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Rural Solar Cookers, an alternative to reduce the timber resource extraction through the use of renewable energy sources: technology transfer and monitoring project.

Luis Bernardo López Sosa[a], Mauricio González Avilés[a], Dante González Pérez[a] Yuritzi Solís Gutiérrez[a] [1]

[a]*Área de Desarrollo Sustentable, Universidad Intercultural Indígena de Michoacán, Finca la tsipecua, Carretera Pátzcuaro-huecorio Km 3, Páztcuaro, Michoacán C.P. 61614. México.*

Abstract

In this paper, it's presented an integral project of technology transfer. Based in the development of several prototypes of solar cookers, all of them with our own design and construction, whose functionality is to compound parabolic concentrators of revolution, this project performed how to implement this ecotechnology. The prototype implemented uses mirror polished aluminum reflectors, aluminum pressure cooker manual tracking device and solar tilt. With the help of social programs, 70 solar cookers were implemented in an indigenous community in Michoacán, México; previously it was implemented a diagnostic of timber resources consumption to each beneficiary family. Also, firing tests were performed with various prototypes plots to select the best one with thermal and ergonomic characteristics. The project expects to reduce the consumption of timber as fuel used for cooking by 30%; to encourage the use of renewable energy, to mitigate respiratory diseases caused by the inhalation of combustion smoke and help the family's economy. Currently we are working with the monitoring to quantify the improvements achieved in consumption-appropriation. There is already an user manual of maintenance and construction of solar cookers in the indigenous language and the project wants to be the basis for future Eco technologies' implementations.

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[1] * Corresponding author. Tel.: 01-(434)-342-5532; fax: 01-(434)-345-8088.
E-mail address: ecoberso@gmail.com, sosabernardo@hotmail.com. gamauricio@gmail.com

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1. Introduction.

The use of conventional fuels (hydrocarbons), in Michoacán, México, to meet the daily various needs is inevitable in every home. The gas, for example, is extremely necessary for cooking in urban and rural areas, lesser use is due, due to the total or partial use of wood as fuel. The use of timber resources in rural areas, used for as cooking fuel, has caused respiratory diseases in family members, large emissions of carbon dioxide and deforestation in the forest, which along with forest fires and illegal logging, is an environmental degradation in many cases irreversible. Therefore, alternatives are required to improve the quality of people's life, mitigate the use of conventional fuels, reduce carbon dioxide emissions and contribute to family and economic savings. Solar cookers are a complementary alternative to meet the basic energy needs in a cooking matter, they can to mitigate to a lesser or greater the problems described above; favoring the rural sector, environment, social and economic welfare.

2. Development of solar cookers with Compound Parabolic Concentrators of revolution.

The solar cookers have been used for several years to cook using sun energy. Although there are many designs in the world, the fact is that there is still a lot to investigate. Until now it had not used the compound parabolic concentrator (CPC) in three dimensions with non-imaging optics for the construction of solar cookers. This proves a field that until now has not been worked with great benefits.

A CPC is an efficient means of solar concentration used for several years, in addition to be an application of the non-imaging optics, offers the user several advantages: no emission of light flashes that can damage eyesight, good performance in rainy season, because they use diffuse radiation, and they not require too much time for cooking.

3. Construction and evaluation of solar cookers with CPC of revolution

Applications of the CPC of revolution in three dimensions [1] show an increased thermal and optical performance that CPC in two dimensions used as compound parabolic channel. This justifies the construction of solar cookers with CPC features of revolution; based in the curves used in 2002 to the solar oven Tolokatsin [2], but considering its rotation with respect to the symmetry axis (Figure 1) was obtained one surface of revolution in three dimensions, which of course is a different surface of a paraboloid of revolution. And whose equations are shown below:

$$x = R\cos\theta + R\left(\theta + \frac{\pi}{2}\right)\sin\theta \tag{1}$$

$$y = R\sin\theta - R\left(\theta + \frac{\pi}{2}\right)\cos\theta \tag{2}$$

By forming the curves CPC of revolution described above and with the benefits of the use of non-imaging optics, the solar cookers construction represents a scarce area explored to perform some research.

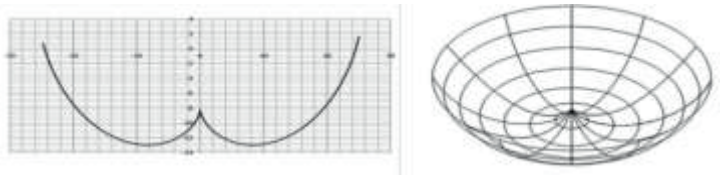

Fig.1. CPC of revolution.

Using metal sections was formed the CPC of revolution to give rise three prototypes of solar cookers (Figure 2) that, gradually, they improved thermal and functionality.

Fig. 2. Solar Cookers CPC of revolution

The Solar Cooker 1 (CS-1) was built with reflectors of stainless steel sheet mirror finish, additionally, used a basis of three sticks to sustain the CPC; its solar collection area was 0.47 m^2. With a cooking container of 2 liters has the cooking power reached 19 watts [3] and the cost of the prototype was of approximately $40 dollars.

The Solar Cooker "Jorhejpataranskua" 1 (CSJ), the Purhépecha name given (One of the indigenous languages of the state of Michoacán, México) language "cook with sun", used the CS-1, reflectors stainless steel sheet mirror finish, its solar collection area was 0.73 m^2, its base included a tilt manual device and tracking solar, additionally, included a 5 liter black pot capacity [4]. Its cooking power was 95 watts [5] and had a cost of approximately $96 dollars.

The Solar Cooker Rural 1 (CSR-1) was built using the basis of the CSJ, it included an express black pot of 6 liters of capacity, its reflectors were of anodized aluminum sheet mirror finish and its catchment area was 0.67m^2. Its cooking power was 130 watts (Figure 3) and the cost was approximately $280 dollars [6].

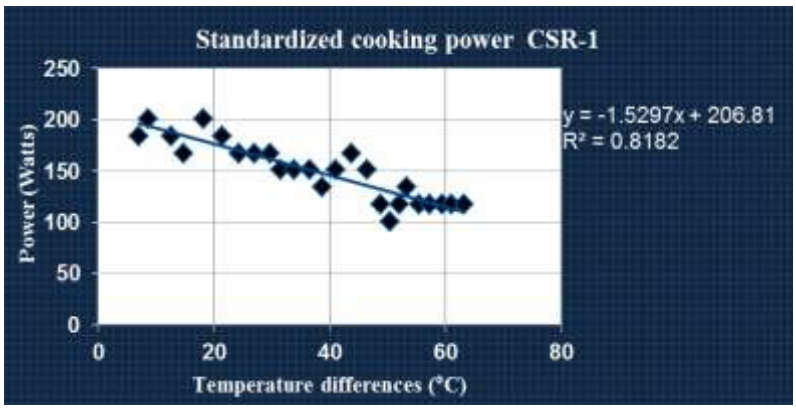

Fig. 3. Cooking Power of CSR-1.

The Cooking power was calculated based on standard ASAE S580 [7], which establish a procedure for testing solar thermal for solar cookers and provides a framework for the setting of "Cooking Power normalized" to an uniform insolation [8]. The objective of this test is to produce a simple but significant measure of performance for solar cookers. Also the average thermal efficiency, [9] was calculated (Figure 4) of the CSR, which was obtained in 30%.

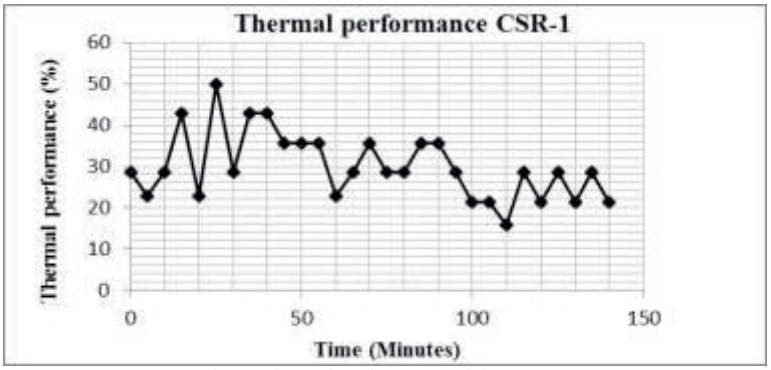

Fig. 4. Thermal performance of the CSR-1.

The constructions of three solar prototypes was based in find one with better thermal performance and ergonomics. The CSR-1 was the solar cooker with the best features suitable to be implemented in any community.

4. Ecotechnologies Implementation Project in indigenous communities

One of the main challenges of basic research is to apply it to the society, generating significant benefits in matter of science, technology and appropriation. Many investigations are never used in real life, others do not pass of the citations and the rest do not generate a tangible benefit to the sector for which they were made.

Therefore, it was decided to undertake a project that would provide the benefits of the solar cookers in the urban and rural sectors. However, like the sector is a vulnerable zone and operate the cliché "think globally, local current" we decided to perform the project "Implementing of Eco technologies in indigenous communities as a strategy for the conservation of forest resources."

The implementation project was performed considering:

- The selection of the recipient community of the project.
- Diagnostic of extraction and consumption of fuel wood.
- Bilingual Handbook on the use, maintenance and construction of solar cookers.
- Implementation of solar cookers.
- Initial Monitoring of use and appropriation of solar cookers.

5. Diagnostic of use and extraction of timber resource.

As a first step we selected the indigenous community (Purhépecha) of Santa Fe de la Laguna, a town of Quiroga, Michoacán, México, hosted community of the project. A sample of approximately 10% of all

families in the community, 150 families were chosen by the community according to the scarcity of economic resources. The 150 families were surveyed with the intention of making the diagnosis of timber resources in terms of use, consumption, extraction and buying fuel wood.

6. Evaluation of extraction and consumption of fuel wood.

Of all the families surveyed the results showed that the annual consumption of fuel wood for household is 6.9 tons (Figure 5).

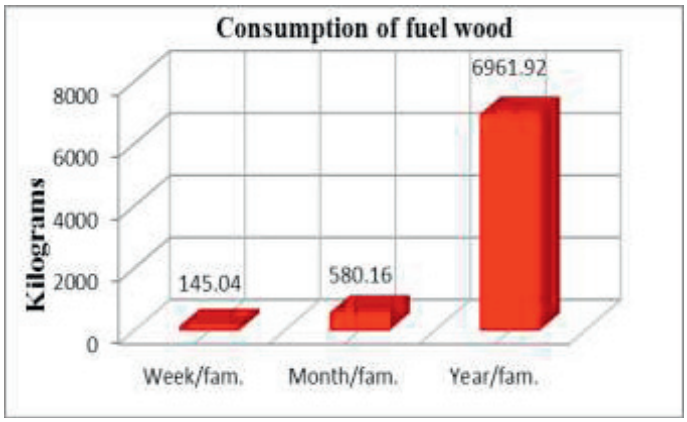

Fig. 5. Gradual consumption of fuel wood per family

Hence, consumption is significant. However, in the majority of families (62%), fuel wood extraction performed once for week, while only 1% is most often weekly (Figure 6). On average, five extractions are performed of fuel wood every month.

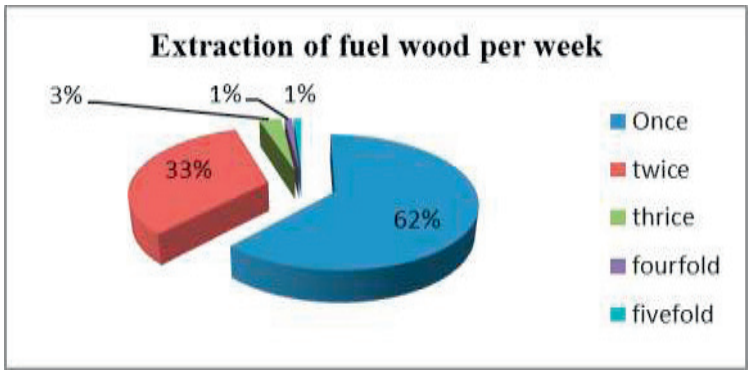

Fig. 6. Number of extractions per week per family.

When you can't remove the wood for various reasons, including the rainy season, the population is forced to buy the fuel wood to an average cost of approximately $8 dollars for weekly consumption. This represents a high cost in the case of households receiving weekly approximately $48 dollars.

7. Assessment the use for fuel wood to combustion.

Of the total timber resources for fuel consumed per week, most of it was used to carry tortillas (Figure 7); the rest was consumed in different activities like preparing soup, porridge, cooking vegetables, tamales, milk, cook meat, cook egg, cook beans and heat water.

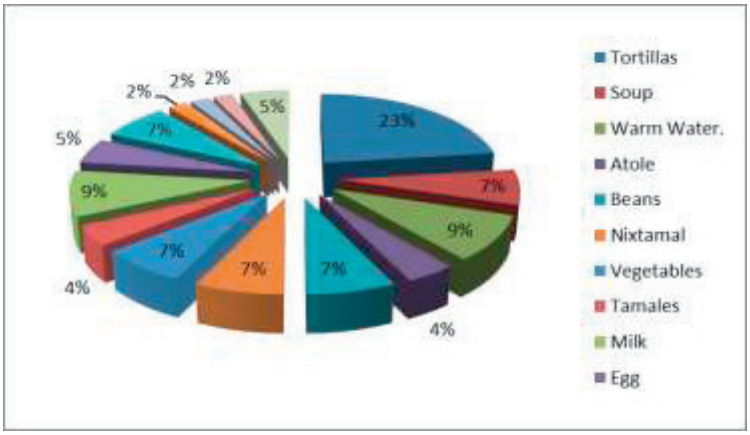

Fig. 7. Percentage of firewood consumption in everyday activities.

Moreover, the use, of fuel wood, of different species of trees used for combustion, in descending order (Figure 8), showed that the most endangered species were *Quercus and Pinus*, while *Arbutus unedo* and *Ladaniferus Cistus* represented less exploitation. Data were obtained from the total of fuel wood consumed per household and the percentage represented by each species.

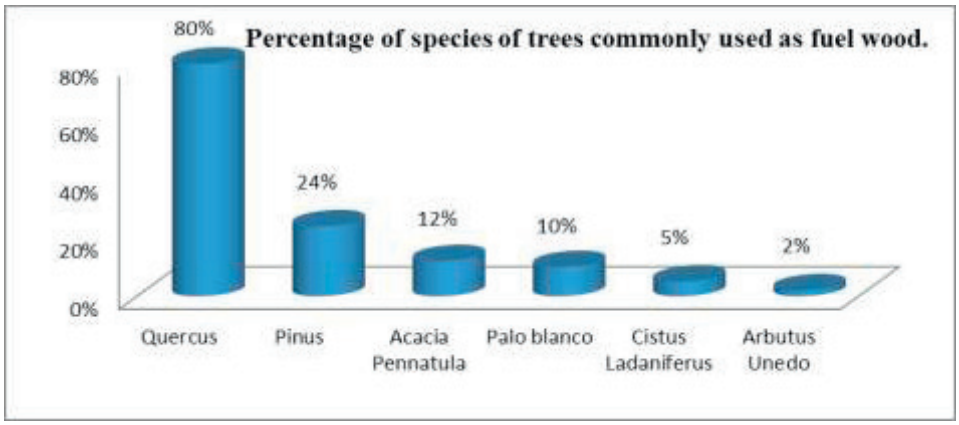

Fig. 8. Tree species exploited more intensively.

8. Training for the use, maintenance and appropriation of solar cookers.

According to data of diagnosis, the consumption of firewood employee to make tortillas was the only activity in which could not be replaced with using solar cookers, due to that solar cookers proposals only

allow cooking food. Consumption of fuel wood could be reduced by 30% if cooked daily, at least to medium day, because every family in the community eats three times a day.

After diagnosis of fuel wood, based on indicators: number of persons per household, timber resource consumption, resource extraction and timber purchasing, selection was made from 75 families benefited with one solar cooker. For the construction 75 of the devices were trained 5 people in the community.

Moreover, to achieve the transfer and appropriation of technology, is considered perform a training to beneficiaries on solar cookers. In a bilingual form (Spanish and Purhépecha) to the beneficiaries were taught a workshop on the use, maintenance and construction of solar cookers. Simultaneously with the workshop training was developed a bilingual manual (Figure 9), in Spanish and Purhépecha, to achieve transfer and appropriation these solar thermal technologies in more places in the state of Michoacán. It is expected the book to be translated into more indigenous languages and implementation project to be replicated in different latitudes, in rural and urban areas, with the aim of generating profits in the quality of life of people.

9. Implementation of solar cookers.

After receiving appropriate training, beneficiaries attended a formal ceremony where they signed a cooperation agreement, pledging, each beneficiary family, to use the solar cooker and, if applicable, if not used give to another family interested. So were delivered solar cookers (Figure 9) and consolidated most of the deployment project. However, to complete the project was necessary to culminate realization of project monitoring.

Fig. 9. (a) Bilingual Manual of solar cookers (b) Delivery of solar cookers.

10. Implementation of solar cooker.

The evaluation based on interviews with beneficiaries, showed that 85% of the beneficiaries have used the solar cooker, while only 15% not used for various reasons among which are: change of address and family separation. The results of the first monitoring are not so bad, because it sees the acceptance and appropriation of this new solar thermal technology is good.

The 85% of users of solar cookers, said that the timing with which they use solar cooking more often is in April and May, spring in Mexico.

The use for solar cooker has been varied, from the cooking of vegetables, peppers, tomatoes, chicken, until water heating reflected part of the acceptance of the new eco-technology. Moreover, the beneficiaries expressed interest in receiving a second solar cookers training, in order to optimize its use, as well as the interest of having a tabulator cooking of the solar cooking.

Among the improvements suggested in the view of users, expressed interest in to use solar cookers to fry foods and warming tortillas. Due that the CSR-1 is designed to achieve the cooking the food and not can fry.

11. Benefits generated by the use of solar cookers

To tell other monitoring results, the use of solar cookers every week in each beneficiary family was very diverse (Figure 11), but the majority of the respondents use more than twice a week your device for cooking food.

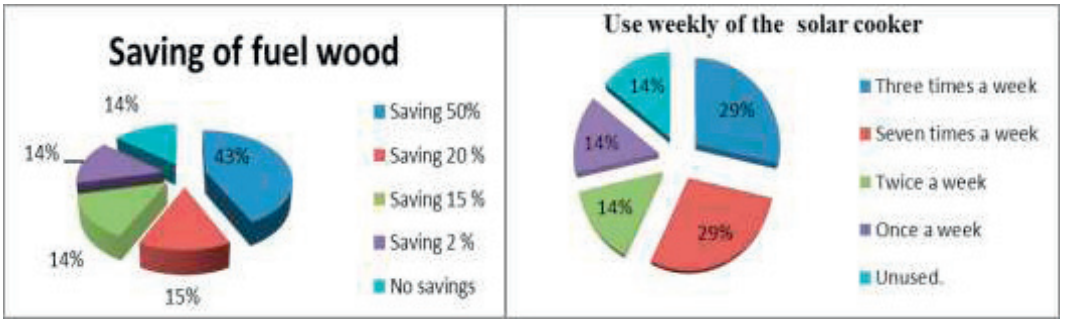

Fig. 11. (a) Use weekly of the solar cooker. (b) Percentage saving of fuel wood in users of solar cookers.

The savings in fuel wood consumption is an important transcendental data, although each family consumed about 145 kg of fuel wood, used for combustion, per week, many households have had a savings of 50% (Figure 11) with the use of solar cooker.

With the use of the solar cooker the extraction of fuel wood is less frequent and less intense. Besides the time spent cooking food is less, and is intended time to other activities. Some beneficiaries mentioned that for future implementations will be considered raise the performance of solar cooking, in order to reduce the cooking time of food and cooking with solar-power more than once a day.

12. Disadvantages in the use of solar cookers.

The beneficiaries were very punctual with the disadvantages. Contain more than one container, increase cooking power, to reduce the cooking time of food, improve safety and mobility, find that the taste of food does not will change with use solar cooker, were the repeated comments in the respondents.

Discussion.

It is true that solar cookers are not the solution to all problems of fuel wood consumption in rural communities, however, in many households, beneficiary families have generated fuel reduction by 50%, and public health benefits future will be seen in a gradual and significant. Tree species "*Quercus* and *Pinus*" are less exploited and see its development in young species by decreasing the extraction of these trees. The appropriation of technology is growing day by day and generate more media encourage this appropriation to the extent that aspects such as language, community engagement and participatory assessments are performed more often in technology implementation projects with alternative energy sources.

Conclusions.

Solar cookers have been an alternative that generates benefits in rural communities. It takes more research in order to accelerate and encourage the transfer and appropriation of new technologies in indigenous areas. However, the willingness of the population to insert new eco-technologies to their everyday lifestyle is great.

The fuel wood saving locally representing the use of solar cookers is significant, therefore, very beneficial for the care of the environment. Also, the benefit economic and public health, are proof that the use of alternative sources of energy generates sustainable projects for the benefit of the poor people, and encourage ways of good living in rural areas and indigenous.

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