

DESIGN AND CONSTRUCTION OF SOLAR OVENS: A PRACTICAL APPROACH TO THE GREENHOUSE EFFECT AND CLIMATE CHANGE

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Abstract

This article describes the use of solar ovens as a practical way of understanding how the greenhouse effect can cause warming of any object or the earth's surface, a phenomenon known as global warming. The design and construction of solar ovens requires a basic knowledge of the physical effects of solar radiation, the forms of heat transfer and its relation to the temperature of objects, but there is no need of complicated formulas or mathematical calculations. The article also shows several activities with elementary students (8-12 years) who were able to perform the construction and use of solar ovens with excellent results. The activities were carried out in two schools of Barrantes (Tomiño) and Gondomar, and IES Valadares (Vigo), all of them in Galicia, Spain.

1. Introduction

In XVIII century swiss scientist Horace de Saussure cooked some fruits and vegetables in a triple glass box insulated with wool. It was one of the first documented experiences of solar ovens construction and solar cooking.

From these early experiences a major research effort has been carried out in the field of solar energy for both thermal and electrical applications.

In recent years growing concern about climate change and global warming recommended to make extensive work teaching on these issues to increase knowledge of the general public and promote searching of possible solutions.

The construction of a solar oven concentrates on a single experience all the scientific principles involved in the global warming phenomenon, which can be verified and measured on a small scale. In addition it is a fun experience and with the help of a little sun the result can be tasted in the form of a delicious cake or dessert that students will not forget.

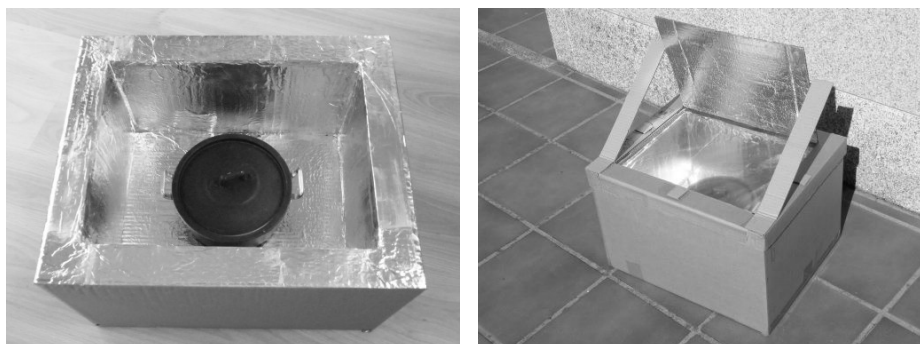


Figure 1: Solar oven without cover (left) and with cover and reflector (right)

2. Solar cookers in practice

Modern history of solar cooking box-type oven begins in the 70's with Barbara Kerr and Sherry Cole, two of the founders of Solar Cookers International. Their design, made of cardboard and foil, is a model of simplicity and efficiency.

The use of solar ovens is not limited to food preparation, but is the basis for numerous industrial and energy applications. In Odeillo, in the French Pyrenees, has been operating for several decades an oven (which really is a concentrator) for the metallurgical testing, and the Plataforma Solar de Almería (Spain) has also a similar system.

From a technological point of view a solar cooker is a solar thermal collector designed specifically for heating solids such as food (although it can also be used for liquids stored in pots or bottles).

The determining parameter of cooked foods is the temperature, so that the design of a solar cooker is oriented to achieve a rapid increase of the temperature of the food and keep it the time required for proper processing.

There are two ways to achieve the temperature rise in a solar kitchen: capturing the maximum possible solar radiation by concentration or the accumulation of heat in an insulated box ("heat trap").

The principle of heat accumulation present in the solar ovens can be observed in many real cases, as in automobiles, homes and in the atmosphere (greenhouse gases also cause warming on the earth surface). In all cases there is a transparent window and an enclosure that accumulates the heat.



Figure 2: Barbara Kerr and Sherry Coke (left) and solar oven at PSA (right)

3. Solar ovens design

Solar ovens design and construction involves a careful study and application of principles of energy and heat transmission by conduction, convection and radiation. These principles will be revised in the next paragraphs

3.1. Radiation

Solar energy reaches a solar oven by radiation. Visible, ultraviolet and near infrared radiation get into the oven and get absorbed by a black pot and lid that works as a black body. White or reflecting pots don't work the same way and reject sun radiation. Glass or plastic window in the upper part of the oven must allow this type of radiation get into the oven.

On the other hand, lower radiation frequencies like far infrared should not be allowed to escape from the oven, so window must reflect them inside. This effect (known as the 'greenhouse effect') leads to a net storage of heat inside the oven and raising of inner temperature.

Some techniques to achieve the maximum amount of radiation inside the oven:

- proper orientation of the oven (south at midday)
- use of reflectors to increase the collector area (plans, parabolic).
- transparent surfaces of glass or plastic to maximize the radiation transmission
- reflective surfaces for internal radiation reflection

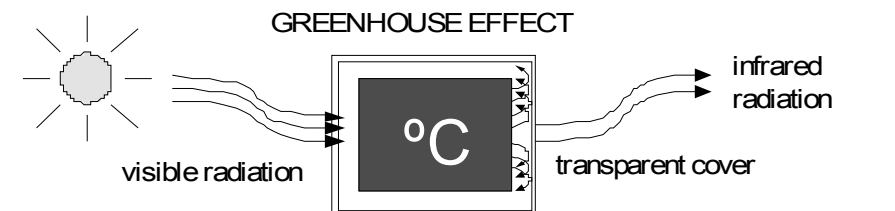


Figure 3: Solar radiation and greenhouse effect

3.2. Conduction and Convection

Heat stored in the oven escapes by conduction through solid walls of the oven and convection of air trapped inside. The hot pot generates infrared radiation, so it must be surrounded by surfaces that reflect the radiation (mirror, glass, some types of plastic like polypropylene, polyester, methacrylate). Any hot area must be separated from the outside elements and surrounded by insulation or air. Wood, cardboard and paper are good low cost insulations. Hot air surrounding the

pot can transfer heat to the upper cover and walls. For the cover, it can be avoided with a double layer of transparent glass or plastic. It must be noted that in solar cookers the upper part is warmer than lower (as opposed to the traditional cuisine)

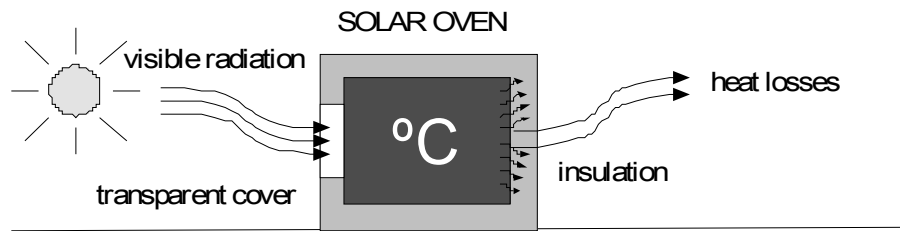


Figure 4: Heat losses in a solar oven

4. Solar oven construction

We have chosen the original solar oven model developed by Barbara Kerr and Sherry Cole. A detailed description of the construction process can be found in (Solar Cookers International 2004).

The activities were carried out in CEIP Barrantes (Tomiño, Spain), CEIP Chano Piñeiro (Gondomar, Spain) and IES Valadares (Vigo) with several groups of students of different ages. The activities took two days, the first for the construction of the solar ovens and the second to use them. It is recommended to leave at least one night to completely dry all the glued parts of the ovens.

The first day there was a presentation about solar energy types and devices and how can contribute to sustainable development and stop climate change. In second place there was an explanation of the construction steps of the solar ovens and after that students started to make their own ovens.

The second day was dedicated to food preparation and different activities like games and basic scientific experiences about solar energy.



Figure 5: Explanation and first construction steps (CEIP Barrantes)



Figure 6: Covering with aluminium foil (CEIP Barrantes)

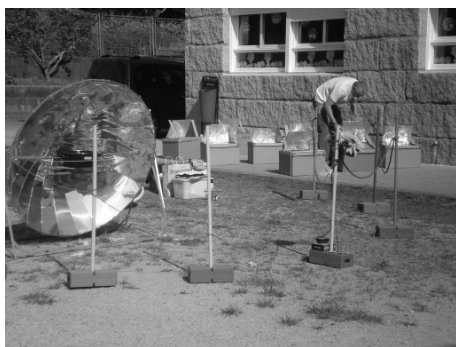


Figure 7: Solar ovens ready to cook and the delicious result (CEIP Barrantes)

5. Complementary activities

Use of solar ovens means waiting a long time before food is ready, specially for children. To “fill the gap” several activities were made, like construction of water pasteurizers, solar games, using of parabolic cookers to boil water, etc.

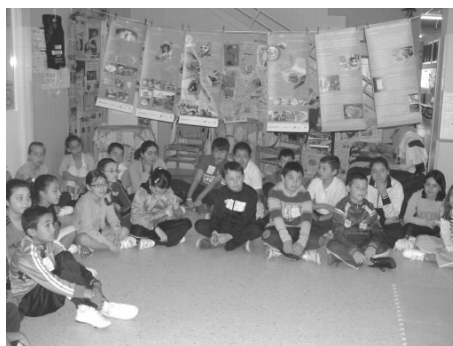


Figure 8: Exhibition of solar devices and presentation (CEIP Barrantes)



Figure 9: Sunflowers painting workshop and boiling water with the parabolic cooker (CEIP Barrantes)



Figure 10: Solar pasteurization workshop (CEIP Chano Piñeiro)



Figure 11: Solar activities and games (CEIP Chano Piñeiro)



Figure 12: Solar oven workshop at IES Valadares (Vigo)

6. Acknowledgements

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7. References

Solar Cookers International (2004) Solar Cookers: How to make, use and enjoy (10th Edition)