The Solar Cooking Archive

The "Minimum" Solar Box Cooker

A great solar oven you can build quickly from two cardboard boxes

Experiments in Seattle and Arizona have proven that solar box cookers can be built more simply than even the simple method we have been using. These discoveries have paved the way for a simpler construction method that allows a cooker to be built in a few hours for very little money.

When we designed this cooker, we named it the "Minimum Solar Box Cooker" because, at the time, it represented the simplest design we could devise. What we didn't communicate with that name was that this is a full-power cooker that works very well, and is in no way "minimum" as far as capabilities.

What You Will Need

- Two cardboard boxes. We would suggest that you use an inner box that is at least 15" x 15" (38cm x 38cm), but bigger is better. The outer box should be larger all around, but it doesn't matter how much bigger, as long as there is a half inch (1.5cm) or more of an airspace between the two boxes. Also note that the distance between the two boxes does not have to be equal all the way around. Also, keep in mind that it is very easy to adjust the size of a cardboard box by cutting and gluing it.
- One sheet of cardboard to make the lid. This piece must be approximately 2" - 3" (4 - 8cm) larger all the way around than the top of the finished cooker.
- One small roll of aluminum foil.
- One can of flat-black spray paint (says on can "non-toxic when dry") or one small jar of black tempera paint. Some people have reported making their own paint out of soot mixed with wheat paste.
- At least 8 ounces of white glue or wheat paste.
- One Reynolds Oven Cooking Bag®. These are available in almost all supermarkets in the U.S.

and they can be mail-ordered from Solar Cookers International. They are rated for 400° F (204.4° C) so they are perfect for solar cooking. They are not UV-resistant; thus they will become more brittle and opaque over time and may need to be replaced periodically. A sheet of glass can also be used, but this is more expensive and fragile, and doesn't offer that much better cooking except on windy days.

Building the Base

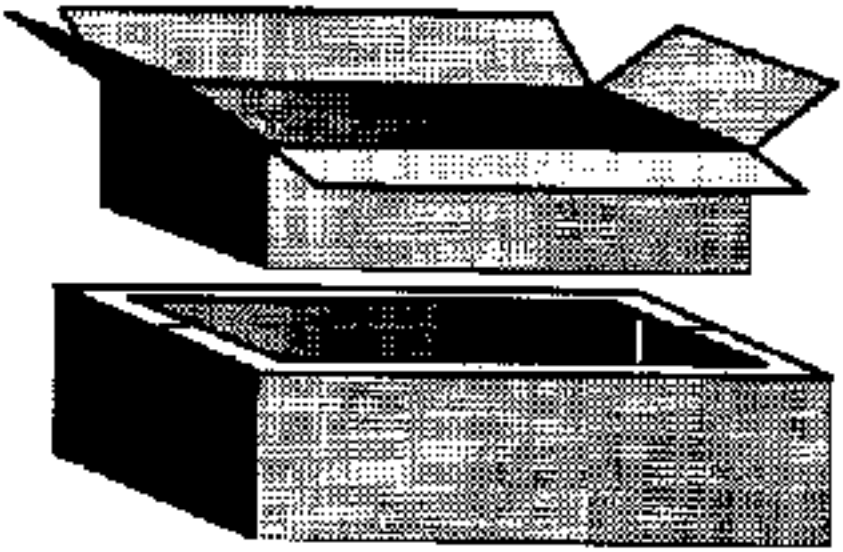

Figure 1

Fold the top flaps closed on the outer box and set the inner box on top and trace a line around it onto the top of the outer box, Remove the inner box and cut along this line to form a hole in the top of the outer box (Figure 1).

Decide how deep you want your oven to be (about 1" or 2.5cm bigger than your largest pot and at least 1" shorter than the outer box) and slit the corners of the inner box with a knife down to that height. Fold each side down forming extended flaps (Figure 2). Folding is smoother if you first draw a firm line from the end of one cut to the other where the folds are to go.

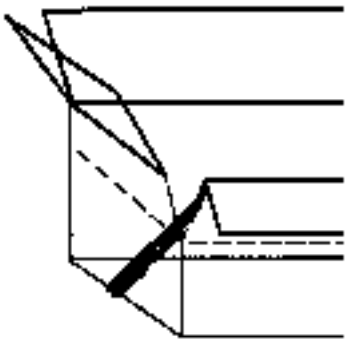

Figure 2

Glue aluminum foil to the inside of both boxes and also to the inside of the remaining top flaps of the outer box. Don't waste your time being neat on the outer box, since it will never be seen, nor will it experience any wear. The inner box will be visible even after assembly, so if it matters to you, you might want to take more time here. Glue the top flaps closed on the outer box.

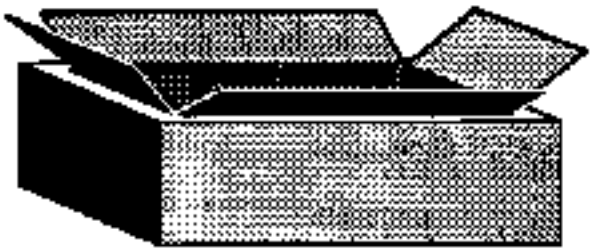

Figure 3

Place some wads of crumpled newspaper into the outer box so that when you set the inner box down inside the hole in the outer box, the flaps on the inner box just touch the top of the outer box (Figure 3). Glue these flaps onto the top of the outer box. Trim the excess flap length to be even with the perimeter of the outer box.

Finally, to make the drip pan, cut a piece of cardboard, the same size as the bottom of the interior of the oven and apply foil to one side. Paint this foiled side black and allow it to dry. Put this in the oven (black side up) and place your pots on it when cooking. The base is now

finished.

Building the Removable Lid

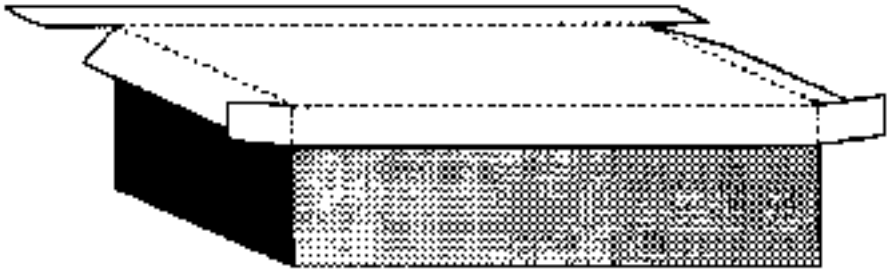

Figure 4

Take the large sheet of cardboard and lay it on top of the base. Trace its outline and then cut and fold down the edges to form a lip of about 3" (7.5cm). Fold the corner flaps around and glue to the side lid flaps. (Figure 4). Orient the corrugations so that they go from left to right as you face the oven so that later the prop may be inserted into the corrugations (Figure 6). One trick you can use to make the lid fit well is to lay the pencil or pen against the side of the box when marking (Figure 5). Don't glue this lid to the box; you'll need to remove it to move pots in and out of the oven.

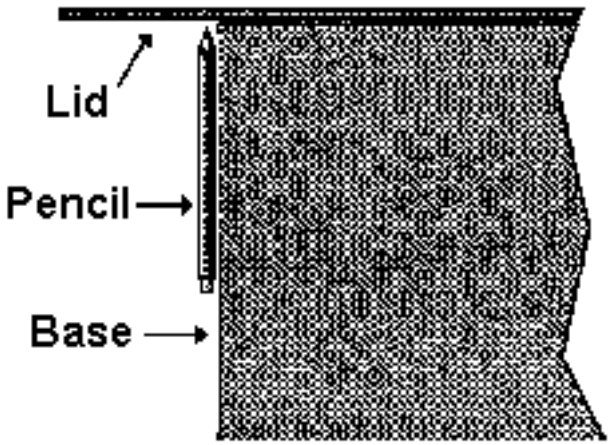

Figure 5

To make the reflector flap, draw a line on the lid, forming a rectangle the same size as the oven opening. Cut around three sides and fold the resulting flap up forming the reflector (Figure 6). Foil this flap on the inside.

To make a prop bend a 12" (30cm) piece of hanger wire as indicated in Figure 6. This can then be inserted into the corrugations as shown.

Next, turn the lid upside-down and glue the oven bag (or other glazing material) in place. We have had great success using the turkey size oven bag (19" x 23 1/2", 47.5cm x 58.5cm) applied as is, i.e., without opening it up. This makes a double layer of plastic. The two layers tend to separate from each other to form an airspace as the oven cooks. When using this method, it is important to also glue the bag closed on its open end. This stops water vapor from entering the bag and condensing. Alternately you can cut any size oven bag open to form a flat sheet large enough to cover the oven opening.

Improving Efficiency

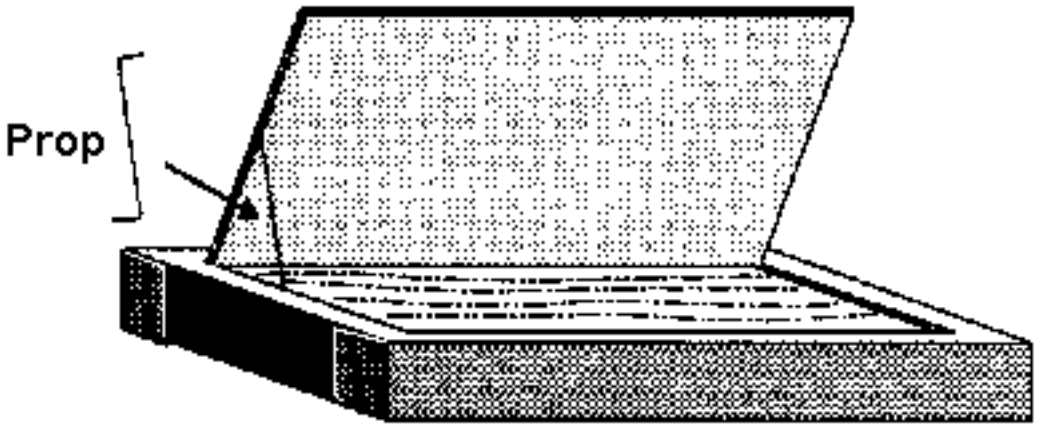

Figure 6

The oven you have built should cook fine during most of the solar season. If you would like to improve the efficiency to be able to cook on more marginal days, you can modify your oven in any or all of the following ways:

- Make pieces of foiled cardboard the same size as the oven sides and place these in the wall spaces.
- Make a new reflector the size of the entire lid (see photo).
- Make the drip pan using sheet metal, such as aluminum flashing. Paint this black and elevate this off the bottom of the oven slightly with small cardboard strips.

Here are some good documents to read to learn more about solar cooking:

- Solar Cooking Frequently-Asked Questions (FAQ)
- Developing an Intuitive Feel for the Dynamics of Solar Cooking
- Principles of Solar Box Cooker Design
- Solar Cooking Hints
- Three Reasons Solar Cooking Deserves New Attention
- Solar Cookbooks

For more information contact:

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This document is published on Solar Cooking Archive at http://solarcooking.org/minimum.htm

The Solar Cooking Archive

The "Easy Lid" Cooker

Designed by Chao Tan and Tom Sponheim

Aqui en Español

Although designs for cardboard cookers have gotten simpler, fitting a lid can still be difficult and time consuming. In this version, a lid is formed automatically from the outer box.

Making the Base

1. Take a large box and cut it in half as shown in Figure 1. Set one half aside to be used for the lid. The other half becomes the base.

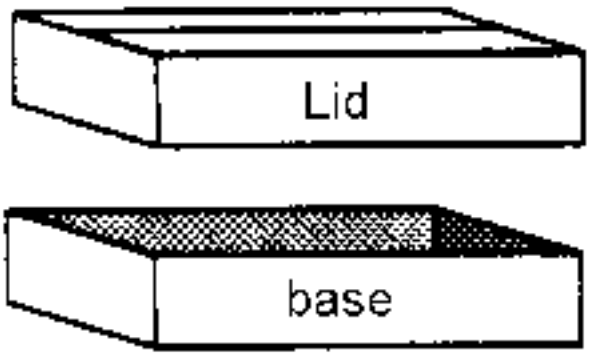

Figure 1

2. Fold an extra cardboard piece so that it forms a liner around the inside of the base (see Figure 2).

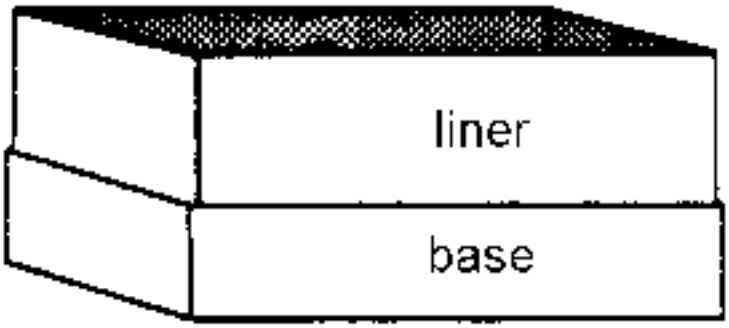

Figure 2

3. Use the lid piece as shown in Figure 3 to mark a line around the liner.

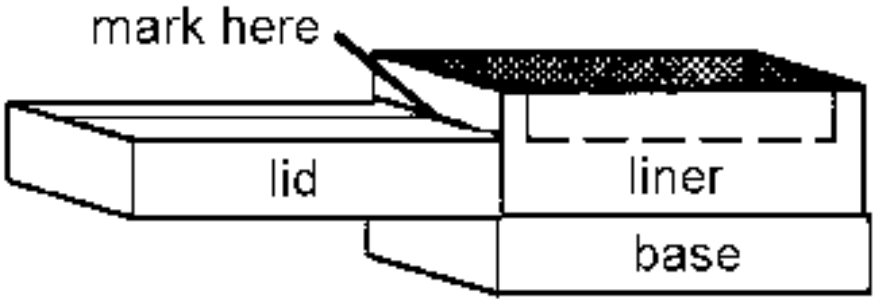

Figure 3

4. Cut along this line, leaving the four tabs as shown in Figure 4.

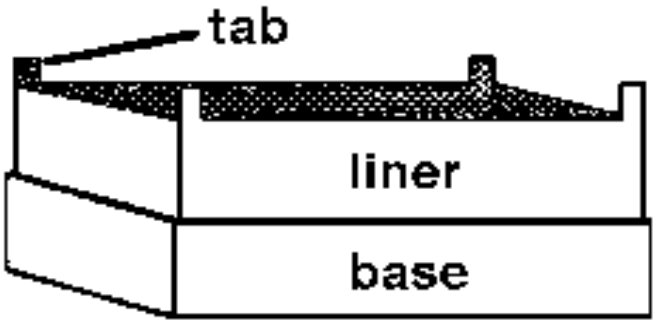

Figure 4

5. Glue aluminum foil to the inside of the liner and to the bottom of the outer box inside.
6. Set a smaller (inner) box into the opening formed by the liner until the flaps of the smaller box are horizontal and flush with the top of the liner (see Figure 5). Place some wads of newspaper between the two boxes for support.

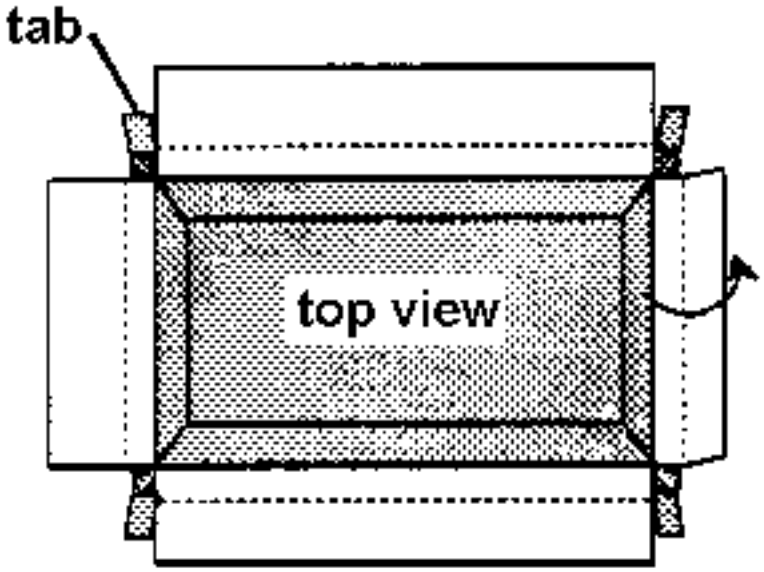

Figure 5

7. Mark the underside of the flaps of the smaller box using the liner as a guide.
8. Fold these flaps down to fit down around the top of the liner and tuck them into the space between the base and the liner (see Figure 6).
9. Fold the tabs over and tuck them under the flaps of the inner box so that they obstruct the holes in the four corners (see Figure 6).

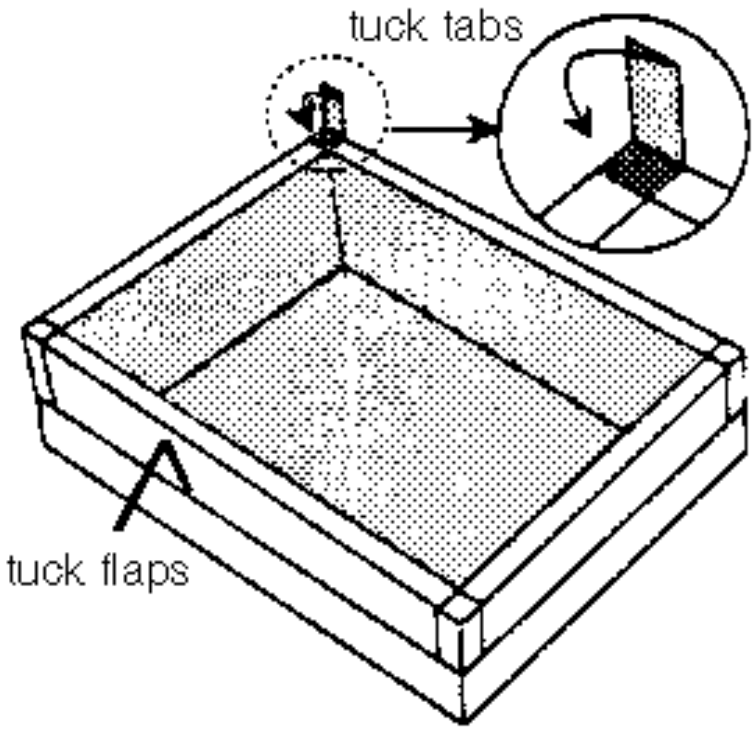

Figure 6

10. Now glue these pieces together in their present configuration.
11. As the glue is drying, line the inside of the inner box with aluminum foil.

Finishing the Lid

1. Measure the width of the walls of the base and use these measurements to calculate where to make the cuts that form the reflector in Figure 7. Only cut on three sides. The reflector is folded up using the fourth side as a hinge.
2. Glue plastic or glass in place on the underside of the lid. If you are using glass, sandwich the glass using extra strips of cardboard. Allow to dry.

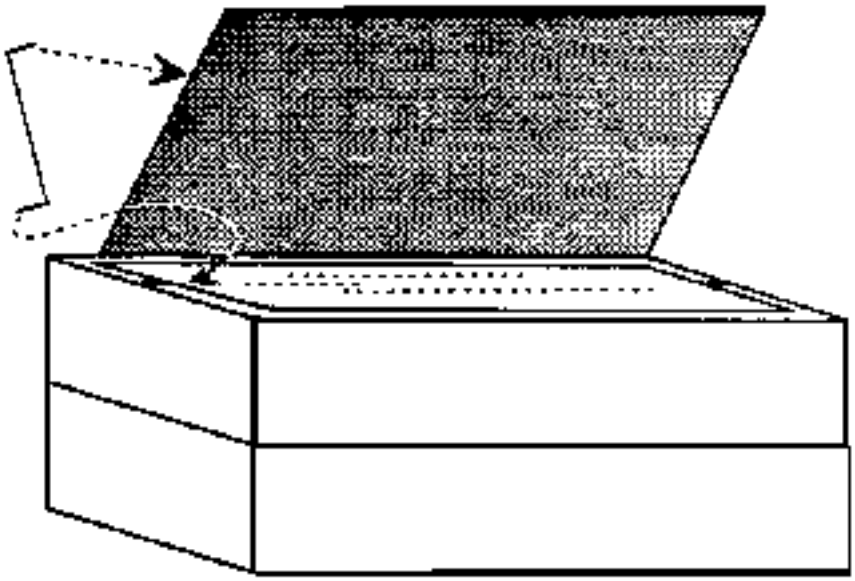

Figure 7

3. Bend the ends of the wire as shown in Figure 7 and insert these into the corrugations on the lid and on the reflector to prop open the latter.
4. Paint the sheet metal (or cardboard) piece black and place it into the inside of the oven.

Improving Efficiency

1. Glue thin strips of cardboard underneath the sheet metal (or cardboard) piece to elevate it off of the bottom of the oven slightly.
2. Cut off the reflector and replace it with one that is as large as (or larger than) the entire lid. This reflects light into the oven more reliably.
3. Turn the oven over and open the bottom flaps. Place one foiled cardboard panel into each airspace to divide each into two spaces. The foiled side should face the center of the oven.

For more information contact:

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or email: info@solarcookers.org

The Solar Cooking Archive

How to Make a Collapsible Solar Box Cooker

It is pretty simple to make a collapsible solar box cooker from two cardboard boxes. The trick is to cut off the bottom of each box, creating two pieces: the base; and the sides. After that, it is possible to collapse the box by folding up its sides and laying them into the base; or, when you want to use the cooker, insert the sides right into the base (Figure 1), extend the accordion sides, and fold the flaps down inside (Figure 2).

The lid fits perfectly onto the base of the larger box, so that, when collapsed, the cooker takes the form of a convenient, briefcase-size box.

The instructions below only show how to make the collapsing box part of the cooker. The top can be built following the instructions for the lid on the Minimum Solar Box Cooker.

Click any of the photos below to see a larger version:

Figure 1

Cut the bottom off the larger box. Make an accordion fold in each of the shorter sides. Then place the sides down inside the base.

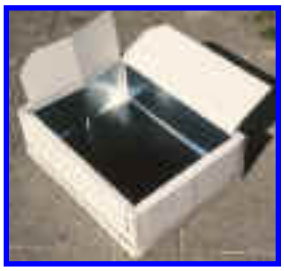
 Figure 2	Make two creases in each flap so that once they are folded down, they form a double wall with about a 1" (2cm - 3cm) airspace. Note that you will have to trim down the shorter flaps on each side so that they can be folded down after the longer sides have already been folded down.
 Figure 3	Place two cardboard hoops into the bottom of the larger box. These will maintain the airspace between the larger box and the smaller box.
 Figure 4	Cut the bottom off the smaller box and place it inside the larger box so that it rests on the cardboard hoops. Place the black metal drip pan into this base.
 Figure 5	Prepare the sides of the smaller box as you did with the sides of the larger box. Then set them down inside the assembly so that they go inside the base of the smaller box.
 Figure 6	Then fold down the sides of the smaller box so that they tuck into the base of the larger box. Trimming off one corner on each flap makes the tucking much easier.

 Figure 7	Now you have a completed base.
 Figure 8	Place the lid on, and you're ready to cook. You can make any size cooker using this method.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http://solarcooking.org/collapsible-box.htm

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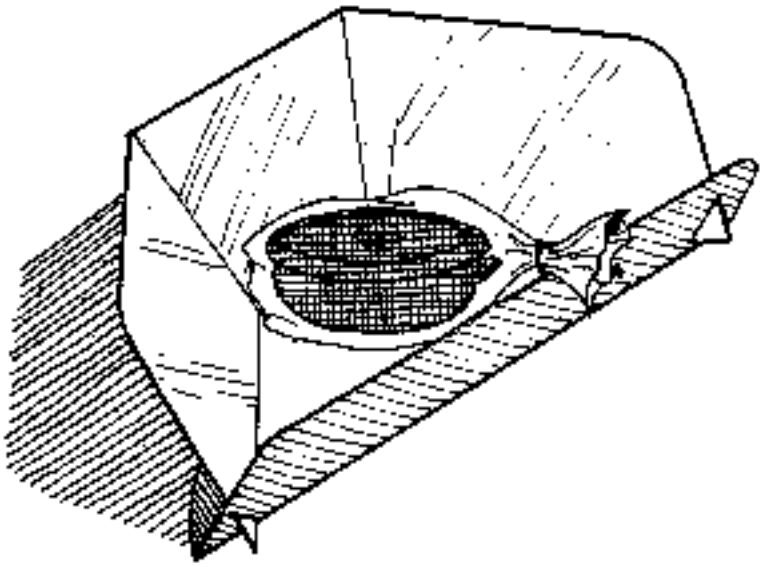
The "Cookit" Foldable Family Panel

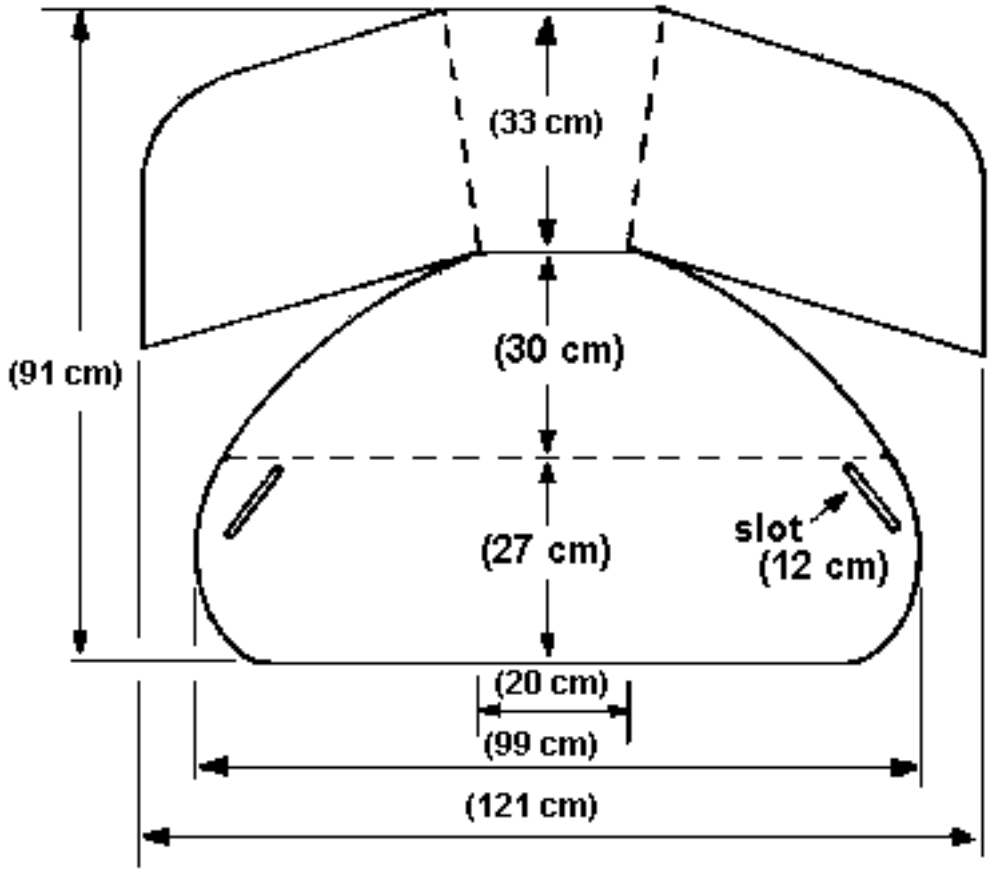


The Foldable Family Panel is neither a "solar oven" or "curved concentrator" but a happy hybrid. Its utter simplicity belies its powerful cooking power. Its low cost brings solar cooking to a much wider market of people.

It is handy for cooking food, baking breads, pasteurizing water, and teaching the basics of solar energy.

Co-developers are Roger Bernard of France and Barbara Kerr of the USA, with work also by Edwin Pejack, Jay Campbell, and Bev Blum of Solar Cookers International. Extensive field tests in the USA and with refugees in Kenya confirm its performance, convenience, low cost, acceptance, and adaptability to diverse needs.

Construction



Start with a big piece of cardboard about 1m x 1.33m (3'x 4'). Cut and fold as shown. The angles and folds shown are best, but small variations are OK.

Hints: To make clean straight folds in cardboard, first make a crease along the line with a blunt edge such as a spoon handle, then fold against a firm straight edge.

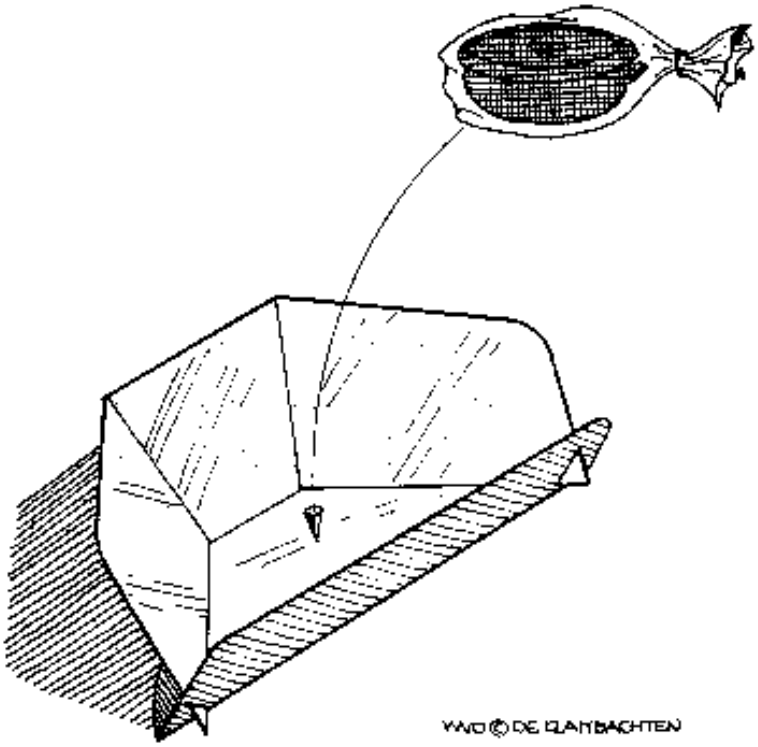
Make the slots a little too small and narrow so that they fit snugly to hold up the front panel.

Glue aluminum foil on the side that will form the inside surfaces when the oven is set up for cooking.

To set up, lay panel flat with shiny side up. Fold up front and back parts and fit back corners into the slots in front.

You're ready to cook! Put your food into a dark-colored pot. Then place the pot inside a plastic bag (an oven cooking bag will withstand the heat best). Close the open end of the bag and place pot and bag into the center of the cooker.

You can order a pre-built Cookit here.



Tips and Tricks

-  Dr. Steven Jones found that raising the pot on a wire frame improved cooking in a panel cooker.
-  Wietske Jongbloed created a simple frame to protect plastic bags from damage.

Questions or comments:
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http://solarcooking.org/cookit.htm

The Solar Cooking Archive

The Bernard Solar Panel Cooker

A simple, portable model that may open new horizons

It is generally assumed that a solar cooker should have some minimal capacity in order to work properly. For instance, in the booklet *Your Own Solar Box*, Solar Cookers International (SCI) recommends an inner box at least 45 cm X 55 cm (18" x 22"). The result is a rather large box, well suited to family use, but which can prove unnecessarily cumbersome in some cases

Smaller cookers would be appreciated by the following:

- people living or traveling alone,
- people living with their family but needing a special diet,
- elderly people who feel reluctant to carry a heavy box,
- teenagers wishing to build and experiment their own first cooker.

If you belong to one of these categories, here is how you can build a cheap and fairly efficient small cooker.

Choose a cardboard box (figure 1) with the height BC greater than the width DC. For example, in my own cooker BC = 30 cm (about 12"), DC = 23 cm (9") and CG = 25 cm (10").

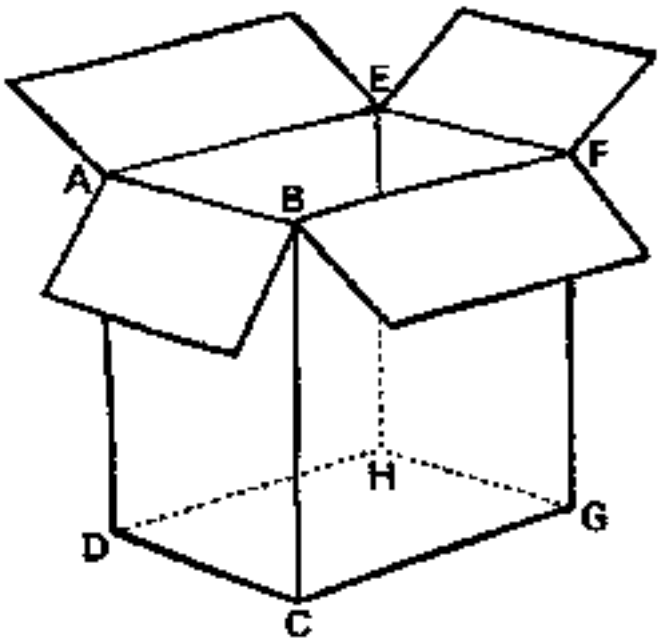

Figure 1

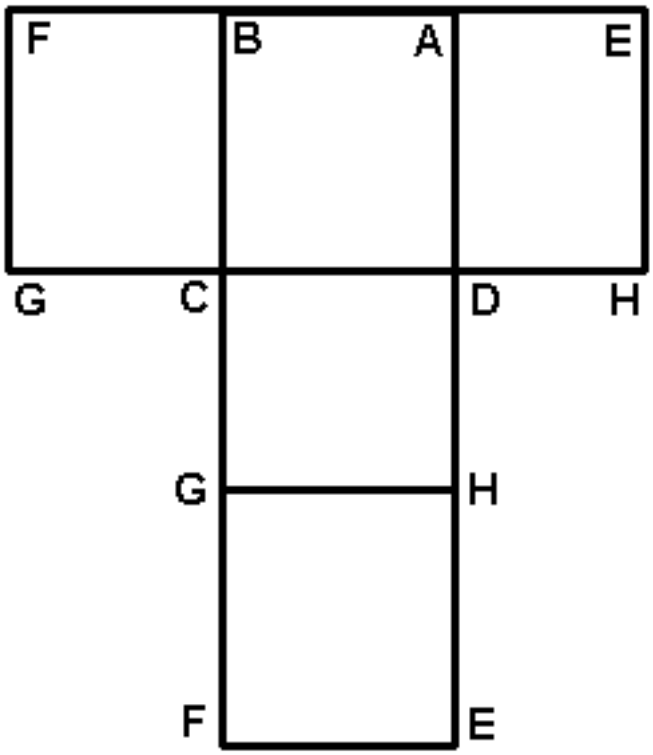

Figure 2

Cut the flaps off the box. Then cut the seams along FG and GC. Do the same on the other side along EH and HD. The carton folds out to a flat assembly of five rectangles as shown in figure 2 (Letters appearing twice on this figure indicate two points which were the same point before cutting). If the cardboard is thin, reinforce the rectangle CDHG by gluing another rectangular piece of cardboard onto it to better insulate the bottom of the pot. Then glue aluminum foil to one side of the five rectangles (the inside of the original box).

Now, keeping the rectangle CDHG horizontal on a table or on level ground, position the other rectangles as shown in figure 3. The front "mirror" EFGH is tilted about 30 degrees above the horizontal plane (Put a rock or other object under it). The "wing mirrors" BFGC and AEHD are vertical, the angles GCG and HDH being about 45 degrees. A few rocks as shown in figure 4 will be helpful, especially in windy weather.

The black cooking pot is put on the horizontal base CDHG and covered with a colorless glass salad-bowl [or oven cooking bag, see next article, ed.] replacing the glass window of a classical box cooker. To avoid convective heat losses, the diameter of the salad-bowl should not exceed the width CD.

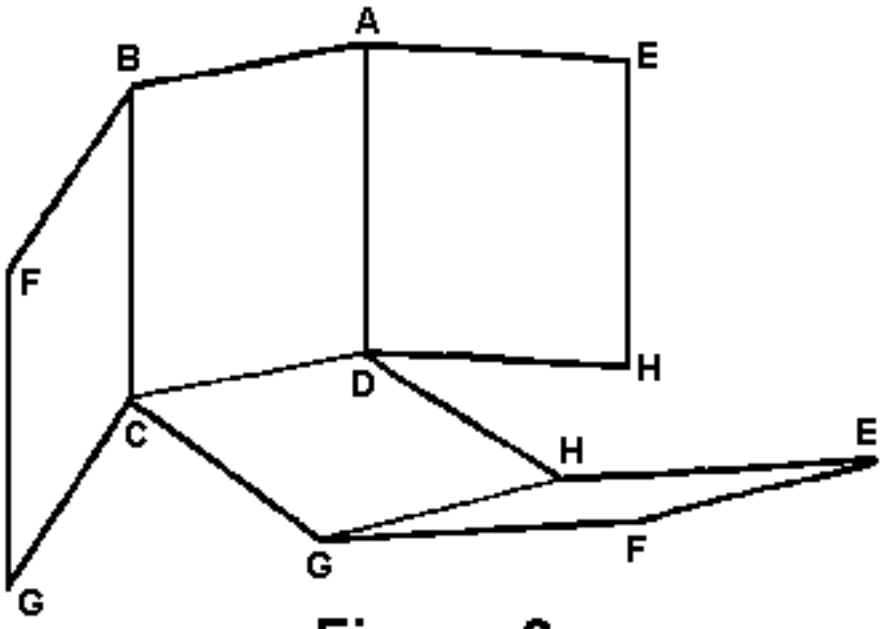

Figure 3

A more convenient way of keeping the reflective system in good shape is to mount the panels on a wooden board in which you will drive a few nails on each side of GC and HD to maintain the wing mirrors in their correct position (see figure 5).

Although this cooker uses (slightly) concentrated sunlight, it is not necessary to worry about a constant tracking of the sun. A big vertical nail at the front of the board can act as an "orientation indicator". Its shadow should be seen on the white triangular piece of paper glued on the board (figure) and whose 30 degree angle roughly corresponded to 2 hours of absentee cooking in my experiments. Most of the following results have been obtained without any readjustment of the cooker orientation.

All cooking was done in an aluminum pot painted black. Scrounged glass jars may be used, even without the salad-bowl, but cooking times are increased.

The latitude of Paris is about 45 degrees. When cooking at lower latitudes the vertical reflectors become less effective; it remains to be tested whether this design will work as well there. On the other hand, people living at latitudes above 40 degrees could find it more efficient than a simple, one-reflector box cooker. I'm interested in knowing the results obtained by readers who live in other parts of the world.

Roger Bernard can be contacted at

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Barbara Kerr Tests The Solar Panel Cooker

I am really excited by the opportunities opened up by Roger Bernard's panel cooker design. We have

known that multiple reflectors can be used to concentrate solar radiation, but until I watched my lentil stew bubbling under the glass salad bowl, I did not see this as a serious cooker. Suddenly, I realized that an oven cooking bag could be used in place of the salad bowl. This would provide a very abbreviated solar "box." All we have learned over the years with box-type cookers could be helpful in utilizing Solar Panel Cookers (SPCs). Now we may have both our "oven" and our "hot plate."

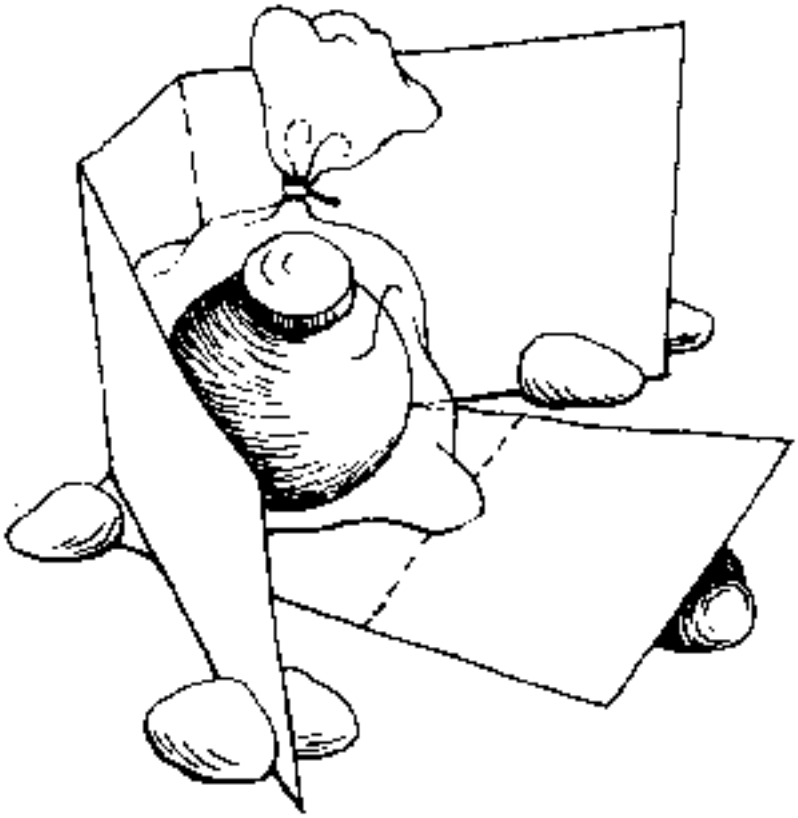
By limiting ourselves to flat foil-covered panels, the danger of eye damage is greatly reduced but remains a problem. Retinal damage, which can occur when sunlight shines into the eyes, is not painful. You cannot tell it is happening, but a retinal burn produces permanent damage and can result in blindness. Be extremely careful if using anything that concentrates the light or reflects the sunlight directly into your eyes.

The first cooker I made based on Roger Bernard's specifications would not fold neatly. The illustrations show a slight modification of Roger's design. Since the panels are all the same size, they fold to form a flat packet which is so small and light-weight that it can be used by backpackers and others who do not have space for much storage. The extra cuts and folds also provide areas where rocks can be placed to anchor the panels without blocking any sunshine. Our winds are fierce and unpredictable! I have found that a cardboard SPC in this configuration tolerates the wind very well.

Place the cooking pot in an oven cooking bag with the opening at the top so you can open the bag, check the food and seal it again without disturbing the cooking. And that part of the bag is usually dry. This is important because food in a panel cooker usually does need to be stirred and checked, since the heat is not as even.

First I closed the baking bags with clothes pins--too heavy and bulky. Then with paper clips tore up the baking bag which otherwise was good for many uses. Then with a thin piece of wire worked well but the twisted wire broke after several uses. Now I am using wire but simply wrapping it tightly around the baking bag top, without twisting. Since there is no pressure, it works fine and the twist ties last a long time.

Too often I have found jars or pots have vigorously boiled over, spilling juice and making a mess. Got to remember to allow more space at the top to contain a boil, at least until I get a handle on when this is going to happen. A delightful problem. Food does not have the delicately enhanced flavor of SBC cooked food, probably because of the higher temperatures.



Then I noticed a cold spot on the foiled reflector directly under a pot and remembered the advantage the University of Washington engineers found through elevating the SBC tray off the cardboard bottom. I looked around the kitchen for an "elevator" and seized on canning rings. It is clear that pots heat faster when sitting on a canning ring than when sitting on the foiled cardboard. Darkened canning rings work better than shiny, of course. But the center is dark and I wondered if it would help to get light to shine under the pot. I put three little pebbles, dark and oiled, under a pot. That seems to work even better. I like that . . . three little pebbles used in memory of the historic three stone fire that has served humanity for thousands of years. Women, nostalgic for the wood fire where there is no more wood, might even take tiny pieces of wood and form a little "fire" within the pebbles under the pot. It would keep us from feeling so torn away from roots.

Solar cooking continues to get simpler. I have put major attention on simple solar cooker designs for 20 years, working to have them easier and more accessible to everyone. Today, I held a Solar Panel Cooker and realized our 20 year mountain of work had truly brought forth a mouse. A mighty mouse! Simplicity is so difficult...difficult to see, not difficult to do, once the idea forms. I think that box-style cookers will remain part of the solar kitchen where time, material and circumstances dictate, but the SPC has opened up a new level of simplicity.

We are doing pretty well with reducing the materials needed to solar cook. If only we could eliminate the need for oven cooking bags of heat-resistant nylon. I used regular kitchen plastic bags and they seemed to hold up under the heat for several cooking times. But January 12 was brighter, the air was warmer, and three different kinds of regular plastic bags melted. I guess we will have to stick with baking bags . . . too bad. But the baking bags I started with two months ago are still in good shape, having cooked many dishes and been washed and dried many times. Perhaps they can be obtained wholesale and distributed one or two at a time where they are not available in stores. We should be able to get them wholesale if someone puts a little effort into it.

It seems that "open-box" cookers will now be an integral part of serious solar cooking. It will just take finding out specifically how to use them.

Please send your findings and comments to me as well as to Roger Bernard. We'll keep everyone else up-to-date through Solar Box Journal.

Barbara Kerr
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The Solar Cooking Archive

The Reflective Open Box Solar Cooker

Roger Bernard offers a new compact reflective cooker design

I have been very impressed to read, in SBJ #17, that the solar panel cooker (SPC) idea, as publicized by Barbara Kerr and myself in the preceding issue, had met with an abundant response. Even negative results can be of interest when we seek to understand them. For instance, in the comment, "I used a "turkey - size" oven cooking bag and a dark ceramic teapot. Nothing!", there are two interesting clues. First the ceramic teapot was not a good choice because ceramic can be a bad conductor of heat [depending on its density, Ed.]. Food can remain lukewarm, even if the pot is very hot on the outside. And secondly, a turkey is an enormous bird, and using a bag appropriate to hold it may mean that the quantity of food could have been too big for the cooker.

Let us not forget that the SPC was designed as a substitute for the traditional box for small quantities of food. The dimensions given for my prototype in SBJ #16 are appropriate only when cooking for one person.

During the 1994 summer, I somewhat improved the SPC's convenience and efficiency by introducing two changes: a new system for creating the greenhouse effect and a more compact design.

Undoubtedly, oven bags are unbeatable for their lightness, but in my city (Lyon, 500,000 inhabitants) there are no oven bags available in the supermarkets. On the other hand, Pyrex salad bowls are very easy to find everywhere in France--even in small towns. Their price (about $4 US) is ten times the price on an oven bag, but they can be used hundreds of times for solar cooking as well as for other purposes in the kitchen. For traveling, however, they are relatively heavy and cumbersome.

Salad bowls and oven bags share the following disadvantages: they hamper access to the food, and they retain the moisture coming from the heated food and need periodic drying [see Tips and Tricks, Page 3]. These drawbacks can be avoided if we put only the lower part of the cooking pot inside of a glazing (figure 1), instead of the whole pot with its lid.

Figure 1

This can be done by placing the dark pot into a glass dish whose diameter is slightly larger than that of the pot.

Obviously the advantages of such a system are partially offset by extra heat loss from the uninsulated lid. By raising the pot off the ground a further gain is achieved. In fact, my experiments have shown that cooking times with this new system are no longer than with the original design with a salad bowl up-turned over the pot.

In order to improve stability, I reduced the number of panels from five to four. A pleasant surprise was that the removal of the central back panel not only resulted in a more compact and stable cooker, but also improved the efficiency of the reflective surfaces, by permitting multiple reflections between the two remaining vertical panels. This peculiar assembly I propose to call a "reflective open box" (ROB) to distinguish it from the original solar panel cooker (SPC).

Construction

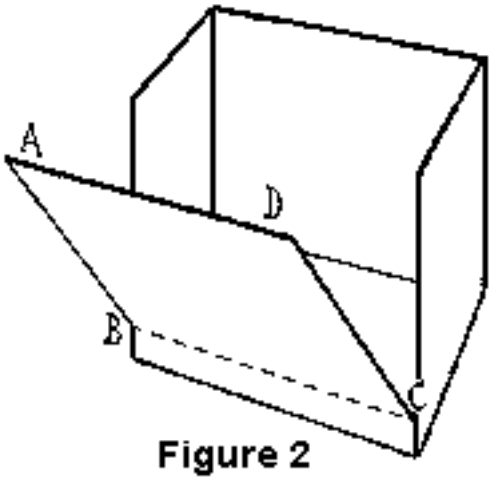

Figure 2

To make an ROB, start with a rectangular, rather tall, cardboard box (see below for dimensions). On one of the broader sides, draw a horizontal line (BC) about two inches above the bottom (figure 2) and cut the seams along AB (stop at B) and DC (stop at C). Fold down the front panel ABCD using BC as a hinge. Stack a few rectangular pieces of cardboard in the bottom of the box, to raise the floor level up to the level of BC.

Cut and fold another piece of cardboard so that it can be inserted into the box to form panels 1 and 2 in figure 3. The angle formed by these panels is adjustable at time of construction. Smaller angles concentrate the sun more, but require more frequent adjustment to follow the sun. A good compromise seems to be any angle between 60 and 90 degrees. Cover this piece with aluminum foil and glue or staple it in place. Apply aluminum foil to panels 3 and 4 as well.

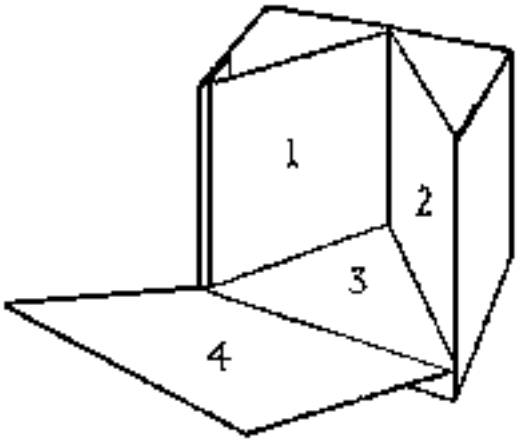

Figure 3

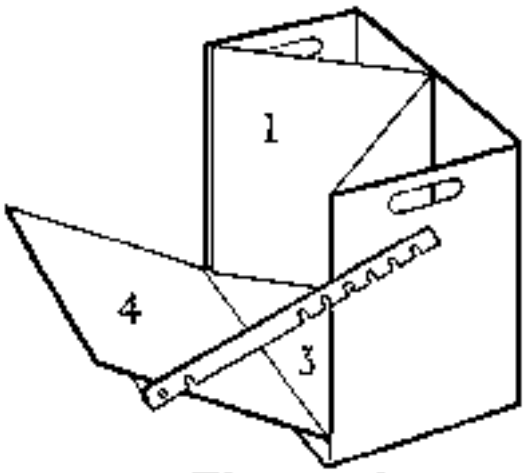

Figure 4

The ROB shown in the photograph has the following over-all dimensions: Length: 46 cm (18"), Width: 32 cm (12.5"), and height: 42 cm (16.5"). These dimensions correspond to a reflective area of about 5,000 sq. cm. (770 sq. in.) which proved sufficient to cook for two persons.

A wooden prop can be used to adjust the front panel (figure 4). The single notch near panel 4 is used to lock this panel in a closed position for storage. Rocks can be placed in the triangular chambers behind panels 1 and 2 to stabilize the cooker in the wind.

In summary, the ROB seems to be a more convenient and efficient design that could replace the original SPC for regular home cooking. Of course, the latter equipped with an oven bag remains a better design if a light-weight, foldable cooker is needed.

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The Solar Cooking Archive

The Solar Funnel Cooker

How to Make and Use The BYU Solar Cooker/Cooler

by Steven E. Jones, Professor of Physics at Brigham Young University (BYU), with Colter Paulson, Jason Chesley, Jacob Fugal, Derek Hullinger, Jamie Winterton, Jeannette Lawler, and Seth, David, Nathan, and Danelle Jones.

Introduction

A few years ago, I woke up to the fact that half of the world's peoples must burn wood or dried dung in order to cook their food. It came as quite a shock to me, especially as I learned of the illnesses caused by breathing smoke day in and day out, and the environmental impacts of deforestation -not to mention the time spent by people (mostly women) gathering sticks and dung to cook their food. And yet, many of these billions of people live near the equator, where sunshine is abundant and free. Ergo...

As a University Professor of Physics with a background in energy usage, I set out to develop a means of cooking food and sterilizing water using the free energy of the sun. First, I looked at existing methods.

The parabolic cooker involves a reflective dish that concentrates sunlight to a point where the food is cooked. This approach is very dangerous since the sun's energy is focused to a point which is very hot, but which cannot be seen. (BYU students and I built one which will set paper on fire in about 3 seconds!) I learned that an altruistic group had offered reflecting parabolas to the people living at the Altiplano in Bolivia. But more than once the parabolas had been stored next to a shed -- and the passing sun set the sheds on fire! The people did not want these dangerous, expensive devices, even though the Altiplano region has been stripped of fuel wood.

The box cooker: Basically an insulated box with a glass or plastic lid, often with a reflecting lid to reflect sunlight into the box. Light enters through the top glass (or plastic), to slowly heat up the box. Problems: energy enters only through the top, while heat is escaping through all the other sides, which have a tendency to draw heat away from the food. When the box is opened to put food in or take it out, some of the heat escapes and is lost. Also, effective box cookers tend to be more complicated to build than the funnel cooker.

While studying this problem, I thought again and again of the great need for a **safe**, **inexpensive** yet **effective** solar cooker. It finally came to me at Christmastime a few years ago, a sort of hybrid between

the parabola and a box cooker. It looks like a large, deep funnel, and incorporates what I believe are the best features of the parabolic cooker and the box cooker.

The first reflector was made at my home out of aluminum foil glued onto cardboard, then this was curved to form a reflective funnel. My children and I figured out a way to make a large card-board funnel easily. (I'll tell you exactly how to do this later on.)

The Solar Funnel Cooker is safe and low cost, easy to make, yet very effective in capturing the sun's energy for cooking and pasteurizing water -> Eureka!

Later, I did extensive tests with students (including reflectivity tests) and found that aluminized Mylar was good too, but relatively expensive and rather hard to come by in large sheets. Besides, cardboard is found throughout the world and is inexpensive, and aluminum foil is also easy to come by. And individuals can make their own solar cookers easily, or start a cottage-industry to manufacture them for others.

Prototypes of the Solar Funnel Cooker were tested in Bolivia, and outperformed an expensive solar box cooker and a "Solar Cookit" - while costing much less. Brigham Young University submitted a patent application, mainly to insure that no company would prevent wide distribution of the Solar Funnel Cooker. BYU makes no profit from the invention. (I later learned that a few people had had a similar idea, but with methods differing from those developed and shown here.) So now I'm trying to get the word out so that the invention can be used to capture the free energy of the sun - for camping and for emergencies, yes, but also for every day cooking where electricity is not available and even fuel wood is getting scarce.

How it Works

The reflector is shaped like a giant funnel, and lined with aluminum foil. (Easy to follow instructions will be given soon.) This funnel is rather like the parabolic cooker, except that the sunlight is concentrated along a line (not a point) at the bottom of the funnel. You can put your hand up the bottom of the funnel and feel the sun's heat, but it will not burn you.

Next, we paint a jar black on the outside, to collect heat, and place this at the bottom of the funnel. Or one can use a black pot, with a lid. The black vessel gets hot, fast. But not quite hot enough to cook with... We need some way to build up the heat without letting the air cool it. So, I put a cheap plastic bag around the jar -- voila, the solar funnel cooker was born! The plastic bag, available in grocery stores as a "poultry bag", replaces the cumbersome and expensive box and glass lid of the solar box ovens. You can use the plastic bags used in American stores to put groceries in, as long as they let a lot of sunlight pass. (Dark- colored bags will not do.)

I recently tested a bag used for fruits and vegetables, nearly transparent and available free at American grocery stores, that works great. This is stamped "HDPE" for high-density polyethylene on the bag

(ordinary polyethylene melts too easily). A block of wood is placed under the jar to help hold the heat in. (Any insulator, such as a hot pad or rope or even sticks, will also work.)

A friend of mine who is also a Physics Professor did not believe I could actually boil water with the thing. So I showed him that with this new "solar funnel cooker," I was able to boil water in Utah in the middle of winter! I laid the funnel on its side since it was winter and pointed a large funnel towards the sun to the south. I also had to suspend the black cooking vessel -- rather than placing it on a wooden block. This allows the weaker sun rays to strike the entire surface of the vessel.

Of course, the Solar Funnel works much better outside of winter days (when the UV index is 7 or greater). Most other solar cookers will not cook in the winter in northern areas (or south of about 35 degrees, either).

I thought that a pressure cooker would be great. But the prices in stores were way too high for me. Wait, how about a canning jar? These little beauties are designed to relieve pressure through the lid -- a nice pressure cooker. And cooking time is cut in half for each 10º C we raise the temperature (Professor Lee Hansen, private communication). I used one of my wife's wide-mouth canning jars, spray-painted (flat) black on the outside, and it worked great. Food cooks faster when you use a simple canning jar as a pressure cooker. However, you can also put a black pot in the plastic bag instead if you want. But don't use a sealed container with no pressure release like a mayonnaise jar -- it can break as the steam builds up! (I've done it.)

How to Build Your Own Solar Funnel Cooker

What You will Need for the Funnel Cooker:

1. A piece of flat cardboard, about 2 feet wide by 4 feet long. (The length should be just twice the width. The bigger, the better.)
2. Ordinary aluminum foil.
3. A glue such as white glue (like Elmer's glue), and water to mix with it 50-50. Also, a brush to apply the glue to the cardboard (or a cloth or paper towel will do). Or, some may wish to use a cheap "spray adhesive" available in spray cans. You can also use wheat paste.
4. Three wire brads-- or small nuts and bolts, or string to hold the funnel together.
5. For a cooking vessel, I recommend a canning jar ("Ball" wide-mouth quart jars work fine for me; the rubber ring on the lid is less likely to melt than for other jars I've found. A two-quart canning jar is available and works fine for larger quantities of food, although the cooking is somewhat slower.).
6. The cooking jar (or vessel) should be spray-painted black on the outside. I find that a cheap flat-black spray paint works just fine. Scrape off a vertical stripe so that you have a clear glass "window" to look into the vessel, to check the food or water for boiling.
7. A block of wood is used as an insulator under the jar. I use a piece of 2"X4" board which is cut into a square nominally 4" x 4" by about 2" thick. (10cm square x 5cm thick.) One square piece of

wood makes a great insulator.

8. A plastic bag is used to go around the cooking-jar and block of wood, to provide a green-house effect. Suggestions:

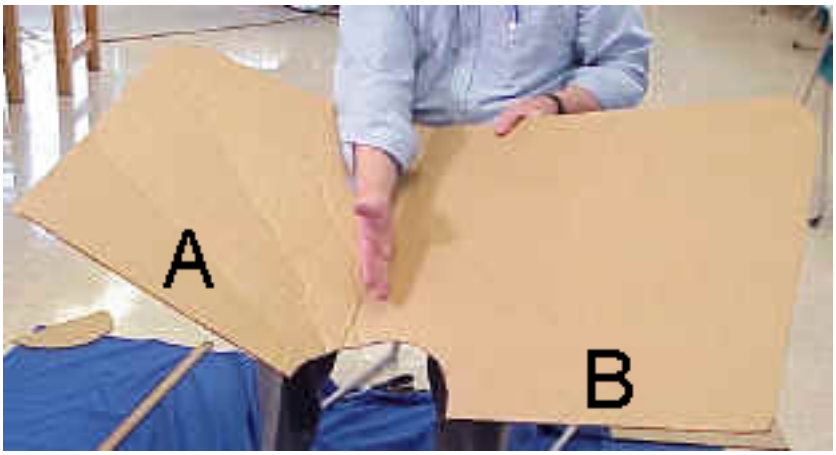
    - Reynolds™ Oven Bag, Regular Size works great: transparent and won't melt. (Cost about 25 cents each in U.S. grocery stores.)
    - Any nearly-transparent HDPE bag (High-density Polyethylene). Look for "HDPE" stamped on the bag. I've tested HDPE bags which I picked up for free at my grocery store, used for holding vegetables and fruits. These are thin, but very inexpensive. Tested side-by-side with an oven bag in two solar funnels, the HDPE bag worked just as well! (Caution: we have found that some HDPE bags will melt should they contact the hot cooking vessel. For this reason, we recommend using the oven-safe plastic bag wherever possible.)
    - An idea attributed to Roger Bernard and applied now to the BYU Funnel Cooker: place a pot (having a blackened bottom and sides) in a glass bowl, and cover with a lid. Try for a tight fit around the bottom to keep hot air trapped inside. The metal pot or bowl should be supported around the rim only, with an air space all around the bottom (where the sunlight strikes it). Put a blackened lid on top of the pot. Then simply place this pot-in-bowl down in the bottom of the funnel - no plastic bag is needed! This clever method also allows the cook to simply remove the lid to check the food and to stir. I like this idea - it makes the solar cooker a lot like cooking over a fire. See Photographs for further details.

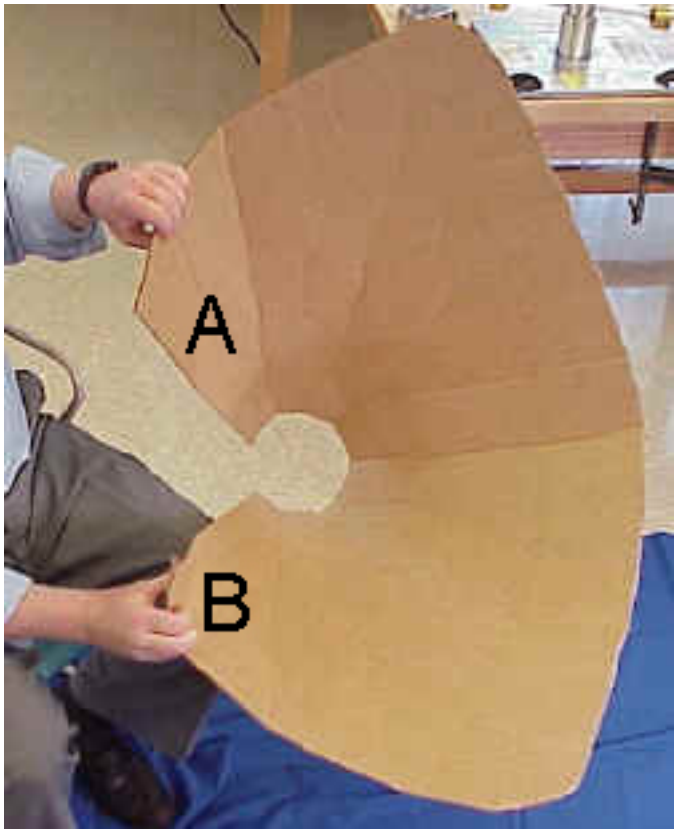
Construction Steps

Cut a Half-circle out of the Cardboard

Cut a half circle out of the cardboard, along the bottom as shown below. When the funnel is formed, this becomes a full-circle and should be wide enough to go around your cooking pot. So for a 7" diameter cooking pot, the radius of the half-circle is 7". For a quart canning jar such as I use, I cut a 5" radius half-circle out of the cardboard.

Form the Funnel



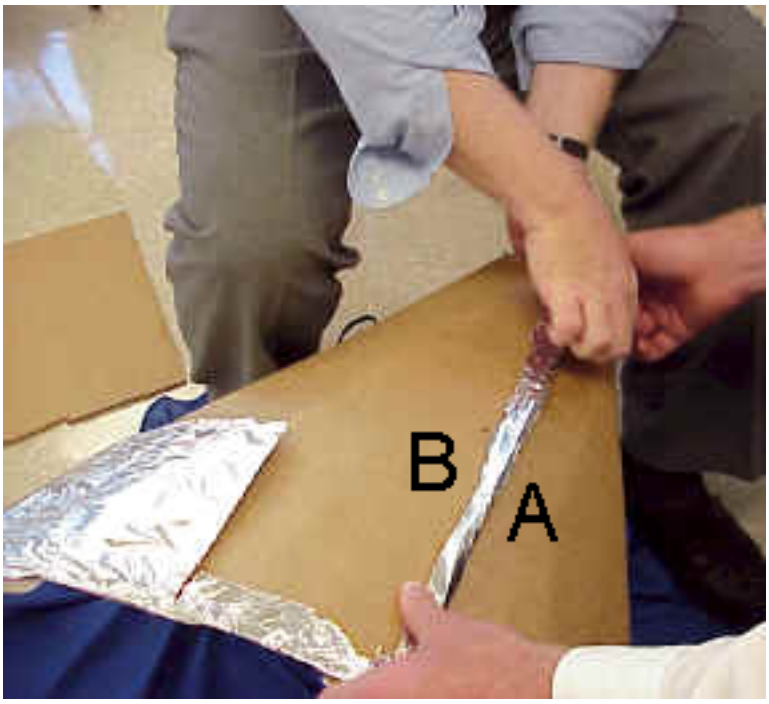


To form the funnel, you will bring side A towards side B, as shown in the figure. The aluminum foil must go on the INSIDE of the funnel. Do this slowly, helping the cardboard to the shape of a funnel by using one hand to form creases that radiate out from the half-circle. Work your way around the funnel, bending it in stages to form the funnel shape, until the two sides overlap and the half-circle forms a complete circle. The aluminum foil will go on the INSIDE of funnel. Open the funnel and lay it flat, "inside up", in preparation for the next step.

Glue Foil to Cardboard

Apply glue or adhesive to the top (inner) surface of the cardboard, then quickly apply the aluminum foil on top of the glue, to affix the foil to the cardboard. Make sure the shiniest side of the foil is on top, since this becomes your reflective surface in the Funnel. I like to put just enough glue for one width of foil, so that the glue stays moist while the foil is applied. I also overlap strips of foil by about 1" (or 2 cm). Try to smooth out the aluminum foil as much as you reasonably can, but small wrinkles won't make much difference. (If even cardboard is not available, one can simply dig a funnel-shaped hole in the ground and line it with a reflector, to make a fixed solar cooker for use at mid-day.)

Join side A to side B to keep the funnel together.



The easiest way to do this is to punch three holes in the cardboard that line up on side A and side B (see figure). Then put a metal brad through each hole and fasten by pulling apart the metal tines. Or you can use a nut-and-bolt to secure the two sides (A & B) together.

Be creative here with what you have available. For example, by putting two holes about a thumb-width apart, you can put a string, twine, small rope, wire or twist-tie in one hole and out the other, and tie together.

When A and B are connected together, you will have a "funnel with two wings". The wings could be cut off, but these help to gather more sunlight, so I leave them on.

Tape or glue a piece of aluminum foil across the hole at the bottom of the funnel, with shiny side in.

This completes assembly of your solar funnel cooker.

For stability, place the Funnel inside a cardboard or other box to provide support. For long-term applications, one may wish to dig a hole in the ground to hold the Funnel against strong winds.

Final Steps

At this stage, you are ready to put food items or water into the cooking vessel or jar, and put the lid on securely. (See instructions on food cooking times, to follow.)

Place a wooden block in the INSIDE bottom of the cooking bag. I use a piece of 2X4 board which is cut into a square nominally 4"X4" by about 2" thick. Then place the cooking vessel containing the food or water on top of the wooden block, inside the bag.

Next, gather the top of the bag in your fingers and *blow air into the bag, to inflate it*. This will form a small "greenhouse" around the cooking vessel, to trap much of the heat inside. Close off the bag with a tight twist tie or wire. Important: the bag should not touch the sides or lid of the cooking vessel. The bag may be called a "convection shield," slowing convection-cooling due to air currents.

Place the entire bag and its contents inside the funnel near the bottom as shown in the Photographs.

Place the Solar Funnel Cooker so that it Faces the Sun

Remember: Sunlight can hurt the eyes: Please wear sunglasses when using a Solar Cooker! The Funnel Cooker is designed so that the hot region is deep down inside the funnel, out of harm's way.

Put the Solar Funnel Cooker in the sun pointing towards the sun, so that it captures as much sunlight as possible. The design of the funnel allows it to collect solar energy for about an hour without needing to be re-positioned. For longer cooking times, readjust the position of the funnel to follow the sun's path.

It helps to put the Solar Funnel Cooker in front of a south-facing wall or window (in the Northern Hemisphere) to reflect additional sunlight into the funnel. A reflective wall is most important in locations farther from the equator and in winter. In the Southern Hemisphere, put the Solar Funnel Cooker in front of a North-facing wall or window to reflect additional sunlight into your cooker.

After Cooking

Remember that the cooking vessel will be very hot: Use cooking pads or gloves when handling! If you are heating water in a canning jar, you may notice that the water is boiling when the lid is first removed - it gets very hot!

Open the plastic cooking bag by removing the twist-tie. Using gloves or a thick cloth, lift the vessel out of the bag and place it on the ground or table. Carefully open the vessel and check the food, to make sure it has finished cooking. Let the hot food cool before eating.

Helpful Hints

1. Avoid leaving fingerprints and smudges on the inside surface of the cooker. Keep the inner surface clean and shiny by wiping occasionally with a wet towel. This will keep the Solar Funnel Cooker working at its best.
2. If your funnel gets out-of-round, it can be put back into a circular shape by attaching a rope or string between opposite sides which need to be brought closer together.
3. For long-term applications, a hole in the ground will hold the Funnel Cooker securely against winds. Bring the funnel inside or cover it during rain storms.
4. The lids can be used over and over. We have had some trouble with the rubber on some new canning-jar lids becoming soft and "sticky." "Ball canning lids" do not usually have this problem. Running new lids through very hot water before the first use seems to help. The lids can be used over and over if they are not bent too badly when opened (pry off lid carefully).
5. The jar can be suspended near the bottom of the funnel using fishing line or string (etc.), instead of placing the jar on a block of wood. A plastic bag is placed around the jar with air puffed inside,

as usual, to trap the heat. The suspension method allows sunlight to strike all surfaces of the jar, all around, so that heats faster and more evenly. This suspension method is crucial for use in winter months.

6. Adjust the funnel to put as much sunlight onto the cooking jar as possible. Look at the jar to check where the sunlight is hitting, and to be sure the bottom is not in the shadows. For long cooking times (over about an hour), readjust the position of the funnel to follow the sun's path. During winter months, when the sun is low on the horizon (e.g., in North America), it is helpful to lay the funnel on its side, facing the sun.

Tests in Utah

I have personally used the Solar Funnel Cooker to cook lunches over many weeks. My favorite foods to cook are potatoes (cut into logs or slices) and carrot slices. Vegetables cook slowly in their own juices and taste delicious. I also make rice, melted cheese sandwiches, and even bread in the Solar Funnel Cooker. I usually put the food out around 11:30 and let it cook until 12:45 or 1 pm, just to be sure that it has time to cook. I've never had any food burn in this cooker.

I have also cooked food in the mountains, at an altitude of around 8,300 feet. If anything, the food cooked faster there - the sunlight filters through less atmosphere at high altitudes.

I find that people are surprised that the sun alone can actually cook food. And they are further pleasantly surprised at the rich flavors in the foods which cook slowly in the sun. This inexpensive device does it!

Students at Brigham Young University have performed numerous tests on the Solar Funnel Cooker along with other cookers. We have consistently found much faster cooking using the Solar Funnel Cooker. The efficiency/cost ratio is higher than any other solar cooking device we have found to date. Mr. Hullinger also performed studies of transmissivity, reflectivity and absorptivity of alternate materials which could be used in the Solar Funnel Cooker. While there are better materials (such as solar-selective absorbers), our goal has been to keep the cost of the Solar Cooker as low as possible, while maintaining safety as a first priority.

Tests in Bolivia

The BYU Benson Institute organized tests between the Solar Funnel Cooker and the "old-fashioned" solar box oven. The solar box oven cost about $70 and was made mostly of cardboard. It took nearly two hours just to reach water pasteurization temperature. The Bolivian report notes that "food gets cold every time the pots are taken from and into the oven." The solar box oven failed even to cook boiled eggs.

(More expensive box cookers would hopefully work better.)

An aluminized-mylar Solar Funnel Cooker was also tested in Bolivia, during the Bolivian winter. Water pasteurization temperature was reached in 50 minutes, boiled eggs cooked in 70 minutes, and rice cooked in 75 minutes. The Bolivian people were pleased by the performance. So were we! (La Paz, Bolivia, August, 1996)

I also donated two dozen solar funnel cookers for people in Guatemala. These were taken there by a group of doctors going there for humanitarian service. The people there also liked the idea of cooking with the sun's free energy! For an aluminized-Mylar Solar Funnel Cooker kit, please contact CRM (licensed manufacturer) at +1 (801) 292-9210.

Water and Milk Pasteurization

Contaminated drinking water or milk kills thousands of people each day, especially children. WHO reports that 80% of illnesses in the world are spread through contaminated water. Studies show that heating water to about 65º - 70º C (150º F) is sufficient to kill coliform bacteria, rotaviruses, enteroviruses and even Giardia. This is called pasteurization.

Pasteurization depends on how hot and how long water is heated. But how do you know if the water got hot enough? You could use a thermometer, but this would add to the cost, of course. When steam leaves the canning jar (with lid on tight) and forms "dew" on the inside of the cooking bag, then the water is probably pasteurized to drink. (The goal is to heat to 160º Fahrenheit for at least six minutes.) With a stripe of black paint scraped off the jar, one can look through the bag and into the jar and see when the water is boiling - then it is safe for sure.

Think of all the lives that can be saved simply by pasteurizing water using a simple Solar Cooker! (See also Recent Advances in Solar Water Pasteurization)

Safety

Safety was my first concern in designing the Solar Funnel Cooker, then came low cost and effectiveness. But any time you have heat you need to take some precautions.

- The cooking vessel (jar) is going to get hot, else the food inside won't cook. Let the jar cool a bit

before opening. Handle only with gloves or tongs.
- Always wear dark glasses to protect from the sun's rays. We naturally squint, but sunglasses are important.
- Keep the plastic bag away from children and away from nose and mouth to avoid any possibility of suffocation.

Cooking with the Solar Funnel Cooker

What do you cook in a crock pot or moderate-temperature oven? The same foods will cook about the same in the Solar Funnel Cooker -- without burning. The charts below give approximate summer cooking times.

The solar cooker works best when the UV index is 7 or higher. (Sun high overhead, few clouds.)

Cooking times are approximate. Increase cooking times for partly-cloudy days, sun not overhead (e.g., wintertime) or for more than about 3 cups of food in the cooking jar.

Stirring is not necessary for most foods. Food generally will not burn in the solar cooker.

Vegetables (Potatoes, carrots, squash, beets, asparagus, etc.)
Preparation: No need to add water if fresh. Cut into slices or "logs" to ensure uniform cooking. Corn will cook fine with or without the cob.
Cooking Time: About 1.5 hours

Cereals and Grains (Rice, wheat, barley, oats, millet, etc.)
Preparation: Mix 2 parts water to every 1 part grain. Amount may vary according to individual taste. Let soak for a few hours for faster cooking. To ensure uniform cooking, shake jar after 50 minutes.
CAUTION: Jar will be hot. Use gloves or cooking pads.
Cooking Time: 1.5-2 hours

Pasta and Dehydrated Soups
Preparation: First heat water to near boiling (50-70 minutes). Then add the pasta or soup mix. Stir or shake, and cook 15 additional minutes.
Cooking Time: 65-85 minutes

Beans
Preparation: Let tough or dry beans soak overnight. Place in cooking jar with water.
Cooking Time: 2-3 hours

Eggs
Preparation: No need to add water. **Note**: If cooked too long, egg whites may darken, but taste remains

the same.
Cooking Time: 1-1.5 hours, depending on desired yolk firmness.

Meats (Chicken, beef, and fish)
Preparation: No need to add water. Longer cooking makes the meat more tender.
Cooking Time: Chicken: 1.5 hours cut up or 2.5 hours whole; Beef: 1.5 hours cut up or 2.5-3 hours for larger cuts; Fish: 1-1.5 hours

Baking
Preparation: Times vary based on amount of dough.
Cooking Times: Breads: 1-1.5 hours; Biscuits: 1-1.5 hours; Cookies: 1 hour

Roasted Nuts (Peanuts, almonds, pumpkin seed, etc.)
Preparation: Place in jar. A little vegetable oil may be added if desired.
Cooking Time: About 1.5 hours

MRE's and prepackaged foods
Preparation: For foods in dark containers, simply place the container in the cooking bag in place of the black cooking jar.
Cooking Times: Cooking time varies with the amount of food and darkness of package.

How to Use the Solar Funnel as a Refrigerator/Cooler

A university student (Jamie Winterton) and I were the first to demonstrate that the BYU Solar Funnel Cooker can be used - at night - as a refrigerator. Here is how this is done.

The Solar Funnel Cooker is set-up just as you would during sun-light hours, with two exceptions:

1. The funnel is directed at the dark night sky. It should not "see" any buildings or even trees. (The thermal radiation from walls, trees, or even clouds will diminish the cooling effect.).

2. It helps to place 2 (two) bags around the jar instead of just one, with air spaces between the bags and between the inner bag and the jar. HDPE and ordinary polyethylene bags work well, since polyethylene is nearly transparent to infrared radiation, allowing it to escape into the "heat sink" of the dark sky.

During the day, the sun's rays are reflected onto the cooking vessel which becomes hot quickly. At night, heat from the vessel is radiated *outward*, towards empty space, which is very cold indeed (a "heat sink").

As a result, the cooking vessel now becomes a small refrigerator. We routinely achieve cooling of about

20º F (10º C) below ambient air temperature using this remarkably simple scheme.

In September 1999, we placed two funnels out in the evening, with double-bagged jars inside. One jar was on a block of wood and the other was suspended in the funnel using fishing line. The temperature that evening (in Provo, Utah) was 78º F. Using a Radio Shack indoor/outdoor thermometer, a BYU student (Colter Paulson) measured the temperature inside the funnel and outside in the open air. He found that the temperature of the air inside the funnel dropped quickly by about 15 degrees, as its heat was radiated upwards in the clear sky. That night, the minimum outdoor air temperature measured was 47.5 degrees - but the water in both jars had ICE. I invite others to try this, and please let me know if you get ice at 55 or even 60 degrees outside air temperature (minimum at night). A black PVC container may work even better than a black-painted jar, since PVC is a good infrared radiator - these matters are still being studied.

I would like to see the "Funnel Refrigerator" tried in desert climates, especially where freezing temperatures are rarely reached. It should be possible in this way to cheaply make ice for Hutus in Rwanda and for aborigines in Australia, without using any electricity or other modern "tricks." We are in effect bringing some of the cold of space to a little corner on earth. Please let me know how this works for you.

Conclusion: Why We Need Solar Cookers

The BYU Funnel Cooker/Cooler can:

- Cook food without the need for electricity or wood or petroleum or other fuels.
- Pasteurize water for safe drinking, preventing many diseases.
- Save trees and other resources.
- Avoid air pollution and breathing smoke while cooking.
- Use the sun's free energy. A renewable energy source.
- Cook food with little or no stirring, without burning.
- Kill insects in grains.
- Dehydrate fruits, etc.
- Serve as a refrigerator at night, to cool even freeze water.

(Try that without electricity or fuels! See also Balancing the Scales.)

The burden for gathering the fuel wood and cooking falls mainly on women and children. Joseph Kiai reports from Dadaab, Kenya: "Women who can't afford to buy wood start at 4 am to go collecting and return about noon... They do this twice a week to get fuel for cooking... The rapes are averaging one per week." From Belize: "Many times the women have to go into the forest dragging their small children when they go to look for wood. It is a special hardship for pregnant and nursing mothers to chop and drag trees back to the village... they are exposed to venomous snakes and clouds of mosquitoes." (Anna K.) (Quoted in newsletters by Solar Cookers International.)

And the forests are dwindling in many areas. Edwin Dobbs noted in *Audubon Magazine*, Nov. 1992, "The world can choose sunlight or further deforestation, solar cooking or widespread starvation..."

Americans should be prepared for emergencies, incident to power failures. A Mormon pioneer noted in her journal: "We were now following in their trail traveling up the Platte River. Timber was sometimes very scarce and hard to get. We managed to do our cooking with what little we could gather up..." (Eliza R. Snow) Now there's someone who needed a light-weight Solar Cooker!

Here's another reason to use a solar cooker. Many people in developing countries look to see what's being done in America. I'm told that if Americans are using something, then they will want to try it, too. The more people there are cooking with the sun, the more others will want to join in. A good way to spread this technology is to encourage small local industries or families to make these simple yet reliable solar cookers for others at low cost. I've used this cooker for three summers and I enjoy it. Cooking and making ice with the funnel cooker/cooler will permit a significant change in lifestyle. If you think about it, this could help a lot of people. The BYU Solar Funnel Cooker uses the glorious sunshine -- and the energy of the sun is a free gift from God for all to use!

Answers to commonly-asked questions

Will the cooker work in winter (in the United States)?

As the sun moves closer to the southern horizon in the winter, the solar cooker is naturally less effective. A good measure of the solar intensity is the “UV index” which is often reported with the weather. When the ultraviolet or UV index is 7 or above– common in summer months– the solar cooker works very well. In Salt Lake City in October, the UV index was reported to be 3.5 on a sunny day. We were able to boil water in the Solar Funnel Cooker during this time, but we had to suspend the black jar in the funnel so that sunlight struck all sides. (We ran a fishing line under the screw-on lid, and looped the fishing line over a rod above the funnel. As usual, a plastic bag was placed around the jar, and this was closed at the top to let the fishing line out for suspending the jar.)

The solar “minimum” for the northern hemisphere occurs on winter solstice, about December 21st each year. The solar “maximum” occurs six months later, June 21st. Solar cooking works best from about March 20 - October 1 in the north. If people try to cook with the sun for the first time outside of this time window, they should not be discouraged. Try again when the sun is more directly overhead. (One may also suspend the jar in the funnel, which will make cooking faster any time of the year.)

It is interesting to note that most developing countries are located near the equator where the sun is nearly directly overhead all the time. Solar Cookers will then serve year-round, as long as the sun is shining, for these fortunate people. They may be the first to apply fusion energy (of the sun) on a large

scale! And they may accomplish this without the expensive infrastructure of electrical power grids that we take for granted in America.

How do you cook bread in a jar?

I have cooked bread by simply putting dough in the bottom of the jar and placing it in the funnel in the usual way. Rising and baking took place inside the jar in about an hour (during summer). One should put vegetable oil inside the jar before cooking to make removal of the bread easier. I would also suggest that using a 2-quart wide-mouth canning jar instead of a 1-quart jar would make baking a loaf of bread easier.

What is the optimum "opening angle" for the funnel cooker?

A graduate student at Brigham Young University did a calculus calculation over two years ago to assess the best shape or opening angle for the Solar Funnel. Jeannette Lawler assumed that the best operation would occur when the sun's rays bounced no more than once before hitting the cooking jar, while keeping the opening angle as large as possible to admit more sunlight. (Some sunlight is lost each time the light reflects from the shiny surface. If the sunlight misses on the first bounce, it can bounce again and again until being absorbed by the black bottle.) She set up an approximate equation for this situation, took the calculus-derivative with respect to the opening angle and set the derivative equal to zero. Optimizing in this way, she found that the optimum opening angle is about 45 degrees, when the funnel is pointed directly towards the sun.

But we don't want to have to "track the sun" by turning the funnel every few minutes. The sun moves (apparently) 360 degrees in 24 hours, or about 15 degrees per hour. So we finally chose a 60-degree opening angle so that the cooker is effective for about 1.2 hours. This turned out to be long enough to cook most vegetables, breads, boil water, etc. with the Solar Funnel Cooker. We also used a laser pointer to simulate sun rays entering the funnel at different angles, and found that the 60-degree cone was quite effective in concentrating the rays at the bottom of the funnel where the cooking jar sits.

For questions regarding the complete Solar Funnel Cooker kit using aluminized Mylar and a jar for the cooking vessel, please contact CRM at +1 (801) 292-9210. Recent updates to this project can be found at http://physics1.byu.edu/jones/rel491/solarbowl.htm.

HOW TO MAKE A SOLAR COOKER

Mini Panel Cooker

<Materials>

Aluminum or steel beverage can (500ml)

Clear PET bottle (1.5 or 2 L)

Metal lid of glass jar that fits top of a can

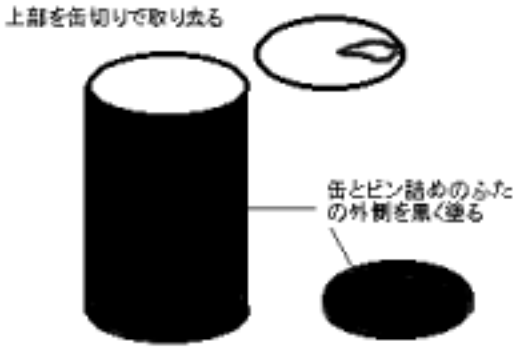
Two paper clips or clothes pins

Aluminum tape or adhesive tape

Black Marker (non-xylene type if available)

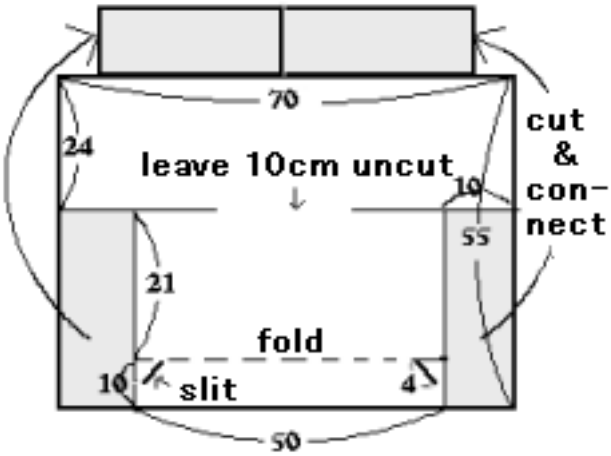
Laminated aluminum sheet about 55cm X 70cm
(If one piece of aluminum sheet is not available, use cardboard and glue aluminum foil, or connect several juice cartons.)

1. Cooking Pot: Cut off top of the can and paint outside and the bottom with black marker. Paint outside of the metal lid of jar also.



2. Insulator: Cut off top of the PET bottle at the level of 3 cm taller than the can.

3. Panel Cooker: Cut aluminum sheet as shown in the drawing. Connect cutout sides to the back panel with tape. Insert corners of both sides into slits and pinch with paper clips.



4. Place cooking pot in the center of panel cooker and cover it with insulator. It will heat up faster if you put a small cake rack or a few pieces of sticks under cooking pot and insulator.

[How to make] [My favorite link] [Various solar cookers] [FAQ] [About me]

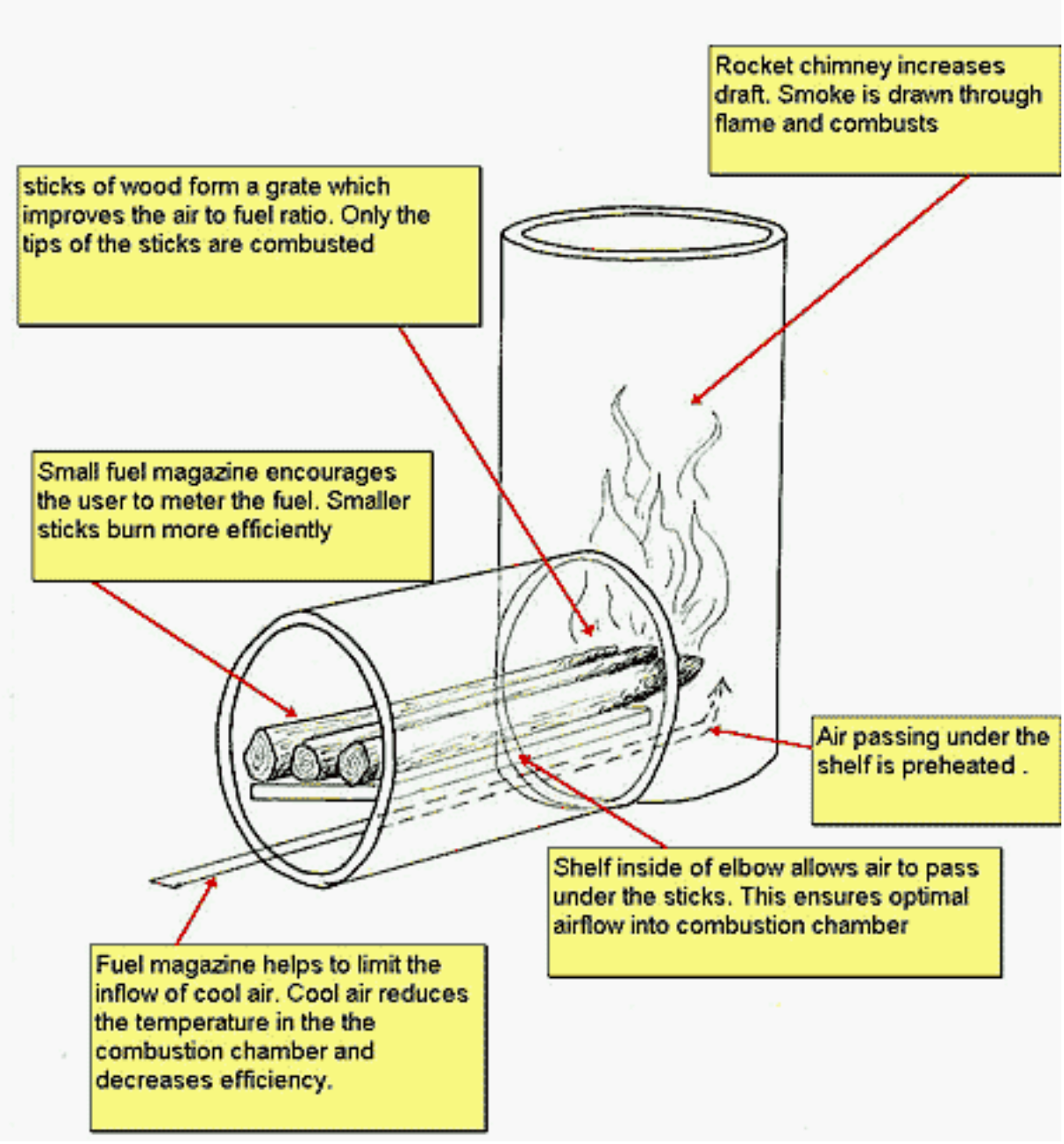
THE WINIARSKI ROCKET STOVE

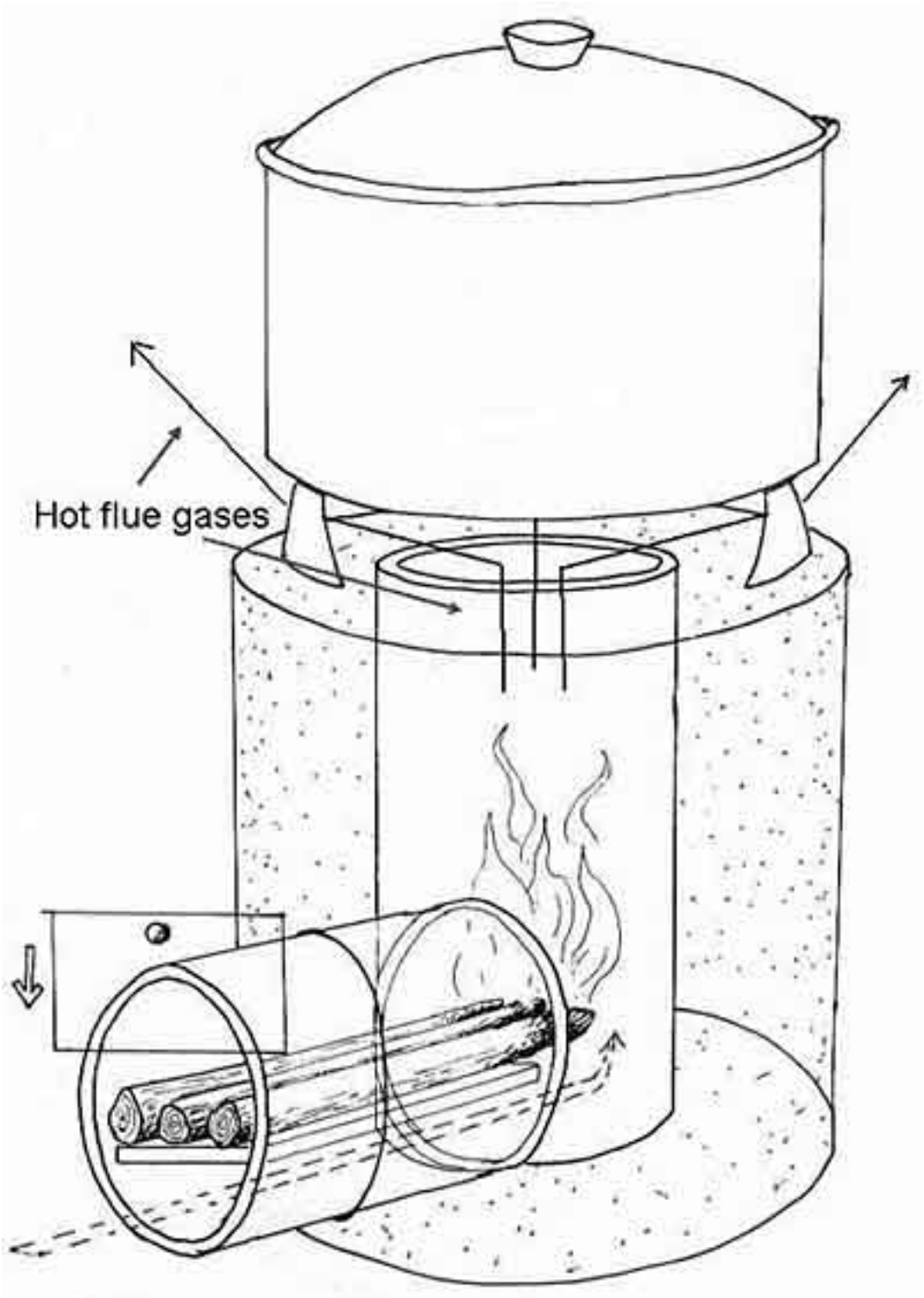
In the last 13 years, variations of the Rocket Stove have been built in over 20 countries.

· Efficiency**: 12-42%. The efficiency depends on type of a heat exchanger used.**
· Construction**: Simple to construct with a number of different materials. The simplest Rocket Stove can be built with thick tin cans and wood ash (5,000 of these were built in refugee camps in Zaire).**
· Material costs**: $0-$20 US. In Honduras we made a simple refugee version of this stove for approximately $1.50 US in material costs.**
· Life expectancy**: Is 2 weeks to ten years depending on the materials used.**

The Rocket elbow can be made from different materials to improve its durability. We have used sand/clay (Lorena), pumice/concrete, heavy steel pipe, 430 stainless steel or special heat resistant ceramic. Currently all of our stoves in Honduras are built with this type of refractory ceramic.

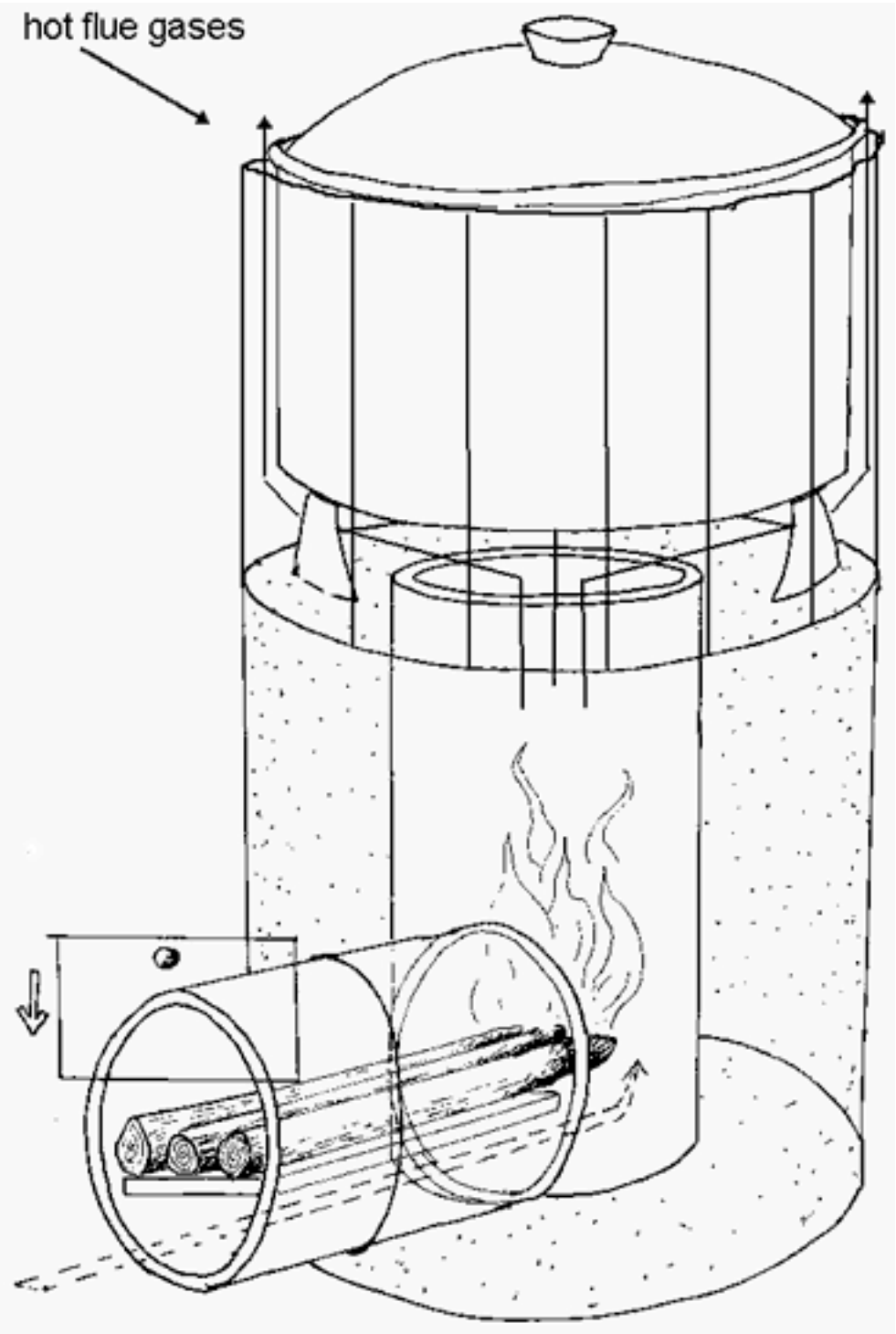
Each of our wood cookstoves incorporates a unique combustion chamber. This is how the Rocket elbow works:





This elbow is then placed inside of a container that is filled with insulation . The container can be made from almost any material. We have used 5 gallon drums, brick, clay, cement. For insulation we suggest using wood ash or pearlite, or pumice,. Do not use massive things such as earth, sand,or cement. These will rob heat from the stove and reduce your combustion efficiency. For optimal use we recommend a 9" chimney and a 4" fuel feed magazine.

The Rocket stove is an improvement over the three stone fire but it is only one part of the equation. In order to really save fuel wood we must maximize the heat transfer to the pot.



This picture shows a thin piece of metal (a skirt) wrapped around the pot. This skirt forces the hot flue gases to rub against the bottom and the sides of the pots. The gap between the pot and the skirt should be about 1cm (assuming you are using an average-sized pot). In our tests, this simple heat exchanger (an old coffee can works well!) almost doubles the efficiency of the rocket stove.

CLICK HERE FOR MORE INFO ON OUR STOVE RESEARCH

RETURN TO STOVE PAGE

 **Home**

Instructions for Building a Solar Box Cooker

Read the instructions in the previous section, Supplies and Equipment, for information about the materials. After all the supplies are gathered, the first step in constructing the solar box cooker is cutting the cardboard and foil-backed foam board insulation into the correct sizes.

Once the cardboard and foil-backed foam board insulation are cut into the correct sizes, the actual construction begins. The box knife is used to score the cardboard to make neat folds. Elmer's glue adheres the foil to the cardboard. Aluminum foil tape holds all the pieces together.

Components in completed solar oven:

- Inner box lid constructed from a five inch strip of cardboard
- Inner box bottom constructed using the lid of an office paper box
- Cardboard and foil reflector made of two large boxes
- Plate glass, 12 1/4" by 18 3/4"
- Outer box, approximately 15" by 22" and at least 6" deep

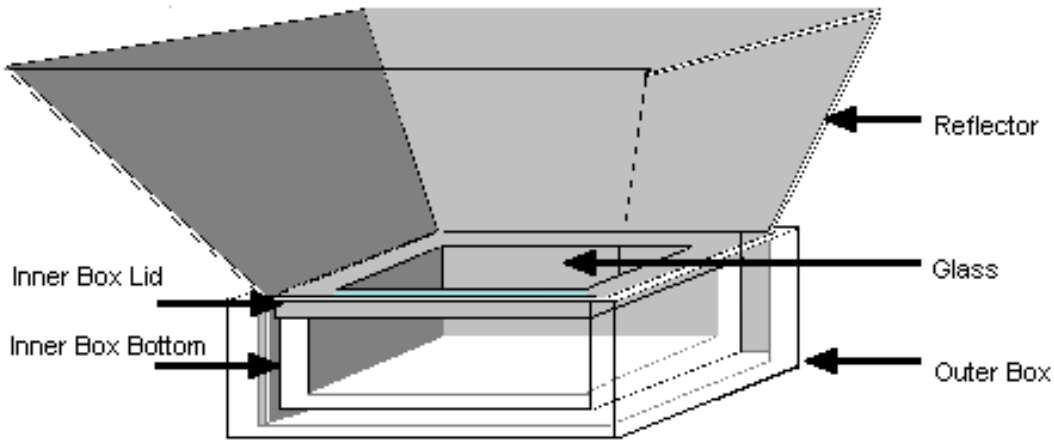


Figure 6: Diagram of complete solar oven.

The instructions cover constructing the three-part inner box, which is insulated to trap the heat used for cooking. The reflector, four pieces of sturdy cardboard covered with foil, is constructed next. The last stage is to use the outer box and bungee cords to hold the reflector and inner box together. Use Figure 6, a diagram of the complete solar oven, to help identify the parts.

The instructions are broken down into the following sections:

Notes:

1. Refer to the Skill Tip: Gluing Foil to Cardboard and Skill Tip: Scoring and Folding Cardboard for extra hints.
2. Cut cardboard and insulation on a protected surface the box knife will not damage.

Caution:

Use care when cutting with the box knife. Avoid cutting yourself by keeping one hand on the handle and the other hand well out of the way.

Preparing Supplies by Cutting Them to the Correct Sizes

Instructions for cutting the cardboard and insulation for the inner box are first. The cardboard for the reflectors is next. The reflectors are an odd shape, and big, but the illustration for them is carefully made to scale.

Cutting cardboard for the inner box. This first piece is the easiest! Cut on a protected surface, and use the straight edge and T-square to make strips of even widths. (I suggest using aluminum foil tape to tape pieces together throughout the project, as all other tapes dry and crack when exposed to high temperatures.)

1. Cut 5” wide strips of cardboard until you have 62” when they are placed end to end

2. Use the aluminum foil tape to tape the pieces together to create the 5” wide and 62” long strip.

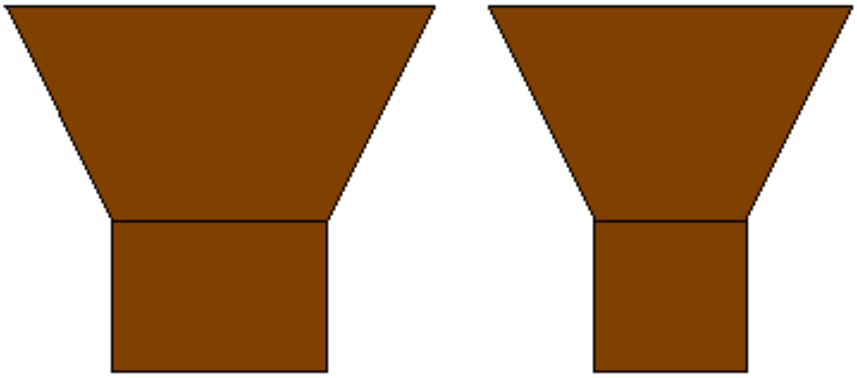
Cutting insulation for the inner box. Now that you have practiced cutting 5” wide rectangles on cardboard, cutting the pieces of foil-backed foam board insulation will be easier. I prefer to wear leather gloves when handling insulation to avoid itchy hands.

1. Cut two strips that are 5” wide by 18” long and two strips 5” wide by 12 1/2” long.

2. Next cut a rectangular piece 12 1/2” by 19”.

3. Check the fit; the five pieces should fit around the office paper box lid as shown in Figure 8 in the next section.

Cutting cardboard for the reflectors. The hardest cutting was saved for last. The four trapezoid shaped reflectors form



the reflector illustrated Figure 6 when fastened together. The inner box is rectangular, so two of the reflectors that surround it are wider than the other two. The illustration in Figure 7 shows one of the wider reflectors, with a width of 20” at the narrow base, on the left. The reflector on the right is one of the two narrower reflectors, with a width of 14” at the narrow base. The instructions will cover cutting each size separately.

Figure 7. Cutting cardboard for the reflectors. Cut two of each size.

To create the two wider reflectors, as shown on the left:

1. Cut a rectangle 40” by 35”. Mark one of the 40” sides as the top of the reflector.

2. Measure and mark a horizontal line, parallel to the top, 20” from the top of the reflector. Make a mark 10” from each side along this line. This marks where the next line should intersect.

3. Turn the cardboard so the top is facing towards you. Use the protractor to measure and mark a 22 1/2 degree angle at each end of the 40” width. Make the resulting lines long enough to intersect the horizontal line at the marks drawn in step two.

4. Check the measurements. You should have a trapezoid with a long side of 40” marked as the top, a short side of 20” and a height of 20” drawn on the cardboard.

5. Mark the bottom rectangle shown under the trapezoidal shape in Figure 7. Draw a straight line from the short side of the trapezoid to the bottom of the reflector. The rectangle should have two sides of 20”, and two 15” sides.

6. Cut along the outlines marked on the cardboard and shown in Figure 7. Do not cut along the solid line that connects the trapezoid and the rectangle.

7. Repeat steps 1 through 6 to create the second wide reflector.

The instructions for the two narrower reflectors are very similar, but the entire set of instructions is repeated to avoid confusion. To create the two narrower reflectors, as shown on the right:

1. Cut a rectangle 34” by 35”. Mark one of the 34” sides as the top of the reflector.

2. Measure and mark a horizontal line, parallel to the top, 20” from the top of the reflector. Make a mark 10” from each side along this line. This marks where the next line should intersect.

3. Turn the cardboard so the top is facing towards you. Use the protractor to measure and mark a 22 1/2 degree angle at each end of the 34” width. Make the resulting lines long enough to intersect the horizontal line at the marks drawn

in step two.

4. Check the measurements. You should have a trapezoid with a long side of 34” marked as the top, a short side of 14” and a height of 20” drawn on the cardboard.

5. Mark the bottom rectangle shown under the trapezoidal shape in Figure 7. Draw a straight line from the short side of the trapezoid to the bottom of the reflector. The rectangle should have two sides of 14”, and two 15” sides.

6. Cut along the outlines marked on the cardboard and shown in Figure 7. Do not cut along the solid line that connects the trapezoid and the rectangle.

7. Repeat steps one through six to create the second narrow reflector.

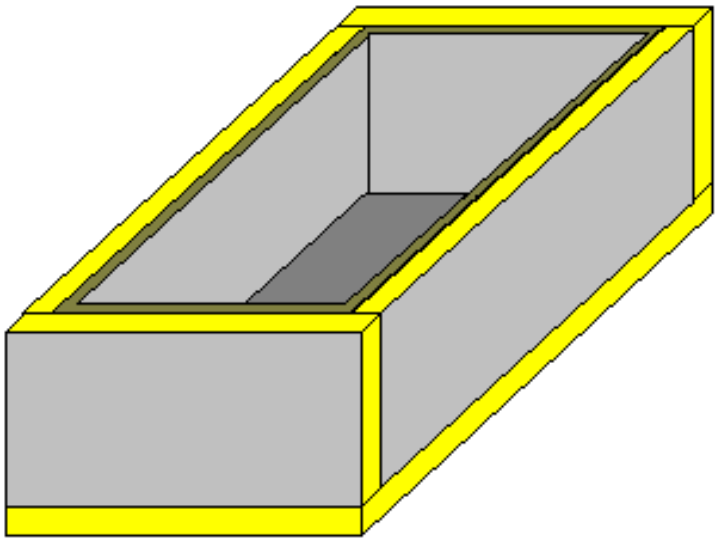
You have now cut the pieces necessary to construct the solar box cooker. The next three stages of the construction will not require extensive cutting, but you will need the box knife to score the cardboard so it folds easily.

Constructing the Inner Box

The inner box of the solar box cooker traps the heat used for cooking. The food to be cooked is placed inside the inner box, which is covered with the piece of glass. The sun’s rays enter through the glass top. The heat from the sun’s rays is trapped, heating the inside to temperatures over 200 degrees. It is important that the inner box be very well-insulated and constucted of material that withstand high heat.

The inner box has three parts: the bottom, the glass cover, and the lid. The bottom is constructed by insulating the lid from an office paper box. The glass is checked for fit and strips of adhesive-backed foam insulation are applied to the edges. The inner box lid is constructed by scoring the 5” wide strip of cardboard so it will fold easily, lining it with foil, then folding and taping it in place.

Constructing the inner box bottom. The bottom of the inner box is constructed by insulating the lid of the office paper



box with aluminum foil and foil-backed sheathing. Follow these four steps to create a well-insulated inner box bottom:

1. Line the inside of the box with aluminum foil. Glue the foil to the inside of the box following the instructions in the Skill Tip: Gluing Foil to Cardboard below.

2. Fold any foil that extends above the top edge of the box to the outside.

3. Fit the 5 pieces of foil-backed sheathing to the outside of the box. Figure 8 illustrates how the five pieces fit around the box. Use a few dabs of unthinned white glue to hold them in place temporarily.

Figure 8. Fit the five pieces of sheathing to the bottom and sides of the box.

4. Permanently attach the sheathing to the outside of the box by taping in place with the aluminum foil tape. Figure 9 illustrates where to tape the pieces in place.

Note: The sheathing has friable fiberglass that will flake away over time. Cover all exposed edges with the aluminum foil tape.

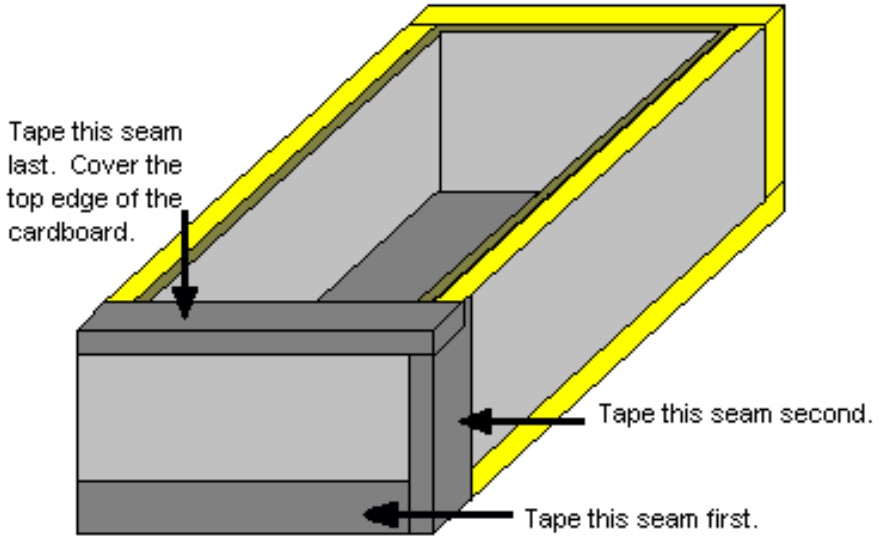


Figure 9. Tape the sheathing in place with aluminum foil tape.

Skill Tip: Gluing Foil to Cardboard
Follow these steps to glue foil to cardboard neatly: 1. Mix 1/3 part water to 2/3 parts glue. 2. Wet the brush with glue. 3. Apply a thin even coating of glue to the cardboard. 4. Lay a sheet of foil in place. 5. Use a damp paper towel to smooth the foil out. Start in the middle and work out to the edges. Gently press foil into folds 6. Repeat steps 2 through 5 until all surfaces are covered. 7. Wipe up any glue that seeps out at seams.

Preparing the glass. The piece of glass lays on top of the inner box bottom constructed in the last phase. There are two steps to preparing the glass to use in the inner box: (1) check the fit, and (2) apply weatherstripping.

1. The glass which covers the top is 12” by 18 1/2”. Now that the 1/2” thick sheathing has been attached to all four sides of the box, lay the glass on the inner box bottom and check the fit. It should cover the inner box bottom completely. If it does not fit, carefully measure the outside length and width of the inner box bottom and get a piece of glass to fit those measurements.

2. Once you have checked that the that the piece of glass is the right size, apply the 1/2” wide adhesive-backed foam weatherstripping. Place it along the four edges on one side of the glass where the glass rests on the top edge of the inner box bottom, as shown in Figure 10. The weatherstripping seals the gap between the inner box bottom and the glass and keeps the glass from sliding around. The weatherstripping also makes the glass easier to hold on to when lifting it off the inner box bottom so you can get your hot food out of the oven.

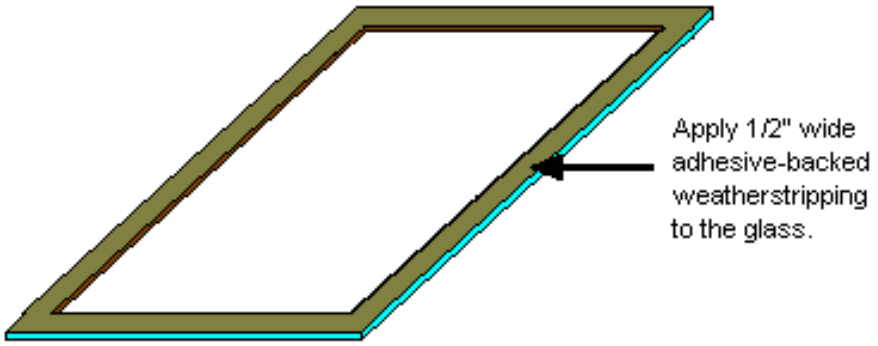


Figure 10. Apply weatherstripping to the edges of the piece of glass.

Constructing the inner box lid. The cardboard lid for the inner box holds the inner box bottom and glass together. The open center allows the sun’s rays to enter the oven. The 5” wide strip of cardboard is first cut and scored. Then foil is applied to the cardboard, which adds extra insulation to the outside of the inner box. Finally, it is folded into a rectangle and taped in place. Follow these five steps to cut and score the cardboard for the inner lid:

1. Use the straight edge, T-square and marking pen to mark a line the length of the cardboard and 1” from one of the long edges of the 5” wide strip of cardboard.

2. The 62” length of cardboard is divided into 4 sections. Mark a line the width of the cardboard 12 1/4 ” from one end. Mark a second line 18 3/4” from the first. Mark the third line 12 1/4 ” from the last line. This last line should be 18 3/4” from the end.

3. Use the box knife to cut through the cardboard at black lines shown in Figure 11.

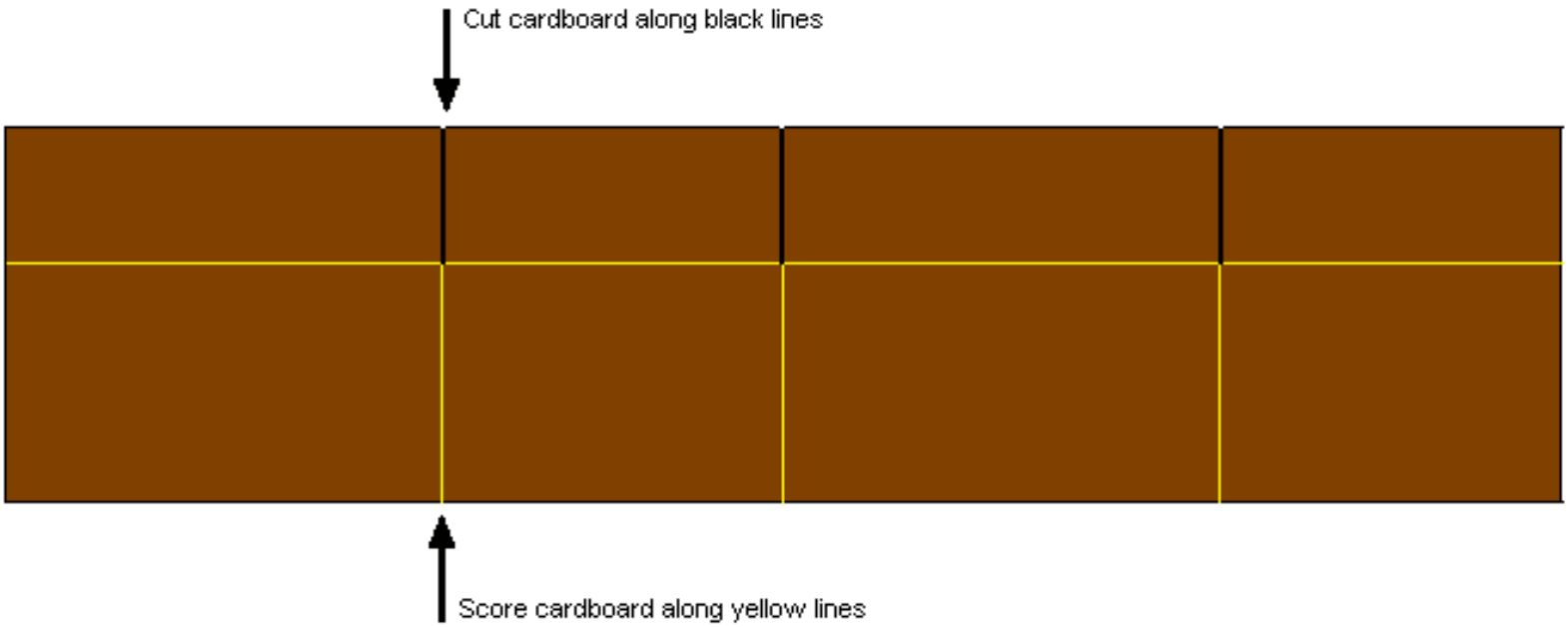


Figure 11. Cut and score the 5" strip of cardboard for the inner box lid.

4. Score cardboard along the yellow lines indicated in Figure 11. Refer to the hints in the Skill Tip: Scoring and Folding Cardboard below to score the cardboard for neat folds.

5. Check the fit of the inner box lid. Fold it into a rectangle, and slide it over the inner box bottom. It should slide over the bottom easily, but without too much extra space.

Skill Tip: Scoring and Folding Cardboard

Follow these steps, demonstrated in Figure 12, to make neat folds in cardboard:

1. Cut through one layer of the corrugated cardboard with the box knife
2. Completely retract the box knife blade. Use the blade end of the closed box knife to make a channel along the cut surface of the cardboard.
3. Place a straight edge along the channel and gently fold.

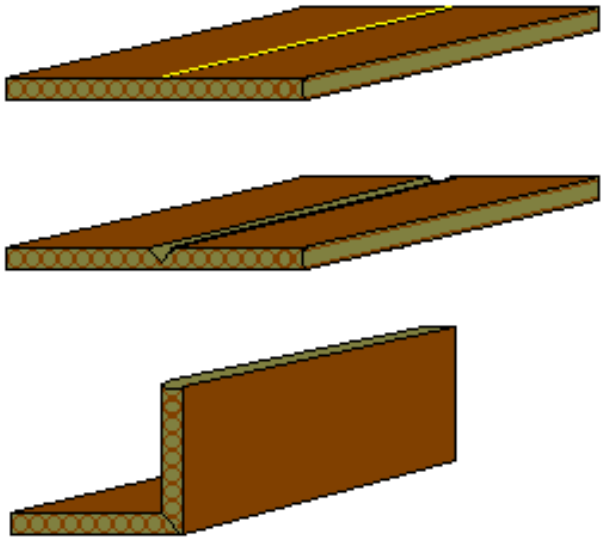


Figure 12. Score cardboard for neat folds.

Insulating and taping the inner box lid. Now that the piece of cardboard used for the inner box lid is cut and scored, you can cover it with foil, tape it into a rectangle, and apply a strip of weatherstripping. Follow these steps, using the illustrations for more information:

1. Lay the cardboard out flat, and glue aluminum foil to both sides. Press the foil gently into the score lines.

2. Use aluminum foil tape to seal the top and bottom edges. Cut through the tape at the three 1” deep cuts along the top edge.

3. Fold into a rectangle, and tape as illustrated in Figure 13.

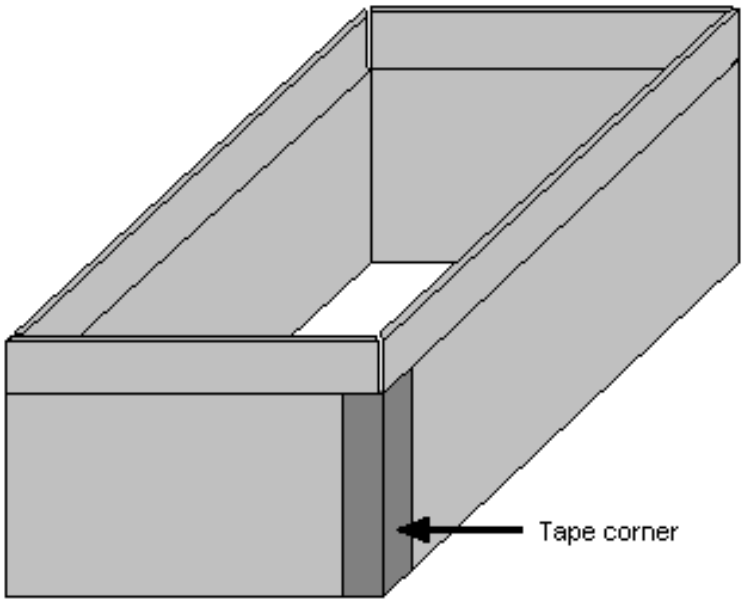
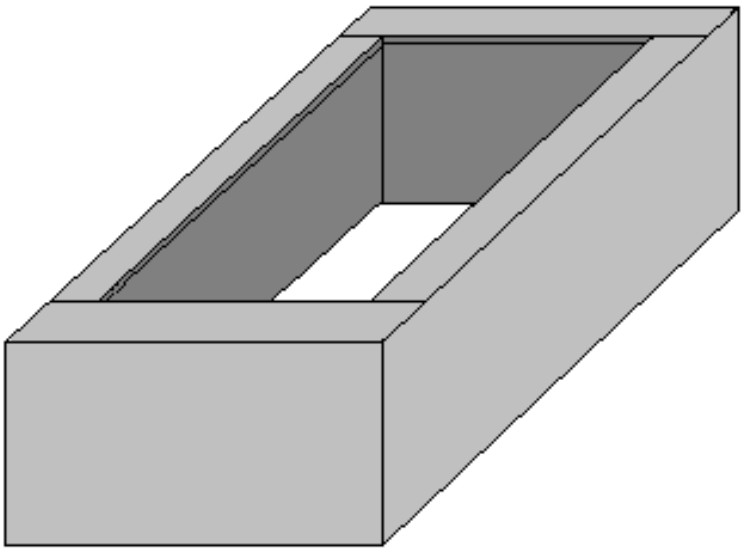


Figure 13. Fold the 5” wide strip of cardboard into a rectangle. Tape the ends together.



4. Fold the top flaps down, and tape into place. Figure 14 shows the completed inner box lid with its open center, which will allow the sunlight into the oven.

Figure 14. Fold the flaps down to make a box lid with open center.

5. Turn the lid so the folded-in flaps are face down on the table. Apply a strip of the 1/2” adhesive-backed foam insulation to the inside corner of the box lid.

Congratulations! Figure 15, from top to bottom, shows the inner box lid, the piece of glass, and the inner box bottom. Check the fit of the three pieces you have made which fit together to create the inner box of the solar box cooker.

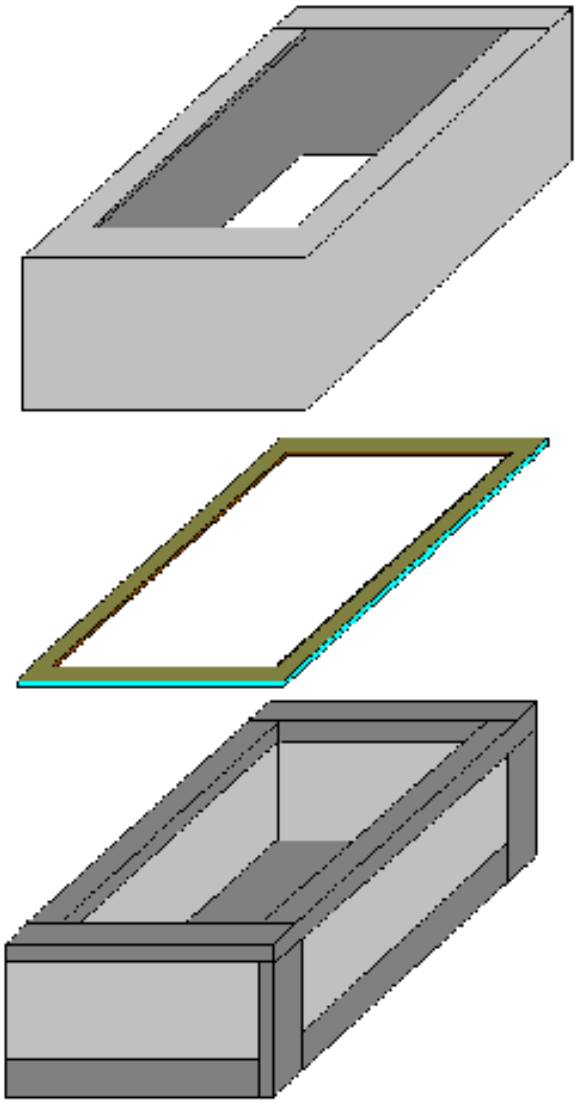


Figure 15. The inner box lid, the glass, and the inner box bottom pieces fit together to create the inner box.

If the sun is straight overhead, this inner box alone will heat to temperatures of about 180 degrees in twenty minutes. The reflector, which is built next, increases the amount of sunlight which strikes the box.

Constructing the Reflector

The reflector is easy to finish, though a bit cumbersome. The final step of constructing the reflector requires a very large flat space to lay the four pieces out before taping them together. A clear space on the floor is probably best for this last part.

1. Get the four pieces cut for the reflector, and lay them out.

2. Glue aluminum foil to the top trapezoidal shaped parts of the cardboard reflectors, as illustrated by the gray areas in Figure 16. Refer back to the Skill Tip: Gluing Foil to Cardboard for tips.

3. Mark a line 5” below the base of the foiled trapezoid, as illustrated by the yellow line in Figure 16. Score and fold

the cardboard along this line. Refer back to the Skill Tip: Scoring and Folding Cardboard if necessary.

4. Lay the four reflectors out, alternating wide and narrow, in the shape shown in Figure 17. Using aluminum foil tape, tape the reflectors together along three of the angled sides.

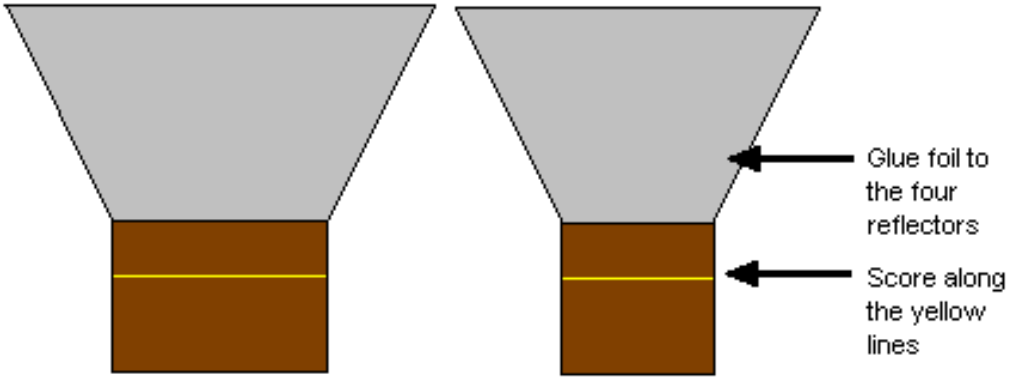


Figure 16. Glue foil to the four reflectors. Score the cardboard along the yellow line, 5" below the base of the trapezoid.

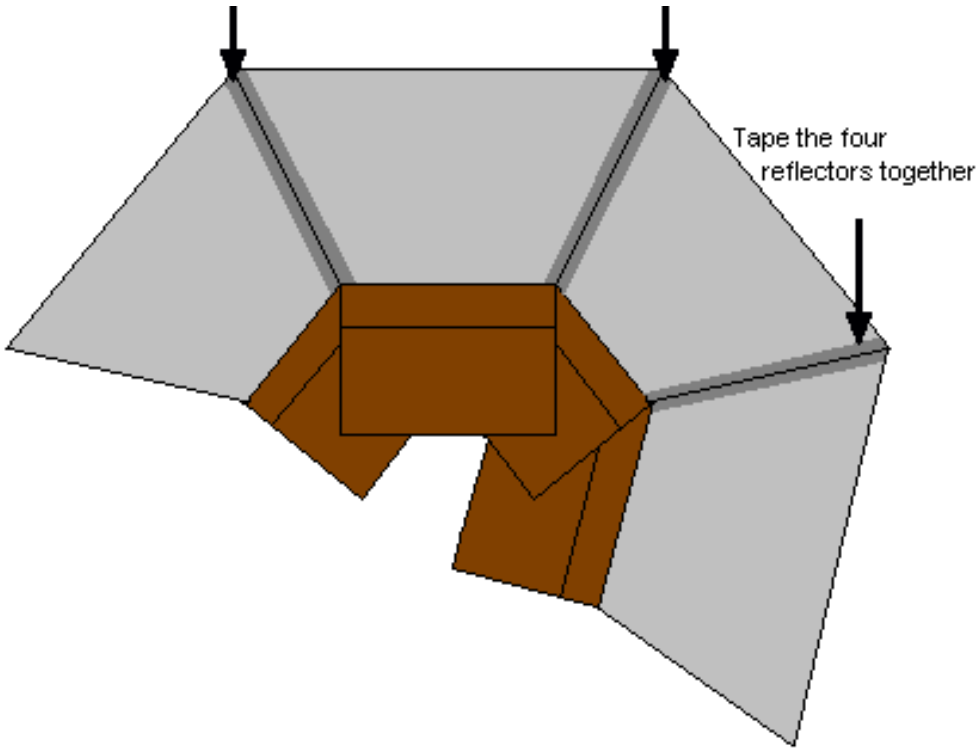


Figure 17. Tape the four reflector pieces together.

The reflector is now completed. The final step of folding it into the rectangular funnel shape that reflects light down into the solar oven is included in the last stage of construction, assembling the oven. Follow these four steps to assemble the solar box cooker:

Assembling the Solar Box Cooker

The inner box and the reflector are now completed. The outer box does not require any construction. If it is bigger than 16” by 22” or deeper than 6” you may need to use some wadded up newspaper or scrap cardboard to hold the inner box and reflector in place. The bungee cords and clothespins are used to hold the reflector closed around the inner box.

1. Fold the reflector along the taped seams to form a rectangular funnel shape, as illustrated in Figure 18.

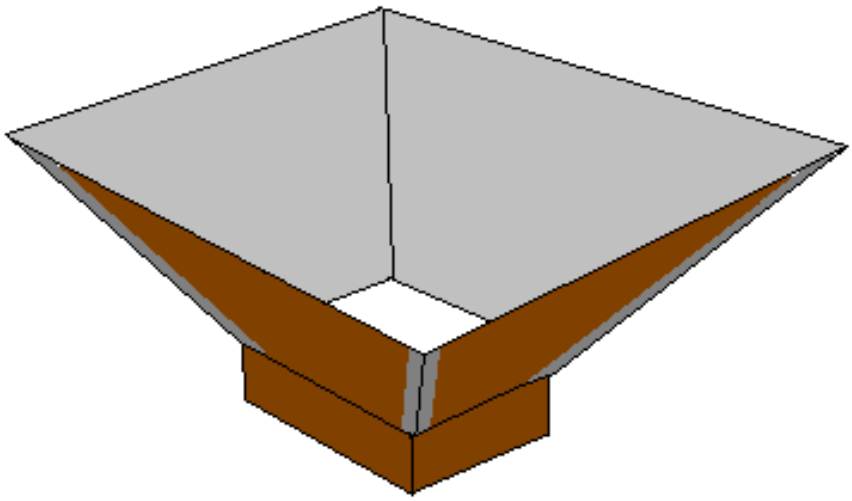


Figure 18. The reflector folded into a rectangular shape.

2. Fold the bottom of the reflectors along the score line to form a base.

3. Place the reflector in the outer box and ask someone to hold it in place.

4. Place the inner box into the center of the reflector. It is heavy enough that it will anchor the reflector in place. Fasten the reflector closed with bungee cords at the base and clothespins and string along the top edge.

The construction of the solar box cooker is now complete. The next section, Tips for Use, will guide you through the first heating of the oven in the sun, which will drive off any fumes from the construction materials, and allow you to check the oven’s performance. After the box cooker’s first heating, it is time to cook and experiment.

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