SolCafe'
A Solar Cooking Facility for Schools and Small Catering Business in Hot Arid Areas♠

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Abstract

A solar cafeteria, termed, \`SolCafe' was designed and commissioned at a residential school of hundred children in Kothara-Kutch. In this paper we present the experience of its first year of operation. Cooking modules of the café consists of two large box type solar cookers. One cooker has an aperture of 0.5 m^2 and the other 1 m^2. Cookers are of front-loading type. Installation permits the cook to operate from indoors without having to go in the sun. One year of experience has shown that the cookers are easy to use. The only maintenance needed was regular cleaning of glass covers. Such facilities can also be useful to small catering business in hot arid areas.

A solar cafeteria, termed, \`**SolCafe**' was installed in a 100-children residential school at Kothara (Kutch). Kutch is characterized by high insolation, cloud-free sky (barring rainy season), and widespread shortage of fuelwood. In short, it is an area of good potential for solar cooking. Solcafe installed in June 2003, is in regular use. In this paper, we present the experience of this, first year of operation.

♠ Development of SolCafe was supported by Gujarat Energy Development Agency (GEDA). Mr. Nilesh Mania and Mr. Kamlesh Jethva assisted in the project as Research Engineers.

Figure-1 shows a schematic diagram of the installation. The key component of the café is the cooking module consisting of two especially designed large box cookers (A1 and A2). Specification of the cookers is also given in the figure. A-1 has an aperture of 1 m x 0.5 m and A-2 of 2 m x 0.5 m. These are placed side by side on a platform on the south face of the canteen building. Cookers are front-loading type and placed on small castor wheels, which move on aluminium guide rails. Cookers are pulled forward for loading and pushed back into the sun for cooking. Wheels make it easy to move. Cook always works from inside the kitchen. No tracking is required. Total cost of the cookers was Rs 20,000.

Each cooker has a reflecting mirror. Mirror is mounted separately on framework above the northern end of the cooker. Mirrors are easily rotated back against the sun when not in use. Top cover of cookers is fixed permanently to the body and slopes 23^{o} towards south. This is nearly equal to the latitude of the location. **Figure-2** shows the finished installation.

Cooker A-1 was tested at Sardar Patel Renewable Energy Research Institute (SPRERI), Vallabh Vidyanagar, accredited to carry out BIS prescribed tests. Tests included Stagnation and Water Heating, as per BIS guidelines. The two figures of merit are

F 1 : 0.14 ^{o}C / w.m^{2}

F 2 : 0.443 / s

F1 is higher than the minimum stipulated in the Standards.

Monitoring

While the café is operated by the school, our project engineer visited daily to monitor the experience for the first ten months. Daily record of items cooked, quantity and time taken in cooking, solar radiation during cooking period, ambient temperature, wind velocity and sky condition (visual) were maintained. Notes of operation and maintenance related problems were made. Informal interviews were held to obtain feedback from canteen staff and school children.

Cooking Season

Table-1 shows the log of cooking during the year. Cooking was possible in nine out of twelve months. During rainy season, though there may not be rains, sky is obscured making it difficult to cook. Winter conditions however did not present problems. Cooking continued through winter months satisfactorily.

Time Taken in Cooking

Normally the items cooked included rice, dal, vegetables, khichadi,khaman, dhokla. On occasions snacks and biscuits were also done. It took two hours in summer and three hours in winter to cook lunch.

Energy required to cook consists of heat needed to raise the temperature of the admixture of water and raw food from initial to cooking temperature; heat absorbed by food in endothermic reaction in cooking process; and heat used-up in vaporizing water during cooking. Besides the quantity of food material and its thermal properties, energy needed also depends on the skill and experience of the cook. Time taken to complete the cooking process will depend on the rate at which heat is made available to the vessel.

A certain threshold level of radiation is required to raise the temperature enough to start the cooking process. This level appears to be upwards of 370 w/m2 for these cookers. Level of radiation is low in winter days. On January 1, for instance, radiation was only 384 w/m^2 when cookers were loaded, and on December 16, slightly less -- 374 w/m^2. Cooking was, of course, satisfactory on both days. These were the lowest radiation levels when cooking could be done.

Quantity and type of food being the same, higher radiation and ambient temperature, slower wind speed means faster cooking . **Table-2** shows the cooking time and the three weather variables. Regression analysis showed that only radiation and ambient temperature (not the wind speed) had significant effect.

$$T = -0.251\, I_h - 5.146\, Ta + 458.68 \qquad \text{-------- } 1$$

($R^2 = 0.608$)

where

T = cooking time (min)

I_h = solar radiation (w/m^2)

T_a = ambiant temperature (^0C)

Equation (1) was developed using the cooking time data of identical amount of food (rice, khichadi) cooked in different months. For this reason - quantity - does not figure in the expression. Each vessel could be loaded with up to 700 gm raw material. This expression is empirical and will hold for cookers similar to the ones used in SolCafe.

Cooker A-2 accommodates four vessels in full load. It was observed that the cooking time was not reduced when the cooker had fewer vessels as long as each vessel was fully loaded. These cookers behave as though each vessel is placed on an independent burner or hot plate.

Maintenance

There was no breakdown or malfunction at all in this period. Cooker A-1 developed a small deposition of vapor in one corner. The extent of this was small enough such that the performance of the cooker was not affected. Workers tended to neglect clean-up initially. Layer of the dust on the top covers requires daily removal. Birds tended to perch on the frame holding the mirrors causing soiling. Plain sheet of plywood was nailed vertically on top to eliminate the perch. Clean-up was also needed to remove food debris from the platform daily.

User Feedback

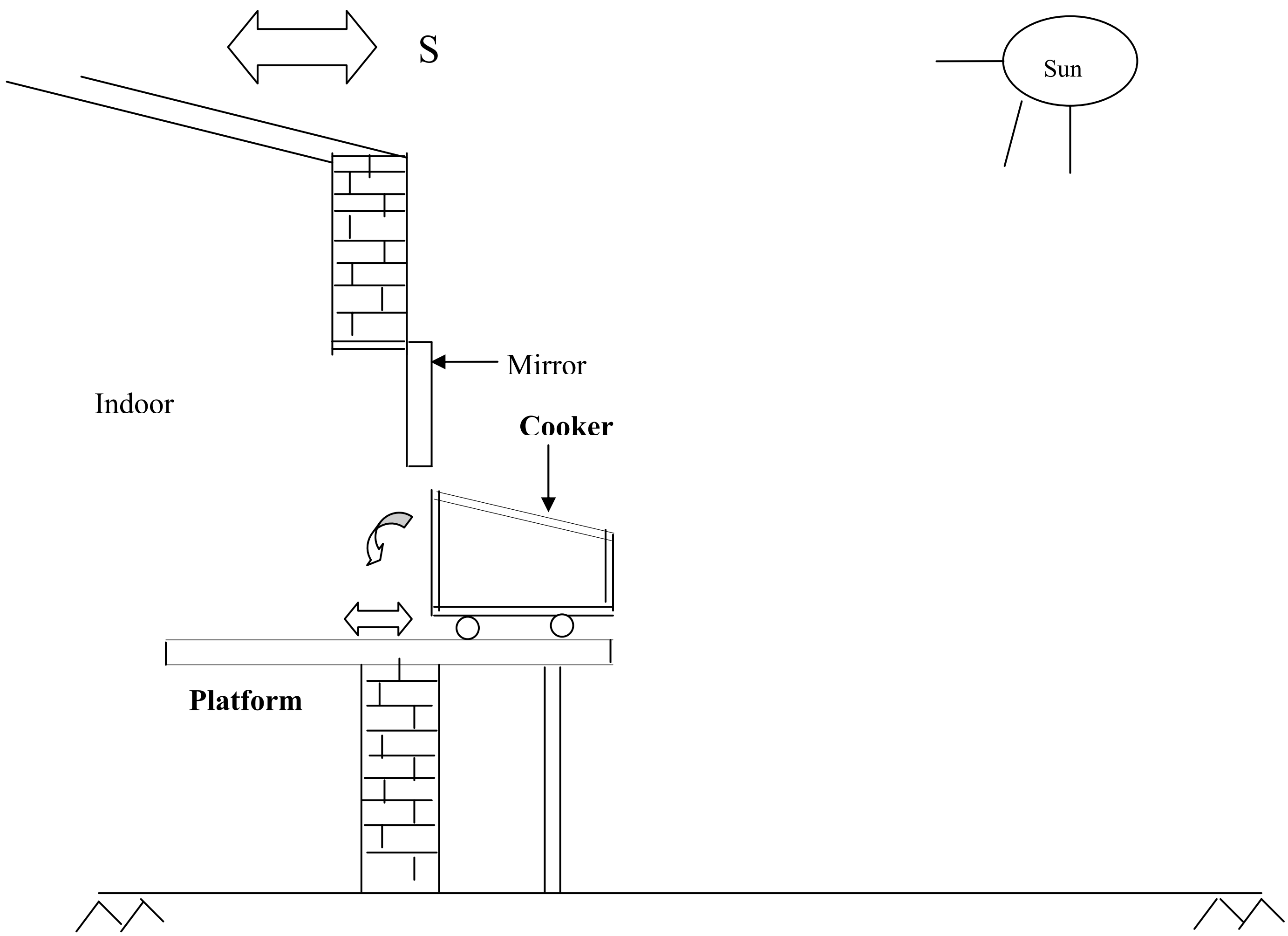
A systematic feedback was collected from school Principal, teachers, canteen workers and students. There was general appreciation of the better taste of food cooked in solcafe , ease of operation and maintenance. This café also works as a model to teach the concepts of solar physics to schoolchildren. Canteen workers especially appreciated the convenience -- no need to go out in the hot sun to orient the cookers or to check the cooking.

Summary

Kutch is hot and arid. It offers vast opportunities for solar appliances. Convenience of use and ease of maintenance need to be built in the product design to make it user friendly. These features greatly improve the acceptance of new devices.

SolCafe described here can also be used for small catering business on roadside and community cooking at the time of emergencies.

Figure-1 : Schematic Diagram of Sol Café Installation



Specifications	**A-1**	**A-2**
Length (cm)	100	200
Width (cm)	68	68
South side height (cm)	21	21
North side height (cm)	35	35
Glazing area (cm)	91 x 59.8	191 x 59.8
Booster mirror (cm)	98.2 x 67	200 x 67
Glazing	2-glass cover 23^0 slope	2-glass cover 23^0 slope
Vessel (33.5 cm in dia. and 8 cm in height)	2 Nos.	4 Nos.
Food Loading	Front Loading	Front Loading
Capacity, kg	1.5	3
Vessel capacity, gm	700	700

Figure-2 :   School Children in front of SolCafe

Table-1 : Summary of SolCafe Operation during the Year		
Month	**No. of days cooking was done**	**Remarks**
June	26	4 days cooking was not done due to dense clouds in sky marking onset of rainy season
July	4	Most of the days sky obscured , dense clouds
August	6	Sky obscured
September	12	Sky obscured
October	18	End of rainy season, sky clear, School closed from Oct 19 to Nov 16 for Diwali
November	13	Café use resumes Nov 16 onwards
December	30	
January	25	Holidays for 5 days
February	25	Holidays for 5 days
March	24	Holidays for 6 days
April	9	School closed April 8 for summer

Table-2: Time to Complete Cooking and Weather Variables					
Month	**Quantity (gms)**	**Time to complete cooking (min)**	**Average Solar radiation (w/m^2)**	**Average Ambient temp. (^0C)**	**Average Wind velocity (m/s)**
January	3000	180	649.5	26.0	5.5
February	3000	120	767.5	29.0	5.5
March	3000	120	710.0	32.5	5.5
April	3000	120	616.0	30.0	6.5
May	-	-	-	-	-
June	1500	135	664.0	32.0	8.0
July	3000	150	652.0	33.0	7.0
August	3000	120	678.5	30.0	6.0
September	1500	135	664.0	32.5	6.0
October	3000	85	790.0	31.5	6.5
November	2500	140	600.0	31.5	8.0
December	3000	180	589.5	25.5	6.0