



## A review on technical improvements, economic feasibility and world scenario of solar water heating system



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### ABSTRACT

The solar water heating system (SWHS) is one of the most common application of solar energy utilization system. The usage of solar water heating system is not commonly employed throughout the globe, due to its high initial cost. The advancement in SWHS will lead to be beneficial over conventional system over the long span of time. The eco-friendly nature of such system promotes these systems to be used frequently in both domestic and industrial heating. The investigators throughout the globe focusing on technical advancement as well as economic feasibility of SWHS. The present study focused on to report such studies, which demonstrates the economic feasibility of SWHS in the long run. The payback period of SWHS varies from one origin to other as it depends on numerous factors like price of fossil fuels, rate of subsidy, solar insolation etc. Initially the paper reported the basic components of SWHS, and their advancements, further the global scenario of SWHS is discussed, followed by the studies reported on a techno economic analysis of SWHS, which shows that the economic feasibility is equally important as technical feasibility for its implementation. The last section inculcates the recent studies on the technical advancement of SWHS and the future research trends of SWHS were discussed.

### 1. Introduction

“ENERGY” it is the reason for which a number of scientists are performing their research with a motive to save it [1–3]. The conventional sources of energy are major key in making the human life much comfortable on earth. But the fear of today's world is the limited quantities of these sources. In this situation the solar energy can play a tremendous role as it is the most powerful source of energy. There are a number of applications of solar thermal energy, out of which the solar water heating and solar air heating can play a very impressive role in utilizing the solar energy in the most beneficial manner [4]. There are a number of review papers has been reported by many authors. As the price of fossil fuels has been continuously rising because of their limited quantity, so there is a need for move towards the renewable sources. In that direction, an author reported the studies on performance analysis of the existing designs of the solar thermal systems, their mathematical simulations and the modifications done or suggested in different studies [4]. According to another author, the solar collectors and thermal energy storage systems are the two core components of thermal applications, so he gives a detailed review about them [5]. With the aim to investigate the applications of

nanofluids in the solar thermal systems, an author reported the various research which are published recently, as their results are appreciable [6]. A number of studies reported on the use of phase change materials (PCM) as a thermal energy storage medium in SWHSs. So these studies are summarized, analyzed and compared the results of with and without PCM in a paper [7]. An author reviews about the various research which are done to obtain the various techniques for enhancing the thermal efficiency in SWHSs [8]. In another paper, the author reported the various development in the major key components of SWHS i.e. solar collector, heat exchanger and storage tank. The refrigerator technology and advancement in them with cost effectiveness is also discussed [9].

As per the report of EIA 2013, out of the total energy consumption 18.3% is used for heating water in USA [17]. Similarly, the share of the aggregate residential energy utilization for other countries is about 25% in Australia [18], 22% in Canada [19], 14% in Europe [20], 37% in South Africa [21], 27% in China [22] and 29% in Mexico [23]. If this energy demand is fulfilled with the help of SWHSs, it will be the great utilization of solar energy. The main five nations who have taken the benefits of SWHS are all together – China, Turkey, India, Brazil and after that Germany. The limit surpassed for sun oriented water and air

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Nomenclature		ST	Storage Tank
SWHS	Solar Water Heating System	GGs	Gas Geyser System
EIA	Energy information administration	EWS	Electric Water Heating
PSWHS	Passive solar water heating system	ANN	Artificial neural network
ASWHS	Active solar water heating system	ICSSWHS	Integrated collector storage solar water heating system
FPC	Flat plate collector	COP	Coefficient of performance
ETC	Evacuated tube collector	RET	Renewable Energy Technology
RES	Renewable Energy Sources	PCM	Phase Change Material

authority is from 283 GWth in 2012 to 330 GWth before the end of 2013 [17]. As in past years, China was the principle request driver, representing more than 80% of the worldwide market. Europe saw quickened combining amid the year, with a few extensions suppliers reporting their way out of the business. Industry desires for business improvement are the brightest in India and Greece [17].

In terms of the technical advancement of SWHS, these systems are designed to fulfill the requirement as per the local climatic conditions. From the 1960s, the SWHSs are upgrading day by day, but still there are possibilities for the implementations in terms of efficiency and reliability [24]. There has been an expanding enthusiasm to improve thermal execution of SWHSs by method for enhancing the absorber plate qualities, upgrading the thermal stratification of the storage tank, advancing the design parameters, and augmenting the heat transfer region from '80 s to the present date [25]. But it is found that only technical studies are not sufficient for taking the decision of implementation of SWHS for an individual case. The economic feasibility should always be necessarily checked.

This paper is focused on SWHSs, their global scenario, technical advancement as well as the economic benefits. The paper describes initially the type of SWHS on the basis of their flow of working fluid, later paper contains the description about its basic components and their advancements. A description of its current global scenario, its increasing trend and continental comparison is also reported. There are some studies in which the attention is in checking the economic feasibility. This paper also reported the studies in which economic feasibility is checked. Interest rate of return, payback period, net present value, benefit to cost ratio, etc. are the important terms which should be evaluated during analyzing a system before implementation. Later, the studies on recent advancement done in SWHS, the recent technologies used in solar collectors and the trend of improving the solar collector efficiency are reported. In today's era, there are some software tools like TRNSYS, TRANSOL, FLUENT, System advisor model etc. are used, the studies done with the help of these software tools are also reported in this paper (Table 1).

## 2. Solar water heating system

As we all know the SWHS is a device that is used to heat water which can be used in many domestic and commercial purposes. The main components of SWHS will be described later, but before that the classification according to the flow of water in between the components of SWHS is described. Broadly these systems are of two types: Passive Solar water heating system and Active Solar water heating system.

### 2.1. Passive solar water heating system

The unique feature PSHWS of heat driven by natural convention made these systems different from the other systems. These are of two types, the first one in which the collector and storage tank are integrated called as integrated collector storage SWHS while the other one is known as thermosyphon SWHSs. A concept of a closed pipe in ICSSWHS was introduced in the 1950s, which is still used in many designs [26]. The different studies are done by using different kind of

**Table 1**  
Some previously reported reviews on SWHSs.

Paper title	Salient features	Technical studies	Economical studies	World scenario
<ul style="list-style-type: none"> <li>Potential application of SWHSs for hot water production in Turkey [10].</li> </ul>	<ul style="list-style-type: none"> <li>Solar energy potential of Turkey and SWHSs using metrological and geographical data were investigated for six cities of Turkey.</li> <li>Two types of collectors are compared on the basis of their absorbing material.</li> <li>The prices of these collectors are compared, and their suitability is discussed.</li> </ul>	✓	✓	x
<ul style="list-style-type: none"> <li>Recent developments in integrated collector storage solar water heaters: a review [11].</li> </ul>	<ul style="list-style-type: none"> <li>The various studies on improvement of different types of concentrating and non-concentrating integrated collector storage SWHS are discussed.</li> <li>Phase change material and the techniques for heat retention are also discussed.</li> <li>The recent improvements in increasing the potential of integrated storage collector SWHSs at lower cost also discussed.</li> </ul>	✓	✓	x
<ul style="list-style-type: none"> <li>Solar radiation based benefit and cost evaluation for solar water heater expansion in</li> </ul>	<ul style="list-style-type: none"> <li>Financial evaluation of SWHS in Malaysia is presented.</li> <li>Payback period and cost</li> </ul>	x	✓	x

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