Building a Parabolic Solar Water Heater

RENEWABLE ENERGY
THE INFINITE POWER OF TEXAS

FOR USE WITH FACT SHEET NO. 10: SOLAR WATER HEATERS

TEXAS ESSENTIAL KNOWLEDGE AND SKILLS

The **TEKS** utilized include: **SCI.** 6.1(B) make wise choices in...the conservation of resources; 6.4(A) record information using thermometers; 6.9(B) compare methods for transforming energy in...water heaters; 6.9(C) research and describe energy types from their source to their use and determine if the type is renewable, non-renewable, or inexhaustible; **MATH.** 6.2 (A) model...with...pictures; 6.8(B) measure temperatures; **SOC.S.** 6.7(C) describe ways...technology influences human capacity to modify the environment; 6.2 (A) give examples of scientific discoveries and technological innovations...that...have shaped the world; **L.A.** 6.10(L) represent...as in a graphic organizer; 6.13(E) summarize... making charts; 6.24(A) produce visuals.

OVERVIEW

Students will discuss the concept of a passive solar water heater system and its components. Students will study how a solar water heater functions by making a simple, passive solar model and taking temperature measurements to confirm that it works. The teacher will question why a passive solar system would be desirable, compared to one using other energy sources, such as electricity or gas. Students will discuss the advantages and disadvantages of renewable and non-renewable energy sources.

TIME FRAME

Three 45-minute periods

TEACHER GUIDE

Teaching Instructions

The teacher should read the student activity first. Before giving assignments to the students, discover their prior knowledge regarding solar water heaters by asking some questions and having pairs or small groups discuss, write, and share their thoughts. Questions could include "what do you think you would need to build a solar water heater for your home?" Students discuss why those components are necessary and how they would work. A second question regarding why a solar water heating system would benefit the environment can also be presented for discussion. Students should read Fact Sheet #10, *Solar Water Heaters*, before reading the activity instruction, as the vocabulary will be helpful. Students can be given the instructions for the activity to read and summarize the steps they will accomplish. The summary can be presented in the form of a brief chart. Sketches of what the activity components look like (from the fact sheet or other resource) will help students prepare. Appropriate safety guidelines should be reviewed.

The small amount of water used in this experiment will gain about 3 to 5°C, and upon standing several minutes will lose heat, indicating a need for an insulated storage tank in the home. Using the sun, rather than a lamp, will alter the time frame. Demonstrate proper use and care of thermometers and use of equipment. Discuss with students how they plan to create their graph and how they will label the axes.

The glossary includes words from the Fact Sheet. The terms parabola, convex, and concave should be clear to students.

Discuss the results collected and the answers to the questions. Students

have summarized, created a visual, constructed, measured, collected data and graphed, read the fact sheet, and formed opinions.

ASSESSMENT ANSWERS

Short Answer Questions

1. To maximize the amount of solar energy collected in a passive solar system you can increase the size of the solar collector, enhance the reflective surface by concentrating the rays on the tank, and insure that the position of the tank and system get optimum sunlight.
2. The parabolic curve concentrates or focuses the sun's rays on the collector, which maximizes the heat energy transferred to the water.
3. Black absorbs light because it has no color to reflect.
4. Find materials to further focus the sun's energy; insulate the collecting tank, check the sun's angle at different times of the year; use a thermal mass under and around the collector etc.
5. Some limitations are hot water storage at night, when the sun is not available (good insulation would be required); climate, such as winter in Alaska without sunlight.
6. Sunlight has no cost; oil supplies will not be depleted so fast, if solar energy is part of our energy mix; energy bills would be less; less pollution would be emitted.
7. Accept your students' answers. Passive solar energy is commonly used if south facing windows receive sunlight in winter or simply if clothes are hung outside in the sun to dry (which saves a significant amount of energy).
8. The sun's rays (through radiation) heat the air, which causes convection currents that create wind energy. The sun rays can heat water, as in a solar water heater, where the heat is trapped in a solar collector. The sun rays are used by plants to create food; plants can be used as biomass to create energy. The sun's energy is inexhaustible.

Multiple Choice Questions

1 d 2 b 3 c 4 d 5 b 6 c
7 d 8 a 9 b (best answer)

GLOSSARY

absorb – to gain energy from and reduce the intensity of light (black absorbs)

active solar water heater – a water heater that uses the sun's energy to heat water and that requires equipment such as circulating pumps, collectors, sensors and controller mechanisms

concave – curved like the inside of a circle (looks like a cereal bowl waiting to be filled)

convex – curved like the outside of a circle (looks like a cereal bowl placed upside down)

glazing – covering with glass

parabola – a curve formed where a plane intersects a cone

passive solar water heater – a water heater that uses the sun's energy to heat water and that requires no moving parts and no external energy except the sun; uses only water pressure to operate

radiation – energy transmitted in the form of waves; passage of energy through open space

reflect – to send back light radiation after striking a surface (materials or objects white in color reflect)

solar collector – a device that allows the sun's rays to heat water or other liquid (can include using glass, concentrating solar energy with parabolic shapes, using black to absorb energy, and concentrating rays with shiny reflective materials)

STUDENT ACTIVITY #10: BUILDING A PARABOLIC SOLAR WATER HEATER

Key Vocabulary

define the following terms:

absorb, active solar system, concave, convex, glazing, parabola, passive solar system, radiation, reflect, solar collector

Materials

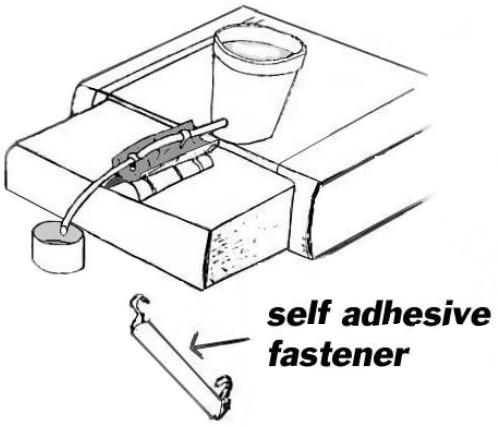
- 30 cm of aquarium tubing, painted black
- a cardboard toilet paper roll
- 1 small sheet of aluminum foil
- 1 pair scissors
- 1 self adhesive fastener for binding holed paper (any office supply store)

- 2 brass brad fasteners
- 1 gooseneck lamp with 100 watt bulb (to represent the sun) or use strong direct sunlight
- 1 styrofoam cup
- 1 collecting jar or small beaker
- 1 pencil
- goggles

Constructing the Solar Water Heater
(wear goggles)
Read through the instructions first and draw roughly what you think the result of each instruction will look like for # 2, 3, 7, 8, and 9.

1. Cut the toilet paper roll in half lengthwise.
2. Flip the tube halves over (back to back) and attach their convex sides at both ends with brass brads, so that they are now joined together.
3. Pull off the paper covering the adhesive side of the self adhesive fastener, and stick the self adhesive fastener (adhesive side down) lengthwise in the middle of one of the open cut tubes.
4. Bend the 2 prongs of the self adhesive fastener straight up and then line the inside of one cut tube with the aluminum foil, shiny side facing up (make slits to slide the foil over the prongs). This now is your parabolic collector or heater.
5. Using a pencil, twist and bend each prong to form a closed circle through which the aquarium tubing will later slide and be supported.
6. Poke a small hole in the side of the Styrofoam cup (in the lower side about one fourth inch from the bottom of the cup). (Note: The hole should allow the aquarium tubing to fit snuggly through it. Do not make the hole too big.) A pencil or other object can be used for this purpose.
7. Insert one end of the aquarium tubing into the hole in the side of the cup (should be a tight fit).
8. Place the cup on a raised flat object, so that it will be slightly higher than the shiny parabolic collector (heater). The cup now is on one level and the shiny parabolic collector is standing half a "stair" lower than the cup. A thick book or some other flat object could be used for placing the cup in a raised position.
9. Slide the free end of the aquarium tubing (which is attached on the other end to the cup) through the pronged support circles on the shiny parabolic collector (like sliding a finger through a ring). The solar collector should be placed slightly lower (another half stair down), than the cup level (a second flat book or object, thinner than the first one used for the cup, could be used).
10. Place a water collector (a small jar or beaker) slightly lower than the level of the second "stair". The table top itself could be used. Now there are three stairs or levels. The cup is the highest, the parabolic solar collector is second highest and the jar or beaker is on the lowest level.

Performing the Experiment
(wear goggles)
1. Using the set up from your construction, place the parabolic water heater (collector) so that the concave, shiny, aluminum covered side faces the light from the goose necked lamp at a distance of 3 cm. (strong direct sunlight can be used and may take longer).
2. Measure 100 ml of water in a beaker or graduated cylinder. Record the temperature of the water in the beaker or cylinder.
3. Add the 100 ml of water to the Styrofoam cup, which is standing on the top level of your set up.
4. Immediately raise or lower the position of the collection jar (which is on the lowest stair or level), so that the water flows through the black tubing of the parabolic shiny collector at a slow rate.
5. Record the temperature of the collected water in the jar or beaker during the collection process, recording the temperature every 30 seconds. Mark the reading when all of the water has flowed through the collector and no more is left in the Styrofoam cup.
6. Keep recording the temperature readings after all of the water has flowed through the solar collector for 5 minutes more.
7. Create a graph to indicate the temperature readings taken every 30 seconds. Indicate the time when all the water has flowed through the tubing.
8. Interpret the results of your graph to include what happens to the temperature during the flow of water and what happens after it has stopped flowing.



ASSESSMENT

Short Answer Questions

1. How can the amount of solar energy collected in a passive solar system be increased?
2. Why is a parabolic curve used as a collector?
3. Why is the tubing painted black?
4. How can you design a bigger and better collector?
5. What are some limitations of a solar water heater?
6. What arguments can you make for using solar energy to heat water?
7. Are you currently making use of solar energy?
8. Give examples of how solar energy works?

Multiple Choice Questions

1. A solar water heater can be:
   a) a passive system
   b) an active system
   c) a money saver
   d) answers a, b, and c

2. A solar water heater collector often is covered with:
   a) A copper sheet
   b) Tempered glass
   c) A large drain
   d) None of the answers

3. A solar water heater system must have:
   a) Wind turbines
   b) PV Cells
   c) A storage tank
   d) Gas

4. Using solar energy has value because:
   a) Solar energy does not pollute the environment
   b) Solar energy saves money
   c) Solar energy is not "used up"
   d) Answers a, b, and c

5. The color black:
   a) Reflects the wavelength of all colors
   b) Absorbs the wavelength of all colors
   c) Should be used to keep cool
   d) Is rarely used

6. Use of solar energy is demonstrated by:
   a) A passive solar water heater
   b) Clothes drying in the sun
   c) Answers a and b
   d) A gas engine

7. A solar water heater:
   a) Can heat water only 20 degrees above outdoor temperature
   b) Can heat only 5 gallons of water at a time
   c) Is best positioned facing north
   d) Can heat water to 180 degrees

8. A solar collector has the following:
   a) Dark surfaces inside
   b) A turbine
   c) Convection currents
   d) Biomass

9. As a homeowner in the future you would:
   a) Never try using a solar water heater
   b) Encourage everyone to use a solar water heater
   c) Plan to use only fossil fuels to heat water
   d) Not worry about energy resources

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Financial Acknowledgement This publication was developed as part of the Renewable Energy Demonstration Program and was funded 100% with oil overcharge funds from the Exxon settlement as provided by the Texas State Energy Conservation Office and the U.S. Department of Energy. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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