Pizza Box Solar Ovens

Students will discover two of the three basic principles of passive solar design (solar gain and insulation) working in concert with each other to accomplish a goal the kids can really relate to: making something yummy!

Grade Level : 6th

Objectives:

- Students will be able to identify the purpose of and specific requirements for making a pizza box solar oven
- Students will create their own pizza box solar ovens.

Materials:

- Pizza boxes
- Several feet of aluminum foil
- 1 sheet of black construction paper
- 2 1/2 feet of clear plastic wrap
- 4 feet of masking tape
- 2 feet of string
- Scissors (teachers or older students may also want to have and exacto knife on hand to cut cardboard with).
- Ruler
- Marker
- Student Directions Handout (found in lesson supplement folder)

Note: Avoid materials that might become toxic when heated

Time Considerations

45 minutes

Related Activities:

Nevada Department of Education Standards

- **Environmental Sciences Content Standard 16.0: Natural Resources—Students demonstrate and understand that natural resources include renewable and non-renewable materials and energy. All organisms, including human, use resources to maintain and improve their existence, and the use of resources can have positive and negative consequences.**
- **Environmental Content Standard 17.0: Conservation—Students understand that humans have the unique ability to change personal and societal behavior based on ethical considerations regarding other organisms, the planet as a whole and future generations.**

Excellence in Environmental Education Guidelines

- **Strand 2.1—The Earth as a Physical System (A, B, C): Learns are able to: identify changes and differences in the physical environment; identify basic characteristics of and changes in matter; become familiar with the basic behavior of some different forms of energy.**
- **Strand 2.2—The Living Environment (D): Learners know that living things need some source of energy to live and grow.**

Background

The simplest pizza box solar oven design, as given below, can get up to two hundred degrees Fahrenheit on a *warm* sunny day…warm enough, for example, to make s'mores (graham cracker sandwiches of chocolate chips and marshmallows). Several optional features will enable the oven to get even hotter, which may be desirable in cooler weather, or for more serious cooking. One should allow ample time for cooking - roughly twice as long as would take in a conventional oven. For s'mores, it works best to leave the sandwiches open while cooking so that direct sunlight falls on the marshmallows and chocolate chips. We do not recommend trying to use the oven outside in temperatures below about 60 degrees Fahrenheit. If it's cool outside, try a sunny window sill. Many pizza shop owners will be more than willing to donate boxes. In return, you may want

to ask a local reporter to cover the event, and ask the reporter to specifically mention the pizza shop's donation in any news article that appears.

Preparations

Have students close their eyes and imagine the hottest summer day. Have students describe how that day felt. Ask students if they have ever heard the expression “hot enough to fry an egg on the sidewalk.” Ask a student to explain what that idiom means. Although, that is just a silly expression to describe summer heat, there is some truth to it: if it were hot enough outside, one could fry an egg on the sidewalk. How would that be possible? Direct the discussion to the idea that the sun is an energy source, known as solar energy. Tap into students’ prior knowledge by asking them what they know about solar energy. What are the advantages of using solar energy? What are the disadvantages? Tell students that they will have the opportunity to experiment with solar energy by building pizza box solar ovens.

Doing the Activity

The ovens that the students will be making utilize the concept of passive solar design. Passive solar design refers to the use of the sun's energy for the heating and cooling of living spaces. Two main principles of passive solar design that are demonstrated by the pizza box solar ovens are solar gain and insulation. Explain these two concepts using the definitions below:

- **Solar Gain** - arranging for sunlight to enter a device as a source of energy. In this case, the gain is accomplished both by reflection and direct gain. This principle also includes using dark colored surfaces to absorb the solar energy that enters a device.
- **Insulation** - containing heat by trapping air inside and around a device to contain heat, and reflecting thermal radiation back into a device.

The third principle of passive solar

design, thermal mass, can also be experimented with the solar oven. Thermal mass is material that stores energy. The thermal storage capacity of a material is a measure of the material's ability to absorb and store heat. Large amounts of food will provide some thermal mass, therefore, causing the oven to heat up more slowly. Before building the ovens, describe the materials given and explain the purpose of each item. Follow the steps (below) to construct pizza box solar ovens.

In the process of building and using the ovens, here are several other points you might want to make:

- Cooking food takes a lot of energy! By using solar energy, we can save a lot of fuel.
- Cooking takes time, and the sun will change position during that time. Therefore, a vigilant cook may need to align the solar oven now and then to keep the oven in direct sunlight. Mechanisms that track the sun and adjust the device automatically are called "heliostats" (like thermostat but with *helio*, which means *sun*, instead).
- Without the reflector flap, the solar oven becomes what is called a "flat plate collector." Flat plate collectors are used for many applications, such as heating water. The reason for not using a reflector is that it is not really needed for these applications, and thus, alignment difficulties associated with reflectors can be avoided.

Solar ovens have been used for a long time. One of the first known uses of solar hot boxes was by the cooks of the Roman Emperor Tiberius who wanted to eat cucumbers all year round. The cooks satisfied his regal appetite by using a solar hot box, a kind of flat plate collector, to grow the cucumbers all winter long! In the 1830s, the British astronomer John Herschel used a solar collector box to cook food during an expedition to Africa. The earliest pizza box solar oven design we are aware of was created in 1976 by Barbara Kerr. Nowadays, one can buy commercial solar ovens, ranging from small single dish units, to large units that can feed many people at once and that have to be hauled around on a trailer. Also, many people use flat plate collectors to heat water for their pools and houses.

After making and testing the solar ovens, ask students the following questions: Describe the steps to make a pizza box solar oven. How did you use the sun to cook food? What was the best angle or position for generating heat in your oven? How well did your oven work? How could you make your solar oven better? What are some advantages of using sunlight as an energy source to cook your food compared to other sources, such as coal? What are some disadvantages? Besides cooking food, how else could you use solar energy in your home?

Pizza Box Solar Oven Instructions:

1. Assemble the pizza box and open it up.
2. Glue aluminum foil to all *inside* surfaces of the sides except the top of the box, with the shiny surface facing *in.* This will create a "radiation trap" that will trap, by reflection, invisible (low-frequency) radiation that is given off by the food and air inside the box.
3. On the top flap of the pizza

box draw a square with edges spaced 1" from the four sides of the box (use a marker to make the square).
4. Cut along *three* of the lines, on the sides and on the front edge of the box, **leaving the fourth line along the box's hinge uncut.** Then fold open the flap, making a crease on the fourth line (see the figure below). Note: Extra supervision may be needed during this step, because students often cut along the fourth line as well by mistake.
5. Glue aluminum foil to the inside surface of the top flap, **with shiny side visible!** This will form a reflector, to reflect sunlight into the oven. Be careful to make as few wrinkles as possible and smooth out whatever wrinkles occur.
6. Tape the black construction paper to the bottom of the box. This will help to absorb the incoming sunlight.
7. Carefully stretch the plastic wrap over the opening of the box, sealing the edges with tape to seal the air in.
8. Cover any air leaks around the box edges with tape, making sure

that the box can still be opened (so that you can place food inside the box and remove it later).
9. Go outside in the sunlight and place oven on a flat, level surface.
10. Place food on some foil (or a paper plate) and place inside the oven.
11. Use string and masking tape to tie back and adjust the reflector, so that sunlight is reflected into the oven, and especially onto the pie tin.
12. Let food cook, and check reflector angle now and then to make sure sunlight is getting inside the oven.

Enjoy your solar treat!

Evaluation—

Informally assess students' knowledge of and ability to create pizza box solar ovens by observing their contributions to class discussion and by observing them as they construct their solar ovens. A formal evaluation could be given to students using the discussion questions found in the conclusion above.

Extension—

- Add additional flaps to reflect sunlight into the oven. This can substantially increase the gain of the oven. This will require some extra cardboard (from some old boxes, for example) and extra foil, glue, and string to adjust the flaps.
- Crumple up some sheets of newspaper and stuff them around the inside of the box to provide extra insulation.
- Add an additional layer of saran wrap across the box opening attaching it to the inside surface of the top flap, such that an air space is created between the layers of wrap (the plastic is bound to stick together in some places: don't worry about this too much). Place a thermometer inside the oven to measure the temperature.

Vocabulary

Solar Gain - arranging for sunlight to enter a device as a source of energy. In this case, the gain is accomplished both by reflection and direct gain. This principle also includes using dark colored surfaces to absorb the solar energy that enters a device.

Insulation - containing heat by trapping air inside and around a device to contain heat, and reflecting thermal radiation back into a device.

Solar Energy: The energy received by the earth from the sun. This energy is in the form of solar radiation.

Thermal Mass: Material that stores energy.

Sources—

http://en.wikipedia.org/wiki/Solar_oven