Investigating the Feasibility of Integrating Vegetation into Solar Chimney Power Plants in the Tamanrasset Region

Sellami Ali
Materials and Energy Research Laboratory, Faculty of Science and Technology, University of Tamanghasset, Algeria
sellamiali2023@gmail.com (corresponding author)

Benlahcene Djaouida
Faculty of Science and Technology, University of Tamanghasset, Algeria
sellami2003@hotmail.com

Received: 16 April 2024 | Revised: 3 May 2024 and 5 May 2024 | Accepted: 7 May 2024

 DOI: https://doi.org/10.48084/etasr.7506

ABSTRACT

This work investigates integrating vegetation into solar chimney power plants (SCPPs) using numerical simulations of an SCPP prototype in Spain. A 2D axisymmetric computational fluid dynamics model with radiation heat transfer was employed to evaluate the impact of vegetation beneath the solar collector roof on system performance. Different SCPP configurations were analyzed: a standard design, one with a secondary collector roof, and another with secondary and tertiary collector roofs. Results indicate the secondary and tertiary roof configuration exhibited the highest annual electricity generation capacity of 34-80 kW. While introducing vegetation under the collector appears feasible, it is likely to reduce the overall energy output. In summary, simulations suggest that vegetation influences SCPP operation, decreasing power production, while incorporating multiple collector roofs enhances the generation capacity.

Keywords-vegetation under collector; solar energ; solar chimney; numerical simulation; electrical gGenerator

I. INTRODUCTION

The growing energy demand and reliance on non-renewable fossil fuels has raised many environmental concerns. Solar Chimney Power Plants (SCPPs) offer a promising clean energy solution. This renewable technology harnesses solar radiation to heat air and convert its energy into electricity using wind turbines. The concept of utilizing air flow for power generation was first proposed in the early 1900s [1]. In the 1980s, researchers built and tested a prototype Solar Upwind Power Plant, also called a Solar Chimney Energy System or Solar Tower, based on that idea [2]. Solar upwind/chimney systems provide a green method to harness solar energy for electricity generation [3]. The Solar Chimney Power Plant converts solar energy into thermal energy, then thermal into kinetic, and ultimately kinetic into electrical energy [4]. The design was introduced in the late 1970s and a prototype constructed from that design was demonstrated in Manzanares, Spain in the early 1980s [5].

In recent times, several pieces of sofware, like FLUENT and TRNSYS, have utilized the widely employed Computational Fluid Dynamics (CFD) software to analyze SCPP performance [6-12, 31]. Authors in [13] reviewed the impact of crosswind velocity on SCPP efficiency. Authors in [10] evaluated SCPP performance through CFD simulations in TRNSYS. Authors in [14] modeled a Spanish prototype plant using Boussinesq and Discrete Ordinates (DO) models for natural convection and radiation simulations. They found that higher solar radiation increases temperature differentials and pressure at collector intake/outflow and between collector and chimney transition. Authors in [9] deployed a 3D CFD model with a two-band radiation model to simulate the greenhouse effect and heat transfer in the system, demonstrating the importance of modeling the greenhouse effect for SCPP performance evaluation. Authors in [15] integrated models of radiation, solar load, and actual turbine systems to investigate power regulation strategies for solar chimney turbines, comparing fan and real turbine model results. Several computational studies utilizing CFD software have examined crucial system factors like radiation, convection, greenhouse effects for solar chimney prototype plants to evaluate influences on system efficiency and power output regulation.

Other recent studies have looked at various aspects of solar chimney performance. Authors in [16] explored the effect of Corona wind on solar chimneys and authors in [17] optimized a small-scale (3 m height, 3 m collector diameter) pilot solar chimney design. Authors in [18, 19] assessed the thermal efficiency of solar chimneys using phase change materials. Authors in [20] compared a 3D CFD model of a SCPP with the Manzanares prototype to evaluate SCPP viability in Tunisia. Authors in [21] examined the economic efficiency of a 200 MW coal-fired SCPP in India. Authors in [31] studied a modified solar chimney design that combines power generation and vegetation cultivation. The work in [32] focuses on optimizing and controlling a large-scale SCPP [32].

The objective of the current study is to investigate the feasibility of incorporating vegetation under the collector roof of a solar chimney to impact performance. Integrating vegetation into SCPP designs offers several compelling justifications worth considering. The heated air and greenhouse effect under the collector roof could enable agricultural integration, allowing the facility to combine solar power generation with sustainable agriculture or plant cultivation practices. This diversification expands the system's functionality beyond mere energy production. Furthermore, the presence of vegetation can provide an aesthetic appeal by creating a more natural, green environment around the solar chimney facility. While the simulation results indicate that vegetation may reduce the overall power output, this potential drawback could be outweighed by the environmental benefits it offers, such as carbon sequestration, improved air quality, shade provision, and an overall more eco-friendly design approach. Looking ahead, future research could explore design modifications or optimized operating conditions that minimize any power reduction from the vegetation integration while still preserving the intended agricultural, aesthetic, and environmental advantages. With further optimization, the integration of vegetation may enable solar chimney facilities to become multifunctional sustainable systems.

In comparison to [31, 32], while sharing the common theme of SCPPs, the present work investigates a distinct objective of assessing the feasibility of integrating vegetation into SCPPs in the Tamanrasset region of Algeria through numerical simulations using a 2D axisymmetric CFD model with radiation heat transfer. The acquired results suggest vegetation incorporation is viable, but likely to reduce energy generation, with the SCPP configuration incorporating secondary and tertiary collector roofs disclosing the highest electricity output capacity. In contrast, authors in [31] studied a modified SCPP design that combines power generation and vegetation cultivation, utilizing both CFD simulations and experimental measurements. Their findings revealed that the modified design improved energy efficiency and enabled vegetation growth beneath the collector. Authors in [32] focused on optimizing and controlling large-scale SCPP systems in general, employing techniques like optimization methods and control strategies to enhance the overall system performance. While the current study centered on a specific region and evaluated various SCPP configurations with and without vegetation, authors in [31] proposed a modified design for integrated power and crop production. Authors in [32], however, tackled optimization and control challenges applicable to large SCPP facilities.

II. PHYSICAL MODEL

A physical model of a SCPP was developed to study the effects of buoyancy on flow and heat transfer. The design is based on the Manzanares prototype, with a 194.6 m tall chimney (Hch) of 10.16 m diameter (rch). The collector has a 122 m radius (Rcol) and an average 1.85 m height (Hcol), with the turbine located 9 m above the ground. Near the chimney base, the collector height increases up to 6 m, redirecting airflow upwards before the turbine. The ground acts as a 5 m thick energy storage medium.

III. ELECTRICITY PRODUCTION

The effectiveness of the SCPP is dictated by the functioning of its separate components.

A. The Collector

The formula for the heat gained by air in the collector is [11, 12]:

$$Q = \eta_{col} A_{col} G \tag{1}$$

where η_{col}, A_{col}, and G represent the area of the solar collector ($A_{col} = \pi R_{col}^2$), the solar radiation, and the efficiency of the solar collector, respectively. Q signifies the heat generated due to the greenhouse effect in the collector and can be articulated as:

$$Q = C_{P.} m . \Delta T \tag{2}$$

with:

$$m = \rho_{air} V_{ch} A_{ch} \tag{3}$$

Subsequently, the efficiency of the solar collector can be expressed as:

$$\eta_{col.} = \frac{\rho_{air} V_{ch} A_{ch} C_P \Delta T}{A_{col} G} \tag{4}$$

where m stands for the mass flow, A_{ch} indicates the surface area, and V_{ch} refers to the velocity at the chimney entrance.

B. The Chimney

The efficiency of a chimney is given by [11, 12, 22]:

$$\eta_{ch} = \frac{g.H_{ch}}{c_p T_a} \tag{5}$$

where H_{ch} denotes the chimney's height, T_a is the temperature of the surrounding air, and the total flow power P_{tot} is calculated by:

$$P_{tot} = \eta_{ch} \, \text{Q} = \frac{g H_{ch}}{T_a} \rho_{col} V_{ch} \Delta T A_{ch} \tag{6}$$

The difference in pressure between the base of the chimney and its environment, is calculated by:

$$\Delta P_{tot} = \rho_{col} g H_{ch} \frac{\Delta T}{T_a} \tag{7}$$

C. The Turbine

Turbines are installed at the bottom of the chimneys to transform the kinetic energy of the air flow into mechanical energy through rotation. The maximum amount of mechanical power that can be generated by the turbine is [11, 12, 22]:

$$P_m = \frac{2}{3}\eta_{col}\eta_{ch}A_{col}G \quad (8)$$

The amount of electrical energy generated by the central solar chimney is determined by:

$$P_e = \frac{2}{3}\eta_{col}\eta_{turb}\frac{g}{C_pT_a}H_{ch}A_{col}G \quad (9)$$

IV. INCORPORATION OF VEGETATION UNDER THE COLLECTOR ROOF

To incorporate vegetation under the solar chimney collector roof, modifications are made to the existing physical model. As displayed in Figure 1, the collector is split into two zones - one for vegetation and one for the bare ground. The vegetation is assumed to fully surround the collector circumference (360 degrees), planted from the collector perimeter inward to a defined radius (R_{veg}). This vegetation configuration positions it under the collector roof while avoiding the high temperatures nearer the chimney base. The model is adapted to analyze integrating vegetation into a solar chimney plant. The collector has distinct ground and vegetation zones, with plants fully encircling the perimeter at a set radius under the collector roof to prevent exposure to excessive temperatures closer to the chimney.

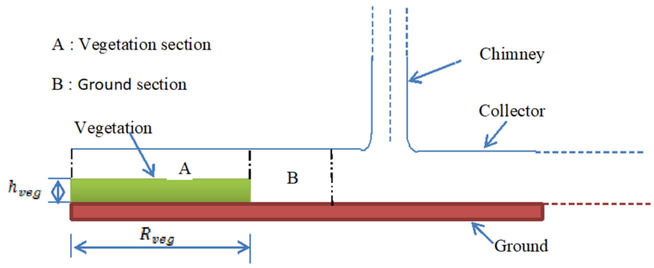

Fig. 1. Placement of plants beneath the collector roof results in the formation of two distinct areas within the collector: the vegetation area and the ground area.

V. BOUNDARY CONDITIONS

In this section, the boundary conditions that are relevant to the physical model are outlined. The various locations in the model and the types of boundary conditions implemented, along with their specific values are enumerated. These include:

- The heat storage layer's sides are represented as an adiabatic wall.
- The bottom wall is represented with a heat transfer coefficient of K = 300 W/m^{2}K and a T_a equal to the ambient temperature.
- The collector cover is represented as a semi-transparent wall, with solar irradiation and a heat transfer coefficient of K = 5.9 W/m^{2}K.
- The chimney's surface and junction are represented as adiabatic walls.
- The collector inlet is represented with a pressure inlet gage pressure of 0 Pa.
- The chimney outlet is represented with a pressure outlet gage pressure of 0 Pa.
- The pressure drop across the turbine is computed using an iterative method.

VI. PARAMETERS EMPLOYED IN THE POROUS MEDIA MODEL

The vegetation cover is modeled as a porous medium using the Fluent 17.1 program for solving fluid dynamics equations, which combines the traditional porous medium approach with the discretization of Darcy and Forchheimer equations. The vegetation cover in this study consists of a row of young cowpea plants surrounding the collector in a 360° orientation, extending to a specified radius, R_{veg}, with a height of 0.3 m. The intrinsic permeability of the porous medium is defined as 0.884 and the nonlinear pressure drop coefficient as 1 [23].

VII. SIMULATION AND RESULTS

Four solar chimney power plant simulations were conducted: 1) without radiation/vegetation, 2) with radiation/no vegetation, 3) no radiation/with vegetation, 4) with radiation/ vegetation. These simulations are based on the previously described plant specifications, the properties of the vegetation, and an assumed maximum temperature of 39 °C at which the vegetation can operate without disrupting photosynthesis (lower than the values determined in [24]). The study examines the incorporation of vegetation under the collector's roof, which extends to 106.5 m radius (R_{veg}).

Figures 2-3 portray the temperature and velocity profiles of the fluid in the collector with and without vegetation for a specific solar radiation level (Q = 1000 W/m^2). Both increase approaching the chimney base. In the vegetated zone, the velocity slightly declines and then gradually increases near the chimney. The highest temperature/velocity values are acquired in the case without vegetation and with radiation. This indicates that vegetation and radiation influence performance.

Simulations were run for three different SCPP configurations as described in [11]: a reference plant, one with a secondary collector roof, and one with both secondary and tertiary collector roofs. The simulation results observed in Table I suggest that the plant designs incorporating secondary and tertiary collector roofs generated the most electricity. However, when vegetation was integrated into any of the solar chimney systems, the amount of power output was reduced. Therefore, even though adding vegetation coverage is a viable option for SCPPs, doing so leads to a considerable decrease in the electricity generation capacity of the plant.

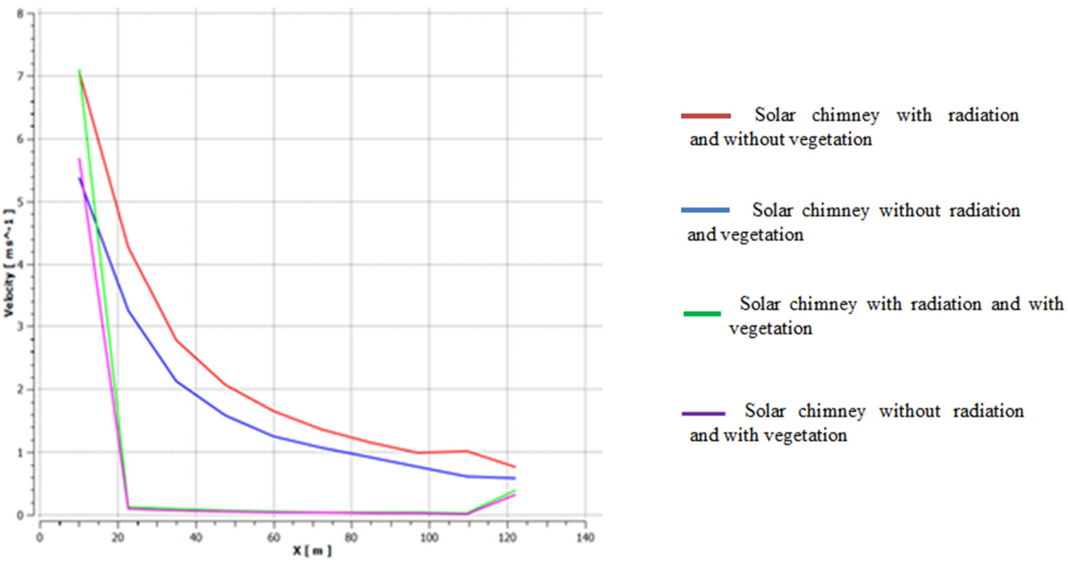

Fig. 2. Velocity profile of the different SCPP systems in the collector at R_{veg} = 106.5 m, Y = 0.2 and $T_{sol\text{-}air}$ = 324 K and solar insolation of 1000 W/m^2.

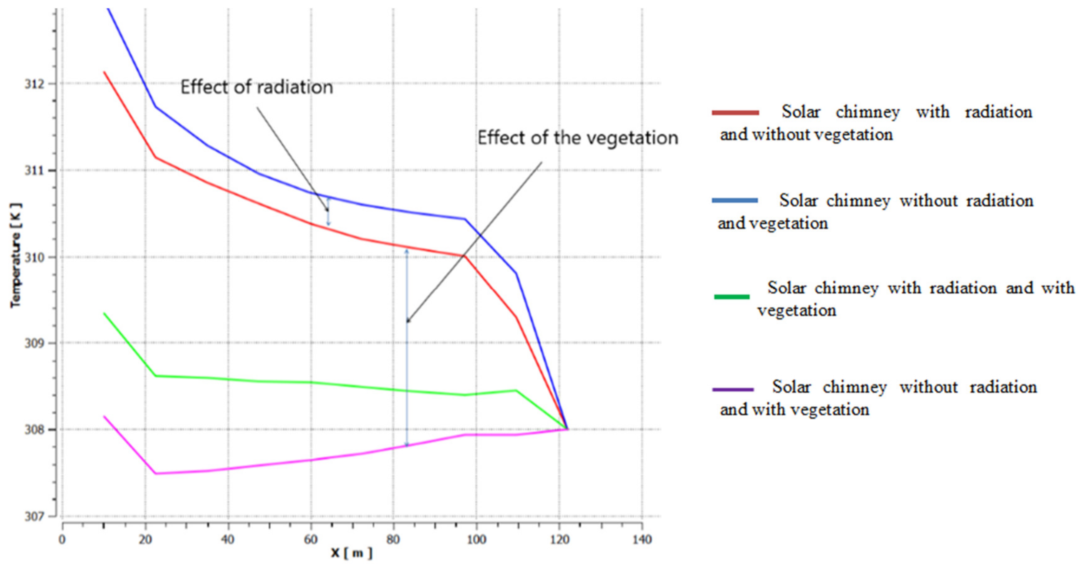

Fig. 3. Temperature profile of the different SCPP systems in the collector at R_{veg} = 106.5 m, Y = 0.2 and $T_{sol\text{-}air}$ = 324 K and solar insolation of 1000 W/m^2.

TABLE I. COMPARISON OF POWER OUTPUT, WHICH SHOWS THE IMPACT OF ADDING VEGETATION UNDER THE COLLECTOR ROOF

Systems	Power output (kW)	
	With vegetation	Without vegetation
Reference plant	31.2	50.01
Plant with secondary collector roof	39.6	59.7
Plant with secondary and tertiary collector roof	60.04	80.2

Conditions: solar irradiation of 1000 W/m^2 and a ground temperature of 324 K.

VIII. A CASE STUDY

The functioning of solar systems is strongly tied to the amount of the solar radiation received. The initial focus of the current study was on this key factor, since Algeria has a higher solar potential than other countries in the Mediterranean region [25-30]. This study focuses on Tamanrasset, a city in southern Algeria with an ideal location for utilizing solar energy and its associated technologies. The city's geographical coordinates are listed in [12]. The average monthly daily solar radiation data, measured in MJ/m^2/day, were obtained from various national and international databases, including the Solar Atlas of Algeria [12, 27, 28], the Photovoltaic GIS, and Metronome, which is a commercial data source. The Tamanrasset region is located in the southern part of Algeria and has a dry Saharan climate with abundant sunshine and flat, unused areas, making it an ideal location for solar energy utilization and the adoption of SCPP technology, which will provide electric power to remote villages in southern Algeria. Additionally, harnessing thermal energy in the collector zone through greenhouse farming practices will significantly reduce the cost of energy production. Tamanrasset experiences high levels of solar radiation (28.8 MJ/m^2/day) [12] and the highest levels occur in June. The average ambient temperature in Tamanrasset can reach 29 °C [12].

Three simulations were conducted for three SCPP configurations: a reference plant, a plant with a secondary collector roof, and a plant with both secondary and tertiary collector roofs. The simulations were based on previously established plant design parameters, vegetation properties, and maximum allowable vegetation temperature as described in [11]. The integration of vegetation under the collector roof was examined, with the vegetation extending from the perimeter edge out to radius R_{veg}. The simulations compared the three plant configurations located in the Tamanrasset region. The results, displayedin Figures 4-6, demonstrate that the secondary and tertiary roof system generates the highest amount of monthly electricity in the Tamanrasset climate. Adding vegetation to the reference solar chimney system reduces the electricity output compared to the same system without vegetation. In general, the secondary and tertiary roof system performs the best out of the three configurations examined, but incorporating vegetation into any of the systems lowers the power generation capacity.

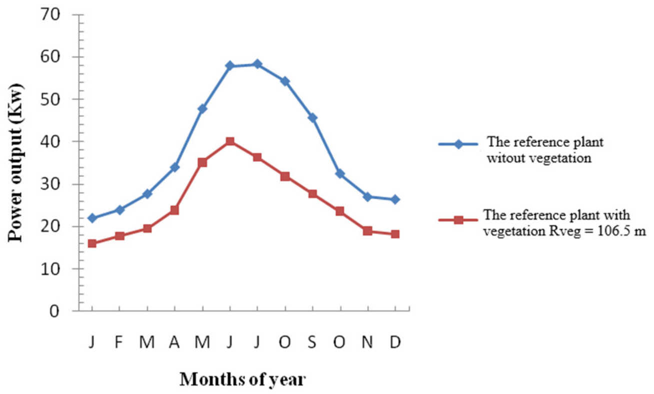

Fig. 4. Monthly average productivity of the SCPP at Tamanrasset.

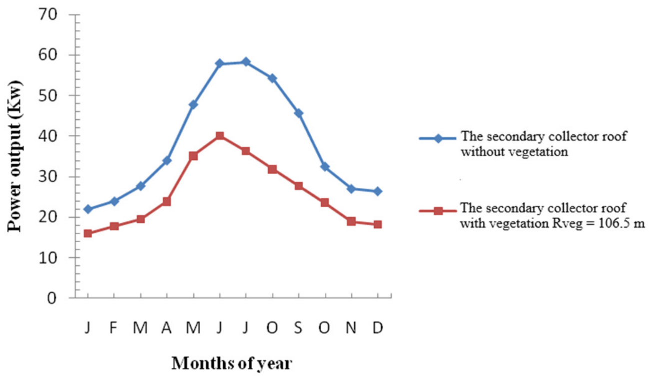

Fig. 5. Monthly average productivity of the SCPP at Tamanrasset.

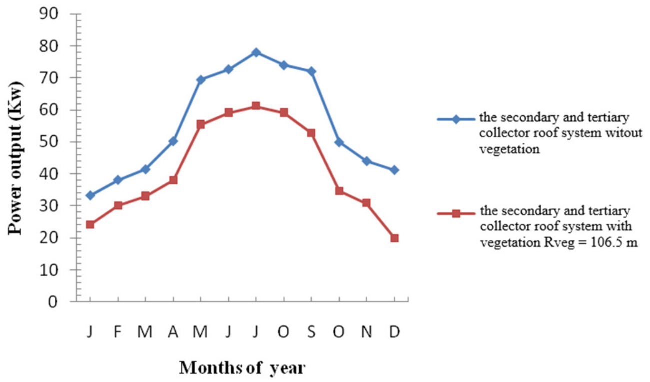

Fig. 6. Monthly average productivity of the SCPP at Tamanrasset.

IX. CONCLUSION

This paper studied numerically Solar Chimney Power Plants (SCPPs) with and without vegetation integration under the collector roof. The primary objective was to assess the vegetation's effect on the power output. A reference SCPP design, one with a secondary collector roof, and configurations with secondary and tertiary collector roofs were analyzed, both with and without vegetation. The results demonstrated that the secondary and tertiary roof system achieved the highest annual electricity generation of 34-80 kW. The findings indicate that while incorporating vegetation into solar chimney plants is likely viable, it would substantially reduce the electricity production capacity. In summary, simulations evaluated the impacts of vegetation and collector roof designs, revealing that vegetation integration decreases the output while implementing secondary and tertiary collectors increases the plant's production capability.

ACKNOWLEDGEMENT

This study was funded by the Ministry of Higher Education and Scientific Research, Algeria (Grant Reference Number A10N01UN110120230001). We extend our sincere gratitude to our Research Laboratory for their invaluable assistance in facilitating a portion of this work.

REFERENCES

[1] A. Dhahri and A. Omri, "A Review of solar Chimney Power Generation Technology," *International Journal of Engineering and Advanced Technology*, vol. 2, no. 3, pp. 1–17, Feb. 2013.

[2] E. M. Heisler, "Exploring alternative designs for solar chimneys using computational fluid dynamics," M.S. thesis, Virginia Polytechnic Institute and State University, Blacksburg, VA, USA, 2014.

[3] M. Humphries, "Solar Tower in Arizona to power 150,000 homes for 80 years," *GEEK, July* 21 (2001).

[4] T. Tayebi and D. Mahfoud, "Numerical Simulation of Natural Convection in a Solar Chimney," *International Journal Of Renewable Energy Research*, vol. 2, no. 4, pp. 712–717, Dec. 2012.

[5] W. Haaf, K. Friedrich, G. Mayer, and J. Schlaich, "Solar Chimneys Part I: Principle and Construction of the Pilot Plant in Manzanares," *International Journal of Solar Energy*, vol. 2, no. 1, pp. 3–20, Jan. 1983, https://doi.org/10.1080/01425918308909911.

[6] R. Rabehi, A. Chaker, Z. Aouachria, and M. Tingzhen, "CFD analysis on the performance of a solar chimney power plant system: Case study in Algeria," *International Journal of Green Energy*, vol. 14, no. 12, pp. 971–982, Sep. 2017, https://doi.org/10.1080/15435075.2017.1339043.

[7] S. Hu, D. Y. C. Leung, M. Z. Q. Chen, and J. C. Y. Chan, "Effect of guide wall on the potential of a solar chimney power plant," *Renewable Energy*, vol. 96, pp. 209–219, Oct. 2016, https://doi.org/10.1016/j.renene.2016.04.040.

[8] H. Hadyan, "Theoretical Analysis and Experimental Optimization of Solar Updraft Power Generator," Ph.D. dissertation, Kyoto University, Kyoto, Japan, 2015.

[9] E. Gholamalizadeh and M.-H. Kim, "Three-dimensional CFD analysis for simulating the greenhouse effect in solar chimney power plants using a two-band radiation model," *Renewable Energy*, vol. 63, pp. 498–506, Mar. 2014, https://doi.org/10.1016/j.renene.2013.10.011.

[10] F. Cao, H. Li, L. Zhao, T. Bao, and L. Guo, "Design and simulation of the solar chimney power plants with TRNSYS," *Solar Energy*, vol. 98, pp. 23–33, Dec. 2013, https://doi.org/10.1016/j.solener.2013.05.022.

[11] B. Djaouida, Z. Aouachria, A. H. Benmachiche, and S. Ali, "Controlling power output of solar chimney power plant according to demand," *International Journal of Ambient Energy*, vol. 41, no. 13, pp. 1467–1481, Nov. 2020, https://doi.org/10.1080/01430750.2018.1517677.

[12] S. Ali, B. Djaouida, A. H. Benmachiche, and Z. Aouachria, "Performance analysis of a solar chimney power plant system in two Algeria regions," *International Journal of Ambient Energy*, vol. 43, no. 1, pp. 4820–4831, Dec. 2022, https://doi.org/10.1080/01430750.2021.1922500.

[13] T. Ming, X. Wang, R. K. de Richter, W. Liu, T. Wu, and Y. Pan, "Numerical analysis on the influence of ambient crosswind on the performance of solar updraft power plant system," *Renewable and Sustainable Energy Reviews*, vol. 16, no. 8, pp. 5567–5583, Oct. 2012, https://doi.org/10.1016/j.rser.2012.04.055.

[14] H. Huang, H. Zhang, Y. Huang, and F. Lu, "Simulation Calculation on Solar Chimney Power Plant System," in *Challenges of Power Engineering and Environment*, K. Cen, Y. Chi, and F. Wang, Eds. Berlin, Heidelberg: Springer, 2007, pp. 1158–1161.

[15] P. Guo, J. Li, Y. Wang, and Y. Wang, "Numerical study on the performance of a solar chimney power plant," *Energy Conversion and Management*, vol. 105, pp. 197–205, Nov. 2015, https://doi.org/10.1016/j.enconman.2015.07.072.

[16] S. Nasirivatan, A. Kasaeian, M. Ghalamchi, and M. Ghalamchi, "Performance optimization of solar chimney power plant using electric/corona wind," *Journal of Electrostatics*, vol. 78, pp. 22–30, Dec. 2015, https://doi.org/10.1016/j.elstat.2015.09.007.

[17] M. Ghalamchi, A. Kasaeian, M. Ghalamchi, and A. H. Mirzahosseini, "An experimental study on the thermal performance of a solar chimney with different dimensional parameters," *Renewable Energy*, vol. 91, pp. 477–483, Jun. 2016, https://doi.org/10.1016/j.renene.2016.01.091.

[18] S. Liu and Y. Li, "Heating performance of a solar chimney combined PCM: A numerical case study," *Energy and Buildings*, vol. 99, pp. 117–130, Jul. 2015, https://doi.org/10.1016/j.enbuild.2015.04.020.

[19] Y. Li and S. Liu, "Numerical study on thermal behaviors of a solar chimney incorporated with PCM," *Energy and Buildings*, vol. 80, pp. 406–414, Sep. 2014, https://doi.org/10.1016/j.enbuild.2014.05.043.

[20] B. F. Attig, M. S. Guellouz, M. Sahraoui, and S. Kaddeche, "A numerical study of solar chimney power plants in Tunisia," *Journal of Physics: Conference Series*, vol. 596, no. 1, Dec. 2015, Art. no. 012006, https://doi.org/10.1088/1742-6596/596/1/012006.

[21] Z. Akhtar and K. V. S. Rao, "Study of economic viability of 200 MW solar chimney power plant in Rajasthan, India," in *1st International Conference on Non Conventional Energy*, Kalyani, India, Jan. 2014, pp. 84–88, https://doi.org/10.1109/ICONCE.2014.6808689.

[22] J. Schlaich, *The Solar Chimney: Electricity from the Sun*. Geislingen, Germany: Edition Axel Menges, 1995.

[23] R. Haxaire, "Caracterisation et Modelisation des ecoulements d'air dans une serre," Ph.D. dissertation, Cote d'Azur University, Nice, France, 1999.

[24] A. Wahid, S. Gelani, M. Ashraf, and M. R. Foolad, "Heat tolerance in plants: An overview," *Environmental and Experimental Botany*, vol. 61, no. 3, pp. 199–223, Dec. 2007, https://doi.org/10.1016/j.envexpbot.2007.05.011.

[25] A. Mefti, M. Y. Bouroubi, and H. Mimouni, "Evaluation du potentiel énergétique solaire," *Bulletin des Energies Renouvelables*, vol. 2, Dec. 2002.

[26] J. C. Maxwell, *Treatise on Electricity and Magnetism, Vol. 1*, 3rd ed. New York, NY, USA: Dover Publications, 1954.

[27] M. R. Yaiche, A. Bouhanik, S. M. A. Bekkouche, A. Malek, and T. Benouaz, "Revised solar maps of Algeria based on sunshine duration," *Energy Conversion and Management*, vol. 82, pp. 114–123, Jun. 2014, https://doi.org/10.1016/j.enconman.2014.02.063.

[28] A. Lahcene, A. Y. Benazza, and M. Benguediab, "The Effect of Geometric Parameters on the Performance of Solar Chimney: A Numerical and Experimental Study," *Engineering, Technology & Applied Science Research*, vol. 10, no. 6, pp. 6456–6461, Dec. 2020, https://doi.org/10.48084/etasr.3901.

[29] A. Oudrane, B. Aour, B. Zeghmati, X. Chesneau, and H. Massaoud, "Study and Simulation of the Density of the Incident Solar Flux on the Walls of a Building in Adrar, Algeria," *Engineering, Technology & Applied Science Research*, vol. 7, no. 5, pp. 1940–1945, Oct. 2017, https://doi.org/10.48084/etasr.1337.

[30] I. Zeghib and A. Chaker, "Efficiency of a Solar Hydronic Space Heating System under the Algerian Climate," *Engineering, Technology & Applied Science Research*, vol. 6, no. 6, pp. 1274–1279, Dec. 2016, https://doi.org/10.48084/etasr.875.

[31] Y. Xu and X. Zhou, "Performance of a modified solar chimney power plant for power generation and vegetation," *Energy*, vol. 171, pp. 502–509, Mar. 2019, https://doi.org/10.1016/j.energy.2019.01.033.

[32] J. P. Pretorius, "Optimization and Control of a Large-scale Solar Chimney Power Plant," Ph.D. dissertation, University of Stellenbosch, Stellenbosch, South Africa, 2007.