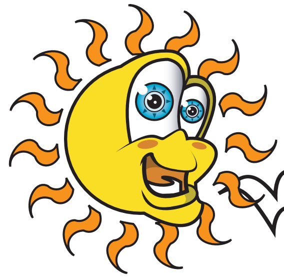

RENEWABLE ENERGY SOURCES
HIGH SCHOOL (9-12)

# IS IT TOO LATE?



**SUBJECTS:** Mathematics, General Science, Economics

**TIME:** 1-3 class periods

**MATERIALS:** student sheets

## Objectives *The student will do the following:*

1. Analyze graphs of energy production and consumption.
2. Demonstrate an understanding of the relationship between production and consumption.
3. Estimate depletion rates for fossil fuels in the United States.
4. Infer from the analysis of graphs and data what sources of energy will be important in the year 2050.

## Background Information

Renewable energy sources are those not depleted by use if they are properly managed. Unlike coal, petroleum and natural gas, renewable energy resources are quickly replaced. Examples of these resources are the sun, wind, falling water and biomass. States are requiring investments in renewable energy technologies. The generation capacity needed to meet demands will depend upon renewables. Estimates are that states will require 5,065 megawatts of central station renewable generating capacity from 2000-2020.

Grid connected photovoltaics are projected to add nearly 900 megawatts to the U.S. market.

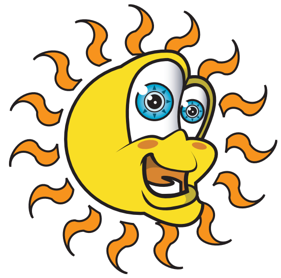
Wind power could be harnessed in parts of the United States, such as in the Plains States. Total wind capacity is expected to double in the year 2020 (2,900 megawatts).

Hydropower, energy available from falling or running water, could supply 4.8-5.5 percent of the United States' needed energy by the year 2001.

Biomass provides energy stored in trees and other plants. It is an energy source with great potential for the United States. Burning biomass, such as wood, crop residues and other wastes, generates heat. Decomposing biomass produces methane *(a burnable gas that can be used to generate heat)*. Biomass can be converted into alcohol *(a liquid fuel)*. Biomass is projected to supply the largest renewable energy increase, from 36.6 B Kwh in 1999 to 65.7 B Kwh in 2020. Landfill gas in projected to increase by 15.9 B Kwh from 1999-2020.

Producing or converting energy near the location at which it will be consumed is efficient and appropriate technology. For example, small digesters, used to convert organic waste to methane, can be located on farms, in homes or at industrial complexes to provide fuel at these sites. Similarly, solar collectors can be used at homes to heat water inexpensively.

Appropriate technology, together with the development of alternative, low-cost energy sources, is essential if the United States is to become energy self-sufficient.



## Procedure

**I.** ***Give students simple definitions of renewable and nonrenewable resources.***

**II.** ***Give each student a copy of the student sheet "U.S. Energy Reserves & Consumption – 1977" (page 162).***
As an introduction, ask the students to examine the chart and answer the questions on the handout. Discuss the questions with the students, making sure they understand the difference between renewable and nonrenewable resources.

**III.** ***Give each student a copy of the student sheet "U.S. Energy Consumption – 1983" (page 163), and have them compare those data with the earlier data (1977).***
Go over the questions with them.

**IV.** ***Discuss fossil fuel "reserves" and "production" with the students.***

**A.** Read the following paragraph to the class and discuss its meaning with them.
The term *"production"* means the amount of fuel made available for use *(e.g., in a given year)*. The term *"reserves,"* as applied to fuel, indicates how much of a fuel exists and could be profitably obtained under present economic conditions and using current technology.

**B.** Give each student a copy of *"Petroleum, Coal, and Natural Gas: Proven Reserves and Production" (page 164)*. Explain to the students that to **estimate** how long domestic supplies of a given fuel will last, the "*reserves*" of the resource are divided by its *"production"* for a given year.

1. Work this example on the chalkboard:

### 1984 COAL SUPPLY DEPLETION ESTIMATE

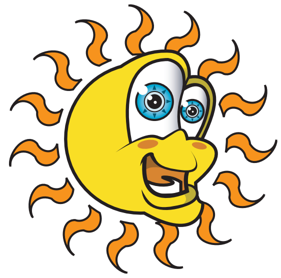
$$\frac{\text{478.7 billion short tons* (U.S. proven reserve in 1984)}}{\text{.82 billion short tons per year (U.S. production in 1984)}} = \text{years of fuel supply remaining}$$

The estimated length of time before the United States runs out of coal *(using 1984 data)* is 583.8 years.

Some assumptions:

1. Coal continues to be used at the 1984 rate.
2. No more coal is discovered in the United States.
3. No new technology is developed to allow production of reserves currently unavailable.

*A short ton is 2000 lbs *(as opposed to a metric ton, which is 2,000 kg)*.



2. Be sure that the students understand the changeable nature of reserve estimates and the fact that many assumptions are made in making such depletion estimates. Can the students think of some assumptions that are not listed above?
3. Have the students use the information in Tables I and II on the student sheet to estimate the depletion dates of U.S. natural gas and oil supplies *(using 1984 data)*. Ask them to list some of the assumptions upon which these estimates are based.
4. Ask the students to assume that *(a)* we continue to use coal, petroleum and natural gas at the 1984 rate; *(b)* new technologies are not developed; and *(c)* new reserves are not discovered. In this scenario, which fossil fuel will be depleted first? Last?
5. Have the students examine the pie chart student sheets and the information from B.3. *(above)*. Make sure they have noted the disparity between U.S. oil reserves and the rates at which we consumed oil in these two years. Have them look at their calculations of a U.S. oil depletion estimate. According to this calculation, the domestic supply of oil may be exhausted before 1993. Why is this not likely? Make sure they understand our dependence on imported oil.

## V. *Discuss what happens when the following situations occur:*

A. Something becomes *"rare"* or *"harder to find."* What happens to its price? Could this happen to our nonrenewable energy resources?

B. Oil and gas become rare and harder to find. Will people be willing to pay more for these resources? Will people be willing to pay more for new technology, new exploration for these resources or imports? Will people use more coal? *(If yes, how will this affect our coal reserves?)* What are some implications for transportation?

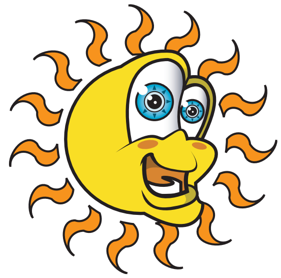
## VI. *Give each student a copy of the student sheet "Consumption of Energy by Source, 1950 – 1995" (page 166).*

Have them answer the questions on the handout. Discuss their answers.

## VII. *Give each student a copy of the student sheet "U.S. Wood Energy Consumption by Region" (page 167).*

Have them answer the questions and discuss the significance of the data with them.

## VIII. *Continue with follow-up below.*



## Follow-Up

**I.** ***Examining energy consumption data, ask the students if they think more alternative energy sources were being used in the 1980s than in the 1970s.***

What do they predict will happen to fuel-use patterns as the year 2020 approaches? What alternative energy sources are most abundant in the region in which they live?

**II.** ***Considering class discussion, examination of graphs and calculations made to answer questions, what do the students think the most important energy sources will be for the United States in the year 2050?***

What about the region in which they live? On what assumptions are they basing their predictions?

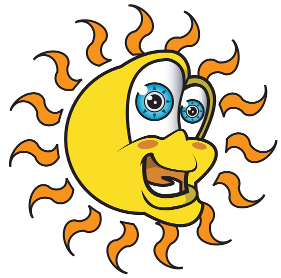
**III.** ***Extension***

***The students might develop a game to simulate our consumption of the fossil fuels, water, biomass and other resources used in meeting our energy demands.***

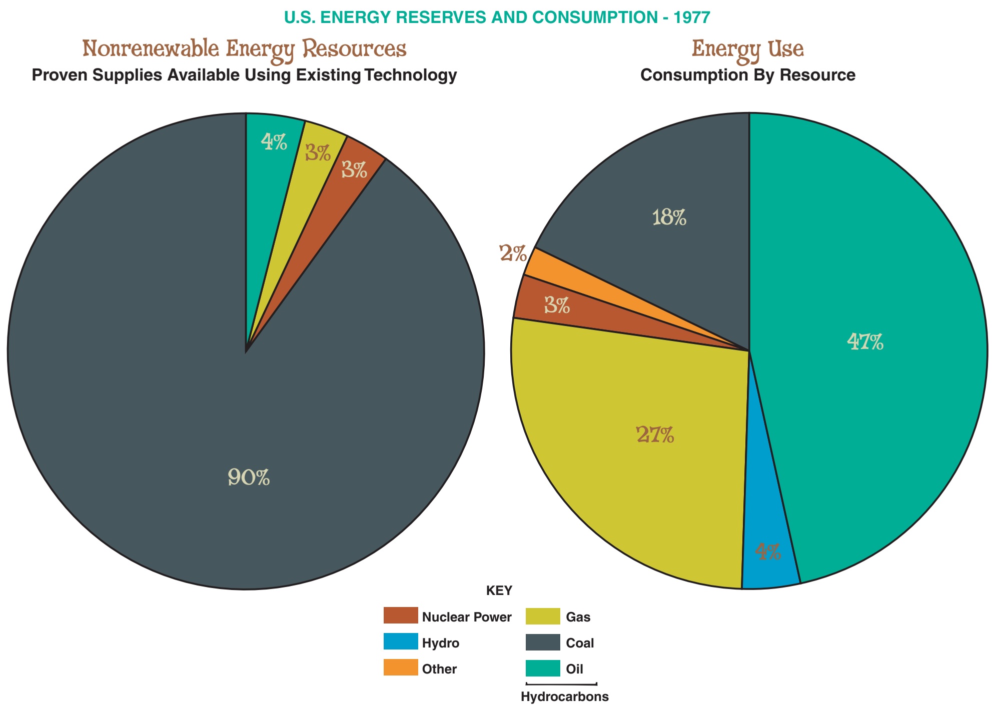
Colored paper can be used as game pieces to represent supplies of energy resources. In making up the game, the students should decide how to identify resources, their relative amounts and the accessibility of the resources. For example, coal could be represented by black slips of paper; it is abundant. Blue could be used to represent natural gas, and so forth. Some slips of paper could be visible but not accessible *"until new technology is available,"* such as those for oil shale. Other slips could be well-hidden to represent undiscovered resources.

The students should also consider differences in the ease of using the resources and in the renewable/nonrenewable aspects of the resources. Questions to be considered might include the following:

1. Why are we using one resource more than another?
2. Is accessibility the only reason?
3. How can we represent a breakthrough in technology which will allow access to resources that are unavailable to us now?
4. How can we simulate a renewable resource, such as biomass, that must be managed properly in order for it to remain available?
5. What do we do when a resource is depleted?



# U.S. Energy Reserves & Consumption - 1977




*(Data from Federal Energy Administration, Energy in Focus: Basic Data, Washington, D.C., 1977.)*

***Examine the circle graphs above and answer the following questions.***

**1.** Most of the energy we consume is in the form of what resource? ______________________________
Is it a renewable or nonrenewable resource? ______________________________
How do our domestic supplies of this resource compare to our consumption of it?

______________________________________________________________________

**2.** What nonrenewable energy resource is most abundant *(using existing technology)*?

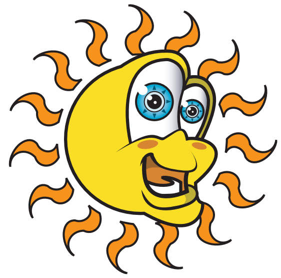
______________________________________________________________________

**3.** According to the energy use pattern, what percentage is provided by *"other"* resources? What do you think this category includes? *(Name several resources.)*

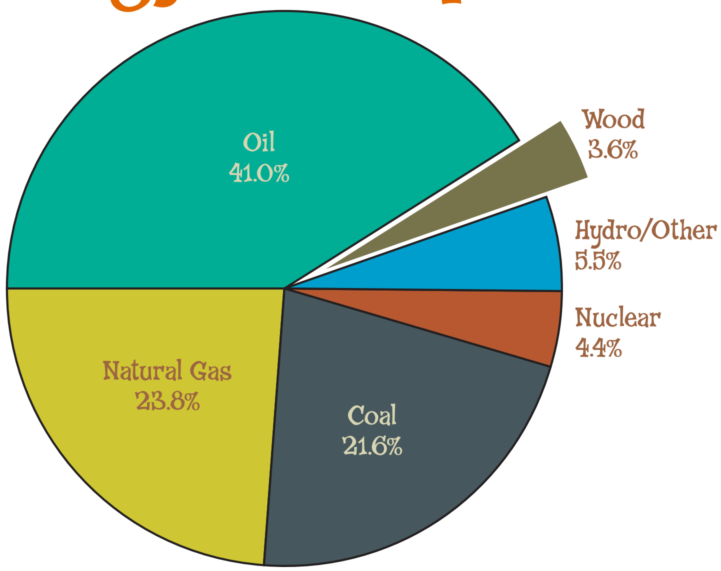
______________________________________________________________________

Are these renewable or nonrenewable resources?

______________________________________________________________________



# U.S. Energy Consumption – 1983




**Note:** *In Estimates of U.S. Wood Energy Consumption. 1980-1983,* wood data was added to the primary energy total given in *Annual Energy Outlook 1983* (DOE/EIA-0383[83]), Washington, D.C., May 1984.

(Data from Energy Information Administration, *Monthly Energy Review, Washington, D.C., 1984*.)

***Examine the circle graph above and "U.S. Energy Reserves & Consumption – 1977" and answer the following questions.***

**1.** How does the data for hydrocarbon fuel *(coal, oil, gas)* use in 1977 compare with the 1983 data?

______________________________________________

Is there a general trend? If so, what is it? ______________________________

**2.** Looking at the consumption graphs for 1977 and 1983, which of the fossil fuels *(hydrocarbons)* was being used most? ______________________________

How does its annual consumption rate compare for the two years? ____________________

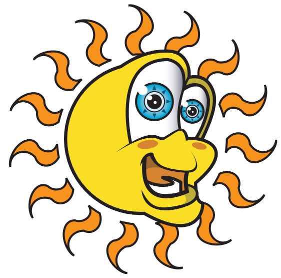
______________________________________________

**3.** Noting that data for the use of wood has been inserted in this chart, what can you say about the use of wood as an energy resource? ______________________________

______________________________________________

In general, did the use of renewable resources increase? ____________________

______________________________________________

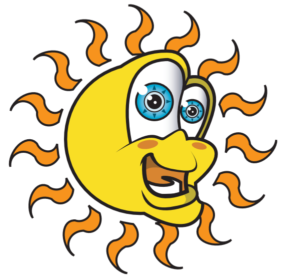


# Petroleum, Coal, and Natural Gas: Proven Reserves and Production

### Table I: Petroleum, Coal, and Natural Gas Proven Reserves

| Resource | As of 1/1/80 | As of 1/1/81 | As of 1/1/82 | As of 1/1/84 | Number of Years U.S. Supply will last (at current rate) |
|---|---|---|---|---|---|
| Petroleum *(in billion barrels)* | | | | | |
| U.S.* | 29.8 | 29.8 | 29.4 | 28.4 | |
| World ** | 641.6 | 648.5 | 670.3 | 700.1 | |
| Coal *(in billion short tons)* | | | | | |
| U.S.* | 472.7 | not available | not available | 478.7 | |
| World ** | 975.2 | not available | not available | 986.2 | |
| Natural Gas *(in trillion cubic feet)* | | | | | |
| U.S.* | 201.0 | 199.0 | 201.7 | 145.3 | |
| World ** | 2,573.2 | 2,638.5 | 2,915.0 | 3,401.8 | |

*U.S. *(Domestic)* figures from ANNUAL ENERGY REVIEW, 1982.
**World figures from INTERNATIONAL ENERGY ANNUAL for 1979, 1980, and 1981.
Both published by the Energy Information Administration, Department of Energy.

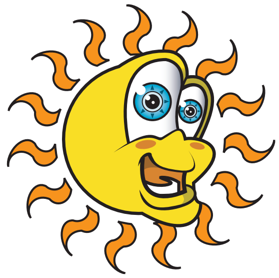


# Petroleum, Coal, and Natural Gas: Proven Reserves and Production

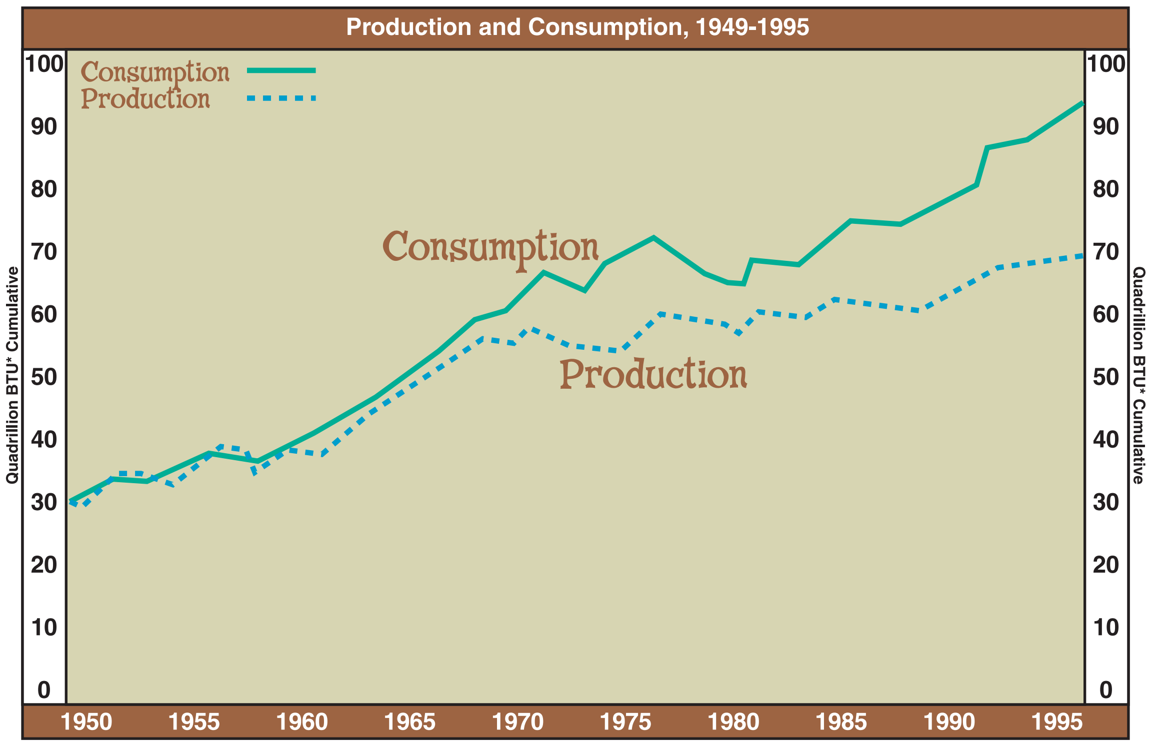
## Table II: U.S. (Domestic) Production of Petroleum, Coal, and Natural Gas*

| Resource | 1978 | 1979 | 1980 | 1981 | 1982 | 1984 | Number of Years U.S. Supply will last (at current rate) |
|---|---|---|---|---|---|---|---|
| Petroleum<br>Million barrels per day<br>Billion barrells per day | 8.71<br>3.18 | 8.55<br>3.12 | 8.60<br>3.14 | 8.57<br>3.13 | 8.67<br>3.16 | 8.88<br>3.24 | |
| Coal<br>Billion short tons per year | .67 | .78 | .83 | .82 | .83 | .82 | |
| Natural Gas<br>Billion cubic feet<br>Trillion cubic feet | 19,974.0<br>19.7 | 20,471.0<br>20.47 | 20,379.0<br>20.38 | 20,178.0<br>20.18 | 18,462.0<br>18.46 | 17,392.0<br>17.39 | |

*Figures from *Monthly Energy Review*, June 1983, published by Energy Information Administration, Department of Energy.



# U.S. Consumption of Energy by Source, 1950-1995*




*One quadrilion BTU is 10 BTU (10 is one followed by 24 zeros)

***Examine the graph above and answer the following questions.***

1. What has been the general trend in energy use? ________________________________________

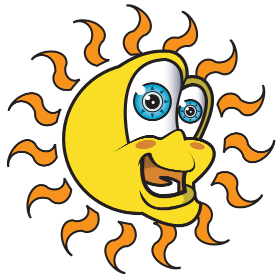
2. What energy resource shows the greatest change in usage over these years? ____________________
   Was it an increase or a decrease?__________________________________________________

3. How does the overall use of renewable resources compare to that of nonrenewable resources?
   ________________________________________________________________________

4. Compare the amount of petroleum consumed in 1950 with that consumed in 1990.
   ________________________________________________________________________

5. Compare the amount of energy provided by all fossil fuels in 1960 with that for 1990.
   ________________________________________________________________________

6. Identify trends in energy consumption by resource over the twenty-year period ending in 1995.
   ________________________________________________________________________



# U.S. Wood Energy Consumption by Region
## 1980 - 1983

| Year | Trillion Btu from Wood by Region | | | | Total Energy from Wood (Trillion Btu) |
|---|---|---|---|---|---|
| | South | West | Northeast | North Central | |
| 1980 | 1,380 | 388 | 386 | 329 | 2,483 |
| 1981 | 1,349 | 416 | 395 | 335 | 2,495 |
| 1982 | 1,392 | 385 | 358 | 343 | 2,478 |
| 1983 | 1,526 | 411 | 380 | 323 | 2,640 |

**Note:** Totals may not equal sum of components because of independent rounding.

Data from: Estimate of U.S. Wood Energy Consumption, 1980-1983, Department of Energy, Washington, D.C.

***Examine the data above and answer these questions.***

**1.** What has been the general trend in the use of wood as an energy resource?

______________________________

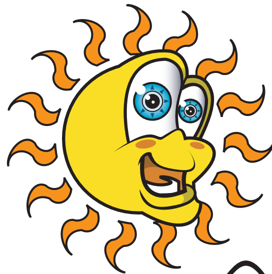
**2.** In which region has there been the greatest increase in the use of wood?

______________________________

**3.** In which region has there been the greatest percentage increase in the use of wood?

______________________________

# MEASURING WIND SPEED



**SUBJECTS:** Earth Science, General Science, Physical Science, Physics

**TIME:** 3-5 class periods

**MATERIALS:** ping-pong balls, dark thread *(8" segments)*, glue, file folders, small weights *(1-oz sinkers or 1/2" flat washers)*, stapler, long sewing needle, tape, student sheets

## Objectives *The student will do the following:*

1. Demonstrate an understanding of the feasibility of using wind as an energy source.
2. Construct a device to measure wind speed.
3. Calculate average wind speed.
4. Determine whether or not wind provides sufficient energy to produce electricity in the local area.

## Background Information

Differences in the amounts of solar radiation received, atmospheric conditions, and the surface of the earth produce uneven heating and cooling of the earth's atmosphere. This uneven heating results in the movement of air masses – wind.

Wind may be as gentle as a breeze or as strong as a tornado or hurricane. Wind helps control climates *(including rainfall amounts)* and moderates changes in temperature.

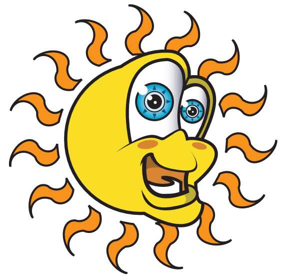
Wind has been used as an energy source for a long time. One example of this is the historic use of windmills to pump water. Today we are using the winds of high altitude jet streams to facilitate the speed of airplanes and save fuel.

There is a problem, however, in attempting to harness wind energy to produce electricity; wind does not blow at a constant speed or from a consistent direction. Generating electricity requires a constant wind speed of at least 13 kilometers per hour *(km/hr)*. A device that measures wind speed is called an anemometer.

## Procedure

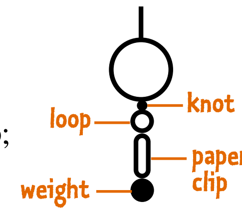
### I. *Have the students assemble wind speed detectors (anemometers).*

A. Share the background information with the students, discussing with them the use of wind energy. Point out that a wind speed of 13 km/hr or more is needed to generate electricity. The wind must strike the blades of a wind generator with adequate force to turn the modified windmill at speeds sufficient to generate electricity. Lower wind speeds may turn the blades, but not fast enough to generate electricity. Is wind a viable option for use as an energy resource in your community? Ask the students to identify where they could get daily or hourly information about wind speed in the local area.



**B.** Divide the students into groups of three. Give each group a copy of the student sheets *"Wind Speed Detector"* and *"Protractor Pattern" (pages 171-172)*.

**C.** Show the students how to assemble the ping-pong ball component of the wind speed detector. Thread the needle with an 8-inch piece of thread. Push it through the ping-pong ball and knot to make sure it remains tied. Open a paper clip; hook one end over the thread loop and use the other end to hook the weight *(sinker or 2-3 washers)*.




**D.** Have the groups follow the directions on the student sheets to assemble their wind speed detectors.

## II. *Have the students measure wind speed.*

**A.** Give each group a copy of the student sheets *"Measuring Wind Speed"* and *"Wind Speed Data Sheet"* (page 173-174). Take the students outside. Have each group use the wind speed detector to determine the wind speed at some location near the school – near an entrance, between buildings, on windward *(direction **from** which wind blows)* and leeward *(direction **to** which wind blows)* sides of buildings, on the football field, or other locations. *(Each group should select a different location.)*
**Note:** Attempt this activity only when wind velocities are predicted to exceed 15 miles per hour *(a moderate breeze)*.

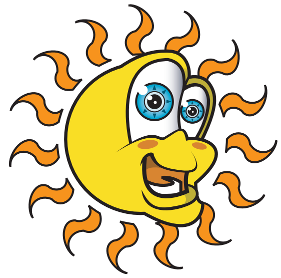
**B.** Have the students record wind speed observations on the data sheet for the next three to five days. If several classes are doing this activity concurrently and data for various times of the day obtained; this could be very useful.
Option: Students could continue collecting data throughout the year.
The students should enter the data and time, the angle of their wind speed detectors, and the angle-to-km/hr conversion figure from table on *"Measuring Wind Speed."*

**C.** Ask the class to complete the conversion of the data to miles per hour *(mph)*.

**D.** Give each group of copy of the student sheet *"Beaufort Scale of Wind Speed" (page 175)*to be used as a reference for converting km/hr to mph and classifying the winds they measured. They are to enter this information on their data sheets.

**E.** After collecting data for several days, have the groups construct bar and/or line graphs to better display the data. Have them mark the graph at 13 km/hr; this line will enable them to see quickly how the data compare with the wind speed necessary for generating electricity.

**F.** Working together as a class, make another graph showing the wind speeds at **all** locations where data were collected. Ask the students to compare wind speeds at various locations *(such as the windward and leeward sides of the building)*.



# Follow-Up

## I. *Discuss the following questions with the students.*

A. Could wind be used to generate electricity in your community? If so, discuss some likely locations. If not, what is the problem? Can the problem be overcome? What could be changed?

B. Is wind feasible as an energy source in mountain passes? What problems exist there?

C. Is wind power a renewable or nonrenewable resource?

D. What are some of the advantages and disadvantages of using wind as a source of power? *(Advantages include that it is free, nonpolluting, and renewable. Disadvantages include the unreliability and unavailability of wind at some places, and the high cost of the equipment to capture wind power.)*

## II. *Extensions*

A. Have the students compare their findings with the television or radio weather reports. Do they differ? How? Why?

B. Discuss with the students the significance of the length of string holding the ping-pong ball. How will the angle of displacement be affected by a given wind speed *(force)*? Have them work out their hypotheses mathematically. Taking readings with different string lengths should verify the results.

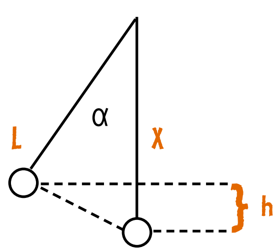
C. Have the students investigate land and sea breezes. Where do they occur? What would be necessary in order to use them to generate electricity? How did the Netherlands use them in the past?

D. Have the students measure wind speeds around their homes, in tree-covered areas, in the middle of fields, or in other locations and record their data for making comparisons later in class. Does the time of the data collection make a difference? Should the time of day be recorded? Why?

E. Some students could make reports on the modern wind turbine.

F. *(For advanced students.)* Have the students calculate the potential energy of the wind, using the angle to which the wind lifts the ping-pong ball.

1. Take the mass of the ping-pong ball.
2. Using trigonometry, determine how high the ball was lifted by the wind.



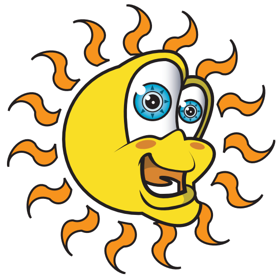

$$h = L - X$$

$$\cos\alpha = \frac{X}{L}$$

$$X = L\cos\alpha$$

$$h = L - L\cos\alpha = L(1 - \cos\alpha)$$

3. Solve for potential energy *(P.E.)* using the equation P.E. = mgh, where m = the ping-pong ball's mass; g = the acceleration of gravity; and $h = L - L\cos\alpha$.



# Wind Speed Detector

*Assembly Instructions*

**1. The frame** *(Use a file folder, scissors, and a stapler.)*

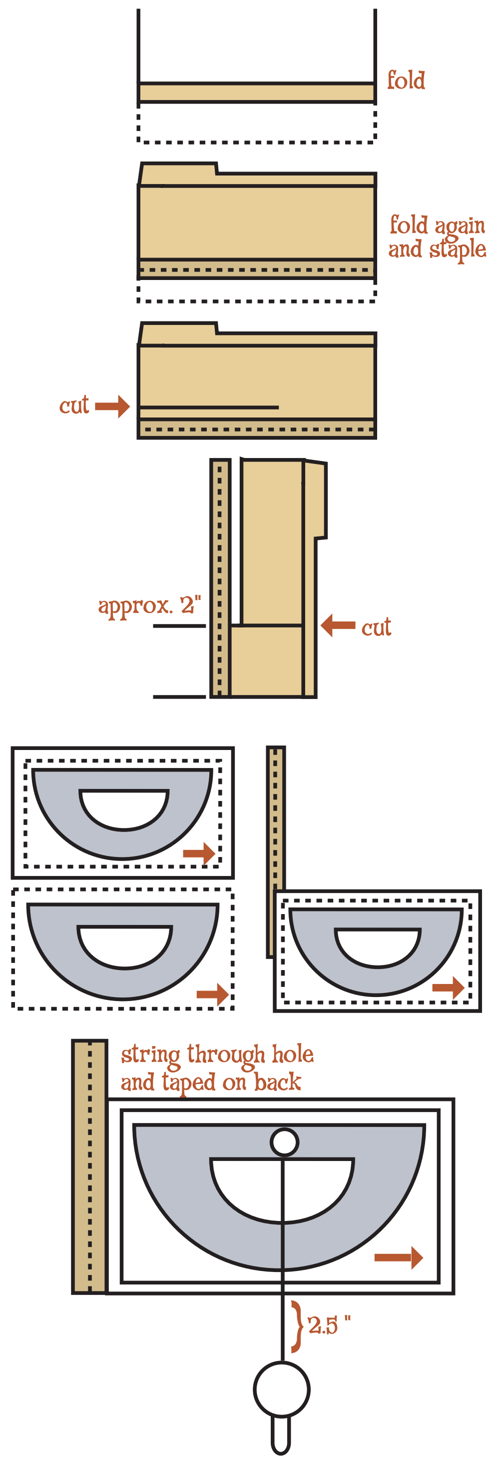
- With the file folder closed, fold up the long edge of the folder 1" to 2" on the side where it is prefolded.
- Fold it a second time, and staple the folded layers together at 5 to 6 places from one end to the other.
- Cut along the edge of the folded layers, stopping about 2" from the end.
- Turn the folder up on its end and cut across – perpendicular to the folded layers – leaving a 2" extension at the bottom.

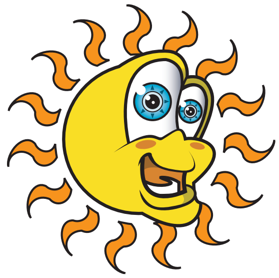
**2. The protractor** *(Use the pattern handout, scissors, and tape.)*

- Cut the protractor out of the handout along the dotted lines.
- Tape the protractor pattern to one piece of the left-over file folder.
- Tape this entire *"protractor"* to the extension of the frame, so that the straight edge of the protractor is at the top of the 2" extension.

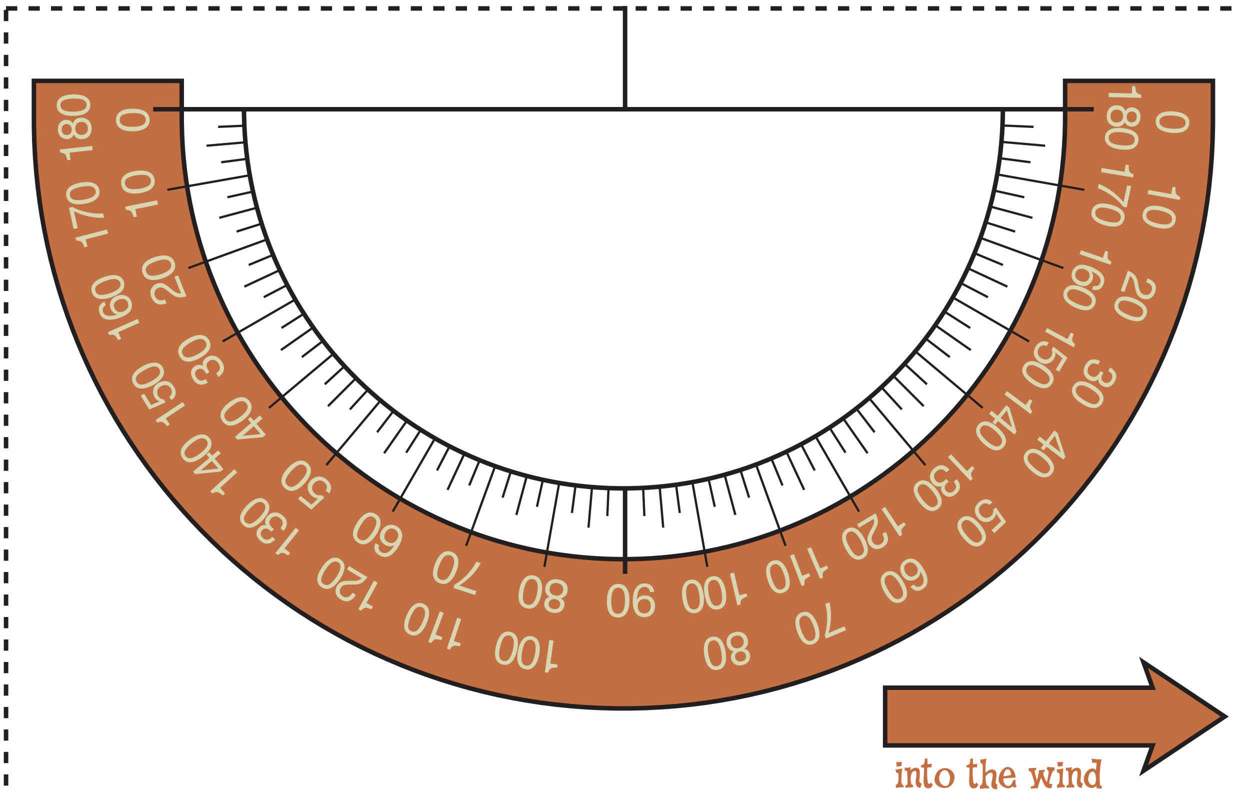
**3. The ping-pong ball** *(Use the ball with the thread, paperclip, weight, and tape.)*

- Assemble the ping-pong ball component as demonstrated by your teacher.
- Punch a small hole at the protractor's center mark and pass the thread through the hole. Knot the thread and tape the knot firmly to the back of the protractor, so that the thread measures 2-1/2" from the bottom of the protractor to the ball.
- Be sure that when the protractor is held level and out of the wind, the ball component hangs at exactly 90°.





# Protractor Pattern

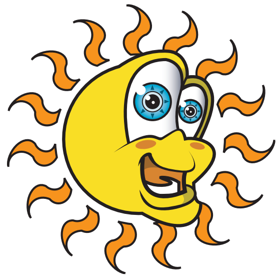



**1.** Cut out along dotted line.

**2.** Tape to stiff backing.

**3.** Tape to frame.

**4.** Punch hole at center mark to attach ping-pong ball component.

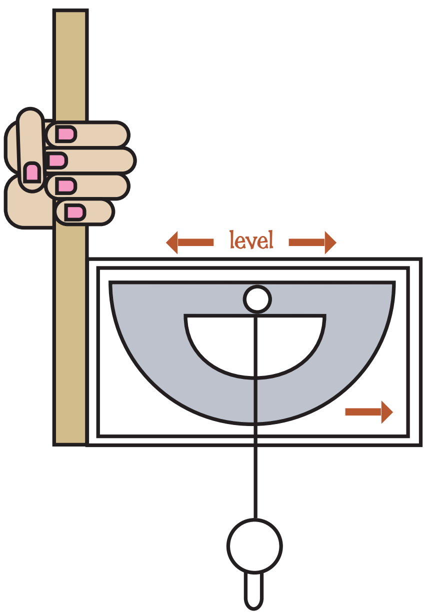


# Measuring Wind Speed

| Angle | Wind Speed km/hr |
|---|---|
| 90° | 0 |
| 85°/95° | 6.5 |
| 80°/100° | 13 |
| 75°/105° | 16 |
| 70°/110° | 19 |
| 65°/115° | 21.5 |
| 60°/120° | 24 |
| 55°/125° | 26.5 |
| 50°/130° | 29 |
| 45°/135° | 31.5 |
| 40°/140° | 34 |
| 35°/145° | 37 |
| 30°/150° | 41 |
| 25°/155° | 46 |
| 20°/160° | 52 |

1. On the *"Wind Speed Data Sheet,"* enter the date, time, and location of the site where the data is going to be collected.

2. Face into the wind and hold the wind speed detector at arm's length in front of you so that:
   a. the flat edge of the protractor is level with the ground
   b. the protractor arrow is pointing **into** the wind
   c. the ball can swing freely in the wind
   d. the thread hangs at exactly 90°.




3. One group member should then carefully remove the paper clip and weight. *(To improve the accuracy of your data collection, practice before recording the measurement.)* Record on the data sheet the highest angle that the thread reaches on the protractor when the ball is pushed by the wind.

4. Use the chart above to find out the wind speed that the angle reading indicates. This is measured in kilometers per hour *(km/hr)*. Record the speed on the data sheet.

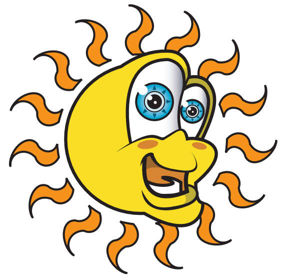
5. After you finish collecting data, convert km/hr to miles per hour *(mph)*. Refer to the left-hand column on *"Beaufort Scale of Wind Speed."* Record this speed on the data sheet. Note the wind classification in the right margin of the data sheet.

**Example:**

**Wind Speed Data Sheet**

**Location:** football field

| Date | Time | Angle | km/hr | mph |
|---|---|---|---|---|
| October 25 | 8:30 a.m | 110° | 19 | 12 *(gentle breeze)* |



Name________________________________

Name________________________________

Name________________________________

# Wind Speed Data Sheet

Location____________________________________________________________

| Date | Time | Angle | km/hr | mph |
| --- | --- | --- | --- | --- |
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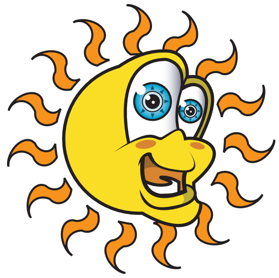
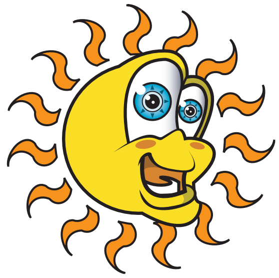


# The Beaufort Wind Scale

| Approximate Speed | Classification of Wind | What You Can Observe |
|---|---|---|
| Up to 1.6 km/hr (1 mph) | Calm | Smoke rises vertically |
| 1.6 to 5 km/hr (1 to 3 mph) | Light breeze | Smoke drifts |
| 6 to 19 km/hr (4 to 12 mph) | Gentle breeze | Leaves and twigs move |
| 21 to 29 km/hr (13 to 18 mph) | Moderate breeze | Dust and loose paper move |
| 30 to 50 km/hr (19 to 31 mph) | Strong breeze | Small trees sway; large branches move |
| 51 to 74 km/hr (32 to 46 mph) | Moderate gale | Whole trees move; twigs break off trees |
| 75 to 86 km/hr (47 to 54 mph) | Strong gale | Some structural damage of buildings |
| 88 to 101 km/hr (55 to 63 mph) | Whole gale | Trees uproot; much structural damage |
| 102 to 122 km/hr (64 to 75 mph) | Storm | Widespread damage |
| Over 122 km/hr (75 mph) | Hurricane | Very extensive damage |

# FAQ ABOUT LANDFILL METHANE PRODUCTION



## Introduction

Landfill gas is created when landfill wastes decompose. The gases that are produced include 50% methane *($CH_4$)* and about 45% carbon dioxide *($C0_2$)*. These gases generally escape into the atmosphere where they may cause local odors and contribute to local smog and global climate change. Methane is a flammable material and landfill emissions could be hazardous. Current technologies allow for the collection of the gases and use of methane as an energy source. Included below is additional information provided in the form of Frequently Asked Questions *(FAQ's)*.

### FAQ # 1 *How can landfill gas be used for energy?*

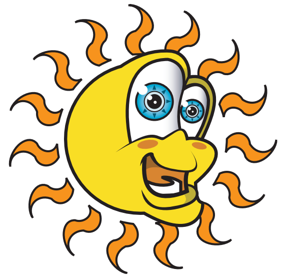
Landfill gas can be a locally available energy source that can be tapped to replace the use of nonrenewable resources such as gas and oil. In fact, the combustion of methane from landfills actually removes this air pollution component from the atmosphere! Landfill gas can be converted and used in a variety of ways. It can be used to directly produce electricity, heat or steam. It may also be utilized for modified automobiles. The Environmental Protection Agency estimates that there are currently about 6,000 landfills across the U.S. and they have approximately 270 projects in place to capture and utilize the methane produced from the decomposing garbage in these sites. The EPA estimates that if we were to add about 700 more methane gathering systems in additional landfill sites, we could produce enough electrical energy to power 3 million homes across the U.S.

### FAQ # 2 *What are the economic benefits of using landfill gas as a resource?*

Construction of these methane collection systems in landfills provides a direct cost benefit for the landfill operators, counties or utility districts that operate the landfill. They can produce profits from the production of electricity. Jobs within the communities are also stimulated as construction requires engineers, construction firms and managers. Local employment will be stimulated during all phases of the implementation of the conversion of the landfill to a methane collection system. The community also benefits as the captured gas can be sold for use as a fuel and sold on the energy market. This renewable *"green power"* source can be a tremendous asset for a local economy using garbage as a productive asset!

### FAQ # 3 *What are the social benefits of using landfill gas as an energy resource?*

Innovative and responsible communities can utilize their local landfill resource to produce new jobs and demonstrate their commitment to be environmental leaders. The reduction of landfill emissions into the atmosphere by converting them to usable forms of energy allow the community to benefit from reduced air pollution problems and smog formation. Surrounding properties benefit from the reduction of the odor of methane from the landfill area. Communities that invest in the harvesting of landfill gases are likely to be viewed as environmentally concerned and proactive in ensuring the well-being of its citizens.
FAQ # 4



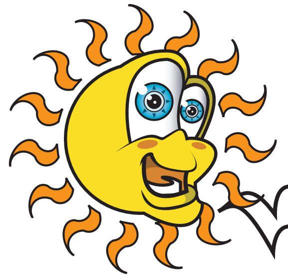
**FAQ # 4** ***What are the environmental benefits of using landfill gas as an energy source?***
If we utilize landfill gases for our energy needs, we can reduce our demand on nonrenewable energy resources like coal and oil. At the same time we will be reducing the air pollution caused by the landfill gases! Methane is an air pollution component that has been linked with the global climate change concern. Communities that develop a landfill gas management system will directly benefit from cleaner air and reduced methane as a *"greenhouse gas."*

**FAQ # 5** ***Who uses recovered landfill gas?***
Landfill gas cna be used for a wide range of purposes. A logical option is for local utility companies to buy the electrical power generated from the methane. Purchasing landfill gas allows utilities to add a renewable energy resource to their power production capabilities. Local industries may also directly pipe the gas to their site.

**FAQ # 6** ***Why promote the use of landfill gas?***
Using landfill gas ends up being a win/win deal for the local community and the landfill operations team. Citizens want environmentally sound techniques for reducing air pollution and conserving limited energy resources. Furthermore, clean air contributes to public welfare and safety issues. Most communities would appreciate increased environmental protection, improved waste management, and responsible community planning.

**FAQ # 7** ***Why is EPA interested in landfill gas projects?***
Landfills are the largest source of methane emissions in the U.S. This accounts for over 40% of the methane emissions. This energy can be captured and utilized for a wide variety of applications. As we strive to reduce greenhouse gas emissions, this is a very cost effective route. New regulations by the EPA are setting standards for target emissions from landfills. Landfill operators will be expected to work to *"flare off" (burn)* or work to capture it. By working to collect and use the methane, landfill owner/operators gain environmental, social and economic benefits. We can truly convert garbage in landfill to gases that provide us with a renewable energy resource.

# THE SUN IN MYTHOLOGY AND HISTORY



**SUBJECTS:** General Science, World History, World Geography, English

**TIME:** 2-3 class periods

**MATERIALS:** *Icarus* by the Paul Winter Consort *(recording)*, world map outline

## Objectives *The student will do the following:*

1. Explain the significance of mythology.
2. Demonstrate library skills.
3. Summarize sun myths and scientific knowledge about the sun.
4. Present summaries of information in a variety of ways.

## Background Information

Daedalus, a character in Greek mythology, was a famous architect and sculptor. According to the myth, he grew jealous of one of his students, Talos. He killed Talos and fled from Athens to Crete, taking his son, Icarus, with him. In Crete, he built the Labyrinth of the Minotaur for King Minos. Daedalus soon fell from favor with the king, and both he and Icarus were imprisoned by Mines. In order to escape, Daedalus built two pairs of wings made of wax and feathers. He cautioned Icarus to fly low over the water and not to get too high or the wax would melt. Icarus, filled with the joy of flying, failed to heed his father's warning. He flew too near the sun, and his wings melted. He plunged into the sea and drowned.

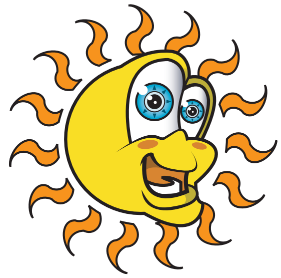
## Procedure

### I. *Play Icarus, a recording by the Paul Winter Consort, for the students.*

A. Ask the students to describe what the music brings to their minds. *(You could have them make drawings.)*
B. Ask if anyone knows the meaning of the title, *Icarus*.
C. Relate the myth above.
D. Ask the students to draw morals from the myth; discuss mythology and its cultural significance.

### II. *Have the students research sun myths and beliefs.*

A. Divide the class into five groups. Assign each group one of the early cultures listed below. Ask the students to find sun myths or beliefs belonging to their assigned cultures. Have the students conduct library research *(either during class time or outside of class)* to find the information they need.
1. Japanese
2. New World Indians *(Aztecs, Incas, Mayas)*
3. Egyptians
4. Babylonians
5. Greeks, Romans



B. Have the students present their findings to the class. Encourage a variety of presentations *(skits, illustrations, etc.)*.

III. ***Discuss present astronomical knowledge about the sun and ask the students to describe some current solar energy technologies.***

A. Have each student return to the library to research our present knowledge of the sun and our use of its energy. Have them construct solar time lines based on the information they gather.

B. Have students locate each culture and each time line entry discussed in class on a world map.

IV. ***Continue with the follow-up below.***

## Follow-Up

I. ***Why did so many early cultures have sun myths?***

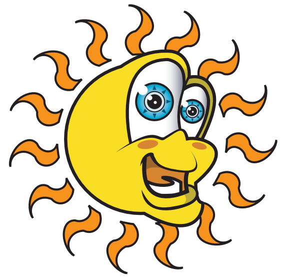
People developed mythologies to explain things they did not understand. This has been especially true of natural phenomena. For example, since one natural phenomenon all cultures experience is the rising and setting of the sun, it is quite natural that mythological explanations of this daily occurrence are common.

II. ***What is an appropriate scale (interval) for the time line? Why was an appropriate interval difficult to determine?***

The early myths establish one end of the time line and the more recent astronomical and solar energy developments establish the other. Because there are many recent developments of significance, the recent end of the time line needs small divisions. One way to deal with this problem is to use a broken time line with two scales. For example, the earliest mythological information can be recorded on a scale measuring thousand-year intervals, but the astronomical and recent solar technology developments need shorter intervals.

III. ***Why are there so many more late entries on your time line than early ones?***

The discussion should center on the incremental effect of scientific discoveries, i.e., one discovery leading directly to several more. There has been a geometric increase in the amount of information gathered in recent years in most subject areas. Advances in information retrieval systems and data collection mechanisms as well as the increased longevity of the population and improving economic conditions have contributed to the explosion of information.



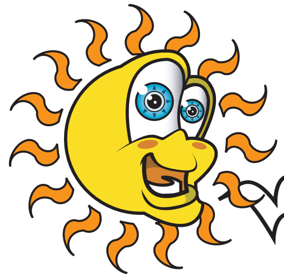
## IV. *What inferences can be drawn from an examination of the world maps on which these cultures and events were located?*

Two possible explanations might be that large parts of the world have not contributed to our solar knowledge or there are areas whose contributions the class has not yet discovered. Hypotheses to explain these two viewpoints should be developed, and each hypothesis could become the focal point for future library research.

## Resources

***Paul Winter Consort***. ICARUS. Epic Records, 1972.

# TRACING THE FLOW OF SOLAR ENERGY



**SUBJECTS:** General Science, Physical Science, Environmental Science

**TIME:** 1-2 class periods

**MATERIALS:** student sheets

## Objectives *The student will do the following:*

1. Trace the flow of solar energy.
2. Associate the First Law of Thermodynamics with the concept of energy transformation.
3. Recognize the relationships between the sun and the following: coal, wind power, hydropower and the food chain
4. Identify examples of: light and heat, potential energy and kinetic energy.

## Background Information

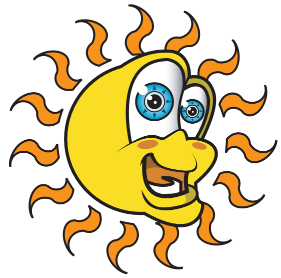
The First Law of Thermodynamics, better known as the Law of the Conservation of Energy, states that energy can neither be created nor destroyed. Energy can be changed from one form to another, but again it cannot be created or destroyed.

When we use energy, it has usually been converted from one form to another. These conversions are not 100 percent efficient; that is, at each conversion, some energy is "lost" in waste heat, friction, noise or other unusable forms. Most energy use processes include several energy transformations. With energy loss at each conversion, the energy we finally use is but a fraction of the amount of energy available at the start of the process.

The sun provides an enormous amount of energy to the earth. Almost incalculable amounts of radiant energy from the sun have reached the earth throughout its history. A small amount of the energy available to the ancient earth was captured by plants living at that time. Green plants capture light energy to perform photosynthesis, assembling energy-rich carbohydrates from carbon dioxide and water. This ancient energy, stored as chemical energy in fossil fuels, provides most of the energy powering vehicles, industries and electric generating facilities today. The energy stored by present-day green plants provides all the chemical energy necessary to maintain life on our planet. Every living thing – including human beings – depends on the solar energy stored in food.

The sun's energy also powers the hydrologic cycle by providing the energy necessary to evaporate water from the earth's surface. We use this energy when we use electricity generated at a hydroelectric power plant.

Radiant energy from the sun also causes wind. Different air masses absorb heat at different rates. Warmer air rises and cooler air moves in, creating currents of moving air in the atmosphere. We can use the energy of wind to provide mechanical energy, and the mechanical energy may be used to provide electricity.



## Procedure

**I.** ***Give each student a copy of each of the four student sheets (pages 184, 186, 188 and 190).***
Explain that they are to trace the flow of energy originating in the sun through each of the four energy use schemes depicted.

- **A.** Review with the students the definitions of radiant energy, kinetic energy, and potential energy. Be sure they understand that radiant energy includes light and heat energy; kinetic energy includes mechanical energy and electricity; and potential energy includes stored chemical energy. Have them label each step as to the type of energy represented there.
- **B.** Discuss with the students the concept of the conservation of energy and how energy transformation is related to that law. Have the students label each transformation with the types of energy that are *"lost."*

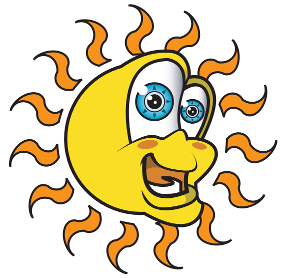
**II.** ***Continue with the follow-up below.***

## Follow-Up

**I.** ***Ask the students how the efficiency of energy transformation might be maximized.***
*(In other words, what could we do to get the most usable energy out of our energy conversions?)* Some possible answers might be the design and use of more efficient generators and machines; more uses of solar energy for lighting, heating and photoelectricity; and energy use processes that involve fewer steps from start to finish. *(If possible, discuss some of the implications of their answers.)*

**II.** ***Trace the flow of energy used to power an automobile.***
The energy came to the earth in the form of sunlight many millions of years ago. Ancient green algae converted the light energy into potential *(chemical)* energy through photosynthesis. The microscopic plants and the animal plankton that ate them died and sank to the bottom of the ancient seas, where they were buried by sediment and partially decayed. The resulting oil was recovered and refined, and the gasoline made from it was used to fuel the automobile. Burning the gasoline converts the chemical *(potential)* energy to kinetic energy, causing the expansion of gases in the cylinder of the engine. The expanding gases force the pistons down; the piston rods turn the crankshaft, which turns the driveshaft, turning the axle, which turns the wheels – all forms of kinetic energy.

**III.** ***How is energy "lost" in an automobile?***
The heat and noise given off by the engine do not contribute to the automobile's motion; this is *"wasted"* energy. Sometimes the gasoline does not burn thoroughly. If the engine needs a tune-up, for example, energy is lost by incompletely burned gasoline going out in the exhaust.

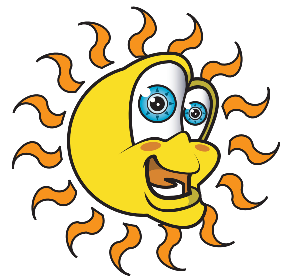


## IV. *How is energy "lost" in the food chain?*

Only green plants can make use of the light energy falling on their leaves. Herbivores *(plant-eaters)* take in the energy stored in the plants, but the herbivores must use this energy to stay alive. Therefore, not all the energy herbivores take in is available to carnivores *(meat-eaters)* since some of it has been used in metabolism. In birds and mammals, much of this energy is used to maintain the animal's body temperature, and energy lost to the environment as body heat. Additionally, digestion is not a completely efficient process as animal wastes have energy content and can be used as fuel.

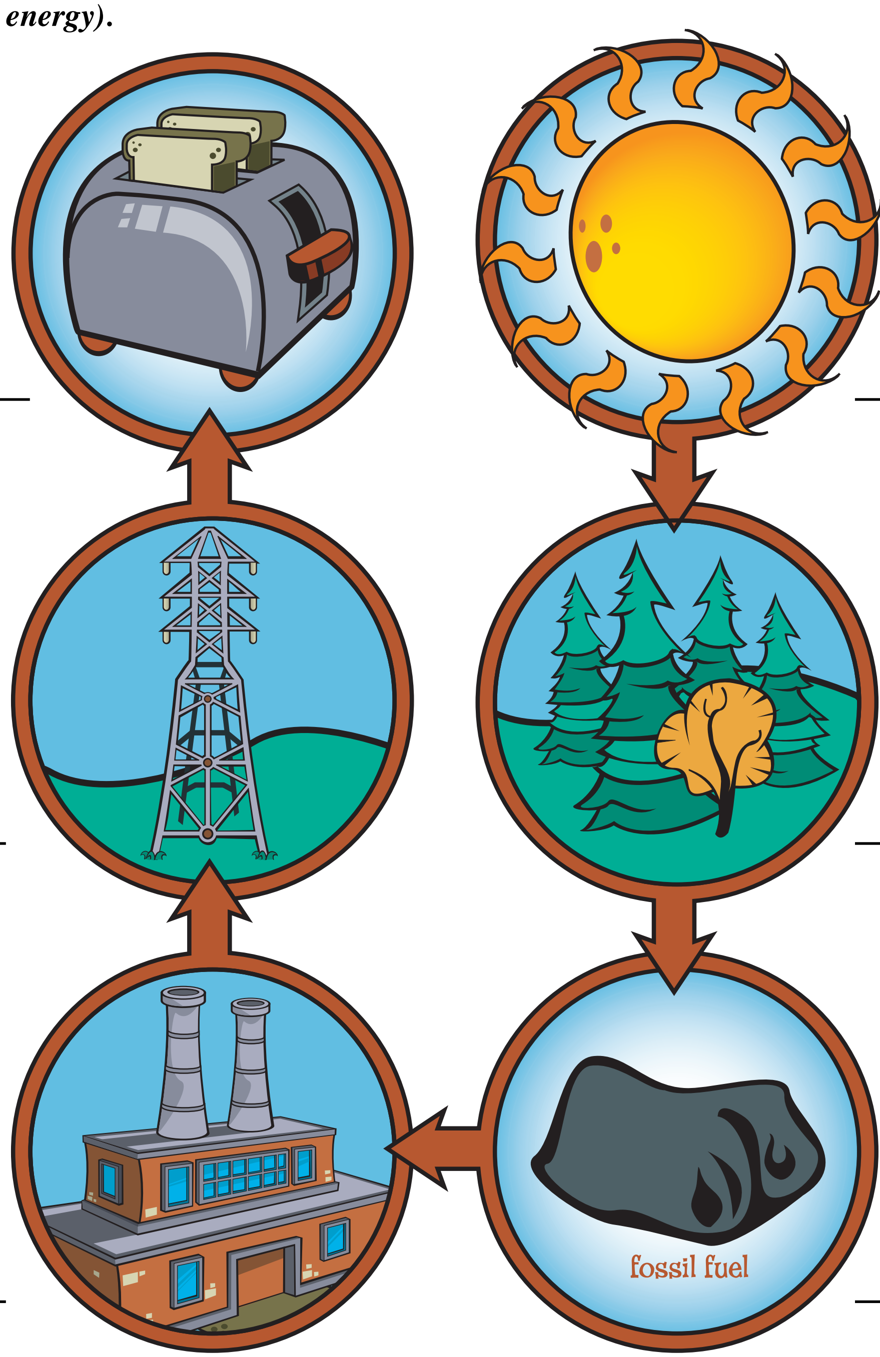
## V. *Can there ever be an electricity generation and transmission system which loses no energy?*

No, a 100 percent efficient system is impossible. Friction between moving parts "*steals*" energy. The energy loss in a power plant is substantial because it is difficult to capture and use waste heat energy. It is also impossible to transmit electricity at 100 percent efficiency. Resistance of the conductors in the system to the flow of electricity causes a loss of energy. *(You may want to discuss superconductors.)*



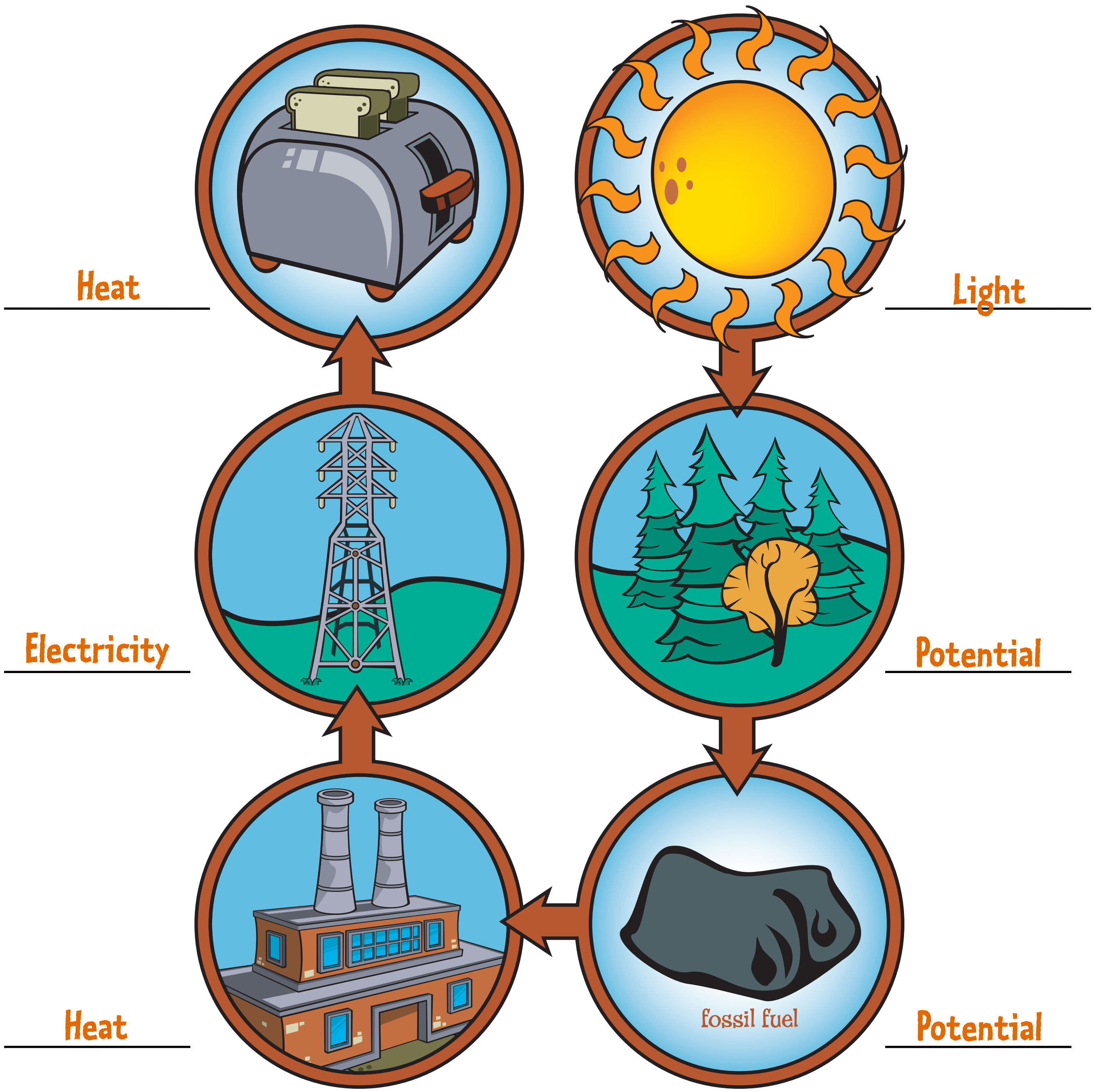
# Tracing the Flow of Solar Energy

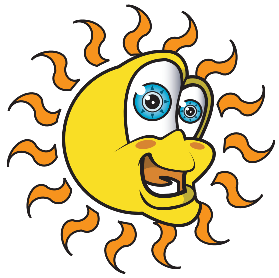
***Beginning at the sun, arrows show the energy flow to each step in the process of using this energy. Indicate the energy's form in each step by filling each blank with one of the following: heat, light, kinetic (motion or mechanical) energy, potential (stored or chemical) energy, or electricity (a specific type of kinetic energy).***



# Tracing the Flow of Solar Energy

***Teacher Key***





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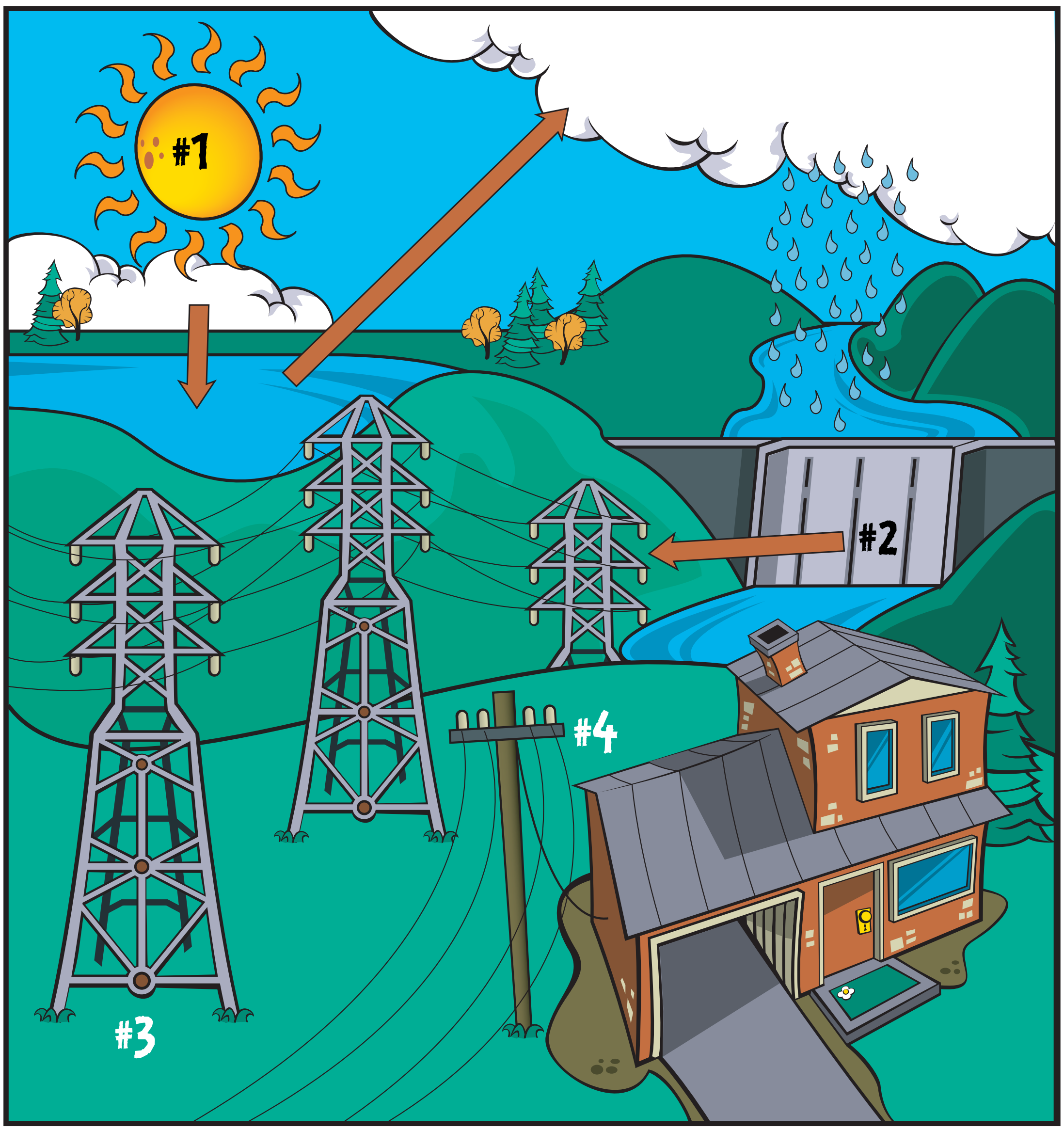
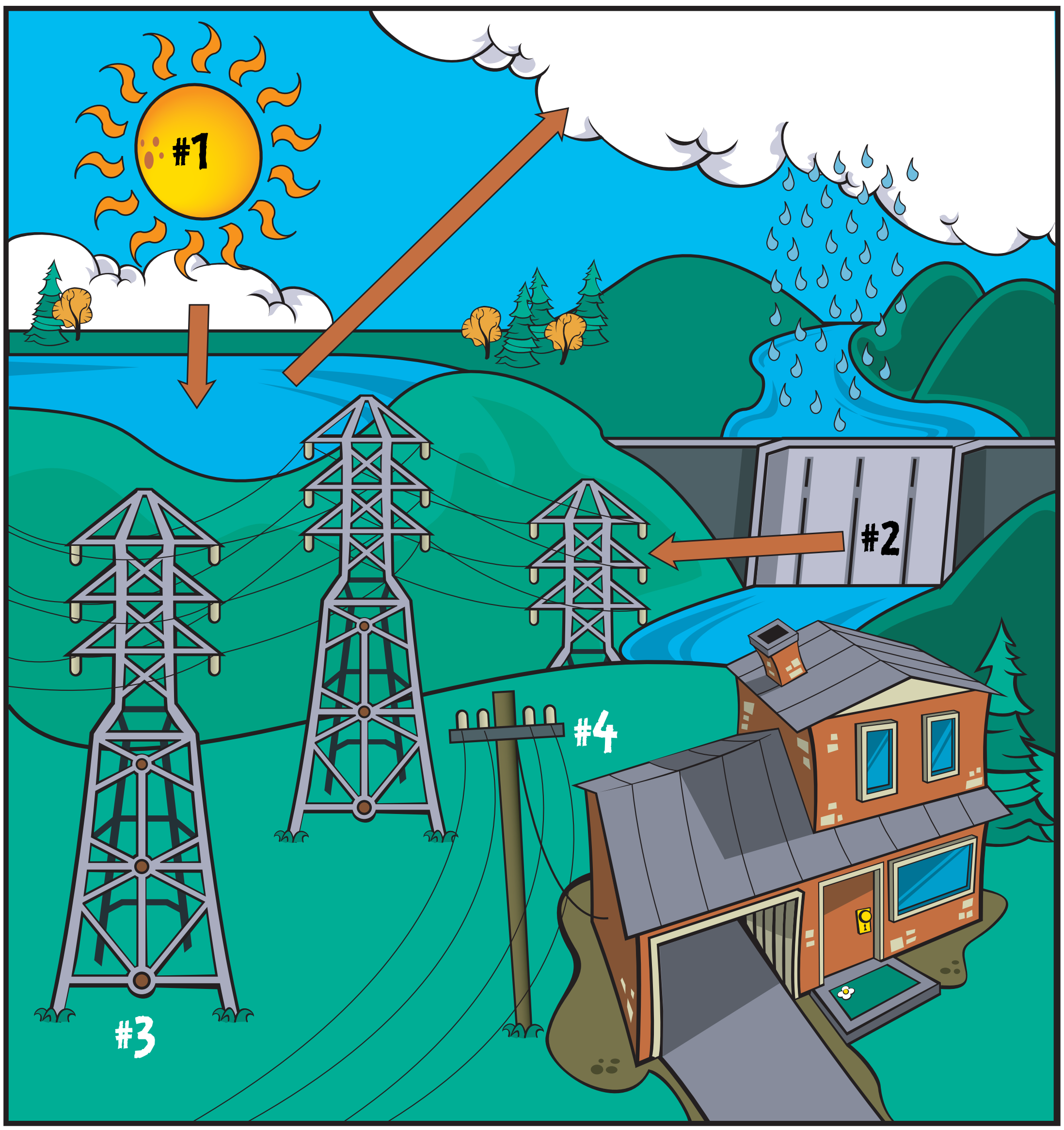



#1 ____________ #2 ____________ #3 ____________ #4 ____________

# Tracing the Flow of Solar Energy

*Teacher Key*

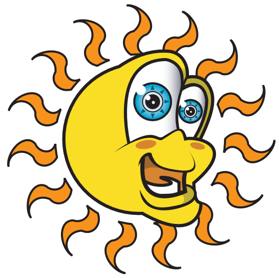



#1 Heat

#2 Potential

#3 Kinetic

#4 Electricity



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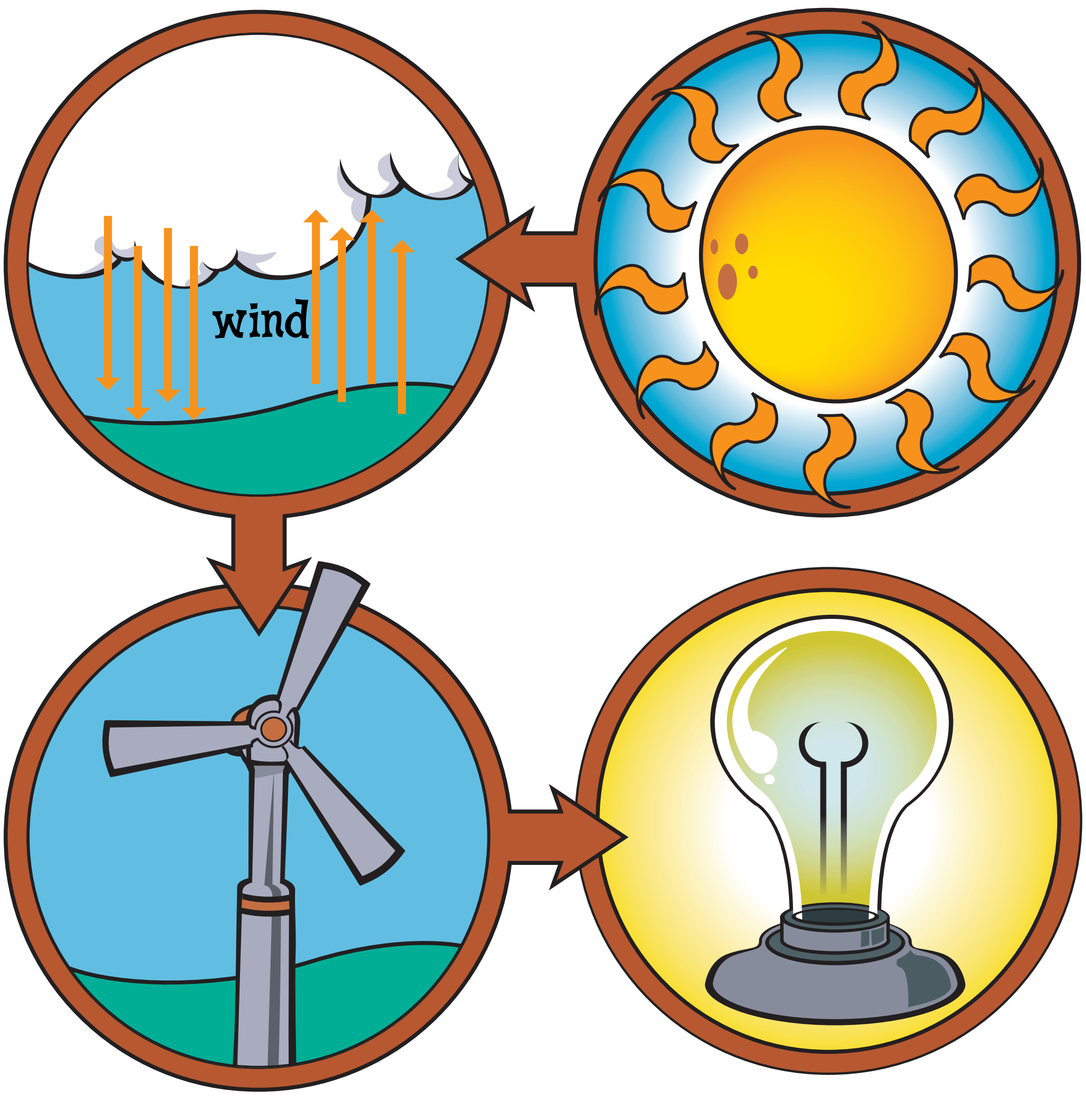
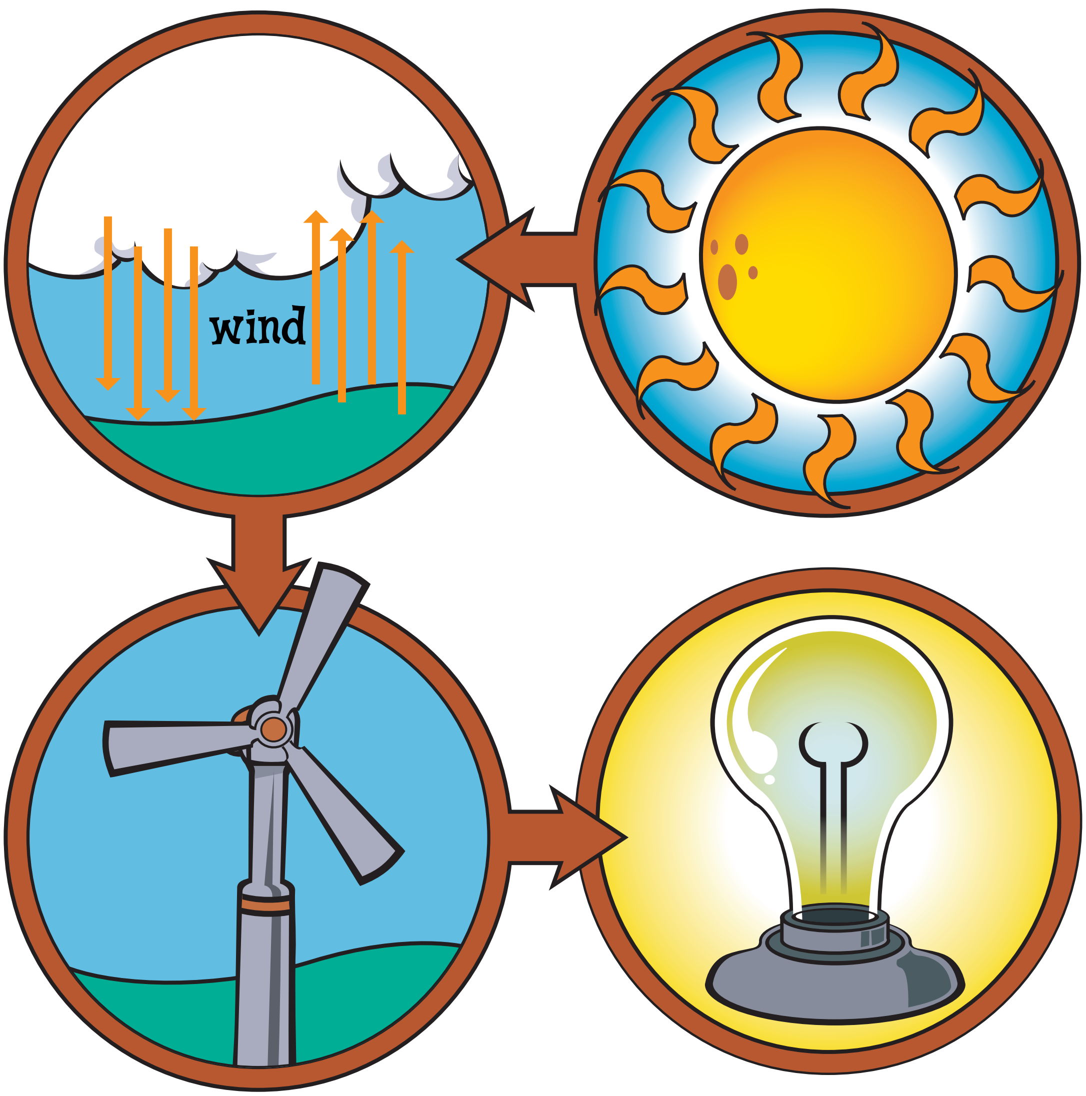



#1 ____________________ #2 ____________________ #3 ____________________ #4 ____________________

# Tracing the Flow of Solar Energy

***Teacher Key***

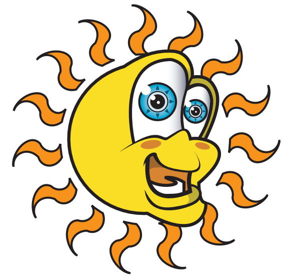



#1 Heat

#2 Kinetic

#3 Kinetic

#4 Electricity



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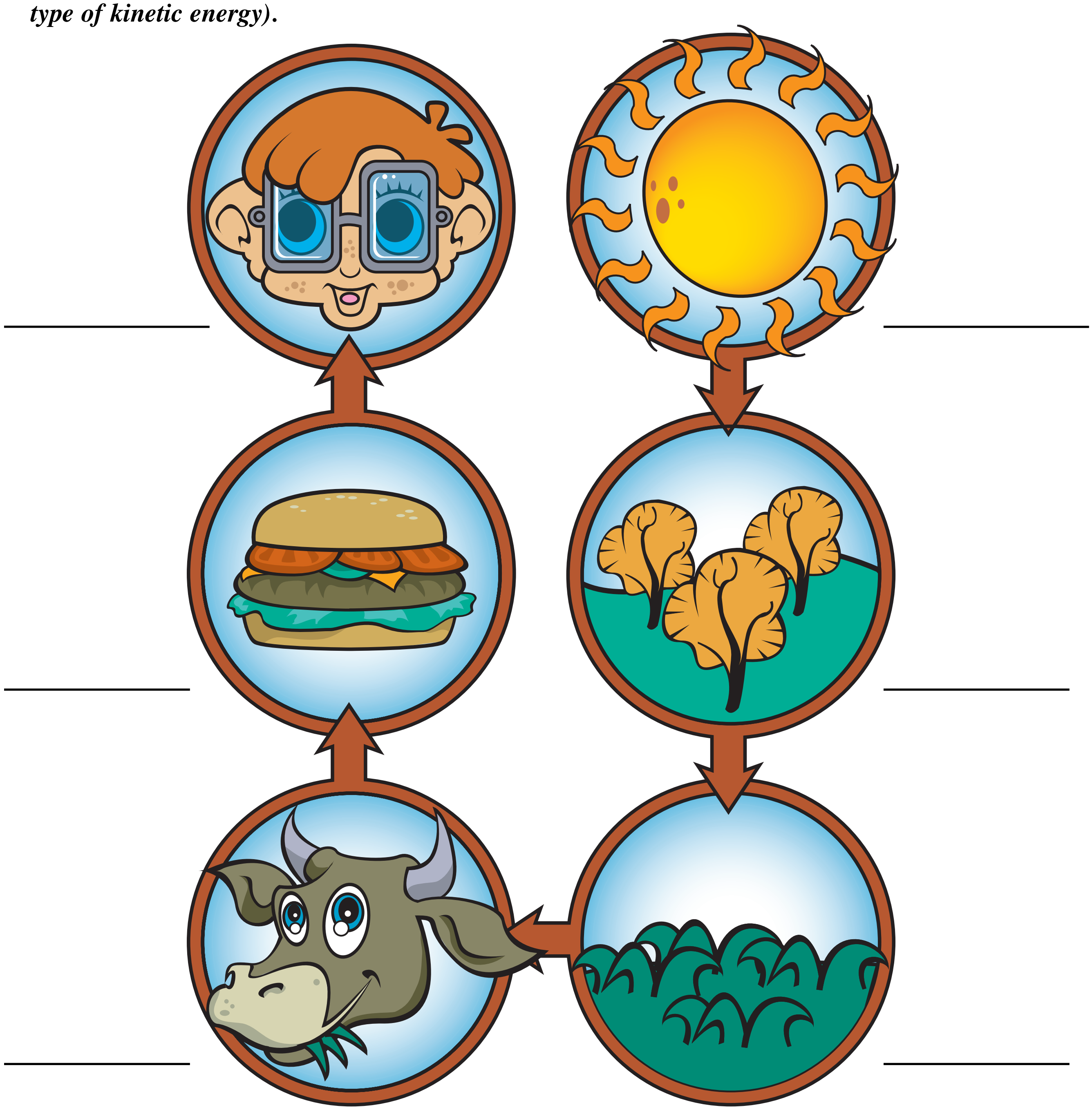
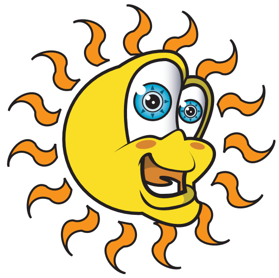
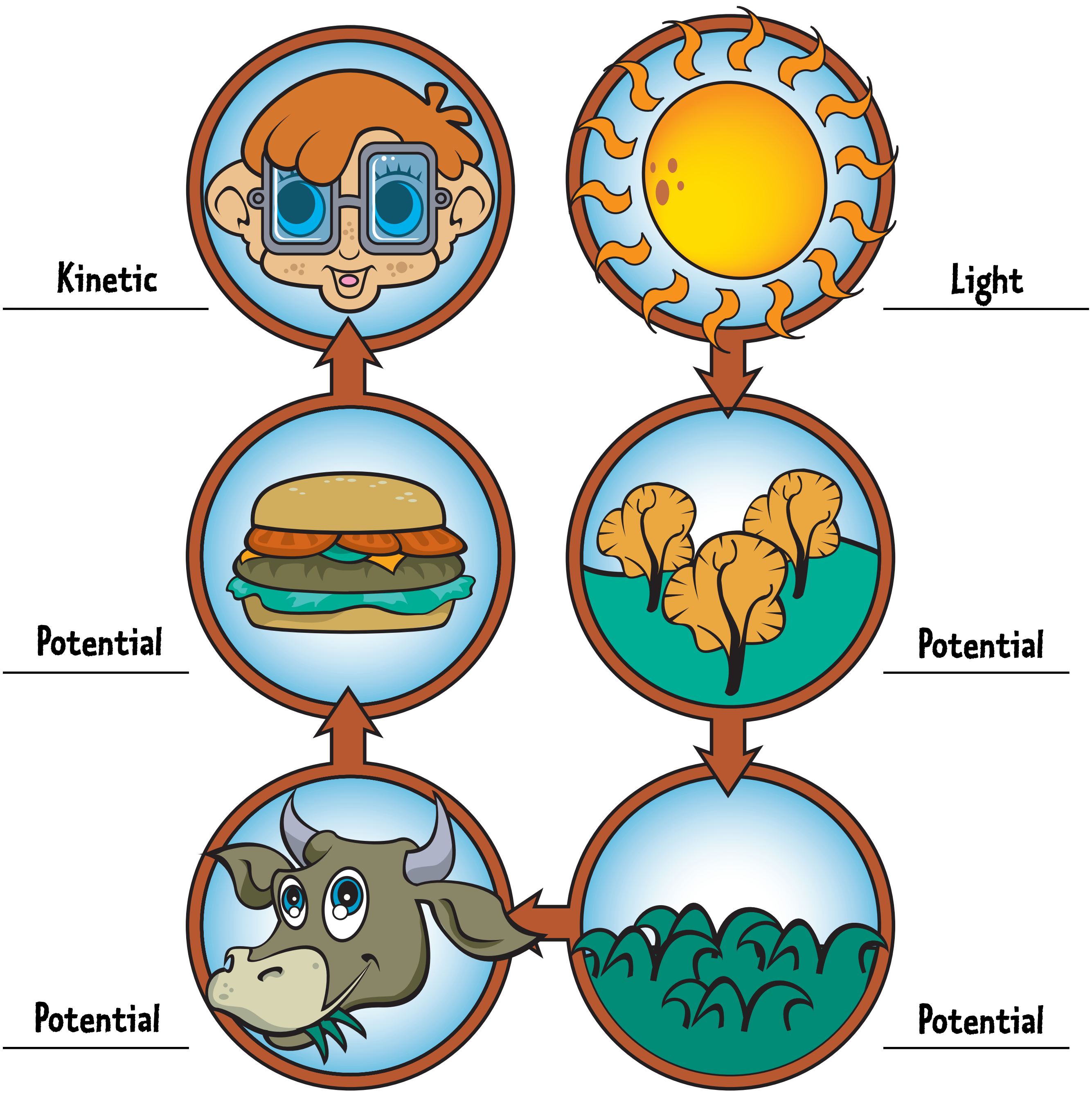


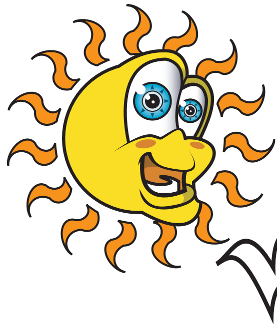


# Tracing the Flow of Solar Energy

***Teacher Key***



# PURIFYING WATER WITH SUNLIGHT



**SUBJECTS:** General Science, Physical Science, Outdoor Education

**TIME:** 2 class periods

**MATERIALS:** *(for each student)* clear plastic wrap, 1 drinking glass or beaker, 1 large pan or tub, muddy or salty water, a small weight, student sheet

## Objectives *The student will do the following:*

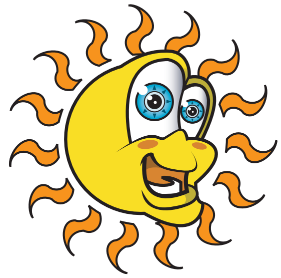
1. Build a simple solar still.
2. Distill water using the sun as the energy source.
3. Explain how using the sun as an energy source could help provide potable water and wastewater treatment.

## Background Information

Heat energy from the sun is constantly evaporating water from the surface of the earth. People can make use of the sun's evaporative energy to make salty or muddy water potable. When water evaporates, the solid substances dissolved or suspended in it do not. The evaporation of salt water is a good example. The water molecules enter the vapor phase, leaving the sodium chloride behind. This is because water has a much lower boiling point than salt. If alcohol, which has a lower boiling point than water, is added to water and the mixture is heated, the alcohol will evaporate first, leaving the water behind. Most of the chemical impurities in water, however, are solids with relatively high boiling points. Bacteria will also be left behind as water evaporates. Evaporation is a process which takes place molecule by molecule; that is, individual water molecules leave the liquid phase independently of each other.

To use the sun's energy to produce potable water, we need a device for capturing and concentrating the diffuse energy of sunlight, evaporating water and condensing purified water. Such a device is called a solar still. A still is a device which captures vapor and condenses it back into the liquid phase. The condensate is said to be distilled.

A solar still's operations can be explained by the Kinetic Theory. As the water in the pan absorbs the heat energy from sunlight, the water molecules vibrate with increasing energy. In the liquid phase, molecules are free to move and to collide with one another. The heat energy of the sun is transformed into the energy of motion – kinetic energy. Some water molecules near the surface gain enough energy to leave the liquid state and enter the air as vapor. Vapor has greater kinetic energy than does liquid. When the vapor molecules strike the plastic covering, they lose energy because the plastic covering is slightly cooler than the air and vapor within the still. The energy loss causes the vapor to re-enter the liquid phase. Pulled by gravity, the water then flows down the concave plastic covering and drips into the container at the center of the still.



## Procedure

I. ***Gather the materials for each student's solar still.***
Mix enough salty or muddy water for the class *(several gallons)*.

II. ***Introduce the activity by sharing the background information with the students.***
Explain that they will build simple solar stills and use them to distill salty or muddy water, making the water potable.

III. ***Distribute the student sheet and the materials needed for the solar stills.***
Supervise the students as they complete the activity.

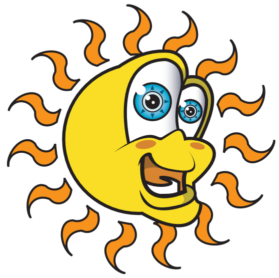
IV. ***If it is more practical to do this activity as a demonstration, you may prepare one solar still.***
Likewise, if it is not possible to put the still in the sunlight, you may place it under a lamp for a period of time *(perhaps overnight)*.

V. ***Continue with the follow-up below.***

## Follow-Up

I. ***Explain how the solar still works. What was the energy source? How was the water cleaned?***
The energy for this process originated in the sun. Light passed through the plastic wrap. The light energy was changed to heat energy as it struck the water, and the heat was then trapped within the pan by the covering. The covering allows visible light to pass through but will not allow infrared energy *(heat)* to pass back through as readily. The solar still acts as a heat trap, similar to a greenhouse. The sunlight provides the energy for the evaporation of the water in the container. The water vapor travels up to the covering, where it condenses because the covering is cooler. Droplets form and gravity pulls them down the weighted covering's slope. At the lowest point, drops form and fall into the glass or beaker located under the weight.

II. ***How might you speed up the distillation process?***
Increasing the energy input will speed up the process, but it is not possible to control the sunlight itself. Therefore, we must improve our collection of the sun's energy. This might be accomplished by increasing the surface area of the water by using a larger pan. Perhaps the pan could be painted black. Some light is being reflected away from the water by the covering; it might be possible to find a less reflective covering material. Concentrating the sunlight might be possible.



**III.** ***What areas of the world might benefit from large-scale solar-powered water purification plants?***

Places lacking fresh water but having access to sea water and abundant sunshine might someday benefit from this technology. Examples are Southern California and the Middle East.

**IV.** ***Could a solar still be used to clean up toxic wastes in water?***

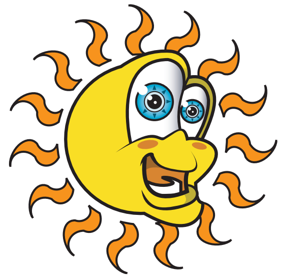
Any substance with a boiling point higher than that of water will remain behind as the water evaporates. Many substances *(particularly organic substances)* have boiling points lower than that of water. These substances often change chemically at high temperatures. Though distillation or evaporation cannot solve our wastewater treatment problems, many waste treatment plants allow the water to evaporate into the atmosphere. This reduces the volume of waste that must be disposed of. The residue is gathered and disposed of in special landfills.

**V.** ***How could this method be used as a survival tactic in the desert where there is no surface water?***

Drinking water can be distilled from the moisture in the ground. First, a hole is dug a few feet into the ground. The hole is covered with a large sheet of plastic or waterproof tarp, and a weight is placed in the center of the covering. A container for catching the condensate is placed directly below the center. Moisture from the soil evaporates, is trapped and condenses.

## Resources

***Oak Ridge Associated Universities.*** SCIENCE ACTIVITIES IN ENERGY: SOLAR ENERGY, N.p.: U.S. Department of Energy, reprinted 1980.

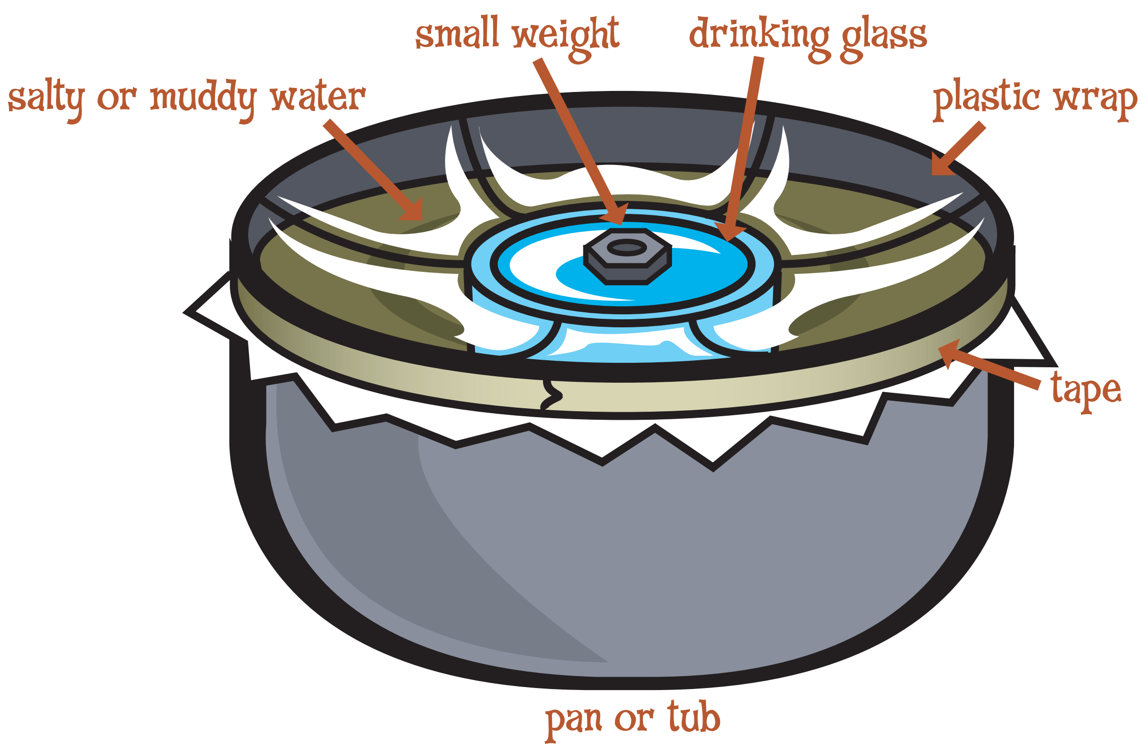


# Purifying Water

***Instructions***

1. Fill a pan or tub to a depth of 5 cm with salty or muddy water. Place a clean drinking glass or small beaker in the center of the pan.

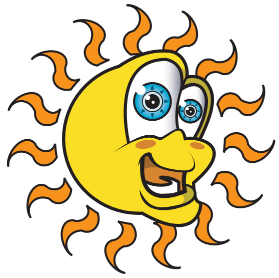
2. Cover the pan with plastic wrap. Tape all the way around the edges, forming a good seal. Place a small weight in the center of the plastic *(above the glass)*.




3. Place the solar still in direct sunlight for several hours.

4. Check the still after the time has elapsed. If you began with salty water, taste the water in the glass. If you began with muddy water, do not taste it. Just look at it; the water will be clean.

# The Influence of Color on Heat Absorption and Loss



**SUBJECTS:** General Science, Physical Science

**TIME:** 2 class periods

**MATERIALS:** *(for each group)* paint *(several colors, including white and black)*, one disposable aluminum pie pan for each color of paint, Celsius thermometer, water, clear plastic wrap, newspapers, student sheet

## Objectives *The student will do the following:*

1. Compare the influence of various colors on heat absorption.
2. Compare the influence of various colors on heat loss.

## Background Information

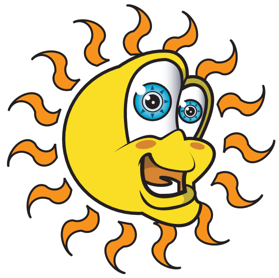
Ben Franklin did an exquisitely simple experiment on the subject of color and heat absorption. He placed a white cloth and a black cloth of the same size and same fabric on a snow bank in the sun. The snow under the black cloth melted, while that under the white cloth did not. One of the fundamental principles of solar technology is that white reflects most light and much heat, while black absorbs most light and much heat. That's why black looks black – it is reflecting almost no light back to the eye. Red absorbs all visible light except red, which it reflects. Yellow surfaces absorb all but yellow, and so on throughout the visible spectrum. This is why solar collectors have dark surfaces – to maximize heat absorption.

## Procedure

I. ***Divide the class into groups of five or six students each.***
Give the groups the listed materials. Have them paint the inside of each pie pan a different color, making sure to paint one white and one black. One may be left unpainted. *(To save class time, you may want to do this ahead of time.)*

II. ***Have them follow the instructions on the student sheet (page 198).***

III. ***When both procedures are completed, continue with the follow-up.***



## Follow-Up

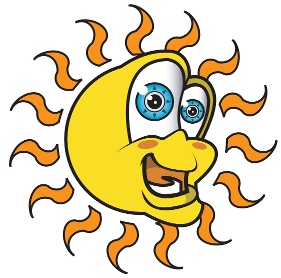
**I.** ***Why are the pans covered with plastic wrap?***
The covering makes the pans act as heat traps. Air is not free to circulate because, if it were, the heat collected would be *"blown away."*

**II.** ***Why are the pans placed on books or stacks of newspaper?***
The metal pans are very good heat conductors. Without the insulating effect of the books or newspapers, heat would be transported by the metal to the ground too quickly.

**III.** ***What were the results of your experiments? Why?***
Share with the students the information given in the background preceding the instructions for this activity.

**IV.** ***Why are solar collectors black?***
The color increases the efficiency of the solar collector as a heat trap.

**V.** ***Which parts of a house should be painted white or a light color?***
In the South, air conditioning costs sometime outweigh heating costs. In this case, a house with a white roof will save on the annual energy bill. Also, south-facing walls should be white or light colored.



# Color and Heat

***Put 500 ml of water in each pan. Measure and record the temperature of each. Cover each pan securely with clear plastic wrap. Place them on books or stacks of newspaper in direct sunlight. After 15 minutes, measure and record the temperature of each. Compute the temperature change for each pan.***

| Color of pan | Initial temp (°C) | Final temp (°C) | Change in temp (°C) |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

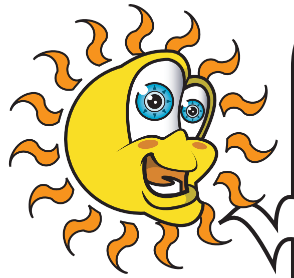
Which color gained the most heat? ______________________ the least heat? ______________________

***Put 500 ml of hot water in each pan. Measure and record the temperature of each. Repeat this procedure every 5 minutes for 20 minutes. Compute the overall temperature change for each pan.***

| Color of pan | Temperature (°C) | | | | | Overall change in temp (°C) |
|---|---|---|---|---|---|---|
| | 0 min | 5 min | 10 min | 15 min | 20 min | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

Which color loses heat most quickly? ______________________ most slowly? ______________________

# ORIENTATION OF SOLAR DEVICES



**SUBJECTS:** General Science, Physical Science, Industrial Arts, Environmental Science

**TIME:** 1 class period

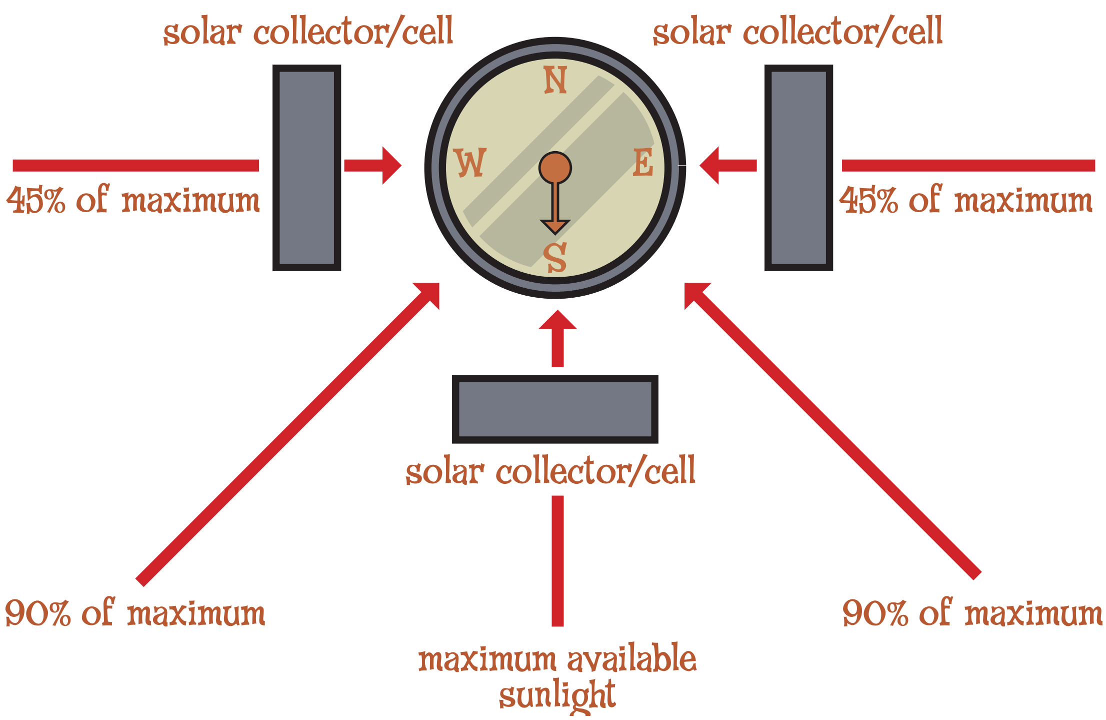
**MATERIALS:** compass, student sheet

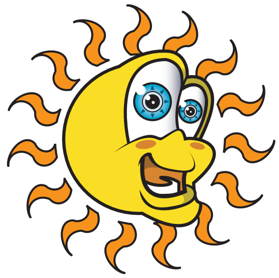
## Objectives *The student will do the following:*

1. Use a compass to determine the orientation of the exterior walls of the school.
2. Determine the degree of variance of the southern-oriented wall from true south.
3. Compare the orientations of the walls to observations of the amounts of sunlight hitting them.

## Background Information

The effective use of energy-saving solar devices depends upon careful selection of their locations. The collectors or cells must be oriented so that they receive the greatest possible amounts of solar energy. To receive maximum amounts of sunlight throughout the year, the southern exposure of a building and/or the solar devices should be oriented as close to true south as possible. If this orientation is not feasible, the direction may vary by up to 30 degrees east or west of south. This will result in only about a 10 percent reduction of the amount of available sunlight. Deviations greater than 30 degrees from true south may significantly affect the energy collection of the system.





## Procedure

I. ***Discuss the importance of orienting solar devices or systems to maximize their energy collection.***

II. ***Demonstrate the use of the compass.***
Explain that the students will use compasses to determine the orientations of the walls of the school.

III. ***Divide the class into small groups (or pairs).***
Distribute the student sheets. Direct the students to the major exterior school walls. Have them determine the orientation of each major wall.

IV. ***Determine which wall has the southernmost exposure.***
When they determine which wall has the southernmost exposure, have them use the *"Sun Finder" (page 202)* student sheet and their compasses to determine the wall's degree of variance from true south.

V. ***Continue with the follow-up below.***

## Follow-Up

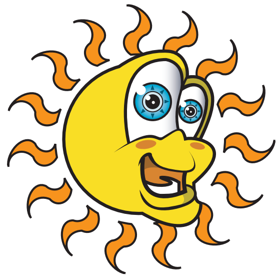
I. ***Which school walls face north? east? west? south?***

II. ***How many degrees east/west of true south is the south-facing wall?***

III. ***If variance from true south cannot exceed 30 degrees east or west without seriously affecting the ability of a solar device located there to collect energy, is the southern wall of the school a suitable place for a solar device?***

IV. ***Ask the students to compare the data collected on the orientation of the school's walls to their observations of the amounts of sunlight hitting the respective walls.***
East-facing walls are exposed to morning sunlight but shadowed in the afternoon. The opposite is true for western walls. Students may have observed that walls with a southern exposure receive sunlight for more hours of the day throughout the year.

V. ***Ask the students for ideas as to how they might be able to demonstrate that the wall whose orientation is nearest to true south receives more solar energy than other walls.***



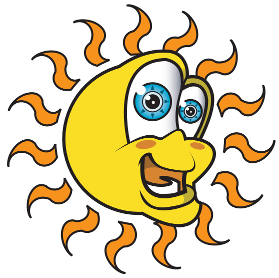
# Orientation of Solar Devices

***Instructions***

1. Using the compass, determine the orientation of at least four walls of your school building that have different exposures. Record the directions they face in the data table.

2. Return to the wall that is the most south-facing. Use the "*Sun Finder*" handout to determine the number of degrees east or west of true south that the wall deviates. Record this data in the column called "*Degrees of Variance*."
3. Observe the exposure of each wall to sunlight at various times of the day. If this is not possible, try to recall each wall's exposure at other times of the day. Describe the amounts of sunlight.

| Wall | Describe Location of Wall | Orientation of Wall | Degrees of Variance | Describe Exposure to Sunlight |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| other | | | | |



# Sun Finder

***Find the exact direction for your solar system example.***

***What you need***

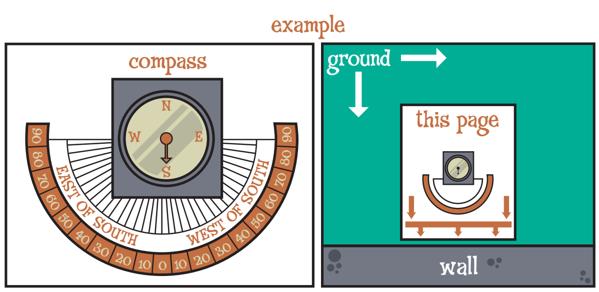
1. this page
2. compass

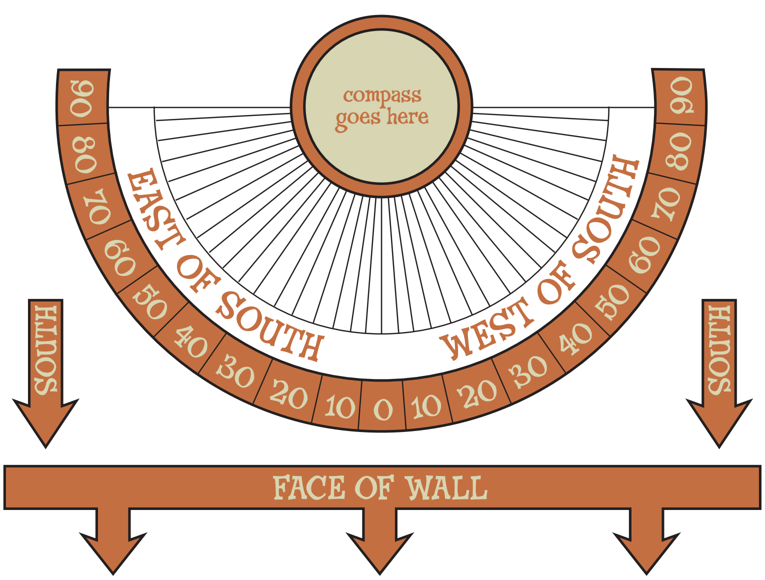
***Where to Place***

1. Using the compass, decide which wall faces closest to south.
2. Place the arrows at the bottom of this page against the face of the south wall.
3. Put your compass exactly in the center of the circle marked "*Compass Goes Here*."

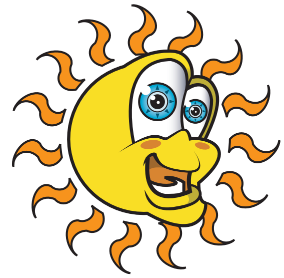
***How to Use***

1. The compass needle will point to an angle printed on this page.
2. This angle will be either east or west of south.
3. This will tell you how many degrees off south your wall faces.



# REFERENCES

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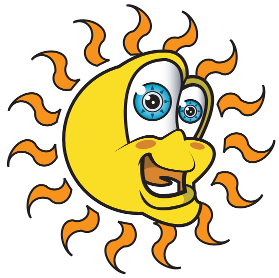
fact sheet

# ALTERNATIVE ENERGY SOURCES



We are searching for less expensive, more reliable, and less environmentally harmful energy sources. The increasing prices of conventional, heavily-used fuels; the impending depletion of domestic oil and gas reserves; the possibility of political interruption of foreign oil supplies; and increasing social and environmental concerns have led us to realize that we must not only conserve energy, but also find new ways to provide the energy we need.

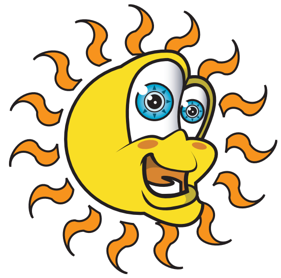
For purposes of our discussion here, all energy comes from resources classified as either renewable or nonrenewable. Renewable, or nondepletable, energy resources include the sun, wind, crops, forests and water. Nonrenewable, or depletable, energy resources include fossil fuels – coal, oil and gas. Uranium, used to fuel nuclear power systems, is also depletable.

The *"energy crisis,"* brought on by the oil embargo imposed on the United States *(U.S.)* by the Arab members of the Organization of Petroleum Exporting Countries *(OPEC),* began late in 1973. In 1974, 94 percent of all the energy used in the U.S. was from nonrenewable resources – meaning that only 6 percent was from renewable resources. During the years following, energy prices escalated, and yet, the consumption of nonrenewable energy resources continued at a high rate. In 1983, 91 percent of the energy used in the U.S. was still from nonrenewable sources – only a slight reduction from the 1974 figure! As we approached the end of the 20th century, we still relied on depletable sources for about 90 percent of our energy.

A number of renewable energy resources are being investigated as possible alternatives to traditional nonrenewable resources. The alternative energy sources that are most applicable in the Tennessee Valley are biomass, wind, and waste.

**Biomass** is the general term for all of the materials of organic origin – plant materials and animal wastes – from which we may obtain energy. The chemical energy stored in biomass is a form of solar energy. Plants capture solar energy through photosynthesis, converting carbon dioxide and water into higher-energy compounds, such as carbohydrates. Trees, grains and other crops, aquatic plants, and animal manures are the principal sources of biomass. These raw materials can be burned to produce heat, which may be used directly or used to drive a generator to produce electricity. Biomass can also be converted into liquid or gaseous fuels and petroleum substitutes.

Using the energy obtainable from biomass is nothing new; it is the oldest known source of fuel. People have always burned wood and other plant materials. Even today, much of the world's population depends on this simplest use of biomass to supply energy, primarily for cooking. Wood remained the chief source of energy in the Western world until the industrial revolution, when coal replaced it as the primary energy resource. Today, oil is the primary energy resource in the U.S., largely due to the use of the automobile. We still use coal



heavily; coal-fired power plants generate most of the electricity we use. Biomass can help supply fuels for residences, vehicles, industries and power plants. The use of biomass can be on a large industrial/commercial scale or a very small scale, for example, using a woodburing stove to heat one's home.

Energy from biomass is important in the Tennessee Valley and may well become even more important in the future. We have extensive and well-located sources of biomass, such as forest and agricultural lands. Major potential benefits of increased employment of biomass include the constructive use of wastes that otherwise contribute to pollution, the opportunity to improve forest productivity, and the displacement of more environmentally harmful energy sources.

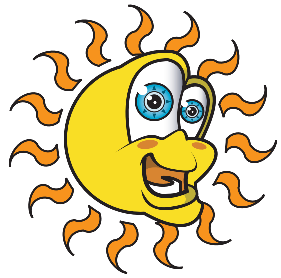
The current most popular biomass uses – wood for residential heating and alcohol fuel from grains – have some potential for environmental damage, as does the use of any energy source. Large increases in wood stove use may lead to increased air pollution and house fires resulting from their improper installation, use and maintenance. The potential problems from using more fuel from grain include increased erosion of crop lands and ecosystem displacement by expanded crop acreage. Nevertheless, if biomass resources and their conversion processes are managed properly, their use has the potential for less environmental damage than the present use of coal and oil or the proposed use of synthetic fuels derived from coal.

In the Tennessee Valley region, wood is a major biomass resource. It serves as a fuel in the form of logs and residues *(excess forest growth and insect-infested or diseased trees)*. Silvichemicals *("silvi" comes from a Latin word for "forest"),* such as turpentine and resin, and carbon-based compounds made from wood's lignin and cellulose are other energy-related wood derivatives. Wood can be used to produce a variety of chemicals such as methanol, aldehydes, ketones and acids, which can be substituted for petrochemicals as either fuels or raw materials.

Herbaceous *(nonwoody)* plants such as grasses have potential as cost-effective energy sources. These plants have a high-yield capacity and can grow on marginal lands with minimal management.

Crops such as corn, wheat, sorghum and sweet potatoes *(as well as sugar beets and sugar cane in other regions)* are processed for their carbohydrate content to make ethanol. Ethanol has many uses; it is being used as a gasoline extender now in the blended fuel called *"gasohol."* Cellulosic materials from crops such as corn and beans can be converted by liquefaction to fuel oil.

Animal manure can be used to produce methane gas by a process called anaerobic digestion *(decomposition in the absence of oxygen)*. Methane, which is the principal component of natural gas, could supply farmers with an alternative energy source for farm operations. This could result in a higher degree of energy self-sufficiency for farmers.



Elsewhere in the country, kelp and algae are potential aquatic sources of biomass. They also have potential as futuristic sources of hydrogen, which may be used as a fuel. Through a process called biophotolysis, a blue-green algae produces hydrogen as a waste product. Kelp produces hydrogen gas through photoelectrolysis, another biological process that uses the energy of sunlight.

**Wind** is air movement caused by the uneven heating of the earth and atmosphere by energy from the sun. Wind energy is an indirect form of solar energy.

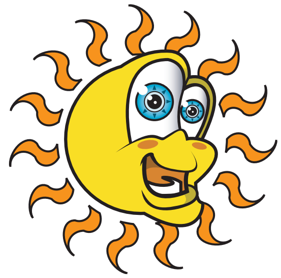
For centuries wind power has been used to supply energy for mechanical tasks throughout the world. Widespread use of windmills in the U.S. began in the 1850s. In the early 1900s, windmills were used to produce electricity on farms and in other rural locations. In 1935, the creation of the Rural Electrification Administration *(REA)* brought a cheap, reliable, centrally-produced supply of electricity to rural areas and windmills began to disappear. The dramatic increases in the costs of conventional energy sources in the 1970s, however, caused us to again consider wind power as a possible energy alternative.

In some regions of the country – the Plains States, sea coasts, and some mountain passes, for example – wind is a viable alternative energy option. In the Valley region, its potential as a significant energy source is limited to a few locations where the wind is consistently strong enough to be useful. In our society, we have relatively few needs that could be met with the mechanical energy provided by windmills, but windmills could effectively generate electricity in some locations.

The use of wind-powered energy production systems has several advantages over centralized fossil fuel or nuclear systems. Wind is abundant, free, powerful and clean; it displaces nonrenewable and/or imported fuels and increases the self-sufficiency of its user. The disadvantages of wind energy systems include possible safety hazards, a lack of constancy, the high initial investment in wind machinery and energy storage systems, and the difficulty of storing the power.

**Waste** materials can also be used as a source of energy. Our lifestyles, often characterized as *"throwaway"* lifestyles, are marked by a high degree of consumption of one-use products. This – along with the degree to which most of these products are packaged – has caused a tremendous increase in the amounts of waste generated in every community. Waste disposal now represents a major problem. . The use of wastes for energy may help solve disposal problems, as well as helping meet our energy needs.

Much of our waste is combustible and could be burned as fuel. Burning waste provides heat to produce steam for heating buildings, powering industries, or generating electricity. Waste materials may also be used to produce methane. The anaerobic decomposition that takes place spontaneously in landfills produces methane that can be collected and used to heat homes or other buildings.

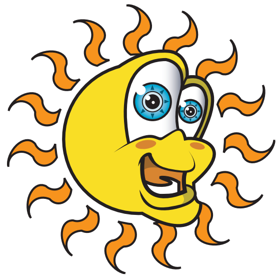


Using waste for fuel or as a source of fuel is not a panacea for our energy supply or waste disposal problems. Incinerating waste produces air pollutants which are not only damaging environmentally, but are also expensive and difficult to control. The ash left must still be disposed of somehow. Burying waste in landfills requires valuable land space and can threaten groundwater resources. Reducing the amounts of waste we generate and recycling are ultimately more desirable than burning waste, but gaining useful energy from waste we have already accumulated is an attractive, feasible option.

Alternative energy sources – renewable, dependable, domestically available, and less environmentally detrimental than the energy sources on which we now rely – offer us opportunities we cannot afford to pass up. Research and development of alternative energy technologies and resources are essential, and must be increased; it takes many years for new alternatives to become practical and economical. We must continue to search for alternatives.

fact sheet

# SOLAR ENERGY



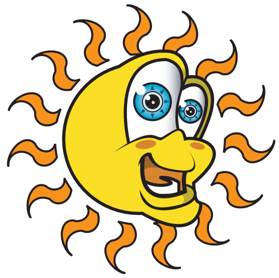
Almost all of the earth's energy originates in the sun. Through photosynthesis, the sun's radiant energy is converted to chemical energy by green plants. This chemical energy – the food value in plants – forms the basis of every food chain. The sun's energy not only supports life, but solar energy that reached the earth long ago powers our cars and cities in the form of fossil fuels. In addition, the sun's heat drives the wind and water cycles. Obviously, we are absolutely dependent on this source of constant, readily available energy; however, solar energy is diffuse and cannot be controlled by human measures. Capturing solar energy and converting it to a usable form is one of the major technological challenges of our time.

Solar energy, unlike the resources currently providing most of our energy, has the tremendous advantage of being renewable. It is a source of **free** fuel for billions of years to come. Solar energy has a great advantage over fossil fuels in that it causes no air pollution. Unlike nuclear power, solar energy produces no dangerous wastes. Solar energy does not have to be mined. Sunlight is available everywhere on earth. Admittedly, there are some disadvantages in the use of solar energy, as there are with all energy resources. Solar energy technologies often require large initial investments. The availability and strength of sunlight differs at various locations, and we have no control over weather factors which affect the use of solar energy. Perhaps the major drawback is that sunlight is not available at night when heating needs are greatest.

We we are researching and developing new technologies to make use of this important resource although using solar energy is not a new idea. Humans have always used the sun's warmth and light. Throughout history civilizations have not only made direct use of the sun's energy but also have used it indirectly by using wind power in sails and windmills, hydropower technologies like waterwheels, and biomass fuels. The sun's energy has played an important role in human history. Early people dried animal pelts and food in the sunlight. Greeks designed passive solar homes in response to shortages of wood for heating. Solar energy heated water in Roman public baths. Solar water heaters, stills and other devices have long contributed to human well-being. Our use of the sun's vast supplies of energy has taken many forms and has been of varying relative importance among other energy resources. As new ways to conserve energy and new alternative technologies are sought, solar power technologies can only become more important.

There are two basic kinds of solar technology – active and passive. An active solar energy system is one which captures the energy and transports it to be used somewhere else; active systems have mechanical parts. A solar water heater is an example of an active energy system. The water is heated by the sun, then goes to another area of the house for use. Passive solar systems are heat traps. For example, buildings or rooms are designed to function as passive solar energy systems by capturing the sun's heat. A greenhouse is an example. Passive systems generally do not have moving parts.

There are numerous methods of collecting solar energy for active use. Flat-plate collectors are the most common devices for heating water. These are the flat, dark, glass-covered boxes seen on roofs and in backyards. A flat-plate collector box acts as a heat trap. Heated water leaves the collector and is transferred to a storage tank or to a conventional water heater. The heated water can be used for such normal household purposes as bathing. In some systems, the water is used to heat the house and is stored in tanks in the basement until its heat is needed.



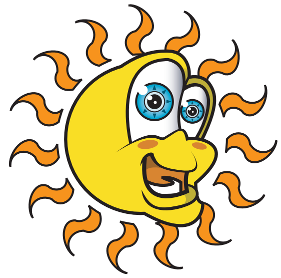
Solar *(photovoltaic)* cells, the electronic devices which convert light directly into electricity, are a special kind of active solar energy technology. They are commonly used in hand-held calculators. The wing-like structures on artificial satellites are panels of solar cells. In space, where there are neither clouds nor day/night cycles, solar cells provide an endless supply of electricity and are very efficient. A solar-powered ultra-light airplane, the Gossamer Penguin, has been successfully flown. Some solar electric cars have been built; General Motor Company's Sunraycer won a solar-powered auto race in Australia and toured the Eastern United States in the 1990s.

Although solar energy itself is "*free*," the present cost of arrays of solar cells large enough to provide power for a household is prohibitive, as is the cost of providing a solar electric-powered house with the necessary storage batteries. Nevertheless, the cost of solar cells has fallen about 90 percent in the last 10 years, making solar-produced electricity much more attractive. At the present time, the small solar cells available from scientific or electronic supply houses or catalogs may be used effectively for a variety of small-scale uses. Such uses include powering communication devices such as telephones, radios, and televisions. This is particularly important in developing countries.

Current uses of the sun's energy for producing large amounts of electricity require employing a modification of steam generation rather than photovoltaic cells. A solar furnace uses sunlight concentrated by mirrors to boil water and produce electricity from steam-powered turbogenerators. A huge array of mirrors on a slope focuses sunlight on the furnace's boiler. Solar furnaces are currently producing electricity in France and Arizona. A solar power tower is a variation of the solar furnace. A tower serves as the focal point for a circular array of mirrors on level ground around the tower. Water is heated to steam within the tower and electricity is produced by a turbogenerator. These kinds of generating facilities are most practical for desert areas because of the amount of groundspace they require, as well as the availability of maximum amounts of sunlight.

Passive solar technologies trap the sun's heat and employ only the properties of heated air or water in the energy's storage and use; mechanical devices do not assist in these processes. Passive solar building design, for example, has features which maximize solar heat gain in winter and minimize it in summer. The orientation of windows, the use of shading devices, and landscaping around the building may all play a part. Special features such as thermal masses *(e.g., brick or concrete walls or floors)* which absorb heat and release it slowly, greenhouses and Trombe walls may be included in passive solar designs. Trombe walls are hollow, vented, south-facing exterior walls which act as solar collectors. Air inside them heats up, rises, and exits through vents at the top of the wall to circulate through the room, drawing cool air into the vents at the bottom of the wall. Passive systems are generally considered energy conservation measures.

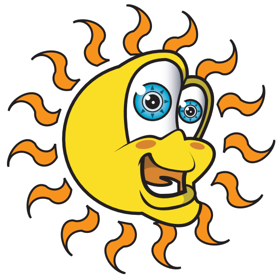
The passive use of solar energy can be done on a very small scale. One example is solar ovens. They are easy to build and use free fuel. Parabolic reflectors are commercially available and are designed to focus the sun's rays on a small area; used with a grill or spit, they make it possible to cook meat as well as other foods with



solar energy. While cooking with such ovens is not always practical, the use of solar ovens to dry food can be very convenient. Solar energy can be used to prepare some foods without using a solar cooker or dehydrator. Making *"sun tea"* is a popular method of preparing iced tea; the heat of the sun is trapped inside the closed jar, and tea is brewed slowly as the water heats up.

Our current standard of living requires an inexpensive, dependable supply of energy. Conventional energy resources may not always be available or affordable. The price of fossil fuels will increase as supplies dwindle; nuclear power is stymied by regulation and adverse environmental effects; and hydroelectric power is available only in certain areas. The sun is a source of environmentally safe, readily available, free energy. Although solar energy cannot totally replace conventional sources, it can help lessen our dependence on nonrenewable fuels (*foreign and domestic)*, while giving us more individual independence and direct control in meeting our energy needs.

# GLOSSARY



***alcohols:*** a class of compounds containing a hydrocarbon group and one or more hydroxyl (*OH*) groups; important in many different usages, including use as clean-burning, renewable fuels.

***anaerobic digestion:*** the process by which microorganisms decompose organic material in the absence of oxygen; for example, in landfills bacteria break down wastes buried there; one product is methane.

***anemometer:*** a device that measures wind speed or force.

***bioconversion:*** the changing of materials or energy from one form to another by the action of living things.

***biomass:*** a general term for plant materials (*in any form, from algae to wood*) and animal waste materials; important as an alternative energy resource.

***biophotolysis:*** a process by which plants use light energy to break down compounds; a possible futuristic use of solar energy to produce hydrogen for use as a fuel.

***British thermal unit (Btu):*** unit measuring heat energy; the quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit.

***calorie:*** the unit of energy used to express quantities of heat; when spelled with a lower case "*c*," refers to the amount of heat needed to raise the temperature of one gram of water one degree Celsius at one atmosphere pressure; when spelled with a capital "*C*," it means 1,000 calories or one kilocalorie *(food energy content in nutrition is always expressed in Calories)*.

***convert:*** to change from one form to another; to transform.

***depletable:*** describes resources that may be used up or exhausted.

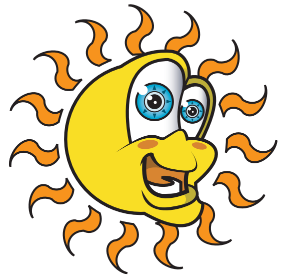
***derivative:*** something taken from another source; not original in form; an extract of something.

***digester:*** a device in which microorganisms produce methane from organic wastes.

***distill:*** to separate substances from the mixture or material in which they are found by vaporization and condensation.

***distillate:*** a liquid substance separated from another substance by vaporization and condensation.

***distillation:*** the process by which a substance is vaporized, condensed, and then collected as a liquid.



***dri-gas:*** a term for a group of manufactured products, which, when added to gasoline, claim to remove water; most of these products contain a high percentage of alcohol.

***end-use:*** the final form in which energy is used directly for work, such as heating or other purposes.

***environment:*** the physical and biological surroundings of an organism.

***ethanol:*** an alcohol having the formula $C_2H_5OH$ *(structurally* $CH_3CH_2OH$*);* formed by the fermentation or decomposition of sugars or starches; widely used in many products, alcoholic beverages, medicines, and gasohol; also known as ethyl or grain alcohol.

***feasible:*** capable of being done or carried out.

***fermentation:*** a process by which complex organic compounds are broken down into simpler compounds; especially, the production of alcohol from sugar by yeast.

***fossil fuel:*** a hydrocarbon fuel formed from the remains of ancient plants and animals; coal, oil, and/or natural gas.

***garbage:*** refuse consisting of food wastes.

***gasohol:*** a mixture of 90 percent gasoline and 10 percent ethanol.

***geothermal:*** describes heat energy from within the earth.

***grain alcohol:*** ethanol produced from the fermentation of grain.

***hydrocarbons:*** a large class of chemical compounds containing only hydrogen and carbon.

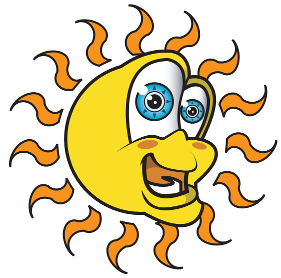
***hydroelectricity:*** electricity produced by generators powered by the energy of falling water.

***incineration:*** controlled high-temperature burning of wastes.

***intermittent:*** describes something that stops and starts again from time to time.

***landfill:*** a place where community waste is layered and buried under shallow layers of soil.

***leeward:*** describes the side of an object that is opposite the side against which the wind blows; that is, the side sheltered from the wind; see *windward*.



***liquefaction:*** a chemical process by which solid or gaseous materials are converted to liquids.

***magnetohydrodynamics (MHD):*** the study of electricity-conducting fluids in electric or magnetic fields; magnetohydrodynamic generation is a proposed technology for burning coal more cleanly and efficiently.

***methane:*** a colorless, odorless, flammable, gaseous hydrocarbon that is a product of the anaerobic decomposition of organic matter; can be burned as a fuel.

***methanol:*** an alcohol having the formula $CH_3OH$; can be formed by the destructive distillation of wood; also known as methyl or wood alcohol; used in a variety of products such as antifreeze, solvents and cleaners and fuel.

***nondepletable:*** describes resources that cannot be used up or exhausted.

***nonrenewable:*** describes resources that cannot be restored, replenished, regrown, or replaced once they are used.

***organic:*** describes chemical compounds based on the element carbon; most of the substances making up and produced by living things are organic compounds, used to mean any material from a living or once-living source.

***paraffin:*** a waxy, solid hydrocarbon mixture produced as a by-product in the refining of oil; used to make candles, lubricants, sealants, and other products.

***petrochemicals:*** chemicals derived from petroleum or natural gas.

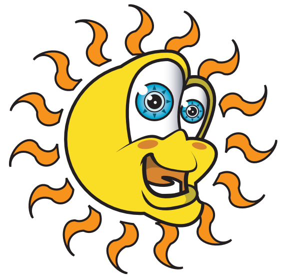
***photochemical:*** describes chemical reactions produced by the radiant energy of light.

***photoelectrolysis:*** a process using the radiant energy of light – as opposed to electrical energy – to produce a chemical change *(particularly decomposition)* in certain kinds of substances; a possible futuristic use of solar energy to produce hydrogen for use as a fuel.

***production (of energy):*** a term used to indicate the amount of fuel made available for use during a specified time.

***renewable:*** describes resources that may be restored, replenished, regrown or replaced as they are used.

***reserves:*** identified deposits of a fuel or mineral that are profitably obtainable under present conditions, using current technology, and that are likely to be so in the future.



***throw-away lifestyle:*** a way of living characterized by a high level of product consumption and discarding, especially if the products are designed for one-time usage.

***tidal power:*** electricity produced by generators powered by the regular rising and falling of ocean water levels along coastal areas.

***trash:*** a term used for wastes that do not include food wastes but may include other organic materials, such as plant trimmings.

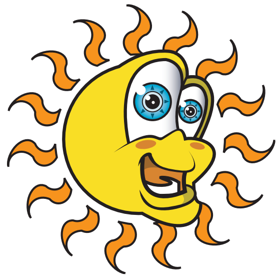
***viable:*** workable; practicable.

***waste:*** anything that is discarded, useless, or unwanted.

***wind power:*** electricity produced by generators powered by the energy of moving air.

***windward:*** of or on the side *(of an object)* that faces the wind; see *leeward*.

# EDUCATORS' WEB SITES



***Alliance to Save Energy Lesson Plans***
URL: http://www.ase.org/educators/lessons/

***Ask ERIC Lesson Plans***
URL: http://www.askeric.org/Virtual/Lessons/

***CEC Lesson Plans***
URL: http://www.col-ed.org/cur/

***Connections t-Science: Solar Energy***
URL: http://www.mcrel.org/resources/plus/science/solar.asp

***ENC: Web Links: Student/Classroom: Lesson...***
URL: http://www.enc.org/weblinks/classroom/lessonplans/science...

***Earth's Energy System***
URL: http://www.wested.org./werc/earthsystems/energy/lpenergy.html

***Education – Alternative Energy Sources***
URL: http://www.leeric.lsu.edu/educat/lesson3.htm

***Environmental Education Lesson Plans***
URL: http://tess.uis.edu/www/environmentaled/framelinks/LESSON...

***The Lesson Plans Page***
URL: http://www.lessonplanspage.com/

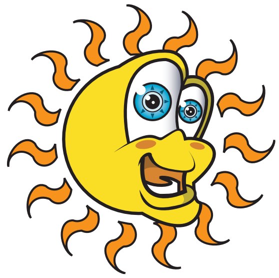
***Lesson Plans and Other Links***
URL: http://www.mcps.k12.md.us/departments/sert/lesson-plans.htm

***Oregon Solwest Renewable Energy LINKS***
URL: http://www.solwest.org/links.htm

***Pro Teacher! Physical Science lesson plans...***
URL: http://www.proteacher.com/110015.shtml

***RReDC Kidzlinks***
URL: http://rredc.nrel.gov/kidzlinks.html

***Renewable Energy Education Framework***
URL: http://www.solarnow.org/renenergyfr.htm



***Renewable Energy Lesson Plans***
URL: http://www.infinitepower.org/lessonplans.htm

***STEDII FMP Lesson Plans***
URL: http://nesen.unl.edu/stedii/fmpplans.html

***SOLAR Center Lesson Plans***
URL: http://solar-center.stanford.edu/teachers/lessons.html

***Teacher's Room***
URL: http://whyfiles.org/004antarctic/teacher4/index.html

***Using Solar Energy***
URL: http://www.eecs.umich.edu/~coalitn/sciedoutreach/funexperime...

***What Can I Do?***
URL: http://www.infinitepower.org/whatcanido.htm