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Investigation Regarding Solar Chimney Power Plants by ET Approach : A Literature Study

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ABSTRACT

Solar Chimney Power Plant is a straightforward control design which utilises cosmic radiation to give skyward momentum to the inflowing air, thereby transforming the thermic energy into dynamic energy. It uses an aggregate of three established technologies:-

1.Wind Turbine,
2.Greenhouse, and
3. Chimney.

In this review work, the circumstances of Solar Chimney Power Plant technologies described, and the status and advancement of this technology critiqued including the philosophical and empirical study status, as well as the commerce for Solar Chimney Power Plant Technology.

The numerous cost prototypes for large-scale solar chimney power plants are accessible in the article. However, the results presented vary significantly, even in cases where the input parameters and the used models are very similar. The foremost intention of this paper is to literature study of Solar Chimney Power Plant by Economic- Techno Approach. Further, the influence of carbon credits on the Levelized electricity cost also reviewed.

Keywords : Solar Chimney Power Plant, Levelized Electricity Cost (LEC), Green House, Power Conversion Unit (PCU).

I. INTRODUCTION

The Solar Chimney Power Plant is a design concept for a Renewable Energy Power Plant for generating electricity from low-temperature cosmic energy. Sunshine heats the air under a large greenhouse, like a roofed collector structure and encompassing the fundamental base of a particularly tall Solar Chimney Tower. The resulting convection affects a hot air updraft in the tower by the Solar Chimney effect. The airflow above drives wind turbines, placed in the chimney updraft or around the chimney base, to generate electricity.

Fig.1 Shows, "Hot air rises." is the most basic fact employed in the design of the gigantic Solar Chimney Power Plant. The spread out solar collectors receive the sunlight and serve as a greenhouse together with the ground. The air in the greenhouse is warmed and accelerated toward the turbines at the base of a chimney at velocities up to 70km/h. The buoyancy effect formed by the pressure difference from the air under the collectors and ambient (atmospheric) air produces a driving force to make sure the air moves fast.

The size of the collector, area, and the height of the chimney decide the capacity of the electricity production. The larger the collecting area, the more airflow and heat it traps; the higher the height of the stack, the more significant the pressure difference.

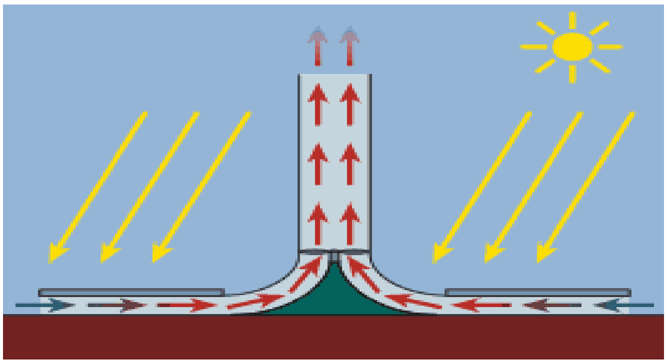

Fig. 1 - Solar Chimney Tower Plant

The ground can store heat fig. 2 shows, Solar Chimney Tower Plant with Thermal Energy Storage. The ground underneath the collector roof embodies the heat and re-radiates it during the night, therefore able to afford energy 24 hours a day. The other uses for space in between-

1.The Roof and

2.The ground has been offered, such as dehydration of vegetables and fruits. The postulate of thermic power storage with water-filled black tubes for extra thermic storage capacity.

The works more reliable than soil alone as water as water's heat capacity is five times higher than that of earth. Also, heat transfer between water tubes and water is much higher than that between the ground surface and the soil layers underneath.

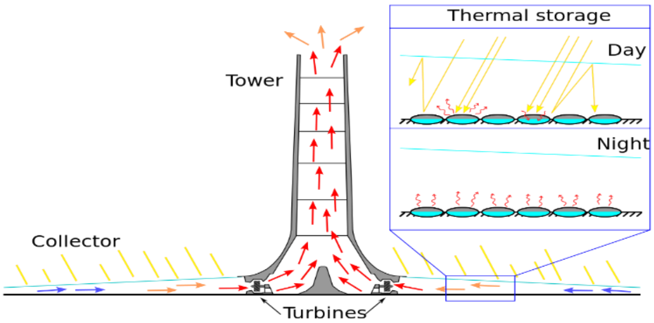

Fig. 2 - Solar Chimney Tower Plant with Thermal Energy Storage.

II. LITERATURE REVIEW

The subsequent study documents are a survey in particular, and the citations of relevant articles are as under:

1. Guo Penghua Li et al. (2019). Interest in solar chimney power plant (SCPP) has seen resurgence due to the continuously increasing awareness on environmental concerns, particularly greenhouse gas emissions from fossil fuels, since the 21st century. Although remarkable advances in the understanding of Solar Chimney Power Plant have been achieved through extensive theoretical, experimental, and numerical studies with different focuses on various aspects of the SCPP technology, no industrial scale Solar Chimney Power Plant has been built. In response to these new scientific advances and challenges for commercialization, seven questions, including parameter influences, turbine design, flow and heat transfer characteristics, similarity analysis, and hybrid systems, are presented in this work. In addition, answers and current understanding are included to provide succinct links to latest knowledge and identify areas that require further research.

2. Ikhlef Khaoula et al. (2018). The present work dedicated to the techno-economic analysis of the solar chimney power plant (SCPP) of the Manzanares site. This site located in the south region of Spain. Manzanares. This prototype reached a production of 44MWh/year with a power peak of 50kW. A mathematical model presented to describe the solar chimney power plant mechanism in detail, establish a

technical study, evaluate the annual performances, and study the effect of various parameters on power output. The economic research based on the calculation of the LCOE "Levelized Cost of Energy," which corresponds to the full price of energy over the lifetime of the equipment. A profitability study of the prototype of Manzanares is developed for Maghreb countries such as Algeria, Tunisia, and Morocco as well as for some European countries: Spain, Germany, and Denmark.

3. Qingjun Liu et al. (2018). A solar chimney PV/T power plant (SCPVTPP), is proposed. Mathematical models established for the PV/T solar collector, the chimney, and the power conversion unit, respectively. Performances of the designed SCPVTPP then simulated. The SCPVTPPs with different PV module areas finally discussed. It found that the PV cells hold the highest temperature in the solar collector. The temperature rise of the PV module has significant influences on its power generation. Without cooling, the PV power capacity has an average decrease of 28.71%. The contradictory forces of temperature rise and airflow cooling lead to an 11.81% decrease in the average power capacity. By adding the power generated by PVT, the total PV-related power contribution increases by 4.72%. With the increase of the solar collector ratio, the temperature rise, and the wind velocity both first decrease, then expand, the SCPP power productivity decreases linearly, and the PV power productivity increases linearly. In contrast, the PVT power productivity first increases linearly then increases super linearly. There is a reversed solar collector ratio, exceeding which the PV generates the most power. In this study, solar thermal power plays a significant role when the solar PV area ratio is smaller than 0.055.

4. Zainab Akhtar et al. (2016). This paper presents the calculation of the capital cost of the solar chimney power plant of different capacities from 5 MW to 200 MW in India using approximate cost formula given by Pretorius and Kroger. The specific cost (Csp) of the chimney defined by Pretorius and Kroger considered estimating the estimated cost of SCPP using the cost model of Pretorius and Kroger. It assumed that the average chimney thickness increment is 1 mm for every one-meter height of the chimney. Using the volume of material used for the stack and specific chimney cost capital cost of the fireplace calculated. The collector cost expressed in terms of particular chimney cost, the height of the chimney, inlet height of the collector, and the diameter of the collector. Energy conversion machinery cost is taken as 10% of the sum of collector and chimney cost. For different plant capacities ranging from 5 MW to 200 MW, capital cost varies from Rs. 75.51 Cr to Rs. 1848.43 Cr and LEC estimated as Rs. 4.22/kWh to Rs. 2.58/kWh under Indian conditions.

5. Xinping Zhou et al. (2016). A Solar Updraft Power Plant (SUPP), also called a Solar Chimney Power Plant, is a kind of promising power generation device that operates naturally under the indoor air buoyancy at the cost of low maintenance and operation cost without the use of the need of refuse disposal, fuel, and cooling water. To date, this SUPP technology, the feasibility of which was verified by the Manzanares prototype built and operated in the 1980s, has not been commercialized mainly due to high investment per MWh of electricity. In this paper, a novel concept of extracting power from the natural valley–anabatic mountain wind-aided by a SUPP collector proposed. In the system, the solar collector is built on the upper mountain slope to use both the heat from the solar radiation received by the collector and the extra heat from the solar radiation received by the lower bare mountain slope. In comparison with that of the conventional sloped-collector SUPP, the performance of this novel SUPP is studied based on the mathematical model developed. Results show that with an increase in the lower bare mountain slope area from 0 to 5 times the collector area, the plant efficiency increases by 183%, and the Levelized Electricity Cost (LEC) decrease by 64.7%. It implies the proposed power extraction from the natural valley–anabatic mountain, wind-aided by SUPP

collector, is a handy measure to enhance the performance and cost-effectiveness of SUPP. This paper lays a solid foundation for studies and commercialization of SUPPs in the future.

6. Weibing Li et al. (2014). This paper develops a model different from existing models to analyze the cost and benefit of a reinforced concrete solar chimney power plant (RCSCPP) built-in northwest China. Based on the model and some assumptions for values of parameters, this work calculates a total net present value (TNPV) and the minimum electricity price in each phase by dividing the whole service period into four phases. The results show that the minimum electricity price in the first phase is higher than the current market price of electricity. Still, the minimum rates in the other aspects are far less than the current market price. The analysis indicates that the vast advantages of the RCSCPP over coal-fired power plants can be embodied in phases 2–4. Also, the sensitivity analysis performed in this paper discovers TNPV is very sensitive to changes in the solar electricity price and inflation rate but responds only slightly to changes in carbon credits price, income tax rate, and interest rate of loans. Our analysis predicts that RCSCPPs have excellent application prospects. To encourage the development of RCSCPPs, the government should provide subsidy by setting higher electricity prices in the first phase, then lower electricity prices in the other steps.

7. Fei Cao et al. (2013). Present work deals with Solar Chimney Power Plant (SCPP) with a long life span is a promising large-scale solar thermal utilization technology. This paper performs economic analysis for the conventional solar chimney power plant (CSCPP) and the sloped solar chimney power plant (CPP) in Northwest China. Cash flow influenced by many factors, including the investment, the payback period, the inflation rate, and the sale price of solar electricity. The techno-economic analyses of the CSCPPs and SSCPPs performed taking Lanzhou, China, as a case study. The results show that the SCPP investment influenced by both its configuration and the material price, and the CPP is more cost-effective than the CSCPP during the system life span. Also, the SCPP with large power capacity holds good competitiveness with conventional fossil fuel combustion plants. The economic evaluation of building SCPPs in Northwest China is of high significance considering the local abundant solar radiation, favourable government policy, and under-developing economics.

8. Babak Ghorbani et al. (2012). In this study, an improved concept design presented to increase the thermal efficiency of the Rankine cycle of a typical steam power plant by combining a solar chimney and a dry cooling tower. The sources of the wind energy generation include the rejected heat from condenser to the air entering the dry cooling tower, solar radiation, and the airlift pumping effect on the airflow created by the stack hot flue gas, which injected into the hybrid tower as a novel change. This research primarily focuses on the Shahid Rajaee 250MW steam power plant to determine the velocity of generated flow at the turbine inlet; a numerical finite volume code was employed for a dry cooling tower having a base diameter and a chimney height of 250m and 200m, respectively. Calculations have emphasized for different angles of chimney walls, slopes of collectors, and the base ground to find their effects on the output power. The wind turbine captures a range of 360kW to more than 4.4MW power by changing the hybrid tower geometrical parameters. Obtained results reveal a maximum of 0.538% increase for the thermal efficiency of the fossil fuel power plant.

9. J. Schlaich et al. (2005). A solar updraft tower power plant – sometimes also called 'solar chimney' or just 'solar tower' – is a solar thermal power plant utilizing a combination of solar air collector and central updraft tube to generate a solar-induced convective flow which drives pressure staged turbines to generate electricity. The paper presents the theory, practical experience, and economy of solar updraft towers: First, a simplified method of the solar tower

described. Then results from designing, building, and operating a small scale prototype in Spain presented. Eventually, technical issues and fundamental economic data for future commercial solar tower systems like the one planned for Australia discussed.

10.N. Pasumarthi et al., (1998). The solar chimney is a natural draft device which uses solar radiation to provide upward momentum to the inflowing air, thereby converting the thermal energy into kinetic energy. A study was undertaken to evaluate the performance characteristics of solar chimneys, both theoretically and experimentally. In this paper, a mathematical model that developed to study the effect of various parameters on the air temperature, air velocity, and power output of the solar chimney is presented, tests conducted on a demonstration model, which was designed and built for that purpose. The mathematical model shown here was verified against experimental test results, and the overall results were encouraging.

III. ET APPROACH

A significant concern with all solar technologies is the extensive use of lands because of the low energy concentration of sunlight. The investment of large-scale Solar Chimney Power Plant is substantial, and the solar collector is the main cost factor of the Solar Chimney Power Plant. The best new use of a solar collector would be for growing fruits or vegetables as a greenhouse for possible additional revenues. The ground under the collector roof requires to flooded with fresh water. However, freshwater could be scarce in the potential construction sites of Solar Chimney Power Plants, which often selected in deserts, where land is cheap, and the sunlight is abundant. To grow fruit or vegetables, some chosen areas for the locations of Solar Chimney Power Plant, which aren‘t yet deserts but threatened to become a desert if the climate change goes on, or which has recently become a desert. With pleasure, the wet cultivated ground is often darker than a dry flat one, so that this effect generates a synergy among agricultural and power productions.

IV. CONCLUSION

1. The details of Solar Chimney Power Plant technology explained, the potentials of citing this power plant, the situation, and evolution of this technology studied, including theoretical study, experimental condition, and economics for this Solar Chimney Power Plant technology.
2. With this possibility, Solar Chimney technology as a relevant technology for power generation.
3. Solar Chimney Power Plant technology is a pure Solar Thermal Power Technology, which incorporates three familiar routines:
a. Process Control Unit, e.g., Turbine Generators.
b. Solar Collector, and
c. Solar Chimney.
4. The records of additional types of Solar Chimney Power Plant technology also prepared; however, the average sunlight hour and solar radiations, respectively.

V. REFERENCES

[1]. Penghua Guo, Tiantian Li, Ben Xu, Xinhai Xu, Jingyin Li. (2019), “Questions and Current understanding about Solar Chimney Power Plant: A review”. Energy Conversion and Management, Volume 182, pp.21-33.

[2]. IKHLEF Khaoula, LARBI Salah (2018),“Technico-Economic Aspect Analysis In The Design Of Solar Chimney Power Plants”, International Conference on Green Energy and Environmental Engineering, ISSN 2356 – 5608, Vol. 37, pp.30-33.

[3]. Qingjun Liu, Fei Cao, Yanhua Liu, Tianyu Zhu, and Deyou Liu,(2018) “Design and Simulation of a Solar Chimney PV/T Power Plant in Northwest China” International Journal of

Photoenergy, ISSN 1687 – 529X, Volume 2018, pp. 1-12.

[4]. Z. Akhtar and K. V. S. Rao, "Estimation of levelized electricity cost of solar chimney power plant in India by using approximate cost model of Pretorius and Kroger," (2016), International Conference on Energy Efficient Technologies for Sustainability (ICEETS), Nagercoil, 2016, pp. 276-279.

[5]. Xinping Zhou, Yangyang Xu, Yong Huang (2016), "Novel concept of enhancing the performance of sloped solar collector by using natural anabatic winds", International Journal of Heat and Mass Transfer, ISSN : 0017-9310, Volume 102, pp. 1356-1361.

[6]. Weibing Li, Ping Wei, Xinping Zhou. (2014), "A cost-benefit analysis of power generation from commercial reinforced concrete solar chimney power plant", Energy Conversion and Management, ISSN:0196-8904, Volume 79, pp.104-113.

[7]. Fei Cao, Huashan Li, Liang Zhao, and Liejin Guo, (2013), "Economic analysis of solar chimney power plants in Northwest China", Journal of Renewable and Sustainable Energy, Volume 5, Issue 2.

[8]. Babak Ghorbani, Mohammad Ghashami, Mehdi Ashjaee, Hamid Hosseinzadegan, (2015), "Electricity production with low grade heat in thermal power plants by design improvement of a hybrid dry cooling tower and a solar chimney concept", Energy Conversion and Management , ISSN: 0196-8904, Vollume 94,pp. 1-11.

[9]. J. Schlaich, R. Bergermann, W. Schiel, G. Weinrebe,(2005), "Design of commercial solar updraft tower systems utilization of solar induced convective flows for power generation", Journal of Solar Energy Engineering, Volume 127, No. 1, pp. 117-124.

[10]. Pasumarthi, N and S. A. Sherif,(1998), "Experimental and theoretical performance of a demonstration solar chimney model—Part I: mathematical model development," International Journal of Energy Research, Volume 22, No. 3, pp. 277-288.

[11]. G.M.Ngala, A.T. Sulaiman, I. Garba, (2013), "Review of Solar Chimney Power Technology and its Potential in Semi- Arid Region of Nigeria", International Journal of Modern Engineering Research (IJMER), ISSN: 0378-7788 Vol.3, Issue.3, pp-1283-1289.

[12]. S. S. Gaddamwar (2018) "Computational Fluid Dynamic Simulation and Investigational Testing of a Membrane Serpentine Tube Heat Exchanger" Journal of Advanced Research in Dynamical & Control System (JARDCS) Scopus Indexed Journal, Vol. 10, 13-Special Issue, pp.2429-2434

[13]. S. S. Gaddamwar, A. N. Pawar (2018), "Similitude of membrane helical coil with membrane serpentine tube for characteristics of high-pressure syngas: A review" American Institute of Physics (AIP) Conference Proceedings Scopus Indexed Journal, Volume 1966, Issue 1, May 2018.

[14]. S. S. Gaddamwar (2019), "An Optimization Of High Pressure And Temperature of Syngas in Underground Coal Mines By Using CFD Analysis of Membrane Serpentine Tube" International Journal of Mechanical and Production Engineering Research and Development (IJMPERD) Scopus Indexed Journal, ISSN(P): 2249-6890; ISSN(E): 2249-8001 Vol. 9, Issue 1, Feb 2019, 617-624.

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