ANALYSIS OF A HYBRID PHOTOVOLTAIC – THERMOELECTRIC SYSTEM

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Overview

Renewable energy technologies stand today as a feasible and sustainable solution for achieving a fossil fuel free power generation model, promising sufficient energy production and minimizing the costs in mineral wealth. Amongst them, photovoltaic cells (PV) have seen significant performance improvement during the last years. However, photovoltaics still face certain drawbacks by the thermal fatigue developed on the photovoltaic panels, which leads to deteriaoration of electrical performace. Therefore, an important issue refers to methods for maintaining the performance of PVs by decreasing the operating temperature of the cells. In this work, the implementation of thermoelectric generators (TEGs) to harvest the thermal energy of PVs is demonstrated, suggesting that they can be used for the cooling of the PVs, while contributing also to the electrical power generation scheme.

Methods

To evaluate the performance of the PV-TEG hybrid, poly-Si PV cells have been coupled with thermoelectric generators and the hybrid system has been evaluated experimentally. A relevant test bench has been constructed (Fig. 1) and several tests were performed in order to assess the effect of different operating parameters on the performance of the hybrid system. Moreover, an analytical model has been used to evaluate also the performance of the hybrid under different operating conditions and provide more flexibility on the evaluation process.

Bi_2Te_3 thermoelectric modules have been used for the construction of the system as well as the theoretical assessment, since they exhibit improved performance compared to other thermoelectric materials under temperature conditions ranging from room temperature up to approximately 200 °C, which includes also the range of interest for the particular application.

The effect of applying alternative cooling mechanisms on the cold side of the TEC units has also been investigated. Furthermore, the performance effects induced when varying certain ambient parameters has been assessed in detail through the analytical model emplyed.

Finally, an attempt has been made to compare the performance of the proposed hybrid system with the one of a PV-thermal system, where water cooling is applied on the back of the PV.

Results

The experimental as well as theoretical results indicate that improved performance an be obtained by the PV – TEG hybridization, especially for ambient conditions favouring the development of excessive temperature on the poly-Si PV module. The power enhancement achieved for different thermoelectric devices vs. the initial operating temperature of the poly-Si cell is illustrated in Fig. 2.

Similarly, comparison of water cooling process has also been tried and evaluating, illustrating an alternative mechanism for maintaining performance, accompanied by thermal energy storage.

It can be concluded that both systems (either related to TEG integration or application of water cooling) are well promising for their implementation in PV parks for maintaining energy performance, while also providing in some cases potential for additional energy harvesting.

Figure 1. Illustration of the test bench used for the experimental evluation

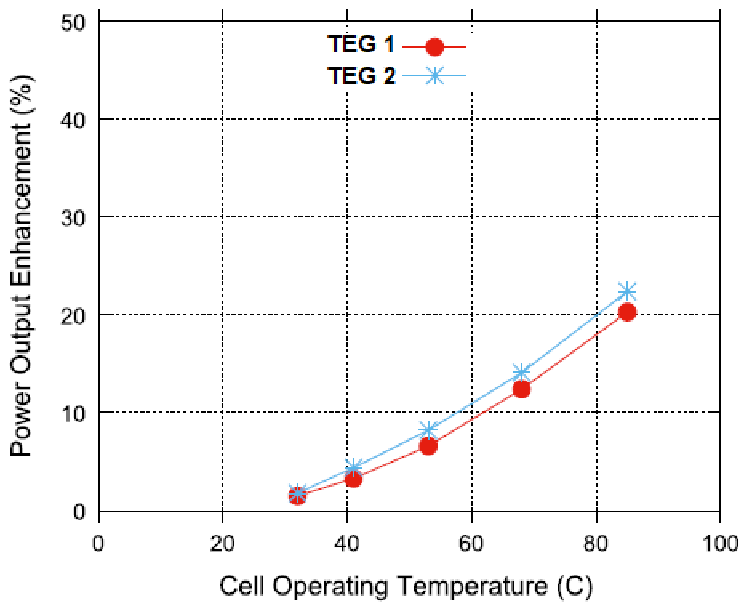

Figure 2. Hybridization power enhancement achieved by integrating different thermoelectric devices

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