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ARE SOLAR TREES A BETTER WAY TO CAPTURE SUNLIGHT? A FEASIBILITY STUDY USING MONTE CARLO SIMULATIONS OF SOLAR RADIATION TRANSPORT

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ABSTRACT It is hypothesized that solar photovoltaic cells arranged in complex three-dimensional leaf-like configurations—referred to as a solar tree—can potentially collect more sunlight than traditionally used flat configurations. The three-dimensional space can be utilized to increase the overall surface area over which the sunlight may be captured. Also, as opposed to traditional flat panel configurations where the capture efficiency decreases dramatically for shallow angles of incidence, the capture efficiency of a solar tree is hampered little by shallow angles of incidence due to the three-dimensional orientation of the solar leaves. In this paper, high fidelity Monte Carlo simulation of radiation transport is conducted to gain insight into whether the above hypotheses are true. The studies show that except for near-normal solar incidence angles, solar trees capture sunlight more effectively than flat panels. The Monte Carlo results were also interpolated to construct a daily sunlight capture profile both for mid-winter and mid-summer for five North American cities located at various latitudes. In the best-case scenario—mid-winter and at high latitudes—the solar tree improved sunlight capture by 322%, while in summer the improvement manifested was 57%.