Economic evaluation and payback period of SWH as compared to other water heating systems

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Abstract- Today's world is full of various forms of energy. Living being uses different forms of energy in one or more ways and so it is important to conserve energy. Energy is one of the major inputs for the economic development of any country. For developing countries, the energy sector assumes a critical importance in view of the ever increasing energy needs requiring huge investments to meet them.

Energy demand will grow by 37 percent upto 2040 on planned policies, an average rate of growth 1.1percent per year (International Energy Agency, 2014). Household sector being one of the largest users of energy in India accounts for about 30 percent of final energy consumption which reflects the need of household sector for energy conservation in national energy scenario (Reddy, 2003). The hot water requirements are primarily met presently by combustion of fossil fuels like coal, fuel oil, LPG and electricity. Fossil fuels are lost at the rate of 4 billions tones a year (CIA World Factbook, 2014).The word itself- solar, describes that we are dealing with some renewable energy source for a hot water systems. The present study was conducted in hisar district, Haryana to assessing the quantity of hot water requirement during different months and calculate the economic evaluation and payback period of SWH as compared to other water heating systems. In this paper the main focus is on monetary savings and payback period of SWH in comparison to other water heating systems. Heating 100 litres of water on SWH resulted in saving on annual basis, Rs 6915 in electric geyser, Rs 4149 in improved *chulha*, Rs 3696 in biomass geyser and Rs 2811in LPG geyser can be saved if SWH is used for heating water in comparison to these systems. Payback period of SWH as compared to electric geyser came out to be around 2 years, 4 years in case of improved *chulha*, 4.5 years in case of biomass geyser and 6 years in case of LPG geyser. Thus after these many years, cost of heating of water will be almost negligible in case of SWH.

Keywords – monetary saving, payback period

1.INTRODUCTION

Today's world is full of various forms of energy. Living being uses different forms of energy in one or more ways and so it is important to conserve energy. Energy is one of the major inputs for the economic development of any country. Technological advancement and modernization have accompanied an increased consumption of energy. There is a direct correlation between the degree of economic growth, per capita income and per capita consumption of energy. The rapid mechanization and scientific innovations over the last few decades have made mankind more and more vulnerable to the after effects of the ruthless exploitation of natural resources. Energy audit is a key to systematic approach for conserving energy. Renewable sources of energy are anticipated to play a significant role in energy generation in India in the future. For developing countries, the energy sector assumes a critical importance in view of the ever increasing energy needs requiring huge investments to meet them. Energy demand will grow by 37 percent upto 2040 on planned policies, an average rate of growth 1.1percent per year (International Energy Agency, 2014).

Household sector being one of the largest users of energy in India accounts for about 30 percent of final energy consumption which reflects the need of household sector for energy conservation in national energy scenario (Reddy, 2003). The hot water requirements are primarily met presently by combustion of fossil fuels like coal, fuel oil, LPG and electricity. Fossil fuels are lost at the rate of 4 billions tones a year (CIA World Factbook, 2014). Pillai and Banerjee (2004) reported that solar water heater (250 LPD) was most cost effective with payback period of about 2.5 years. The cost of saved energy was about Rs1.5/kWh. The cost of energy saved for 250 LPD systems was found to be less than Rs 2/kWh.

REEEP (2010) The cost of solar water heater with a capacity of 100 litre varied between Rs 18000 and Rs 25000. Hence, electric water heater caused about 25 percent of its home energy costs on heating water. Solar water heaters offered the owners saving as much as 50-85 percent annually on their utility bill over the cost of electric water heating. It was possible to get a simple payback of 3-8 years on a well designed and properly installed solar water heater. Jawaharlal Nehru National Solar Mission, also known as the National Solar Mission (NSM), is a major initiative of the Government of India for addressing India's energy security challenge through harnessing of solar energy. Solar water heaters are also an integral part of the NSM. According to (MNRE), Government of India, a 100 litre capacity SWH can replace an electric geyser for residential use and may save approximately 1500 units of electricity, annually, under Indian conditions. Thus, an average family can save 70–80 percent on electricity or fuel bills by replacing its conventional water heater with a solar water heating system. Their payback period is very attractive and it recovers its cost in 2-4 years. However, life of the system is more than 15 years (MNRE 2010).

Veeraboina and Ratnam (2012) reported that current market cost of SWHs is in the range of Rs 15,000-20,000. If SWHs was assumed to cover 75–85 percent of annual hot water demand, then accordingly the cost of hot water decreases in similar ratio. Based on the price of electricity in India, the savings per year for a typical Indian household, through the use of solar water, is in the range of Rs 4000–7000. Since SWHs last 15–20 years, it implies that beyond the breakeven period of four years, get hot water at no cost. The purpose of this study was to know about the on monetary savings and payback period of SWH in comparison to other water heating systems.

2. METHODOLOGY

Locale of study: The study was conducted in urban area of Hisar city of Haryana state which was selected purposively as the researcher is well acquainted with the area.

***Sampling procedure*:**

Phase I- A sample of 50 respondents were selected users and non-users of solar water heaters.

Phase II- An experiment was carried out in the lab for water heating using different energy sources viz. solar water heater, electricity, LPG, biomass and wood.

Tools for data collection:

Phase I: Data were collected personally by the researcher using questionnaire method in order to assess the energy use pattern for hot water requirement.

Phase II: Laboratory Experiment

Procedure- The experiment were conducted on different water heaters and procedure for each is given i.e. SWH, electric geyser, LPG geyser, biomass geyser and improved *chulha*.

(i) A **Solar Water Heater** of 100 litres water capacity was selected. The experiment was conducted for three consecutive days a month from 7:00 h to19:00 h every day, throughout the year. The outlet temperature of the hot water was recorded at two hours interval till constant temperature was achieved. Total quantity of hot water upto 70°C was measured in the evening. The average temperature was calculated. Formula for calculating operating cost is given as under:

Operating cost = cost of /unit and kg ×fuel used

(ii) For **electric geyser** The same experiment was repeated in electric geyser. Total electric consumption (units) was measured using standard electricity meter. Consequently, cost of heating one litre of water was calculated. Cost of electricity was consumed @ Rs 9/unit (Formula given as above).

(iii) For **LPG geyser** The same experiment was repeated in LPG geyser. Total LPG consumption (kg) was measured using standard weighing balance. Consequently, cost of heating one litre of water was calculated. Cost of LPG was derived @ Rs 41/kg (Formula given as above).

(iv) For **biomass geyser and improved *chulha*** The same experiment was repeated in biomass geyser and improved *chulha*. Total wood consumption and biomass (kg) was measured using standard weighing balance. Consequently, cost of heating one litre of water was calculated. Cost of wood and biomass was derived @ Rs3/ kg (Formula given as above).

Analyses of data: The collected information and responses of the respondents were assigned code numbers for subsequent tabulation and analysis. The data were suitably analyzed by using frequencies and percentages**.**

(i) Method for calculating the economic evaluation of water heaters: The following assumptions have been made to carry out the economic evaluation of water heaters.

a. Initial investment

b. Salvage value was taken as 10% of capital

c. Fixed cost (it includes depreciation and interest)

(1) Depreciation **:-** **D = (P-S)/L**

D = Depreciation cost, average cost **(**Rs/year**)**

P = Purchase price **(**Rs**)**

S = Residual value **(**Salvage value)(Rs**)**

L = Useful life **(**years**)**

(2) Interest @12% **A = (P+S)/2**

A = Average purchase price

P = Purchase price

S = Residual value

d. Variable cost or operating cost

e. Total cost (fixed cost and operating cost**)**

f. Annual profit= total annual days of use (300**)**× Daily saving (IS 9164, 1979)

3. RESULTS

The results explain about all the families reported regular use of hot water in winter months i.e. in December, January and February followed by March (89%), November (70%), October (26%) and April (13%). However, a comparison of user and non-user families revealed that, all families were using hot water during peak winter months i.e December, January and February while more users reported use of hot water users than the non-users during the months of October, November, March, and April (Table1)

Table 1 : Hot water requirement during different months

Variables	Users (n=50) f (%)	Non–users (n=50) f (%)	Total (n=100) f*
January	50 (100. 00)	50 (100.00)	100
February	50 (100.00)	50 (100.00)	100
March	49 (98.00)	40 (80.00)	89
April	13 (26.00)	-	13
May	-	-	
June	-	-	-
July	-	-	-
August	-	-	-
September	-	-	-
October	16 (32.00)	10 (20.00)	26
November	38 (76.00)	32 (64.00)	70
December	50 (100.00)	50 (100.00)	100

Multiple responses

*Frequency is equal to the percentage as the total sample size was 100

Gives a clear picture that maximum quantity of hot water > 80 litre per day was used by (81%) of the families followed by the 40-80 l/d (14%) and < 40 litre (5%). However, the comparative analysis shows that user families were using more quantity of hot water i.e. >80 l/d than non-user (72%)(Table 2)

Table 2: Quantity of hot water requirement (l/d)

Quantity of hot water	Users (n=50) f (%)	Non–users (n=50) f (%)	Total (n=100) f*
< 40 l/d	-	5 (10.00)	5
40-80 l/d	5 (10.00)	9 (18.00)	14
>80 l/d	45 (90.00)	36 (72.00)	81

*Frequency is equal to the percentage as the total sample size was 100

Table 3 depicts the type of technology used and possessed for water heating**.** It entails that all the user families were using solar water heater for water heating while 34 percent of non-user families were using electric geyser followed by the user families (24%) and 66 percent of the non-user families were using the LPG geyser. However, 18 percent of the user families possessed the electric geyser followed by gas geyser 16%. It was observed that gas geysers were used by maximum of the non-user families (66%).

Table3: Type of technology used and possessed for water heating

Technology	Users (n=50)		Non-users (n=50)	
	Possessed	Used	Possessed	Used
	f (%)	f (%)	f (%)	f (%)
Electric Geyser	21(42.00)	12 (24.00)	17 (34.00)	17 (34.00)
LPG Geyser	8 (16.00)	-	33 (66.00)	33 (66.00)
Solar water heater	50 (100.00)	50 (100.0)	-	-

Multiple response

Results shows that the average monthly electricity bill for summer season was >Rs 15000 (44%) followed by Rs 5000-15000 (33%) and Rs < 5000 (23%) whereas for winter season it was Rs 4000- 8000 (40%) followed by the Rs < 4000 (37%) and Rs > 8000 (25%). A comparative analysis showed that electricity bill was more for user families than non-user families during summer as well as winter season. This may be due to fact that user families were having larger houses, higher income, larger family size and more electrical gazettes (Table 4)

Table 4: Average monthly electricity bill of the respondents (Rs)

Attributes	Users (n=50)	Non-users (n=50)	Total (n=100)
	f (%)	f (%)	f*
Summer			
< 5000	4 (8.00)	19 (38.00)	23
5000-15000	20 (40.00)	13 (26.00)	33
> 15000	26 (52.00)	18 (36.00)	44
Winter			
< 4000	16 (32.0)	21(42.00)	37
4000- 8000	15 (30.0)	25 (50.00)	40
> 8000	21 (42.0)	4 (8.00)	25

*Frequency is equal to the percentage as the total sample size was 100

Maximum of the non-user families (28%) were using 1-2 LPG cylinder for gas geyser in winter season followed by more than two (26%) and upto one cylinder (12%) whereas none of the user families were using gas cylinder for heating water inspite of their possession (Table 5)

Table 5: LPG cylinders required for gas geyser in winter season

LPG cylinder	Users (n=50)	Non-users (n=50)
	f (%)	f (%)

Upto 1	-	6 (12.00)
1-2	-	14 (28.00)
More than 2	-	13 (26.00)

Economic evaluation of various water heating systems which reveals that initial cost of the solar water heater was Rs 17000 followed by electric geyser (Rs 7000), LPG geyser (Rs 4000), bimass geyser (Rs 1700) and improved *chulha* (Rs 400). Fixed cost of heating 100 litres of water in solar water heater was Rs 4.63 followed by electric geyser (Rs 3.68), LPG geyser (Rs 3.01), biomass geyser (Rs 1.95) and improved *chulha* (Rs 0.46). The operating cost was nil for solar water heater whereas it was maximum for electric geyser i.e. Rs 24/day followed by improved *chulha* Rs 18,biomass geyser Rs 15 and LPG geyser Rs 11.Heating 100 litres of water in electric geyser costed maximum i.e. Rs 27.68 followed by improved *chulha* (Rs 18.46), biomass geyser (Rs 16.95) and LPG geyser (Rs 14.00). Solar water heater was found to be the cheapest mode of heating water as it costed only Rs 4.63 for heating 100 litres of water (Table 6)

Table 6: Economic evaluation of various water heating systems

Parameters	Solar water heater	Electric geyser	LPG geyser	Biomass geyser	Improved *chulha*
Initial cost (Rs)	17000	7000	4000	1700	400
Salvage value (S) (Rs)	1700	700	400	170	40
Life of the unit (L) (yrs)	25	8	5	3	3
Depreciation (Rs/day)	2.04	2.62	2.4	1.7	0.4
Interest (Rs/day)	2.59	1.06	0.61	0.25	0.06
Fixed cost of heating 100 litres water /day (Rs)	4.63 (0.04)	3.68 (0.03)	3.01 (0.03)	1.95 (0.01)	0.46 (0. 00)
Operating cost of heating 100 litres water/day (Rs)	0	24 (0. 24)	11 (0.11)	15 (0.15)	18 (0.18)
Total cost of heating 100 litres water/day (Rs)	4.63 (0.04)	27.68 (0.27)	14.00 (0.14)	16.95 (0.16)	18.46 (0.18)

Figures in parenthesis indicate cost of heating one litre water /day

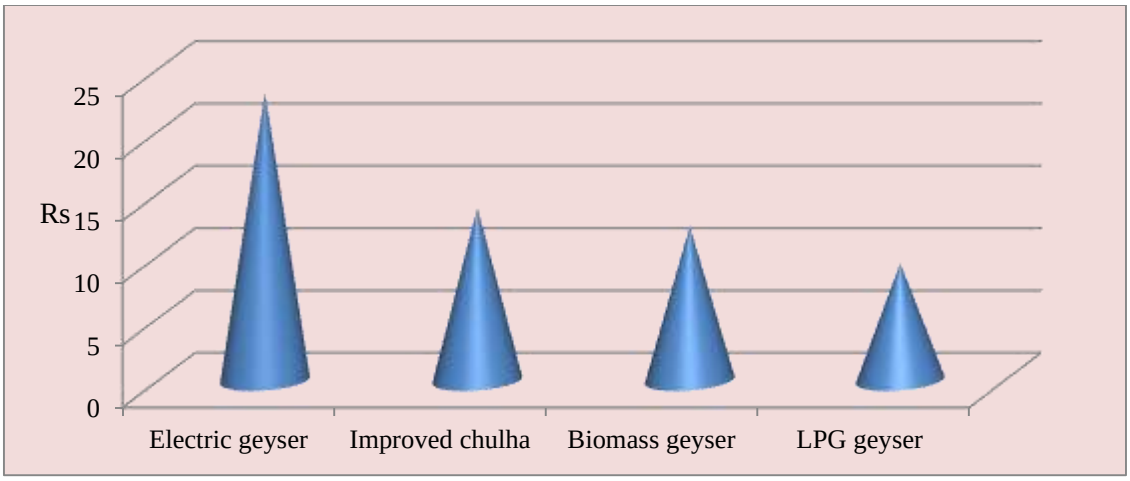

Fig 1: Daily saving of heating 100 litres water in SWH

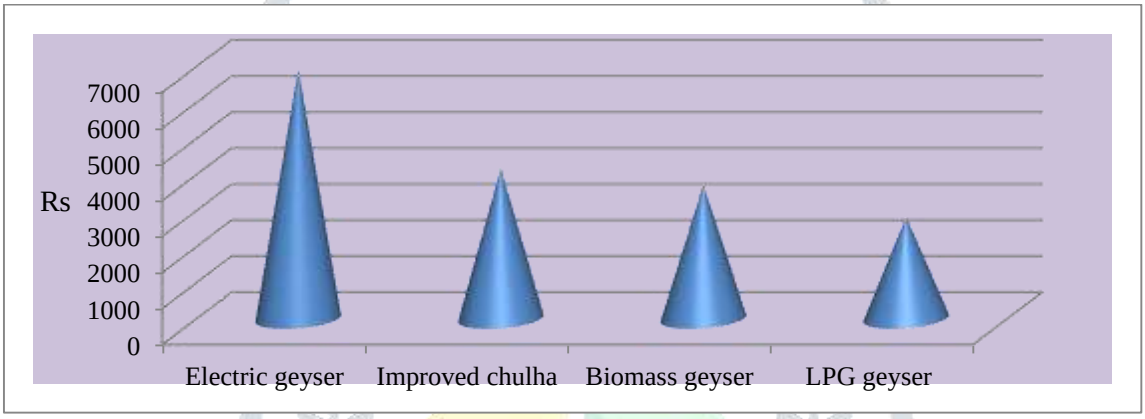

Fig 2: Annual saving for heating 100 litres water in SWH

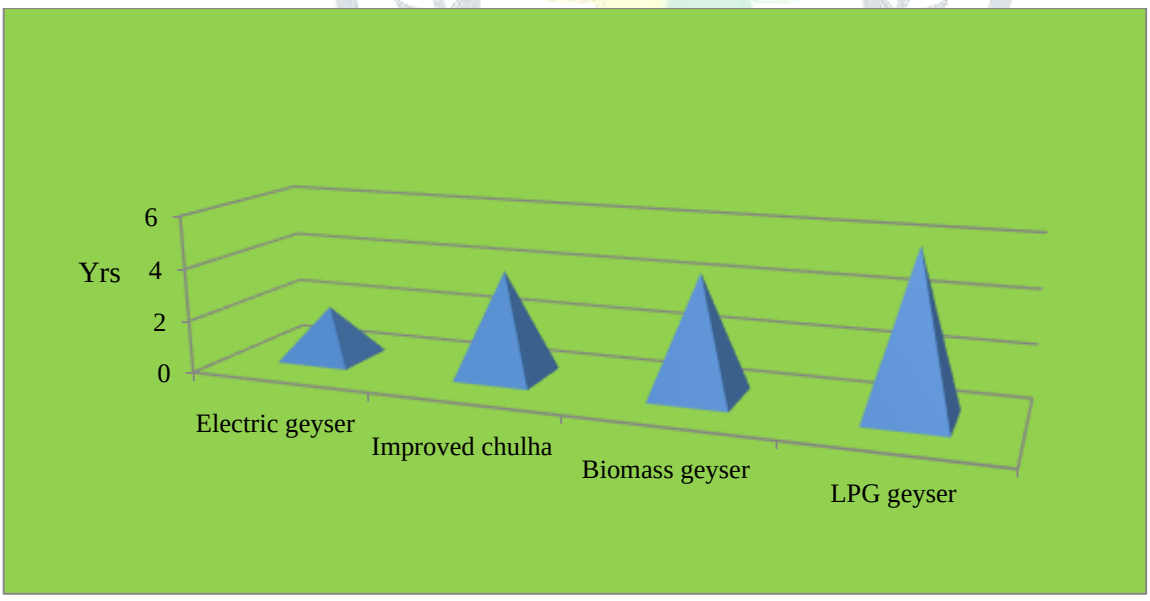

Fig 3: Payback period of SWH as compared to other water heating systems (yrs)

Table 7: Monetary savings and payback period of SWH in comparison to other water heating systems

Parameters	Electric geyser	LPG geyser	Biomass geyser	Improved *chulha*

Daily saving of heating 100 litres water in SWH (Rs)	23.05 (0. 22)	9.37 (0.09)	12.32 (0.12)	13.83 (0.13)
Annual saving of heating 100 litres water in SWH (Rs)	6915	2811	3696	4149
Payback period of SWH as compared to other water heating system (yr)	2	6	4.5	4

Figures in parenthesis indicate cost of heating one litre water /day

Table 7 and Fig. 1 to 3 highlight the monetary savings and payback period of SWH in comparison to other water heating systems. The data reveal that while heating 100 litres of water on SWH resulted in saving of Rs 23.05 per day if replaced by electric geyser. Similarly, there was a saving of Rs 13.83 if replaced by improved *chulha* followed by biomass geyser (12.32) and LPG geyser (Rs 9.37). While on annual basis, Rs 6915 in electric geyser, Rs 4149 in improved *chulha*, Rs 3696 in biomass geyser and Rs 2811in LPG geyser can be saved if SWH is used for heating water in comparison to these systems. Payback period of SWH as compared to electric geyser came out to be around 2 years, 4 years in case of improved *chulha*, 4.5 years in case of biomass geyser and 6 years in case of LPG geyser. Thus after these many years, cost of heating of water will be almost negligible in case of SWH (IS 9164, 1979).

4.CONCLUSION

Solar water heater was found to be the cheapest mode of heating water. Heating 100 litres of water on SWH resulted in saving of Rs 23.05 per day if replaced by electric geyser. There was a saving of Rs 13.83 if replaced by improved *chulha* followed by biomass geyser (Rs 12.32) and LPG geyser (Rs 9.37). While on annual basis, Rs 6915 in electric geyser, Rs 4149 in improved *chulha*, Rs 3696 in biomass geyser and Rs 2811in LPG geyser can be saved if SWH is used for heating water in comparison to these systems. Payback period of SWH as compared to electric geyser came out to be around 2 years, 4 years in case of improved *chulha*, 4.5 years in case of biomass geyser and 6 years in case of LPG geyser. Thus after these many years, cost of heating of water will be almost negligible in case of SWH.

Several research studies over the years have also confirmed that SWH of 100 litres of capacity can save 649 kg of firewood, 152 kg of charcoal, 379 litres of kerosene,182 kg of LPG, 1162 kW/h of electricity, and directly an amount of Rs 4500 to 6500 in cash per year**.** It was also found to be very economical with a payback period of 4 to 5 years. Based on the price of electricity in India, the savings per year for a typical Indian household through the use of solar water heater, was in the range of Rs 4000–7000. Several research studies over the years have confirmed that access to a low cost solar water heater has been quite beneficial to households in developing communities. Many households could reduce their fuel costs by eliminating or reducing their need for wood, gas or electricity to heat water. Although solar water heating is an important potential area to take advantage of solar energy, many households considered solar water heating systems as being too expensive due to the high initial investment costs. .(Kablan, 2003; Crawford *et al*. 2003; MNRE, 2010; Saxena and Srivastava, 2012).

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