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ECONOMIC ANALYSIS OF SOLAR DISTILLATION SYSTEM

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Abstract: Solar still coupled with evacuated tube collector has been developed to evaluate techno-economic performance of solar still. A solar still coupled with evacuated tube collector was designed and developed for distillation of water. The solar still was fabricated as per design specification. Economic indicator viz., payback period, benefit cost ratio and net Present worth of the system for distillation of water in solar still with evacuated tube collector was found to be 1 year 7 months and 24 days, 1.26 and Rs.54349.26, respectively. The value of NPW was found positive. Thus, there was a positive net returns of the investment made in the project. Hence the distillation of water in solar still was found economically viable.

Keywords: Solar System, Distillation System

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INTRODUCTION

Water is essential for life. Around 97.5% of earth's water is salt water while only 2.5% is fresh water that can be used by humans. It is the basis for social well-being of people. As populations continue to grow, scarcity of fresh water sources has driven technological advances in desalination of brackish water and seawater for meeting social and economic needs for potable water (Ali et al., 2011). Solar energy is considered to be a renewable energy source. Solar thermal energy is a very convenient source of heating and a technology that does not depend on scarce, finite energy resources (Yousefi et al., 2012). Evacuated tube collectors can absorb the solar radiation effectively and convert available energy. So the solar distillation system integrated with evacuated tube has been developed and economic evaluation has been carried out.

Methodology

System description

Systematic of proposed design of solar distillation system integrated with evacuated tube collector is as shown in figure 1. Solar distillation system the basin is integrated with with evacuated tube collector which consists of number of concentric borosilicate tubes inclined at an angle from horizontal. The inner glass tubes filled with water and are blackened at its outside surface with a selective coating to absorb maximum radiation. These tubes then transfer heat to water filled inside through its contact peripheral surface. The hot water rises up due to low density whereas the cold water takes its place due to gravity and high density from solar still. The total productivity of the system is then productivity of basin.

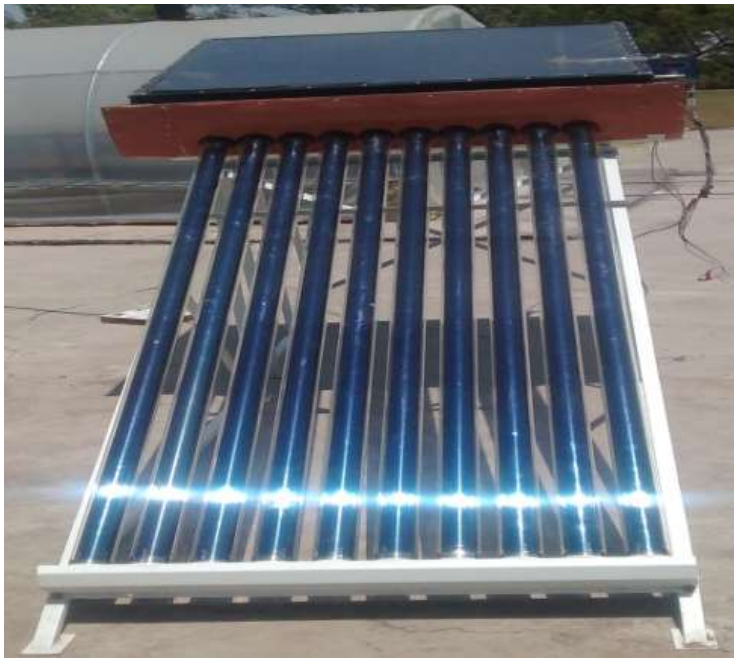

Fig. 1 Solar distillation system integrated with evacuated tube

Economic analysis of the solar still coupled with evacuated tube

The economic viability of any system was calculated through economic analysis of the system. For the success and commercialization of new technology, it is essential to know whether the technology is economically viable or not. Therefore, an attempt was made to evaluate economics of designed solar still. Different economic indicators such

as NPW, BCR and PP etc. were used in computing the economics of the system. The economic analysis was carried out by considering the following assumptions (Du, Yu, 2009).

1. The volume of water in basin of solar still was 60liter per batch for fixed depth of 0.03 m.
2. The total distilled water produced per batch was 28.5
3. 100 batches were performed in year considering one batch of three days.
4. The average selling price of the distilled water was Rs 15 per liter.
5. The cost of solar still was Rs. 20000 /-.
6. The useful life of solar still was 10 years.
7. The cost of labour was Rs.100 per day.
8. The annual repair and maintenance cost of the system was 10% of the system for every 3 years.

Following different economic indicator were used for economic analysis of the solar still system under this study (El-Nashar and Ali, 2001).

1) Net present worth (NPW)
2) Benefit cost ratio (B/C ratio)
3) Payback period

Net present worth (NPW)

The difference between the present value of all returns and the present money require to make an investment is the net present worth. The present value of the future returns was calculated through the use of discounting. Discounting essentially a technique by which future benefits and cost streams can be converted to their present worth.

$$\text{NPW} = \sum_{t=1}^{t=n} \frac{B_t - C_t}{(1+i)^t}$$

Where,

C_t - Cost in each year

B_t - Benefit in each year

t - 1, 2, 3.....n (years)

i-Discount rate, %

Benefit cost ratio

The cost benefit ratio obtained when the present worth of the benefit stream is divided by the present worth of the cost stream. The mathematical benefit-cost ratio can be expressed as:

$$\text{Benefit-cost ratio} = \frac{\sum_{t=1}^{t=n} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{t=n} \frac{C_t}{(1+i)^t}}$$

Where,

C_t - Cost in each year

B_t - Benefit in each year

t - 1, 2, 3.....n (year)

i - Discount rate

Payback period

The payback period is the length of time from the beginning of the project until the net value of the incremental production stream reaches the total amount of the capital investment (El-Nashar and Ali, 2000). The payback period of the project is estimated by using the straight forward formula.

$$P = \frac{I}{E}$$

Where,
P -Payback period of the project, years
I - Investment of the project, Rs
E - Annual net cash revenue, Rs

Results and Discussion

Economics of solar still coupled with evacuated tube collector

Economics of solar still coupled with evacuated tube collector (table 1 and 2), the different economic parameter solar still are summarized in Table 3. The details of cash inflow and outflow up to 10 years are summarized in Table 2.

Considering 300 days in season one year, for distilling of one batch of was completed in three days in solar still. Therefore, total 100 numbers of batches were completed in 300 days.

Net present worth

The present worth of total cash inflow and outflow for solar still was found to be Rs.54349.26. The value of NPW was found positive. Thus, there was a positive net returns of the investment made in the project. On the basis of NPW It is revealed that the system is commercially viable.

Benefit cost ratio

The BC ratio of the system was calculated by dividing present worth of benefit stream and present worth of cost stream. The benefit cost ratio for solar still was found to be1.26as depicted in Table no 4.20. Thus on the basis of B:C ratio, the distillation of water in solar still was found economically feasible.

Payback period

Payback period of solar still to be one year seven month twenty four days for solar still couple with evacuated tube. On the basis of NPW, B:C ratio and payback period, it is revealed that the investment in solar still is profitable and the system was found economically feasible.

Table 1 Cash inflow and outflow statement for solar still coupled with evacuated tube collector

year	cash outflow	PW of cash Outflow	Cash Inflow	PW of cash inflow	NPV
1	2	3	4	5	(5-3)
0	20000	20000.00	0	0	-20000.00
1	30650	27863.64	42750	38863.64	11000.00
2	30650	25330.58	42750	35330.58	10000.00
3	30650	23027.80	42750	32118.71	9090.91
4	30650	20934.36	42750	29198.83	8264.46
5	30650	19031.24	42750	26544.39	7513.15
6	30650	17301.13	42750	24131.26	6830.13
7	30650	15728.30	42750	21937.51	6209.21
8	30650	14298.45	42750	19943.19	5644.74
9	30650	12998.59	42750	18130.17	5131.58
10	30650	11816.90	42750	16481.98	4665.07
				NPV	54349.26
				B:C ratio	1.26

Table 2 Computation of payback period for solar still coupled with evacuated tube collector

Year	PW of total cash outflow in 10 years, Rs	Cash Inflow Rs.	Present worth of cash inflow	Cumulative Cash Inflow
0	208330.982			
1		42750	38863.64	196363.64
2		42750	35330.58	231694.22

Table 3 Economic analysis of solar still

S.N.	Description	Solar still
1.	Initial investment (Rs)	20000
2.	Annual use no. of batches	100
3.	Cost of labour (Rs yr^{-1})	30,000
4.	Operation and maintenance cost (Rs)	650
5.	Total distilled water (lit/batch)	28.5
6.	Total cost of distilled water, Rs	42750
7	B:C ratio	1.26
8	Payback period	1year 7 month 24 days
9	NPW (Rs.)	54349.26

Table 4 Computation of cost of operation of solar still

Sr. No.	Description	Solar still Amount (Rs.)
I	Fixed cost	20000.00
II	Operating cost Rs yr^{-1}	
Ii	Labor cost	30000.00
Iii	Repair and maintenance cost	650.00
Total (Rs.)		50650.00

Conclusions

Economic performance on solar desalination system with evacuated tube collectors is presented in this paper. Economic indicator viz., payback period, benefit cost ratio and net Present worth of the system for distillation of water in solar still with evacuated tube collector was found to be 1 year 7 months and 24 days, 1.26 and Rs.54349.26, respectively. The value of NPW was found positive. Thus, there was a positive net returns of the investment made in the project. Hence the distillation of water in solar still was found economically viable.

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