International Journal of Energy Optimization and Engineering
Volume 10 • Issue 2 • April-June 2021

Research on the Influence of Dust and Ambient Temperature on the Power of Photovoltaic Cells Based on the Regression Method

Sumit Sharma, Department of Mechanical Engineering, ACEIT, India
https://orcid.org/0000-0003-0198-8367

Ashish Nayyar, Department of Mechanical Engineering, SKIT, India

Kamal Kishore Khatri, Department of Mechanical-Mechatronics Engineering, LNMIIT, India

ABSTRACT

Solar energy has huge potential and offers a solution to fulfill the demand for energy and reduce fossil fuel emissions. An effort had been made for assessing the effects of dust accumulation and ambient temperature on module conversion efficiency of 62 KWp grid connected rooftop solar plant. The performance parameters including open-circuit voltage, maximum voltage, short-circuit current, maximum current, etc. were collected and permitting for usual dust addition. These statistics were used for the estimation of the performance ratio (PR), capacity utilization factor (CUF), and power conversion efficiency. This work assesses the decrease in conversion efficiency of cell as a function of dust addition and ambient temperature. A multivariate linear regressions (MLR) model can forecast conversion efficiency closely, with R^2 values close to 91%. It was employed in computing decrease in efficiency due to dust addition only. Result shows that the normal efficiency drops due to dust are 0.872%/day, energy harms are 9.935 kWh/m^2 and Rs. 192.72 or 2.5 dollar per day by the MLR model.

KEYWORDS

Capacity Utilization Factor, Multivariate Linear Regression, Performance Ratio, Photovoltaic

INTRODUCTION

Renewable energy technologies have an excellent potential in India and remarkable growth has been made to till date. During year 2014 an amount of 7.40 billion dollars had been invested for promoting and developing renewable energy across the country. This investment is 14% higher than previous year (Manju & Sagar, 2017). On the globe, India ranks fifth leading power generation capacity with 305.55 GW with an annual incremental rate of 9.4% having a renewable energy bases share of 44.236 GW (Kolisetty & Binu Ben Jose, 2018). In the climate conference held in Paris (COP21), Govt. of India shows its determination about falling carbon footprint by 33 – 35% by 2030 from its 2005 level, by augmenting the non-fossil fuel sector up to 40% of over-all generation ability (Hairat & Ghosh, 2017).

DOI: 10.4018/IJEOE.2021040102

Many efforts are being made continuously to transform this energy in photovoltaic and thermal form. PV modules (solar cells) are exceptional in that they convert the solar radiation falling on their surface into electricity, without air or noise pollution. Dust elements dropped on a PV panel surface may affect its performance depending on the element origin, size and composition and it may reduce the incident solar radiation on the PV-cell (Du, Jiang, Liu, Wu, & Ghorbel, 2019).

The main objective of this work is to examine the effects of dust exposure & ambient temperature on the conversion efficiency of solar module system using Multivariate linear regression (MLR) model. The analysis includes not only performance outcomes of the conversion efficiency, but also have annual Capacity Utilization Factor (CUF) and Performance Ratio (PR) of the plant.

Solar Energy Perspectives

Indian subcontinent has a yearly average global solar incident radiation on horizontal surface, is about 5.5 kWh m^2/day and has potential of generating 5,000 trillion kW's of clean energy (Shiva Kumar & Sudhakar, 2015). As per report in June 2016 renewable dependent capacity became 43,727 MW in the total of 303,100 MW (S. Sharma, Vishwakarma, Bhardwaj, & Mathur, 2018).

The National Solar mission under the program "Solar India" set a target of adding 2 GW of Off-grid capacity and 20 GW of Grid connected by 2022 in three phases. Table 1 shows the phase wise target of the mission.

Solar Photovoltaic Systems

Solar Photovoltaic is a prime technology for shifting to a decarbonized energy generation. Photovoltaic's a simple and elegant process of harnessing the sun radiation energy. PV modules (solar cells) are exceptional devices which directly converts the incident solar radiation into electricity, without noise or pollution.

Photovoltaic (PV) cells are semi-conductor devices with an internal electric field that separates positive & negative charges generated by absorbed (solar) radiation. As a result of selective transmittance of solar radiation absorbed by the panel absorbers will be emission of the long-wave radiation. And due to the ability of glass to hold long-wave radiation, there is a significant increase in temperature inside the space confined by glass (Kharchenko, V., Panchenko, V., Tikhonov, P, V., Vasant, 2018). Semiconductors can exist as doped as well as intrinsic. Doped semiconductors can be P-type (with holes that perform like positively charged particles) or N-type (with electrons as key charge carriers). The quasiparticle is frequently called a "hole" (Kharchenko, V., Nikitin, B., Tikhonov, P., Panchenko, V., & Vasant, 2019) (Vladimir Panchenko, Andrey Izmailov, Valeriy Kharchenko, 2020). As a result of the interaction of photons of solar radiation with a semiconductor, electron-hole pairs are formed. Electric power can be withdrawn by connecting the opposite sides of the PV cell via an external load.

A typical silicon cell produces around 3–4 A current at 0.5 V when fully illuminated, and for commercially accessible silicon PV cells, the conversion efficiencies ranges from 10–18% (David

Table 1. Phase wise target of the mission

S. No.	Sector	Phase I target for (2010-13)	Cumulative Target for Phase II (2013-17)	Cumulative Target for Phase III (2017-22)
1.	Grid associated Power including rooftop	1100 MW	10,000 MW	20,000 MW
2.	Off Grid Solar Applications	200 MW	1000 MW	2000 MW

Source (Raina & Sinha, 2019)

Related Content