EXPLORING SOLAR ENERGY

Teacher Guide

Hands-on explorations that teach scientific concepts of solar energy and photovoltaics to intermediate students.

GRADE LEVEL

Intermediate

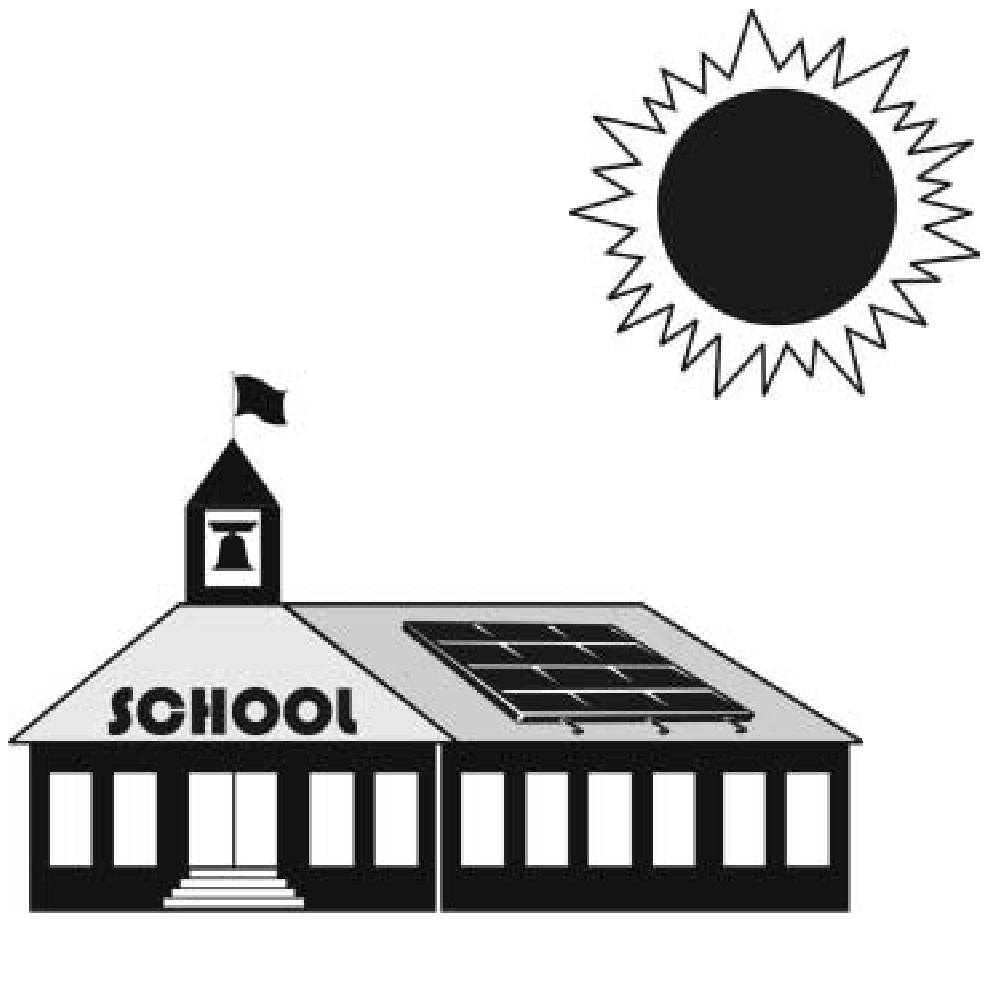
SUBJECT AREAS

Science

Social Studies

Math

Language Arts



NEED

2009-2010

Putting Energy into Education

NEED Project PO Box 10101 Manassas, VA 20108 1-800-875-5029 www.NEED.org

Teacher Advisory Board

Teacher Advisory Board Vision Statement

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.

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

Permission to Reproduce

Printed on Recycled Paper

TABLE OF CONTENTS

MATERIALS NEEDED

Cold and Hot Water
White & Black Construction Paper
Overhead Projectors
5 Metric Rulers
Scissors
Transparency Paper
Clear Plastic Wrap
Rubber Bands
Cardboard Box

MATERIALS IN SOLAR KIT

Class Set of Student Guides
5 Radiation Can Kits
10 Thermometers
12 Concave Mirrors
20 Plastic Containers
5 Beakers
2 Solar Balloons with String
5 Solar PV Kits
1 Solar House Kit
Clay

COST OF KIT: $350.00

NEED Putting Energy into Education

IREC Interstate Renewable Energy Council

Correlations to National Science Standards

(Bolded standards are emphasized in the unit.)

UNIFYING CONCEPTS & PROCESSES

1. Systems, Order, and Organization

a. The goal of this standard is to think and analyze in terms of systems, which will help students keep track of mass, energy, objects, organisms, and events referred to in the content standards.

b. Science assumes that the behavior of the universe is not capricious, that nature is the same everywhere, and that it is understandable and predictable. Students can develop an understanding of order—or regularities—in systems, and by extension, the universe; then they can develop understanding of basic laws, theories, and models that explain the world.

c. Prediction is the use of knowledge to identify and explain observations, or changes, in advance. The use of mathematics, especially probability, allows for greater or lesser certainty of prediction.

d. Order—the behavior of units of matter, objects, organisms, or events in the universe—can be described statistically.

e. Probability is the relative certainty (or uncertainty) that individuals can assign to selected events happening (or not happening) in a specified time or space.

f. Types and levels of organization provide useful ways of thinking about the world.

2. Evidence, Models, and Explanation

a. Evidence consists of observations and data on which to base scientific explanations. Using evidence to understand interactions allows individuals to predict changes in natural and designed systems.

3. Change, Constancy, and Measurement

a. Although most things are in the process of change, some properties of objects and processes are characterized by constancy; for example, the speed of light, the charge of an electron, and the total mass plus energy of the universe.

b. Energy can be transferred and matter can be changed. Nevertheless, when measured, the sum of energy and matter in systems, and by extension in the universe, remains the same.

c. Changes can occur in the properties of materials, position of objects, motion, and form and function of systems. Interactions within and among systems result in change. Changes in systems can be quantified and measured. Mathematics is essential for accurately measuring change.

d. Different systems of measurement are used for different purposes. An important part of measurement is knowing when to use which system.

4. Evolution and Equilibrium

b. Equilibrium is a physical state in which forces and changes occur in opposite and offsetting directions.

c. Interacting units of matter tend toward equilibrium states in which the energy is distributed as randomly and uniformly as possible.

INTERMEDIATE (GRADES 5-8) CONTENT STANDARD–A: SCIENCE AS INQUIRY

1. Abilities Necessary to do Scientific Inquiry

a. Identify questions that can be answered through scientific inquiry.

b. Design and conduct a scientific investigation.

c. Use appropriate tools and techniques to gather, analyze, and interpret data.

d. Develop descriptions, explanations, predictions, and models using evidence.

e. Think critically and logically to make the relationships between evidence and explanations.

f. Recognize and analyze alternative explanations and predictions.

g. Communicate scientific procedures and explanations.

h. Use mathematics in all aspects of scientific inquiry.

INTERMEDIATE STANDARD–B: PHYSICAL SCIENCE

3. Transfer of Energy

a. Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical.

b. Energy is transferred in many ways.

c. Heat moves in predictable ways, flowing from warmer objects to cooler ones, until both reach the same temperature.

d. Light interacts with matter by transmission (including refraction), absorption, or scattering (including reflection).

e. Electrical circuits provide a means of transferring electrical energy.

g. The sun is the 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 earth, transferring energy from the sun to the earth. The sun's energy arrives as light with a range of wavelengths.

INTERMEDIATE STANDARD–C: LIFE SCIENCE

4. Populations and Ecosystems

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

Teacher Guide

HANDS-ON EXPLORATIONS TO TEACH INTERMEDIATE STUDENTS THE SCIENTIFIC CONCEPTS OF SOLAR ENERGY.

BACKGROUND

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

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 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 produce heat, light, and electricity.
- It is difficult to capture the sun's energy because it is spread out—not much 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.

TIME

Five 45-minute class periods.

PROCEDURE

Step One—Preparation

- Familiarize yourself with the **Teacher** and **Student Guides**, and with the materials in the kit. Make sure that the PV cell and motor work smoothly. If the motor doesn't spin immediately, 'jumpstart' it by touching the leads to the ends of a C or D battery.
- If the thermometers have been unused for a long time, they may need to be recalibrated. If they 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.
- Make a transparency of the PV Cell explanation on page 11.
- 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.
- Review the Lab Safety Rules on page 14 .
- Divide the class into five groups.
- Set up five centers that have access to direct sunlight.

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—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 electromagnetic waves—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 (Visible Light, X-rays, Microwaves)
- ♦ Sound (Motion)

TEACHER INFORMATION: 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.

ACTIVITY 1: INTRODUCTION TO SOLAR ENERGY (45 minutes)

Objectives: To learn about solar energy by reading the background information.
To practice reading a thermometer with Fahrenheit and Celsius scales.
To practice conversions between Fahrenheit and Celsius scales.

- ■ Introduce solar energy as the topic of exploration and have the students make a list of the things they know and questions they have about solar energy.
- ■ Distribute the **Student Guides** to the students and have them read the backgrounder. Have the students revise their list of the things they know and the questions they have. Discuss the questions they have and have them research specific questions as homework.

- **Go to PAGE 6 of the Student Guide**. Have the students read and complete the Thermometer worksheet. Review the answers (see page 12 of **Teacher Guide** for answers).
- **Go to PAGE 7 of the Student Guide**. Have the students read and complete the Temperature Conversion worksheet. Review the answers (see page 13 of **Teacher Guide** for answers).

ACTIVITY 2: CONVERTING RADIANT ENERGY TO HEAT (45 minutes)

MATERIALS IN KIT: *5 radiation can kits, 10 thermometers, 5 beakers*

MATERIALS NEEDED: *pitchers of cold and hot water, overhead projectors*

Objective: To learn that radiant energy can be reflected and absorbed by objects. When it is absorbed by objects, some is converted into heat.

- **Go to PAGE 8 of the Student Guide**. Place students in their groups and assign each group to a center. Explain the procedure and have the students complete the activity.
- Review the activity with the students to make sure they understand that:

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.

shiny objects tend to reflect radiant energy.

radiant energy can be produced by the sun or by an artificial source.

ACTIVITY 3: SOLAR CONCENTRATION (45 minutes)

MATERIALS IN KIT: *5 radiation kits, 10 thermometers, 12 concave mirrors, clay, 5 beakers*

MATERIALS NEEDED: *pitcher of cold water, metric rulers*

Objective: To learn that radiant energy can be concentrated on an object with a concave mirror.

- **Go to PAGE 9 of the Student Guide**. Place students in their groups, assign them with A-E labels, and assign each group to a center with the corresponding number of concave mirrors. Explain the procedure and have the students complete the activity. They must get data from the other groups to complete the activity.
- While the students are waiting the 10 minutes, review the activity with the students to make sure they understand that:

a mirror reflects radiant energy.

a concave mirror can concentrate solar radiation onto an object.

ACTIVITY 4: SOLAR COLLECTION (45 minutes)

MATERIALS IN KIT: *20 plastic containers, 10 thermometers, 5 beakers, rubber bands*
MATERIALS NEEDED: *cold water, plastic wrap, black & white paper*

Objective: To learn that radiant energy can be collected, converted into heat, and stored.

- **Go to PAGE 10 of the Student Guide**. Place students in their groups and assign each group to a center. Explain the procedure and have the students complete the activity.
- Review the activity with the students, using the Greenhouse Effect diagram on page 2 of the **Student Guide**, to make sure they understand that:

  radiant energy can pass through transparent materials such as plastic wrap, but thermal energy (heat) does not.

  black objects tend to absorb radiant energy.

  white objects tend to reflect radiant energy.

- **Go to PAGE 11 of the Student Guide**. Play outside with the solar balloons on a sunny day.

TEACHER INFORMATION: Photovoltaics

A slab (or wafer) of pure silicon is used to make a PV cell. The top of the slab is very thinly diffused with an “n” dopant such as phosphorous. On the base of the slab a small amount of a “p” dopant, typically boron, is diffused. The boron side of the slab is 1,000 times thicker than the phosphorous side. Dopants are similar in atomic structure to the primary material. The phosphorous has one more electron in its outer shell than silicon, and the boron has one less. These dopants help create the electric field that motivate the energetic electrons out of the cell created when light strikes the PV cell.

The phosphorous gives the wafer of silicon an excess of free electrons; it has a negative character. This is called the **n-type silicon**. The n-type silicon is not charged – it has an equal number of protons and electrons – but some of the electrons are not held tightly to the atoms. They are free to move to different locations within the layer.

The boron gives the base of the silicon a positive character, because it has a tendency to attract electrons. The base of the silicon is called **p-type silicon** (p = positive). The p-type silicon has an equal number of protons and electrons; it has a positive character but not a positive charge.

Where the n-type silicon and p-type silicon meet, free electrons from the n-layer flow into the p-layer for a split second, then form a barrier to prevent more electrons from moving between the two sides. This point of contact and barrier is called the **p-n junction**.

When both sides of the silicon slab are doped, there is a negative charge in the p-type section of the junction and a positive charge in the n-type section of the junction due to movement of the electrons and “holes” in at the junction of the two types of materials. This imbalance in electrical charge at the p-n junction produces an electric field between the p-type and n-type.

If the PV cell is placed in the sun, photons of light strike the electrons in the p-n junction and energize them, knocking them free of their atoms. These electrons are attracted to the positive charge in the n-layer and repelled by the negative charge in the p-layer. Most photon-electron collisions actually occur in the silicon base.

A conducting wire connects the p-type layer to electrical application such as a light or battery, and then back to the n-type layer, forming a complete circuit. As the free electrons are pushed into the n-type silicon they repel each other because they are of like charge. The wire provides a path for the electrons to move away from each other. This flow of electrons is an electric current that can power a load, such as a calculator or other device, as it travels through the circuit from the n-layer to the p-layer.

In addition to the semi-conducting materials, solar cells consist of a top metallic grid or other electrical contact to collect electrons from the semi-conductor and transfer them to the external load, and a back contact layer to complete the electrical circuit.

ACTIVITY 5: PHOTOVOLTAICS (45 minutes)

MATERIALS IN KIT: *1 solar house kit, 5 solar energy kits with PV cells, motors, and fans*
MATERIALS NEEDED: *cardboard box, transparencies, overhead projectors*

Objectives: To learn that radiant energy can be converted directly into electricity.
To learn that a motor converts electricity into motion.

- **Go to PAGE 12 of the Student Guide**. Make a solar house using the Solar House Kit to demonstrate the uses of PV cells.
- **Go to PAGE 13 of the Student Guide**. Place students in their groups and assign each group to a center. Explain the procedure and have the students complete the activity.
- Review the activity with the students, using the PV Cell Transparency on page 11 of the **Teacher Guide**, to make sure they understand that:
  - ***PV cells can convert radiant energy directly into electricity.***
  - ***motors can convert electricity into motion.***
  - ***sunlight and artificial light are radiant energy.***

ACTIVITY 6: MAKING SOLAR OVENS

MATERIALS NEEDED: *see Materials List on page 14 of Student Guide*

Objective: To make solar ovens.

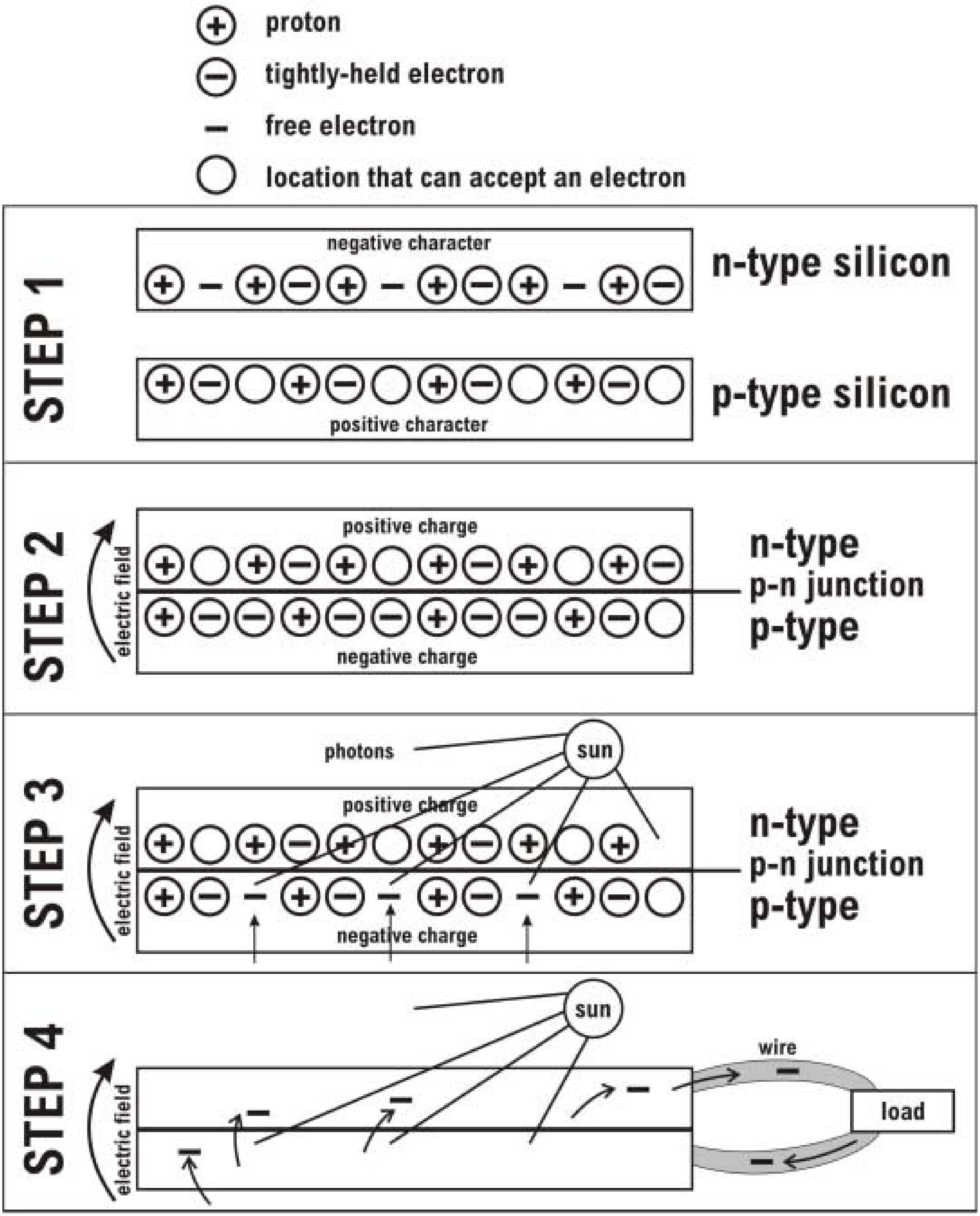
- **Go to PAGES 14-15 of the Student Guide**. Have the students make solar ovens and cook food in them on a sunny day.

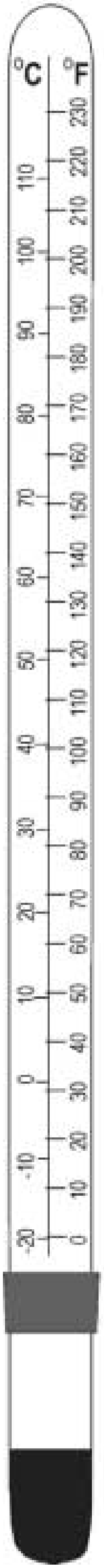
ACTIVITY 7: (Optional) PHOTOVOLTAIC ARRAYS ON THE SCHOOL

Objective: To learn about and monitor the PV arrays on the school.

- Have the school's energy/facility manager or administrator speak to the students about the PV arrays on the school 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 **Monitoring & Mentoring** (Grades 5-6) and **Learning & Conserving** (Grades 7-8) activities for more information.

PHOTOVOLTAIC CELL





THERMOMETER ANSWER KEY

A thermometer measures temperature. The temperature of an object or a substance shows how hot or cold it is. This thermometer is a long glass tube filled with a colored liquid. Liquids expand (take up more space) as they get hotter.

Temperature can be measured using many different scales. The scales we use most are:

CELSIUS

The Celsius (C) scale uses the freezing point of water as 0°C and the boiling point of water as 100°C.

FAHRENHEIT

The Fahrenheit (F) scale uses the freezing point of water as 32°F and the boiling point of water as 212°F. Zero (0°F) on the Fahrenheit scale is the temperature of a mixture of equal weights of snow and salt.

In the United States, we usually use the Fahrenheit scale in our daily lives, and the Celsius scale for scientific work.

ANSWER THESE QUESTIONS

The temperature of the human body is 98-99°F. Look at the drawing of the thermometer and estimate what the reading would be on the Celsius scale: 37°C

A comfortable spring day is about 75°F. What would that reading be on the Celsius scale? 25°C

The temperature of a hot shower is about 105°F. What would that reading be on the Celsius scale? 42°C

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.

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

If C = 5 $\quad F = (\frac{9}{5} \times 5) + 32 \quad F = 9 + 32 = 41$

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.

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

If F = 50 $\quad C = \frac{5}{9} \times (50 - 32) \quad C = \frac{5}{9} \times 18 = 10$

PROBLEMS TO ANSWER:

If C is 50°, what is the temperature in Fahrenheit? ***122°F***

If F is 100°, what is the temperature in Celsius? ***37.78°C***

Lab Safety Rules

EYE SAFETY

Always wear safety glasses when performing experiments.

FIRE SAFETY

Do not heat any substance or piece of equipment unless specifically instructed to do so.

Be careful of loose clothing. Do not reach across or over a flame.

Keep long hair pulled back and secured.

Do not heat any substance in a closed container.

Always use the tongs or protective gloves when handling hot objects. Do not touch hot objects with your hands.

Keep all lab equipment, chemicals, papers, and personal effects away from the flame.

Extinguish the flame as soon as you are finished with the experiment and move it away from the immediate work area.

HEAT SAFETY

Always use tongs or protective gloves when handling hot objects and substances.

Keep hot objects away from the edge of the lab table—in a place where no one will come into contact with them.

Do not use the steam generator without the assistance of your teacher.

Remember that many objects will remain hot for a long time after the heat source is removed or turned off.

GLASS SAFETY

Never use a piece of glass equipment that appears cracked or broken.

Handle glass equipment carefully. If a piece of glassware breaks, do not attempt to clean it up yourself. Inform your teacher.

Glass equipment can become very hot. Use tongs if glass has been heated.

Clean glass equipment carefully before packing it away.

CHEMICAL SAFETY

Do not smell, touch, or taste chemicals unless instructed to do so.

Keep chemical containers closed except when using them.

Do not mix chemicals without specific instructions.

Do not shake or heat chemicals without specific instructions.

Dispose of used chemicals as instructed. Do not pour chemicals back into their containers without specific instructions to do so.

If a chemical accidentally touches your skin, immediately wash the area with water and inform your teacher.

EXPLORING SOLAR ENERGY

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

NEED National Sponsors and Partners

American Association of Blacks in Energy
American Electric Power
American Electric Power Foundation
American Petroleum Institute
American Solar Energy Society
American Wind Energy Association
Aramco Services Company
Areva
Armstrong Energy Corporation
Association of Desk & Derrick Clubs
All Wild About Kentucky's Environment
Robert L. Bayless, Producer, LLC
BP Foundation
BP
BP Alaska
BP Solar
Bureau of Land Management – U.S. Department of the Interior
C&E Operators
Cape and Islands Self Reliance
Cape Cod Cooperative Extension
Cape Light Compact–Massachusetts
L.J. and Wilma Carr
Center for the Advancement of Process Technology–College of the Mainland–TX
Chesapeake Public Schools–VA
Chesterfield County Public Schools–VA
Chevron
Chevron Energy Solutions
ComEd
ConEd Solutions
ConocoPhillips
Council on Foreign Relations
CPS Energy
Cypress-Fairbanks Independent School District–TX
Dart Foundation
Desk and Derrick of Roswell, NM
Dominion
Dominion Foundation
Duke Energy
EDF
East Kentucky Power
El Paso Foundation
EnCana
Energy Information Administration – U.S. Department of Energy
Energy Training Solutions
Energy and Mineral Law Foundation
Energy Solutions Foundation
Equitable Resources
Escambia County School District–FL
FPL Energy Encounter–FL
First Roswell Company
Florida Department of Environmental Protection
Foundation for Environmental Education
Georgia Environmental Facilities Authority
Guam Energy Office
Gulf Power
Halliburton Foundation
Gerald Harrington, Geologist
Houston Museum of Natural Science
Hydro Foundation for Research and Education
Idaho Department of Education
Illinois Clean Energy Community Foundation
Independent Petroleum Association of America
Independent Petroleum Association of New Mexico
Indiana Office of Energy and Defense Development
Interstate Renewable Energy Council
Iowa Energy Center
Kentucky Clean Fuels Coalition
Kentucky Department of Energy Development and Independence
Kentucky Oil and Gas Association
Kentucky Propane Education and Research Council
Kentucky River Properties LLC
Kentucky Utilities Company
Keyspan
KidWind
Lenfest Foundation
Llano Land and Exploration
Long Island Power Authority–NY
Louisville Gas and Electric Company
Maine Energy Education Project
Maine Public Service Company
Marianas Islands Energy Office
Maryland Energy Administration
Massachusetts Division of Energy Resources
Michigan Energy Office
Michigan Oil and Gas Producers Education Foundation
Minerals Management Service – U.S. Department of the Interior
Mississippi Development Authority–Energy Division
Montana Energy Education Council
Narragansett Electric – A National Grid Company
NASA Educator Resource Center–WV
National Alternative Fuels Training Center–West Virginia University
National Association of State Energy Officials
National Association of State Universities and Land Grant Colleges
National Hydropower Association
National Ocean Industries Association
National Renewable Energy Laboratory
Nebraska Public Power District
New Jersey Department of Environmental Protection
New York Power Authority
New Mexico Oil Corporation
New Mexico Landman's Association
North Carolina Department of Administration–State Energy Office
Offshore Energy Center/Ocean Star/ OEC Society
Offshore Technology Conference
Ohio Energy Project
Pacific Gas and Electric Company
PECO
Petroleum Equipment Suppliers Association
Poudre School District–CO
Puerto Rico Energy Affairs Administration
Puget Sound Energy
Roswell Climate Change Committee
Roswell Geological Society
Rhode Island State Energy Office
Sacramento Municipal Utility District
Saudi Aramco
Sentech, Inc.
Shell
Snohomish County Public Utility District–WA
Society of Petroleum Engineers
David Sorenson
Southern Company
Southern LNG
Southwest Gas
Spring Branch Independent School District–TX
Tennessee Department of Economic and Community Development–Energy Division
Toyota
TransOptions, Inc.
TXU Energy
United Technologies
University of Nevada–Las Vegas, NV
United Illuminating Company
U.S. Environmental Protection Agency
U.S. Department of Energy
U.S. Department of Energy–Hydrogen, Fuel Cells and Infrastructure Technologies
U.S. Department of Energy – Wind for Schools
Virgin Islands Energy Office
Virginia Department of Mines, Minerals and Energy
Virginia Department of Education
Virginia General Assembly
Wake County Public Schools–NC
Washington and Lee University
Western Kentucky Science Alliance
W. Plack Carr Company
Yates Petroleum