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A three-dollar cardboard panel solar cooker for low-income communities

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Abstract

Brazil is a tropical country which has an average of 250 sunny days per year. Unfortunately, very little solar energy is used for both heating water, and for food cooking with solar cookers. Traditional cooking process demands fuel consumption while solar cooking takes advantage of the abundant, free solar energy. This article proposes the use of affordable panel solar cookers, with a sustainable design, based on waste materials, such as cardboard and potato chips metallized plastic bags as alternative materials to commercial reflective aluminum foil or reflective plastic films. Our work is an example of the feasibility of simple, fast and low-cost solar cooking apparatus and techniques dissemination among underprivileged communities

Keywords: *Solar Energy; Affordable Solar Cookers; sustainability, waste materials*

1. Introduction

The use of solar cookers is an ecologically important and correct alternative to fossil fuel or firewood usage in food cooking. About two-thirds of the world population (more than 4 billion people) depend on firewood to satisfy their energy needs on a daily basis. This represents annual tropical forest deforestation in the order of 30,000 to 40,000 km^2. Natural forest logging occurs more frequently in tropical regions, which are the most favorable regions to use solar energy, where the sunlight incidence reaches, in some cases, a potential of 1 $kW.m^{-2}$.

The widespread use of solar cooking brings environmental, social and economic benefits, with special positive impact on low-income families living in rural or suburban areas. Predatory deforestation generated by the harvesting of firewood could be mitigated, contributing to the fauna and flora preservation. In addition, the burden of collecting firewood would be replaced by other activities, while the energy cost for cooking purposes would be dramatically reduced worldwide.

Figure1: Solar cooking in low-income communities in Kenya. Source: http://solarcooking.wikia.com/wiki/Kenya

2. Types of solar cookers

2.1 Panel solar cookers

This article proposes to disclose a **Panel solar cooker** model, which are affordable and simple to assembly and use. These solar cookers are usually made from cardboard panels, which can be recycled from used cardboard boxes. Reflective surface coatings can be made of aluminum foil, metallized plastic films used in gift bags, potato chip bags, among others. They are fixed to the cardboard with homemade or white glue. The panels are folded in a way to focus sun heat towards the cooking pan spot. This type of cooker presents lower yield temperatures (up to 150 ^{0}C). Nevertheless, they are efficient to promote food cooking, as this process demands minimum temperatures around 82 ^{0}C. For improved efficiency, the pan used in Panel solar cookers must be wrapped with a plastic oven bag capable of standing 300^{0}C, or covered with a clear glass dome (Pyrex type, Figure 2). The cover acts as a greenhouse trap and retains the heat, significantly increasing thermal cooking efficiency. Solar cookers make cooking process slower than conventional cookers, they also use little to no water, since the food cooks in its own water or steam. In addition, slow cooking is a healthier way of food preparation, as it preserves nutrients. Panel solar cookers are not suitable for frying. On the other hand, they can bake breads, cakes and other baked goods with virtually no carbon footprint.

Figure 2 A panel solar cooker showing a pan covered with a clear glass dome – https://homeplaceearth.wordpress.com/2011/06/28/solar-cooking/

2.2 Box solar cookers

Cardboard, wood or plastic boxes might be used to fabricate Box solar cookers (Figure 3). The glass cover provides a suitable greenhouse effect, and a lateral flap or reflector concentrates the solar thermal energy inside the box.

Box solar cookers have higher thermal yields than panel cookers. They may reach 150^0C, making them suitable for baking, but not for frying. Construction is more money- and time-consuming, and requires re-orientation along the day to ensure optimum sun exposure. These features difficult their use in solar cooking workshops.

Figure 3 A panel solar cooker - http://solarcooking.wikia.com/wiki/Minimum_Solar_Box_Cooker

2.3 Parabolic solar cookers

Undoubtedly, Parabolic solar cookers are most powerful solar cookers. Their shape provides accurate convergent focus, allowing cooking temperatures over 300^0C and shorter cooking times. They are directional, requiring angle adjustments every 15 -20 minutes. By using this type of solar cooker, it is possible to cook, fry, and bake with yields equal to or greater than the thermal energy of a conventional gas stove. They can be constructed with various materials: glass fiber, molded plastic, cardboard, polished aluminum in a support structure, etc. Nevertheless, they are more expensive and more difficult to build, which brings some difficulties in introducing them in day-by-day usage in low-income communities or in solar cooking workshops. Figure 4 shows a parabolic solar cooker ready to use.

Figure 4 A parabolic solar cooker – source: the authors

2.4 Vacuum tubes solar cookers

A new generation of high performance solar cooker sis based on vacuum tubes with large diameters, good insulation, and reflectors to concentrate heat in focus (Figure 5). As these cookers are expensive, they are not suitable options for large use among underprivileged populations.

Figure 5 A vacuum tube solar cooker –https://www.treehugger.com/clean-technology/new-gosun-solar-cooker-bigger-and-better-and-still-absolutely-brilliant.html

As we can see, there are many designs for solar cookers. Each one of them may be useful, depending on the application intended. In our evaluation, Panel solar cookers present the best set of characteristics to be presented for a Do-It-Yourself project using affordable materials. Therefore, we chose the Benhard Muller pattern to introduce Panel solar cooking to the Community of Morro da Cruz, Porto Alegre, Rio Grande do Sul State-Brazil. Our findings suggest that this type of solar cooking apparatus can pave the way to further development of solar cooking techniques in low-income communities.

3. Methodology

3.1Subjects

Eight residents (three male and 5 female) of Morro da Cruz low-income community, Porto Alegre City, Rio Grande do Sul State, south Brazil, accepted an invitation to learn how to make their own cheap cardboard solar cooker. They received all material necessary to make a solar cooker by donation. All instructions on how to make and use the solar cooker were given to the subjects, either in written and by oral presentation. All subjects accepted to participate on the workshop from the beginning to the end.

3.2 Materials and methods to build a Fun Panel solar cooker

Originally proposed by Teong Tan, Fun Panel solar cooker is the model of choice when it comes to make powerful panel solar cookers. This model was further improved and scaled up for better results. In this study we chose Benhard Muller pattern (Figure 6) to build a Panel solar cooker suitable to be implemented as an eco-friendly, affordable cooking option for needful communities. The model consists of two rectangles, which can be fold to make two L-shaped parts joined by adhesive tape. Main parts of the

apparatus are: two folded tabs; a pan area to hold the pan, and a support made with a shoes box.

The materials you need to build a funnel cooker are:

- 2 cardboard or polypropylene (PP) sheets of 85 cm x 60 cm
- 2 reflective sheets of the same size, like aluminium, Mylar, S-ReflecT or similar
- 95 cm of rigid textile reinforced tape to connect both halves
- glue (or double-sided adhesive tape) to stick the reflective sheets onto the cardboard or PP.

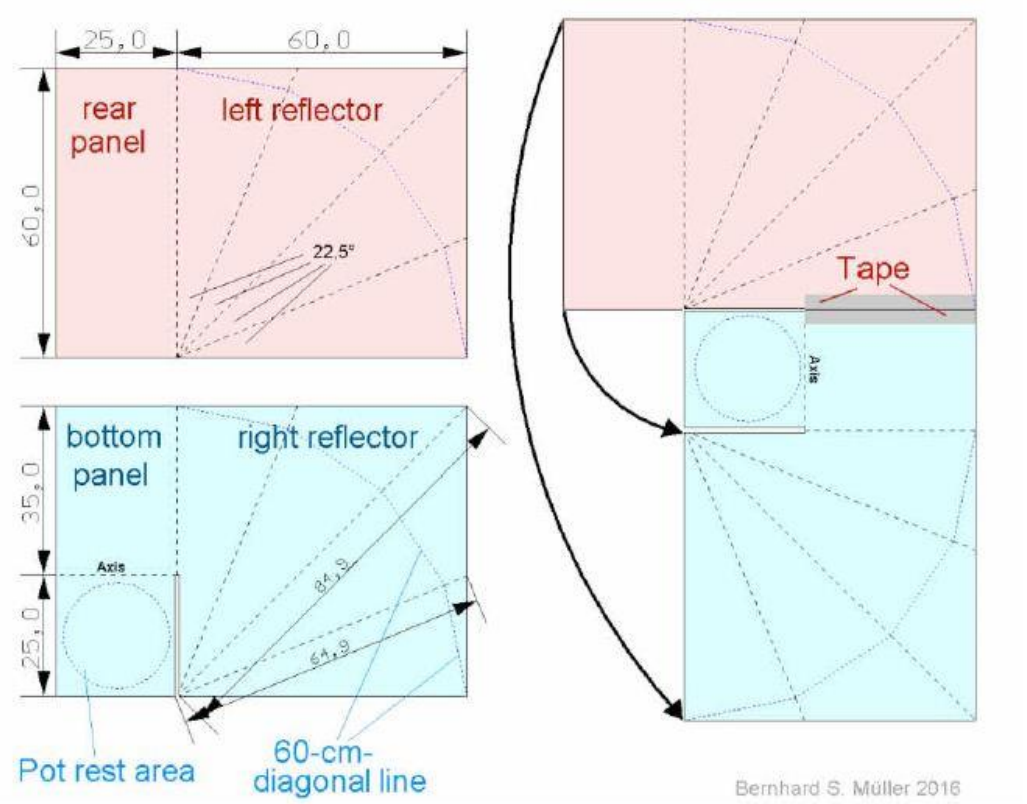

Figure 6 – Fun Panel solar cooker pattern – Bernhard Muller

The cardboard used in the Panel solar cooker can be waste material. For example, LCD TV packages usually have adequate dimensions to make a good Panel solar cooker. Large cardboard boxes, in sizes superior to 60 x 60 cm, are also good alternatives.

The reflexive material can be made out of waste potato chip bags, metallized biaxially-oriented polypropylene (BOPP) sheets used in gift bags, or aluminum foil, but with less reflexibility and poorer mechanical resistance.

Reflexive material can be glued to the cardboard with homemade glue or white glue. However, best results are achieved with double-sided tape, as the reflexive cover presents less wrinkles and better reflexivity.

The instructions provided to the subjects were:

a) Cut two cardboard rectangles, in dimensions showed in the pattern (Figure 7).

b) Cut the two reflexive sheets, in the same size of cardboard rectangles. For best results, apply double sided tape in the edges of cardboard, with vertical glue lines, as shown in Figure 8.
c) Apply double-sided adhesive tape in the cardboard sheets.
d) Stretch reflexive film over the cardboard sheets.
e) Fold and join the two "L" sheets to make the Panel solar cooker, as shown in Figure 9.

Figure 7 – Cardboard sheets and metallized BOPP plastic reflexive sheets. Source: The authors

Figure 8 – Schematics on double sided tape and glue line to glue reflexive the sheet on the cardboard. Source: The authors

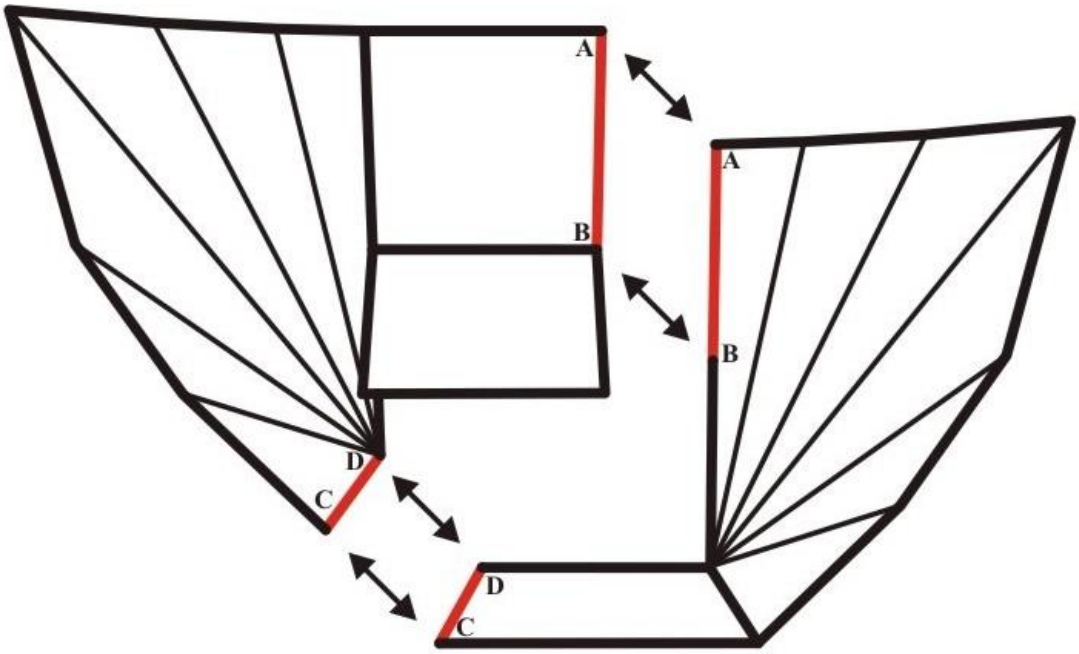

Figure 9 – Schematics on how to join the two "L" sheets makes the solar cooker. Source: The authors

4. Results and Discussion

Subjects were able to follow Procedure "a" without further assistance from the instructors. Figures 10 to 12 show photographs of the subjects following the constructing instructions for the Panel solar cooker manufacturing. Figure 9 shows the execution of Procedure "b". The special double-sided tape is attached to a paper that acts as protective coating, in order to avoid tape adherence loss due to the contact with air.. This paper must be removed before applying reflexive plastic material, to expose the glued surface for an effective adherence. Subjects were encouraged to perform this procedure in pairs.

Figure 10 – Applying double-sided adhesive tape in cardboard sheets – Source: The authors

Figure 11 shows the execution of Procedure "c" and 'd'. Special care must be taken in stretching the reflexive sheets to avoid wrinkles, which may decrease reflexivity. Resulting good quality panels are shown in Figure 12.

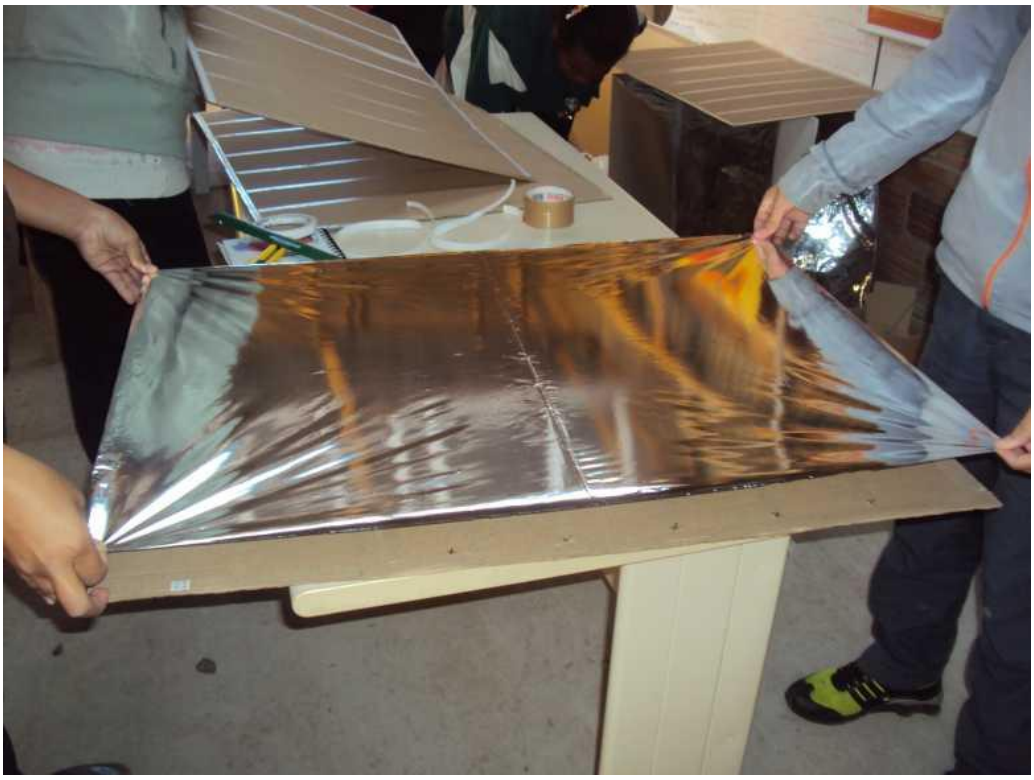

Figure 11 – Stretching reflexive film to glue in the cardboard sheets. Source: The authors

Figure 12 – Two cardboard sheets covered with reflexive films. Source: The authors

After following Procedure “e”, the subjects were able to assembly their own Fun Panel solar cooker (Figure 13). A shoes box was used as pan support. . A 1m long, 4mm in diameter metallic bolt was used to keep the cooker open.

Figure 13 – An assembled, ready-to-use Fun Panel solar cooker manufactured in the Morro da Cruz Workshop. Notice the shoes box used as pan support. Source: The authors

Figure 14 shows the final results of the Morro da Cruz Workshop. In two hours, the pairs of residents easily built their own Panel solar cooker and were oriented on how to use them. However, further efforts must be done in order to implement the effective use of solar cookers on a daily basis. Additional instructions must be passed on to the community members regarding solar cooking techniques applied to simple recipes, such as cooked white rice, chicken breast, or pasta; and baked goods.
Solar cooking demands black pans to improve heat absorption and achieve better Greenhouse effect. Thus, community members might be instructed to paint common aluminum pans or glass preserve jars in black, and use plastic oven bags to cover their pans.

Another important aspect to be considered is the need to recruit sponsors to provide the basic materials needed, adequate working space and appropriate workshop furniture,

e.g. large size sturdy tables. Such facilities are not readily available in most low-income communities.

Figure 14 – Workshop in Morro da Cruz poor community – Porto Alegre - RS. Source: The authors

5 Conclusions

Our findings revealed that the Fun Panel solar cooker could be fast and easily manufactured by a group of eight members from the Morro da Cruz low-income community, suggesting that this pattern might be a good starting point to disseminate the use of thermal solar energy for cooking and baking as an alternative to fossil-fuel-based conventional cooking.

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