Instantaneous Responses of on-grid PV Plants to Changes in Environmental and Weather Conditions

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Abstract- The operation of an on-grid, 20 KW, PV, pilot plant is analysed. The instantaneous environmental variables and weather conditions including solar irradiance, temperature, wind speed, and clouds are recorded and analysed, simultaneously along with plant responses including PV module temperature, generated power, current, and voltage. The power decreases with increasing ambient temperature. Increasing solar irradiance increases the temperature difference between modules and ambient. Instantaneous energy and exergy efficiencies during three different days, representing sunny, partly cloudy, and cloudy days, are further calculated. The energy efficiency varies between 5.76% and 15.53%, while that of exergy varies between 4.84% and 15.73%. For cloudy days, the exergy efficiency is higher than that of energy, while for a sunny day it is in reverse. Another important parameter affecting the generated power is partial shading on PV modules, particularly during early mornings and late afternoons. The shading changes from 3% to 9%, because of small azimuth and elevation angles. It was found that partial shading of 4.73% on PV modules may result a significant power decrease of 52.3%. A new algorithm based on Fuzzy Logic is proposed to overcome these power decreases under partial shading.

Keywords PV cell; instantaneous respond; exergy and energy efficiency; partial shading.

1. Introduction

Nowadays, with increasing different sources of energy based on fossil fuels, the environment is polluted more than ever. Therefore, there is a critical need to renewable sources of energy such as Photo Voltaic (PV) cells, wind turbines, concentrated and non-concentrated solar power. A number of technologies to harvest solar energy are in progress and solar cells received more attention due to rapidly developing technology and potential applications to cover the energy demands of the developing world [1].

PV cells are the equipment that generate directly electricity from solar radiation. However, the operation and the efficiency of PV cells depend on the environmental and weather conditions such as temperature, solar irradiance, shading (from neighbour objects or from could), wind speed, moisture, and dust [2, 3].

In the present paper, the operation of an on-grid, 20 KW, PV plant is analysed under simultaneous changes in the environmental and weather conditions. The transient effects of variations in the environmental parameters such as solar irradiance, ambient temperature, module temperature, and wind speed on the generated power, voltage and current during three days of sunny, partially cloudy, and cloudy days, are presented. The exergy and energy efficiencies are further calculated. Moreover, a validated model developed in PSIM software, is used to calculate the effect of partial shading on the generated power. The measured data from the