# ENVIRONMENTAL FEEDBACK AND ANTHROPOMETRICAL RESULTS OF A SOLAR COOKER FOR HOUSES IN ARID ZONES

Arturo F. Buigues Nollens
Alternative Energies Area - Institute of Applied Mechanics
Electromechanics Department - Faculty of Engineering - U.N.S.J
Av. Libertador Gral. San Martín 1109 - O - (5400)
San Juan – Argentina
e-mail: abuigues@unsj.edu.ar

Esteban O. Rojos
Alternative Energies Area - Institute of Applied Mechanics
Electromechanics Department - Faculty of Engineering - U.N.S.J.
Av. Libertador Gral. San Martín 1109 - O - (5400)
San Juan – Argentina
e-mail: erojos@unsj.edu.ar

ABSTRACT

The objective of this project is to determine the environmental feedback and anthropometrical results of a solar cooker incorporated into current economical, compact houses.

The methodology used the analysis of a bibliographical survey on the topic, the comparative study between the basic types of kitchen- [through-the-wall?] solar cookers, the evolution of the kitchen and the climate of an arid zone. Subsequently, a diagnosis of the the conditions and local needs has led to proposed integration of cardboard solar cooker into the kitchen window of the house in arid areas.

This proposal adapts the job of cooking and improves the life quality of the solar cook in hot, arid areas. Taking into account the results and conclusions at a theoretical-practical level, improvements were made in household efficacy within the kitchen according to the solar cooker performance.

**Key words**: room- anthropometrics - cooker- solar-dryness

## 1. INTRODUCTION

According to the objectives, a medium-sized solar cooker is included in/ transferred to the kitchen of the house in arid areas, increasing convenience and comfor. As a system, it has evolved considering strictly technical aspects (1) related to the thermal performance compared to the transportable designs of the type of suitcases used or operated mainly outside. In many cases, the same ground space is used to lean the cooker or an isolated support structure, but not everyone can transport the solar cooker easily to operate it outside comfortably on uneven surrounding ground or on an isolated light structure far from the kitchen.

This project contributes to a kitchen without any limitations for the solar cook regardless of his/her own physical size, the solar cooker dimensions and the surrounding conditions. It allows him /her to solar cook or bake any kind of food efficiently under rigorous weather conditions, and takes into account the need for the designs to respond the appropriate user (4).

## 2. EVOLUTION OF THE KITCHEN AND CLIMATIC ANALYSIS

The typical, compact kitchen of houses in San Juan (by mutual help, auto constructed or of a social interest) is a laboratory or a hygienic and equipped place to work in.
In general, the domestic efficacy is considered in its design, with the aim of saving not only time but also effort. That is to say, to make the household easier in a healthy way, using attributes like: economy, ergonomics, mechanization, tranquility, domesticity, privacy, functionality. Besides, in some cases it also allows a social gathering (3).

Thus, the mentioned house of the arid zone has evolved to the users' comfort but without taking into account, until now, solar energy use in the kitchen to bake or cook food.

Solar cookers increase attributes of lower cost, better nourishing quality and no environmental pollution at all, when preparing different types of food.

Definitely, these new attributes contribute to obtaining better quality and energetic efficacy in the food preparation. Clearly, under the point of view of energetic expenditure and physical work capacity, it is necessary to combine efficiency and household environment with the energetic efficacy of the S.C. in conditions such as high maximum temperatures of up to 45ºC, daily elevated thermal range of about 14,5ºC, 20% relative humidity, high solar radiation in the neighborhood of 1000 W/m2 and sudden climatic changes which include strong winds and torrential rains seasonally during peak hours in arid areas especially during warmer months.

It is also necessary to consider whether any person would choose to operate the S.C in an external area without any protection or shelter. Clearly, it is necessary to check the thermal environment among other aspects of the working place of the S.C user, Figure 1.

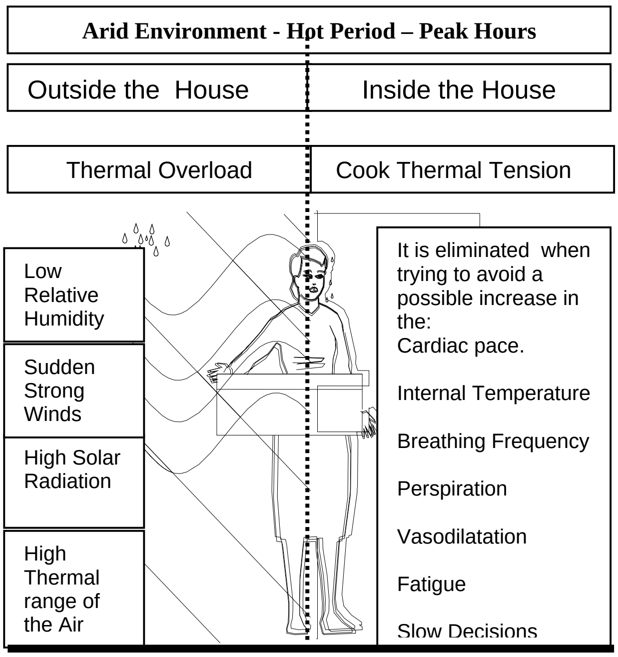



**Figure 1: Organic and environmental behavior to be considered for the use of the S.C. in Arid Zones**

## 3. ENVIRONMENTAL FEEDBACK

The aim of this project is to incorporate the S.C. into the window of the kitchen to get greater household efficacy in varied conditions and to adapt the tasks to the anatomic and physiologic conditions of the people with the following aims:

1- H.S.C System. Reliability improvement considering security and efficacy.
- The inclusion of the cooker in the kitchen in a place exposed to the sun.
- Determination of an external and permanent physical space for the S.C, in view of its inner operability during the period of cooking/baking.
- External visualization and reorientation of the cooker from the inside according to the time of year and the height of the sun through the window.
- Disposal of external reflective surfaces to the cooker for the solar tracking, by means of a component with vertical and horizontal pivotal movements.
- Heat preservation by avoiding opening the top transparent cover during the process of cooking or heating.
- An internal access to the cooker by means of a horizontal swinging door that includes thermal isolation [?insulation?].
- Rational combination of the use of the conventional kitchen with the solar cooker during the month or when there is no sun.

2- Working environment of the S.C operator. Comfort and quality of life improvement in arid zones by means of:
- Control of the inner thermal tension of the cook.[?Reducing stress from heat for the cook?]
- The consideration of the solar energy together with the use of refreshing and healthy frequent winds from insides.
- The utilization of the position of the house to ventilate the kitchen directly to the outside in a natural way.
- The S.C energy saving, together with inside hygro thermal comfort.
- Avoiding the spread of food smells to the rest of the house.
- A general luminary and environmental management from the interior of the kitchen where the S.C. is operated.

## 4. ANTHROPOMETRICAL RESULTS

An application of the anthropometrics is to determine the optimum space that a person “dominates” (4) to carry out activities in relation to the kitchen. This project takes into account features and customs of active women from the current population of the arid zone of Las Lomas, Albardón - San Juan, Argentina.

The anthropometrical data tends to a normal distribution in accordance with Gauss Curve. According to the average and the standard deviation of each dimension of the mentioned population (similar to the Spanish one), it is illustrated how the calculus has been carried out and anthropometrical decisions made as regards the design of the distance the cook must reach with his or her arm to get to the door of the cooker and get the tray out of it when he or she is standing inside the kitchen.

In order to design the distance mentioned above, it considered the vertical line from the waist (the edge of the bottom swinging window) and the access point to the removable tray of the S.C, in coincidence with the outside edge of the sill of the window.

For that, the length of the shorter arm, from the tip of the fingers to the shoulder, was taken into account, Fig. 2. Thus, the percentile 10 was adopted (according to the Percentile Table, Dimensional Relations) and it corresponds to Z=1, 28 (4). With an average of 69cm and a standard deviation of s : 2cm.

Using the expression P: X ± Z . s

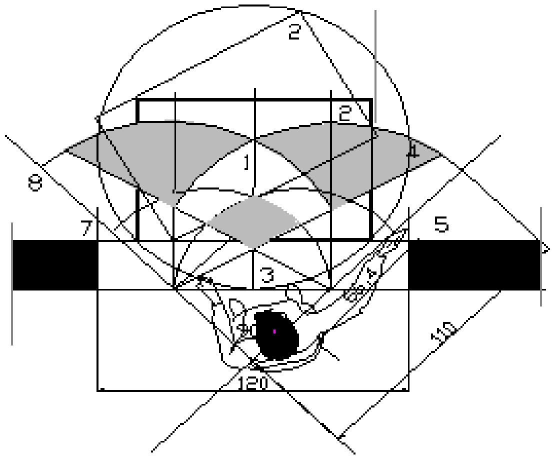
P= Percentile measure in centimeters
s = Interval where the percentage of the population or sample is included.
Z= the number of times that 0 is separated from the average

$$P= 69 – 1,28 . 2$$

P= 66,4 cm.

It is estimated that 90% of the housewives with an arm maximum reach of 66,4 cm more will be able to reach easily the door of the cooker when the bottom swinging window is open and perpendicular to the cook; only 10% of them will be out the reach or will have to stretch a bit more.
From the graphic simulation and findings about the operation of the S.C. for the kitchen of a compact house results were obtained in relation to the following variables:

1- Control of the energy expenditure and the physical work capacity of the C.- S.C System.
- A shorter walk of about 10.20m to reach the S.C. when it works outside only, Fig 4.
- Inside accessibility, with lateral tables to place the necessary implements that favor the preparation of meals in an hygienic way considering reaching areas for the right and left hand as well..
- Location of cooking points and solar baking above the kitchen table height to 0,80m, Fig.5.
- Access to open shelves and to totally removable drawers and mobile shelves that allow an adaptation without any risk of use below 0,80m.
- Quick and safe reach to domestic devices and kitchen implements in cupboards near the cooker up to 1,80m, Fig.5.
- The solar tracking, opening, control of S.C. with slanted cover according to the latitude of the place, Fig. 3, and the control of top mobile reflective surface is performed from the inside by means of the components of the S.C. A removable tray and control of the cooker positioning by means of a tracking table allows easy inside movement, Fig 6, in standing position up to a height of 1,73m and with an arm length of 66,4 cm to more through the window.




References: 1- Right hand and left hand comfort ,2- Solar Cooker, 3- Solar tracking table, 4- Seizing area for the right hand, 5- Advance Area of the right arm, 6- Precision Area, 7 - Minimum reach, 8- Maximum reach.

**Figure 2: Study of the movements and the areas of activity of the window S.C.**

**Figure 3: Technical and physical characteristics of the S.-C.**

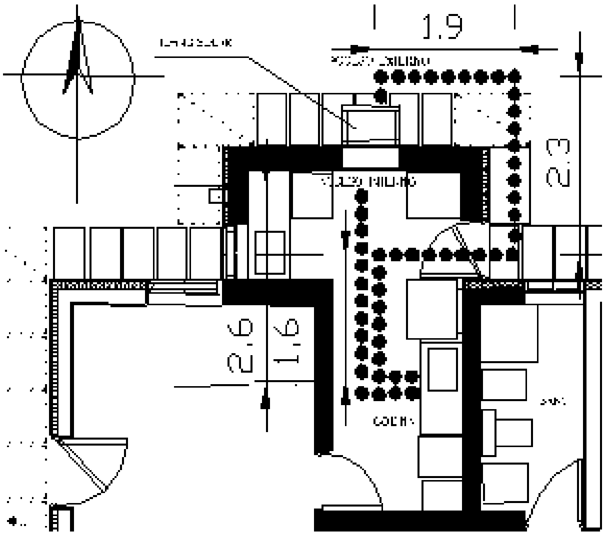
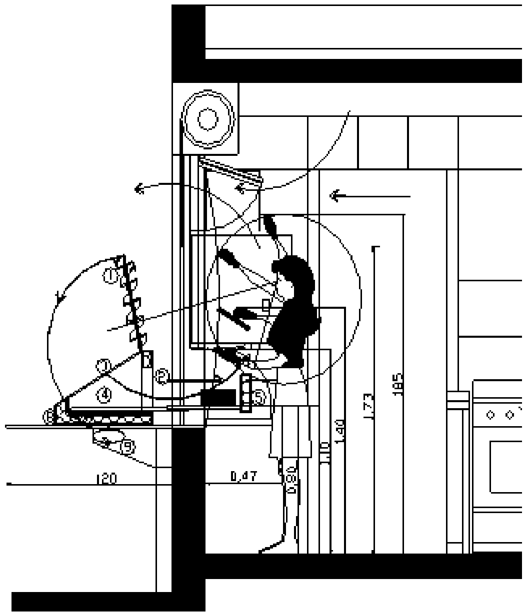


**Figure 4: Distance to go over in order to access and anthropometric results for the W.S.C**


**Figure 6: View of the S.C on the solar tracking table during the experimental campaign**




References: 1-Swinging and regulating reflective surfaces control the Window S.C. 2- Black tray, Removable. saucepan holder. 3- Detachable glass surface 4- Cooking and baking chamber 5- Door and removable tray 6-Internal reflective encircling. 7- Bottom thermal isolation. 8- External protective encircling. 9- Solar tracking table.

**Figure: 5 Study of the feedback to the thermal environment and**

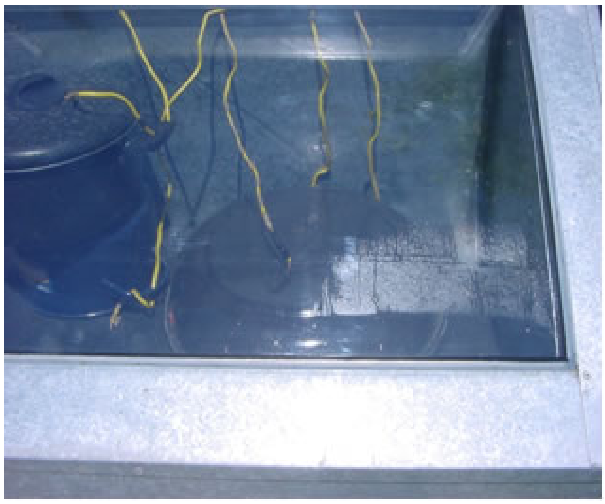
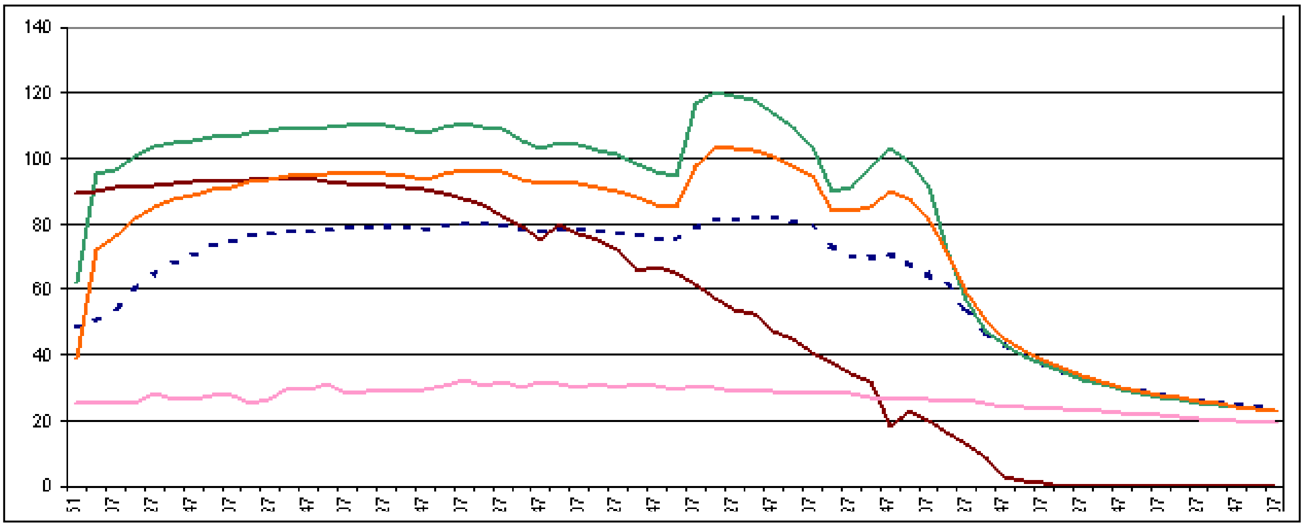


**Figure.7: View of the water boiling in the saucepan and vapor condensation under the glass of the S.C.**

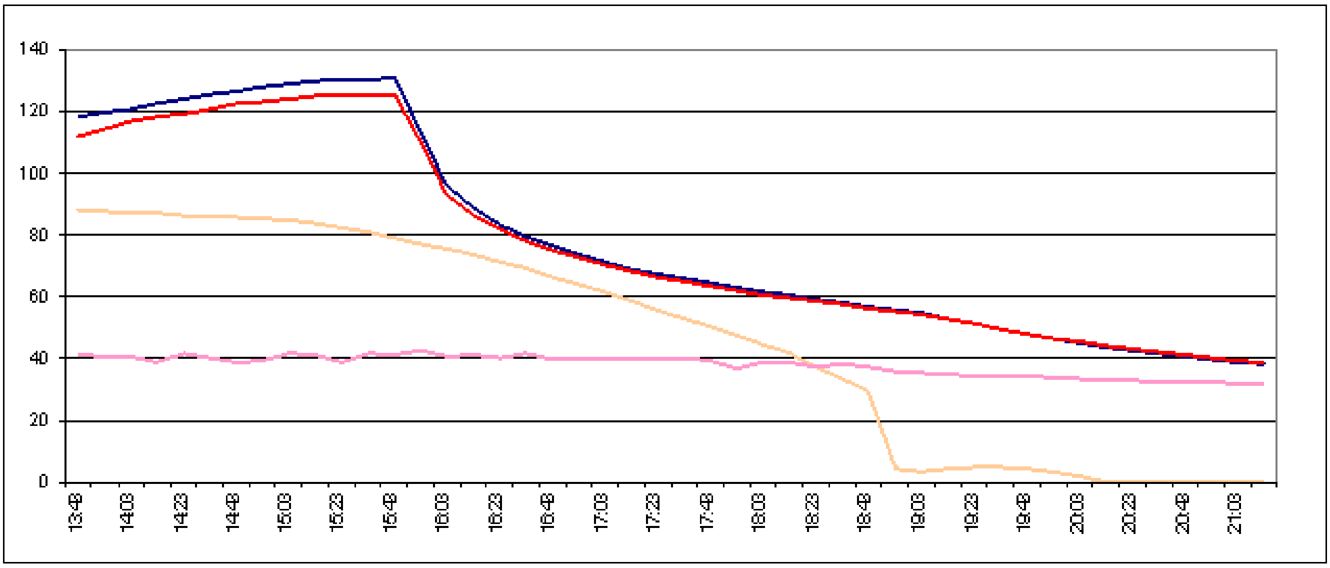
- Disposition of the equipment for the S.C functioning in the kitchen environment provide internal support and working tables necessary for the functioning of the S.C. at 0,80 m from a distance of 0,47m, adequate for any type of saucepans, trays or containers without having to stand up or stretch too much in standing position.

- Easy access to the inside of the cooker through a bottom window, located below 1,10 m according to the internal height of the window sills in economic houses in San Juan, Argentina.




References: _ Big Grill, _Black Tray, _Solar Radiation, _ External Temperature, _Small Grill

**Figure 8: Thermal behavior of the cooker with saucepan or food withdrawal and comfortable external environment**




References: _Black Cover Grill, _Black Tray, _Solar Radiation, _External Temperature

**Figure 9: Thermal behavior of the cooker without saucepan or food withdrawal high temperature in external environment**

-Food insertion, withdrawal and control from the inside of the kitchen through the opening and closure of sheets for direct control and removable tray, and of the visual and luminary control window from 0,80m and up to 1,40m.

- Minimization of frequent movements, using short periods of time that favor the operation considering the areas of activity with comfort in the working plane, 60º for the right and left hand as well, Fig 2.

2- Control of the environmental comfort of the inner space.
- Access to mechanical devises and electrical circuit breakers for thermal control from 1,4
- Access to convective, refreshing air through the design of the window with swinging sheets to the inside. This mechanism regulates ventilation better and avoids unpleasant flows of top descending air in front of the cook, Fig 5.with internal sheets at different heights like:
· Top swinging sheet, h: 1,75
· Medium pivoting sheet, h 1,40
· Bottom swinging sheet, h 1,10
- Access to external control for solar protection, natural light, and visual and internal thermal preservation, by means of a winding and regulating mechanism of the heat radiation or internal reflection respectively. The shutters made of small boards restrain the passage of 78% of solar heat. (5)
Likewise, the area of total solar detection (window plus mirror of 0,86 m2 normal to the direct beam for 5 liters) is controlled in a visual and mechanical way from behind the S.C. avoiding reflections and glare.

3- H S.C Functional compatibility:
During the first experimental tests on the thermal behavior on the black painted tray of the cooker and black flagged cover, 130ºC were obtained within 120 minutes, for a solar radiation on horizontal plane of 800watt/m$^2$.
The transparent collecting surface, Fig 7., of 0,38 m2 has a horizontal projection of 0,337 m2 and shows a relation 1:1 with the surface of the absorbing tray of 0,334 m2 and reflecting area of 0,538m$^2$.
The first merit figure that considers the relation of optical efficacy of the cooker and the heat loss to the outside from the solar energy absorbing tray, reaching F10.106ºCm$^2$/ W (2).
The experimental results show:
- Strong heat losses from the S.C that include all the elements inside it when it is opened in an external environment for the withdrawal of already baked food, Fig. 8.
-Exposure of the cook to an aggressive environment Fig.9, with temperatures of 40ºC or more during the S.C utilization and reorientation period.
- Maximum effective Temperatures of 23,6ºC are reached inside the kitchen, with low cost refreshing systems.
- The S.C temperature rises when it is not opened by the front in an outside environment.
- The temperature of the S.C is kept for a longer period of time and therefore the meals that are cooked in water do not reach more than 100ºC. They maintain their temperature when accessing from inside.

## 5. CONCLUSIONS

The solar cooker here proposed with access from the inside, does not require leaving aside the food preparation and process line, what contributes efficaciously to a better hygiene and security during the process of cooking, ergonomics and applied functionality as well.
In general, the solar cook environment is combinable with the architecture of arid zones as a whole, which proves that the cook and the S.C are not isolated systems and that can be both, protected against the rigorous requirements of the environment.
In conclusion, the improvement of the life quality of the users is linked to the household comfortableness within the environment of the kitchen, making the adequate household efficacy possible and providing a new solution directed to the acceptability and integration of the S.C as appropriate technology within the development of houses by auto construction or mutual help in arid zones.
The future experimental tests will allow complete conclusions on ergonomic studies and thermal performance of the S.C. for windows in rigorous environments.

## 6. REFERENCES

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