Journal of Advances in Science and Technology
Vol. 12, Issue No. 25, (Special Issue) December-2016, ISSN 2230-9659

Energy Extraction from Domestic Roof Top Slab to Support Power System

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Abstract – In this paper an effort is made to utilize the roof top concrete slab, which gets heated up by absorbing the heat radiated from the sun during day and portion of it is transferred to the environment and the top floor, till mid night. Part of this heat energy is transferred to the top floor electrical consumer premises and are forced to utilize air conditioners or air coolers. A set of copper or aluminum tubes carrying water are arranged at the top of a reinforced concrete slab to transfer the heat energy from the concrete mass. The outcome may be either preserved in a thermally insulated tank or fed to the geyser inlet for further heating to utilize in bathrooms. Heat extraction from the rooms top area helps in cooling at the last floor inner surface, thus reducing in electrical power consumption such as air coolers, Air conditioners, fans etc. In brief it is an economizer to reduce the electrical power consumption.

Index Terms – Power System, Energy, Consumer, Economizer, Concrete Slab, Thermal Mass

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1. INTRODUCTION

An electric power system is a huge network of electrical components that are used to supply, transfer and utilize electric power. Power system faces varieties of challenges involving reliability, permissible voltage and frequency at the end user terminals along with reduction of transmission and distribution losses. Per capita electrical energy consumption is the indication of the countries progress, it is the responsibility of the electrical engineers to produce the power at low cost, reduce the losses, maintain the network with reliability, motivate the consumer to utilize the electricity. Increasing demand and unexpected peak loads lead to increase maximum demand at the consumer sides.

II. METHODOLOGY

The energy dissipated from the sun is unlimited, a tiny portion of the energy reaches the earth surface. Energy radiated on the earth can be utilized by many methods.

1. Solar Water heater
2. Solar Cells
3. Solar cookers
4. Direct drying of crops and fruits like grapes etc.
5. Extraction of heat from concrete slab (Proposed)
6. Solar Water Heaters: Solar water heaters are the popular energy saving equipments with wide variety of designs, including a collector and storage tank. They convert radiated heat energy from the sun to useful thermal energy to heat water.

Solar water heaters are classified on the bases of the type of collector used and the method of circulation.

Fig.1.

A. Batch collectors: They are also called as Integrated Collector Storage (ICS) systems, heating up of water in a dark tanks or tubes within an insulated box, storing water until they are drawn for the purpose. Water can remain in the collector for longer periods of time, if left un used, making it very hot. A tempering valve is provided to protect against steaming at the tap. The function of tempering valve is to mix the cold water to bring the water temperature before delivering it to the outlet tap. Batch collectors are not compatible with closed-loop circulation systems. Thus, they are not popularly used for cold climatic conditions.

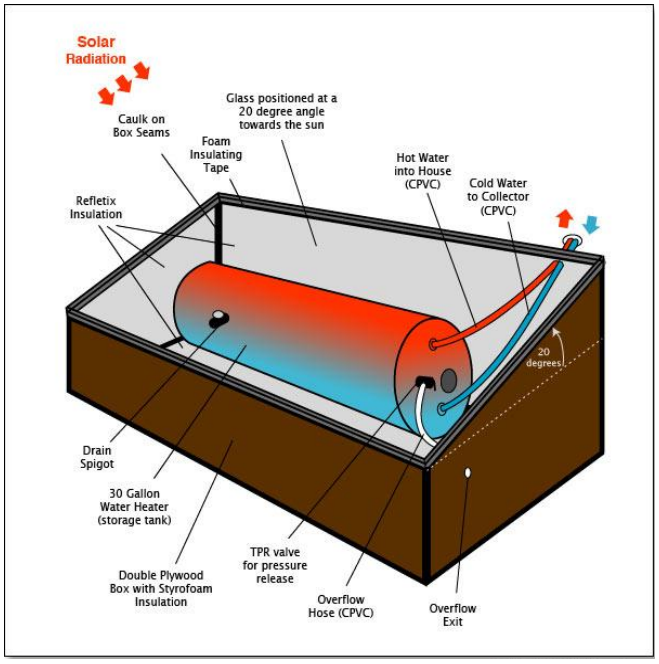

Fig.2.

B. Flat-plate collectors: typically consist of copper tubes fitted to flat absorber plates. The most common configuration is a series of parallel tubes connected at each end by two pipes, the inlet and outlet manifolds. The flat plate assembly is contained within an insulated box, and covered with tempered glass. Flat plate collectors are typically sized to contain 40 gallons of water. Two collectors provide roughly half of the hot water needed to serve a family of four.

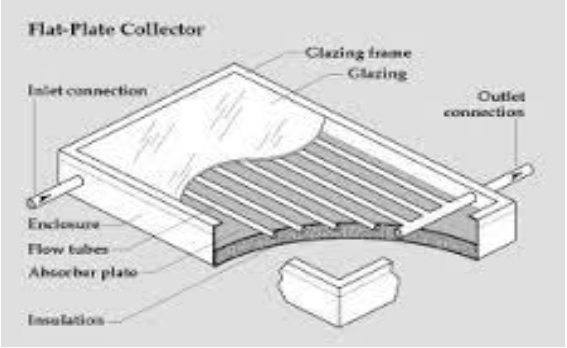

Fig.3.

C. Evacuated tube collectors: These are the most efficient collectors available. Each evacuated tube is similar to a thermos in principle. A glass or metal tube containing the water or heat transfer fluid is surrounded by a larger glass tube. The space between them is a vacuum, so very little heat is lost from the fluid. These collectors can even work well in overcast conditions and operate in temperatures as low as -40°F. Individual tubes are replaced as needed. Evacuated tube collectors can cost twice as much per square foot as flat plate collectors. Closed-loop, or indirect, systems use a non-freezing liquid to transfer heat from the sun to water in a storage tank. The sun's thermal energy heats the fluid in the solar collectors. Then, this fluid passes through a heat exchanger in the storage tank, transferring the heat to the water. The non-freezing fluid then cycles back to the collectors. These systems make sense in freezing climates.

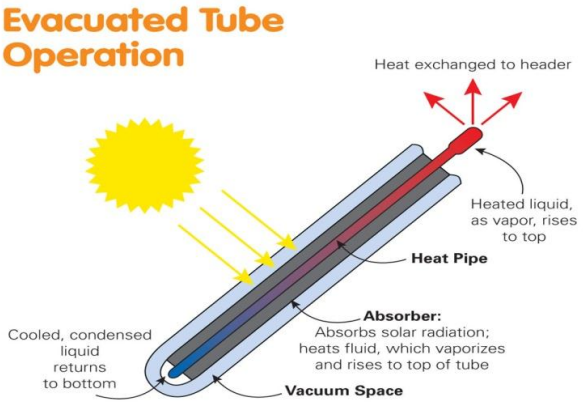

Fig.4.

D. Direct systems: These circulate water through solar collectors where it is heated by the sun. The heated water is then stored in a tank, sent to a tank less water heater, or used directly. These systems are preferable in climates, where it rarely freezes. Freeze protection is necessary in cold climates.

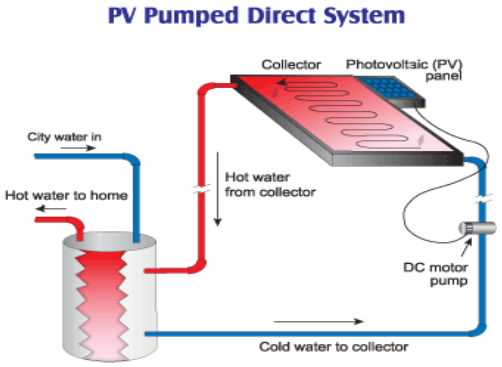

Fig.5.

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E. Closed-loop or indirect: These systems use a non-freezing liquid to transfer heat from the sun to water in a storage tank. The sun's thermal energy heats the fluid in the solar collectors. Then, this fluid passes through a heat exchanger in the storage tank, transferring the heat to the water. The non-freezing fluid then cycles back to the collectors. These systems make sense in freezing climates.

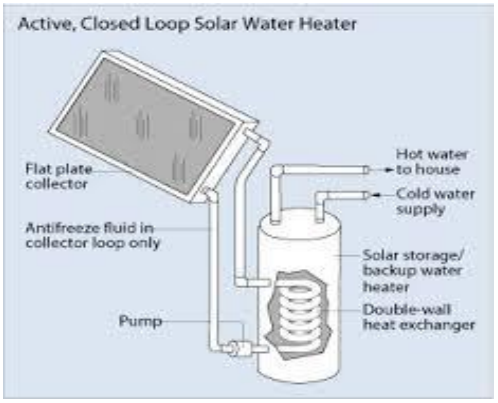

Fig.6.

F. Active**,** or forced-circulation: These systems use electric pumps, valves and controllers to move water from the collectors to the storage tank. These are common in the U.S., Passive systems require no pumps. Natural convection moves water from the collectors to the storage tank as it heats up.

2. Solar Cells: Solar panels include many, smaller units of photovoltaic cells. These are the semiconductor chips that convert sunlight into electricity. Many cells linked together make up a solar panel. Each photovoltaic cell is basically made up of two slices of semi-conducting material.

Fig.7.

To get electric field, manufacturers "dope" silicon with other materials, giving each slice of the sandwich a positive or negative electrical charge. Then, when a photon of sunlight knocks electric field will push that electron out of the silicon junction.

A couple of other components of the cell turn these electrons into usable power. Metal conductive plates on the sides of the cell collect the electrons and transfer them to wires. At that point, the electrons can flow like any other source of electricity. There are other types of solar power technology — including solar thermal and concentrated solar power (CSP) which operate in a different fashion than photovoltaic solar panels, but all extract the power of sunlight to either create electricity or to heat water or air.

3. SOLAR COOKERS: These are the small equipments that directly convert sun rays to heat the dark utensils to cook. Some of the applications extended to manufacture of sugar cane products from juice.

4. DIRECT DRYING: This method is used for drying of crops and fruits like grapes to convert into dry fruits or to protect against decay etc.

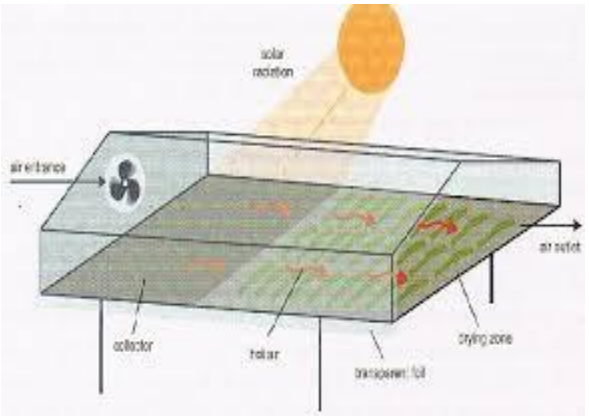

Fig.8. Direct drying model

5. EXTRACTION OF HEAT FROM CONCRETE SLAB SURFACE (PROPOSED) :

Climate change is unpredictable. India's highest temperature recorded is 50°C, during the summer in Rajasthan district. recent studies and implementations have shown that a white painted roof tops considerably reduces the roof top temperature. In summer electrical power consumption increases and almost all the hydroelectric plants will be running at count downs or standstill. Considerable fall in the rain, power crisis, increase in the global temperature are the main challenges to engineers and scientists.

A freely available sun rays can be used during sunny days. As an example fig.9 is the example of the Belgaum (India) city sunny days statistics to implement this project.

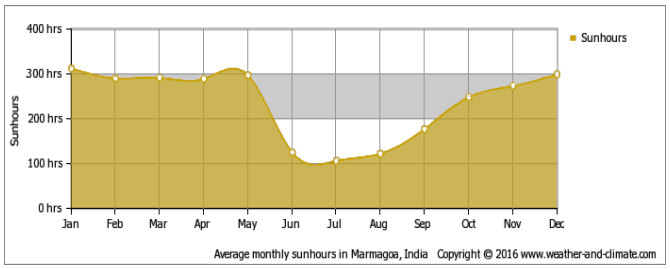

fig.9. Sunny days

In this method following arrangements are essential.

A) During the construction of slab, It is well planned for the required hot water per day and the maximum top floor area available. Floor area may include inclined slabs, but after deducting the side safety walls (parafit), solar panel area, over head water tank, gardening, shaded areas etc.

B) In this method, copper tube collector is preferred because of its high thermal conductivity (385W/mK), Diameter of the copper tubes used are of 25mm, tubes are connected in parallel, that is first ends and last ends are connected separately to form a copper framework.

C) In this project we are taking the advantage of the plaster over the top floor. The copper framework is embedded in the plaster, which is of black oxide type and thickness little higher than the diameter of the copper tubes used, to absorb heat from the incident rays, heat from the concrete mass (if any) and to protect the tubes against mechanical damage.

D) Plaster area without copper framework is covered with a white thermal insulating paint or lime + bonding agent like fevicol to reflect the heat to the environment to avoid over heating of the concrete slab.

Solar energy, that is stored in the concrete slabs plaster (fig.9) is absorbed through the copper tube framework. It is the main element that collects the water from the main tank (over head) through the inlet of the copper grid, water on the way extracts heat from the surroundings, when density falls it rises up in the thermally insulated hot water tank. The gravity flow of the main water tank forces water towards the hot water tank. Hot water tank outlet is connected to geyser inlet, with which hot water can be supplied on demand.

Sun rays that induce heat on the grid surface are climate dependent. If the climate is cloudy, water in the hot water tank may not be hot. During such situations, electric heater (Geyser) is essential. When the water to the geyser inlet is taken from the open concrete over head water tank initial temperature will be low. For taking bath usually geysers rise the temperature from ambient to 60°C.

Energy required to increase the temperature of 1gram of water for 1°C is. When the water inlet to the geyser is fed from the thermally insulated hot water tank, the initial temperature of the inlet water is higher than the ambient temperature, which indirectly reduces the total electrical energy required to reach the target temperature.

Thermal insulation paint applied on the building top surface reduces the most of the surface temperature under control. if any temperature exists in the concrete slab is absorbed by the black oxide plaster of the copper grid, thus reducing the inner temperature of top floor. Temperature of the top floor consumer premises is usually maintained by the air cooler or air conditioners. When the temperature of the slab is maintained, power requirement of the top floor for cooling is also reduced.

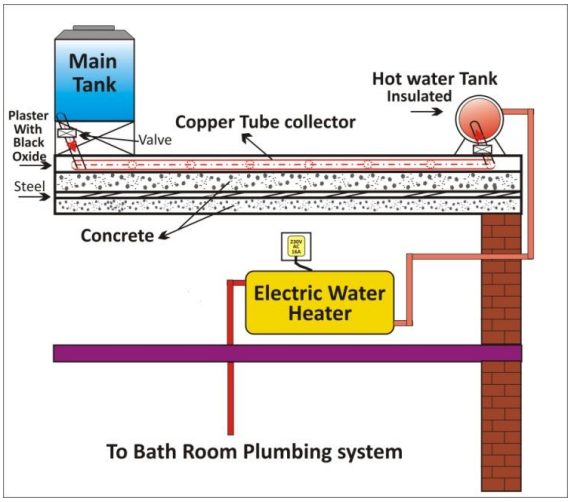

Fig.10. Energy extraction from roof top

III. ENERGY SAVING ESTIMATE:

Considering the copper grid of 25mm diameter and 3m X 3m of parallel copper pipes at a distance of 300mm. Grid is embedded in the plaster on the concrete slab of the top floor. Plaster is the normal plaster (25-30mm thick) with construction purpose used black oxide.

Solar radiation intensity that is heating the roof top surface is not constant throughout the year or unpredictable. It also depends on the location, climatic conditions etc. If the temperature of the black oxide surface is known the heat transferred to the copper tubes, concrete slab, Inner surface of the slab can be estimated with the help of following formula.

$$Q = KA\left(\frac{dt}{dx}\right)$$

Where Q - Heat transferred, A- Area, K- Thermal conductivity, t - temperature difference, x-thickness. Copper grid used with above specifications can handle 20litres of water, heating will be preserved in a thermally insulated hot water storage of 50litres. which is sufficient to feed the preheated (economizer) water to the geyser of a four members family.

Relationship between Electrical and thermal energy are as below.

1kWh=1000watts x 3600 seconds

= 36 x 10^5 Joules

= (36 x10^5) /4.18 calories

= 860 x 10^3 calories = 860 kcal

1 calorie= 1gm of water x 1°C calorie is the amount of heat required to raise the temperature of 1gm of water through 1°C. kilocalorie is the bigger unit.

The electrical energy required to raise the temperature of the geyser water can be estimated as below.

$$Electrical\ Energy\ (kWh) = \frac{V\ X\ 4\ (t2 - t1)}{3412}$$

Where V-volume of water to be heated, t_2 - final tempr. 60°C, t_1- Initial water tempr., other values are constants.

Ex: Electrical energy required to raise 100litres of water from 20°C to 60°C. will be 4.68kWh.

If the initial temperature of the water is 30°C to raise up to 60°C is 3.5kWh. So, 1.18kWh of energy can be saved. Water stored in cement or concrete tank is cooler than ambient temperature which consumes more electricity. In above case only a temperature raise of 5°C in the feed water can save 11% of the energy consumed on heating. Top flooring white wash area helps in reducing the temperature of the inner circulating air, which encourages to change the regulators of the fans or air coolers, air conditioners directly reduce the power consumption as they work on close loop system.

IV. RESULTS :

S.N.	Energy Extraction from	Minimum Energy Saved
1.	Economizer (Geyser)	25%
2.	Top floor cooling- fans or Air conditioners	25%

CONCLUSION:

This is to conclude that the amount of heat extracted from the copper grid can be used feeding water to an electric geyser to economize in other words it can reduce the actual energy needed to raise the temperature of the bathing water. Thermal insulation on the slab top plaster other than the grid area reduces in the top floor inner temperature thus reducing the electrical power consumed in cooling the top floor rooms. Reducing the electrical energy consumption, as thermal need is the bulk and peak load part which reduces the maximum demand on the power system.

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