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Debut in Research: Young Talents from Africa

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Winner

Photovoltaic cell cooling kits

Research Description

Photovoltaic (PV) systems are critical to the global transition toward renewable energy, yet are plagued by challenges like overheating, thermal gradients, and accelerated degradation, all of which threaten their efficiency and longevity. The energy sector is continuously pursuing innovative solutions to enhance the efficiency and sustainability of photovoltaic (PV) systems, and to counter these challenges. The Master's Degree Thesis directly addresses these challenges by developing a novel cooling kit designed for commercial PV panels and large-scale solar power plants. The core objective of this project is to protect PV panels from these detrimental effects and recover energy losses using a passive cooling technique. Central to the design is the integration of bio-based Phase Change Materials (PCMs), which are chosen for their sustainability and high thermal storage capacity. This cooling kit is engineered to regulate the temperature of PV cells, thereby enhancing electrical efficiency and extending operational lifespan. The kit is particularly effective during peak hours when overheating is most prevalent, maximizing energy output. Constructed from bio-based, recyclable materials, it aligns with global sustainability goals, and its cost-effective design ensures compatibility with all PV panel types. The cooling kit is durable, requiring no periodic maintenance and operating without moving parts or electrical components. The research began with a comprehensive analysis of the problems faced by PV panels in real-world conditions. This was followed by identifying the optimal design parameters for the PV/PCM cooling kit, which involved an in-depth examination of material properties, thermal management strategies, and the practicalities of deploying such a system. A controlled experimental setup was then established to rigorously test the cooling kit's performance under varying environmental conditions. The results were notable: the PV/PCM kit successfully reduced the temperature of PV cells by up to 12°C,

leading to an approximate 5% improvement in electrical efficiency. The implications of these findings are profound. In the short term, this innovative cooling solution offers a practical and scalable method to enhance the performance of existing PV systems. By reducing thermal stress on PV panels, the cooling kit not only extends their lifespan but also offers a reduction in maintenance costs, aligning with industry goals for sustainability and cost efficiency. This makes the technology particularly attractive for large-scale industrial applications, where efficiency gains can translate into significant cost savings and increased energy output. In the long term, the integration of bio-based PCMs in PV cooling systems represents a substantial step forward in the pursuit of sustainable and environmentally friendly energy solutions. The use of bio-based materials aligns with global efforts to reduce dependence on fossil fuels and minimize the environmental footprint of renewable energy technologies. Furthermore, by effectively managing the operational temperature of PV panels, the cooling kit reduces thermal gradients and degradation rates, ultimately enhancing the lifespan of solar power plants. This improvement not only boosts the return on investment but also minimizes long-term costs, making it a viable solution for the future. In conclusion, this study contributes to the ongoing research aimed at overcoming the challenges faced by PV systems. The successful development and testing of the PV/PCM cooling kit demonstrate its potential as a crucial component in the future of renewable energy, offering benefits that are both immediate and enduring.