# Effect of Varying Temperature on Performance Of Solar Modules Used In Indian Climate Conditions

**Madhuchandrika Chattopadhyay**
*Research Scholar*
*Department of Mechanical Engineering*
*AMET University, Chennai*

**Dr. Debaprayag Chaudhuri**
*Ph. D Supervisor*
*Department of Mechanical Engineering*
*AMET University, Chennai*

## Abstract

It's a fact that different PV technologies react differently to the irradiance variations. This paper examines the factors that affecting efficiency of solar cells according to scientific literature available. Solar modules are usually rated at Standard Test Conditions (STC = 1000W/m2, 25oC, AM1.5), but their operating temperature is a key parameter for its energy output and is always higher. A PV system engineer starts designing/ sizing a PV system depending on the parameter values provided by the PV manufacturer but these ratings under STC are not capable of predicting exactly how much energy a module will produce in Real Operating Conditions (ROC) i.e., in the field. Therefore, this study can give an idea to an engineer on temperature effects on various solar modules for proper sizing and calculating the actual energy yield from a PV system. The performance ratio of a solar module is high for higher altitude region due to low temperatures and low performance ratio for low altitude region due to high temperatures. So a PV module with less sensitivity to temperature is preferable for high temperature regions.
**Keywords: PV system, altitude region, energy yield**

## I. INTRODUCTION

Apart from limited reserves of fossil fuels, growing world energy demand from fossil fuels plays a key role in the upward trend in CO2 emissions over about 31GtCO2 in 2011. Two sectors produced nearly two-thirds of global CO2 emissions in 2011 by burning carbon-intensive fossil fuels were: electricity and heat generation accounted for 42%, while transport accounted for 22%. World Energy Outlook (WEO) 2013 projects the demand for electricity will be almost 70% higher than current demand and transport fuel demand will grow by nearly 40% by 2035.

Coal-based power production accounted for almost 70 per cent of all of India's coal-related CO2 emissions and grew by about 13 per cent in 2012, the highest annual growth ever. India is the fourth largest emitter of greenhouse-gas emissions after China, the US and the European Union (EU). ). India emits more than 5% of global CO2 emissions and shows clear trend of rapid increase by 3.4% per year from 2011 to 2035 (WEO 2013), at which India accounts for 10% of global emissions.

With about 300 clear sunny days in a year, India's theoretical solar power reception, just on its land area, is about 5 trillion kWh/yr. The daily average solar energy incident over India varies from 4 to 7 kWh/m2 with about 1500–2000 sunshine hours per year, depending upon location. Such amount of radiation is good enough to generate electricity to fulfill our entire electricity requirement using solar PV technology. The climate varies from region to region in India.

The Government of India has planned to go for installation of Solar Power Plants in three phases under its major initiative "Jawaharlal Nehru National Solar Mission" to generate electricity of capacity 20GW by 2020, 100GW by 2030 and 200GW by 2050.

In this case it is important to have an idea on effect of temperature on electrical efficiency and power output of solar modules used for sizing and calculating the actual energy yield from a PV system. Typically Solar modules operates at the temperature range between -40oC to 50oC. Oct.2003.

### *A. Electrical Efficiency and Power Output from Solar Module under Fluctuating Temperatures:*

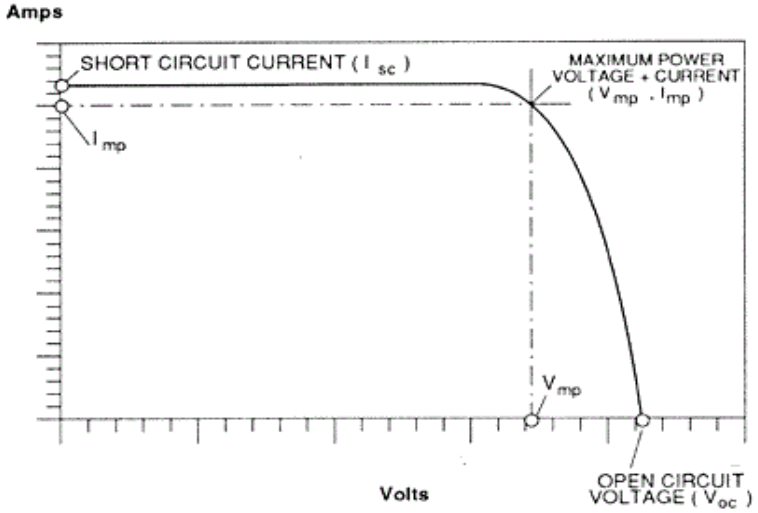


Fig. 1: Source: PV Education

The effect of temperature on the electrical efficiency of a PV cell/module can be obtained from the correlations between the current, I, and the voltage, V, as the maximum power is given by

$$Pm = V\,mIm = (FF)\,Voc\,Isc$$

In this fundamental expression, the fill factor, FF, subscript m refers to the maximum power point in the module's I–V curve, while Voc and Isc denote open circuit voltage and short circuit current values, respectively. It turns out that both the open circuit voltage and the fill factor decrease substantially with temperature owing to increased internal carrier recombination rates, caused by increased carrier concentrations in the semiconductor, while the short-circuit current increases, but only slightly.

The short circuit current (Isc) of a PV module is proportional to solar irradiance and insensitive to module temperature. According to test results of Jia-Ying Ye of Solar Energy Research Institute of Singapore, in the tropical zones (India also lies in this zone) the Isc of a-si single (0.075%/oC) and double junction (0.080%/oC) showed a large range of variability at low irradiances and the Isc of mono crystalline Silicon (0.050%/oC) and hetero crystalline silicon (0.030%/oC) showed average values.

The open circuit voltage (Voc) of a module is influenced by module temperature and is only marginally affected by irradiance. Voc is inversely proportional to the modules temperature. According to Jia-Ying Ye outdoor performance tests, for mono c-Si module, with longer duration of stable irradiance, the average efficiency increases for low irradiances and decreases for high irradiances. The effect of module temperature is not so significant on a-Si technologies but they show a considerable difference between the efficiencies at high and low irradiances.

From the tests done by R. Gottschalg of Centre for Renewable Energy Systems Technology, Loughborough University, UK, it is shown that different environmental effect contributes not more than 15% losses to the annual yield even in different locations.

## II. CONCLUSION

The temperature of the solar module has a huge impact on the efficiency of Solar PV system. Solar modules are usually rated at Standard Test Conditions (STC = 1000W/m2, 25oC, AM1.5), but their operating temperature is a key parameter for its energy output and is always higher. A PV system engineer starts designing/ sizing a PV system depending on the parameter values provided by the PV manufacturer but these ratings under STC are not capable of predicting exactly how much energy a module will produce in Real Operating Conditions (ROC) i.e., in the field. Therefore, this study can give an idea to an engineer on temperature effects on various solar modules for proper sizing and calculating the actual energy yield from a PV system. The efficiency degradation due to the solar module operating temperature can be caused by several aspects. In this study we analysed the performance of various PV technologies under varying temperatures.

## REFERENCES

[1] World Energy Outlook (WEO)-2013 by International Energy Agency (IEA).
[2] Www.mnre.gov.in Ministry of New and Renewable Energy, Govt. of India. February 2010.
[3] On the temperature dependence of photovoltaic module electrical performance: A review of efficiency/ power correlations by E.Skoplaki, J A Palyvos 83 (2009) 614-624.
[4] Outdoor PV module performance under fluctuating irradiance conditions in tropical climates. Jia-Ying Ye, Kun Ding, Thomas Reindl, Armin G Aberle 33(2013) 238-247.
[5] Influences on the energy delivery of thin film photovoltaic modules. R. Gottschalg, T R Betts, A Eeles, S R Williams, J Zhu 119(2013) 169-180.