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Temperature Distribution Inside Hybrid photovoltaic-Thermoelectric Generator Systems and their Dependency on Exposition Angles

Authors : Slawomir Wnuk

Abstract : Due to widespread implementation of the renewable energy development programs the, solar energy use increasing constantlyacross the world. Accordingly to REN21, in 2020, both on-grid and off-grid solar photovoltaic systems installed capacity reached 760 GWDCand increased by 139 GWDC compared to previous year capacity. However, the photovoltaic solar cells used for primary solar energy conversion into electrical energy has exhibited significant drawbacks. The fundamentaldownside is unstable andlow efficiencythe energy conversion being negatively affected by a rangeof factors. To neutralise or minimise the impact of those factors causing energy losses, researchers have come out withvariedideas. One ofpromising technological solutionsoffered by researchers is PV-MTEG multilayer hybrid system combiningboth photovoltaic cells and thermoelectric generators advantages. A series of experiments was performed on Glasgow Caledonian University laboratory to investigate such a system in operation. In the experiments, the solar simulator Sol3A series was employed as a stable solar irradiation source, and multichannel voltage and temperature data loggers were utilised for measurements. The two layer proposed hybrid systemsimulation model was built up and tested for its energy conversion capability under a variety of the exposure angles to the solar irradiation with a concurrent examination of the temperature distribution inside proposed PV-MTEG structure. The same series of laboratory tests were carried out for a range of various loads, with the temperature and voltage generated being measured and recordedfor each exposure angle and load combination. It was found that increase of the exposure angle of the PV-MTEG structure to an irradiation source causes the decrease of the temperature gradient ΔT between the system layers as well as reduces overall system heating. The temperature gradient's reduction influences negatively the voltage generation process. The experiments showed that for the exposureangles in the range from 0° to 45°, the 'generated voltage – exposure angle' dependence is reflected closely by the linear characteristics. It was also found that the voltage generated by MTEG structures working with the optimal load determined and applied would drop by approximately 0.82% per each 1° degree of the exposure angle increase. This voltage drop occurs at the higher loads applied, getting more steep with increasing the load over the optimal value, however, the difference isn't significant. Despite of linear character of the generated by MTEG voltage-angle dependence, the temperature reduction between the system structure layers andat tested points on its surface was not linear. In conclusion, the PV-MTEG exposure angle appears to be important parameter affecting efficiency of the energy generation by thermo-electrical generators incorporated inside those hybrid structures. The research revealedgreat potential of the proposed hybrid system. The experiments indicated interesting behaviour of the tested structures, and the results appear to provide valuable contribution into thedevelopment and technological design process for large energy conversion systems utilising similar structural solutions.

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