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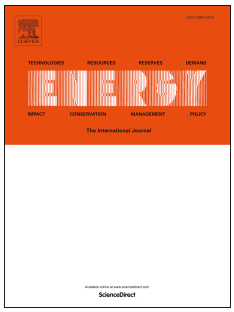

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IMPROVING PHOTOVOLTAICS EFFICIENCY BY WATER COOLING: MODELLING AND EXPERIMENTAL APPROACH

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Abstract:
The increase of photovoltaic cells operating temperature causes an almost linear reduction of their performance. Therefore, continuous efforts need to be done to improve the cells efficiency by controlling their temperature. For this reason, in the present work, the possibility of adding a cooling system to existing photovoltaic units without changing the original module structure is investigated. The selected cooling methods use water to cool the module front side. To investigate the system behaviour, a steady-state and a PV dynamic model have been firstly developed. The steady-state thermal model is used to compute the module permanent regime temperature in relation to fixed and constant ambient conditions and cooling regime while the dynamic model is used to predict the time-response of the module thermal mass during the variation of external parameters. Then, after the design and installation of a test facility, preliminary experimental investigations have been carried out to validate the mathematical models. Finally, the energy and economic performance of the system and the identification of guidelines able to improve the PV overall performance have been presented and discussed. Some preliminary outcomes of the experimental activity on photovoltaic cooling are also outlined.

Keywords:
Photovoltaics; PV cooling; PV steady-state model; PV dynamic model, Water film cooling; Spray cooling.

1. Introduction

The global energy demand is growing faster and the world energy consumption is expected to increase by 33% in the period 2010-2030 [1]. To build a low pollutions power generation system, fossil fuels power plants fed by coal, oil and natural gas need to be limited. Therefore, being renewable energy sources (RES) derived from natural and available resources, characterised by low cost of operation and a minimal impact on the environment, are a viable way to generate clean electricity and heat. Compared to other RES, direct solar radiation has an enormous potential, especially in the tropical regions. Therefore, solar photovoltaic electricity generation is one of the most promising options to encounter the future energy needs. Nowadays, the installation of solar PV panels is increasing all over the world due to their capability of working under different operating conditions. Therefore, it is fundamental to consider that PV panels work at different climatic conditions. For this reason, several researchers have analysed the PV module behaviour and they have estimated that only 15-20% of the solar irradiation can be converted into electricity while the rest is wasted as heat [2]. This aspect constitutes a huge obstacle because the PV module efficiency decreases at a rate of 0.4-0.65% with a one-degree increment of the module temperature [3] [4] [5] [6]. Note that, as observed by Reddy et al. [7] during their investigations, the PV temperature can reach values higher than 80°C if the PV system is installed in hot arid regions. So, there is a considerable interest on controlling the module temperature and, consequently, improving the PV cells performance. In literature, several studies concerning PV cooling and their