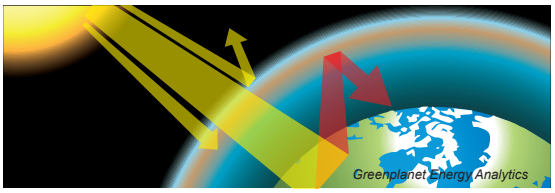
FACT SHEET: Solar Thermal Energy

We use many forms of energy in our everyday life to warm our homes, cook our meals and fuel our cars. Much of this energy produces greenhouse gases. These are the gases that trap heat in the atmosphere that are contributing to climate change.

One way to reduce greenhouse gases is to make use of alternative energy. Let's explore how solar energy can be used to make a heat source.

Importance of Sunlight

- Light is a form of energy.
- The light energy that we receive from our Sun is, without a doubt, the most important element to all life on Earth.
- Sunlight supplies plants with energy which they use (through the process of photosynthesis) to make food (sugar).
- Animals then eat the plants to produce energy.
- Sunlight delivers heat energy that drives ocean currents, wind and on a larger scale, weather and climate systems!
- In fact, nearly all energy on Earth originates from sunlight. Powerful stuff!
- Unless disrupted, light travels in a straight line to Earth.
- The Earth's atmosphere filters a portion of visible light so only about 74% of solar energy reaches the Earth's surface.



Electromagnetic Spectrum

- Most of the light in the universe is invisible to our eyes!
- The sun gives off many types of light which is referred to as the electromagnetic spectrum.
- Visible light, like the rest of the spectrum is transmitted as a wave. The length of the wave (distance from the peak of one wave to the peak of the next) determines the amount of energy.
- Earth receives energy from the Sun in the form of ultraviolet, visible, and near-infrared radiation. These have short wavelengths.
- This energy is absorbed by the land, oceans and atmosphere as heat
- This heat is then radiated back up in the form of invisible infrared energy. (This radiation now has a longer wavelength)
- The majority of the infrared radiation (90%) gets absorbed by certain atmospheric gases, known as greenhouse gases (GHG's).
- This results in the ever-increasing rise in temperature of the Earth's atmosphere.

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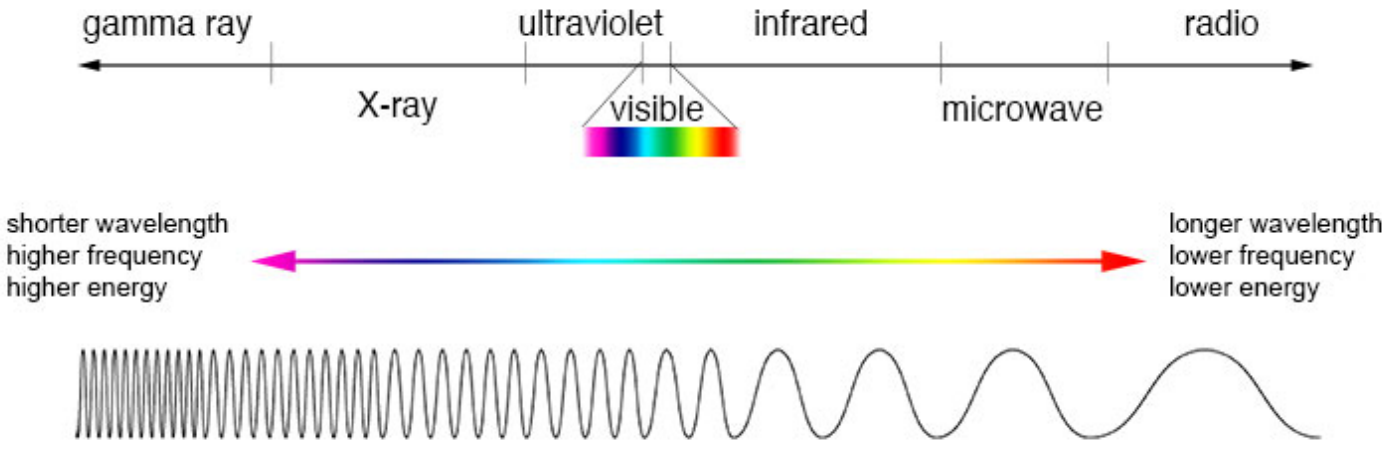
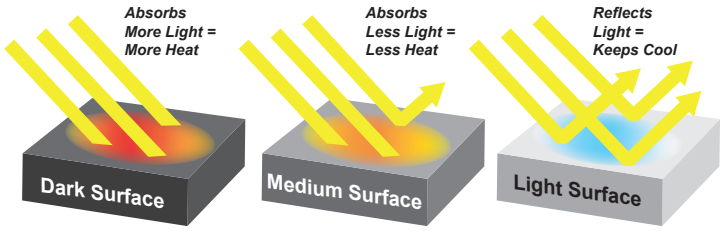


WikiMedia

How Light Makes Heat - Thermal Energy

- The molecules and atoms that make up matter are moving all the time.
- Light traveling through space to Earth will eventually come into contact with molecules in some type of material.
- The light energy is absorbed by the molecules and causes them to move faster, bumping into each other. This increased movement produces heat!
- This process continues as neighboring molecules bump into each other, setting more molecules to move faster until heat is spread throughout the material.
- This material could be anything: water, sand, air or the food in a solar oven.
- Heat is energy. Temperature is a measurement of that energy.
- Heat is called thermal energy.



Greenplanet Energy Analytics

What is Albedo?

- Albedo (al-bee-doh) is a measure of how much light is reflected from a surface without being absorbed.
- Lightly colored things, like snow, have a high albedo - they reflect most of the light, keeping them cool.
- Dark colored objects, such as the ground, have a low albedo. They absorb most of the light that comes in contact with them, causing them to warm up.
- If something has a low albedo, its molecules will end up moving faster than something with a high albedo.
- Dark colored materials (low albedo) are needed to produce maximum thermal energy.

Solar Shower

Mother Earth News

Solar Cooker WikiMedia

Solar Thermal Power Plant David Suzuki Foundation

Uses of Solar Thermal Energy

Solar thermal energy can be used for;

- heating homes and other buildings, often as in-floor heating systems.
- running air conditioning and refrigeration appliances (using solar driven heat pumps and solar chimneys) .
- heating water for homes - for showers, laundry, etc.
- heating indoor and outdoor swimming pools.
- industrial drying of wood, food products, etc.
- solar stills to make drinking water in areas where clean water is not available
- desalination which removes salt from ocean water
- producing electrical power by collecting and concentrating sunlight to produce the high temperature heat needed to produce steam. The steam is then used to power a turbine that produces electricity.
- cooking, using solar ovens or solar cookers

More Resources

What Colors Absorb More Heat?
https://sciencing.com/colors-absorb-heat-8456008.html

Thermal Energy - Feel the Burn - SolarSchools.net
https://www.solarschools.net/knowledge-bank/energy/types/thermal

The 5 Most Common Examples Of Solar Power
https://news.energysage.com/most-common-solar-energy-uses/

Solar Energy to the Earth - Energy Education
https://energyeducation.ca/encyclopedia/Solar_energy_to_the_Earth

Word of the Week: Electromagnetic spectrum - EarthSky
https://earthsky.org/space/what-is-the-electromagnetic-spectrum#:~:text=The%20electromagnetic%20spectrum%20is%20the,alternating%20electric%20and%20magnetic%20fields.

How exactly does light transform into heat - Scientific American
https://www.scientificamerican.com/article/how-exactly-does-light-tr/

Albedo - Encyclopaedia Britannica
https://www.britannica.com/science/albedo

Solar: A brilliant way to get energy - David Suzuki Foundation
https://davidsuzuki.org/story/solar-a-brilliant-way-to-get-energy/

Energy storage gives renewables a jump-start- David Suzuki Foundation
https://davidsuzuki.org/story/energy-storage-gives-renewables-a-jump-start/

VIDEO - Solar Thermal 101 - YouTube - Student Energy
https://www.youtube.com/watch?v=FgjfJGfusdE

VIDEO - Concentrating Solar Power-Power Towers - KeepItCleanCreative
https://www.youtube.com/watch?v=QTNU1JMhzxA

Three Nations ENERGY

SOLAR OVEN

A DIY PROJECT!

Make a way to cook that costs little to make, nothing to run and helps the environment at the same time!

How Do Solar Ovens Work?

Solar ovens use the free light from the sun to cook food. Something reflective like foil is used to direct as much light as possible into the box where the food will be cooked. The light hitting the inside creates heat that is trapped by layers of clear material like plastic wrap.

On a hot sunny day this oven could raise the inside temperature to 200 °C, easily hot enough to cook nachos, s'mores, etc.

Supplies Needed:

- Pizza box *(It's always better to reuse than recycle!)*
- Ruler
- Felt marker
- Aluminum foil
- Box cutter
- Glue / tape
- Scissors
- Clear plastic wrap
- Black construction paper
- Straw

For Experiment

- Thermometer (for air temp. inside and outside box)
- Optional: smart phone app to measure light in Lumens

Step 1

On the top of the lid, measure 2 cm from the front and each side. Draw a square so that it touches the back side of the lid.

Step 2

Cut the front and two sides of the square, leaving the back edge attached. This will make a flap that folds up.

Step 3

Take a piece of foil and glue it to the inside of the flap you just made, shiny side out.

Glue more foil to the inside of the box so it is also covered, shiny side out.

Step 4

Next, make a "double pane" window.

Tape a piece of plastic wrap to the lid of the box, completely covering the hole you made.

Did You Know?

Sunlight travels the 90 million miles to Earth in 10 minutes.

Solar energy is cheaper than fossil fuels as of 2019.

Russell Ohl created the first photovoltaic cell in 1941.

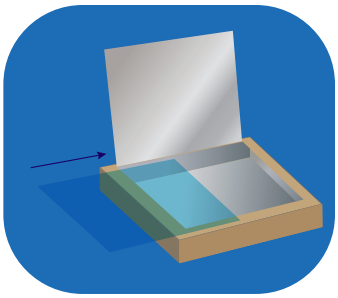
Fort Chipewyan has the largest remote community solar farm in Canada.

174,000 terawatts of energy consistently strike the earth as solar radiation at any moment, even on the cloudiest of days.

Powerful stuff!

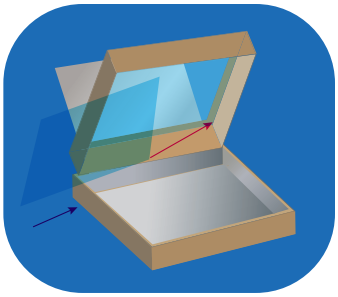
Step 5

Close the top and tape a piece of plastic wrap to the outside part of the window.

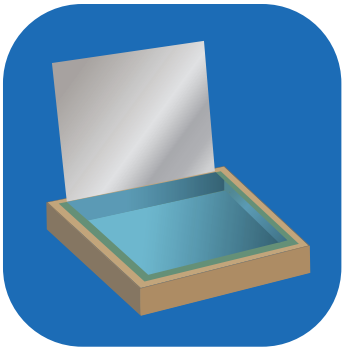


Step 6

Cut your black paper to size and lay it inside the bottom of the box.

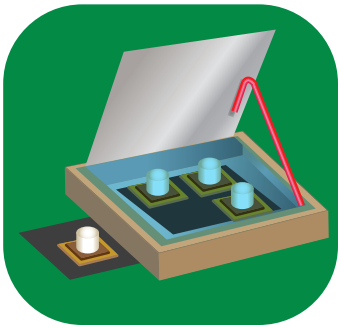


Attach a straw (or other stick) to hold the lid open as shown.



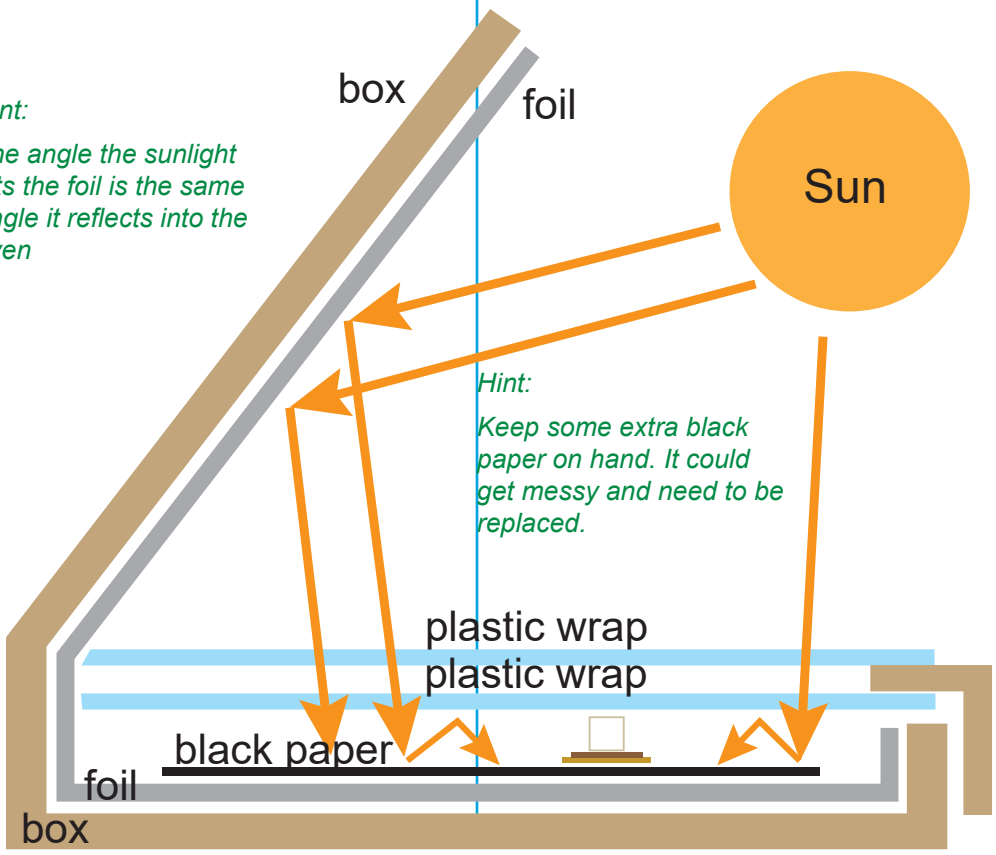
Step 7 - Get Cooking!

Place your oven in the sun and put your food inside. Adjust the straw to help angle the sun into the oven. Watch and enjoy!



Hint:

The angle the sunlight hits the foil is the same angle it reflects into the oven



Hint:

Keep some extra black paper on hand. It could get messy and need to be replaced.

Did You Know?

Light travels through space to Earth as a wave.

When these waves contact a surface, they transfer energy to the molecules which start vibrating faster. This produces more heat!

On a hot sunny day this oven could raise the temperature up to 200 °C.

Questions

1. How is this solar oven like a greenhouse?

2. Why is black construction paper used?

3. What is the function of the aluminum foil?

CHALLENGE!

What other materials could you use for a solar oven?

Will Clouds Make a Difference?

(Takes 2 days, approx. 1 hour per day)

IN A HURRY? Instead of waiting for a cloudy day, just use a shaded area for Part 2. Have some ovens in the sun and the shade at the same time.

An experiment is testing an idea (hypothesis) to see if it is correct.

PART 1 Cook some food on a hot sunny day, in direct sunlight.

We will compare future experiments to this, so it is important to write down what you do. Record these in the chart at the bottom of the page:

- Time of day
- Where you placed your oven
- Type and size of food
- How long it takes to cook your food
- Use a thermometer to test temperatures
  - Temperature outside ˚C
  - Temperature inside the box ˚C

Any other observations (things you saw, felt, smelled, heard or tasted):

_____

_____

_____

In science it is important to have something to compare with so we know when things change - this is called a base line.

Make a hypothesis. Do you think it will cook faster or slower on a cloudy day? _____

What else do you think you could cook in your solar oven?

_____

_____

***Pro Tip!** Take photographs of the temperature, time of day and angle of the sun on the ground, as an easy way to record this information.*

PART 2 On the next cloudy day do the experiment again and be sure to KEEP THE FOLLOWING THE SAME:

- Time of day
- Where you placed your solar oven
- Type and size of food

Record the same information as before in the chart below.

It is important to only change one thing (variable) in an experiment so you know what is causing the difference.

PART 3 What did you find out? Did it cook as well as the first time? Explain why you think it did or did not. Look at some of the hints on the Activity Sheet where it says “Did You Know?”.

_____

_____

_____

_____

How about building a BIG solar cooker? (Wikimedia)

CHALLENGE!

Try changing the design of the oven.

Could you use different materials?

What about a version to fit in a backpack?

Experiment	Time of Day (keep this the same)	Cook Time (keep this the same) Min.	Outside Temperature ˚C	Inside Pizza Box Temperature ˚C
Part 1 - Sunny Day				
Part 2 - Cloudy Day				
Location:		Food:		(◄-keep the same for Part 1&2)

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SOLAR OVEN EXPERIMENT

Advanced

Plan an experiment based on the solar oven activity.

Plan on 2 sessions of approximately 1 hour each.

HINT #1:

- In an experiment, it is important to change only one variable at a time. Why?

HINT #2:

- Data to consider:
  - Time of day
  - Weather conditions
  - Where you placed your oven
  - Shade conditions
  - Angle of the lid
  - Type and size of food
  - How long it takes to cook your food
  - Temperature outside the box ˚C
  - Temperature inside the box ˚C
  - Optional: Brightness of light in Lumens* (See lower right for information how to do this.)
  - Other observations?

HINT #3:

- You have to have a base line to compare with, so how many times will you do the experiment?

Pro Tip! Take photographs of your set-up, the temperature, time of day and angle of the sun on the ground, etc., as an easy way to record your information.

On a separate sheet (or page 8) write out, in point form:

1. Experimental Problem (10%)
2. Hypothesis (10%)
3. Procedure (40%)
   (Include enough detail so someone else could follow your instructions and repeat exactly what you did.)
4. Observation (30%)
   (Design a chart which will include ALL needed observations.)
5. Conclusions (10%)

CHALLENGE!

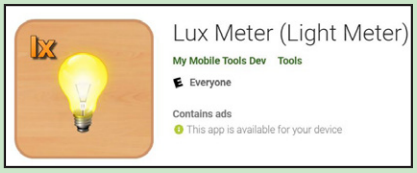
Try changing the design of the oven.

Could you use different materials? How could you improve how it works? What about a backpack version?

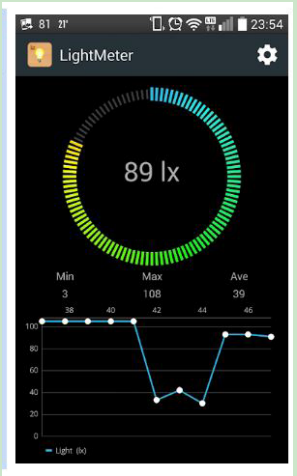
How about building a BIG solar cooker? (Wikimedia)

Light Meter App

There are a number of free apps that turn a smart phone into a light meter measuring the amount of light received by the built-in sensor.



This allows you to lay the phone on the oven to compare how much light is being received to how much heat is being produced. Many have dials and graphics that make the reading very visual and easy to understand.



Sample free apps:

Lux Meter (for Android - shown in photographs)
https://play.google.com/store/apps/details?id=com.tsang.alan.lightmeter&hl=en_CA&gl=US

Lux Light Meter Pro (for iOS)
https://apps.apple.com/us/app/lux-light-meter-pro/id1292598866

SOLAR OVEN EXPERIMENT

Advanced

Record all information:

1. Experimental Problem (10%)

2. Hypothesis (10%)

3. Procedure (40%)

4. Observation (30%) Modify chart as needed.

Experiment Data				

5. Conclusions (10%)

TEACHER RESOURCE: Solar Oven Activity
Grade 10-12

What's Included

The resources are in 3 sections:

1. Teacher Resource (page 1)

2. Solar Thermal Energy Fact Sheet (pages 2-3)

This reviews many relevant science concepts which can be related to the activity.

- The Importance of Sunlight
- Electromagnetic spectrum
- Thermal energy
- What is Albedo?
- Uses of Solar Thermal Energy
- More Resources (for students to explore)

3. Student Activity Sheets

Solar Oven Activity - approx. 30 min. + 1 hr. (pages 4-5)

This activity can be used without the fact sheet and experiment for a lighter, more fun approach. Construction should take about 30 minutes. Cooking time depends on amount of sun and air temperature - allow about 1 hour.

Experiments - two sessions, approx.1 hr. each, Basic & Advanced versions provided (pages 6 / 7-8)

This provides an additional, more in-depth look at the solar oven using scientific procedures.

- Basic version guides the student through a pre-designed experiment to see how shade or cloud cover can affect the operations of the solar oven. (See Lumen app on advanced sheet for added ideas.)
- The advanced version challenges students to design their own experiment, choosing the variable they want to test. You can shorten this activity by assigning a variable and just have students record observations for discussion later.
- An additional challenge is offered to redesign the oven using different materials.

Learning Outcomes

This is a great complimentary exercise if you and your students are exploring society's impact on the environment in regards to greenhouse gases, with a solution based, hands on project.

This can also be used to connect the demonstration of solar thermal energy to other real-world low carbon technologies such as solar thermal space heating and solar thermal hot water technologies.

Curriculum Connections

Science 10 - Unit D: Energy Flow

- Describe, in general terms, how thermal energy is transferred through the atmosphere
- Skill Outcomes - initiating, planning, performing, recording, analyzing and interpreting
- Attitude Outcomes - interest in science, science inquiry, stewardship

Science 14: Understanding Energy Transfer Technologies

- Students will explain the need to encourage and support the development of machines that are efficient and rely upon renewable energy sources.

Science 10–30, Biology 20–30, Physics 20–30, Attitudes-Stewardship

- Students will be encouraged to demonstrate sensitivity and responsibility in pursuing a balance between the needs of humans and a sustainable environment.

Social Studies 10

- Students will explore multiple perspectives regarding the relationship among people, land and globalization (stewardship)

All curriculum connections were derived from: https://www.alberta.ca/programs-of-study.aspx.

More Resources

Thermal Energy - Feel the Burn - SolarSchools.net
https://www.solarschools.net/knowledge-bank/energy/types/thermal

The 5 Most Common Examples Of Solar Power
https://news.energysage.com/most-common-solar-energy-uses/

Solar Energy to the Earth - Energy Education
https://energyeducation.ca/encyclopedia/Solar_energy_to_the_Earth

Word of the Week: Electromagnetic spectrum - EarthSky
https://earthsky.org/space/what-is-the-electromagnetic-spectrum#:~:text=The%20electromagnetic%20spectrum%20is%20the,alternating%20electric%20and%20magnetic%20fields.

How exactly does light transform into heat - Scientific American
https://www.scientificamerican.com/article/how-exactly-does-light-tr/

Albedo - Encyclopaedia Britannica
https://www.britannica.com/science/albedo

Solar: A brilliant way to get energy - David Suzuki Foundation
https://davidsuzuki.org/story/solar-a-brilliant-way-to-get-energy/

Energy storage gives renewables a jump-star- David Suzuki Foundation
https://davidsuzuki.org/story/energy-storage-gives-renewables-a-jump-start/

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