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PG-Water Based Solar Water Heater vs. Electric Heating System (Geyser): A Case Study

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Abstract—*Propylene glycol- Water based solar water heater has efficiency around 65%. In India maximum electric energy is generated from coal based thermal power plant that have very less thermal conversion efficiency and also increases pollution in environment.*

Here we take a case study of a hostel that is in the campus of NIT Kurukshetra (Haryana). Hostel number 9 also known as Indivar Bhawan has a capacity of around 400 students. 20 Electric geysers are in use in the hostel and their power rating is 2 KW.

Compare to this electric water heating system our Propylene glycol-Water based solar water heater is cheaper in terms of operating cost and also ecofriendly in nature. This paper suggests some reason why we should use Propylene glycol- Water based solar water heating system instead of Electric water heating system.

Keyword*: Propylene Glycol (PG), Solar water heater, Electric water heater*

1. INTRODUCTIONS

With the development of economy, the demand of urban and rural residents for living and bathing has increased substantially. Together with electric water heater and gas water heater, solar water heater becomes one of the major products supplying hot water for domestic use.

A number of factors have contributed to the large scale use of solar water heating in India, especially in low temperature applications in the commercial sector. Hot water is a major requirement for hotels, restaurants and other food processing establishments in India. The continuing increases in the sector's electricity tariffs as well as problems associated with the electricity supply such as outages and voltage fluctuations have aided the market for solar hot water systems. Most parts of India receive high amount of solar radiation, which makes solar water heating an attractive and viable option. India's Ministry of Non-Conventional Energy Sources (MNES), operating through the Indian Renewable Energy Development Agency (IREDA) and other public sector organizations, provides soft loans to domestic and institutional solar hot water systems, which makes the investment more attractive.

2. SOLAR WATER HEATER

Fig. 1: Experimental setup

Solar water heaters are characterised by its thermal performance and it largely depends on the transmittance, absorption and conduction of solar energy and the conductivity of the working fluid.

Solar water heater utilizes the solar energy that is available free of cost and in northern India it is available in bulk. We can install our Propylene glycol-Water based solar water heater on the hostel's roof where it can get sunlight. This energy is use to heat water and supply to hostels mess or in bathrooms. Heated water can also store in insulated tank so we can use it later.

This experiment setup installed at thermal energy lab in NIT Kurukshetra, some parts of our experimental setup are:

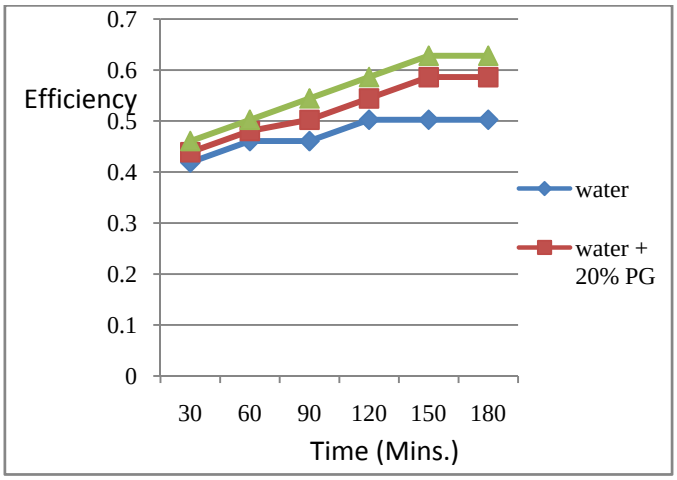
- Flat plate collector
- Storage tank (heat exchanger)
- Mounting frame

- Pump with supply reservoir
- Connecting pipes
- Solar simulator

This experimental analysis was done at different constant intensity so that we can analyze what is the exact behavior of heat exchanging fluid here that is Propylene glycol and water mixture.

After the analysis it is found that 40^0-50^0 C is easily achievable and we can also see the deviation of efficiency when we use Propylene glycol-water instead of pure Water.

Result of 450W/m^2 of intensity



Graph 1: Result of 450W/m^2 of intensity

The rise in efficiency is easily visible in above graph when we increase the ratio of Propylene glycol from 0% to 30% in water. After 180 minutes it is found that efficiency increase from 50% to 63% for pure water and 30% Propylene glycol in water simultaneously.

3. ELECTRIC WATER HEATER (STATIONARY STORAGE TYPE)

Fig. 2: Bajaj platina electric water heater

Electric heaters are in use in Hostel number 9. Bajaj platina water heater having the rating of 2KW and cost is around Rs.16000. The cost is not a big issue but the main issues are high operating cost and non-ecofriendly in nature.

Although electric water heater installed only in bathrooms but here we are assuming that heaters also utilizes in hostels mess.

Calculation of operating cost per heater per year

This calculation made for 6 month from October to march because requirement of hot water mostly arises in this period.

Rating = 2 KW

Average no. of hours of use = 8

Consumption of energy per day = 16 KWh

Electricity charges in Kurukshetra = Rs. 9 per KWh

Total operating cost per year = consumption of energy per day×182 days×electricity charges

Total operating cost per year = Rs. 26,280

So this huge amount requires each year as operating cost per electric heater.

4. COMPARISON

	Solar Water Heater	Electric water heater
Initial cost	Rs 18000	Rs 16000
Input	0	2KW
Volts	0	230 V AC
Capacity	160 liter	80 liter
Class	NA	1
Fuel	Solar Energy	Electricity
Fuel cost	0	Rs 9 per KWh

We can ignore the difference of initial cost of these two systems. But we cannot ignore the type of fuel used in these two systems.

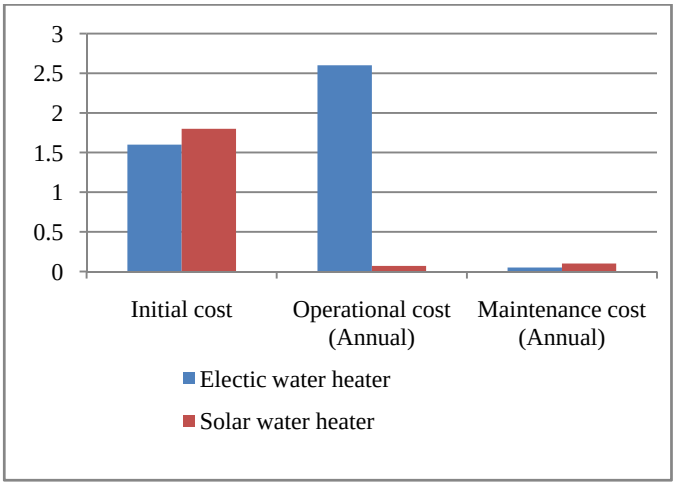


Chart 1: Various cost analysis

Solar water heater uses solar energy that is available free of cost and in bulk but on the flip side Electric water heater uses the electrical energy that is costly and also not ecofriendly in nature. Electric water heater is not economical because of the cost of electrical energy that is associated with electric water heater.

Electric water heater requires less maintenance so the maintenance cost is little bit less for electric water heater than solar water heater.

5. PAYBACK PERIOD

We can define the payback period for PG-Water based solar water heater because it uses the solar energy that is available in bulk, free of cost.

Calculation of payback period of solar water heater:

This readings record in thermal energy lab of NIT Kurukshetra on 25 February 2015, around 10:00 AM when surrounding temperature at 18^0C.

Mass (m) = 20 liter per hour = 0.0056 Kg / s

Specific heat of Water (c) = 4180 J/Kg-K

Inlet temperature = 16^0 C

Exit temperature = 31^0 C

$Q = m \times c \times (T_{exit} - T_{in})$

$= 0.0056 \times 4180 \times (31-16)$

$= 351.12$ J/s $= 0.35112$ KW

Average no. of hours of use per day = 6

Energy saved per day = 2.11 KWh/day

1 KWh cost = Rs. 9

Saved money per year = Rs. 3465

Operational and maintenance cost per year = Rs. 1700

Total saving per year = Rs. 1765

Payback period=Initial investment / Total saving per year

Payback period = 10 Years

This is the payback period without considering subsidies and electricity rebate by state, central government. At present, Ministry of New And Renewable Energy (MNRE) provides Rs. 6600 for flat plate collector having collector area 2 m^2 and in Haryana state government provides subsidy of Rs. 4000 for flat plate collector having capacity of 100 liters per day. Rebate in electricity bill upto Rs. 100 per month for 3 years, so total electricity rebate of Rs. 3600 also provided by state government. So if we calculates payback period with considering all subsidies and rebates then payback period becomes approximately 1 year.

6. DISCUSSION

Although approximately in all aspects our PG-Water based solar water heater is better than electric water heater but we cannot completely depends upon solar water heater due to unavailability of good radiation from the sun in winter.

But hot water required throughout the year because it requires in mess for utensils washing, for cloth washing so we cannot neglect these requirement.

If we installed some PG-Water based solar water heater in the hostels rooftop and make this system as a central system that simultaneously provide water to hostels mess and in bathrooms then it is more advantageous.

7. CONCLUSION

From this detailed analysis we can conclude that the use of PG-Water based solar water heater is more economical than electric water heater, on the second hand we can use the hybrid system of the above discussed two system because in winter we usually not get good intensity so from this hybrid system our requirement get fulfilled.

8. ACKNOWLEDGEMENTS

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