

Teacher's Instruction Guide
Solar Energy Grand Challenge Demonstration: Creating Solar Ovens

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Introduction

The proposed activity from Team Icarus for the after-school program students is a demonstration over solar energy. The demonstration will consist of two parts. First, the students will create their own solar ovens. Second, the students will listen to a presentation which covers the topic of solar energy. The demonstration will conclude with the students eating s'mores cooked in the solar ovens which they built. A detailed expected schedule can be found in *Appendix A*.

After evaluating the six engineering grand challenges, the challenge focused on was "Making Solar Energy Economical". A hands-on demonstration which covers several Indiana Science Standards was chosen. *Appendix B* details the standards met and how they were met. The hands-on demonstration was desirable because it allowed the children to be very active in their own experiment.

Materials List/Budget

An expected budget for each child building their own solar oven was created which assumed that all supplies for the demonstration would be bought specifically for this project. Total costs can be decreased as buying in bulk will decrease the total price spent per child. This budget allows for a class size of fifty.

Table 1: Estimated Budget for Solar Energy Grand Challenge Demonstration

Cardboard Boxes	\$12.50 for 50
Tape/Glue	\$15.00
Glass Thermometer	\$6.81
Clear Sheet protectors	\$5.99
Aluminum Foil	\$5.98 for 180 sq. ft.
Black Construction Paper	\$1.89 for 50 sheets
Craft Sticks	\$2.47 for 75
Subtotal for boxes	\$50.64 for 50 boxes
Graham crackers	\$2.18 for 3 packs
Marshmallows	\$2.98 for 1 bag
Chocolate bars	\$6.00 for 12 bars
Subtotal for s'mores	\$11.16
TOTAL	\$61.80

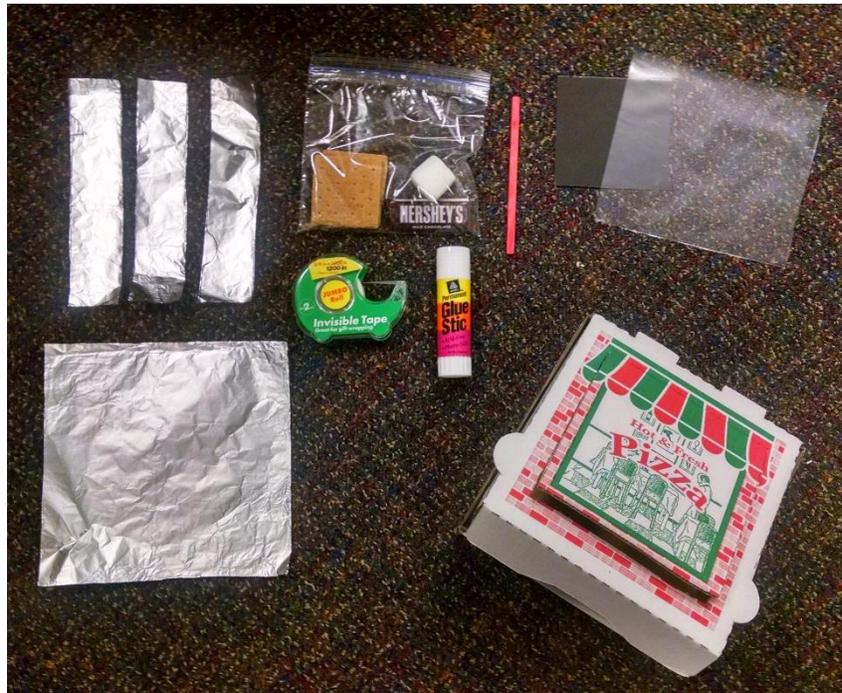


Figure 1: An image containing the supplies required for one solar oven. The dimensions of the cut foil sheets, black construction paper, and clear plastic sheet can be found in the preparation section of *Building the Solar Oven*.

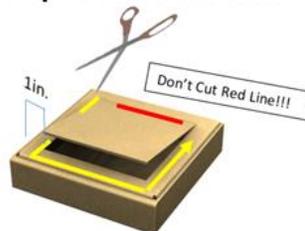
Building the Solar Oven

Preparations before Activity

Before beginning the activity with the children, prepare all necessary items discussed below:

- 8" x 8" Pizza Box
 - Cut a 6" x 6" flap into the lid as shown. Cut three 6" slits into the lid. Leave 1" of space from the edges of the box.

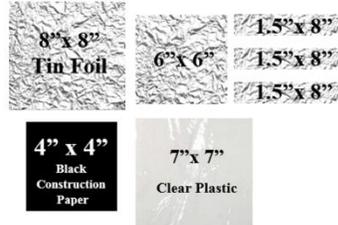
1 Prepare the Pizza Box



Cut the following:

- Aluminum Foil
 - 3 sheets of 1.5" x 8"
 - 1 sheet of 8" x 8"
 - 1 sheet of 6" x 6"
- Black Construction Paper
 - 1 sheet of 4" x 4"
- Clear Plastic Sheet
 - 1 sheet of 7" x 7"

2 Cut the Tin Foil, Black Construction Paper, and Clear Plastic sheets

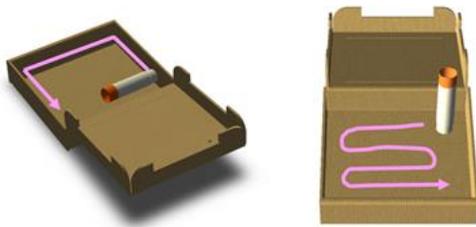


Place the foil, black construction paper, and clear plastic sheet inside each pre-cut pizza box. Additionally, the pizza boxes should also contain a BBQ skewer, glue, and tape. Prepare a box and supply set for each student participating in the activity.

Activity Directions

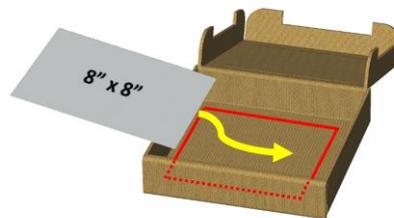
The following steps are the detailed outline of building a solar oven that each child will follow. Steps 1 and 2 are included in the *Preparation before Activity* section above.

3 Apply Glue for the bottom aluminum foil



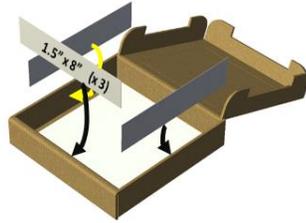
Open the box and apply glue to the sides and bottom of the box.

4 Place the 8" x 8" Tin Foil in the Bottom of the Box



Carefully smooth the foil as you position it on the glue.

5 Place the 1.5"x 8" pieces on the sides of the box



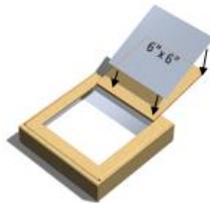
Carefully smooth the foil as you position it on the glued sides.

6 Glue the Flap



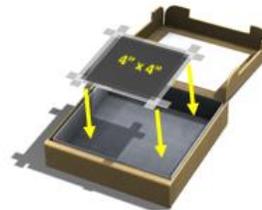
Cover the flap you cut in **Step 1** with glue.

7 Place Foil on the Flap



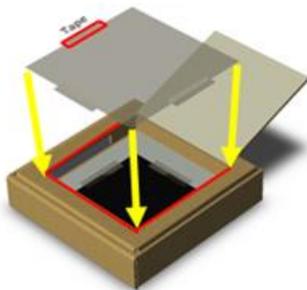
Place the 6"x 6" foil square onto the flap you just glued. Smooth the foil until it is flat.

8 Place Black Construction Paper onto Foil



Place the 4"x 4" black construction paper in the middle of the aluminum foil on the bottom of the pizza box. Use tape to secure it.

9 Place the Plastic Sheet Protector



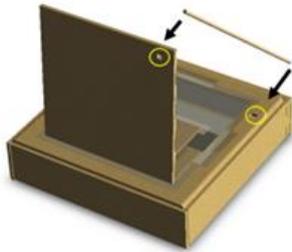
Close the lid and open the flap.
Place the sheet protector (cut in half) on top of the lid opening securing it with tape.

10 Place your s'more inside



Place your s'more on the center of the black construction paper.

11 Use the Skewer as a Flap Kickstand



Place the BBQ Skewer into the holes circled in yellow in the picture.

12 Cook Your S'more



Place the assembled solar cooker into direct sunlight to cook the s'more!

Enjoy!

In order to assist the children in the activity, the following methods of helping are also recommended.

- (1) The teacher can build a solar oven at the front of the room to verbally walk the students through the process of building the solar oven. As this will be happening in real time, the students can watch and listen to each step as they work on that step themselves.
- (2) The student can receive an instruction manual containing step-by-step instructions of how to build the solar oven. The step-by-step Instruction Manual in pamphlet formatting may be found in *Appendix C*. This guide will act as a visual aide for the student to follow.
- (3) If the classroom has teacher aides, have them walk around the room as the students are building their solar ovens. They can assist students as problems are encountered.
- (4) The teacher can bring a premade solar oven to showcase the final product.

Presentation and Technical Background

The proposed solar energy presentation is in the form of a PowerPoint, which can be found in Appendix D. The presentation should cover the following:

- (1) What solar energy is

Solar Energy is the energy emitted by the sun in the form of heat, light, and radiation. It is what enables life to exist on Earth [1].

- (2) The greenhouse effect

The greenhouse effect is the trapping of the sun's energy by the Earth's atmosphere. Some energy in the form of infrared heat actually escapes the greenhouse gases. Water vapor, carbon dioxide, methane, nitrous oxide, and ozone are the gases responsible for trapping the energy from the sun. Only 1% of Earth's gases are actually responsible for causing the greenhouse effect [2].

(3) How the greenhouse effect works in the solar oven

Each essential element of the solar oven was designed to trap heat. The transparent plastic stops heat from escaping the box, the aluminum foil reflects the rays from the sun into the box, and the black construction paper absorbs the heat. Warm surfaces such as the construction paper in the box radiate heat in order to cook the food in the solar oven. Some of this radiation escapes through the thin plastic film as heat. Convection is observed as heat escapes through the cracks in the solar oven [3].

(4) Other technologies that utilize solar energy

There are more expensive and complex forms of technology that harness solar energy. For example, photovoltaic cells collect light and convert it directly into electricity [4]. Dish-engine systems collect heat from the sun and convert it to electricity through mechanical means [5].

(5) Why we should pursue solar energy.

Solar energy is perfectly renewable unlike current fuel sources [6]. Solar energy is also clean, in that it does not pollute the Earth's atmosphere. In addition, technologies for collecting solar energies are reusable, thus reducing cost in the long run [7]. Solar energy is getting cheaper every year, with solar power now being less than a quarter of the price than it was in 2008 [8].

Take-Home Message

The students should understand the basics of solar energy and how heat from the sun transforms into energy on earth. They should have a thorough understanding of the greenhouse effect and how it relates to solar energy. The students should also know a few other technologies and the costs associated with using solar energy. The take-home message for the students is that an investment in solar energy technologies now will have a large pay-off in the future. Finally, the students should understand that they can be engineers and solve the Grand Challenges themselves.

The take-home materials of the presentation will allow the students to have elements from the project to show their parents. These materials are:

- (1) The solar oven created during the presentation.
- (2) The instruction manual that lists the supplies and steps necessary for creating another solar oven, if the student wishes to build another with their parents. The instruction manual will also contain the information covered by the PowerPoint over solar energy.

Teacher Resources

<http://www.renewableenergyworld.com/rea/home/solar-energy>

Discusses multiple forms of renewable energy. Its section on Solar Energy covers news, opinions and commentary, new technologies, and more. Adult oriented.

<http://solarforward.com/solarkids/>

A website for the students to explore. Includes games and activities as well as information over solar energy.

<http://www.sciencemag.org/content/315/5813/798.full>

A science article discussing the current drawbacks and hurdles of making solar energy efficient.

Sources

- [1] "Solar Basics" http://www.eia.gov/kids/energy.cfm?page=solar_home-basics
- [2] "The Greenhouse Effect" <http://scentofpine.org/gw101-1/>
- [3] "Principles of solar cooker box design" <http://solarcooking.org/sbcdes.htm>
- [4] "How do Photovoltaics Work?" <http://science.nasa.gov/science-news/science-at-nasa/2002/solarcells/>
- [5] "Concentrating Solar Power (CSP) Technologies" <http://solareis.anl.gov/guide/solar/csp/>
- [6] "Why Solar?"
<http://www.engineering.com/SustainableEngineering/RenewableEnergyEngineering/SolarEnergyEngineering/WhySolarEnergy/tabid/3893/Default.aspx>
- [7] "Solar Energy 101" <https://www.greenmountainenergy.com/why-green/renewable-energy-101/solar-energy-101/>
- [8] "10 things you should know about investment in renewable energy"
<http://www.theguardian.com/sustainable-business/investment-renewables-10-things-climate-change>

Sources for the PowerPoint pictures:

- <http://www.bbc.com/future/story/20130912-solar-powered-record-breakers>
- <http://imgarcade.com/1/solar-powered-phone-case/>
- <http://solarfinancing.com/disruptive-models/the-solar-economys-business-ecology/>
- <http://cleantechnica.com/2014/09/04/solar-panel-cost-trends-10-charts/>
- http://en.wikipedia.org/wiki/Stirling_engine
- <http://taskhomerepair.com/tag/solar-power/>
- <http://scentofpine.org/gw101-1/>

Appendix A: Expected Schedule

Scheduled Activity	Expected Time
Introduction	5 minutes
Building the Solar Oven	20 minutes
Presentation over Solar Energy	15 minutes
Conclusion	5 minutes
TOTAL:	45 minutes

Appendix B: Science Standards

Indiana Science Standard	Standard in Action
4.12: Investigate the variety of ways in which heat can be generated and moved from one place to another. Explain the direction the heat moved.	4.12: Sun generated heat travels through space to reach Earth where it is trapped and contained inside our solar cooker through the greenhouse effect.
6.1.7: Explain that energy may be manifested as heat, light, electricity, mechanical motion, and sound and is often associated with chemical reactions.	6.1.7: Energy from the sun in the form of heat is will be used to cook the s'mores inside a solar cooker.
6.4.3: Describe the transfer of energy amongst energy interactions.	6.4.3: Because of the greenhouse effect, the gases inside of the cooker will prevent incoming hot gases from escaping.
7.1.2: Describe and give examples of how energy can be transferred from place to place and transformed from one form to another through radiation, convection and conduction.	7.1.2: Energy from the sun as heat will heat up the plastic and gases in the solar cooker as radiant energy keeping other energy entering the cooker from escaping once it has entered.
7.1.4: Recognize and provide evidence of how light, sound and other waves have energy and how they interact with different materials.	7.1.4: The sun's light waves reflecting off the aluminum foil will be absorbed by the black construction paper and plastic to heat the s'mores.
7.4.2: Explain that energy can be used to do work using many processes.	7.4.2: The solar energy is doing work by cooking the s'mores through the greenhouse effect. We will explain how solar panels are being used today in many places to generate electrical energy.

Appendix C: Instruction Manual

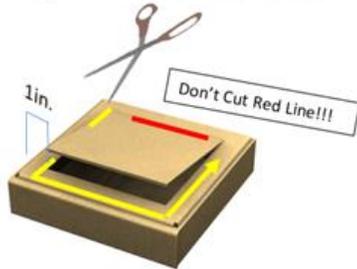
**If you were going to make a solar oven without these instructions, what would it look like?
Draw a picture!
How could you make it better?**



Required Materials

- Pizza Box (8" x 8" x 1.5")
- Clear Sheet Protector
- Black Construction Paper (4" x 4")
- Tin Foil (approx. 11" x 24")
- 1 BBQ Skewer
- Tape and Glue
- Scissors and/or Box Cutter
- Adult Supervision

1 Prepare the Pizza Box



With the help of a parent, cut three 6" slits in the lid leaving 1" of cardboard around the edges.

DON'T CUT THE RED BACK EDGE OF THE LID

You and Engineering

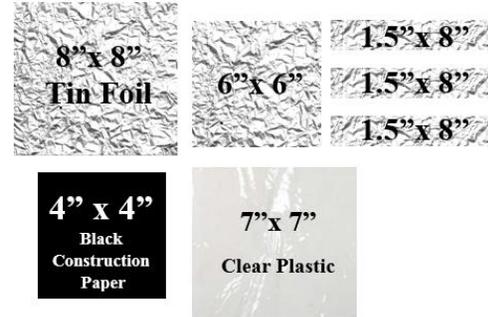
Engineers design things.
How could we have designed the solar cooker better?



Ideas:

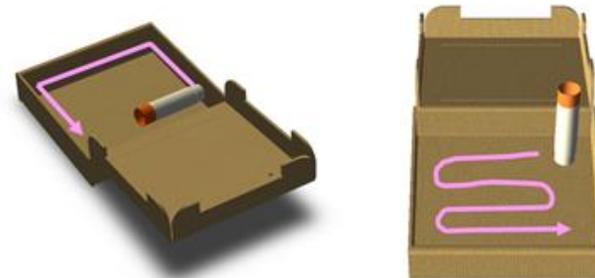


2 Cut the Tin Foil, Black Construction Paper, and Clear Plastic sheets



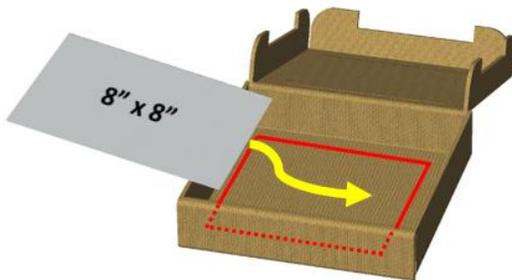
Use scissors to cut the foil, black construction paper, and clear plastic into the pieces shown above.

3 Apply Glue for the bottom aluminum foil



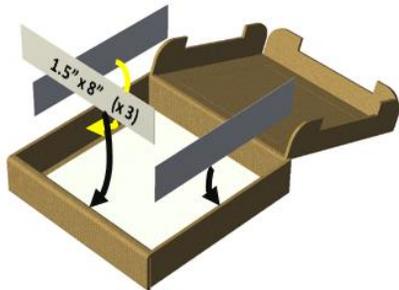
Open the box and apply glue to the sides and bottom of the box.

4 Place the 8" x 8" Tin Foil in the Bottom of the Box



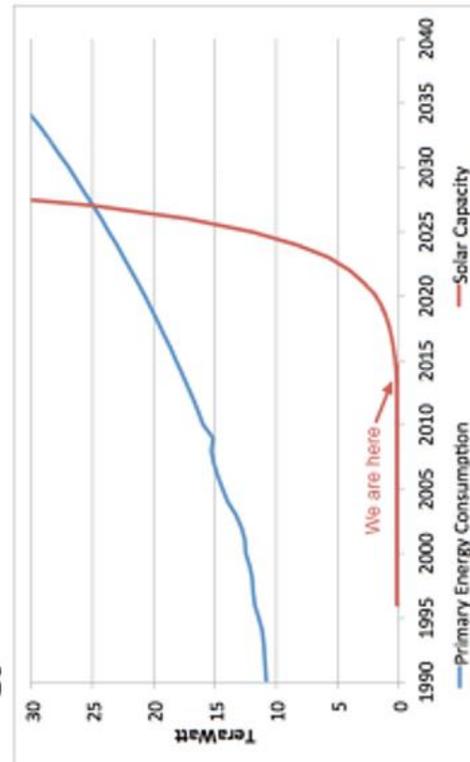
Carefully smooth the foil as you position it on the glue.

5 Place the 1.5" x 8" pieces on the sides of the box



Carefully smooth the foil as you position it on the glued sides.

With the right technology, we could use the sun for all of our energy needs.



<http://solarforecasting.com/disruptive-models/the-solar-economy-business-ecology/>

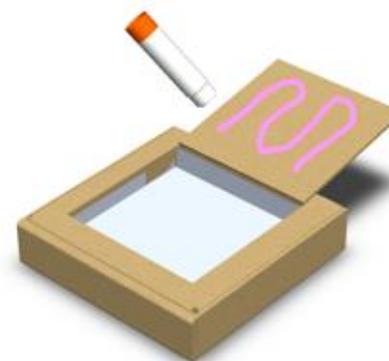
Rising rates of electricity will lead to harnessing of renewable energy



Electricity rates are projected to rise by 5% in 2015 which would encourage individuals to harness renewable energy, such as wind and solar, with solar being the most abundant

6

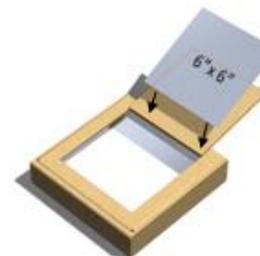
Glue the Flap



Cover the flap you cut in **Step 1** with glue.

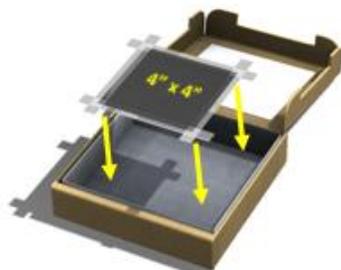
7

Place Foil on the Flap



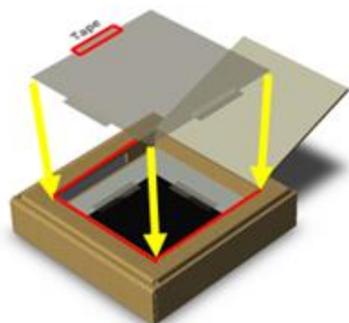
Place the 6" x 6" foil square onto the flap you just glued.
Smooth the foil until it is flat.

8 Place Black Construction Paper onto Foil



Place the 4" x 4" black construction paper in the middle of the aluminum foil on the bottom of the pizza box. Use tape to secure it.

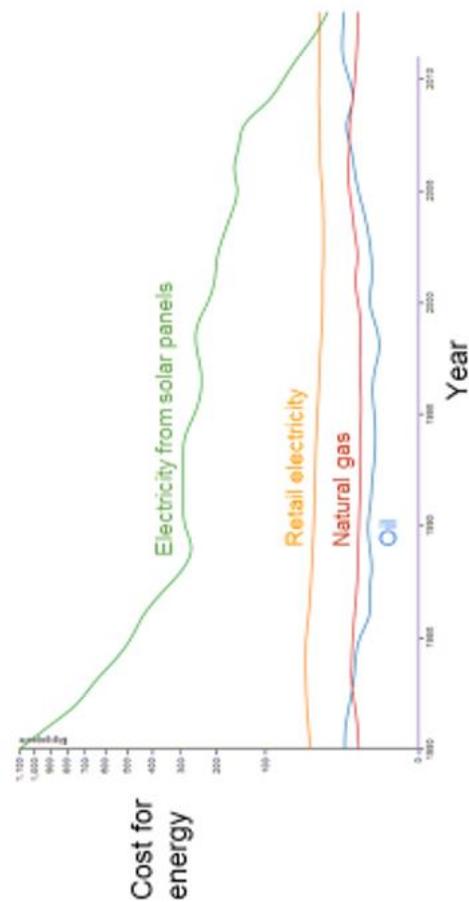
9 Place the Plastic Sheet Protector



Close the lid and open the flap.

Place the sheet protector (cut in half) on top of the lid opening securing it with tape.

Oil and coal will eventually run out, but solar energy keeps getting cheaper.



<http://cleantechnica.com/2014/03/04/solar-panel-cost-trends-10-charts/>

We have developed many different types of technology to use solar energy in different ways.

Photovoltaic cells collect light



<http://taskhomerepair.com/tag/solar-power/>

Dish-engine systems collect heat



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

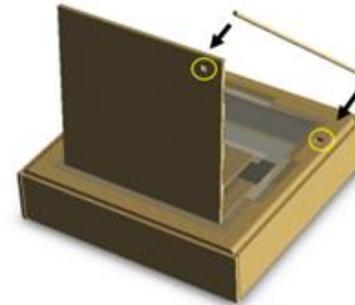
We can use solar energy to create electricity and power homes and businesses - and it's getting cheaper every year.

10 Place your s'more inside



Place your s'more on the center of the black construction paper.

11 Use the Skewer as a Flap Kickstand



Place the BBQ Skewer into the holes circled in yellow in the picture.

12

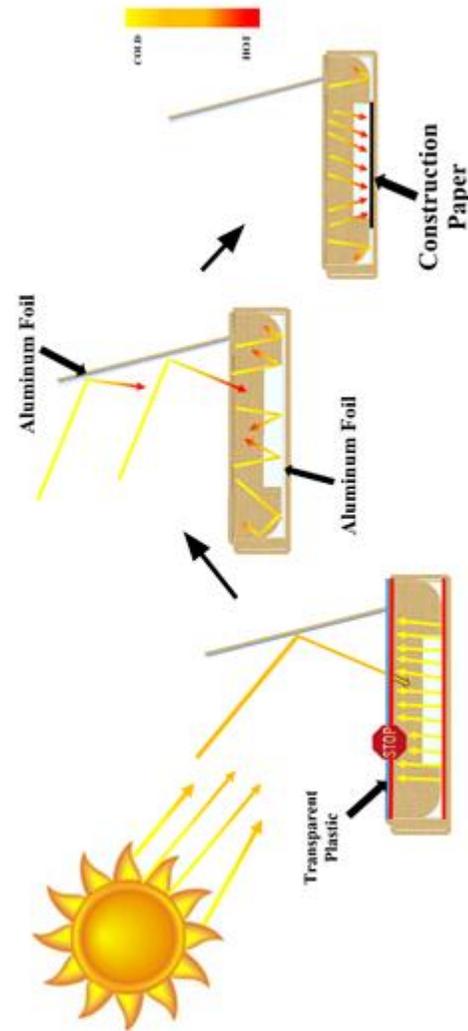
Cook Your S'more

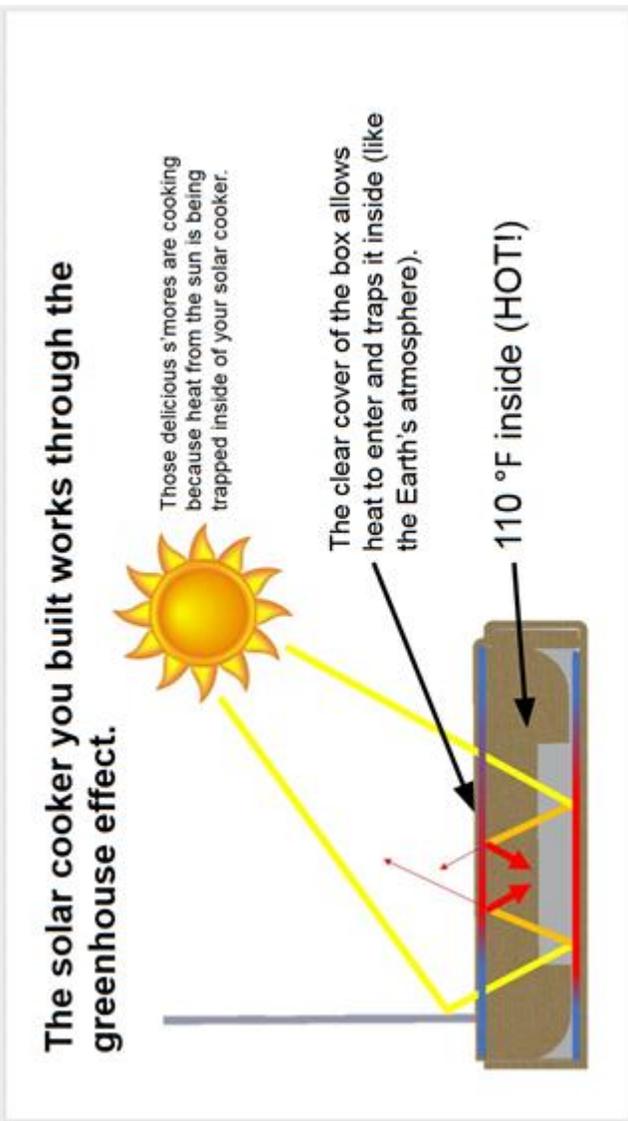


Place the assembled solar cooker into direct sunlight to cook the s'more!

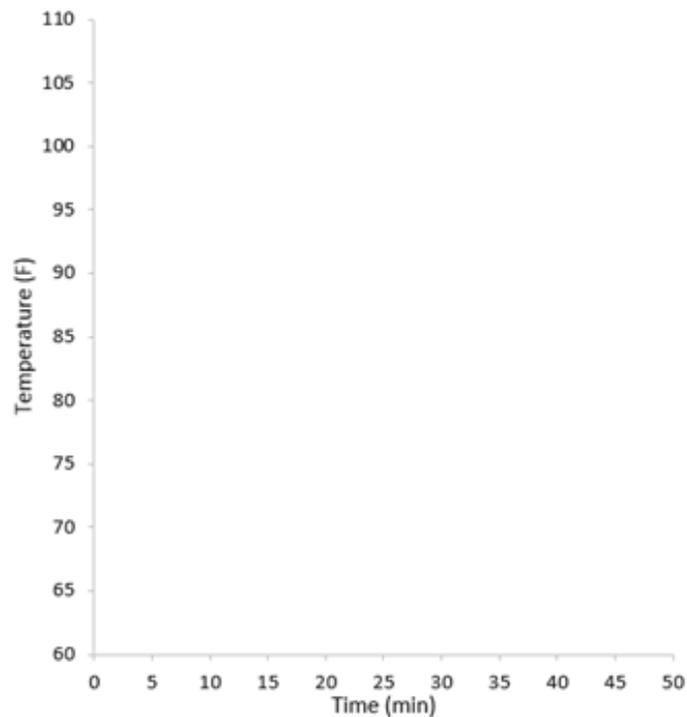
Enjoy!

Each part of the solar cooker is designed to make the box hot enough to cook.

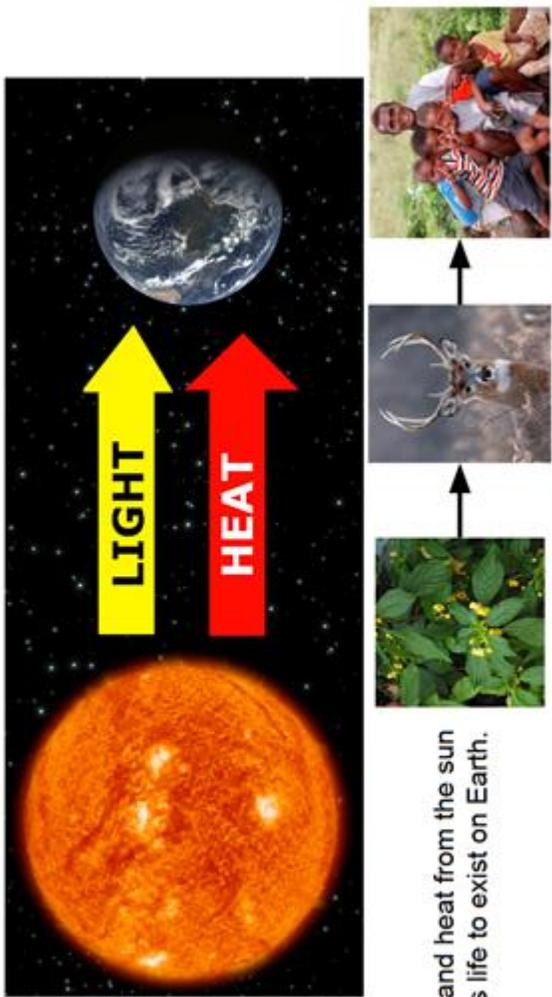




Plot the temperature of the inside of your solar cooker

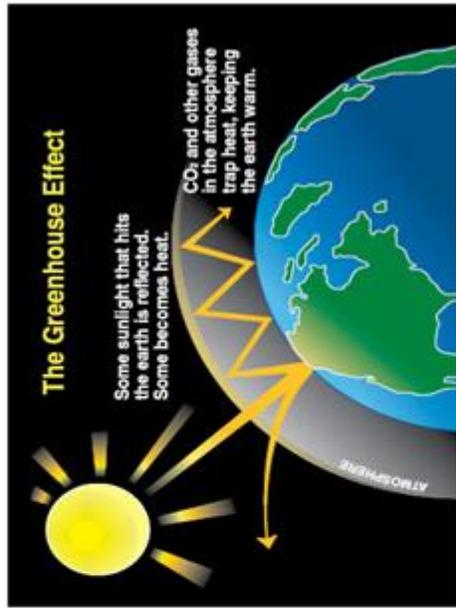


The sun sends energy to the Earth in the form of light and heat.



Light and heat from the sun allows life to exist on Earth.

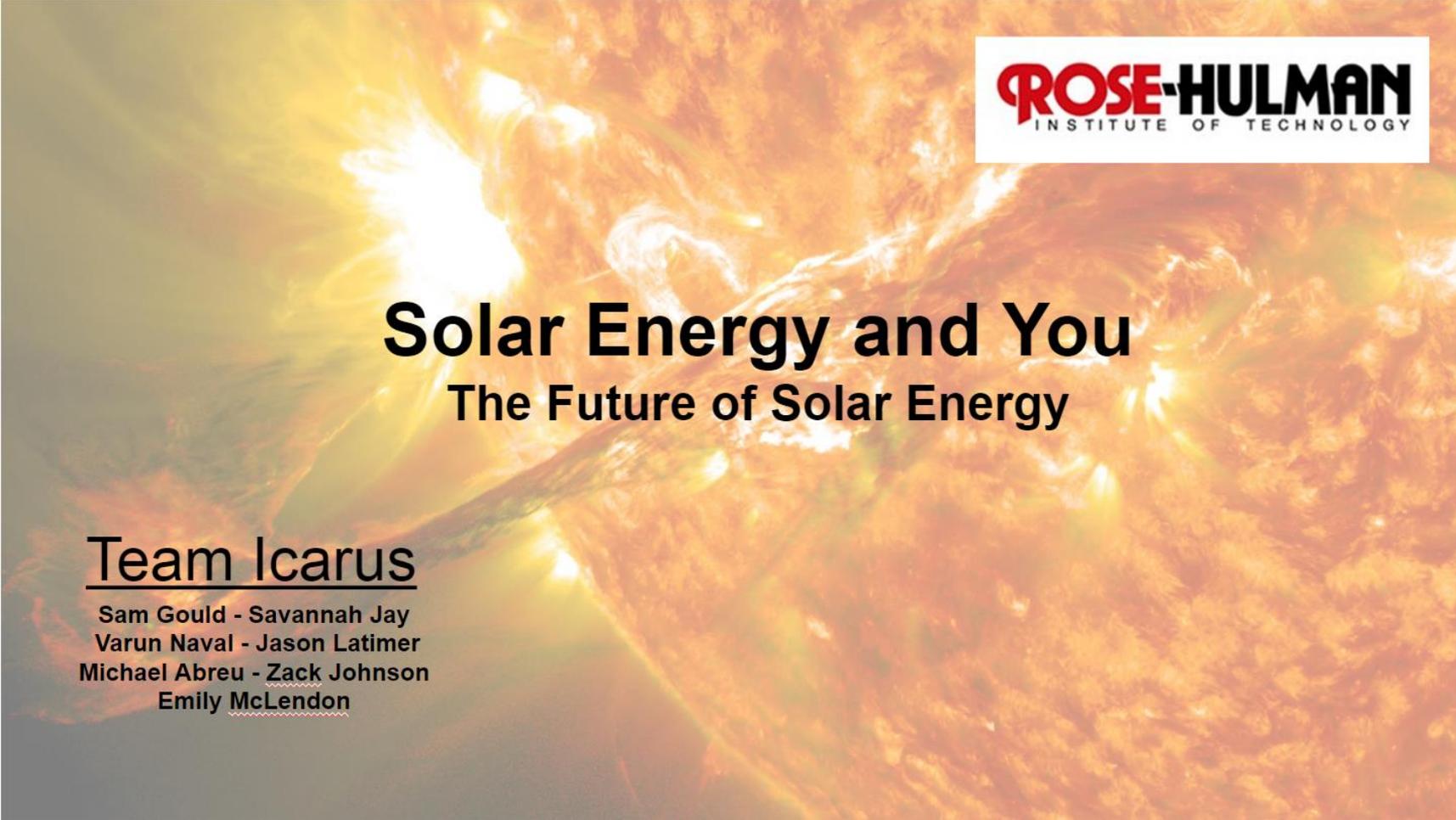
The Earth retains heat from the sun with the greenhouse effect.



The main greenhouse gases are water vapor, carbon dioxide, methane, and ozone

<http://scentoipine.org/gw101-1/>

Appendix D: PowerPoint Slides



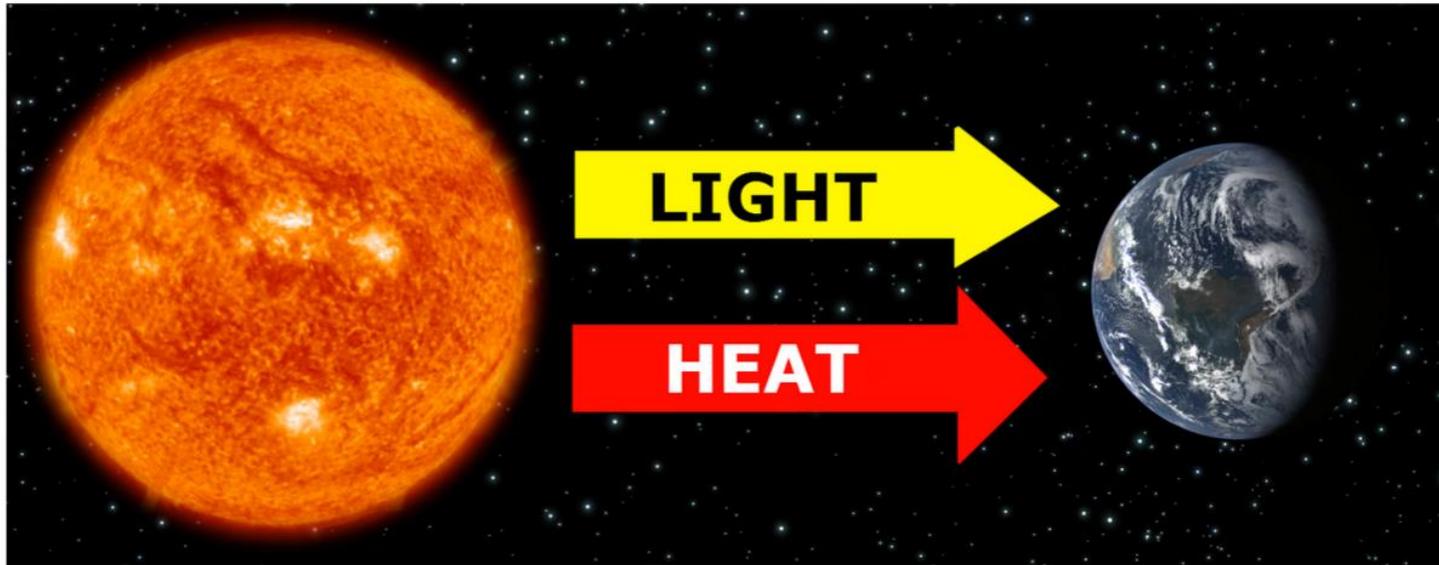
ROSE-HULMAN
INSTITUTE OF TECHNOLOGY

Solar Energy and You

The Future of Solar Energy

Team Icarus
Sam Gould - Savannah Jay
Varun Naval - Jason Latimer
Michael Abreu - Zack Johnson
Emily McLendon

The sun sends energy to the Earth in the form of light and heat.

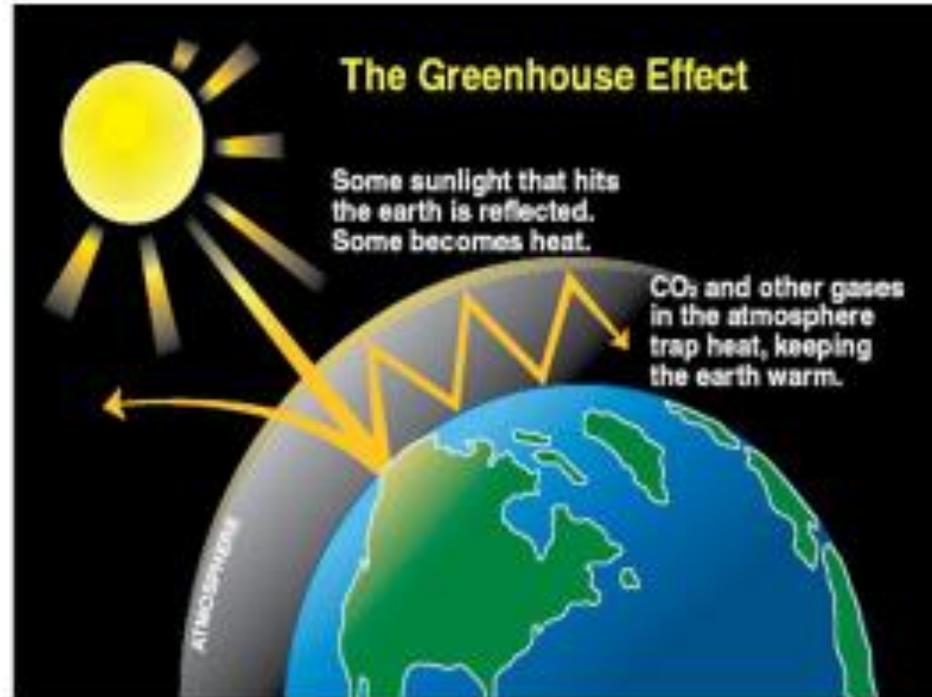


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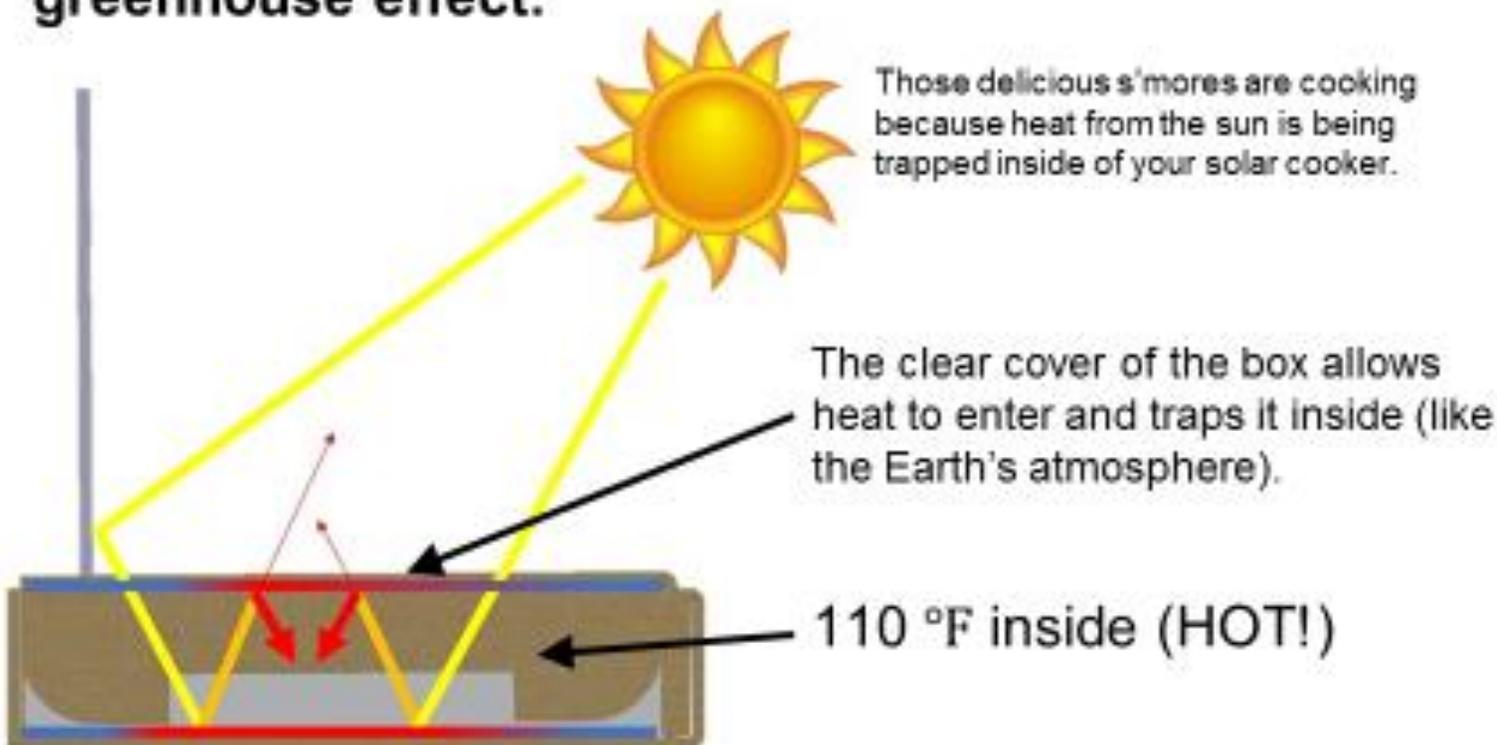
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The main greenhouse gases are water vapor, carbon dioxide, methane, and ozone

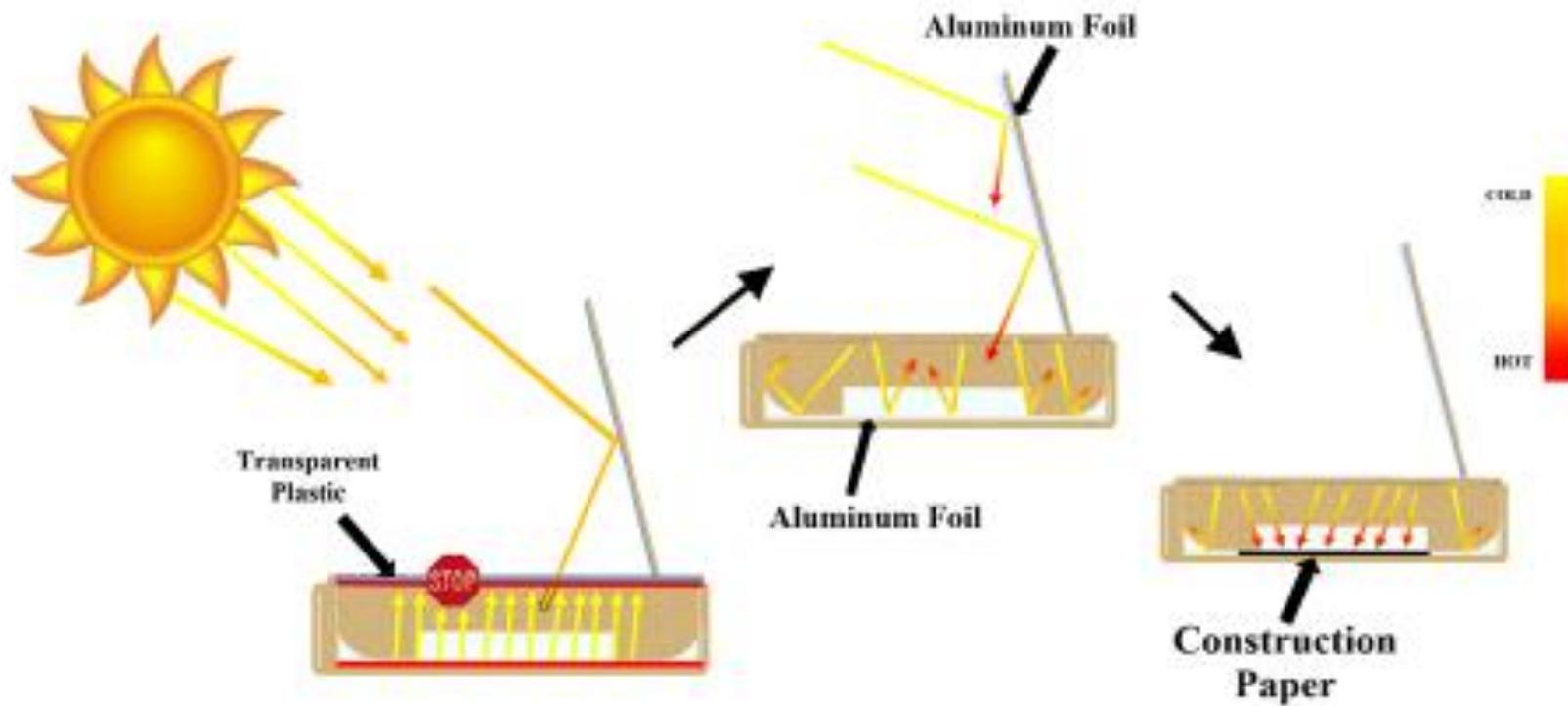


<http://scentofpine.org/gw101-1/>

The solar cooker you built works through the greenhouse effect.



Each part of the solar cooker is designed to make the box hot enough to cook.



We have developed many different types of technology to use solar energy in different ways.

Photovoltaic cells collect light



<http://taskhomerepair.com/tag/solar-power/>

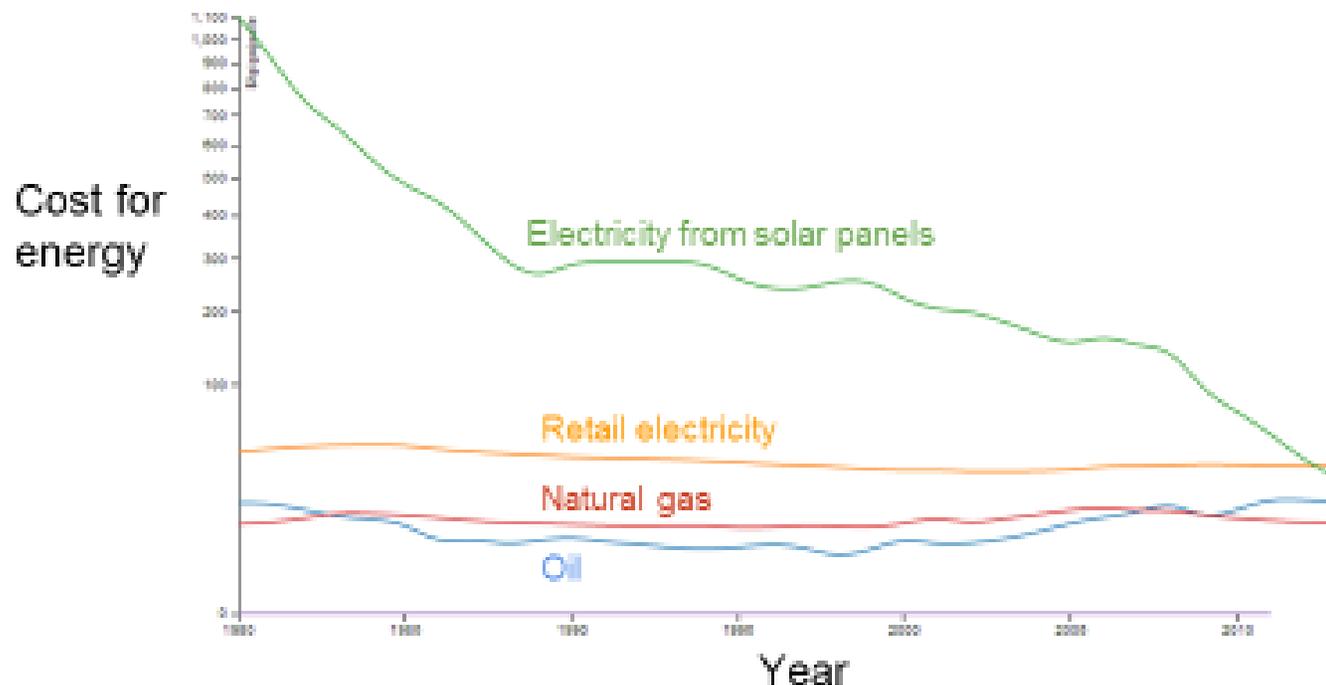
Dish-engine systems collect heat



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

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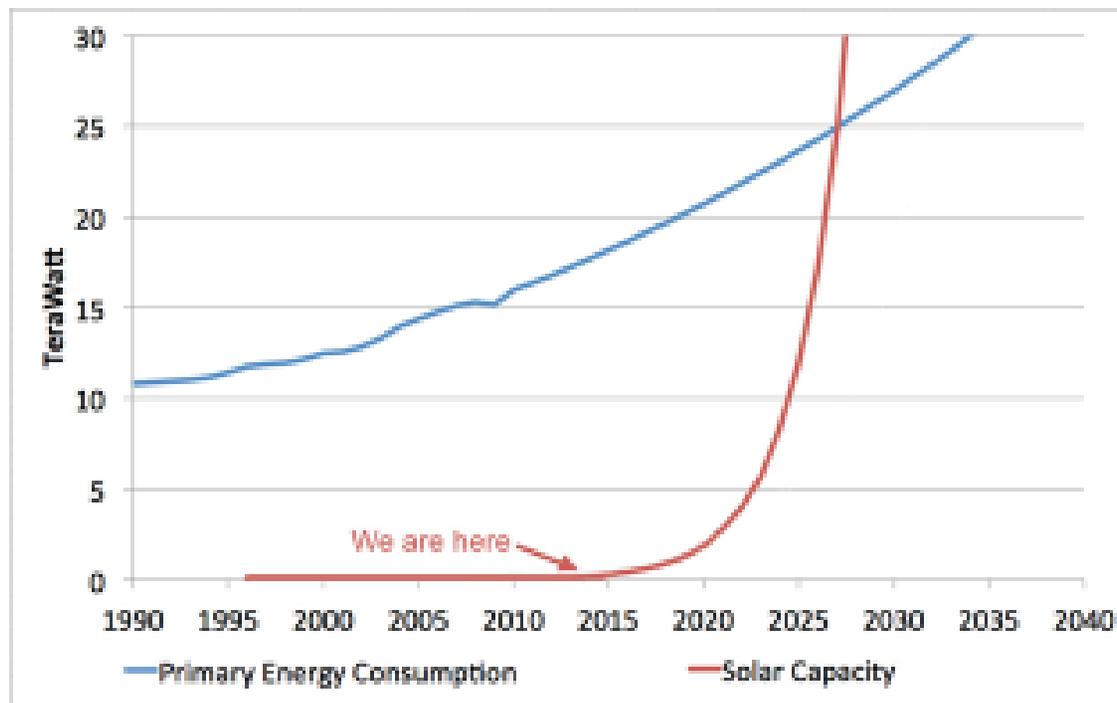
<http://cleantechnica.com/2014/09/04/solar-panel-cost-trends-10-charts/>

Rising rates of electricity will lead to harnessing of renewable energy



Electricity rates are projected to rise by 5% in 2015 which would encourage individuals to harness renewable energy, such as wind and solar, with solar being the most abundant

With the right technology, we could use the sun for all of our energy needs.



<http://solarfinancing.com/disruptive-models/the-solar-economys-business-ecology/>



<http://imgar200.com/1-solar-powered-phone-case/>



<http://www.abc.com/future/story/20130812/solar-powered-record-breaker/>



<http://www.abc.com/future/story/20130812/solar-powered-record-breaker/>

You and Engineering

Engineers design things.

How could we have designed the solar cooker better?