Solar Schools
for British Columbia

A collection of lessons to assist teachers and students with their exploration of solar energy

SolarBC
Join the Solar Revolution

Acknowledgements

Author
Marnie Olson Engaging Minds Consulting

Contributing Authors
Deb Calderon Calderon Consulting
Susanna Solecki Teacher, WildBC Facilitator
Johan Stroman GreenLearning BC
Keri Laughlin

Editors
Tammy Keetch Education Consultant
Susanna Solecki Teacher, WildBC Facilitator
Kerrie Mortin Coordinator, WildBC
Peter Ballin WildBC Facilitator

Graphic Design
Kristine Webber + Alison Garrad
Earthwise|Design

Publishers
SolarBC
WildBC

Other Contributors
Students
Helen Hunter-Perkins former Oak Bay Secondary student

Teachers and School District Administrators
Terry Argotow Como Lake Middle School, SD#43
Darlene Braeder SD #39
Deb Calderon Calderon Consulting
David Derpak SD #39
Joanne Dueck Tremblay Elementary, SD #59
Danyell Dutka McLeod Elementary, SD #59
Beno Fodor South Peace Secondary, SD #59
Lindsey Foell Charles Tupper Secondary, SD#39
Laura Lyn Helton Colquitz Middle School, SD#61
Jennifer Hong Admirals Seymour Elementary, SD#39
Terry Howe King George Secondary, SD #39
Vicky Hughs King George Secondary, SD #39
Vicki McCarthy SD #39
Timothy George Mcgeer SD #39
Kevin Millsop Sustainability Coordinator, Vancouver School Board
Robert Mouro SD #39
Kelly Nordin WildBC Facilitator
Ellen Perkins SD# 61
Tristesse Seeliger Eric Hamber, SD #39
Robert Schindel SD #39
Shannon Sorochan King George Secondary, SD #39
Maria Teresa Taddei SD #39

Community Partners
Darla Simpson Destination Conservation
Johan Stroman GreenLearning BC

Engineers & Scientists
Rob Barry Island Energy
Simon Boone Generation Solar
Dave Egles HES Home Energy Solutions
Susan Huber Swiss Solar Tech Ltd.
Morgan MacDonald, Patrick Spearing Thermomax
John Stonier Day4Energy

Sponsor
Nitya Harris Executive Director, SolarBC
Julia Roberts Assistant to Executive Director, SolarBC

SolarBC Join the Solar Revolution
BC Sustainable Energy Association
WildBC
Habitat Conservation Trust Foundation
British Columbia The Best Place on Earth

For more information contact: wildbc@hctf.ca #107-19 Dallas Road, Victoria BC V8V 5A6

Cooking with solar

Build your own solar oven

What will happen

Students will identify how solar energy is used to generate thermal energy by building and will experiment with different solar ovens to understand factors that affect their efficiency.

Students will

- Know that solar collectors collect the sun's energy to create thermal or heat energy;
- Know that sunlight is reflected, transmitted and absorbed;
- Construct and experiment with 2 different types of solar cookers;
- Evaluate factors the affect the efficiency of a solar cooker.

Total Time 1½ - 2½ hours	Establish what students know	Activity - Part A	Activity - Part B	Debrief what students learned
	10 - 20 minutes	60 minutes	10 - 20 minutes	10 - 20 minutes

What you need to know

There are many solar cooking recipes but the easiest and simplest things to bake are s'mores. To experiment further, try cooking with different recipes to observe the different amounts of time and heat needed to cook with a solar oven. A quick online search will bring up a variety of solar oven recipes such as mini pizzas, cookies, bread, nachos, etc.

You may simplify this lesson by building only the pizza box oven.

The other building instructions are for a parabolic solar oven. A parabola is defined as a set of points that are the same distance from both a point (called the focus) and a straight line (called the directrix).
http://www.intmath.com/Plane-analytic-geometry/4_Parabola.php#formula

What might surprise you

- Solar cells produce 9-17 times more energy than is needed to make them.
  Source: Siemens Solar
- Canada's first major solar electricity plant is a 40MW facility in Sarnia, Ontario. This is enough power for about 10,000 homes.
- Solar collectors can be placed on buildings and over parking lots without conflicting with other land uses.
- Over half the world's population uses wood or animal dung to fuel their cooking stoves. Solar ovens provide a clean safe way to cook food and purify water. They also free people of the burden of collecting, or using their limited resources to purchase fuel.
- Every year, almost 2 billion tonnes of wood are burned in cooking fires.

WildBC

SolarBC
Join the Solar Revolution

What you need

General supplies

- Smore's Ingredients: chocolate, marshmallows and graham crackers
- Different types of containers for cooking food (i.e. food safe items like glass and ceramic dishes; aluminum or metal cookie sheets)

Pizza box oven	Parabolic oven
• one pizza box per group (most pizzerias will supply for free or minimal cost) • oven bags (1 bag will provide windows for about 4 pizza boxes) • black paper • newspaper • aluminum foil • scissors, x-acto knife, or box cutter • double-sided tape • one thermometer per group	• one long narrow cardboard box per group (ex. shoe box) • aluminum foil • poster board • markers • scissors, x-acto knife or box cutter • tape • non-toxic glue • one paint-free coat hanger or food safe skewer per group • oven thermometer per group

Establish what students know

- With student input, review how an oven works.
- Tell students that they will be making a solar oven. Ask them to suggest how they would go about collecting the sun's energy into a pizza box. Then, ask them to suggest how they would collect the sun's energy into an open box.
- Tell the students that the class will make two types of solar ovens to explore some of the principles of solar heating with an emphasis on how to concentrate thermal solar efficiency.
- Remind students that solar thermal energy is a form of energy in which the sun is used to produce heat. This should not be confused with solar voltaic power, in which the sun's light is used to produce electrical energy.
- Ensure that students know how to make s'mores.

Main Activity

What you do

Part A

1. Form small groups and assign some to construct parabolic solar cookers and others to make pizza box cookers as per instructions provided.
2. Provide each group with the ingredients to cook s'mores.
3. As the s'mores are cooking have students record their observations.
   - measure the temperature of the cooker
   - measure the outside temperature
   - describe the atmospheric conditions such as cloud cover and wind speed

Part B

1. Have students summarize their results and make a graph to illustrate the temperature changes over time.
2. Compare results between the different cookers.

Debrief what students learned

As a class, discuss the solar cooking experiment

- What would happen if you changed the type of cooking tray the food is on?
- How might you alter the arrangement of ingredients to change the speed that the chocolate melted or the marshmallow softened?
- How could you make the ovens get hotter and hold heat longer?
- How would you insulate the oven?
- How could the sun's rays be directed more efficiently towards the box?
- How does your solar oven compare to how a building is affected by the sun?
- Solar ovens are an example of solar thermal energy. What does this tell you about how solar thermal energy works?
- How might greenhouse gas emissions be affected if a solar oven is used instead of burning wood on an open fire or operating an electric oven?

Assessment

- Have students explain how they were able to cook using the sun.
- Have students describe how to optimize the sun's energy when constructing a solar oven.
- Have students record and present observations from their solar cooking experiments. This could be done in the form of a poster or cartoon strip.
- Have students identify factors that affect the efficiency of a solar cooker.

Extensions

- Enter the Canadian Solar Oven Challenge. http://www.re-energy.ca/whatisnew.shtml
- Hot rocks. Experiment with stones and insulating materials to begin an exploration of best practices for designing and building a solar-savvy home or other building. http://www.sunwindsolar.com/a_lessons/stone.html
- Survivor Student. How would you choose to cook with the sun? Study the pros and cons of various designs and select one to improve upon or design one to cook for a particular application or situation of your choosing. Submit your design online. http://solarcooking.wikia.com/wiki/Category:Solar_cooker_plans
- Over 130 designs for inspiration are posted at http://solarcooking.wikia.com/wiki/Category:Solar_cooker_designs
- Stir up a solar recipe event. Attract crowds of people curious to learn what you know about solar energy by demonstrating tasty recipes. Raise knowledge and funds for solar cookers to be distributed around the world. Show how that benefits people and places where desertification has eliminated wood as a fuel for cooking. Turn this into a celebration for Solar Days. http://www.solarbc.ca/learn/200-solar-days

Check out

Links

- Find the basic principles that are used in the design of solar box cookers summed up here. http://solarcooking.org/sbcdes.htm
- 60 major designs, 69 variations and over 100 drawings of solar cookers can be found at http://www.solcooker.net/Cindex.htm
- The Solar Cooking Archive - a great starting point for lesson planning or for student exploration. http://solarcooking.org/default.htm
- Panel cooker design and rationale http://solarcooking.wikia.com/wiki/Cookit
- Student-posted solar cooking results http://pbskids.org/zoom/activities/sci/solarcookers.html
- Why cook solar? http://solarcookers.org/basics/why.html
- Make a sun path chart for your school (University of Oregon's Solar Radiation Monitoring Laboratory) http://solardat.uoregon.edu/SunChartProgram.html
- Concentrating solar energy (CSP) http://www1.eere.energy.gov/solar/csp_program.html

Variations On Oven Instructions

- parabolic http://sci-toys.com/scitoys/scitoys/light/solar_hotdog_cooker.html
- pizza box http://www.reachoutmichigan.org/funexperiments/agesubject/lessons/other/solar.html
- panel http://www.re-energy.ca/t_solarheat.shtml

Video

- Solar Schoolhouse Pizza Box Cooker: Step-by-step guide http://video.google.com/videoplay?docid=5882947445845337205#
- Background on solar cooking around the world and types of solar cookers from http://solarcooking.org/media/presentations/voa_files/default.htm

Simulator

- Explore 27 different solar cookers by selecting different combinations of components http://www.pspb.org/e21/media/SolarCooker.swf

Case Studies

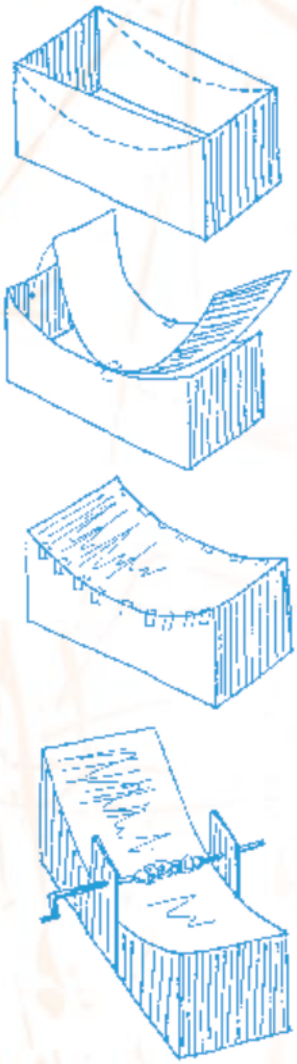
- Information and links to leaflets, slide shows and other information resources about clean power from deserts, concentrating solar energy (CSP) and the DESERTEC ideas. http://www.trec-uk.org.uk/resources.htm

  National Renewable Energy Lab's Research &Development projects in concentrating solar energy focus on parabolic trough solar technology and advanced concentrating solar energy technologies. http://www.nrel.gov/csp/projects.html

student worksheet

How to make a Parabolic Cooker

Instructions



1. Select a long narrow box; the longer the box the more heat collection is possible
2. Choose a focal length between 12 and 24 cm and design a parabolic curve as seen in the picture. Trace the curve on the open end of the box so that it is centered and straight. The bottom of the parabola is called the vertex. The vertex is always halfway between the focus and the directrix.
3. Cut out the curve with a utility knife. **It is important to be exact.**
4. Measure and cut a piece of poster board that will fit flush against the opening to the box. Attach this with tape beginning at the center and working toward to edges.
5. Cover the curve with white glue and apply aluminum foil shiny side out. Start in the middle and smooth toward the edges. **Try not to wrinkle or fold the foil;** you want it as smooth as possible.
6. Use two scraps of cardboard taped to each side as supports. Using the sun or a projector light, test the focal point. There should be a bright spot where light is concentrated; mark this spot and punch a hole for the skewer. Use a section of a coat hanger from which the paint has been removed for a skewer.
7. Prepare the food twice. Place one on the skewer and the other one outside the oven on a flat piece of aluminum foil in the sun. This is the 'control.'
8. Predict how long you think your oven will take to cook the food. Record your observations as the item cooks. Measure the temperature of the food over time and the outside temperature, along with wind and cloud cover conditions.
9. The skewer should be turned every couple minutes to prevent black lines from being burned into the food. Note the time when the food is cooked.

Did you Know? A square meter of the earth's surface gets about 1000 watts of power from sunlight. How many square metres of reflective surface is your cooker? Calculate the equivalent number of watts for your solar cooker.

What you need

- ❑ long narrow cardboard box
- ❑ poster board
- ❑ aluminum foil
- ❑ marker
- ❑ x-acto knife
- ❑ tape
- ❑ non-toxic glue
- ❑ paint-free coat hanger or food safe skewer
- ❑ ingredients for what you're cooking
- ❑ oven thermometer

Adapted from:
http://www.energyquest.ca.gov/projects/solardogs.html

student worksheet

How to make a Pizza Box Oven

Instructions

1. Draw a 2.5 cm border on all four sides of the top of the pizza box. Leave the line along the back of the box uncut, and cut along the other three sides (Diagram 1).
2. Gently fold along the uncut line to form a crease and cut a piece of aluminum foil to fit on the underside of the flap. Smooth out any wrinkles and glue into place, (Diagram 2).
3. Measure a piece of plastic from oven bag to create a window. **The plastic should be cut larger than the opening** so that it can be taped to the underside of the box top. Be sure the plastic is tightly sealed.
4. Cut another piece of aluminum foil to line the bottom of the pizza box shiny side out and secure into place with glue or tape.
5. Cover the aluminum foil on the bottom of the oven with a piece of black construction paper and tape into place. (Diagram 3)
6. Assemble the recipe ingredients twice. Place one on a cooking dish and then, onto the black paper. Place the other one outside the oven on the same type of dish. This is the 'control.'
7. Close the pizza box. Your oven is ready to cook.
8. Open the flap and adjust it to reflect the most sunlight through the window and into the oven, (Diagram 4). Cut a straw and secure it to hold the lid at that angle.
9. Predict how long you think your oven will take to cook. Record your observations as the item cooks. Measure the oven temperature over time and the outside temperature, along with wind and cloud cover conditions.
10. Roll up a tube of newspaper that's long enough to wrap around all four inside edges of the oven.
11. Repeat the experiment.

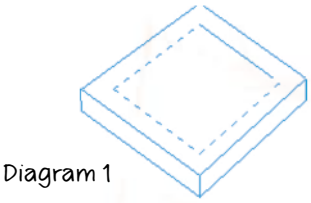


Diagram 1

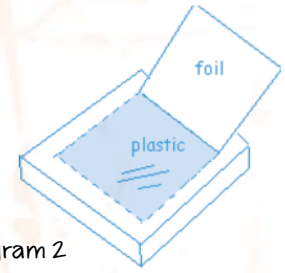


Diagram 2

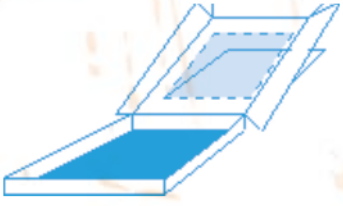


Diagram 3

Diagram 4

What you need

- ❑ pizza box
- ❑ oven bag
- ❑ black paper
- ❑ newspaper
- ❑ ruler
- ❑ marker
- ❑ scissors
- ❑ straw
- ❑ double-sided tape
- ❑ non-toxic glue
- ❑ ingredients for what you're cooking
- ❑ thermometer

Adapted from:
http://www.solarnow.org/printpizzabx.htm