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Tandem Concentrated Photovoltaic-Thermoelectric Hybrid System: Feasibility Analysis and Performance Enhancement Through Material Assessment Methodology

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Abstract : Photovoltaic (PV) power generation, as one of the most commercialized methods to utilize solar power, can only convert a limited range of solar spectrum into electricity, whereas the majority of the solar energy is dissipated as heat. To address this problem, thermoelectric (TE) module is often integrated with the concentrated PV module for waste heat recovery and regeneration. In this research, a feasibility analysis is conducted for the tandem concentrated photovoltaic-thermoelectric (CPV-TE) hybrid system considering various operational parameters as well as TE material properties. Furthermore, the power output density of the CPV-TE hybrid system is maximized by selecting the optimal TE material with application of a systematic assessment methodology. In the feasibility analysis, CPV-TE is found to be more advantageous than sole CPV system except under high optical concentration ratio with low cold side convective coefficient. It is also shown that the effects of the TE material properties, including Seebeck coefficient, thermal conductivity, and electrical resistivity, on the feasibility of CPV-TE are interacted with each other and might have opposite effect on the system performance under different operational conditions. In addition, the optimal TE material selected by the proposed assessment methodology can improve the system power output density by 227 W/m2 under highly concentrated solar irradiance hence broaden the feasible range of CPV-TE considering optical concentration ratio.

Keywords : feasibility analysis, material assessment methodology, photovoltaic waste heat recovery, tandem photovoltaic-thermoelectric
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