COOKERS FOR THE ECUATORIAN SUN

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ABSTRACT

The apparent movement of the equatorial sun determines a certain orientation of solar collectors, in relation to other geographical places of northern and southern latitudes. From this perspective an operational efficiency of the best solar cooking stoves has been evaluated in the equatorial zone, classifying them into:

1. Those that are adapted to equatorial sun, and do not require design modifications
2. Those created for equatorial sun, be they recreations or new designs
3. Those that require some corrections for their effective operation
4. Those that cannot be used with efficiency

The observations are the product of the experience of the author during training workshops on the use and technology of solar cooking stoves/ovens, carried out in more than 150 communities of Ecuador by Inti Uma foundation. If it be necessary, the designs should be adapted to the needs of each geographical site.

Keywords: Equatorial solar stoves, designs

1. INTRODUCTION

Andean cultures, from their origin, followed the path of the sun, that guided their actions, life, philosophy, and social organization. Their temples, houses, agricultural lands, tombs, and other testimonies of their daily life, are part of an architecture directed by the cycle of solstices and equinoxes that rule climatic changes, agro-productive activities, festivities, and constitute direction points.

From their cosmogonic conception of life, they conceived phenomena related to human beings and nature as part of a great world harmony. Energy that human beings required for their life was the same that nature needs, in a constructive relationship.

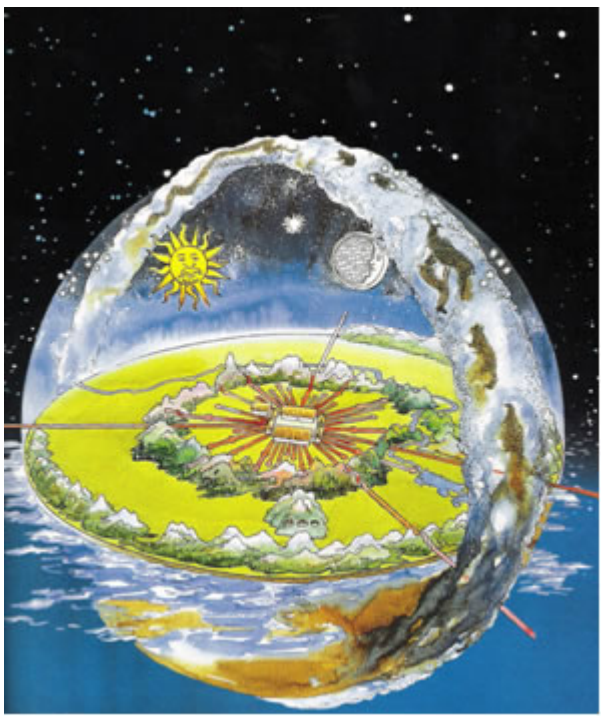

Fig. 1 Universe conception of the Incas. Source: National Geographic Magazine.

To access that knowledge is the policy of the future. To discover our roots and to assimilate technology is a way of interpreting local reality based on universal knowledge.

The ancestral solar geometry of the tropical Andes has full application nowadays. Solar energy use, for any application, begins with a correct orientation of the collector opening (maximum plane projection of the surface which collects total incoming solar energy), to guarantee maximum capture of solar radiation.
In the case of the collectors located in the northern hemisphere, they should maintain, in function of their

latitude, a certain slope southward; inversely, those located in the southern hemisphere must be oriented northward. Those located in the equatorial zone, during six months should be sloped southward, and during the other six months, northward.[1]
However, when they are approaching 23 and-23 degrees of northern and southern latitude, that coincide with the Tropics of Cancer and Capricorn, the collectors maintain a unique orientation.

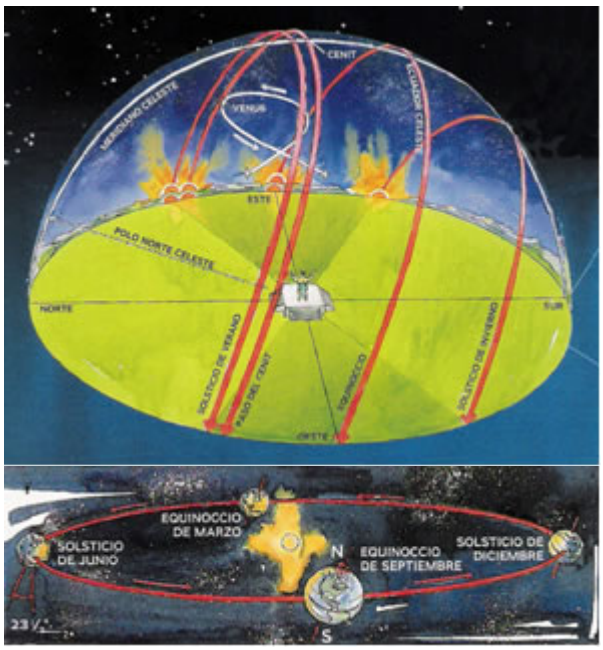

Fig. 2 Observation of the sun's trajectory in relation to the movement of the Earth, from the equatorial zone in the solstices and equinoxes. Source: National Geographic Magazine.

2. BACKGROUND

The problematic flow of energy that the world currently depends upon uses almost exclusively non-renewable sources that are very harmful, such as fossil (coal, oil and gas) and nuclear fuels. There is a correlation between energy consumption and development. A country is considered as developed as its energy consumption per capita is; this favors the increase of demand that, in correspondence with the offer, forms a rising spiral.

In light of the global ecological and energetic crisis, on the "Earth Day" (April 22nd 1990) citizens from all over the world, each in his or her field of action, conceived proposals to save the planet during the Green Decade (1990-2000).

Among the practical projects, simple and of deep scientific, technological, political, administrative, educational, economic, cultural, ecological, and human implications that were presented to the world, the one of Solar Box Cookers International, "Make your own solar box," was the beginning of a world movement. We joined this movement and , after fifteen years, we continue cooking with the sun and teaching many other people to do the same.

However, the ambitious goals that SCI proposed in 1990 were not achieved; unfortunately, it turned out not to be true that in the year 2000 there would exist two million solar cookers. But, on the other hand, at least there is in our modern world a profound awareness of solar culture.

During fifteen years we have cooked with the sun, as part of the activities of Inti Uma Foundation, through a method of direct experimentation, with investigation meetings with communities and students.
We have carried out public demonstrations, using several solar stove designs, dehydrators, and even water heaters and purifiers, photovoltaic panels, and all sort of models created by the most enthusiastic local cooks.

We have organized training workshops, especially in rural communities. In each workshop we built a minimum solar cooker and/or a Solar Cookit.[2]
In addition to the diffusion of the use and technology of solar cooking stoves, we have researched solar dehydrator applications, carrying out the following studies with students of the Schools of Industrial Engineering and Biochemistry.

- "Determination of the nutritional value of peach, banana, and coconut before and after the solar dehydrator". (Authors: Lorena Yunga and Nelly Cabrera).
- " Optimization of the drying process of yucca starch using solar energy " (Authors: Ruth Sánchez and Marís Vintimilla).

- " Chuño obtention with solar dryers " (Chuño: Traditional Andean Technology and Magical Ritual Aymaran ideology) (Authors: Inés Suarez y María Vazquez).

- "Charqui production" (Author: Inti Raymi Cartuche).

[1] This would be the concept of "equatorial zone" (approximately 20 and-20 degrees northern and southern latitude)

[2] The main sources used to carry out the project of constructing stoves were different journals such as Solar Box Journal of Seattle, Solar Cookers International, Newsletter, and Solar Cooker Review, and also the abstracts of international conferences as the one of Heredia, Costa Rica; Coimbatore, India; San Padro Sula, Nicaragua; and Cuenca, Ecuador: "Solar Energy for Everybody" P. Serrano, y "The Solar Stove-oven" Sh. S. Nandwani.

- "Cochinilla solar drying, cochinilla carmine extraction, and applications" (Author: Diego León).

With other groups we have worked on monographs about solar cooking stoves as part of Environmental Education inside high schools and bachelor theses.
Also, the Electric Engineering thesis: "Design of a photovoltaic system for a rural house." Authors: Fernando Fajardo and Ulises León.

In addition to the author`s experience, ideas were gained from participation in the following congresses where the solar stove was presented:

Earth Friends World Congress, 1990, Acrra-Ghana
Workshop on global warming and climate change. Amsterdam-Holland 1991, Miliudefense
Latinoamerican/ Caribbean Meeting, Yojoa-Honduras, 1993 Second World Conference on Solar Cooker Uses and Technology, Heredia- Costa Rica, 1994 Third World Conference on Solar Cookers and Technology, Avinashlingam, Coimbatore-India, 1997. The author organized the Second Latin American/Caribbean Conference on solar cooking stoves, uses, and technology in Cuenca-Ecuador, 1997.

3. THIS PROJECT

3.1 Stoves that are adapted to equatorial sun

Do not require design modifications

3.1.1 Flat Collectors

- Minimum Solar Stove. Model 1990 from the Solar Box Cookers International.

Fig. 3 Great Pioneers of the solar cookers.

Fig. 4 Solar Gourmet: Model 1991 by Tom Sponheim (Solar Cookers Northwest)

Fig. 5 Other models derived from "Minimum Solar Box" with one or more reflectors.

- Fruit and food dehydrator. Artesol Model SS-01 and SS-02.

Fig. 6 Greenhouse effect conventional solar dehydrator.

3.1.2 Concentrators

Fig. 7 Parabolic SK 12, Model 1992. Gerhard L. Jobst. EG. Solar Altöting. Germany and SK-14

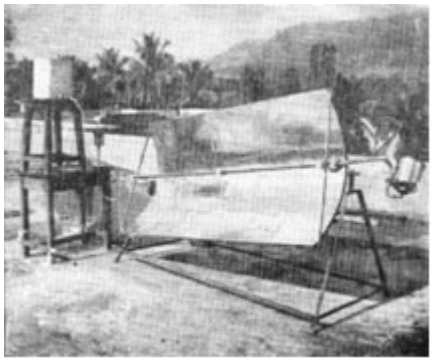

Fig. 8 Parabolic Solar Steam Cooker. Model K. Perumal and Jayaprakash. Coimbatore 1997.

Fig. 9 Solar Cookit. Model SCI 1997 and "Sun Toy" SCI. (However, the slope of the reflector´s central segment (more than 90 degrees) does not favor reflection in low solar altitude positions).

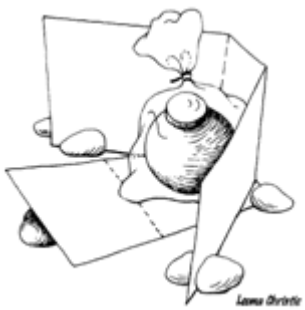

Fig. 10 Panel Cooker. Susan Carmody. Tanzania 1995.

Fig. 11 "WebQuest" Suzette Delbono. Oakview 2004.

3. 2 Models created for equatorial sun: Recreations and new designs

3.2.1 Collector planes

Fig. 12 Inti Churi. Rodrigo Carpio 1993. Recration of the Minimum Solar Box.

Fig. 13 Multi reflector Inti 2000. Rodrigo Carpio 1994, second place in the Third Annual Solar Cooker Contest. California. Home Power Magazine. ISSUE No. 43

3.2.2 Concentrators

- Vegetable fiber parabolic. Manuel Alvarez 1997. Cuenca-Ecuador.

Fig. 14 "Girasol/Sunflower". Rotating Hexagonal Reflecting Panel. Rodrigo Carpio 2002. Presented in Cubasolar 2002.

3.3 Stoves with adjustment requirements

To improve performance

3.3.1 Flat collectors

- Window of sloped attraction. Slope up to 23,5 degrees. (At the sun´s zenith, the back reflector must turn to an angle bigger than 90 degrees. If it is linked to a "cup" of reflectors, a base which levels ahead and lateral reflectors must be added. For example: The "Global Sun Oven".

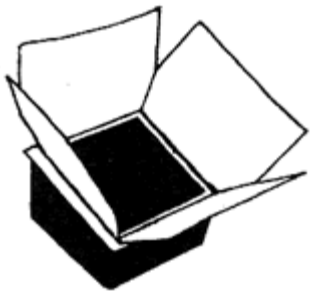

Fig. 15 "Global Sun Oven".

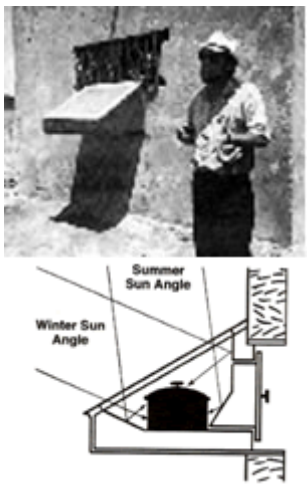

Fig. 16 "Through the Wall Ovens". Model 1994 Paul Funk´s.

To be used all year long it must be fixed to two opposite walls, one towards the north and the other to the south.

Fig. 17 "Sunstove" by R. Dick Wareham. South Africa 1994, and SOS "Sport"

They need at least two reflectors added: ahead and back to attract zenithal radiation. Without reflectors, the back wall would project shadow.

3.3.2 Concentrators

- All parabolics must allow the reflecting surface to rotate completely over the horizontal axis, and that this one displaces according to solar azimuth.

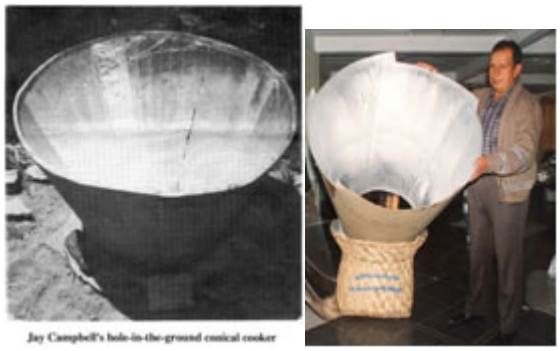

Fig. 18 Ground conical cooker. Jay Campbell´s 1993 and Conical Reflector by Manuel Alvarez 1997. Cuenca-Ecuador.

They require a device to spin, probably from their base. Without it their performance is effective only in midday hours, approx. from 10h00 am. to 2h00 pm.).

- Dats Solar Cooker. Tan. 2002. (Device in which pot is placed must be fastened without contact with the parabola which must have a rotary axis).

- "Open Type"cookers by E. Goetz. Switzerland 1997. (It is necessary to clip the reflector base to allow a slope a bit more than 90 degrees in zenithal sun).

3.4 Stoves that can not be used effectively

Their structure does not help the following of solar trajectory and requires more complex adaptations:

3.4.1 Flat collectors

Fig. 19 Dan Freeman

With pronounced slope (more than 23,5 degrees), used in high latitude (north or south) geographical places. Attractors of higher slope, reduce their opening before zenithal radiation, the reason they have been discarded.

3.4.2 Concentrators

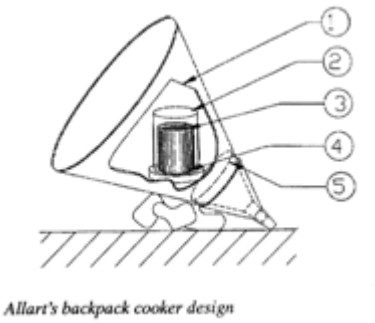

Fig. 20 Cone-shaped backpack cooker. SCI 2000.

Fig. 21 Parabolic Jack Thompson.

While the cone-shaped cooker is not able to follow the altitude movement of the sun over a horizontal axis, the Parabolic cooker, is not able to follow the azimuth movement turning over a vertical axis.

4. CONCLUSION

The orientation of the collectors towards the south or toward the north depends on the latitude of the geographical site in which they are used. In the case of the equator, during six months the collectors should have southern orientation, and during the other six months a northern one.

The angle of inclination or the collectors will depend on the distance from the equator. The greater the distance, the greater the angle of inclination. In the case of the equator, the angle of inclination of the collectors varies between 0 degrees +/- 23.5 degrees.

In the equatorial zone, flat collectors like the minimal solar stove and its applications (Solar Gourmet, Conventional Solar Distillery, Dehydrator of fruit and food and others) can be used without further modifications.

Also in the equatorial zone, concentrators and paraboloids can be used, as long as they maintain an axis of horizontal rotation and another one of vertical

The best way for solar cooks to research about the complexity of light and shades is the daily practice of solar cooking .

Each geographical place on earth has its own feature , therefore, all designs created for other locations must be adapted in order to acquire their best proficiency.