Abstract

Problems of greenhouse effect and depletion of conventional resources in the last two decades have resulted in a worldwide exponentially growing photovoltaic market for renewable power generation. The Indian government has recently announced a goal of achieving 100 GWe photovoltaic installations by 2022, out of which 40% is to be generated in the rooftop segment, thus making the power generation distributed in nature. This work identifies the different technological configurations for rooftop photovoltaic (RPV) and conducts their techno-economic feasibility analysis from the customer point of view for the development of a sustainable PV market in India.

A comprehensive model is developed for analysing various types of RPV systems taking into account the availability of solar resources, technological options and economic feasibility across the different states of India. Solar resource assessment is made using a clear-sky model brought in line with the recent satellite data using a correction factor. The systems are designed for different capacities ranging from 1 to 2 kWe with different storage capacities. The various PV configurations analysed in this work include a) fixed tilt, b) 2-tilt, c) 3-tilt, d) single-axis tracked, and e) dual-axis tracked, panels. Analysed RPV systems are grid-tied which do bi-directional transactions of energy with the grid to balance excess or shortage of energy as per user's need. In the economic analysis, it has been assumed that total initial cost of the system installation is obtained through a loan with 100% debt fraction and repaid through equated monthly instalment in 25 years.

Two sets of inputs are introduced in the model, one consisting of geographical variables and another related to economics. The results show that cities lying below the latitudes of Panjim and Raipur also need wall azimuth angle adjustment for a certain period in a year for 2-tilt and 3-tilt system respectively. The percentage of energy gain through single-axis and dual-axis tracker system as compared to fixed tilt system lies in a range of 10% to 29% depending on the location. Through economic analysis, considering 15% of Indian government subsidy over the system cost, comparison of levelized cost of electricity (LCOE) for each RPV configuration is made, which articulates that fixed tilt with no storage as the pre-eminent configuration among all studied configurations. Mumbai in Maharashtra resulted in minimum LCOE, i.e. Rs. 5.5/kWhe from the fixed tilt RPV system without storage, which is due to the availability of maximum solar radiation. However, as LCOE does not consider inflation over the grid electricity tariff, to know the economic competitiveness of the system from the long-term perspective, further analysis is conducted with net present value (NPV). To determine the profitability of an RPV installation, the NPV of saving and the Pay-Back Period are found. Through this profitability analysis, majority of the states turned out to be demotivating for the RPV system due to very low electricity tariff; for example, the NPV of Savings is minimal (negative) in Srinagar due to the very low tariff of grid electricity, i.e., Rs. 1.8/kWhe, whereas Kolkata starts showing savings just after 1st year of installation due to grid parity of electricity from the RPV system even with storage capacity up to 1 kWhe. With increase in the battery capacity, the NPV of savings decreases drastically due to higher battery replacement cost and short battery life.