



International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 15, Issue 02, February 2026)

MVP`S Rajarshi Shahu Maharaj Polytechnic, Nashik Hybrid Solar Power Generation from Waste Using Solar and Thermoelectric Generator

Shlok Ahire¹, Jayesh Mohite², Piyush Pagar³, Prathamesh Shinde⁴

^{1,2,3,4}Department of Electrical Engineering, MVP`S Rajarshi Shahu Maharaj Polytechnic, Nashik, Maharashtra, India

Abstract— The growing demand for electrical energy, coupled with depletion of fossil fuels and rising environmental concerns, necessitates the development of sustainable renewable energy systems. This paper presents a hybrid solar power generation system utilizing solar photovoltaic (PV) energy and waste heat recovery from canteen waste using thermoelectric generators (TEGs). Solar energy provides primary power during daytime, while thermal energy released from decomposing or heated biodegradable waste is converted into electrical energy through the Seebeck effect. The proposed hybrid system enhances energy efficiency, improves waste management, and reduces environmental pollution. The design is simple, economical, and suitable for small-scale institutional applications.

Keywords—Hybrid energy system, Solar photovoltaic, Thermoelectric generator, Waste heat recovery, Canteen waste.

I. INTRODUCTION

Rapid industrialization and urbanization have significantly increased energy consumption worldwide. Conventional fossil fuel-based power generation contributes to greenhouse gas emissions and environmental degradation. Renewable energy sources such as solar and biomass offer cleaner alternatives; however, single-source systems suffer from intermittency and inefficiency. Hybrid renewable energy systems combine multiple energy sources to improve reliability and performance. Canteen waste generated in educational institutions contains biodegradable materials capable of producing thermal energy during decomposition. This waste heat is typically lost to the environment. Integrating waste heat recovery with solar power generation provides an innovative approach to sustainable energy utilization.

II. PROBLEM STATEMENT

Solar energy generation is intermittent and limited by weather conditions, while canteen waste disposal poses environmental and health challenges. Despite containing recoverable thermal energy, canteen waste remains underutilized. There is a need for a hybrid system that efficiently combines solar power and waste heat recovery to generate reliable electrical energy while addressing waste management issues.

III. OBJECTIVES

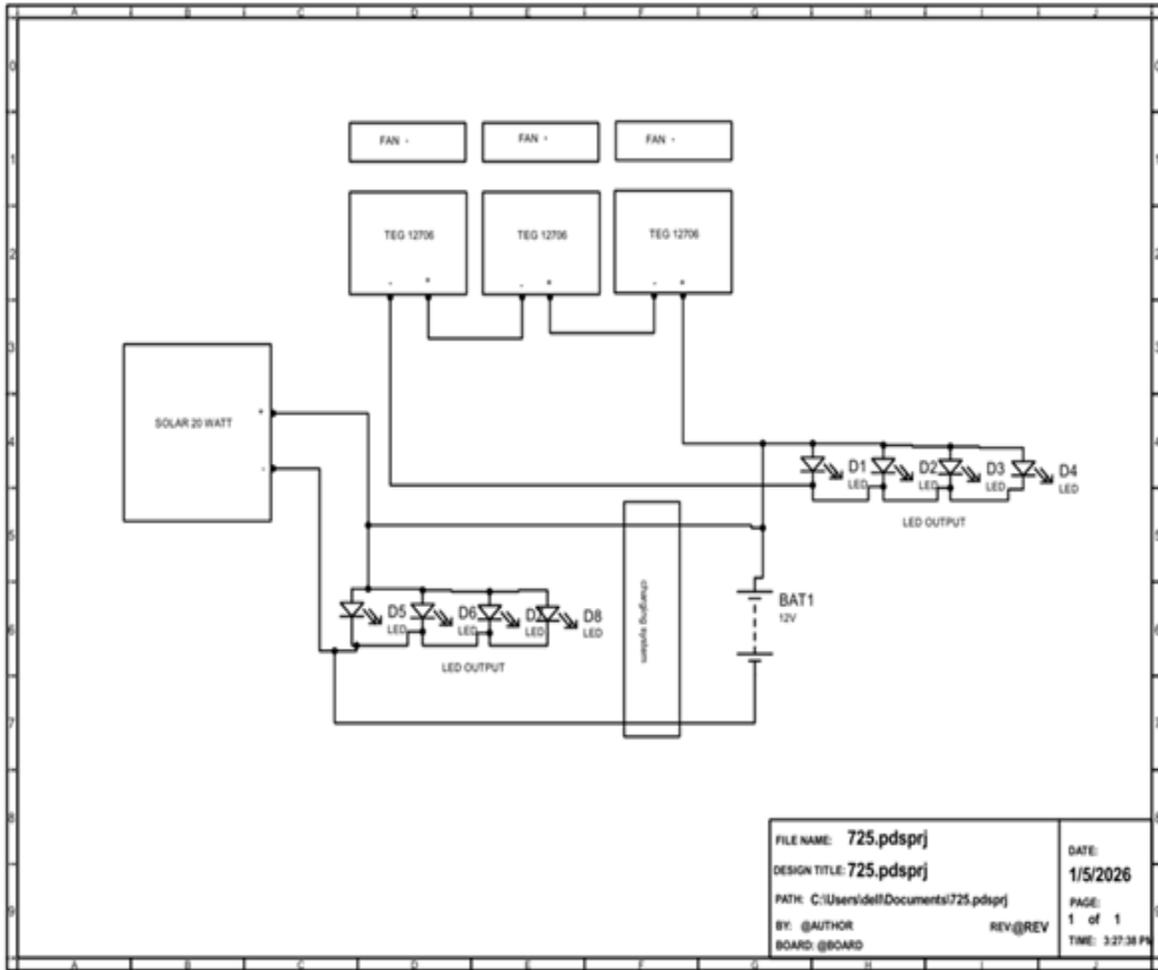
The objectives of the proposed system are:

- 1) To design a hybrid renewable energy system integrating solar PV and thermoelectric generation.
- 2) To utilize canteen waste as a source of recoverable thermal energy.
- 3) To improve overall system efficiency and reliability.
- 4) To promote eco-friendly waste management

IV. LITERATURE SURVEY

Previous studies have explored hybrid solar-thermoelectric systems for enhanced energy harvesting. Hanani et al. demonstrated improved efficiency by integrating TEGs with PV panels to capture waste heat. Sahari et al. reported increased power output in PV-TEG hybrid configurations. Other researchers have investigated advanced thermal management and optimized materials to improve thermoelectric performance. Literature confirms that hybridization improves energy utilization compared to standalone systems.

➤ DIAGRAM



V. SYSTEM DESIGN

The proposed system consists of two main subsystems: a solar energy generation unit and a canteen waste heat recovery unit. The solar unit employs photovoltaic panels to convert solar radiation into electrical energy. The waste heat recovery unit utilizes a thermoelectric generator attached to a heat collection chamber containing biodegradable canteen waste. Heat sinks maintain temperature difference across the TEG to enable power generation.

VI. WORKING PRINCIPLE

The solar subsystem operates on the photovoltaic effect, where incident sunlight generates direct current electricity.

Simultaneously, thermal energy released from canteen waste creates a temperature gradient across the thermoelectric generator. According to the Seebeck effect, this temperature difference produces an electrical voltage. Outputs from both subsystems are combined to supply electrical loads.

VII. ADVANTAGES AND APPLICATIONS

The hybrid system offers reduced pollution, improved energy efficiency, decentralized power generation, and effective waste management. Applications include educational institutions, hostels, community centers, and small off-grid installations.



International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 15, Issue 02, February 2026)

VIII. FUTURE SCOPE

The Hybrid Solar Power Generation from Canteen Waste Using Solar and Thermoelectric Generator system has significant potential for further development and improvement. Future work can focus on increasing system efficiency by using advanced thermoelectric materials with higher conversion efficiency. Improved heat transfer mechanisms, such as optimized heat exchangers or phase change materials, can be incorporated to enhance waste heat recovery.

The system can be scaled up for higher power generation by increasing the number of solar panels and thermoelectric modules. Integration with energy storage systems such as batteries can provide continuous power supply during non-operational periods. Automation and monitoring systems can be introduced to optimize performance and ensure safe operation.

IX. RESULTS AND DISCUSSION

The system demonstrates stable power generation using renewable sources. Although thermoelectric efficiency is relatively low, the utilization of waste heat enhances total energy output. The hybrid configuration improves reliability compared to standalone solar systems.

X. CONCLUSION

The literature clearly demonstrates the evolution of hybrid solar-thermoelectric systems from conceptual modeling to experimental validation. Across multiple configurations — from simple PV-TEG pairings to advanced evacuated tube integrations — research consistently finds that combining solar power harvesting with thermoelectric conversion of waste heat can improve overall energy efficiency and system utility. Ongoing challenges remain, particularly in materials, thermal management, and scalability; nevertheless, hybrid systems represent a promising direction in sustainable energy research.

REFERENCES

- [1] M. N. Hanani et al., "Development of a Hybrid Solar and Waste Heat Thermal Energy Harvesting System," ETASR, 2023.
- [2] N. Sahari et al., "Hybrid Photovoltaic and Thermoelectric Generator for Energy Harvesting," IJETT, 2022.
- [3] H. Al-Tahaine and A. AlEssa, "Hybrid TEG/Evacuated Tube Solar Collectors," Springer, 2022.