The Parametric Analysis and Modelling of a Low-Concentrating Compound Parabolic Concentrator Photovoltaic System

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Abstract

Daily performance monitoring and measurement of current-voltage (I-V) characteristics of a ≅15.93W photovoltaic (PV) module in a compound parabolic concentrator (CPC) cavity with a concentration factor of X4 is undertaken. The system is operated under different cooling mechanisms to determine the effects of module temperature on the power output. The data obtained is used to modify the I-V characteristic model to predict the daily power output characteristics of the system. An optimum concentration factor for the system is determined and the performance of the system with this concentration factor and under ideal conditions evaluated using the model.

Daily power output measurements show that at irradiance levels of ~1100W/m^2 the power drops from 26.7W at module temperatures of 48°C to 7W when the module temperature is 110°C. Without concentration the maximum power output of the module is 13.5W. The model developed shows reasonable accuracy with deviations less than ± 8.3%. An optimum concentration factor of X2.59 is determined which, on a clear sky day, keeps the module temperature below 70°C and increases the daily energy output of the system by 17% to 122Wh. Retaining a concentration factor of X4 and keeping the module temperatures below 48°C increases the daily energy output by 59% to 155Wh. Ideal cell conditions; zero series resistance and infinite shunt resistance, give a theoretical limit of 255Wh. This shows that even at reasonably low module temperatures the parasitic resistances reduce the output of the system by as much as 39%, with series resistance playing the much larger role.

Keywords: Cooling; compound parabolic concentrator; modeling; daily power output; optimum concentration factor