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WHAT'S COOKING WITH SOLAR?

SCHOOLGEN ACTIVITIES **LEVELS 5-6**

Facilitator/Student Resource

This activity investigates solar energy and how it can be harnessed as a source of power for heating (in this case the heating of food). The activity implicitly involves heat transfer processes, energy transformation, insulation, reflection and absorption, and provides a practical context to make these concepts explicit.

WHAT'S COOKING WITH SOLAR?

TEACHER NOTES

Rationale for the Activity

The activity enables students to see how scientific concepts are applied in the design and construction of effective technologies, and therefore to better understand the concepts.

The scientific concepts that are implicit in the design (and that may need to be covered before and after this activity) are:

- Heat transfer processes (radiation, conduction and convection).
- Physical properties of materials that mediate heat transfer (reflection, transmission and absorption of light, thermal conductivity, solid/gas).
- Energy transformation, Particle theory of matter.

New Zealand Curriculum Links

Science - Physical World

Level 5

Physical inquiry and physics concepts*: identify and describe the patterns in physical phenomena found in simple everyday situations involving…* ***light, waves and heat****.*

Using Physics*: Explore a technological … application of physics.*

Level 6

Using Physics*: Investigate how physics knowledge is used in a technological application.*

Nature of Science:

Investigating in Science

Principles:

Future Focus (exploring future focused issues such as sustainability).

Coherence (makes links, provides for coherent transitions and opens up pathways to further learning).

Intended learning outcomes (students will …)

- Construct and test a basic solar energy collector.
- Identify and describe the key science behind the oven's design:
    - Conduction (of heat energy from the surrounding materials inside the oven to the food).
    - Convection (of heat energy from the convecting air trapped inside the oven.)
    - Radiation (of heat energy from the sun to the food via the reflective foil, from the oven/food to the cooler surroundings)
    - Reflection (of radiant energy by the reflective metal foil)
    - Transmission (of radiant energy by the plastic film)
    - Absorption (of the sun-light's energy by the black paper/card)
    - Low conductivity (insulation by the paper etc)
    - High conductivity (of heat by the metal foil)

Pre-activity focus

- How can we collect solar energy to heat houses and buildings etc?
- Brainstorm the materials required to construct a solar oven to heat food.
- Discuss the properties of those materials chosen and why they might work.

Managing the activity

- Divide the class into teams of three.
- Provide each group with the diagram, instructions, materials, and equipment to make a solar oven.
- Allow the students 10 minutes planning time before assembling the solar oven.
- Check the students are clear about the purpose of the activity and their roles. Allow plenty of time to build and test models (2 - 3 hours total).

Post-activity class discussion

- How was the food heated?
- What happened to the food (chemical/physical changes)?
- What are the main features of an efficient solar energy collector?
- What things could you do to enhance the effectiveness of your solar collector?

- Identify and describe the main physical phenomena involved (reflection, transmission, absorption, conduction, convection, radiation).

Materials used in oven	*Function performed?*	*Heat transfer process maximised*	*Heat transfer process minimised*
Foil (on flap)	Reflection	Radiation (of solar spectrum)	
Plastic film (window)	Transmission	Radiation	
Air trapped between double layer of film	Insulation		Convection
Black card	Absorption (very low reflection)		Radiation (of visible solar spectrum)
Rolled paper (includes air gaps) & bubble wrap	Insulation		Conduction (+ convection)
Foil lining	Reflection	Radiation of infrared (back into the box)	Radiation of infrared (out of the box)
Cardboard box	Insulation		Conduction

Reflecting on the Activity

- What did this activity tell you about how solar energy can be used?
- Is there anything you might change to improve the oven and why?
- What other applications are there for solar energy that don't involve cooking?

Possible Questions

1. State which material/s are poor conductors (good insulator)s.
2. State which material is both a good conductor and a reflector.
3. Identify and describe a design feature which minimises heat loss by conduction.
4. Identify which design feature minimises heat loss by radiation.
5. Identify a design feature that minimises heat loss by convection.
6. Explain why the black plate becomes hot.
7. Explain using the particle model why the rolled paper reduces heat loss.

Extension

- Use a thermometer or temperature sensor and data logger to record the increase in temperature over time inside the solar oven.
- Find the maximum/minimum temperature inside the oven and locate areas of heat loss with an infrared thermometer.
- Investigate how the optimum angle of the reflector flap relates to the angle of the sun.
- Provide the students with the opportunity to redesign their solar energy collector or build a different design. Does the redesigned/new solar energy collector work better? Explain why it works better than before.
- How could the solar oven be modified to become a solar water heater? Students could be provided with plastic tubing and black paint. Use convection or possibly a small pump to circulate water through the water heater and into an insulated storage 'tank'
- How does the design features of the solar oven compare to those of an energy efficient house? (windows with double glazing, internal absorbers, thermal mass, insulation, radiant barriers).

Supporting Resources

- Solar ovens can be used in developing countries to reduce the need for collecting and burning scarce wood resources, improving safety and the environment and reducing time, effort and money (for fuel). Find out more at: http://www.solarcookers.org/
- A short video clip from National Geographic showing the use of solar ovens in developing countries http://solarcooking.wikia.com/wiki/Solar_Cookers_International
- Plans for building a simple but powerful solar oven can be found here: http://solarcooking.wikia.com/wiki/Cookit
- Parabolic solar collector – A curved mirror can be used to concentrate radiant energy. This project uses a curved mirror to demonstrate and investigate a method for focusing solar energy. http://hilaroad.com/camp/projects/solar_energy/Hila_Solar_Energy.html
- Building a Parabolic Solar Water Heater: An activity that shows students how to make a solar water heater and explores renewable and non-renewable energy. http://www.infinitepower.org/pdf/10-Lesson-Plan.pdf
- Solar thermal power station use concentrated solar rays to turn water into steam and power a generator: http://news.bbc.co.uk/2/hi/science/nature/6616651.stm http://www.largescalesolar.org/technology.php
- Energy efficient homes and buildings use heat transfer to their advantage in many similar ways to solar ovens. As a result they are more healthy, comfortable and cost-effective. Students could identify what type/s of heat transfer is present in each of the building design features shown in this high quality info-graphic (Adobe Flash) at http://www.righthouse.co.nz/.
- A really good educational website on solar ovens, and renewable energy in general, can be found at **Green Learning Canada**. http://www.re-energy.ca/solar-oven There are links to many designs of solar oven to explore and build.

WHAT'S COOKING WITH SOLAR? *STUDENT ACTIVITY SHEET*

Aim

To make a simple solar powered oven that effectively heats food and to understand how the scientific concepts of conduction, convection, radiation are used.

Equipment

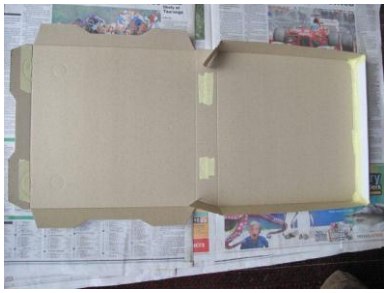
- pizza box
- aluminium foil (about 70 cm of roll)
- black paper/card/surface
- clear plastic wrap (about 60 cm total)
- newspapers (3 sections of ~10 pages each)
- bubble wrap (optional)
- tape (masking and/or sellotape)
- glue
- scissors and/or craft-knife
- A4 paper x 2
- pencil/pen
- ruler
- protractor and blu-tak
- Optional: food to heat/cook (with low moisture content is better)

Method for Building a Pizza Box Solar Oven

Seal up air gaps

1. Tape over any holes or perforations in the pizza box.

This will reduce the ability of hot air to escape and cool air to enter (through convection).



Create Reflection Surfaces (inner and outer)

2. Spread the aluminium foil <u>shiniest side up</u> from the bottom to the end of the box. *The aluminium foil will reflect more solar energy into the box as well as reducing heat loss through radiation of infra-red light.*

3. Put some glue (spray glue is useful) on the bottom of the box at one end and then smooth the foil carefully onto the cardboard.

4. Lift up the rest of the foil and spray/paste some glue onto the cardboard. Carefully <u>smooth</u> the foil down onto the cardboard. Trim any excess foil and fold the top of the box back down.

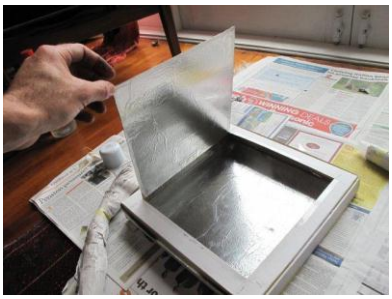
You have now created a radiation reflector! 1) Solar energy hitting the reflector flap will be reflected into the box. 2) Heated objects inside the oven generate invisible infra-red radiation. The foil lining inside the box reflects this infrared back into the box stopping it passing out through the bottom of the oven. This reduces energy transfer out of the box by radiation.

Create Reflection Flap

5. On the lid of the pizza box, use a ruler to measure 3 cm in from each edge and draw lines to make a square (it should be parallel to the sides).

6. Cut along 3 of the lines with a craft knife or scissors. Don't cut the line nearest the hinge of the box as this is where you fold it to make a flap.

7. Gently fold the flap back along the uncut edge to form a crease (to make it easier to fold you might like to very slightly score the surface of the cardboard first).



Create Wall Insulation

8. Open the box and roll up some newspaper tightly (a section of the newspaper with about 10 pages is good). It should be about 3 cm in diameter. Tape the ends of the roll. Make 3 rolls. *The layers of newspaper provide insulation, which reduces the rate of heat transfer out of the walls through conduction.*

9.

Fit the newspaper around the inside edges of the box. Tape the newspaper to the bottom of the box, not the lid or to the sides (or you won't be able to close the lid properly).

Create Radiant Barrier with air-gap

10. Cut out a square of bubble wrap and place it in the box. *The bubble wrap is a good insulator. One function of the bubble wrap is to separate the hot black absorber from the metal foil which otherwise might increase conduction through the bottom of the box. In buildings there should be an air gap between the building foil and the internal surfaces. This is because metal is a good thermal conductor as well as a good reflector.*

Create Absorber Plate (Solar Collector)

11. Place the black paper/card on top of the bubble wrap (or paper) the inside of the box. *This will absorb the solar radiation energy and transform it into heat energy (vibration of particles).*

Create Double-Glazed Window

12. Cut two 30 cm long pieces of plastic wrap. Tape one piece of plastic wrap to the underside of the flap opening by its 4 corners. Adjust the plastic film so that is tight and smooth and well centered over the window. Tape the 4 sides to seal it against the cardboard.

13. Close the box and place two sheets of A4 paper over the plastic film window. This will stop the next layer immediately sticking to it.

14. Do the same as you did with the first layer. Remove the paper before you seal the final edge. *This creates a thin layer of air, like double glazing, which acts as insulation to slow down the heat loss from inside the oven.*

15. To adjust the angle of the solar reflector so that it reflects as much light as possible into the oven you can use a piece of masking tape attached to the back of the box. Alternatively use a ruler and string, blu-tak etc.

Instructions for Testing a Pizza Box Solar Oven

1. On a sunny day, carry the box outside with your food
2. Find a sunny spot. If it's cold outside, place a towel or blanket under the box so the underneath doesn't get cold.

3. Open the box, place the food to be heated in the centre (a small square of cooking paper underneath keeps the oven clean), and close the box.
4. Open the reflector and turn the box so that it is directly facing the sun.
5. Adjust the angle of the reflector so that sunlight optimally reflects into the box.

6. Expect heating time to take about twice as long as conventional methods and allow about 20 -30 minutes to cook.
7. Foods with a lot of moisture content may fog up the window with condensation, so either use low moisture foods or put the food in a sealed plastic bag.

Science of the Solar Oven

Complete Table 1 and 2 to show the key scientific design features of a solar oven.

Table 1

Material	*Function*	*Heat transfer process used*	*Heat transfer process prevented*
Foil (on flap)			
Plastic film (window)			
Black card			
Rolled paper			
Foil (backing)			
Air trapped between plastic film			
Cardboard box			

Table 2

Material	***Explanation of how it works*** *(see Method notes for clues)*
Foil (on flap)	
Plastic film (window)	
Black card	
Rolled paper	
Foil (backing)	
Air trapped between plastic film	
Cardboard box	