PORTABLE SOLAR OVEN FOR DOMESTIC USE

1. INTRODUCTION

There are dozens of types of solar cookers on the internet, each of them having very different characteristics. In this tutorial we describe in detail the manufacturing of a portable solar oven of our own design than can cook a meal for a small family (2-3 people). [For larger amounts, see below] This model has been used successfully and repeatedly for cooking (even in the average annual sunshine of Thessaloniki, Greece), although performance may fluctuate significantly depending on the quality and accuracy of each construction, and the conditions of its use. In any case, if you follow these instructions and heed the advice provided, you will easily, quickly and with very little cost be able to cook with the sun.

In this model concentration of solar rays is performed by means of conical reflective surfaces on a black pot, which is tightly enclosed in a cooking bag. The pot must be closed (i.e. with lid) and black in order to absorb the maximum heat while the seal into baking bag creates the greenhouse effect, trapping the sunlight and increasing the temperature inside. The reflective surfaces amplify the phenomenon, easily reaching temperatures high enough for cooking any type of food.

2. MATERIALS REQUIRED

- Cardboard 1mm or 2mm thick, dimensions 2,00x1,00 meters (or individual pieces joined together to form the pattern shown below-also see appendix). You can get it in shops selling boxes, cartons etc. for about 2€ a piece dimensions 1,05x0,75 m. Alternatively, you can use whatever cardboard you want, however the ones mentioned have a good combination of strength and elasticity. Note, the 1mm cardboard can be folded tighter, but the 2 mm one performs better at maintaining its conical shape and for this reason it is preferred among the two.

- Wrapping paper (mylar, with one reflective surface), dimensions 2,00x1,00 meters (or individual pieces joined together to form the pattern shown below-also see appendix). You can get it in stores selling wrapping and packaging materials for about 0.90€ per piece dimensions 1,00x0,80 m. Alternatively, you can even use aluminum foil, but with reduced results. The general rule is: the better the reflection, the better the result.

- Adhesive aluminum tape (with a high-temperatures-resistant adhesive). You can get it in hardware stores for about 1€. Alternatively, you can try any other adhesive tape, but it may not hold at high temperatures. The reflective surface is also preferred, since a transparent one will slightly lower the performance.

- Cooking bags size large or roll of baking bag. Plain size cooking bags you can get in any supermarket, but the large version may take some time to find. It costs about 3.20€ the eight small-sized ones and 2.50€ the four large ones. The large one is preferable, since it can easily enclose the pot, while the small one is much more restrictive as far as the size of the pot is concerned.

- Black pot, average size. You can get it in shops with kitchenware and household items for about 8.50€, including the rack used as a basis, like the illustrated picture. You can use any kind of closed (with a lid) pot or pan, as long as it's black, in order to absorb the maximum heat. You can even paint one yourself, but we advise against it, due to possible toxicities from the paint, especially at high temperatures. However, you will definitely need a rack as illustrated, upon which the pot will rest.

3. TOOLS REQUIRED

- Oven Thermometer: You should always have an oven thermometer enclosed by/on the pot not only to keep track of the performance of the oven, but also to ensure that you reach temperatures high enough to cook every meal. You can purchase an (analog) "oven thermometer" (indicating from 0º to 250º or 300ºC) from shops with industrial equipment (burners, boilers, thermostats etc.) at a cost of about 11€.

- Scissors and / or cutter: One of the two will do, but both are better, depending of course on what suits you for the job required.

- Ruler: necessary for measurements and the drawing of straight lines

- String/Twine: Optional, but useful for making large circles (by holding one end fixed to the center of the circle and tying a pencil on the other) and for keeping the construction in the required position, later on, when using the oven. However, these two tasks can be performed in many other ways, using imagination and ingenuity.

- Scotch tape or duct tape or glue: For putting the whole thing together, apart from the joins on the reflective surface, where the adhesive aluminum tape is required. You could also only use the aluminum one, but may not be enough and it costs more than the other kinds mentioned.

4. INSTRUCTIONS

- Take the cardboard and cut and tape/glue the pieces together, so as to form the shape of the illustrated piece below (this is design 1 of the appendix) and

do the same with the mylar. You may need to use individual pieces, since it is hard to get rolls of each. This is not necessarily a problem, but we would prefer to have as few joints as possible, since they can lead to a reduction of strength and stability and loss of "form" (by creating a hinge) as far as the cardboard is concerned, while the reflecting surface may suffer a (rather slight) loss of performance, even when using the aluminum tape.

- When you have a single piece of each of the two materials, glue one on top of the other, and then connect the two straight sides in a way that the reflective surface remains internally in the creation of the illustrated large funnel. It is recommended that the connection is temporary in some way, if we want the funnel to open up and to wrap up tighter, making it easier to transport. Again with imagination and ingenuity a lot can be done, e.g. holes and straps, cords or strings etc. Personally, we tried stitching a separated zipper on the thick cardboard and it works like a charm. Actually, however difficult, it is recommended initially joining the cardboard, and then - while maintaining the shape of the funnel - gluing the much more flexible mylar on it. This way, if done correctly, less folds and wrinkles will form (in comparison to gluing the two materials together and then folding them), thus keeping the reflection rate high.

(* In the above illustration the funnel wrapped and tied closely is made from cardboard 1mm)

- Place the pot containing the food inside a baking bag, using the rack so that the pot and the bag do not come in direct contact (not only to avoid destroying the bag with the hot pot, but also to let the hot air all around the pot). As mentioned, it always helps to keep the thermometer inside too, in order to


monitor the temperatures reached. Close the bag air-tightly, trapping some air within. The closure may be achieved with any kind of strap or string etc., so long as it can be easily removed and reused. The trapped air also serves to prevent the contact between the bag and the hot pot.

- Turn and place the funnel in a way that it is directed towards the sun (the large opening that is), securing it any way you can and then place the bag with the pot inside the funnel to rest at the small opening. Every half hour or so, adjust the funnel, by redirecting it exactly towards the sun, since thus its performance is maximized. Although depending on many parameters, such as the date, the sun, the wind, the humidity, and the correct application of all of the above, you will be able to cook whatever you like.


5. CAUTION – RISK INVOLVED

- IMPORTANT: As much as the simplicity of this design may fool you, bear in mind that this is in fact an oven, which can reach temperatures similar to conventional ovens. The risk of burning is apparent, especially with the funnel.

If mere exposure of bare human skin to the sun can be dangerous, imagine what damage can be done when the sun's rays are concentrated. Do not put hands, feet, etc. inside the funnel while it is facing the sun, unless protected (e.g. with oven mitts, long sleeves) and keep children away from the oven when it is in use.

- When cutting the cardboard and mylar, be careful of hurting yourself. Also, make sure you don't cut too deep and destroy what lies beneath.

- If it gets cloudy or any other problem arises and the cooking session is not completed in the sun, resume in a conventional oven or any other way; in any case do not consume undercooked food, because there could be serious risk of gastrointestinal disorders or other complications.

- The minimum temperature for most food is generally around 75º C, but keep in mind that the temperature indicated by the thermometer is higher than the actual one in the pot. After some testing, you can use the indication of the thermometer to know at what percentage cooking has been completed.

6. USEFUL TIPS

- Cooking with the sun generally takes more time than in a conventional oven. Usually it takes about twice as long. It is recommended to set the oven relatively early (e.g. 10-11 am) in order to have your meal ready by 1-2 pm. Do not worry too much about burning the food; it is difficult to burn food in a solar oven (due to the use of a closed pot). Every half an hour or so, when you adjust the funnel, you may also check on the food, but try not to tear the bag in doing so, because you'll then need to replace it.

- The conical shape of the funnel essentially simulates part of the parabolic surface of satellite dishes that concentrate rays on a single point and are the ideal instrument for gathering rays. We take advantage of the fact that we do not want a concentration of rays at a single point, but at an area (i.e. the pot). Also the cone provides extra advantages (wrapping and easy transport, ease of manufacture, use of low weight and low cost materials) in comparison to any parabolic surface. Specifically, it is designed so that - when facing the sun - it directs all rays entering from the large opening to the small one with only (up to) one reflection, thus achieving greater efficiency.

- Try to place the pot in the bag and the bag in the funnel so that pot and bag are not in contact. The bags can withstand temperatures up to 200° C according to the manufacturer, but experience has shown that it will withstand even higher baking temperatures, unless it gets into direct contact with the pot, in which case it may melt and create a hole. In such a case, you will

notice immediately a large drop in the thermometer’s indication. By being careful, you can avoid this and use and reuse the same bag for plenty of cooking sessions.

- When storing and not using the funnel, it is recommended to keep it upside down (large opening facing down) and not wrapped if possible, since it will gradually lose its form and will "fold" in an unwanted way when it is turned into a full size funnel again.

- The prices (in euros €) are only included to give you a general idea of the total cost; you might as well find lower or maybe higher prices for that matter. Although the overall cost is already quite low, there is a possibility for further reduction. It is even possible to assemble the funnel mostly out of discarded materials, if you have the patience to collect and use them. The only thing that you must be aware of is to try and have the best possible reflecting surface and a rudimentary overall strength of the funnel, so as not to lose its shape from its own weight or the wind.

- Larger quantities of food require a larger pot, which means you need a larger opening on the narrow side of the funnel. This will automatically mean an extension of the cone so as not to diminish the quantity of rays entering the funnel. As a result, the overall size of the cone increases and issues of stability of the whole funnel arise. The alternative designs 2 and 3 of the Annex have been tested and work equally well, as far as performance of the funnel is concerned. The problem with using a larger pot is not so much the funnel, although harder to handle and support. The problem is the baking bags, since even the large ones do not fit the bigger sized pots. Without the bag, there is no greenhouse effect and the performance drops significantly. We need to find larger bags (we haven’t managed that yet) or create a different construction to replace them, for example use a glass box that fits the pot inside it and itself fits in the funnel (which greatly sacrifices portability of construction, among other issues).

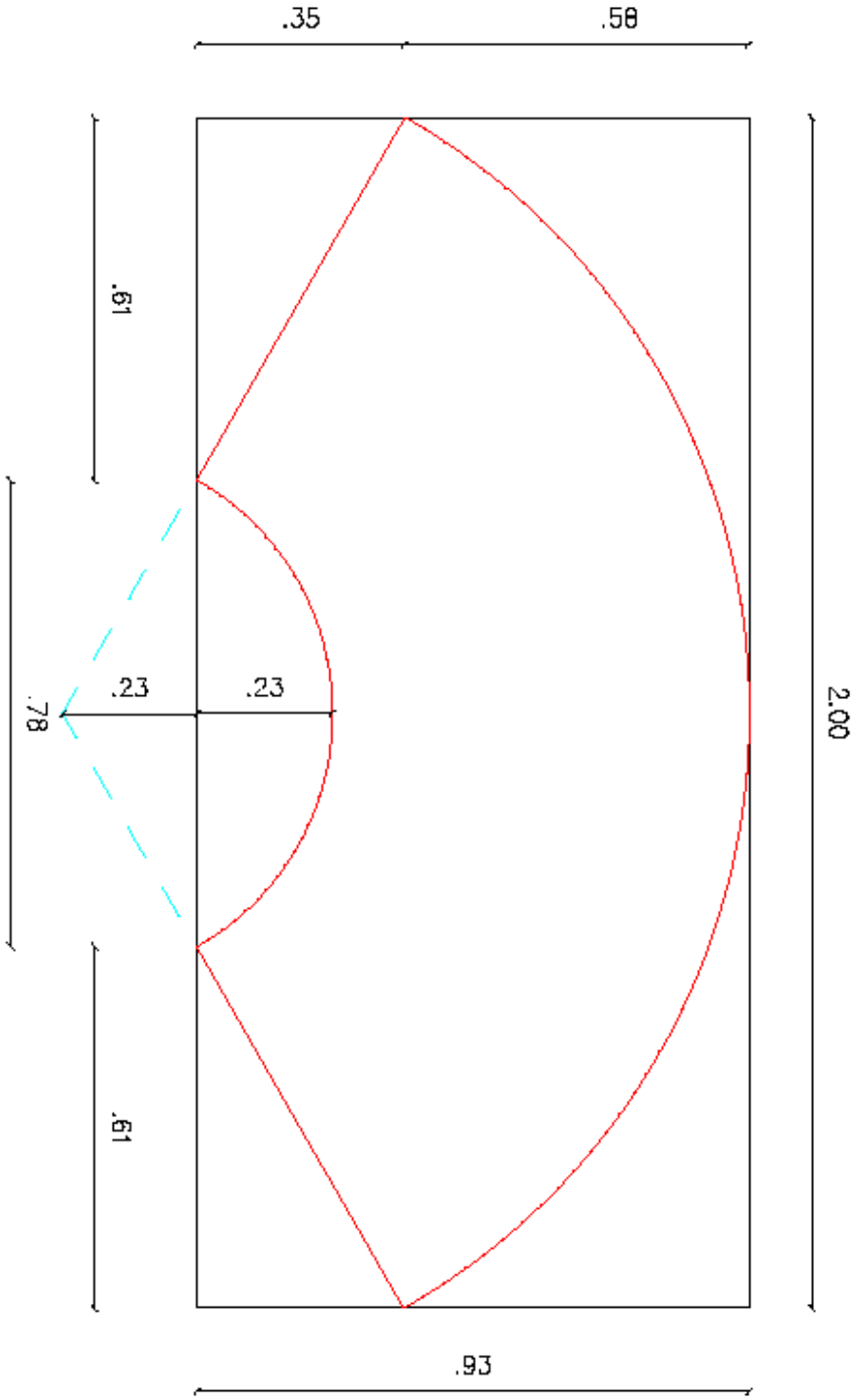
7. EPILOGUE

You can deviate much as you want from the above instructions and improvise and experiment, if you like. Send us your experiences and help us make the model even more easy and functional. This model is open and free for anyone to build and upgrade, as long as it is always open and free and not used for profit or commercial purposes (Creative Commons Attribution 4.0.)

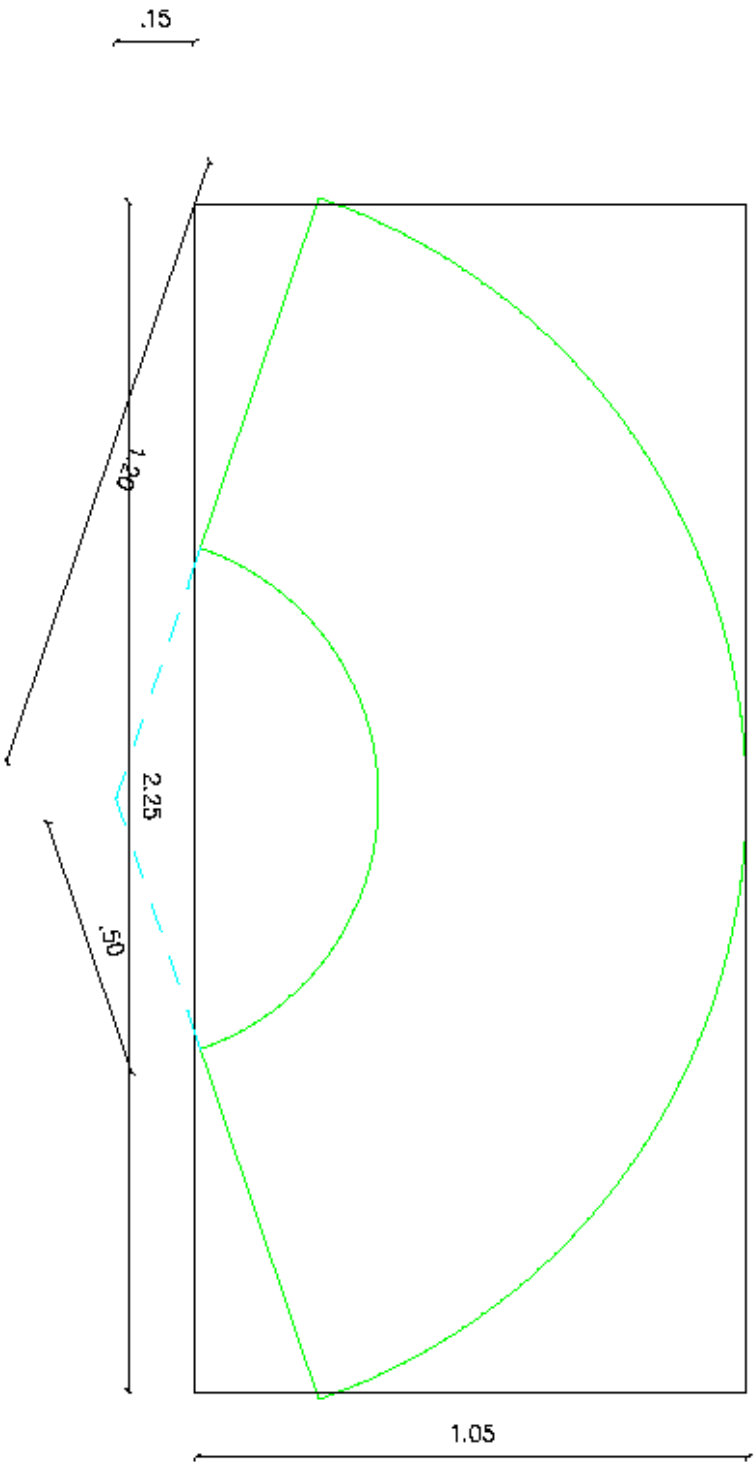
Happy sun-cooking!

APPENDIX

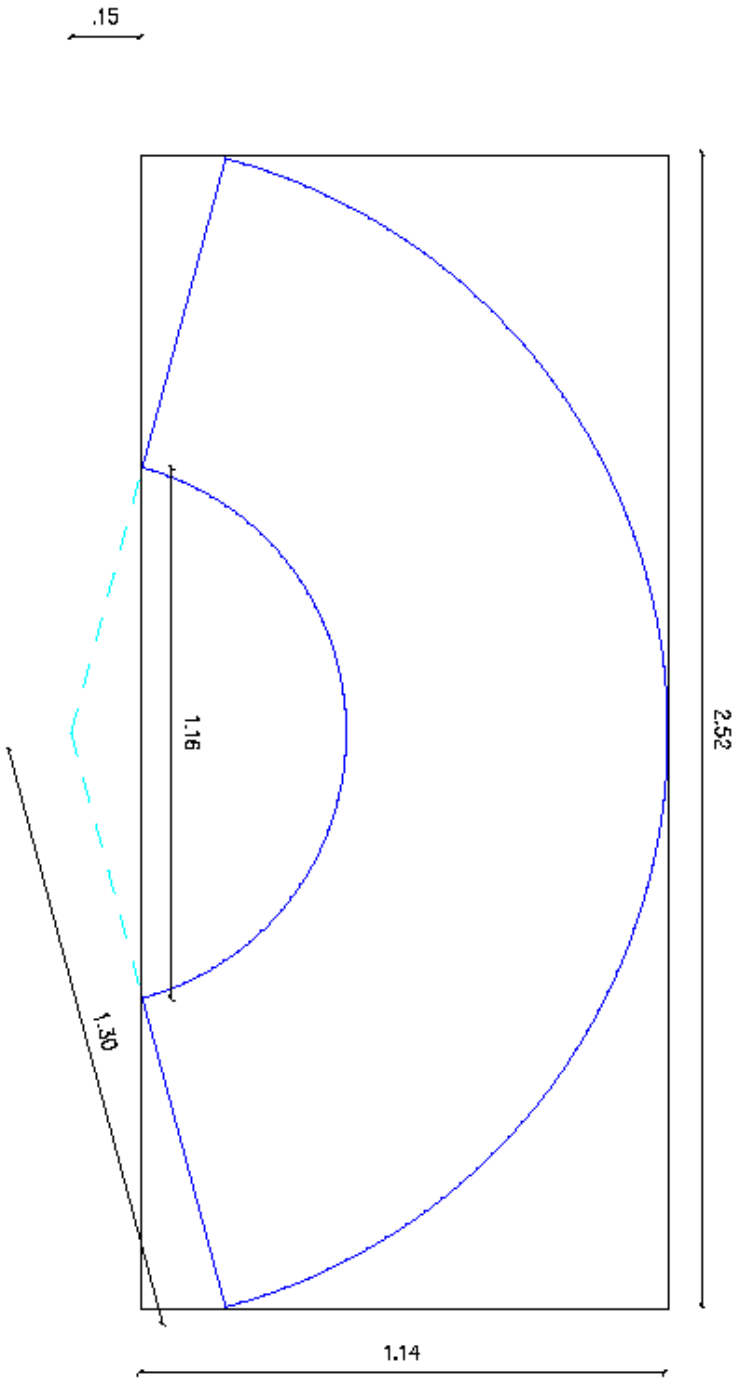
(all dimensions are in meters)



Design 1. Diameter of small opening 30 cm



Design 2. Diameter of small opening 40 cm



Design 3. Diameter of small opening 50 cm