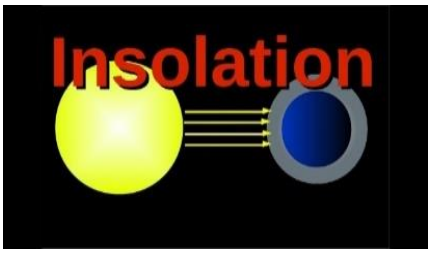
Full STEM Ahead Long Island: Energy

Resources for Your Classroom

Video: *Energy* https://www.youtube.com/watch?v=W1a0IkWfg-w&feature=youtu.be



https://i.ytimg.com/vi/J--HBqLLnFg/maxresdefault.jpg

Background: Sunlight takes about 8.3 minutes to reach Earth from the surface of the Sun. In a single **hour**, the amount of power from the sun that strikes the Earth is more than the entire **world** consumes in a year.

At any moment, the sun emits about 3.86×10^{26} watts of energy. Add 24 zeros to the end of that number, and you'll get an idea of how unimaginably large that amount of energy is!

Our solar technologies are still new and increasing in efficiency all the time. So how much power **we can get** from the sun is one thing, but how much power **is available** from the sun is another.

Most of that energy goes off into space, but about 1.74×10^{17} watts strikes the earth. (or 174,000,000,000,000,000, or 174 quadrillion watts).

If there are no clouds in the way, then one square meter of the earth will receive about one kilowatt of that energy. For the six hours in the middle of a sunny day, an area the size of a small backyard swimming pool (48 m^2) will receive about 288 kilowatts of energy. That's nearly 10 times what the average US household uses in an entire day! In the United States, the average daily electricity use is around 30 kilowatt hours per household.

Even on an overcast day, that same area will receive about 28 kilowatts of energy in the same six hour period. And best of all, solar power is extremely clean, with zero greenhouse gas emissions.

Solar energy is harnessed using a range of ever-evolving technologies such as photovoltaics, molten salt power plants, solar heating, and solar cooking.

Careers in energy include engineering (electrical, mechanical, computer, systems, project, materials, and industrial manufacturing), finance, customer service professional, information technician, lineman, education, public relations, government, research, and many more.

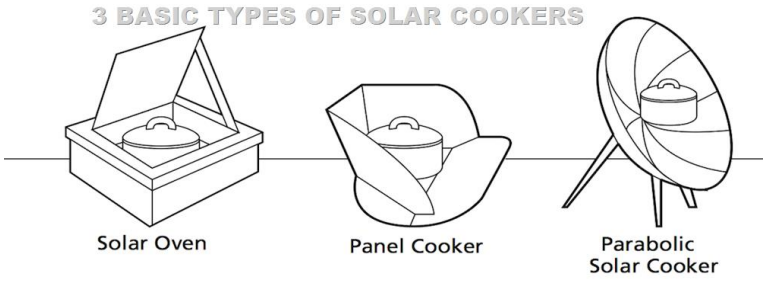
Learning Objective: To build a solar powered oven using everyday materials. **[SAFETY: Use caution as contents of solar ovens may get hot. See details in procedure below.]**

Vocabulary: Conduction, Convection, Radiation, Emissivity, Insolation, Insulation, Renewable, Nonrenewable, Watt, Thermal Conductivity

Introduction

WHAT IS A SOLAR OVEN AND HOW DOES IT WORK?

Before solar panels were used to harness the sun's energy for electricity, people used the sun's energy to cook.

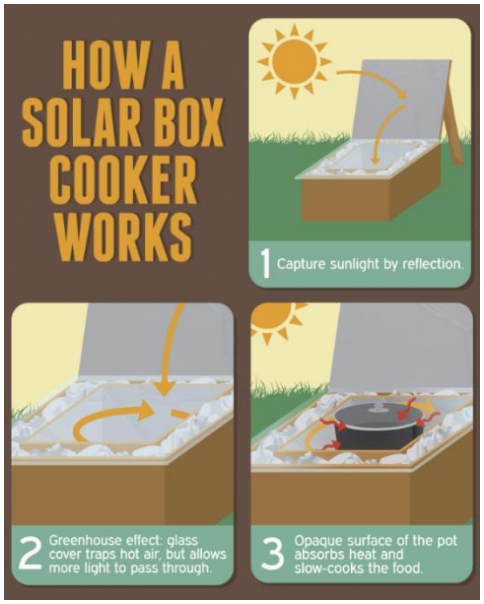


Source: https://throughtheluminarylens.files.wordpress.com/2016/04/solar_cooker_illustrations_thumb.png?w=1000&h=391

Solar ovens are sunlight powered heating units made to warm up and bake foods. They are a low-cost, ecologically friendly technology. There are lots of different designs of solar cookers! Each suited for different conditions and using different materials.

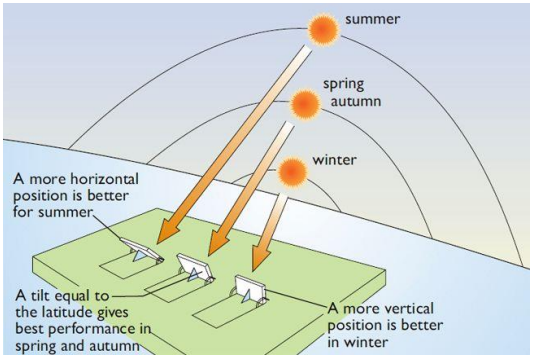
Solar ovens take advantage of thermal conductivity. Thermal conductivity is the quantity of heat transmitted during a specific time through a thickness of material, in a direction normal (perpendicular) to a surface of area. In simple terms, a solar cooker absorbs more heat than it releases. Thermal conductivity may be measured mathematically using the following equation:

$$Thermal\ conductivity = \frac{(heat\ flow\ rate) * (distance)}{(Area) * (temperature\ difference)}$$



Source: https://www.fix.com/assets/content/15521/how-solar-box-cooker-works.png

When designing a solar cooker, it's important to think about the position of the sun in the Earth's sky. In winter, in either the northern or southern hemisphere, the sun is low in the sky and days are short. In summer, the sun is high in the sky and days are long. You will need to plan the positioning of your solar oven to take advantage of the suns current position in the sky. Use reflectors to focus the insolation so you don't need to continuously move the cooker as the sun moves.



https://i.pinimg.com/originals/79/c2/61/79c2619b87c40c8cc252102b3df5aadd.jpg

The simple solar oven you will build in this activity is made of a box, aluminum foil, plastic wrap and a sheet of black paper. You will cut a flap out of the box's lid and line this flap with aluminum foil. This will reflect sunlight into the box. You'll also seal the opening with plastic wrap. This plastic "window" works like a greenhouse roof, allowing (direct and reflected) sunlight to pass into the box, while also retaining heat. At the bottom of the box, you will place black paper. This will act as a heat sink that absorbs direct and reflected sunlight to warm it, which will heat food placed on top of it.

Materials

- Pizza box (The larger the box, the better the oven should work.)
- Pencil or pen
- Ruler
- Scissors **(Always make sure you have adult help when using sharp objects.)**
- Aluminum foil
- White school glue
- Plastic wrap
- Shipping tape or black electrical tape
- A sheet of black paper
- A wooden skewer or pencil
- Warm, sunny day. To do some cooking with your solar oven, you will need sunlight and fairly warm outside temperatures—the hotter the better. (It should also not be windy.)
- Graham crackers, marshmallows and a chocolate bar (Optional, if you want to cook some s'mores in your solar oven.)

***Content of the solar cooker will be hot. Use cooking mitts.**

***Be careful when opening oven after it has been sitting in the sun. It will be hot and may release steam, which can burn skin.**

Procedure

- If needed, clean out the pizza box so it is ready to become a solar oven. Remove any liners that came with the box.
- On the top of the pizza box's lid, draw a square that is about one inch inward from each edge.
- Get an adult's help to use a utility knife (and the ruler as a straightedge) to carefully cut along each side of the square you just drew except for the side that runs along the hinge of the box. Cut all the way through the cardboard on those three sides of the square. Then fold the flap back slightly along the attached side.
- Line the inside of the cardboard flap with aluminum foil. Fold the edges of the foil over the flap to help hold the foil in place and glue the foil onto the flap. Keep the foil as smooth as possible.
  What do you think the purpose of this foil is?
- Cover the opening made by the flap (in the lid) with a layer of plastic wrap. Attach the plastic wrap to the opening's edges using shipping tape or black electrical tape. Make sure there are no holes in the plastic wrap and that all of its edges are completely attached to the lid.
  Why do you think it's important to make sure the plastic wrap completely seals the lid's opening?
- Line the inside of the box with aluminum foil so that when you shut the box the entire interior is coated with foil. It is easiest to do this by covering the bottom of the box with foil and then covering the inside part of the lid (going around the plastic-covered opening) with foil, too. Glue the foil in place.
  Why do you think you should coat the inside of the box with foil like this?
- Glue or tape a sheet of black paper to the bottom of the box, centered there. This will act as your solar oven's heat sink.
  How do you think it will help cook your food?
- Lastly, use a wooden skewer or pencil (and some tape) to prop the solar oven's lid up, at about a 90-degree angle from the rest of the box.
- Leave the solar oven outside on a hot day (non-windy days of at least 85 °F work best).
  Does the oven get very warm?

Challenge: If you want to cook a s'more, break a graham cracker in half and place a marshmallow and small piece of chocolate between the cracker halves. Place the prepared s'more on a small square of aluminum foil that is slightly larger than the s'more (this will serve as a tray) and put it in your solar oven on top of the black sheet of paper. Put the solar oven outside where it will get full, direct sunlight for at least 30 minutes and keep it turned so that the flap faces the sun. When the marshmallow is soft your s'more should be ready to eat and enjoy! *How long does it take to cook the s'more in your solar oven? Was the amount of time within your expectation? How so?*

- **Extra:** There are a lot of variables that you can adjust to make your oven even better.
  Can you make your solar oven more efficient by changing the angle of the reflector flap, using different materials to insulate it or changing its shape or size?
- **Extra:** Use a thermometer to quantify how efficient your oven is; record the temperature readings inside your oven over time. *How hot can it get? How does this compare with a real oven?*
- **Extra:** The weather outside can significantly affect how well a solar oven performs.
  How well does it cook on a warm day versus a very hot day?
  What about a sunny day versus an overcast one?
- **Extra:** In this activity you made a very simple box-type solar oven, but you could build another oven using a more efficient design to make the solar oven get even hotter!
  How efficient can you make a solar oven?

Don’t stop there, try melting some cheese over nachos or even baking a potato!

Ingredients (Author: Merry Bevill)

- 2 cups tortilla chips
- ½ - 1 cup of cheddar or Mexi-blend cheese

Instructions

1. Place the tortilla chips in the pie pan.
2. Sprinkle the cheese on top.
3. Place the pan into a turkey cooking bag and twist shut.
4. Place the pie pan up very close to the reflector.
5. Heat until the cheese is melted.

How can a project like this help others?

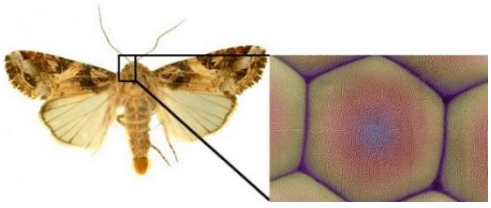
This two-minute YouTube video is about the Infinity Bakery solar oven—a low-cost solution that enables bakery entrepreneurs and communities in the developing world to harness the power of the sun for baking and cooking more sustainably: see https://www.youtube.com/watch?v=6ZRqPYwlYt0

Did You Know …

Dark materials are vital to solar cooking and solar panels?

Dark materials are known to absorb the sun's heat well, the same property that makes dark materials cook better also makes better solar panels. Scientists at Brookhaven National Lab's Center for Functional Nanomaterials are studying materials to improve solar panels. They are looking to nature for inspiration and design.

Biomimicry: By observing animals, plants and natural processes, we gain insight into what works and what does not. For engineers, these observations are helpful in both the design process and inspiring new inventions using natural technologies. There are many examples of biomimicry, with one of the most well-known being Velcro — a product designed to behave like the cockleburs that stick to animals (and people) when they brush by the plant.



Scientists at Brookhaven Lab are improving solar panels by mimicking black moth eyes. Learn more about this here:

- Artificial Moth Eyes Enhance the Performance of Silicon Solar Cells
  https://www.bnl.gov/cfn/research/highlights/news.php?a=25850

The Northeast Solar Energy Research Center is a multi-purpose research facility at BNL where scientists test new solar technologies. Learn more and look at real-time solar insolation data here: https://www.bnl.gov/energy/nserc/

Acknowledgements: This content was developed from the following resources:

Scientific American, Sunny Science: Build a Pizza Box Solar Oven. An engineering enterprise from Science Buddies https://www.scientificamerican.com/article/sunny-science-build-a-pizza-box-solar-oven/

"What Is Heat?" https://www.teachengineering.org/lessons/view/ucd_heat_lesson01

"Heat Transfer" https://www.teachengineering.org/lessons/view/cub_housing_lesson01

Cooking with the Sun - Creating a Solar oven
https://www.teachengineering.org/activities/view/duk_solaroven_tech_act

6 Easy Recipes For Kids |Pizza Box solar oven recipe | Solar Cooking

https://www.sunshineonmyshoulder.com/6-easy-recipes-for-kids/

Harper, Gavin DJ. Solar Energy Projects for the Evil Genius 50 Build it Yourself Projects

Additional Resources:

Energy Innovation: Brookhaven National Lab

https://www.bnl.gov/newsroom/factsheets/files/pdf/energy-innovation.pdf

Exploring Energy at Brookhaven National Lab

https://www.bnl.gov/newsroom/factsheets/files/pdf/exploring-energy.pdf

Tackling the Nation's Energy Challenges

https://www.bnl.gov/science/energy.php

Energy Innovation: Brookhaven National Lab

http://www.bnl.gov/bnlweb/pubaf/fact sheet/pdf/brochure-BES.pdf

Soaking up the Sun at the Long Island Solar Farm Energy Research at Brookhaven National Lab

https://www.bnl.gov/newsroom/news.php?a=23953

Research for a Sustainable Future

https://www.bnl.gov/about/sustainability/research.php

PV education.org : Calculation of Solar Insolation

https://www.pveducation.org/pvcdrom/properties-of-sunlight/calculation-of-solar-insolation

Animations and examples of all three types of heat transfer at this Wisconsin Online Resource Center website:

http://www.wisc-online.com/objects/index_tj.asp?objID=SCE304.