Applications of Solar Energy in Kitchen Technology for Rural Benefits

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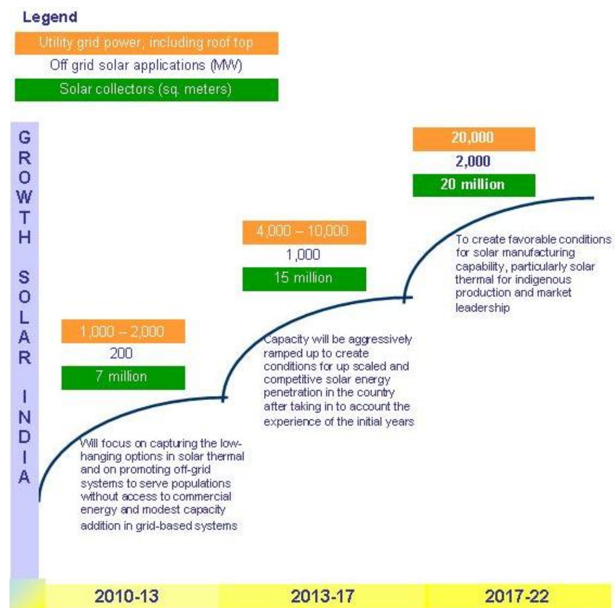
Abstract- **India is densely populated and has high solar insolation , With India receiving daily solar energy in the region of 5 to 7 KWH/M2 for 300 to 330 days in a year. Solar energy has been used since time immemorial to dry agricultural products, to provide space heat in cold seasons or to create ventilation in homes, applications which are still used in many developing countries. This paper presents the principle and application of solar energy in kitchen technology for cooking purpose in rural areas.**

Index Terms- **Solar cooker, Solar radiation, Solar collector, radiation.**

I. INTRODUCTION

The sun is responsible for all of the earth energy. Plants use the sun's , w light to make food. Decaying plants hundreds of millions of years ago produced the coal, oil and natural gas that we use today. Solar energy is most commonly collected by using solar cells. Of course solar energy can be put to use to heat or light up a room by simply having well placed windows and skylights. We can also use solar energy to dry our clothes in the sun. The sun is a continuous fusion reactor, turning hydrogen is turned into heliumith a diameter of 1.39 x 10^9m and effective blackbody temperature of 5762 K. From August 2011 to July 2012, India went from 2.5 MW of grid connected photovoltaics to over 1,000 MW.

According to a 2011 report by BRIDGE TO INDIA and GTM Research, India is facing a perfect storm of factors that will drive solar photovoltaic (PV) adoption at a "furious pace over the next five years and beyond". The falling prices of PV panels, mostly from China but also from the U.S., has coincided with the growing cost of grid power in India. Government support and ample solar resources have also helped to increase solar adoption, but perhaps the biggest factor has been need. India, "as a growing economy with a surging middle class, is now facing a severe electricity deficit that often runs between 10% and 13% of daily need". Fig1. shows the growth of solar energy in India.



Source File: Jawaharlal Nehru National Solar Mission Solarishi

Fig1. Growth of Solar energy in India

The daily average solar energy incident over India varies from 4 to 7 kWh/m^2 with about 1,500–2,000 sunshine hours per year (depending upon location), which is far more than current total energy consumption. For example, assuming the efficiency of PV modules were as low as 10%, this would still be a thousand times greater than the domestic electricity demand projected for 2015.

II. RURAL ELECTRIFICATION

Lack of electricity infrastructure is one of the main hurdles in the development of rural India. India's grid system is considerably under-developed, with major sections of its populace still surviving off-grid. As of 2004 there are about 80,000 unelectrified villages in the country. Of these villages, 18,000 could not be electrified through extension of the conventional grid. A target for electrifying 5,000 such villages was set for the Tenth National Five Year Plan (2002–2007). As of 2004, more than 2,700 villages and hamlets had been electrified, mainly using solar photovoltaic systems. Developments in cheap solar technology are considered as a potential alternative that allows an electricity infrastructure consisting of a network of local-grid clusters with distributed electricity generation.It could allow bypassing (or at least relieving) the need to install expensive, lossy, long-distance, centralized power delivery systems and yet bring cheap electricity to the masses. Projects currently planned include 3,000 villages of Orissa, which will be lighted with solar power by 2014. This Paper explains more about the utilization of solar energy for cooking purpose. Especially for rural areas those who couldn't able to use LPG and other electrical utilities for cooking purpose.

III. SOLARBOX COOKER

People use solar cookers primarily to cook food and pasteurize water, although additional uses are continually being developed. Numerous factors including access to materials, availability of traditional cooking fuels, climate, food preferences, cultural factors, and technical capabilities, affect people's approach to solar cooking. With an understanding of basic principles of solar energy and access to simple materials such as cardboard, aluminum foil, and glass, one can build an effective solar cooking device.

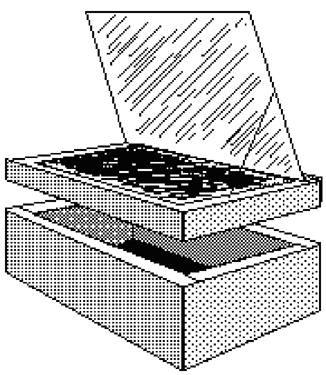


Fig.2 Solar box cooker with cover, window and reflector

I.Heatprinciples: The basic purpose of a solar box cooker is to heat things up - cook food, purify water, and sterilize instruments - to mention a few. A solar box cooks because the interior of the box is heated by the energy of the sun. Sunlight, both direct and reflected, enters the solar box through the glass or plastic top. It turns to heat energy when it is absorbed by the dark absorber plate and cooking pots. This heat input causes the temperature inside of the solar box cooker to rise until the heat loss of the cooker is equal to the solar heat gain. Temperatures sufficient for cooking food and pasteurizing water are easily achieved. The following heating principles will be considered first:

a. Heatgain b.Heatloss c.Heatstorage

a.Heatgain - Greenhouse effect: This effect results in the heating of enclosed spaces into which the sun shines through a transparent material such as glass or plastic. Visible light easily passes through the glass and is absorbed and reflected by materials within the enclosed space. The light energy that is absorbed by dark pots and the dark absorber plate underneath the pots is converted into longer wavelength heat energy and radiates from the interior materials. Most of this radiant energy, because it is of a longer wavelength, cannot pass back out through the glass and is therefore trapped within the enclosed space. The reflected light is either absorbed by other materials within the space or, because it doesn't change wavelength, passes back out through the glass. Critical to solar cooker performance, the heat that is collected by the dark metal absorber plate and pots is conducted through those materials to heat and cook the food.

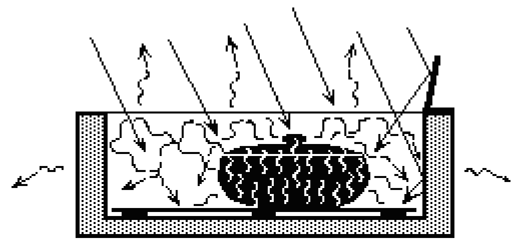


Fig.3 Greenhouse effect

b.Heatloss - Conduction: The handle of a metal pan on a stove or fire becomes hot through the transfer of heat from the fire through the materials of the pan, to the materials of the handle. In the same way, heat within a solar box is lost when it travels through the molecules of tin foil, glass, cardboard, air, and insulation, to the air outside of the box. The solar heated absorber plate conducts heat to the bottoms of the pots. To prevent loss of this heat via conduction through the bottom of the cooker, the absorber plate is raised from the bottom using small insulating spacers.

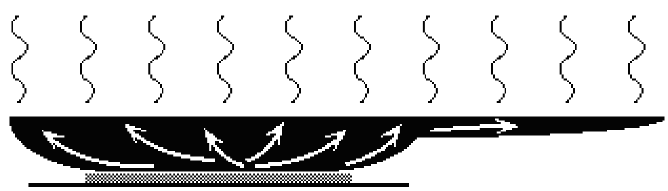


Fig.4 Heat conducted through the pan and handle

Radiation: Things that are warm or hot -- fires, stoves, or pots and food within a solar box cooker -- give off heat waves, or radiate heat to their surroundings. These heat waves are radiated from warm objects through air or space. Most of the radiant heat given off by the warm pots within a solar box is reflected from the foil and glass back to the pots and bottom tray. Although the transparent glazings do trap most of the radiant heat, some does escape directly through the glazing. Glass traps radiant heat better than most plastics.

Convection: Molecules of air move in and out of the box through cracks. They convect heated air molecules within a solar box escape, primarily through the cracks around the top lid, a side "oven door" opening, or construction imperfections. Cooler air from outside the box also enters through these openings.

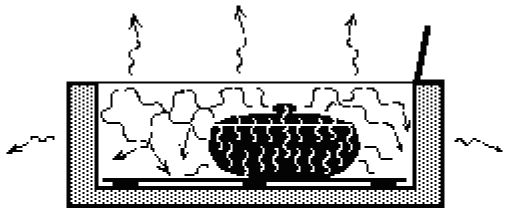


Fig.5 Heat radiates from warm

c.Heatstorage:

As the density and weight of the materials within the insulated shell of a solar box cooker increase, the capacity of the box to hold heat increases. The interior of a box including heavy materials such as rocks, bricks, heavy pans, water, or heavy foods will take longer to heat up because of this additional heat storage capacity. The incoming energy is stored as heat in these heavy materials, slowing down the heating of the air in the box. These dense materials, charged with heat, will radiate that heat within the box, keeping it warm for a longer period at the day's end. The solar heated absorber plate conducts heat to the bottoms of the pots. To prevent loss of this heat via conduction through the bottom of the cooker, the absorber plate is raised from the bottom using small insulating spacers.

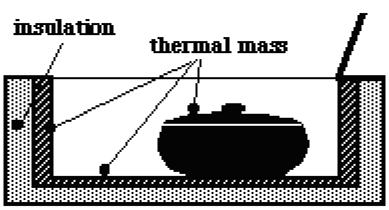


Fig.6 Thermal mass inside of the solar box

II. Solar box cooker operation:

One of the beauties of solar box cookers is their ease of operation. For mid-day cooking at 20° N - 20° S latitude, solar box cookers with no reflector need little repositioning to face the sun as it moves across the mid-day sky. The box faces up and the sun is high in the sky for a good part of the day. Boxes with reflectors can be positioned toward the morning or afternoon sun to do the cooking at those times of day. Solar box cookers used with reflectors in the temperate zones do operate at higher temperatures if the box is repositioned to face the sun every hour or two. This adjustment of position becomes less necessary as the east/west dimension of the box increases relative to the north/south dimension.

IV. SOLAR COOKERS IN INDIA

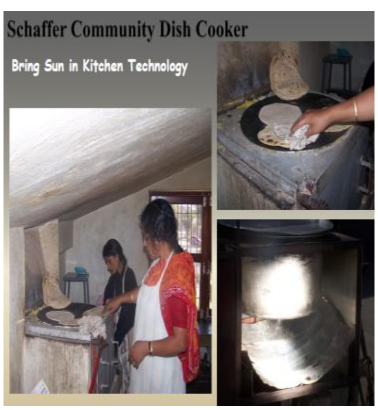
Solar cookers introduced some years back in India, have proved popular inspite of reduction in subsidy rates.Most popular in India are the box type solar cookers with a single reflecting mirror being promoted by the Ministry of Non-conventional Energy Sources since 1982. These cookers are manufactured mainly by small/tiny industries to a set of specifications developed by MNES, later approved by Bureau of Indian Standards. There is an estimated potential demand of 10 million solar cookers in this country. In India a major portion of the market is covered by box type cooker and a small portion of the market share is taken up by community type box cooker/parabolic type cooker. Manufacturers intending to manufacture and market solar cookers under the subsidy scheme have to compulsorily get the cooker tested and certified by an authorized test center. There are about 40 manufacturers whose combined annual production capacity is 75000 solar cookers. These cookers have proved immensely popular in the rural areas where women spend a lot of time foraging for firewood. To popularize the solar cookers in urban areas the Ministry has formulated a strategy to introduce cookers with electrical backup which consume low electrical power. Solar cookers are available with and without electrical back in different sizes and can be procured from dealers/ manufacturers/ nodal agencies/ Aditya solar shops all over India.

A family size solar cooker is sufficient for 4 to 5 members and saves about 3 to 4 cylinders of LPG every year. Life of this cooker is 10 to 20 years. This cooker costs around Rs. 1000 after allowing for subsidy**.** Concentrating solar cookers have been developed and deployed but the quantity is low and until wider acceptance is gained or some modification is made in the concentrating solar cooker which will allow the solar rays to be directed to a hot spot inside the kitchen, people will shy away from these giant contraptions. A community type parabolic concentrating solar cooker developed by ULOG Group of Switzerland is being promoted by an NGO in Gujarat and has met with moderate success. This cooker is designed to direct the solar heat to a secondary reflector inside the kitchen which focuses the heat to the bottom of a cooking pot. This cooker costs upward of Rs. 50000 and it is also possible to actually fry, bake and roast food. More than 50 such cookers have been deployed under a project sponsored by Sardar Patel Renewable Energy Research Institute and Gujarat Energy Development Agency.

Unique in India is the solar steam cooking system installed at Brahmakumari's Ashram at Mount Abu with financial assistance from German Government. This system consists of 24 Scheffler paraboloid reflectors, two each of which are installed to focus sunlight on a square type insulated fin and tube receiver. Twelve such receivers are focused by 24 reflectors. The concentrators track the Sun automatically using a mechanical clockwork arrangement and a DC motor run by photovoltaic power panel helps in resetting the reflectors to face the Sun as required. This system generates 500 Kgs of steam which is enough to cook two meals for 500 people. More than 1000 people can expect to receive cooked food from this system within an hour, provided sunshine is adequate.

Table 1.Models of Solar cookers marketed in India		
Size	Vessels	Weight
60 x 60 cm	4	12-15 kgs
50 x 50 cm	2/3	8-10 kgs
40 x 40 cms (with electrical backup	1	6 kgs
Community type (detailed specs below)		
Number of facets of mirror reflectors		160
Material of construction of mirrors		Polyester film
Size of focal area		40 cm
Focal length		2700 mm approx
Dimension and shape		2.4 mtr x 3.8 mtr
Surface area of reflector		7 sq. mtrs
Tracking of Sun		automatic
Number of persons catered to		50
Mode of cooking		Indoor

Fig.7 Solar Cooking Devices Models Used In Tamilnadu



- Solar Box Cookers
- Solar Seifert Domestic Cookers
- Solar Scheffeler Community Cooker
- Solar Steam Cooking System

V. BENEFITS OF USING SOLAR FOR COOKING

1. HEALTH BENEFITS :

a. Respiratory diseases are the cause of death for millions of children every year - polluted indoor air due to cooking over open fires in houses without chimneys or ventilation..
b. Survey reports says that Eye Diseases like cataract are more in Rural women folk due to cooking methods .
c. Rural women spend ½ of the day in collection of fire wood.
d. Health aspects – contaminated water spread 80% of illness Can be eliminated by boiling the water with solar cooker .

2. ENVIRONMENTAL BENEFITS

a.1/3 of world population use fire wood for cooking.
b.Every year they destroy 20000 to 25000 km2 of forest.
c.350 Million ton of fire wood is burnt per year for cooking.
d.In urban sector LPG consumption for cooking is increasing day by day-
e.Subsidy money wasted

f.It is inflating our Currency exchange rates.

3. SOFT LOAN FACILITIES FROM BANK

a.2 % per annum rate of interest
b.5 years loan repayment period
c.5 years Annual Maintenance Contract
d.85% of project cost as loan
e.Loan available for any capacity
f.Loan available of any end user
g.80% Depreciation for end user

VI. CONCLUSION

Solar energy is a versatile technology and can be designed to suit the specific requirements. It can generate economically viable thermal, power and process heat, to meet the requirements of domestic, industrial and other sectors. Solar thermal and photovoltaic are two promising climate compatible technologies with enormous potential for power generation. This is papers gives insight overview of applying solar energy in kitchen for domestic appliances. Creating an awarness towards the same in rural area, people of the same origin may get benefited.

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