Solar Installations and Reduction in LPG Consumption

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Abstract: **With increasing awareness of solar technology among people, they expect a little more from the solar industry. The paper highlights the annual cost reductions in LPG by its reduced consumption across the entire country. The paper throws light on the savings achieved per Indian household with solar installations which is a considerable amount since little extra effort is involved.**

Keywords: Solar heated water, LPG, Urban local bodies, Panchayats

I. INTRODUCTION

EVERY middle class household in India always tries to reduce consumption and looks forward to saving money as much as possible. But this seldom happens because of lack of awareness in technology. Even though, GOI – Government of India has announced a huge subsidy on solar technology, people rarely believe it works. The paper attempts to educate the people about an everyday benefit obtained in households by solar installations.

II. LITERATURE SURVEY

Kanagawa *et al.* estimated the impacts of energy access improvement on socio-economic situation in the rural areas of developing countries. They focused on socio-economic impacts of cooking demand through changes in stoves adopted by the rural households. They developed an energy-economic model of rural areas in India to analyse the links between energy, income, and health hazard, applying both cost for fuelwood and exposure to Respirable Suspended particulate matter (RSPM) [1]. Li *et al.* acquired data on rural household energy use and based on substitutable analysis, using a quantitative model, estimated the environmental and economic costs under different energy consumption structures. The substitutable structures were commercial energy, solar energy and biogas. Among these structures, the total cost, cash payout, environmental cost and economic cost were to the minimum with solar energy and biogas [2].

Sovacool *et al.* investigated the concepts of energy poverty and energy ladders. They elaborated on the connection between modern energy services and development, public health, gender empowerment, and the degradation of the natural environment. They argued that energy poverty affects both the gender roles within society and educational opportunities available to children and adults [3]. Nussbaumer *et al.* emphasised that modern energy services are a critical factor for sustainable development and is central to everyday lives of people. They discussed the adequacy and applicability of existing instruments to measure energy poverty across Africas and proposed a Multidimensional Energy Poverty Index-MEPI. MEPI focuses on the deprivation of access to modern energy services, and captures both incidence and intensity of energy poverty. It helps in policy making [4].

III. METHODOLOGY

Every Indian household has a pressure cooker. Pressure cooker works on the principle of cooking food by steam formation in a closed pot. The superheated steam increases the pressure in the pot and results in cooked food. Moreover, the food is cooked in a quarter of time when compared to cooking food in an open pot. The water absorbs heat and converts itself into a superheated steam at a temperature of 393K and a pressure of 2 bar [5].

Every household uses LPG-Liquefied Petroleum Gas or an electric cooker to cook food. The LPG is available in India in different sized cylinders but mostly 14 kg LPG cylinder is used across the country. LPG is a mixture of propane and butane in the ratio 60:40 [6]. Be it a pressure cooker or an electric cooker, the water to rice ratio is 1.5:1. Without varying the quantity of water, let the input temperature of water be varied to 333K instead of room temperature. This results in a sensible heat difference yielding to a reduced consumption of LPG.

IV. HYPOTHESIS

Installed solar water heater gives a percentage passive earning of 9.73 annually to every household in India, upon onetime daily cooking.

Analysis and Discussion

TABLE 1 -- SUPERHEATED STEAM PROPERTIES AT 0.20 MPA [11]

Temperature (^{0}C)	Specific volume(v) m^3/kg	Specific internal energy (u) KJ/kg	Specific enthalpy(h) KJ/Kg
100	0.8857	2529.5	2706.7
120	0.91526	2548.46	2731.54
150	0.9596	2576.9	2768.8

TABLE 2 -- SATURATED WATER (LIQUID-VAPOUR) PROPERTIES [11]

Temperature (^{0}C)	Specific volume(v) m^3/kg		Specific internal energy (u) KJ/kg			Specific enthalpy(h) KJ/Kg		
	Sat liquid v_f	Sat vapour v_g	Sat liquid u_f	Evap. u_{fg}	Sat vapour u_g	Sat liquid(h_f)	Evap h_{fg}	Sat vapour(h_g)
25	0.001003	43.36	104.88	2304.9	2409.8	104.89	2442.3	2547.2
60	0.001017	7.671	251.11	2205.5	2456.6	251.13	2358.5	2609.6
100	0.001044	1.6729	418.94	2087.6	2506.5	419.04	2257.0	2676.1
120	0.001060	0.8919	503.50	2025.8	2529.3	503.71	2202.6	2706.3

TABLE 3 -- SENSIBLE HEAT DIFFERENCE CALCULATION AT INPUT TO PRESSURE COOKER

Parameter	**Equation(h=u+Pv)**
Sensible heat of Input water at room temperature	205.18 KJ/Kg
Sensible heat of water at 333K	352.81 KJ/Kg
Sensible heat difference	147 KJ/Kg
Total heat in raising temperature of steam to 393K	5.24 MJ/Kg

TABLE 4 -- CALCULATION ON NUMBER OF LPG CYLINDER CONSUMPTION PER ANNUM

Parameter	**Value**
Steam Pressure in a cooker [5]	2 bar=0.20MPa
Steam temperature in a cooker [5]	120 +273 =393K
Total heat in raising the steam to 393K	5.24 MJ/Kg
Gross Calorific value of LPG [6]	49.6 MJ/Kg
Time to cook in a 10 liter pressure cooker	15 minutes
Rate of energy supply in 14kg LPG cylinder [6]	16 MJ/hr
Specific gravity of LPG [6]	2.1 kg/m^3
Amount of heat generated in burning LPG when water is input at room temperature	16*10*2.1*15/60*(120-25)=7.980MJ/kg
Heat needed when input water is 333K	16*10*2.1*15/60*(120-60)=5.040 MJ/kg
Reduction in heat needed	2.94 MJ/Kg
Annual rice consumption in India [10]	94854.48 MT
Annual LPG savings in one time cooking rice	94854.48*2.94 *10^15 =278.9*10^18 Joules
Energy in 14kg LPG cylinder	14*2.1*49.6=1458 MJ
Number of lpg cylinders	191.3 *10^9
Number of urban local bodies(ULB)[7]	3641
Number of panchayats [8]	238617
Reduction in LPG cylinders per ULB and panchayat	191.3*10^9/(3641 + 238617)=7,89,654
Cost per cylinder without subsidy	Rs.1000
Number of cylinders in a year per household	6
Annual savings in a household per one time daily cooking	7,89,654/6000 =131.61 INR
Percentage Annual savings in a household per two times daily cooking	9.73

V. CONCLUSION

The projected inflation by 2050 in India is 4.53 [9]. However, due to depleting natural resources, either the consumption must be reduced or an alternative must be searched for. Once, solar water heaters are installed in households, the solar heated water could be utilised to cook food. The solar heated water could be poured in a pressure cooker or an electric cooker to cook food. Irrespective of the variation in time to cook, the calculations show a considerable reduction the LPG consumed. Moreover, these LPG cylinders have to transported physically in various parts of India. The solar heated water would also reduce the consumption of gasoline in automotives since the cylinders are less transported in a town or a city. Still, India is yet to lay gas pipelines in every urban local body of the country. Thus, the solar heated water results in many indirect benefits like reduced manpower, increased labour time for rest of the jobs. The solar water heater is useful only at the time of taking bath and rest of the day, it is of no use. Now, by utilising solar heated water to cook food, each household can increase its revenue.

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