Performance and land footprint analysis of a solar photovoltaic tree

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ABSTRACT
Solar energy is abundant in quantity and free of cost. Solar PV technology converts incoming radiation from Sun directly into electricity, which makes it one of the most promising renewable technologies available for sustainable development. However, it consumes a large amount of land, which can be used for other human activities. Solar PV tree is a novel technique used for Sunlight capture. It consists of PV panels fixed as leaves on a tree-like structure, and it reduces the land footprint of the PV system. In this study, six different semi-dome shape solar PV tree structures were designed based on increasing number of layers and panels (structures (a) to (f)), at different tilt angles and orientation angles. The performance of these models was estimated and analyzed through simulation and results were compared with a land-based PV system of the same capacity for Kuala Lumpur, Bhopal, and Barcelona. The study showed that as the number of panels and layers are increased while keeping the total capacity constant, the structure produces more energy. Structures (d), (e) and (f) with five, six and seven layers respectively, produced more energy than land-based PV system for all the three locations. Structure (f) with seven layers and 49 panels was the best performing structure for all three locations considered in this study. Its annual energy generation at Kuala Lumpur, Bhopal and Barcelona was 17.79%, 41.06% and 20.97% more than the energy generated by the land-based PV systems of the same capacity at these three locations respectively. The study also suggested that the percentage increase in land use efficiency due to the use of a solar PV tree for Kuala Lumpur, Bhopal and Barcelona is 32.09%, 43.35%, and 33.87% respectively.

KEYWORDS:
Solar PV tree; Solar PV system; Land footprint; Effect of orientation angle; Effect of tilt angle