ANALYSIS OF BLOWER FAN EFFECTS ON THE HYBRID PV/T

D.Prince Winston[1], A.E. Kabeel[2], M.Pravin[1], A.G.Akash[1], Ravishankar Sathyamurthy[2,3], A. Muthu Manokar[4]

[1] Department of Electrical and Electronics Engineering, Kamaraj College of Engineering and Technology, Madurai-625 701, Tamil Nadu, India.
[2] Mechanical Power Engineering Department, Faculty of Engineering, Tanta University, Tanta, Egypt
[3] Department of Automobile Engineering, Hindustan Institute of Technology and Science, Chennai-603103, Tamil Nadu, India,
[4] Department of Mechanical Engineering, BS Abdur Rahman Crescent Institute of Science and Technology, Chennai - 600 048, India

ABSTRACT

A blower incorporated hybrid PV/T active solar still and a conventional passive solar still with single slope were designed, fabricated and experimented at a water depth of 1 cm. For increase in production of distillate water, a blower fan is placed inside the solar still to increase the condensation rate. This method also incorporates modern solar PV cooling system which cools the solar panel by the saline water thereby increases the efficiency of the solar PV as well as the distillate water production. The daily yield from the proposed hybrid active (PV/T) solar still is 3.3 times more than the conventional passive still. This modern system of solar energy based electric power and distillate water production is highly self-sustainable for all the places. From the experimental readings it is very clear that, the proposed blower incorporated hybrid active (PV/T) solar still gives an increase in overall thermal and electrical efficiency that is nearly 15% higher than the conventional passive still.

Keywords: hybrid solar still, active mode, fresh water

1 INTRODUCTION

Solar PV has a drawback of the decrease in efficiency due to increase in temperature. This drawback can be overcome by cooling it. The proposed system is an efficient active hybrid solar PV/T (Photo Voltaic/Thermal) desalination system in which, the efficiency of solar PV is increased by allowing the saline water to flow on the panel to cool it in discrete time manner with a valve control. Solar still is simple in construction, low in both initial cost and maintenance cost but has a drawback of low productivity discussed by Kaushal et al. (2010). Recently lot of research work has been done for constructing the various structures of stills (one slope by Samee et al. (2007); weir-type by Sadineni et al. (2008); two slope by Dwivedi et al. (2010)) and for increasing efficiency lot of experiments were done by using fin discussed by Velmurugan & Deenadayalan et al. (2008), glass cover cooling discussed by Abu-Arabi et al. (2002) and rotation of air inside of solar stills discussed by Ali et al. (1991 & 1993). Also, researchers analyzed the still performance by incorporating fin, wick, and sponge as storage material inside the still and reported an increase in productivity to 45.5%,29%, and 15.3% respectively discussed by Samee et al. (1991) and Omara et al. (2015). Kabeel et al. (2009) innovated a solar still which includes concave wick evaporation surface for performance improvement and reported it had an average efficiency of 30% and productivity of 4.1 L/m^2. Sadineni et al. (2008) worked on the weir-type inclined solar still and reported as it has a daily productivity of 5.5 L/m^2 and has higher performance if the water depth is low. Phadatare et al. (2007) also reported similar conclusion regarding the depth of water. Rahim et al. (2010) divided

two regions as condensing region and evaporating region and concluded the productivity of still was increased to 32%. Some researchers as Abu-Arabi et al. (2002) modelled and discussed by two glass collector still and proved that the productivity of still increases by increasing the water- glass temperature difference. The daily productivity can be enhanced by increasing the thickness of the rubber and size of the gravel in the still discussed by Nafey et al. (2001). Although many researches done in this area still there is a scope to increase the productivity with different forms. This paper presents performance analysis of solar still with inbuilt blower fan.

2 EXPERIMENTAL SETUP AND PROCEDURE

Design and fabrication of the proposed hybrid PV/T still with single slope basin system for validating the proposed work, two stills (Active solar still with conventional passive solar still) were designed and fabricated. The conventional passive solar desalination system with a single slope basin of area 1 m^2 (0.5 m × 2 m) is the first one designed and fabricated with a wall depth of 25 cm on high-side and 10 cm on low-side. To increase the rate of absorption of heat from the sun black paint is coated on the full surface of the basin (bottom and side wall) from inside. Polystyrene sheets with 5 cm thickness are used to insulate the basin from all outer sides (side wall). This providing of insulation reduces the loss of heat from the still to the atmosphere which is supported by transparent adhesive cellulose tape. A transparent glass sheet of 3 mm is used to cover the single slope basin from the top and placed at an angle of 10^0 horizontally, that is the approximate latitude of our research location (Kamaraj College of Engineering and Technology), Virudhunagar, Tamilnadu, India. Fig. 1(a) shows the photograph of the conventional passive and proposed active solar desalination system. The proposed still (solar PV fed heater still) is the second one which is similar to the conventional still with same dimensions shown in Fig. 1(a). The particulars used and the top view of the condensate water formation in both conventional and proposed active methods are shown in Fig. 1(b). There are two changes over the conventional still; they are (i) the insertion of the blower fan that is fitted in the higher side wall inside the solar still and (ii) the panel arrangements. The brackish water from the storage tank is made to flow over the solar PV panel by using the spreading pipe and then the warm up the water from the panel is collected and give supply to the basin in a periodic manner by using a solenoid valve. The Blower fan is placed and screwed inside the basin and the input to the blower fan is powered by the solar PV battery controller. The solar PV module size is about 1 m × 0.65 m. In this method uses a battery for storing solar power from the solar PV panel, hence the production of distilled water can be achieved even in the low irradiance time. All the arrangements of the proposed solar still and blower fan (Fig. 2) is shown in the schematic diagram.

To measure the required Parameters for hybrid PV/T still with the help of various measurements which are as follows.

i) Digital thermometer: All the temperatures (Brackish water, warm up water, basin water, basin, glass cover, panel, ambient) are measured with individual digital thermometer TPM-10 for each. It has a resolution of 0.1 ° C. These sensors are integrated with a controller to read data.
ii) Anemometer: Zephyrus Wind meter (anemometer) application which has been installed in a smart mobile phone is used to measure airflow velocity.
iii) Pyrometer: LX-101A digital meter is used to measure the solar irradiance.
iv) Measuring flask: Finally collected output distillate water is measured using a calibrated flask.
v) Voltage and current measurements: Voltage divider and current sensor ACS714 modules which are coupled with a controller for Maximum Power Point Tracking (MPPT) which are used to measure the panel's voltage (Voc, VL) and current (Isc, IL).
vi) Controller: Arduino MEGA 2560 (15 analog and 53digital pins) is used as a controller to control the blower fan in the still.

vii) Solenoid valve: To control the flow of water in PV panel solenoid valves are used and thecontroller is used to trigger the solenoid valve.

viii) DC blower fan: A 12 V DC blower fan is used to circulate the heat inside the still.

3 EXPERIMENTAL PROCEDURE

Figure 1 shows the schematic diagram of the proposed hybrid (PV/T) active solar still. Figure 2 shows the experimental setup of the proposed hybrid (PV/T) active solar still. The whole experiments are conducted on the terrace of D-Block, Kamaraj College of Engineering and Technology, Tamilnadu, India during March 28th of 2019. The readings of the experiments are taken on an hourly basis from 9AM to 5PM. Brackish water is given to the basin via the solar panel in a proper periodic manner using solenoid valve. To prove the proposed technique experimentally, water in the basin is kept at a depth 0.10m. Also, two set of readings are taken (i)conventional passive still, and (ii) Proposed hybrid active (PV/T) solar still with12V DC blower fan. Blower fan is used to circulate the heat and increases the evaporation rate. The whole experimentation is carried out on the day and the readings are taken instantly for each and every hour. Hence, Blower fan is used alone for this work and also it is suggested for experimenting in case of long-term. The respective are the readings taken hourly for 24 h, solar irradiance(G), solar energy (E), temperature above solar PV (Tapv), temperature below solar PV (Tbpv), storage brackish water temperature (Tsw), warm up water temperature (Twpv), basin water temperature (Tbw), basin temperature(Tb), glass inner temperature (Tgi), glass outer temperature(Tgo), ambient temperature (Ta), airflow velocity (Va), output distillate water($\dot{m}$ew), maximum PV output power (Pm).

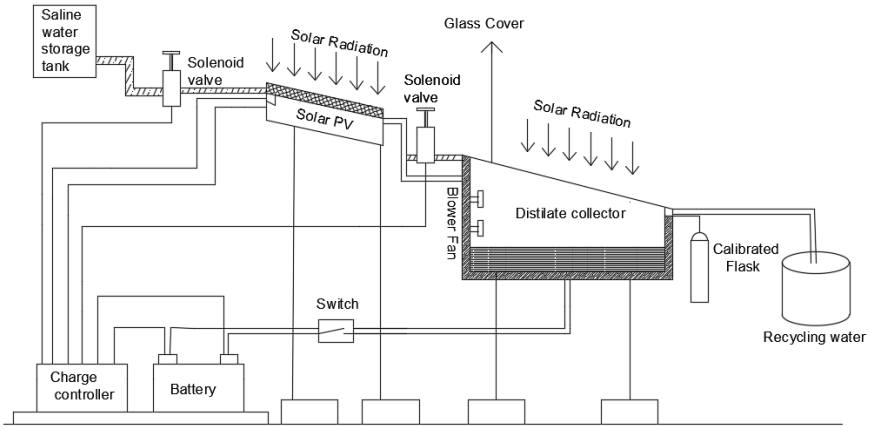

Figure1.Schematic diagram of the proposed hybrid (PV/T) active solar still.

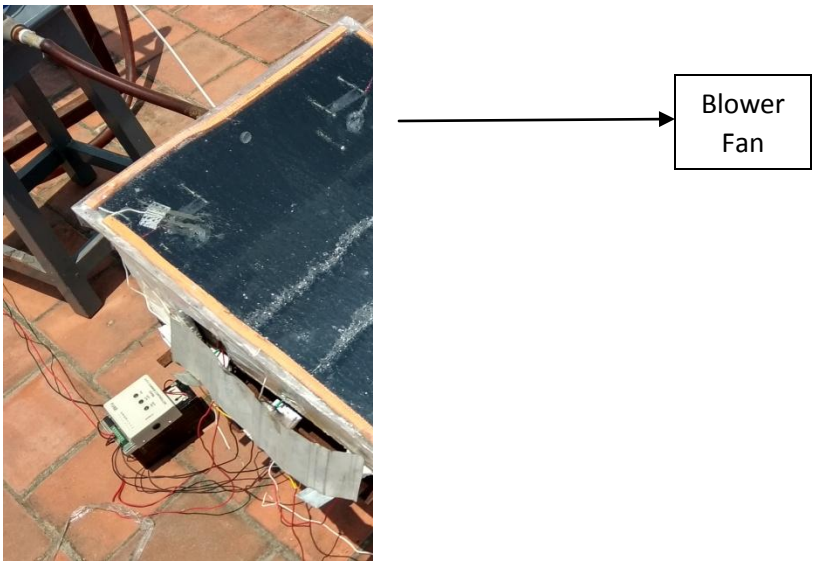

Figure2. Experimental setup of the proposed hybrid (PV/T) active solar still.

Table 1 Hourly variation of various parameters conventional still under 1cm water depth

Time	G (W/m^2)	T_a (^oC)	V_a (m/s)	T_b (^oC)	T_{bw} (^oC)	T_{go} (^oC)	T_{gi} (^oC)	T_{apv} (^oC)	T_{bpv} (^oC)	P_m (W)	$\dot{m}_{ew}$ (L/h)
07:00	166	16.2	0.2	18.1	18.0	17.1	21.9	20.0	19.0	5.9	0.08
08:00	266	18.1	0.3	20.9	20.7	19.0	23.8	21.9	20.9	12.6	0.09
09:00	290	23.8	0.3	26.6	26.5	23.8	28.5	24.7	22.8	14.3	0.10
10:00	413	28.5	0.4	33.3	33.0	31.4	36.1	30.4	27.6	19.3	0.11
11:00	527	31.4	0.5	37.1	37.0	33.3	38.0	33.3	31.4	23.8	0.14
12:00	605	36.1	1.4	43.7	43.5	40.9	46.6	37.1	33.3	25.5	0.24
13:00	755	45.6	1.6	52.3	52.2	45.6	51.3	46.6	44.7	31.4	0.29
14:00	741	35.2	2.1	45.6	45.5	43.7	47.5	36.1	35.2	32.8	0.33
15:00	711	33.3	2.6	42.8	42.6	40.9	45.6	34.2	33.3	32.3	0.32
16:00	606	31.4	2.9	40.9	40.6	39.0	43.7	32.3	31.4	29.0	0.30
17:00	504	28.5	3.0	38.0	37.9	36.1	42.8	30.4	29.5	23.0	0.29
18:00	219	22.8	2.5	36.1	35.9	33.3	40.9	26.6	28.5	9.7	0.22

Table 2. Hourly variation of various parameters of proposed hybrid (PV/T - active) still under 1cm water depth

Time	G (W/m^2)	T_a (^oC)	V_a (m/s)	T_b (^oC)	T_{bw} (^oC)	T_{go} (^oC)	T_{gi} (^oC)	T_{apv} (^oC)	T_{bpv} (^oC)	P_m (W)	$\dot{m}_{ew}$ (L/h)
07:00	166	16.2	0.2	23.8	23.6	22.8	24.2	18.1	19.0	7.4	0.11
08:00	266	18.1	0.3	27.6	27.5	24.7	26.1	20.0	21.9	13.3	0.14
09:00	290	23.8	0.3	34.2	33.9	26.6	30.4	20.9	22.8	14.7	0.27
10:00	413	28.5	0.4	41.8	41.4	32.8	37.1	22.8	23.8	20.4	0.33
11:00	527	31.4	0.5	46.6	46.1	39.0	42.8	28.5	30.4	24.7	0.48
12:00	605	36.1	1.4	54.2	54.0	45.6	49.4	33.3	34.2	25.7	0.68
13:00	755	45.6	1.6	63.7	63.6	55.1	56.5	38.0	39.9	32.3	0.97
14:00	741	35.2	2.1	56.1	55.8	53.7	54.6	33.3	35.2	33.3	0.96
15:00	711	33.3	2.6	52.3	51.8	51.8	53.2	31.4	33.3	34.2	0.94
16:00	606	31.4	2.9	49.4	51.2	50.8	52.3	29.5	31.4	29.5	0.93
17:00	504	28.5	3.0	46.6	46.4	46.6	47.5	26.6	28.5	24.7	0.81
18:00	219	22.8	2.5	42.8	42.3	42.8	43.7	23.8	25.7	10.5	0.59

4 RESULT AND DISCUSSION

The proposed work was tested in a typical sunny day on 21st Feb 2019 and hourly basis readings were taken for various parameters of solar irradiance, air velocity, solar energy, and ambient temperature, the temperature of basin and basin water with the water depth of 0.10 m and were shown in Table 1 and 2. To evaluate the proposed system it is compared with conventional still. The continuous variation of solar irradiance, air velocity and ambient temperature on the experimental day were shown in table 1 and 2 respectively. It can understand from tables that the minimum values of solar irradiance, air velocity and ambient temperature were obtained at 07:00 h and the maximum values of solar irradiance at 13:00 h, air velocity at 17:00 h and ambient temperature are obtained at 13:00 h. The conventional still yields 2.1L/day and the proposed still yields 7.1 L/day. A huge increase in water productivity by the use of blower fans in the solar still.

5 CONCLUSION

The experimental studies of the two different solar still with single slope basin designs (conventional passive solar still and proposed hybrid active (PV/T) solar still with Blower fan) with water depth of 1cm on the day have been presented. Also, a complete performance of the passive solar still with the existing hybrid active solar still has been presented and the conclusions have been made.

From the practical study it is identified that

- The overall average temperature range of the water in the basin for the proposed hybrid active (PV/T) solar still is 15% higher than the conventional passive solar still that is due to the absorption of heat from the solar PV panel surface and the heat circulation with Blower fan.
- The power output from the proposed solar PV is 15% higher than the conventional.
- The conventional still yields 2.1L/day and the proposed still yields 7.1 L/day. A huge increase in water productivity by the use of blower fans in the solar still.

REFERENCES

Abdallah, S & Badran, OO 2008, 'Sun tracking system for productivity enhancement of solar still', Desalination, vol. 220, pp. 669-676.

Abdenacer, PK & Nafila, S 2007, 'Impact of temperature difference (water-solar collector) on solar-still global efficiency', Desalination,vol. 209, pp. 298-305.

Abu-Arabi, M 2002, 'Modeling and performance analysis of a solar desalination unit with double-glass cover cooling', Desalination, vol. 143, pp. 173-182.

Abu-Arabi, M, Zurigat, Y & Al-Hinaib, H 2002, 'Modeling and performance analysis of a solar desalination unit with double-glass cover cooling', Desalination, vol. 143, pp. 173-182.

Ali, HM 1991, 'Experimental study on air motion effect inside the solar still on still performance', Energy Conversion and Management, vol. 32, pp. 67-70.

Ali, HM 1993, 'Effect of forced convection inside the solar still on heat and mass transfer coefficients', Energy Conversion and Management,vol. 34, pp. 73-79.

Arunkumar, T, Denkenberger, D, Velraj, R, Sathyamurthy, R, Tanaka, H & Vinothkumar, K 2015, 'Experimental study on a parabolic concentrator assisted solar desalting system', Energy Conversion and Management,
vol. 105, pp. 665-674.

Bacha, B, Dammak, T & Abdalah, B 2007, 'Desalination unit coupled with solar collectors and a storage tank: modeling and simulation', Desalination, vol. 206, pp. 341-352.

Dehghan, AA, Afshari, A & Rahbar, N 2015, 'Thermal modeling and exergetic analysis of a thermoelectric assisted solar still', Solar Energy, vol. 115, pp. 277-288.

Desai, PS 2004, 'Thermoelectric refrigeration, refrigeration and air conditioning for engineers, 1st ed, Romesh Chandra Khanna'pp. 313-322.

Dwivedi, VK & Tiwari, GN 2010, 'Experimental validation of thermal model of a double slope active solar still under natural circulation mode', Desalination, pp. 49-55.

Dwivedi, VK & Tiwari, GN 2010, 'Experimental validation of thermal model of a double slope active solar still under natural circulation mode', Desalination, vol. 250, pp. 49-55.

El-Agouz, SA, El-Samadony, YAF & Kabeel, AE 2015, 'Performance evaluation of a continuous flow inclined solar still desalination system', Energy Conversion and Management, vol. 101, pp. 606-615.

Eltawil, MA, Zhengming, Z & Yuan, L 2009, 'A review of renewable technologies integrated with desalination systems', Renewable Sustainable Energy Rev., vol. 13, pp. 2245-62.

Franchini, G & Perdichizzi 2014, 'A modeling of a solar driven HD (humidification dehumidification) desalination system', Energy Procedia, vol. 45, pp. 588-97.

Harman, TC, Walsh, MP, Laforge, BE & Turner, GW 2005, 'Nanostructured thermoelectric materials', J Electron Mater, vol. 34, no. 5, pp. 19-22.

Javad Abolfazli Esfahani, Nader Rahbar&Mehdi Lavvaf 2011, 'Utilization of thermoelectric cooling in a portable active solar still - An experimental study on winter days', Desalination, vol. 269, pp. 198-205.

Kabeel, AE 2009, 'Performance of solar still with a concave wick evaporation surface', Energy, vol. 34, pp. 1504-1509.

Kabeel, AE, Omara, ZM & Essa, FA 2014, 'Improving the performance of solar still by using nanofluids and providing vacuum', Energy Conversion and Management, vol. 86, pp. 268-274.

Kabeel, AE, Omara, ZM & Younes, MM 2015, 'Techniques used to improve the performance of the stepped solar still-a review', Renewable and Sustainable Energy Reviews, vol. 46, pp. 178-188.

Kabeel, AE, Arunkumar, T, Denkenberger, DC & Ravishankar Sathyamurthy 2017, 'Performance enhancement of solar still through efficient heat exchange mechanism - a review', Appl. Therm. Eng. 114, pp. 815-836.

Kabeel, AE, Omara, ZM, Essa, FA 2014, 'Enhancement of modified solar still integrated with external condenser using nanofluids: An experimental approach, In Energy Conversion and Management, vol. 78, pp. 493-498.

Kabeel, AE, Elkelawy, M, El Din, HA & Alghrubah, A 2017, 'Investigation of exergy and yield of a passive solar water desalination system with a parabolic concentrator incorporated with latent heat storage medium', Energy Conversion and Management, vol. 145, pp. 10-19.

Kaushal, A & Varun 2010, 'Solar stills: a review', Renewable Sustainable Energy Rev., vol. 14, pp. 446-453.

Kumar, S & Tiwari, A 2008, 'An experimental study of hybrid photovoltaic thermal (PV/T)-active solar still', International Journal of Energy Research, vol. 32, pp. 847-858.

Kumar, S, Dubey, A & Tiwari, GN 2014, 'A solar still augmented with an evacuated tube collector in forced mode', Desalination, vol. 347, pp. 15-24.

Kumar, M & Kumar, A 2017, 'Performance assessment and degradation analysis of solar photovoltaic technologies: A review', Renewable and Sustainable Energy Reviews, vol. 78, pp. 554-587.

Madhlopa, A & Johnstone, C 2009, 'Numerical study of a passive solar still with separate condenser', Renewable Energy, vol. 34, pp. 1668-1677.

Manokar, AM, Murugavel, KK & Esakkimuthu, G 2014,'Different parameters affecting the rate of evaporation and condensation on passive solar still–A review', Renewable and Sustainable Energy Reviews, vol. 38, pp. 309-322.

Manokar, AM, Winston, DP, Kabeel, AE, El-Agouz, SA, Sathyamurthy, R, Arunkumar, T & Ahsan, A 2017, 'Integrated PV/T solar still-A mini-review', Desalination.

Mohammad Behshad Shafii, Mojtaba Shahmohamadi, MeysamFaegh, Hani Sadrhosseini 2016, 'Examination of a novel solar still equipped with evacuated tube collectors and thermoelectric modules',Desalination,
vol. 382, pp. 21-27.

Muthu Manokar, A, Prince Winston, D, Kabeel, AE, Ravishankar Sathyamurthy & Arunkumar, T 2017, 'Different parameter and technique affecting the rate of evaporation on active solar still - a review', Heat Mass Transfer, vol. 53, pp. 1-38.

Nafey, AS 2001, 'Solar still productivity enhancement', Energy Conversion and Management, vol. 42, pp. 1401-1408.

Ninic, N, Klarin, B & Tolj, I 2012, 'Hybrid wind-power-distillation plant', Therm. Sci. vol. 16, no. 1, pp. 251-261.

Omara, ZM, Kabeel, AE & Essa, FA 2015, 'Effect of using nanofluids and providing vacuum on the yield of corrugated wick solar still', Energy Conversion and Management, vol. 103, pp. 965-972.

Omara, ZM, Kabeel, AE & Younes, MM 2014, 'Enhancing the stepped solar still performance using internal and external reflectors', Energy Conversion and Management, vol. 78, pp. 876-881.

Omara, ZM, Abdullah, AS, Kabeel, AE & Essa, FA 2017, 'The cooling techniques of the solar stills' glass covers–A review', Renewable and Sustainable Energy Reviews, vol. 78, pp. 176-193.

Panomwan Na Ayuthaya R, Namprakai, P & Ampun, W 2013, 'The thermal performance of an ethanol solar still with fin plate to increase productivity', Renewable Energy, vol. 54, no. 6, pp. 227-234.

Phadatare, MK & Verma, SK 2007, 'Influence of water depth on internal heat and mass transfer in a plastic solar still', Desalination, vol. 217,pp. 267-275.

Prasad, B & Tiwari, GN 1996, 'Analysis of double effect active solar distillation', Energy Conversion and Management, vol. 37, pp. 1647-1656.

Praveen kumar, B, Prince Winston, D, Pounraj, P, Muthu Manokar, A, Ravishankar Sathyamurthy & Kabeel, AE 2017, 'Experimental investigation on hybrid PV/T active solar still with effective heating and cover cooling method', Desalination.

Rahbar, N & Esfahani, JA 2012, 'Experimental study of a novel portable solar still by utilizing the heat pipe and thermoelectric module', Desalination, vol. 284, pp. 55-61.

Rahbar, N & Esfahani, JA 2012, 'Experimental study of a novel portable solar still by utilizing the heat pipe and thermoelectric module', Desalination, vol. 284, pp. 55-61.

Riffat, SB, Ma, X 2003, 'Thermoelectrics: a review of present and potential applications', Appl. Therm. Eng. 23, pp. 913-935.

Sadineni, SB 2008, 'Theory and experimental investigation of a weir-type inclined solar still', Energy, vol. 33, pp. 71-80.

Sadineni, SB, Hurt, R, Halford, CK & Boehm, RF 2008, 'Theory and experimental investigation of a weir-type inclined solar still, Energy,vol. 33, pp. 71-80.

Saman Rashidi, Javad Abolfazli Esfahani & Nader Rahbar 2017, 'Partitioning of solar still for performance recovery: Experimental and numerical investigations with cost analysis', Solar Energy, vol. 153, pp. 41-50.

Samee, MA 1991, 'Design and performance of a simple single basin solar still', Renewable and Sustainable Energy Reviews, 11, pp. 543-549.

Samee, MA, Mirza, UK, Majeed, T, Ahmad, N 2007, 'Design and performance of a simple single basin solar still', Renewable Sustainable Energy Rev., vol. 11, pp. 543-549.