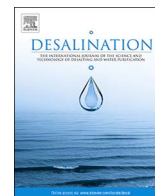




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Integrated PV/T solar still- A mini-review

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ABSTRACT

Water is a critical component for living existence on earth. Clean water is the need of hour, but the amount of clean water available in earth is drastically reduced due to water pollution caused by industrialization and rapid urbanization. Overall global climatic and seasonal changes also have a significant impact on the reduction of amount of fresh water. The need for clean water is continuously growing due to rise in human residents for the last few decades. Use of contaminated water leads to several water borne diseases and based on the intensity of contamination sometimes it leads to death. There are various processes for obtaining fresh water from contaminated water, but the most economical and preferable method is solar distillation since the process involved in it is similar to natural hydrological cycle which requires only solar energy for its operation. Solar stills are potable and do not require any additional skills for its operation and maintenance which makes it user friendly. Integrated PV/T solar still is used for isolated communities facing electrical energy troubles and a scarcity of good quality water. The daily fresh water produced from passive solar still was found to be 2–5 kg/m² whereas from an active solar still integrated with PV/T collector can produced daily yield of about 6–12 kg/m². In this paper, a comprehensive review of integration of solar still and PV module has been presented.

1. Introduction

Fresh water is requiring of hour. The required for fresh water is rapidly increasing due to growing residents and fast urbanization. In addition to drinking purpose, fresh water plays a vital role in numerous industrial applications such as batteries, pharmaceuticals and research laboratories. There are various separation processes like phase change, electro dialysis, reverse osmosis, multi-stage flash evaporation and solvent extraction, but they involve much cost for making of small quantities of fresh water. Solar distillation is the most preferable method for obtaining potable water in a small level even in isolated locations where there is shortage of water and electricity. It is the simplest and most economical method, as it requires only solar energy for its operation similar to natural hydrological cycle. India receives an average daily solar radiation about 8 kW h per square meter and on average has 270–310 clear sunny days in a year, thus receiving abundant solar energy. India being a tropical country has abundant

solar energy available all over the year [1]. Passive solar stills are used widely for obtaining fresh water but it does not meet the demand owing to less productivity. Fresh Water and electrical power are the two most important things for the sustainable improvement of the earth. There is a severe scarcity of both energy and water, especially in the undeveloped countries. It is expected that with worldwide population expansion (especially in the developing countries), the water scarcity situation will be more and more critical over the next two decades or so. Solar based Desalination techniques play an essential role to solve fresh water scarcity in different regions of the world. Hybrid Photo Voltaic Thermal (PVT) System means integration of PV module and solar collector or solar still. The most important advantages of a PVT collector over a PV module are higher electrical and thermal yield per unit surface area, reduced fixing costs and cleaning costs especially in dirty regions like near the seashore and deserts. Progresses in improving the efficiency of single basin passive solar still have been done by Murugavel et al. [2]. Velmurugan et al. [3] have done the Performance

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study of solar stills based on different factors disturbing the yield. Kabeel et al. [4] had done a detailed review of researches and developments on solar stills. Sathyamurthy et al. [5] have done a detailed review on the technology of integrating solar collectors to solar still. Kabeel et al. [6] studied the performance development of solar still through efficient heat exchange mechanism. Samuel et al. [7] review the improving the Solar Still productivity by Increasing the Surface Area of Water. Different factors affect the evaporation rate and condensation rate in passive solar still has been reviewed by Muthu Manokar et al. [8]. Renewable and sustainable approaches for desalination have been reviewed by Gude et al. [9]. Byrne et al. [10] have done a complete review on combination of cooling, desalination and solar photovoltaic systems. Sharon et al. [11] have done a detailed review of solar energy operated desalination methods. Gonzalez et al. [12] had done a comprehensive review on Sustainability consideration of electrodialysis power-driven by photovoltaic solar energy for clean water making. Renewable energy incorporated desalination: A sustainable way out to beat expectations fresh-water scarceness in India has been reviewed by Manju et al. [13]. A detailed review on heat and power creation systems using solar energy has been done by Modi et al. [14]. In this review article, a complete analysis of incorporation of solar still and PV module has been presented. (See Table 1.)

2. Solar still with PV module

2.1. Flat plate collector

Kumar et al. [15] experimentally studied the inside heat transfer co-efficient of a hybrid (PV/T) active solar still. Fig. 1.a shows the side view of the conventional single slope passive solar still (CSSPSS). It is made up of glass reinforced plastic (GRP) material. The condensing cover inclined at an angle of 30° to the ground surface. Fig. 1.b shows the side view of the hybrid active solar still (HASS). It consists of solar still, PV integrated flat plate collector (FPC) and Direct Current (DC)

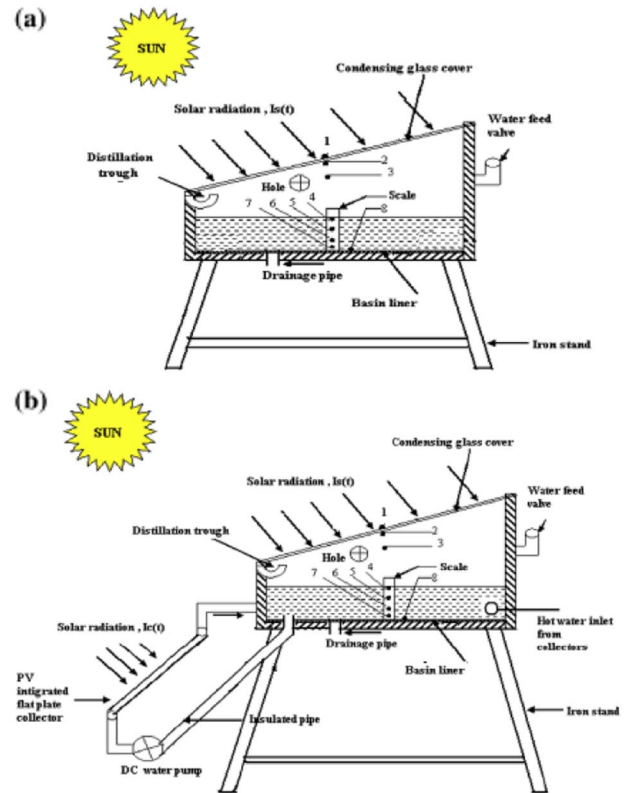


Fig. 1. (a) Schematic side view of a single-slope passive solar still. (b) Schematic of a hybrid (PV/T) active solar still [15]

motor pump. Pump is used to pass the water under forced circulation mode. The experiments were conducted on the CSSPSS and HASS during the year in the natural climatic condition of India.

Table 1
Different research works made in Integrated PV/T solar still.

SNo	Author name	Testing place and latitude	Experimental work done	Performance of the still	Yield
1	Kumar et al. [15]	New Delhi, India 28°35'N	Analysis of internal heat transfer co-efficient of a hybrid (PV/T) active solar still.	Average convective heat transfer co-efficient for CSSPSS and HASS is $3.6 \text{ W m}^{-2} \text{ K}^{-1}$ and $18.3 \text{ W m}^{-2} \text{ K}^{-1}$ respectively	6–10 kg/m ²
2	Dev et al. [16]	New Delhi, India 28°35'N	solar still with flat plate collector (FPC) integrated with photovoltaic (PV) module	Productivity of HASS is 3.5 times higher than passive solar still (PSS) at water depth of 5 cm with nine hours pump operation.	7.223 kg/m ²
3	Kumar et al. [17]	New Delhi, India 28°35'N	Hybrid photovoltaic/thermal (PV/T) active solar still	The thermal efficiency of passive and active solar still for 0.05 water depth is 28.4% and 19.4% respectively whereas the overall thermal efficiency of HASS is higher than PSS	7.22 kg/m ²
4	Gaur et al. [18]	New Delhi, India 28°35'N	Optimization of number of collectors for integrated PV/T hybrid active solar still	The maximum daily yield is 7.9 kg for 50 kg water mass and flow rate of 0.055 kg/s	7.9 kg/m ²
5	Eltawil [20]	Egypt 31°07'N	Integrating solar still using solar photovoltaic, flat plate collector and hot air	Percentage increase in yield of DSS integrated with Hot water-spray, hot air and condenser was about 148% higher than CSS.	6–10 kg/m ²
6	Saeedi et al. [21]	Iran 29°45' N	Optimization of PV/T (photovoltaic/thermal) active solar still	The optimum mass flow rate and optimum number of collectors for active PV/T solar still is 0.44 kg/s and 7 respectively with efficiency of 21.56% and productivity of 8.37 Kg.	8.37 kg/m ²
7	Al-Nimr et al. [27]	Jordan 32° 45' N	PV cells at the bottom of the still basin and coupled with outside finned condenser	The yield of hybrid solar still and CSS is 6.8 kg/day and 4.07 kg/day respectively with individual efficiency of 56.5% and 28.6%.	6.8 kg/m ²
8	Singh et al. [23]	New Delhi, India 28°35'N	Active solar still integrated with two hybrid PVT collectors	Highest value of thermal, thermal exergy, electrical exergy, overall exergy and overall thermal efficiency of PVT-FPC solar still are 75%, 20.74%, 28.53%, 25% and 69.06% respectively.	6–10 kg/m ²
9	Yari et al. [24]	Iran 29°45' N	Integration of solar still and PV module	Maximum fresh water yield of 4.77 kg/m ² .day and 5.89 kg/m ² .day was achieved for PV integrated glass cover and normal glass cover respectively having basin depth of 0.07 m and thirty ETC tubes in both configurations.	4.77 kg/m ²
10	Abdallah et al. [25]	Jordon 32° 02' N	Solar still integrated with Super Heat Conduction Metal Vacuum Tube (SHCMV)	The daily yield of SHCMV integrated solar still and conventional solar still are 12 l/m ² /day and 1 l/m ² /day respectively. The proposed system has a percentage increase in yield of 90%.	12 l/m ²
11	Ali-Riahi et al. [28]	Malaysia 4° 2' N	Solar still integrated with AC-heater and PV module for sustainable clean water production	CSSPVH produces 6 times higher yield than CSS. The daily productivity of CSSPVH and CSS are 5.7 kg/m ² and 0.9 kg/m ² respectively.	5.7 kg/m ²

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