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6. Hybrid Solar Chimney with Salt Water Desalination and Power Generation

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ABSTRACT:

In order to generate both electricity and fresh water, this study introduces a brand-new solar chimney power system that incorporates sea water desalination. Using the sun's power to generate electricity is a new technology called solar technology.

Turbine, longer-height vertical chimney, and solar radiation-absorbing glass roof collectors make up the system's three basic components, all of which are simple and straightforward to implement. This technology has the potential to provide electricity twenty-four hours a day, a year, even in a country like India, where the sun shines nearly nine months out of the year in the majority of the country. Solar chimneys and Humidification–Dehumidification desalination processes are combined in a unique way.

Water drops are injected into the air stream to humidify it in this system. Later, a small amount of water vapour in the air condenses on the cold water tube's outer surface. The rise in water production would lead to a drop in electricity output, according to the results. Additionally, the number of dehumidifier tubes should be increased in order to generate more fresh water.

KEYWORD:

Water Desalination, Solar, Chimney, Power Genration.

Introduction:

Researchers and specialists have been searching for a renewable and non-polluting source of energy because of the high oil price and the enormous pollution caused by traditional energy sources. When it came to finding a solution to the global energy dilemma, solar power was the first option that scientists considered Low-cost solar energy can be used for human needs, and it doesn't require advanced technology in order to do so. One of its biggest drawbacks is that it isn't always available, necessitating the development of a system for storing and retrieving solar energy when needed. Solar power is generated by a variety of technologies, including solar cells, chimneys, solar lakes, and more. In order to generate power from the sun, solar chimneys are a necessity. [1]

The survival of this planet and the human race is directly tied to our capacity to curb population growth in the so-called "Third World." We must do everything we can to improve the quality of life for those who are living in poverty and misery. Mechanization and energy are required for development. Energy use rises in direct proportion to economic expansion, but population growth is decreasing exponentially at the same time. Using a greenhouse collector, a vertical chimney, and a turbine, solar chimneys may create a significant amount of energy, all while producing power continuously and for a minimal investment. [2] It is imperative that this technology be adopted globally in the same way that other conventional sources are.

SCPWDP (solar chimney power-water distillation plant) Description:

Converting sunlight into electrical energy is the primary function of a solar chimney system In the collector, the solar energy will be converted into heat energy. The generated thermal energy is transferred into kinetic energy by the chimney, which is then converted into electric energy by a wind turbine and a generator in combination.

There are three main components to the solar chimney collector: a support matrix, column structure, and a transparent top. The SCPWDP is separated into three sections: the heating zone, the evaporation zone, and the chimney zone. [3] Similar to a SCPP, but with an added water pool at the base, a SCPWDP is similar to a SCPP. Collection, base, water pool, turbine, and chimney all play major roles in the SCPWDP. When solar radiation warms the air trapped between the collector and the base, the SCPWDP gets to work, beginning the entire process. (Tilting) elevation of the SCPWDP collector causes air to become lighter and travel toward the chimney.

During the chimney's ascent, the moistened air passes over the water. Upon reaching the base of the chimny-, where the turbine is located-the air is struck by the turbine's fans, causing the energy to be transferred to the turbine itself. [4] Once the turbine reaches its cut-in speed, it begins producing electricity. At the intake of the chimney, the velocity of the air determines how much power is generated. As soon as the turbine area is passed, the air continues its journey up the chimney till it reaches the top. The moist air, however, condenses on the chimney's inner wall as it rises through the chimney. The water condenses and drops to the (pool) bottom of the chimney, where it is collected. SCPDWP's collected water is then routed to an outside facility for additional processing via water pipes buried beneath the pool of water. [5]

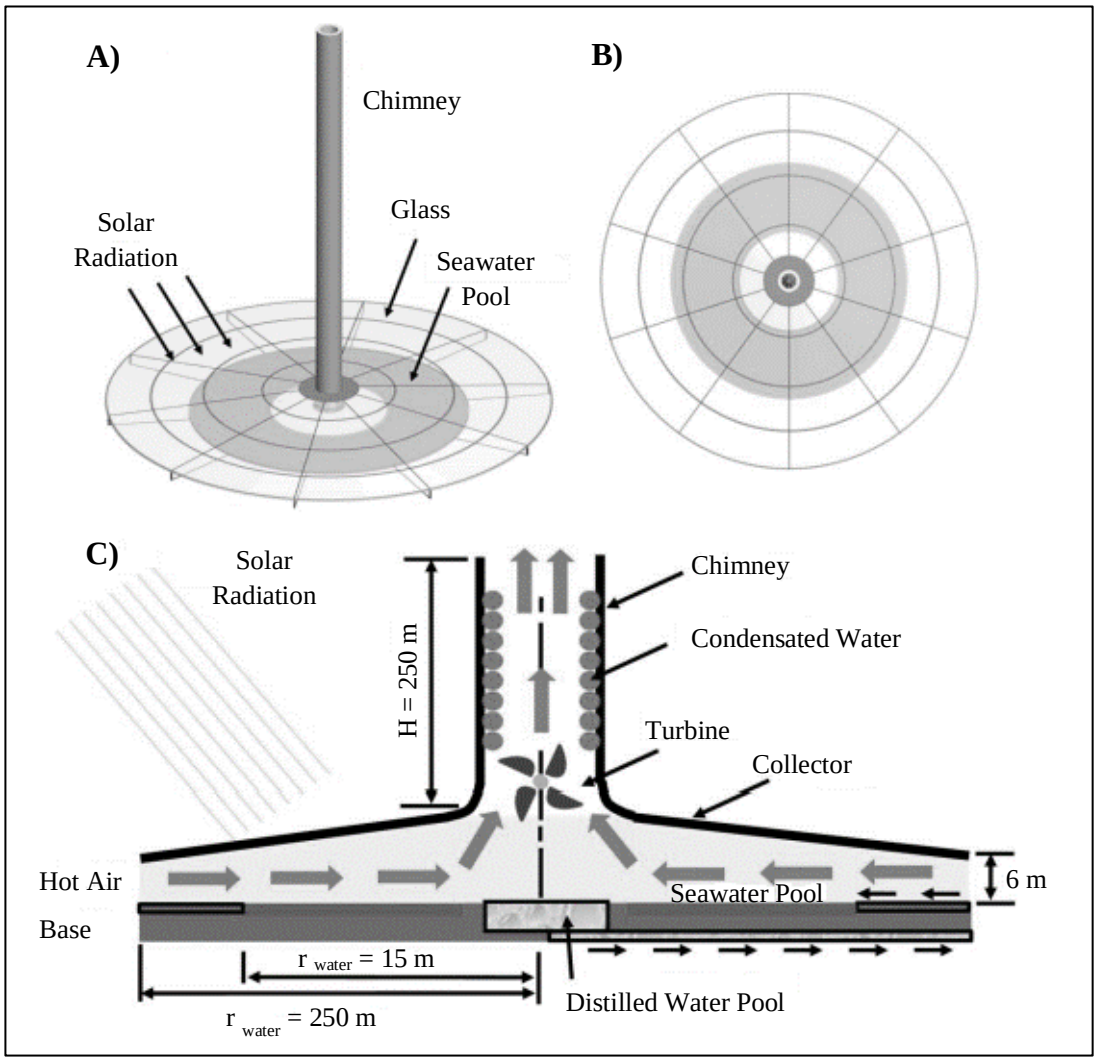

Fig. 1: Schematic diagram of the proposed system: (a) 3d model view, (b) top view and (c) cross section

Review of Literature:

As a result of the greenhouse effect, hot air becomes lighter in density as it travels from the glass cover to the chimney floor. In the solar chimney, it ascends to reach the highest point, where it is circulated by the wind turbine installed at the bottom (Guo et al., 2019) [6].

Dawoud et al. [7] investigated the feasibility of using air humidification–dehumidification to cool the condenser of seawater greenhouse desalination. In a humidification–dehumidification desalination cycle, Alhazmy [8] offered a theoretical study based on the second law of thermodynamics to estimate the lowest labour necessary for air dehumidification to produce drinkable water. According to Mahmoudi et al. [9], it is possible to generate electricity from wind to power greenhouse desalination plants in the southern part of Algeria, the case study country.

For electricity generation and seawater desalination, researchers Zou et al. [10] examined SSC and CSCS performance using a single solar chimney (SSC).

For desalination, they suggested combining a new solar chimney system with an existing solar still system. Theory shows that the integrated system considerably improves both solar energy and land resource usage efficiency.

For both electricity generation and seawater desalination, Zhou et al. [11] suggested a combination solar chimney system (CSCS).

When the dry ambient air runs through a layer of seawater extracted from the adjacent sea, it becomes heated and saturated.

A high-efficiency condenser built at the chimney exit condensed the vapours in the air into fresh water. In order to maintain this model's turbine and chimney, a large pond would need to be constructed.

Objectives:

1. Fabrication of Solar energy driven solar chimney desalination system experimental setup with low cost vapour condensing system and electric power generation with diffuser
2. Analysis of production of fresh water from desalination system with and without waste heat recovery
3. Analysis of power generation with and without desalination system
4. Analysis of power generation with and without thermal storage and without desalination

Research Methodology:

Based on secondary sources such as books, journals, academic articles, government publications and printed and online reference materials, this study is descriptive rather than prescriptive in character.

Result and Discussion:

Effect of water production on power output:

While the length of humidifier is considered to be constant, Fig. 2 demonstrates that power output decreases as water production increases.

In a constant temperature environment, the dehumidifier's DBT will decrease due to the temperature's effect on the air humidity ratio. [12]

The dehumidifier's needed heat transfer area would have to be raised in order to produce more fresh water. Tubes are the same length as collector roof height, which necessitates an increase in the number of pipes. [13]

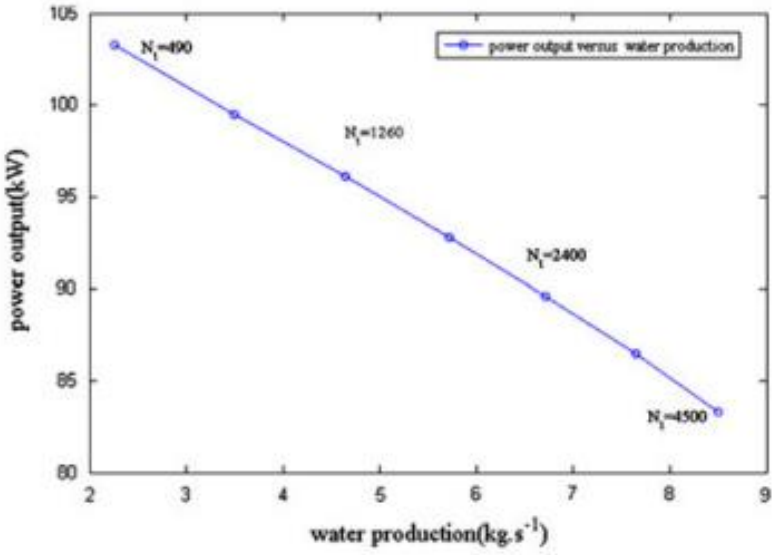

Fig. 2: Power output vs. maximum water production

Effect of Humidifier Inlet Water Temperature:

In Fig. 3, the maximum fresh water which can be desalinated in dehumidifier is shown

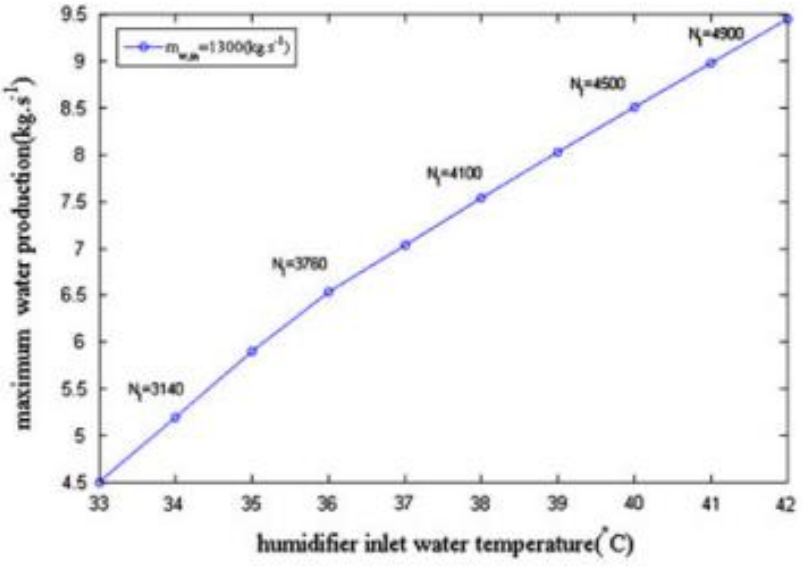

Fig. 3: Maximum water production vs. humidifier water temperature.

Solar chimney power-water distillation plant collector materials' properties.

Material Characteristic	Value
Glass Transmissivity	0.90
Glass Emissivity	0.90
Glass Absorptivity	0.05
Water Transmissivity	0.90
Water Emissivity	0.95
Water Absorptivity	0.05
Base Absorptivity	0.95
Base Emissivity	0.95

Table 1: SCPWDP collector materials' properties.

Hourly productions of water and power were added and tallied for each month. The results for the entire year are reported in Table 2. The table illustrates the production of electric power (kWh) and distilled water (ton) month-by-month starting from January and finishing in December. [14]

Month	Average Monthly Global Solar Irradiation kWh/m^2)	Electric Power (kWh)	Distilled Water (ton)
January	112.06	21,846.24	4662.90
February	126.61	26,542.74	6066.50
March	186.81	42,384.30	10,054.61
April	206.22	47,485.61	12,041.33
May	233.99	53,760.64	14,072.61
June	248.17	57,934.94	14,975.27
July	248.90	57,222.29	14,700.75
August	232.43	52,992.54	14,778.50
September	192.43	42,322.52	11,846.42
October	160.64	33,813.33	9511.02
November	122.69	24,201.08	6185.75
December	108.23	20,934.28	4857.83
Sum	2179	481,440	123,753

Table 2: Monthly values of power and water production for the SCPWDP

Conclusion:

There appears to be no commercial solar chimney power plants despite the outstanding attempts to improve the performance of the technology through several experimental and theoretical studies. A solar chimney combined with seawater desalination may not only increase power output, but it may really do so to a degree. De-salting more water will result in a drop in power production.

Increase in dehumidifier tubes has a considerable impact on both distillate flow rate and kilowatt production. The performance of the humidifier is affected by the temperature and flow rate of the humidifier incoming water. It may be advantageous to raise humidifier inlet water temperature and mass flow rate in order to boost both power and desalinated water production.

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