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Energy Saving by the Application of Domestic Solar Heating Systems

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Abstract

There is no doubt that India, a developing country with a huge population, has growing needs of energy. The conventional thermal energy generation that involves the burning of a particular quantity of coal releases twice as much carbon dioxide into the atmosphere. This will have a disastrous effect on our environment. Mere 1.5% of 1.5% of the non-conventional energy resources are being exploited in India. The increasing demand of power is forcing new research and developments in renewable energy sources. One such energy source is solar energy which is the most abundant and reliable source. In addition, generation of power from solar energy has least environmental impact. If all the solar energy available around the world could be harnessed, it would be enough to provide as much as 20,000 times the present world energy consumption. Sun provide 1,400 W/m^2 at the distance of earth's orbit, but less at ground level. The flux of incident radiation is at best approximately 1,100W/m^2 (without optical considerations) and it is variable. The most widespread thermal use of solar energy, so far has been for water heating, cooking , electricity production and in air-conditioning. Apart from all these uses, solar water heaters have most prominent use.However, the technical feasibility of domestic solar water heating systems (DSWHS) has long been established and their financial viability needs to be carefully examined, particularly in tropical countries with relatively lower annual capacity utilization and poor purchasing power of potential users. By detailed data analysis, calculations show that for a family of six persons we can save up to Rs 8,949 by installing a DSWHS. In addition, we can save 1.68 cylinders of LPG per year by using solar cooker. The purpose of putting the effort is to save energy and by doing so we can definitely make effective use of solar energy.

Key words : Solar energy, Liquefied petroleum gas (LPG), Domestic solar water heating systems (DSWHS).

Energy saving by the application of solar water heating system is a non-conventional method of meeting our daily energy requirements. The most widespread thermal use of solar energy, so far has been in water heating (1). The solar constant is a value of 1367 W/m^2. This is the sum of the UV visible and infrared radiated energy that is available. The highest intensity that we get in a clear day, with low air pollution is 83% of 1367 W/m^2, which is 1134 W/m^2. For simple engineering figures it is best to stick to 1 k W/m^2.

Domestic Solar Water Heating Systems (DSWHS)

A solar water heater (SWH) is a device that uses solar energy to heat water. Solar water heater has several advantages over conventional water heating systems (2). For consumers, they save electrical energy, save interior space (because they are usually located on roof tops) and eliminate the risk of accidents in bathrooms due to electrical water heating equipment. They require little or no care and attention while providing hot water for about 300 days in a year in most part of India.

The Government of India has launched a demon-

Table 1. Energy saving per person by the use of solar water heater (SWH).

Mass of water required m (kg)	Temperature required (C)	Tap water temperature (C)	Energy saved in (kWh)
5	35	22	0.0754
20	38	23	0.3483
30	32	23	0.3135
5	34	24	0.058
15	38	23	0.2612
Total 75			1.0564

Table 2. Yearly per day saving of energy per person in kWh.

Jan (kWh)	Feb (kWh)	Mar (kWh)	Apr (kWh)	May (kWh)	Jun (kWh)	Jul (kWh)	Aug (kWh)	Sep (kWh)	Oct (kWh)	Nov (kWh)	Dec (kWh)	Total (kWh)
0.754	0.754	0.754	–	–	–	–	–	–	0.754	0.754	0.754	4.524
0.3483	0.3483	0.3483	–	–	–	–	–	–	0.3483	0.3483	0.3483	2.0898
0.3135	0.3135	0.3135	0.3135	0.3135	0.3135	0.3135	0.3135	0.3135	0.3135	0.3135	0.3135	3.762
0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.696
0.2612	0.2612	0.2612	0.2612	0.2612	0.2612	0.2612	0.2612	0.2612	0.2612	0.2612	0.2612	3.134
											Total	14.206

stration of domestic solar water heating systems (DSWHS) during 1980s promoting DSWHS in the country. Financial incentives are also offered. The flat plate collector is normally used for water heating. The heated water is then stored in an insulated storage tank. The mode of transfer of heated water from collector to storage tank can be either natural or forced circulation. Further the transfer of heated water may be carried out either directly or through a heat exchanger. Hence a solar water heating system has the following main components : A flat plate collector, a heat exchanger and insulted storage tank.

Solar Water Heating

It consists of an absorber, a storage tank, insulation, piping and a transport cover. In typical north Indian weather conditions on sunny winter day, 1 m^2 of collector area can be expected to heat around 50 liter of water by a temperature of 30—40 C. Typical flat plate collectors made in India have an area of around 2 m^2 and are thus, capable of heating around 100 liters of water in a day. As per the temperature requirement in different months for different activities (like brushing and shaving, bathing and washing clothes tea and washing utensils, cooking) the total savings of energy is given in Table 1. In calculation of yearly saving of energy as shown in Table 2, the monthly saving of energy were calculated by assuming that lowest temperatures of 22.23,24 and 23C at different day times remain same throughout the year.

Calculation

$$Q = mc_p \Delta T$$

where Q is the energy saved in kJ, *m* is the mass of water in kg, c_p is the specific heat of water = 4.18 kJ/kg K and ΔT is the temperature difference in K = Temperature required - Ambient temperature (Table 1). Data collected for different mass of water, Q Total = 1.056 kWh per person per day . For a family of 6 persons it becomes 6.339 kWh per day, for a months 190 kWh and the yearly saving of energy = 14.2062 × 6 × 30 = 2557.116. We know I kWh of electricity costs Rs 3.50. Therefore, saving = Rs 667 month and yearly saving is Rs 8,949.

Solar Cooking System

India, being a vast country with a population of over one billion, consumes its significant share of energy consumption towards cooking. The sources available for cooking are firewood, crop residues and animal dung in rural areas and LPG, kerosene oil and

Table 3. Mean value of half an hour interval.

Time	Temperature of water (C) Day 1	Day 2	Day 3	Mean temperature (C)	Solar radiation (W/m^2)	Ambient temperature (C)
11.30	12	13.0	13	13	560	17
12	38	39.5	39.7	39.7	560	16
12.30	64	62.0	64.3	64.33	540	17
13	82	84.0	84.3	84.33	520	18
13.30	98	98.8	99.3	99.26	540	20

Table 4. Efficiency calculation.

Energy saved mcpΔt) (kJ)	Time	Temperature of water (C)	Solar radiation (W/m^2)	Ambient temp (C)	Efficiency (%)
1197	11.30-12.00	26.7	560	16.5	32
1020	12.00-12.30	24.6	550	16.5	30
840	12.30-13.00	20	530	17.5	25.32

coal. The smoke emitted not only affects health of the family but also pollutes the environment. On clear sunny days, it is possible to cook both noon and evening meals in a solar cooker. Solar cooking does not fully replace conventional fuels, but it helps in substituting such fuels partly (3). The aim is to convert the sun's energy into heat for which we make use of solar cookers. Solar cooker is an insulated box with glass cover and a top lid, which has a mirror on the inside to reflect sunlight into the box when the lid is kept open. The inner part of the box is painted black. Up to 4 black vessels are placed inside the box with the food to be cooked. Insulation materials generally used are glass, plastic, wood, cardboard or plastic bags. Insulation allows retaining heat. The cooker takes one and a helf to two hours to cook items such as rice, lentils and vegetables. It can also be used to prepare simple cakes, roasting dry fruits etc. It, however, cannot be used for frying or making chapatti. For a mass of 30 kg of water, mean values for an interval of half an hour of readings are noted (Tables 3 and 4).

Calculation of Energy Produced per Day

Total Q = 0.849 kWh (amount of energy in a day); For month = 30 × 0.849 = 25.47 kWh; One cylinder of LPG will produce 14.2 × 46 × 1000 = 653.2 × 1000kJ = 181.44 kWh. Therefore we can save 1.68 cylinders of LPG per year by using solar cooker.

Conclusion

Solar energy is an abundant source of energy that can be utilized to meet our basic energy requirements. Domestic solar water heating system and solar cooking units are examples of such utilization. Domestic solar water heating system not only provide heated water, but also save electrical energy, save interior space and eliminate the risk of accidents in bathrooms. Installation domestic solar water heating system in a house of family of 6 members can save up to Rs. 8949 per year. We can save 1.68 cylinders of LPG by using solar cooker for cooking food. Solar cookers utilize solar energy for cooking food. These can cook both cook both noon and evening meals on clear sunny days. We can save 1.68 cylinders of LPG annually by using solar cooker.

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