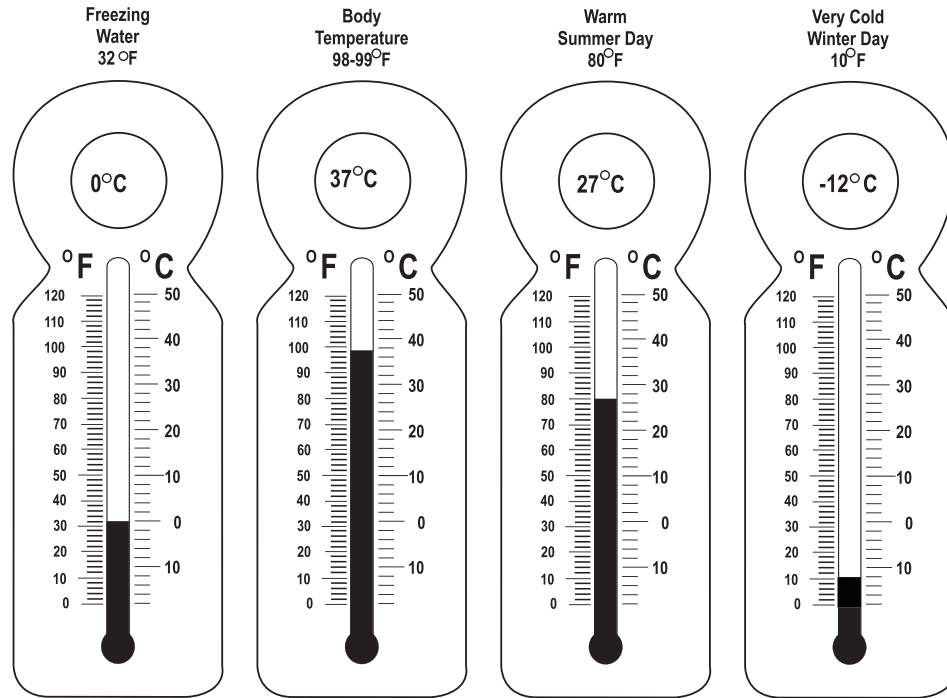
Fill in the blanks with the words in the box at the bottom of the page. Use each word only once.

- Water as a gas is called **water vapor**.
- Rain and snow are called **precipitation**.
- The air around the earth is the **atmospheric**.
- When water turns into a gas, it **evaporates**.
- Near the shore, the air over **land** heats up faster than air over the water.
- A **wind turbine** is a machine that captures the energy in moving air.
- Warm air **rises** into the atmosphere.
- Moving air is called **wind**.
- Gravity** moves water from high to low ground.
- Wind turbines and hydropower dams turn the energy in moving air and moving water into **electricity**.

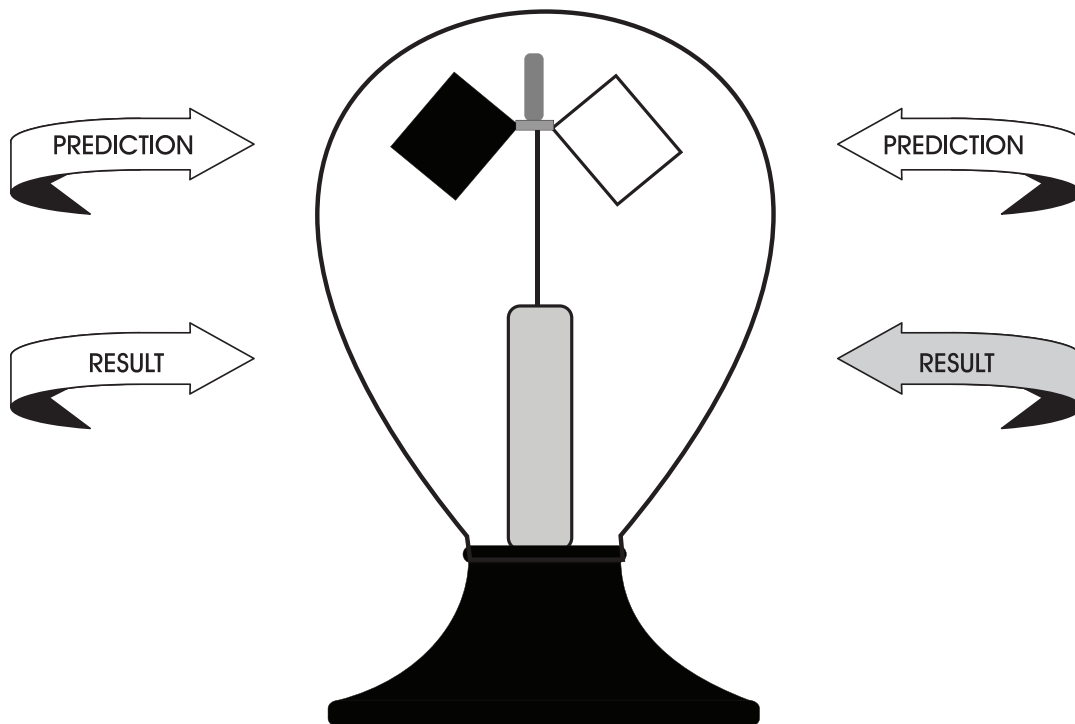
evaporates rises water vapor precipitation gravity
wind turbine electricity land atmosphere wind

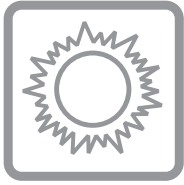


Thermometer Answer Sheet



Radiometer Answer Sheet





Energy From the Sun Evaluation Form

State: _____ Grade Level: _____ Number of Students: _____

1. Did you conduct the entire activity? Yes No
2. Were the instructions clear and easy to follow? Yes No
3. Did the activity meet your academic objectives? Yes No
4. Was the activity age appropriate? Yes No
5. Were the allotted times sufficient to conduct the activity? Yes No
6. Was the activity easy to use? Yes No
7. Was the preparation required acceptable for the activity? Yes No
8. Were the students interested and motivated? Yes No
9. Was the energy knowledge content age appropriate? Yes No
10. Would you use the activity again? Yes No

How would you rate the activity overall? excellent good fair poor

How would your students rate the activity overall? excellent good fair poor

What would make the activity more useful to you?

Other Comments:

Please fax or mail to: **NEED Project**

PO Box 10101
Manassas, VA 20108
FAX: 1-800-847-1820

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National Fuel
National Hydropower Association
National Ocean Industries Association
National Renewable Energy Laboratory
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New York Power Authority
New Mexico Oil Corporation
New Mexico Landman’s Association
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Offshore Technology Conference
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PNM
Puerto Rico Energy Affairs Administration
Puget Sound Energy
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