Solar energy for food security in West Africa

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Topics addressed: Solar food processing and back-up systems, how to ensure sustainable energy supply

1. Introduction

Burkina Faso's economy, like many other developing countries, relies strongly on agriculture. Due to a lack of reliable and competitive energy sources, processing of agricultural products remains at the cottage industrial stage particularly in rural areas, with a very low efficiency resulting in considerable production losses. But in macroeconomic terms, the most important loss consists in the gap between the economic potentials (available raw products, uncovered demand) and the realized actual incomes collected by this particular industry. An environmentally sound economic development is feasible in Africa through intensified agriculture and access to appropriate food processing solutions.
New Food security threats make the optimization of our production necessary. Traditional cereals (maize and sorghum), who are the most consumed, are not produced in the dry season and have a yield that does often not exceed 1 ton per hectare, whereas cassava can have a yield up to 25 ton per hectare. Cassava has also a flexible harvest period, reducing the harvesting peak.
Furthermore, rapid urbanization causes profound changes in the consuming patterns. The traditional cereals, the gardening products and the wild fruits and leaves are less and less transformed for use in the family diet. There is a strong local demand for transformed products which would meet the rising standards in terms of quality, sanitary and nutritional requirements.

There is equally a strong demand for high quality groceries on export markets, which access is totally conditioned by the respect of strict norms. Even with a smaller volume, the incomes generated by export would be important for the agrifood producers and for the economy of the whole country.

Despite the abundance of raw materials (without taking into account climatic uncertainties) the emergence of the food processing sector as well as the development of businesses and other initiatives are hindered by the cost of production factors such as energy. The lack of appropriate technological solutions and of available or affordable energy sources makes this situation worse. In Burkina Faso access to energy is limited and costly, it's rate being one of the most expensive in the world.

Affordable energy would contribute to the development of economic and industrial activities, therefore leading to human development. Depending on the production process, the availability of energy in the form of process heat from 5 to 250 kW is sufficient to satisfy a large range of applications. This power range can be easily produced on solar and biomass energy applying mature and economically proven technologies.

The goal of this proposal is to develop and implement an innovative, affordable and environmentally friendly food processing unit (dried mangos and cassava couscous) based on intermediate technologies linking food processing systems to renewable energy production, this in order to:

- fight against poverty, more specifically in the rural areas
- achieve food security through better self-sufficiency, better food conservation and quality
- Process High yield products like cassava to fight against the alimentary crisis.

- promote the use of sustainable energy,
- Develop local resources and create local added-value.

This full-sized food processing pilot project is very flexible and can be used for any agricultural processing as its combines both a wet and a dry process line.

2. Summary

The aim of the rural food processing unit is to develop a sustainable and well adapted solution to the specific food security threat in Burkina Faso:

- The seasonal farming, and severe lack of adapted food processing facilities in the rural areas.

It also aims at promoting in much larger scale renewable energy sources for sustainable local economic development purposes by demonstrating on field the efficiency of such systems.

The project is innovative building on a simple, flexible, original approach.
The target is a new actor-group in the Sahel region such as farming cooperatives as well as food-processing SMEs which are more and more prevalent in West Africa.
It also targets production in rural zones by developing a quasi-autonomous unit based on solar and biomass energy which can be produced from agricultural wastes or management of sustainably yielded grass
The technical aspect is based on a revolutionary method which combines in a new and smart way mature technologies such as:

- Large solar parabolic mirrors applying in Indian community kitchens for more than 10 years;
- Solar water heaters;
- Pasteurization and packaging systems for juices and sauces that are already applied in most of the world;
- Vegetal oil burners
- Solar dryers
- Boilers

The food processing unit will be implemented in Loumbila, a village at 25 kilometers from Ouagadougou (capital of Burkina Faso). The production unit will be run base over 75% on renewable energy.
The row products such as mangoes and cassava will be locally produced. The end products, like attiéké will be marketed in micro-doses package sizes which are specially designed for the West African market, while the dried mango will be exported.

PROCESSING OF VEGETABLES IN A SOLAR DRYER IN ARID AREAS

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Topic addressed: Solar food processing and back-up systems, how to ensure sustainable energy supply

Introduction

India stands third next to US and China in the production of many raw foods; it is still in the lowest place in processing as well as value addition to raw food leading to phenomenal wastages. When the production is high, the farmers have to sell the material on the same day of harvesting at very low price as high moisture content of fresh vegetables leads to rapid deterioration in the quality of the product because of the growth of micro flora, insect infestation etc. Therefore, there is a great loss to the farmers. But this loss can be minimized by dehydrating the material up to safe moisture content that can be achieved by improvement in processing techniques, the important part is drying. Direct sun drying method has been practiced since ancient time and it is still being widely used in developing countries. Although this method of drying is cheap yet it is associated with the problems like contamination by foreign materials by dirt, dust and wind blown debris and insect infestation as well as uneven drying. During rainy season, the material can not be dried to desired safe storage moisture and the material also may get wetted. Thus the huge fraction of the product is spoiled due to open drying. Moreover, the quality of the dried product obtained by this method is poor as nutrient sensitive to heat and light are attached due to prolonged exposure during drying. The poor quality of the dried product cannot be accepted in the world market. Therefore, to improve the quality of the dried product, mechanical dryers run by fossil fuel or electricity can be used. However in many rural areas electricity is either not available or too expensive for drying of vegetables. Thus in rural areas, the electrically operated dryers are not feasible. Alternatively, the mechanical dryer, in which heat from the fuel is used to raise the temperature of drying air, can be adopted. These fossil powdered dryers have several advantages such as high reliability and high efficiency but in spite of all these favourable points, such units are beyond the reach of small and marginal farmers due to high investment and need to use fossil fuels for drying purpose. Fortunately India is blessed with abundant solar energy, therefore, solar dryers seem to be good substitute for mechanical dryers.

Summary

The natural convection type dryer is based on the principle of temperature difference i.e. difference in densities of air inside and outside the dryer force the air to flow through the drying chamber. However, in forced convection type dryer needs electricity to run blower. In general, the construction of natural convection type dryer is simple, easy to maintain and inexpensive. Therefore, the natural convection dryers can be successfully used for drying of small batch loads in areas with high solar insolation. Thus, in arid regions, the low humidity of ambient air and high insolation (7600 – 8000 MJm^{-2}) suggest the use of natural convection type solar dryer instead of forced convection dryers, which are more costly and dependent on electrical power, therefore, natural convection type solar dryer has been used for dehydration of vegetables. Optimally inclined surface receive 22.8 % more solar radiation as compared to horizontal surface. Hence, optimally tilted solar dryer (Fig.1) has been used for this study. Drying of different types of vegetables viz. cucumber, aloe vira, onion, spinach, tinda, green chillies, cauliflower etc. were carried out and successfully dried in both direct and indirect mode. The time taken was 3-4 days in direct and indirect mode respectively. **The farmers can dehydrate vegetables when these are available in plenty and at low cost. Dehydrated vegetables can be sold in the off season when prices of vegetables are high and farmers can generate more income.** The use of solar dryer will be a great boon for farmers in the developing countries.

Fig. 1 Optimally tilted solar dryer in direct and indirect mode

Solar-Trough-Baking-Oven for small Businesses

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Topic addressed: Local solar food processing technologies

1. Introduction

Image 1: The Solar bread baking oven in Lesotho

Solar Cookers have been deployed in developing countries to alleviate poverty and fight deforestation. The solar cookers have been mainly used for household purposes and are designed to be versatile and flexible.

Designing a cooker for a specific purpose ups efficiency and allows more precise implementation. The Solar Baking Oven, as constructed by Mr. Ivan Yaholnitsky in Lesotho, promises to be an efficient tool to implement in villages where bread forms a major part of the regions diet.

With the first prototype a small bakery is being run in Lesotho. Further field tests are being made in order to further prove its suitability for powering a small baking enterprise.

2. Summary

Image 2: Bread baked by Solar Baking Oven

Mr. Yaholnitsky described some areas in the design of his baking oven which he feels should be improved upon in order to present this oven as a viable option for running a successful bakery in rural areas.

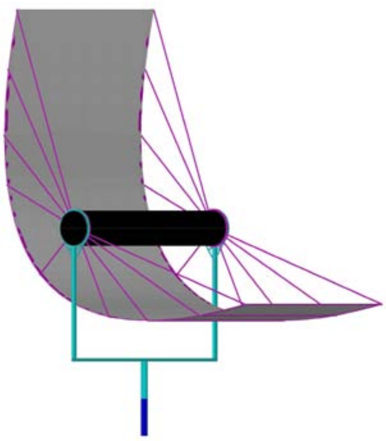

Image 3: CAD future design

With modern technology and materials it is possible to improve the design, and thus the efficiency of this baking oven. In our workshop in Germany we have all the requirements to take up this optimisation task, and develop the production of a highly efficient solar baking oven.

The improvements are made according to criteria which allow the later reproduction under rural circumstances.

- Materials should be attainable
- Construction should be simple
- Baking oven should be user friendly

In the final stage of the project a construction manual will be written in English including a tutorial on basic accounting and business practice.

De Wet van Rooyen

Performance analysis Solar Parabolic concentrator for cooking applications

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Topic(s) addressed: ***Examples of solar food projects: successes and hindrances, networking and cooperation***

1. Introduction

Energy requirements for cooking account for 36 % percent of total primary energy consumption in India. The demand for cooking energy is increasing annually at a rate of 8.1 %. In household sector, 47 % of energy requirements are met by fuel wood and agri wastes; the rest is met by kerosene and LPG. India is blessed with good sunshine around 300 days per year and the mean daily solar radiation in the range of 5-7 Kwhm^{-2}. The Parabolic solar cookers are very efficient. In this article, we describe a parabolic cooker for cooking of rice and vegetables. It cooks at substantially constant power for one hour using tracking mechanism.

2. Summary

In this study a scheffler type solar parabolic concentrator with the area of 7.14m^2 was used as a primary reflector. Mirror strips are used for reflecting materials in the reflector. The concentrated solar energy reflected to the receiver or secondary reflector. Here this receiver acts as a reflector for cooking vessel that placed above this portion. In the secondary reflector the Aluminium foil used as reflecting material. In this concentrator mechanical clock tracking was used track the system thought the day and harvest the maximum energy from the sun. Here only direct cooking should be done. This system designed for cooking lunch and dinner for 50 children's in the hostel at Madurai, Tamilnadu. The efficiency of the solar cooking systems mainly depends upon controlled and uncontrolled variables. A controlled variable represents the loading pattern of the solar cooker, tracking mechanism and temperature sensors. In the same time uncontrolled variables represents wind speed, solar radiation, solar angle, ambient temperatures.

The efficiency of the cooking system calculated by this formula

$$\textbf{Efficiency of Cooking} = \mathbf{M \times (C_w + C_r) \times (T2 - T1) / A \times I \times 0.86 \times t}$$

Here M –Mass of material to be cooked in Kg, C_w,C_r – Specific heat of water and rice in KJKg^{-1}k^{-1} , T_1, T_2 - Initial and Final temperature of the process, A – Aperture Area solar scheffler concentrator, I – Solar radiation and t – time taken for cooking.

Experiments are carried out in the period of Jan to Mar for water heating method to analyse solar parabolic cooker performance. The mean solar radiation varies from 850 -905 wm^{-2} and time taken for reaching the boiling point of water from 55 -75 minutes depends upon the climate conditions. After the water heating method the cooking experiments are carried out with Bengal gram, rice with different day. To study the overall system efficiency by using water heating and cooling and cooling and cooling method comes not less than 40 %. for the same parabolic concentrator was used as cooking device for cooking rice, dhal and vegetables, etc comes around 30 to 32 % for around 5 kg of rice every day. It is concluded that these parabolic concentrators are used in the domestic and community cooking results the conservation of energy, reduction of carbon emissions in the atmosphere, clean working environment for cooking process.

Kadam' (Wild Cinchana) fruit preservation using solar dryer

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Topic: Local Solar food processing Technologies.

1. Introduction:

Kadam is large tree with broad crown and straight Cylindrical bole. It is a very rapid growing tree with grey bark. Kadam flower is ball of flowers with golden co lour. The fruit is edible while the timber is used for plywood and light constructions. According to Hindu tradition 'Kadam' tree is holy which was very common in the garden of Lord Krishna. Kadamba the child of Lord Shiva and Parvati was born under Kadam tree. Kadam tree is considered as the tree of Buddhism also. Kadam flowers are an important raw material in the production of 'Attar' which is Indian perfume. Kadam plant is used for fever anemia, pemples, sores, Cholera, dysen and renderpest.

2. Summary

2.1 Collection and preparation of 'Kadam' fruits for drying Kadam tree starts flowering during the monsoon season and fruits appears at the end of the monsoon season. Fruits will be ready by the middle of the winter. Once the ripening of the fruits starts within twenty days all the fruits fall down. Very few fruits are collects for the use of making 'Chutteny'. While we collect the fruit for drying better to pluck the fresh fruits from the tree itself. Collected fruits should wash in the clean water and split into four pieces in order to put in the Solar Dryer.

2.2 Drying and preserving process.

Drying of 'Kadam' fruit is bit slow. Since radiation during the winter is poor kadam fruit drying is also slow. After drying the fruit the co lour will be dark brown. Centre part of the fruit which is of sovour taste takes more time to dry. Center portion of the dried fruit will be dark in co lour. Dried fruits should be preserved safely from the moisture and wind.

2.3 'Chutteny' preparation

Dried fruits can be powdered and preserved in air tight jars. This powder can be used for making 'Chutteny' throughout year. The famous South Indian 'Chutteny' called curry leaves powder can be made with kadam fruit powder. North Indian type of 'Chutteny' can be made by adding garlic and chilly powder.

2.4 Healing properties of 'Kadam' fruit.

Fruit juice has got medicinal effect for children. The medicine prepared out of fruit juice is good for the Gastic problems of the children and for throat infection. Fruit juice is also good for the thirst due to fever.

2.5 Possible potential use of 'Kadam' fruit.

Considering the common nature of this tree and its high potential use of the fruits in food processing. Fruits can be used for making Jam, Jelly, and Juice etc.

2.6 'Kadam' as a mythical holy tree

Can be useful very much once we try to find out the different uses of its fruits by processing and preserving. Many schools hostels in India started using the dried powder of 'Kadam' fruit. Solar food processing technology can be a big help for the processing of Kadam Fruit.

'BAEL' Fruit (Stone apple) Drying and preserving using Solar Dryer

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Topic(s) Local Solar food processing Technology.

1. Introduction

Beal is a large tree with a big stout trunk. It has got aromatic leaves, sweet scented and greenish white flowers. It has got aromatic fruit with hard shell. Inside the fruit it is pulp with numerous seeds and densely covered fibrous hair. It has got many mythical importance and has mentioned in the sacred books of Hindu religion. Bael fruit has got many curative properties.

2. Summary

2.1 Origin, distribution and Composition.

Bael is a handsome tree of native North India, but is found widely through India Sri Lanka and Burma. It grows wild throughout the low hills of Himachal Pradesh.

2.2 Historical and Mythical importance.

Writings are there about 'Bael' dating back to 800 Bc. It is being cultivated throughout India mainly in temple gardens. It is grown in some Egyptian gardens and in Surinam and Trinidad. Bael fruit are offered to Lord Shiva, the God of health.

2.3 Analysis of Bael fruit

Analysis of Bael fruit shows that, it consists of moisture 61.5%, minerals 1.7% Carbohydrates 31.8%. It has got many minerals and Vitamins including Calcium, Phosphorus, iron, Carotene thiamine etc. Its Calorific Value is 137. Some of the Chemical Constituents are alkaloids, Coumarins and steroids. The active Constituents of the fruit is Marmorosin, which is identical to Imparatorin. Also it contains Altoemparatorin and B Sitosterol.

2.4 Drying and preserving method of Bael fruit.

Bael fruit very seasonal. It is mainly a summer fruit and last only for two months. During the season it is abundant but very well used for making 'Sarabat'. Fully riped fruit well have semi yellow or fully yellow co lour. There is very little method of preserving Bael fruit. Bael fruit powder is used in Ayurvedic treatment. Bael fruit pulp can be removed from the hard shell by split opening and break into small pieces. These pieces can be kept in a Solar dryer for drying. The dried fruit can be powdered and strained well. This powder can be preserved in an air tight container for future use.

2.5 Healing and curative properties of Beal fruit.

Beal is one of the most useful medicinal plants of India. Its medicinal properties are mentioned in the ancient medical treatise in Sanskrit Charak Somhita. The fruit is medicinal value is high when it just begins to ripen. The fruit is aromatic and arrests secretion or bleeding. The unripe or half-ripe fruit is good for digestion. Ripe Bael fruit is regarded as best of all laxatives. The Bael fruit powder is also used for Diarrhea and dysentery. Bael fruit beverage helps to heal ulcers.

2.6 Few precautions.

Regular intake of Bael fruit is not healthy. High dosage of consuming Bael fruit may produce a sensation of heaviness in the stomach and body. The 'Sherbet' of Bael is should be very thin and should not drink in hurry.

Conclusion.

Considering the high vitality of the Bael fruit developing and wide popularization of Bael fruit processing and preservation can be highly beneficial. Our experience in this area is very much encouraging.

OYWA COOKIT

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TOPIC: LOCAL SOLAR FOOD PROCESSING TECHNOLOGIES:

1. Introduction

One of the commonest methods of food processing for human beings is cooking. This activity distinguishes humans from all other creatures. There are many ways of processing foods and one of them involves the use of heat from various sources. The age old practice known to humans has been the use of wood fuel; this practice is now seriously compromised in the face of diminishing wood resources. More than 3 billion people in the world are suffering from domestic fuel scarcities thus necessitating the urgent need to seek alternatives in an attempt to reduce and even overcome the negative consequences associated with this matter.

Surprisingly, many of the needy people live in sun rich regions of the world and can use solar power to answer to their needs including their cooking. This is now possible because of the advancements in the solar cooking technology. Solar cooking is the use of solar power in various technologies to cook food. There are three main types of solar cookers i.e. Box or oven types, concentrator types and the panel types. All these exist and can be used for many other applications besides cooking. Of all these one stands out this is the CooKit.

2. The CooKit

The solar Cookit represents a breakthrough in the evolution of solar cookers. It is not exotic or high-tech, but a practical application of sound engineering, whose appearance belies its genius. Cookit is an elegantly simple in design, often made from humble cardboard and aluminum foil or similar reflective material and glue. Cookits need far less building material and are now produced independently in 23 countries at a cost of $3-5 US. Cookits weigh less than one pound (half a kilogram), folds to the size of a big book for easy transport, and lasts for about two years.

2.1 OYWA CooKit

OYWA Cookit is and innovation by SCI (EA), adopted from the SCI's original CooKit. OYWA CooKit came about as an answer to a challenging need for a durable technology adding on to the already aforementioned great qualities of the CooKit. OYWA CooKit has three distinct features that make it stand out.

a) It is made from a three ply cardboard that has wax to the outside to prevent moisture or insects from destroying it.
b) It has coloured cloth binding round the edges that helps keep the three ply cardboard together and stops them from peeling off from each other. The cloth binding enables ease of handling and use and it does not require cloth pegs to maneuver the front flap. The coloured clothe adds to its attraction.
c) It is branded with simple to read instructions in local languages. Since it lends itself to local assembly OYWA CooKits are cheaper than factory assembled CooKits.
d) It is sturdy and a user is comfortable leaving it to be used by anyone without worry of it being damaged.

In addition to the above, OYWA CooKits are easily assembled by local users, youth and women and they do not require complicated machinery tools or skills. In an 8 hour working day a woman can assemble to completion five OYWA CooKIts. The durability of OYWA CooKit has been tested with a confirmed life span of about 3 years over the 2 years of the original CooKit.

OYWA CooKit

To use the OYWA CooKit, one requires a dark, covered pot and a transparent high temperature plastic bag. With a few hours of sunshine, the OYWA Cookit cooks tasty meals for 5-6 people at gentle temperatures like a crock-pot – ideal for cooking food and preserving nutrients without burning or drying out. Larger families use two or more cookers. OYWA CooKit can cook most or all foods that require roasting, boiling and baking. It has also been widely used for water pasteurization and vegetable drying.

Because it is can be made from locally available materials, and can be produced quickly, OYWA Cookit has a niche in the world of solar food processing. OYWA CooKit as an innovation won the Pan African Women Invent and Innovate Awards, (PAWII) Accra Ghana 2005.

Dissemination of solar cooking process in Portugal and Chile during last two years

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Topics: *dissemination of solar cooking*

1. Introduction

Algarve and Alentejo are regions of tourism in Portugal with a large potential for solar applications in general. However, the potentialities for solar cooking process in particular are not yet well known. So, the dissemination activity of solar cooking is important as well the inclusion of disciplines focusing solar cooking process in the programmes of the courses of schools of technology and of hostelry. Moreover domestic and industrial solar cooking process examples must be implemented with success to become in a short time well multiplied.
Aculeo Lake, Chile, just in 33 degrees south latitude is a region for summer tourism in the Metropolitan area of Santiago, the Chilean capital. Sunny days are common during summertime's. This paper shows the development of a little subside program, from GEF PNUD UE, that works in the transfer of solar cookers and solar ovens to little familiar enterprises, that make solar food in the side of principal road.
Portugal and Chile has similar conditions for solar cooking, like a result from a network development the technologies used are similar and the situation and methodology are different.

2. Summary

2.1 Experiences and dissemination of solar cooking in Portugal

The intensive use of solar cookers by the author, professor Celestino Rodrigues Ruivo, began after his participation in the Solar Cookers Conference in Granada-Spain, July 2006, becoming "well contaminated with the virus of solar cooking" and an important advocate for solar cooking in Portugal. He has held several solar cooker conferences and workshops in Portugal, Spain and also in Brazil.
Celestino Rodrigues Ruivo credits Pedro Serrano, of Chile's Red de Cocinas Solares de Latinoamerica (RECOSOL), and others for helping him overcome his initial scepticism. Ruivo learned to solar cook using the cardboard solar CooKit. He has since made and used several solar cookers, most of them low cost apparatus using recycled materials.
The activity of dissemination and the intensive solar food processing during the last two years became useful for the right development and optimization of different types of solar cookers. Most of the experiences were conducted using panel solar cookers (solar cookit) during summer and also winter conditions in Portugal. In the first summer, August and September 2006, several meals have been cooked in panel cookers made of cardboard with an adhesive reflective foil, a black pot and common plastic bag. In these first experiences, the main critical problem detected was the fusion of the plastic bag. The experiences have been continued during autumn and winter time but with difficulty due the low efficiency of the apparatus. Another critical point observed was the fact that cardboard is not water resistant.
During the second year of experiences the results were much better. More efficient solar panel cookers were developed using sheets of polypropylene and using recycled windows of cloth washing machines.

2.2 Experiences and dissemination of solar cooking in Chile: Solar food micro enterprises

Solar cookers are already in Chile 30 years of process, primarily in developments of social projects. These developments have been driven by the obvious impact from the use of wood for all sorts of uses, both in domestic heating and cooking food

Negative impacts have been registered, both socially and in the environment, from the widespread, intensive and long term use of firewood in these territories, which have also witnessed a slow but steady increase in population.

Among the social impacts is the time used for each family gathering their firewood, child labour, the cost in working hours that this implies, and the intra-family pollution resulting from the use of open fires.

On the environmental side, an advanced deterioration in the river valley systems has been detected, with an increase of erosion and the emergence of harder desert to the south. There is a loss in water retention, and an outgrowth of local climate characteristics that are ever most desert-like, with hot days and cold nights, and little or no precipitation, all of this associated with the loss of biodiversity.

There are two local approaches to address technologically the challenge of firewood: The first is the search for technologies to improve its efficiency of use. The second alternative is to develop and transfer technology for the replacement with a solar culture. It is even difficult to think of a total replacement, so the strategies tend to be mixed: Efficient use and replacement with a sustainable energy, which in the case of this work is solar energy.

The availability of daytime sun for more than 300 days a year in the Chilean central areas, with high solar radiation intensity especially around mid-morning and mid-afternoon, makes the use of solar cookers and ovens a real and efficient offer. There exists in the world a true boom in solar cookers. But the use of solar technology for food enterprises is an interesting approach, a very tourist approach.

In Chile, the Canelo Corporation has for almost 20 years been disseminating various models of solar cookers and ovens in development programs funded by competitive resources of the state, international cooperation, U.E. or UN program funds for development [UNDP]. The important thing about these models is that they are able to replace 100% of the firewood for cooking and heating and water pasteurisation in the days of sunshine, which is higher than 300 per year. Research on household consumption of firewood in the area of reference indicates an average of firewood use per family of 10.4 tons per year of which 80% is earmarked for cooking. This is 8.3 ton, which indicates that a solar system substitutes up 6.8 tons of firewood / family per year, which is a saving 1.83 g. calories per year.

During 2007 2008, Canelo de Nos, with the technical assistance, models of stoves and ovens created by the engineer Pedro Serrano, has developed a solar program subsidized by GEF / UNDP, during the program has developed a technology transfer solar toward families who live at one side of the main road leading to Lake Aculeo, a tourist place near the capital of Chile, where transit thousands of people especially during the summer period.

The program has been accompanied by improved stoves and ovens for firewood to supplement the solar cookers. The project educationally implemented is focused in make meal with these equipments. Solar cookers draw attention of tourists, tourist who tends to the ecological and gives preference to this kind of food business.

The meals were produced with solar energy are highly diversified, from dough, bread or corn cakes sewn up, chicken or meat in general. Indeed the tourist attraction of solar stoves and solar ovens presents an advantage when drawing the attention of the tourist who passes. That is, apart from energy, firewood economy, and environmental impacts of solar stoves and ovens, these are a good ally for business.

BUILDING SIZE FIXED REFLECTOR CPC TROUGHS and BOWLS for FOOD PROCESSING FACILITIES

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Abstract

Topic: Local solar food processing technologies

Building integrated stationary concentrating building size reflectors for solar thermal food processing applications and facilities in non-seismic regions are schematically presented for: water distillation, drying, cooking and refrigeration. Fixed mirror concentrating collector technologies are: nonimaging (NI) CPC type troughs for low concentrations (E-W horizontal for equatorial tropics, and N-S inclined for higher latitudes); and solar bowls (fixed spherical segment reflector with two axis tracking linear receiver) for mid to high beam imaging concentrations. Fixed flat glass mirror segments are supported on panels or stabilized excavations and masonry vault and dome structures. Targets for the NI CPC troughs are: walk-in stills (Fig.1gh); dryer with "sea shell" concentrator (Fig.1i); greenhouse type ovens (HotPot™, 'fishbowls', etc.)(Fig 1k-r); and flat plates/evacuated tubes (ET) transverse to trough. Main materials are compressed stabilized earthen blocks (CSEB) and flat glass laminated silver mirrors. Glass and CSEB (from UNESCO earthen architecture Auroville unit) with thin silicone sealant coatings appear to bond well. Flat glass laminated mirrors can be tiled directly to CSEB masonry when formed accurately enough to be a NI CPC trough substrate. Masonry vaults and CPC troughs can have sympathetic form relation, and CSEB vaults can have 15m/50ft spans and rises according to architect Satprem Maïni. Truncated NI-CPC trough schematics include: 1-sided CPC, CPC, involute, and split-involute (Fig.1c-f). A CPC trough has 1-sided ET or flat-plates. A reference ratio of 1.66 is CPC trough inlet to outlet width. A "seashell" trough circular segment under a 1.72m/5.6ft wide receiver (and trough radius) has six flat glass mirror segments each about 49cm/19" x 1m/40". The 49cm/19" mirror width is sized to fit a substrate of two standard 24cm CSEB (with AURAM™ Press 240) plus mortar joints (Fig.1ij). Schematic adjustable trough end reflector studies include fail-safe connections to avoid high wind damage. The reflector width of flat glass silver mirrors (adhered with full coverage glue to low cost glass) is an optical design factor for stepped NI CPC troughs. Studies include greenhouse type oven (30cm/12"o.d. HotPot™) mid size kitchens with short thru-wall lintel spans (Fig.1pq); 1-sided CPC and involute with precast concrete base to stabilize oven holders and drain for outside cooking (Fig.1k-o); and carts (Fig.1r). Involutes reflect to oven bottoms. Out gassing (from insulation, paint, glue, etc.) is a concern with reflector augmented box cookers. Solar bowl architectural schematic studies are presented for mid-size process heat applications with various rim configurations (Fig.1s-v). To reduce on-site work solar bowl advance requires workshop production with precise adhesion of small flat glass mirrors (sized in accord with the receiver) to spherical segment substrate panels. Panel technology similar to molded communication dishes with bio-materials sheet-molding composites has potential radius of curvature commonality with reflector facets for tracking parabolic large dishes. A set of rectilinear and trapezoid reflector panels has some compatibility with a parallel strips bowl paving pattern and the square rim configuration (Fig.1s-v). NI CPC low concentration troughs, and imaging mid-high concentration solar bowls can be constructed with masonry structures (vaults and domes) to support fixed mirrors. CPC troughs can proceed with large area flat mirror facets (reference: glass mirrors laminated to glass in Auroville solar bowl). A large bowl with tracking and compact steam distribution compared to several smaller dishes, may be durable with locally manufactured and repairable parts, whereas broken imported evacuated tubes (ET) cannot be repaired.

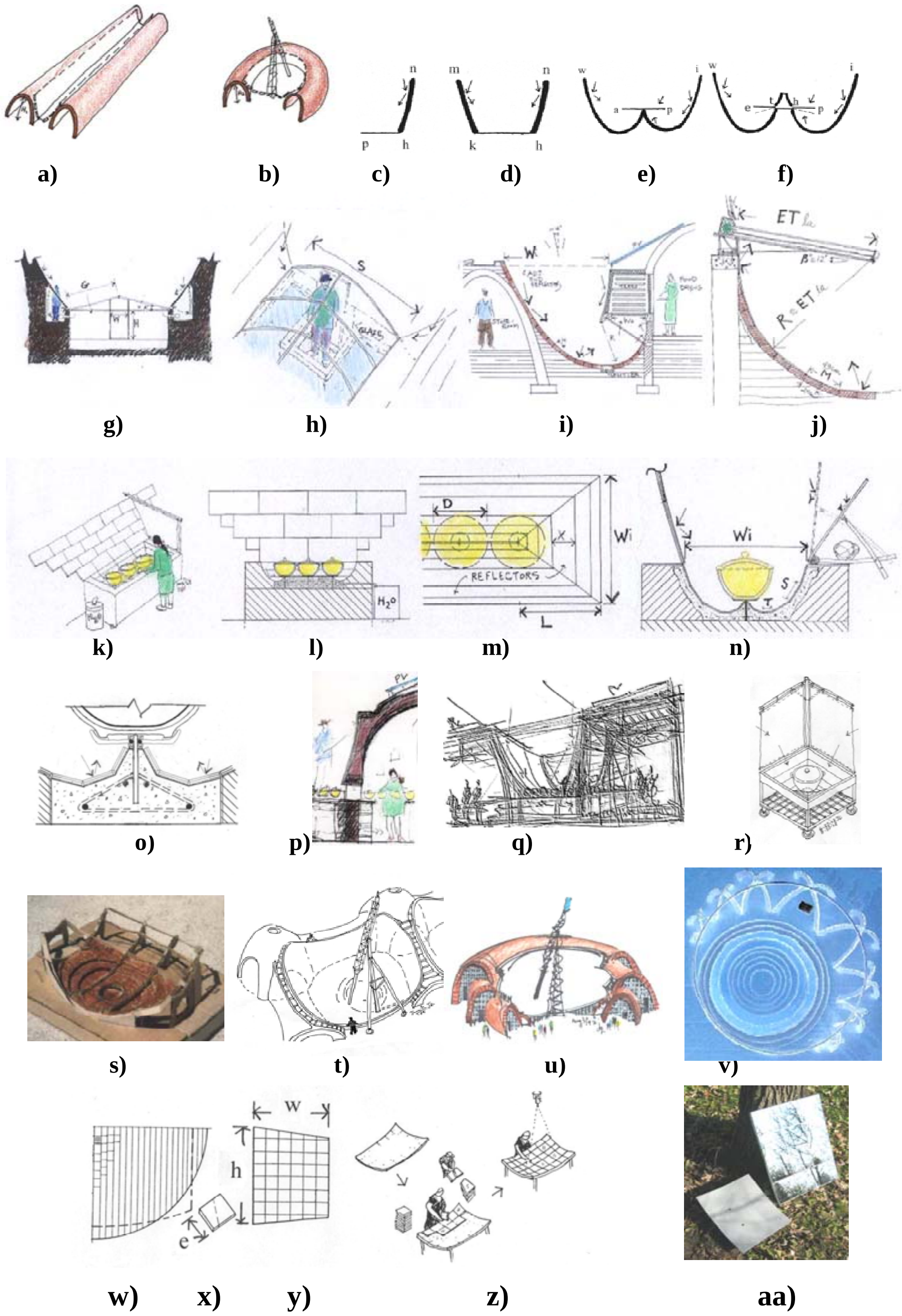

Fig. 1- BUILDING SIZE FIXED REFLECTOR CPC TROUGHS and BOWLS for FOOD PROCESSING FACILITIES: a) CPC trough; b) solar bowl; c) one sided CPC; d) CPC; e) involute; f) split involute; g-h) walk-in still; i) "seashell" dryer; j) circular trough under ET; k-n) one-sided CPC and involute for greenhouse type ovens; o) precast base for oven holders; p-q) thru wall kitchens with greenhouse ovens on sliding trays; r) greenhouse oven cart; s-v) solar bowl rim types with masonry vaults and domes; w) trapezoid reflector panels with parallels paving pattern; x) flat mirror segment sized for receiver, y) trapezoid reflector panel, z) workshop panel fabrication; aa) reflector panel studies.