World Academy of Science, Engineering and Technology
International Journal of Energy and Power Engineering
Vol:18, No:02, 2024

Nighttime Power Generation Using Thermoelectric Devices

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Abstract : While the sun serves as a robust energy source, the frigid conditions of outer space present promising prospects for nocturnal power generation due to its continuous accessibility during nighttime hours. This investigation illustrates a proficient methodology facilitating uninterrupted energy capture throughout the day. This method involves the utilization of water-based heat storage systems and radiative thermal emitters implemented across thermometric devices. Remarkably, this approach permits an enhancement of nighttime power generation that exceeds the level of 1 Wm-2, which is unattainable by alternative methodologies. Outdoor experiments conducted at the King Abdulaziz City for Science and Technology (KACST) have demonstrated unparalleled performance, surpassing prior experimental benchmarks by nearly an order of magnitude. Furthermore, the developed device exhibits the capacity to concurrently supply power to multiple light-emitting diodes, thereby showcasing practical applications for nighttime power generation. This research unveils opportunities for the creation of scalable and efficient 24-hour power generation systems based on thermoelectric devices. Central findings from this study encompass the realization of continuous 24-hour power generation from clean and sustainable energy sources. Theoretical analyses indicate the potential for nighttime power generation reaching up to 1 Wm-2, while experimental results have reached nighttime power generation at a density of 0.5 Wm-2. Additionally, the efficiency of multiple light-emitting diodes (LEDs) has been evaluated when powered by the nighttime output of the integrated thermoelectric generator (TEG). Therefore, this methodology exhibits promise for practical applications, particularly in lighting, marking a pivotal advancement in the utilization of renewable energy for both on-grid and off-grid scenarios.

Keywords : nighttime power generation, thermoelectric devices, radiative cooling, thermal management
Conference Title : ICSTESH 2024 : International Conference on Solar Thermal Energy and Solar Heating
Conference Location : Jeddah, Saudi Arabia
Conference Dates : February 19-20, 2024