PARABOLIC SOLAR COOKER

The Benefits of using Solar Cookers

Solar cookers save money and fuel

Solar cookers save time

Solar cookers can be made from locally available and recycled materials

Solar cookers are safe, healthy and convenient

Solar cookers can kill disease-causing organisms in water

Traditional foods can be prepared with solar cookers

Solar cookers are easy to transport

Using solar cookers preserves trees, the atmosphere and the soil.

Information

Pamphlet

Parabolic Solar Cookers

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Learn about parabolic solar cookers and box ovens:

- Advantages of cooking with solar energy.
- Average cooking temperatures
- How to build one yourself.
- Mathematics behind the parabola

Individual Highlights:

Why Cook with the Sun?

By Jennifer
Edited by Bart Orlando and Krystal Rogers

The sun sustains life on earth; it is available to everyone daily. There is no cost for solar radiation. Using parabolic, box, or panel cookers means no gas or electricity costs. They are easy to maintain and just as easy to build. With a little planning and some basic mathematical calculations, anyone can own their own solar cooker.

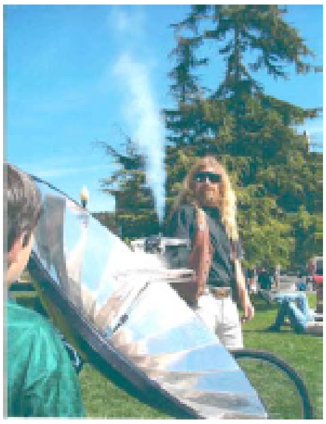
But what are the advantages to using a solar cooker? Besides the economic savings, solar cooking helps in the fight against global warming and deforestation. By using the sun's rays to cook meals, firewood is saved and in many remote areas time is used more usefully than for gathering the necessary firewood needed for wood burning stoves.

In the remote areas of the world a solar cooker can be used to distill drinking water and feed villages. Many people in the world must survive on polluted surface water that is difficult for them to decontaminate. Solar cookers offer an easy solution to this problem.

Often times, it is necessary to collect wood to build large fires in order to purify water. Solar cookers distill water cheaply by using the sun's rays to heat a pot of water. They can be a cost effective solution for those that may otherwise have no resource to purify their drinking water. Solar cookers are also easily transported to remote locations. In many parts of the world they can be easily built using local materials. There are several organizations and programs world wide that promote the construction of these solar cookers.

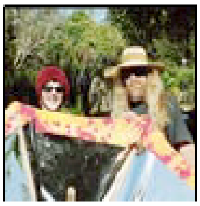
Many ask, how effective are solar cookers? The effectiveness of a solar cooker can vary depending on what materials are used, how well they are crafted, and what type of climate you live in. Cooking time with a parabolic cooker is similar to a conventional stove, and a box oven is similar to a conventional oven. Cooking may take longer is there are fog, clouds or shadow.

Using a solar oven to slow cook a meal means the food is cooked uniformly and doesn't burn no matter how long it is allowed to cook. Since



dishes are allowed to blend and cook in their own juices, the food retains its nutrients. No vitamins or minerals are lost in the process. The only necessity is sunlight; even snowy climates can enjoy the advantages of solar cooking. Parabolic cookers require closer attention because the y can reach much higher temperatures.

One concern for people is the safety of using solar cookers. The most important safety tip for cooking with the sun is NOT TO STARE INTO THE REFLECTED RAYS. YOU SHOULD WEAR DARK SUNGLASSES WITH UV PROTECTION AT ALL TIMES. The sun's rays can burn your eyes and cause blindness if the proper precautions are not taken. Special attention should be given to fire safety as well. Parabolic solar cookers should be covered when not in use.



Holly Bradford & Bart Orlando displaying an umbrella solar cooker

Kendra Cecil and Bart Orlando making popcorn on CCAT's parabolic solar cooker.

"A small burning mirror typical of those used by natural scientists during the 1500's and 1600's." ~Butti & Perlin

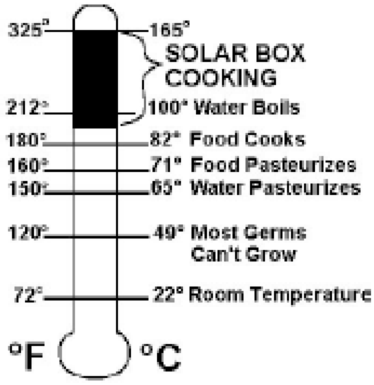
How hot do solar cookers get?

This depends primarily on which type of cooker you are using and the size of cooker you build.

Parabolic cookers can reach extremely high temperatures. Therefore, they are quite capable of reaching average cooking temperatures of between 212° F (100°C) and 350°F (177°C) for frying, boiling and baking foods. Cooking time is affected by the size of the parabolic dish, the size of the cooking pot and outside temperatures.

Parabolic cookers can cook any type of food with a variety of different methods and have shorter heat up times than solar ovens. However, they can be inconvenient to use because of size, cost, risk of fires, and glare.

Typically box ovens can reach temperatures of 350°F (176°C). One advantage of cooking with a solar oven is that you can leave the food to cook without supervision: it is not always necessary to achieve high temperatures to cook food. Cooking at lower temperatures allows the food to cook evenly and remain warm without burning or scorching.



$C° = (5/9)(F - 32)$

$F° = (9/5 \cdot C°) + 32$

The History of Solar Energy Use

The harnessing of solar energy began with the ancients. They were the first to begin using passive solar design in their homes and to use glass to trap solar heat. The use of curved mirrors to concentrate the sun's rays was developed by the Aztecs, Greeks, Romans, and Chinese. The concept of "burning mirrors," for weapons, has been considered for millennia. It was through the Greeks geometric development that they discovered a parabolic surface held the ideal shape for these burning devices.

Awareness of the ability for glass to trap solar heat became increasingly important in the eighteenth century. It was during this century that the first "hot box" was invented by Horace de Saussure. With the advances in science and technology during the Industrial Revolution, came the development of various devices designed to harness solar energy. Solar pumps, solar cookers, solar heat engines, and solar stills are just some of the inventions of this time.

Augustin Mouchot, a professor of mathematics at the Lyceé de Tours, was an important figure in this revolution. He was the first to develop a solar cooker; he was successful in finding a benefactor to fund his research. This lead him to Africa where he invented a portable solar oven for the French troops.

Although these various solar inventions were never very successful on a large scale, they did aide in the advancement of a practical development of this revolutionary technology.

It was in the 1950's that solar cookers began to evolve into the products we see today. The United Nations and other agencies began solar cooker design studies. These studies found that when properly constructed, solar cookers not only cooked food thoroughly and nutritiously, but also were easy to build and use. Programs were created to introduce these designs to remote locations in the hope of aiding those in need.

"One cannot help coming to the conclusion that it would be prudent and wise not to fall asleep regarding this quasi-security. Eventually industry will no longer find in Europe the resources to satisfy its prodigious expansion…Coal will undoubtedly be used up. What will industry do then?"

~Augustin Mochot,

Professor of Mathematics1860

A gimbaled pot support made from 12" used bicycle rim attached to metal tubing.

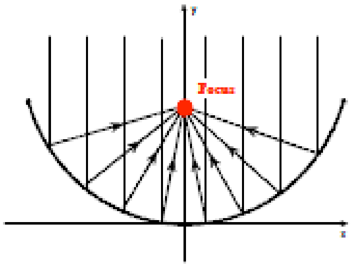
HSU Students using a Beverly shear to cut aluminum sheets into triangular facets.

Why Use a Parabolic Shape?

When a three dimensional parabola (i.e. a paraboloid) is aimed at the sun, all the light that falls upon its mirrored surface is reflected to a point known as the focus. If a black cooking pot is placed at the focus it will absorb the light's energy and become very hot. A satellite dish is an example of a parabaloid that can be made into a cooker. Parabolic Solar cookers heat up quickly and are used like a standard stovetop range to sauté or fry foods, boil water, or even bake bread. They can also be used to generate steam, power sterling engines, crack water to produce H_2 gas, and even plasma matter.

It is easy to see in today's world that this shape is successful in its use. The parabolic shape can be seen in satellite dishes, radio towers, and yes, even in solar cookers around the world. It is simple to say it works, and just as simple to understand how it works.

Parabola Shape



This diagram shows the unique properties of the parabola.

HSU student riveting aluminum to dish.

How to Build a Parabolic Cooker

One of the easiest beginnings for a parabolic solar cooker can be found in thousands of backyards across the United States—the satellite dish, from the large C-band to the small digital dish. What happens to these relics once they are discarded? They are large and awkward and not easily recycled. Building your own solar cooker is a great way to reuse these parabolic-shaped units while reducing waste in the landfill.

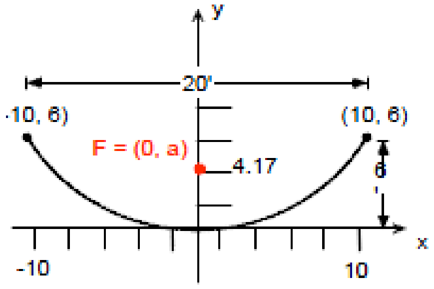
Once you have decided to build your parabolic solar cooker it is important to find a dish that is as concave a s possible in order to have an accessible focus point to cook at. Next, measure your dish and locate your focus. If you have a satellite dish with the receiver/antenna still attached, your work is done for you since these are located at the focus of the dish. However, if you obtain one without it, you will need to make some simple calculations. Use the sample problem on the next page to guide you through this process.

The focus can also be found by direct observation after you have lined the dish with a reflective material. Hold a piece of cardboard close to the center of the dish, then move it up and down toward the sun and back. A circle of light will appear on the underside of the cardboard. When the circle is smallest, the position of the focus is found.

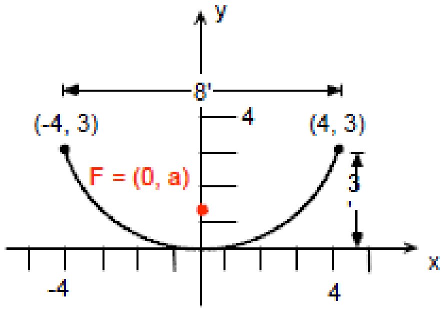
The most popular material used to line the dish is a reflective, mirror-finished, anodised aluminium sheet. These are cut into narrow triangular facets no wider than ten inches, then riveted to the dish. Sheet metal supply companies can be found online or in the phone book. Riveting supplies can be found at a hardware store.

The pot stand, located at the focus, can be made from a used 12" bicycle rim attached to pieces of metal tubing so that the rim and cooking pot can be levelled. Place a grate across the rim to support the pot.

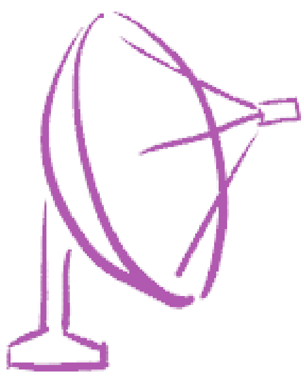
Remember while you are constructing your cooker, NEVER STARE DIRECTLY into the cooker once you have installed your reflecting material. ALWAYS WEAR UV PROTECTIVE DARK SUNGLASSES WHEN WORKING WITH YOUR COOKER!



When building your own parabolic cooker it is important to build your pot stand at the focus. Simply measure the length and depth of your parabolic shape.



Using the rectangular coordinate system allows us to draw the picture and determine mathematically where the focus should be located for maximum usage.



How to Calculate the Focus.

Example 1: A mirror is shaped like a paraboloid of revolution and will be used to concentrate the rays of the sun at its focus, creating a heat source. If the mirror is 20 feet across at it's edge and is 6 feet deep, where will the heat source be concentrated?

Solution: We draw the parabola used to form the dish on a rectangular coordinate system so that the vertex of the parabola is at the origin and its focus is on the positive y-axis.

The form of the equation of the parabola is $x^2 = 4ay$ and its focus is at (0, a).

Since (10, 6) is a point on the graph, the equation is:

$$10^2 = 4a(6)$$
$$100 = 24a$$
$$a = \frac{100}{24} \Rightarrow 4.17\,feet$$

The heat source will concentrate 4.17 feet from the center (vertex) of the dish, in a direct line of sight toward the sun.

Example 2: A satellite dish is shaped like a three-dimensional parabola. The signals that emanate from a satellite strike the surface of the dish and are reflected to a single point, where the receiver is located. (When sunlight strikes the mirrored surface of the dish, it will reflect to the same point. This is where the cooking pot should be located for solar cooking.) If the dish is 8 feet across at its origin and is 3 feet deep at its center, at what position should the receiver be placed?

Solution: We draw the parabola used to form the dish on a rectangular coordinate system so that the vertex of the parabola is at the origin and its focus is on the positive y-axis. The form of the equation of the parabola is $x^2 = 4ay$ and its focus is at (0, a).

Since (4, 3) is a point on the graph, the equation is:

$$4^2 = 4a(3)$$
$$16 = 12a$$
$$a = \frac{4}{3}$$

The receiver should be located 1_ feet from the center (vertex) of the dish, along a direct line of sight toward the sun.

Brown rice cooked in 30 min in a pressure cooker on a parabolic dish.

The pot support on this 6' stainless steel dish is attached to a piece of tubing coming up through the center of the dish.

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We're on the Web!
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The Solar Cook - http://www.solarcook.com/

The Solar Cooking Archive – Sponsored by Solar Cookers International
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Email: info@solarcookers.org website: http://solarcooking.org/

About Our Organization...

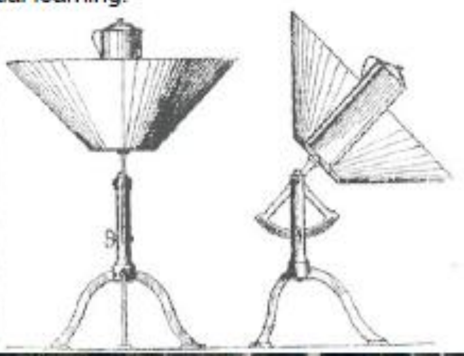
At the Campus Center for Appropriate Technology (CCAT) we value a healthy planet and its ethical treatment. CCAT seeks to demonstrate that living lightly upon Earth is neither difficult nor burdensome.

Purpose

We accomplish our mission by showcasing technologies, which contribute to a healthy environment, sponsoring discussions about the ethical and social consequences of the use of technology, and providing a forum for experiential learning.

Support CCAT

If you are interested in helping further the goals of CCAT, and would like to make a tax-deductible donation, we are a registered non-profit and gladly accept both material and financial contributions.



THE PROBLEM:

A parabolic solar cooker with a surface of 0.80 m^2 turns 45% of the incident energy into calorific energy. Assuming the solar power reaching in that city is 850 W/m^2.

Calculate:

1º) The necessary time to boil 750 ml of water that is initially at 20 ° C

2º) The amount of butane necessary to heat the previous water under the same conditions as well as the amount of CO_2 emitted. State the result in volume, under Standard Ambient Temperature and Pressure.

The fuel used has a calorific value of 40000 kJ/kg and we obtain an output of 60% of the energy of combustion.
Data: 1 kg of butane gas emits 2, 96 kg of CO_2.