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Impact of PV Panel Cleaning on Solar-Assisted Dates Drying Performance in Arid Climates

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Extended Abstract

The integration of renewable energy technologies in agriculture, particularly for post-harvest processing such as dates drying, is becoming increasingly important in arid and semi-arid regions where energy demand is high and resources are constrained. Solar-powered drying systems, typically reliant on photovoltaic (PV) panels to generate the necessary thermal and electrical energy, encounter significant operational challenges in desert environments due to the high rate of dust accumulation on panel surfaces. This accumulation reduces light absorption capacity, thereby lowering electrical efficiency and indirectly affecting the thermal performance of solar dryers. To address this issue, the present study investigates the experimental performance of a hybrid PV panel cleaning system that combines compressed air jets with fine water spraying. It evaluates its impact on both the electrical output of the PV modules and the drying capacity of a solar dryer designed explicitly for date fruits. To replicate varying ambient temperature and humidity conditions, field experiments were conducted in Riyadh, Saudi Arabia, during the summer and fall seasons. The study assessed key parameters, including PV conversion efficiency, air inlet temperature to the drying chamber, evaporation rate, and moisture reduction in dates.

The findings showed that although routine cleaning brought about a certain degree of improvement in PV efficiency, the enhancements were relatively minimal, with electrical performance only increasing by around 0.06%. This marginal increase in power generation translated into a slight elevation of the drying chamber inlet temperature by up to 0.6°C, leading to minor enhancements in drying kinetics. The hybrid cleaning system demonstrated comparative advantages over air-only and water-only methods, offering improved dust removal efficiency while reducing excessive water consumption, thereby contributing to greater operational sustainability in water-scarce environments. Nevertheless, the study demonstrates that the dominant factors influencing drying effectiveness were the naturally fluctuating ambient conditions, primarily air temperature and relative humidity, rather than PV cleanliness alone. These findings emphasize that while maintaining PV panel cleanliness can provide supportive gains for solar-powered agricultural dryers, optimizing system design and operation must also incorporate adaptive strategies to cope with varying environmental conditions. This research enhances the performance and reliability of renewable energy-based food processing systems in arid regions, highlighting the need for integrated solutions that address both technological and environmental challenges.