



Artificial neural network models for predicting the solar radiation as input of a concentrating photovoltaic system



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ABSTRACT

The energy production analysis of a system based on renewable technology depends on the inputs estimation accuracy. The solar energy is a free resource characterized by high variability; hence, its correct evaluation is a strategic factor for the feasibility of a solar system. In this paper a new methodological approach is presented in order to evaluate more accurately the electric and thermal energy production of a point-focus concentrating photovoltaic and thermal system (CPV/T). Two Artificial Neural Network (ANN) models for predicting solar global radiation and direct normal solar irradiance (DNI) are developed adopting different parameters such as climatic, astronomic and radiometric variables. In particular, a new combination of parameters is proposed in this paper and adopted first of all for the global radiation evaluation whose ANN model can be easily compared with the literature; the data are trained and tested by a multi layer perceptron (MLP). Hence, the results validation for the global solar radiation evaluation has encouraged to design an ANN model for the DNI by means of a similar variables set. The MLP network is trained, tested and validated for the hourly DNI estimation obtaining the MAPE, RMSE and R^2 statistical indexes values respectively equal to 5.72%, 3.15% and 0.992. Finally, the electric and thermal outputs of a point-focus CPV/T system are evaluated varying the concentration factor and cells number, and adopting as input the DNI evaluation results obtained by the ANN model presented in this paper. The CPV/T system outputs are estimated referring to the city of Salerno (Italy) under different meteorological conditions.

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1. Introduction

Renewable technologies play a relevant role in the energy production field. Their impact has become considerable in order to satisfy the energy demands of residential and industrial users [1]. Solar energy is widely recognized as the main renewable source; it constitutes a free resource largely available in the world [2]. The solar energy can be exploited by means of photovoltaic and solar systems in many applications as: demand balancing of electrical energy in national grids, reduction of environmental pollution, design and size of integrated energy systems. In particular, the concentrating photovoltaic and thermal systems (CPV/T) have been highly developed in the last years. Their main characteristic is to concentrate sunlight on a photovoltaic receiver by means of optical devices and then to decrease the solar cells area proportionally to the concentration factor (C) [3] equal to the ratio between the primary concentrator area and receiver area. High temperatures are also reached by means of the sunlight concentration [4]; so, it is necessary to cool the cells. The CPV/T systems usually

adopt triple-junction cells, whose electric efficiency is less affected by the temperature increase [5]. Hence, the CPV/T systems allow the simultaneous production of electrical and thermal energy. These devices are more complex in comparison with the traditional photovoltaic systems and a standard configuration does not exist. In literature many CPV/T systems are present [6] and are different for optical [7], photovoltaic and thermal characteristics [8]. However, since the optics has to focus the sunlight on the cells, these systems can work only with the solar radiation direct component. For this reason it is basic to achieve an accurate evaluation of global and direct radiation. Many models have been developed in literature in order to evaluate the solar radiation. There are empirical [9], numerical and statistical models [10], physical models, etc., but the solar radiation prediction based on most of these models can't be accurate because of the intrinsic complexity of the problem.

The Artificial Neural Network (ANN) models are a very useful solution for problems which depend on many physical phenomena [11]. They adopt the long-term data series obtaining a higher level of reliability. Kalogirou has reported the ANN use in renewable energy systems applications [12]. Moreover, many ANNs have been developed in order to evaluate the global solar radiation. Azadeh et al. [11] estimated monthly the global solar radiation for six cities

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