ABSTRACT
Solar water heater has wide variety of applications in domestic as well as industrial sector due to need of hot water requirements of them. According to Renewable Energy Policy Network data (2010), more than 70 million people require daily usage of hot water. Solar water heater is not only environment friendly but requires very less maintenance and operation cost compared with any other solar operated devices. It also consists of very less energy payback time of 2 years to 3 years. Mainly solar water heater is consisting of two types called active solar water heater and passive solar water heater. Here, this review paper shows comprehensive review and researches on solar water heater by various researchers of the world.

1 INTRODUCTION
Solar water heater is a device which mainly used for heating the water. In is operated by sun, hence it is called as solar water heater. It consists of various components like absorber plate, casing, pipes, storage tank etc. It is widely used in industrial as well as domestic. There are various industries, which requires water temperatures of more than 50 degree or upto 70 degree Celsius, at that time, solar water heater is a feasible solution. Because it increases water temperatures upto 70 degree Celsius. There are various researchers have made on solar water heater to increase efficiency or effectiveness of solar water heater. In all researches more than 90 percent researches have made on absorber plate, because it is very useful part of solar water heater. Fig.1 shows actual figure of solar water heater. [1]

2 Solar Water heater Systems
Solar water heater system possess many advantages includes it does not require any cost of electricity. It has also very low running cost as well as maintenance cost. All the solar water heater systems are broadly classified as Active solar water heater and passive solar water heater. In passive solar water heater, only solar energy is used to increase temperature of water but in Active solar water heater, not only solar energy but also some mechanical force is required to increase temperature of water. Fig.2 shows simple line diagram of passive solar water heater.

2.1 Passive solar water heater
Passive solar water heating systems depend on heat driven convection to circulate water or heating fluid in the system. These passive systems can be divided into the two main categories, the integrated collector storage storage and the thermosyphon SWH systems. Integrated collector storage solar water heaters (ICSSWH) use a tank that acts as both a Storage and solar collector apparatus. This system is also popularly known as a batch SWH system. One of the simplest designs of ICSSWH system is in which a simple tank is enclosed with a glass cover such that it performs as a collector as well. However, one of the main drawbacks of this design is the heat loss, which is more pronounced at night [3].

The first detailed study on closed and exposed single tank systems was carried out by Brooks at the University of California Agricultural Experimental station in the US in 1936 [4]. While the investigations showed promising potential, further research was eclipsed by the increased use of natural gas and oil in the US, but the research in solar water heating gained momentum in Japan.
Prime requirement of every solar water collector is to increase efficiency of solar collector, which is also a part of solar water heater. To increase efficiency of solar water heater, researchers have introduced reflectors in order to maximize the solar radiation incident on the absorber surface [4-10]. Reflecting concentrator designs can be either flat or curved, line axis, symmetrical or asymmetrical depending on the main concentrations. Davis et al. [16] developed a symmetric cusp reflector ICSSWH system particularly to suit Colorado's cold weather conditions, and found that the collector efficiency can reach as high as 72%. Stickney and Nagy [11-13] designed an inverted ICSSWH system which consisted of a glass lined tank enclosed in insulation with a double glazed aperture facing downward to collect the reflected solar radiation from the parabolic reflector. This accomplished increased heat retention during night and affected the increased daytime temperatures. Yet another design focusing on insulation was introduced by Schmidt et al. [13], comprising of a pressure- resistant single tube
Numerous analytical and experimental studies have been intensively carried out on the thermosyphon SWH system to analyze its performance [15-20]. Fundamental models to estimate the thermal performance of the natural circulation for SWH systems were developed to predict the heat gain in the thermosyphon-driven SWH, when subjected to no drain-off conditions. The models were validated with experimental data [12]. Yet another mathematical approach utilizing “finite-difference method” (FDM) was carried out by Ong [11] to evaluate the thermal performance of a natural- recirculation SWH system. However, the measured experimental data were contradictory to the theoretical predictions. Hence, the model was modified by taking into account the experimental conditions and used the FDM to predict the gain in the temperature at a given time step. Similarly, Sodha and Tiwari [13] used explicit expression to analyze the performance of a SWH system with natural thermosyphon circulation between the storage tank and the collector. The results confirmed that the SWH system’s performance can be predicted accurately by using simple explicit equations.

### 2.2. Active solar water heater

Unlike passive systems, active systems use one or more pumps to circulate the working fluid in the system. Active systems can be categorized into direct circulation and indirect water heating systems. In the direct or open-loop systems, water from the storage tank is directly circulated to the collector to be heated by solar energy, whereas in the indirect active system the heat transfer fluid is circulated through the collector and rejects heat through a heat exchanger to the water in the storage tank.

![Fig. 3. Active solar water heater](image)

In general, direct heating systems are commonly employed in regions with ample sunshine and experience moderate ambient conditions. For regions with less sunshine hours and low ambient conditions, indirect water heating systems are employed. These systems are reliable in operation and ensure effective freezing protection [9]. Heat transfer fluid (HTF), such as ethylene glycol and other refrigerants is circulated between the collector and the heat exchanger. Indirect SWH systems operate on a heat pumps (HP) mode, to supplement the solar energy gain in the collector. These HP based SWH systems have shown several design improvements during last 20 years. The hot water is generated utilizing waste heat or other low temperature sources, in which an exclusive working fluid is circulated in the collector and the heat gain is rejected through a heat exchanger to the storage-water. The solar assisted heat pump is a commonly used type; however one of the challenges is that its performance is very low when the ambient temperature is low. There exists numerous studies [21-23] related to the indirect mode of SWH systems to improve its performance, and some of the recent research is discussed.

Apart from heat pumps, heat pipes were also introduced to further enhance the system’s performance. A heat-pipe water heater was fabricated and tested/modeled by Huang et al. [11]. The performance of the combined solar heat pipe collector and conventional HP were examined to calculate the overall COP of the system. When solar radiation was low, the system operated in HP mode. However, during clear sunny days, the heat-pipe mode operated independently of electrical energy input, for higher thermal efficiency. The results showed that the COP of the hybrid-mode of operation could attain as high as 3.32, and as such its performance was higher by about 28.7% compared to the HP mode of operation. [25]

### 3. Collector Types

Design of the collector is also a very important point in designing of solar water heater. Because, if collector temperature is low then difference between inlet and outlet temperature is also less hence efficiency is also less. Because efficiency of solar water heater is directly proportional to the temperature difference between inlet and outlet temperature. Generally flat plate collector and evacuated glass tube collectors are mainly used.

**Flat Plate Collector**

Solar collector concepts presently being developed, the relatively simple flat plate solar collector has found the less applications so far due to its lower temperature difference so far. Its characteristics are known, and compared with other collector types, it is the easiest and least expensive to fabricate, install, and maintain. Moreover, it is capable of using both the diffuse and the direct beam solar radiation. For residential and commercial use, flat plate collectors can produce heat at sufficiently high temperatures to heat swimming pools, domestic hot water, and buildings; they also can operate a cooling unit, particularly if the incident sunlight is increased by the use of a reflector. Flat plate collectors easily attain temperatures of 40 to 70°C. With very careful engineering using special surfaces, reflectors to increase the incident radiation, and heat-resistant materials, higher operating temperatures are feasible.

![Fig. 4. Components of flat plate collector](image)
Evacuated glass tube collector

A type of solar collector that can achieve high temperatures, in the range 170°F (77°C) to 350°F (177°C) and can, under the right set of circumstances, work very efficiently. Evacuated-tube collectors are, however, quite expensive, with unit area costs typically about twice that of flat-plate collectors. They are well-suited to commercial and industrial heating applications and also for cooling applications (by regenerating refrigeration cycles). They can also be an effective alternative to flat-plate collectors for domestic space heating, especially in regions where it is often cloudy. For domestic hot water heating, flat-plate collectors tend to offer a cheaper and more reliable option.

An evacuated-tube collector consists of parallel rows of glass tubes connected to a header pipe. Each tube has the air removed from it to eliminate heat loss through convection and radiation. Evacuated-tube collectors fall into two main groups called direct fluid and evacuated glass tube collector.

4. CONCLUSION

Renewable energy research has become increasingly important since the signing of the Kyoto Protocol. Solar water heating (SWH) is one of the most effective technologies to convert solar energy into thermal energy and is considered to be a developed and commercialized technology. However, there exist opportunities to further improve the system performance to increase its reliability and efficiency. A concise review primarily on the design features and related technical advancements of the SWH systems in terms of both energy efficiency and cost effectiveness has been presented. Several solar water heating designs have been introduced in the market and are more commonly utilized in the tropical regions of developing countries. Recent developments in heat pump based solar collector technology exhibit a promising design to utilize solar energy as a reliable heating source for water heating applications in solar adverse regions. Heat pump based solar water heating is influenced by many factors including the nature of the refrigerant. Due to the environmental concerns,

REFERENCES