Advance Physics Letter

Solar Energy as Non-conventional Energy Source Utilization for Water Heating - A techno-economic study

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Abstract— Minimising the use of fossil fuels is truly key to resolving both air pollution and climatic change. This is also of prime importance because the resources of fossil fuels are limited and depleting at faster rate. Improvements in energy efficiency, use of non-polluting or less polluting sources of energy and behavioural change can lead us to safe level. Solar energy is one of best non-polluting alternative. Solar energy can be utilize as solar thermal for fluid heating and solar power for power production. This paper includes a specific area of solar thermal for water heating for commercial purpose. Also the device, which converts solar energy in to useful form of energy as heat, with the required design has been discussed.

Index Terms— Solar Energy, Water Heating, Solar Collector.

I. INTRODUCTION

Energy is one of basic need in life. Thus requirement of energy is fulfilled by conventional sources which is fossil fuels based. Since these resources are limited and will be lasted in forthcoming future. The best suited alternatives are still being identified. Solar energy is one of best alternative. The work has been focused in this field. The country receives abundant amount of solar radiation about 4 kWh/m^2 - 7 kWh/m^2. The sunny hours in the India is about 2300 hrs. -3200 hrs. Per year and vary according to location. India is largely located in the equatorial sun belt of the earth, thereby receiving abundant radiant energy from the sun. The country receives about 5,000 trillion kWh / year equivalent energy through solar radiation. In most parts of India, clear sunny weather is experienced 250 to 300 days a year.

The annual global radiation varies from 1600 to 2200 kWh/m^2, which is typical of the tropical and sub-tropical regions. The average solar insolation incident over India is about 5.5 kWh /m^2 per day. Just 1% of India's land area can meet India's entire electricity requirements till 2030 [1]. In commercial and industrial sector hot water is one of most important part that is needed. Water is heated either by heating coils which utilizes electricity and or by using solar energy which employs a device called solar water heater. In commercial sector mostly the heating coil of 2000 Watt capacity is used.

The economic analysis investigated assuming run time of one hour in a day for single home and following outcomes obtained-

Heating Device	Capacity	Avg. Use Time	Power Consume	Cost Per Day	Cost Per Year
Heating Coil	2000 Watt	1 hour	2 kWh	7 Rs.	2,555 Rs.

Table 1. Techno-economic analysed data of heating coil

The CO_2 emission and coal consumption are also investigated when using the heating coil and reported-

Device Of Heating	Capacity	Co_2 Emission	Coal Consumption
Heating Coil	2000 Watt	6.752 kg	0.996 kg

Table 2. Estimation of coal and CO_2 emission for heating coil

From table 1 and table 2 it is concluded that the using conventional sources of energy are really be priceful. This may be short in term of economical or this may be in term of environmental deterioration. But the issue of air pollution and climate change is really forcing us to utilize some new sources of energy, some non-depleting, non-polluting resources.

To use solar energy, two components are required. One component to collect solar radiation and convert solar radiation in to heat and second component is to store the accumulated heat by means of suitable medium of fluid. Solar water heater with a flat plate collecting unit is driving market since many decades. The efficiency of flat plate collector ranges between 45% - 60% depending upon location and solar radiation intensity. Solar energy besides being advantageous it has few but important disadvantages and so becomes for flat plate solar water heater. These are-

A. Advantages-

I. Solar energy is abundant and long lasting.

II. This is clean and green energy.

III. It does not create any pollution.

B. Disadvantages-

I. Solar energy is present for fixed few hours during day time.

II. This is absent in rainy season and cloudy day.

III. Energy storage is required because of its intermittent nature.

II. SOLAR ENERGY CONVERSION

Energy is one of the basic needs to sustain the lives. Energy in various forms is required to make systems continue. Per person energy consumption represents the growth status of any country. Higher the consumption revealing symbol of higher status. Till today world depends mostly on conventional fossil fuels for energy production. By gone of few decades world's fuel reserves has degraded drastically. It has been estimated that the world's coal reserves will last within 200 years [2].

III. SOLAR THERMAL COLLECTORS

The solar energy is collected through a device called solar thermal collector. The solar energy collection device mainly consists of two components - a collector (surface) and an energy storing unit. The collector surface is coated with selective materials. The selective layer enhances the absorption of solar radiation. Mainly used selective materials are Al-N, AlN-Cu. This layer offers a very low emissivity and high absorption – absorption > 95% and emittance < 5%. Coating is done by means of sputtering process [3].

A. Flat Plate Collector

The most common design for low temperature solar thermal conversion is the flat-plate collector. These collectors can supply hot water or hot air at temperatures up to 71°C with relatively good efficiency [4]. They require no moving parts, have good durability and can collect both direct and diffuse radiation.

B. Evacuated Tube Collectors

Evacuated-tube collector, in which the absorber pipe is surrounded by a vacuum to reduce thermal losses. These collectors can supply hot water up to 177°C at good efficiency, but they are more expensive than ordinary flat-plate collectors [4].

C. Design Considerations

In order to get useful heat from solar collector device to meet the energy requirements certain parameters like radiation intensity, inclination of collector unit, collector facings etc. has to be incorporated while placing the system for use. As the system design has been carried and discussed in various researches.

Solar thermal collector's heat output solely depends on collector area, heat transferring element and solar radiation intensity. The collector area may be calculated as [2,5]

$$\tau\alpha = m.c.\ (\Delta T/\Delta t).(1/I.A) \qquad (1)$$

Where, m is mass of water in kg,

C is average heat capacity of receiver tube in J/kgK,

ΔT is temperature difference of fluid in K,

Δt is time period in seconds,

The thermal performance of a solar collector is measured by collector efficiency η_{th}. The empirical relation of collector thermal efficiency is given by [6].

$$\eta = Q_u/A_c.I \qquad (2)$$

Where Q_u is useful heat gain by working fluid,

A_c is collector area and,

I is solar radiation intensity

D. Performance Comparision

An evacuated tube solar collector is 16.12% more efficient then flat plate collector [7]. Flat plate collector system has greater radiation losses. Losses in flat plate collector system is by means of conduction, convection and radiation takes place. Where as in evacuated tube collector system vacuum prevents the convection and radiation losses. Thus vacuum assists greatly to increase the thermal energy collection. Due to less heat loss in the evacuated tube systems these are more efficient at lower ambient air temperatures. Flat plate collectors are more useful for low temperature applications but for high temperature requirement like steam generation, evacuated tube solar collectors are best suited.

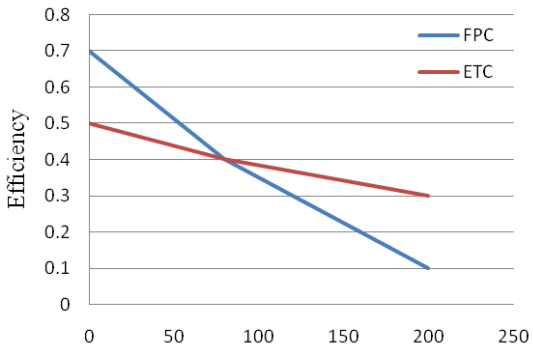

Figure-1 Efficiency Comparison [8]

IV. ECONOMICS OF SOLAR THERMAL COLLECTORS

Benefits of solar thermal collectors certainly outweighs the costs. Analysis has been made for economy of solar thermal collectors and found that the pay-back period for evacuated tube collector is 567 days and for flat plate collector is 2.4 years in Raipur region.

V. ENVIRONMENTAL IMPACTS

The reserves of coal and petroleum will somehow be sustained for further few decades. Also the pollution and emission of hazardous bi-products from combustion will reduce to a greater extent. Various researches in this field have revealed that adoption of renewable sources for energy generation is one of the safer ways.

VI. RESULTS AND DISCUSSIONS

The study presented reveals about energy consumption scenario in terms of electricity. This has been identified that utilization of non-conventional energy sources specifically solar option, is beneficial to protect the environment with reserves of fossil fuels. The study presented results in commencing the suitability of solar collectors and identified that evacuated tube solar collector is fit for our energy need. Thus with proper attention and consideration of system design an appreciable performance can be made.

VII. FUTURE SCOPE

The work can be extended to optimize the thermal performance by raising its solar radiation absorbing capacity. This may be achieved by inserting higher heat conducting element in to tube. The other way is to create vacuum in flat plate collector region.

VIII. ACKNOWLEDGEMENTS

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