# Exergoeconomic and enviroeconomic analyses of single slope solar desalination unit loaded with/without nanofluid: A comprehensive review

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# Exergoeconomic and enviroeconomic analyses of single slope solar desalination unit loaded with/without nanofluid: A comprehensive review

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**Abstract**. The exergoeconomic and the enviroeconomic analyses of basin type single slope distiller unit based on solar energy can play an important role for mitigating the contemporary problem of acute shortage of drinking water throughout the world particularly developing and under developed countries. The technology of solar distiller unit has been known to humankind since the 16th century; however, it has not been preferred for purifying water on a large scale till date because of low potable water output, high initial investment, and non-availability of a technician at the local level. This technology is simple in nature and has the potential to mitigate the drinking water shortage; however, it has not been fully explored so far. A lot of configurations have been reported by various researchers since the development of solar distiller unit technology. This paper summarizes some of the important contributions reported so far on the basis of exergoeconomic and enviroeconomic parameters of single slope solar desalination units by incorporating the effect of nanofluid. A comparative study has been presented followed by a detailed discussion about exergoeconomic and enviroeconomic parameters of a single slope solar desalination unit loaded with/without nanofluid. It has been observed that the application of water-based nanofluid in the distiller unit results in the enhancement of performance. At last, the future scope has been presented.

## 1. Introduction

The design and analysis of basin type single slope solar desalination unit on the ground of exergoeconomic and enviroeconomic parameters can play an important role in mitigating the contemporary issue of shortage of fresh water throughout the globe. The access of water to human beings is limited to less than 1 percent and even this small amount of water is getting polluted day-by-day due to various anthropogenic activities. The basin type single slope solar desalination unit can work in passive as well as active modes. In the case of passive mode of operation of single slope solar desalination unit, external source of heat is not present for supplying heat to water in the basin; whereas, in the case of active mode of operation, an external source of heat in the form of solar

collector or similar other device is present which supply heat to water in the basin. This review paper talks about the analysis of a single slope solar desalination unit on the basis of exrgoeconomic and enviroeconomic parameters.

## 2. Exergoeconomic and enviroeconmic parameters

Exergoeconomic parameter can be stated as the ratio of either exergy gain per unit uniform annual cost or exergy loss per unit uniform annual cost. If exergy loss is considered, then the objective is of minimization type. The exergy represents the quality and hence analysis of the system on the basis of exergy is a more realistic analysis. The exergy loss of various components is calculated and the component responsible for the highest exergy loss is targeted to minimize so that objective can be fulfilled. If exergy gain is considered, then the objective is to maximize the output. The exegoeconomic parameter correlates the exergy with the uniform annual cost. enviroeconomic analysis controls the pollution of the environment by giving motivation for reducing pollutants and encourages the use of renewable energy technology which does not create pollution. The enviroecomic parameter is also known as environmental cost. It is calculated by computing the amount of carbon mitigation on the basis of exergy. This amount is multiplied with the cost of carbon on the international level to get environmental cost.

## 3. Nanofluid

If nano-particles in controlled amounts are mixed with fluid using some technology, then the resulting fluid is termed as nanofluid. ultimate physiological properties in it and shows remarkable progress in the field of nanotechnology. Nano-fluids are the result of the latest innovation which has extra-ordinary thermo-physical and optical properties and coined a well-known name i.e. nano-fluid for the foremost instance. Nano-fluid can be produced by the standardized mixture with the optimum concentration ratio in between working medium to nano-particles (NPs) having 1-100 nm sized NPs in the base fluid. In the case of water-based nano-fluid, nano-particles are mixed with water and similarly, other kinds of base fluids are also available which are used accordingly as per the application.

## 4. Basin type passive/active single slope solar desalination unit loaded with/without nanofluid

Working in the field of enviroeconomic and the exergoeconomic scrutiny of Single Slope Solar still (SSSS) distiller unit, several researchers have made an effective attempt in characterizing the setup and to develop the process for enhancing the quantity and quality of drinkable water in all atmospheric conditions. The use of nanofluids also plays a significant role in enhancing the heat and mass transfer in the available solar still.[1]. The effective comprehensive analysis containing the elaborative study of the application of nanofluids in solar still is discussed by Bait & Si-Ameur.[1] The study revealed that the application of nanofluids in various distiller units enhances several characteristic properties like thermal conductivity, heat transfer, stability etc. the size, shape, orientation etc. of nanofluids also plays an influential role in the characterization. [1].

Tiwari et al. [2]in 2015 effectively Characterized elaborative Exergoeconomic and enviroeconomic analyses in their laboratory with flat plate collector of partially covered photovoltaic active solar distillation system. The comparative study with various past research analysis were made.[2]. Energy calculation based on entropy was initiated. The authors conclude comparatively better exergy and overall thermal efficiency. The setup was innovatively designed as shown in Fig. 1.

FPCs partially covered active SSSS designed and Fabricated was designed and fabricated. The final results obtained have been likened with the results obtained by other researchers working in similar technology and applications. The results projected the daily thermal efficiency of the proposed model is comparatively not as much of the other two models. The daily exergy efficiency of the model under study is higher than the model in Fig. 2 but at the same time, it was a little lower than the model

in Fig. 3. Also, the exergy, the thermal energy, the overall efficiency and the energy efficiency evaluated on a daily basis of the proposed model are greater than the other two models[2].

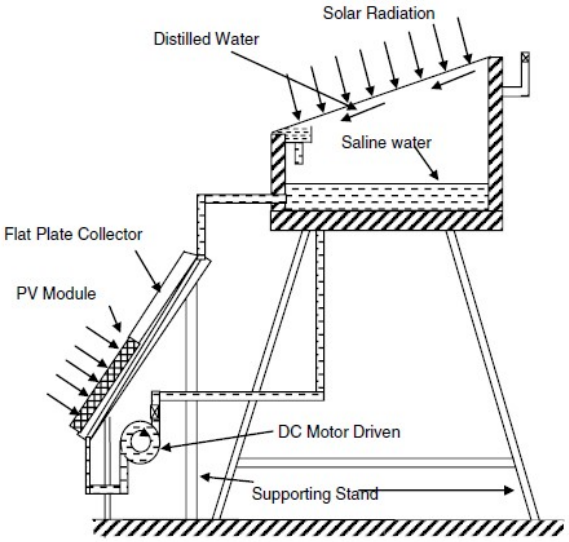


**Figure 1.** Side view of an active PVT solar distillation system [2]

Singh & Tiwari [3] gave the descriptive review on the Exergoeconomic parameters, enviroeconomic parameters and the productivity analyses of basin type N-PVT-CPC-SSSS. Figure 4 shows the effective Pectoral view of N-PVT-CPC-SSSS[3]. Several systems were analyzed and reviewed by Singh and Tiwari [4] and the revolution in the field of solar energy and economical energy was elaborated. The sustainable evaluation was developed with the experimental analysis of various solar collectors setups.

**Figure 2**. Hybrid (PV/T) active solar still [2]

The use of various nanofluids in SSSS setup with N identical PVTs were also characterized.[5]. Systematic and experimental study on single basin SSSS with different water nanofluids were also accomplished by Elango et al.[5] Different nanofluids like $Al_2O_3$, ZnO, $Fe_2O_3$ and $SnO_2$ which are water-based were experimentally (chemically) prepared and then one by one analyzed. Observations revealed that SSSS with water-based nanofluids gave higher exergoeconomic and enviroeconomic characteristics.[5] The cost of production, thermal analysis and the overall efficiency of the system gave optimum results. The interesting fact from the analysis says that 29.95% (almost one third) higher production rate was observed when the SSSS with aluminum oxide water-based nanofluids were used [5]. Panchal et al. gave the experimental analysis of heat pipe collector based SSSS that are properly coupled [6].

**Figure 3**. Integrated FPCs and DSSS[2]

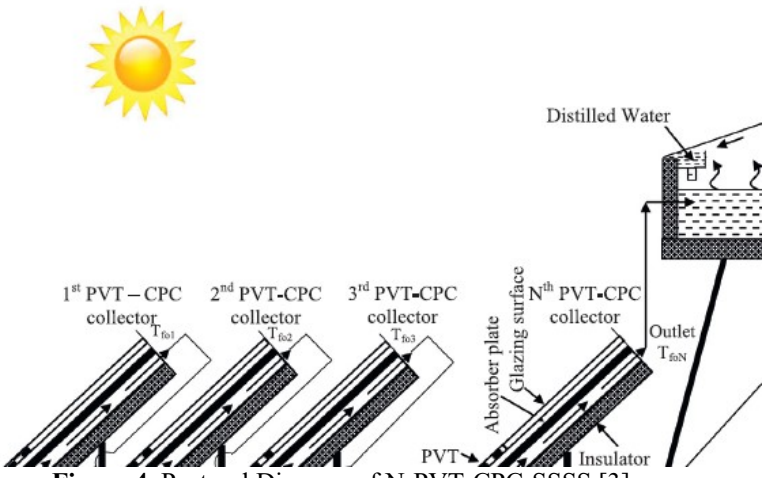


**Figure 4**. Pectoral Diagram of N-PVT-CPC-SSSS [3]

Ibrahim et al. [7] gave the Exergoeconomic analysis on SSSS for the cost analysis and converting the feasible results into optimizing outputs. The setups were developed and also the computational analysis was performed until the optimality [7]. The comparative diagnosis was done between the existing system and the developed system for the exergoeconomic and enviroeconomic characterizations. The outputs revealed that there is almost 36% reduction in the cost of exergy destructions and the fact is there is also a decrease of 45% in the exergoeconomic cost of fresh water soon after the optimization. One of the effective descriptions of solar still was simulated and optimized by Rashidi et al. on the volume of the fluid system. The entropy generation and flow of water-based nanofluid in the SSSS were simulated.[8] The productivity and improvement in SSSS with Aluminium oxide nanofluid which was under water-based atmosphere were identified. The entropy generation, solid volume fraction, productivity etc. of the SSSS with water-based nanofluids have been examined[8]. The generated Volume of Fluid model helps to simulate the condensation and boiling phenomenon of fluid in SSSS. The arithmetic results deliver the systematic outputs and showed that the productivity of SSSS is directly proportional to the solid volume fraction of nanoparticles. The productivity raised by almost five times as the solid volume fraction is raised between 0 to 5 percent. Also the average Nusselt number is raised by 18% with the solid volume fraction rise in the same range. Thermal entropy and viscosity showed different values at different geometric positions of the solar still. [8]. The entire fluid energy and exergy based analysis were carried out in a single slope solar still setup.

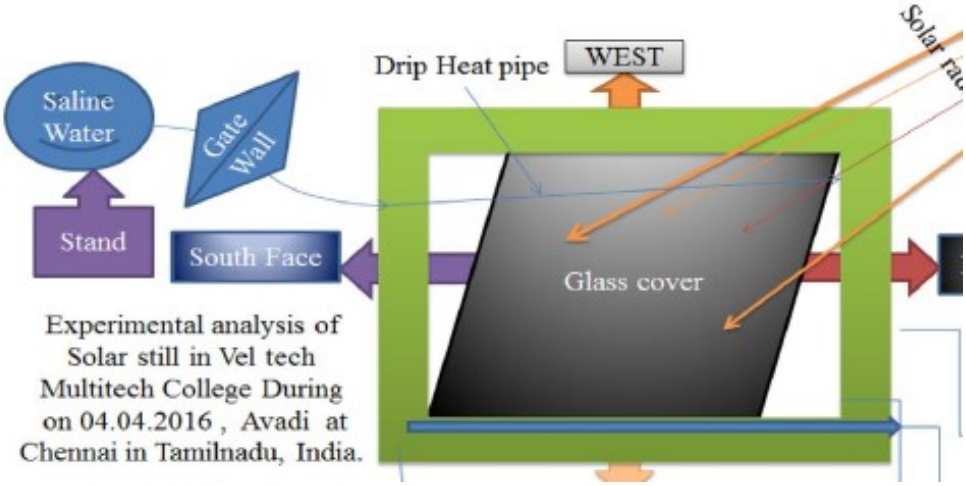


**Figure 5.** Setup of SSSS with different fin wick absorbing materials[11]

Rashidi et al. [9] optimize the stepped solar still cascaded with nanofluids. The series of optimization techniques and productivity enhancements were diagnosed. Here, the computational fluid dynamics approach was used to differentiate the RSM and the calculated results. The output shows a 2.1 % deviation in the comparative outputs. Also on adding the nanoparticle (range between 0 – 5%), the hourly productivity is raised by 22%[9]. The reviews showcase the effect of adding different particles to the existing system. Singh et al. [10] also revealed the Effect of enviroeconomic and exergoeconomic matrices on the existing life cycle and cost analysis of passive solar stills with single slope available with and without water-based nanofluids. [10] Environment conditions also play a vital role in the diagnosis of the exergoeconomic properties of the system. Therefore, when tested in the climatic conditions of Delhi in the month of May, the 0.144 kWh per unit cost based on

exergoeconomic parameter has been identified to be 0.144 kW h/Rs which is slightly higher than double slope solar still having 0,137kWh/ Rs values under similar atmosphere. Shanmugan [11] worked on some of the miscellaneous materials having absorbing characteristics and performed the productivity enhancement analysis of solar still by the inclusion of PCM and various shaped Nanoparticles. The particles have different compositions based on suitability and availability. [11]. Very effective characterization was obtained on different compositions. Figure 5 shows the Setup of SSSS with different fin wick absorbing materials. Various combinations in the setup would be probably the solar still without fins, Materials variations of fin wick required in still, Calculation setup for solar intensity per second absorbed to a still etc.

**Conclusions**

It has been tried to review the effect of nanofluid on the performance of basin type double slope solar desalination unit. On the basis of present work, the following conclusions can be drawn:

i. The output of passive single slope solar desalination loaded with/without nanofluid is not appreciable and needs to be improved for making it popular as well as competitive.
ii. The demerits of low outputs of passive type single slope solar desalination unit can be overcome by active double slope solar desalination unit.
iii. The use of nanoparticles with water enhances the performance of a single slope solar desalination unit on the basis f exergoeconomic and enviroeconomic parameters.

**Recommendations**

The exergoeconomic and enviroeconomic parameters of solar desalination unit loaded with nanofluid can further be improved by optimizing the mass flow rate, number of collectors and water depth with the help of optimization techniques.

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