# Impact of Temperature over the Output of Solar PV Power Generation: Case Study at SAC-ISRO, Ahmadabad

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***Abstract*—Photovoltaic (PV) cell converts a part of the solar energy into electrical energy and the remaining part is converted into heat. This heat inversely affects the efficiency of the solar cell. In this paper, the effect of the actual cell temperature on the performance of a photovoltaic cell is investigated. Module temperature of a photovoltaic (PV) has an inconsistent impact on its power production. The design and analysis of photovoltaic modules require a tool that can predict the behavior of photovoltaic generators. Manufacturer's usually provide electrical specifications of the PV panels at Standard Test Conditions, namely solar radiation of 1000 W/m$^2$ and cell temperature of 25$^0$ C. To characterize the performance of photovoltaic (PV) module, under varying weather conditions .As per the real performance data observed at SAC-ISRO is collected and same is simulated on System Advisor Model (SAM) software by NREL (USA) to analysis the temperature behavior over the output of solar PV generation.**

***Index Terms*—renewable energy, solar module, temperature effect, irradiance**

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## I. INTRODUCTION

PV power generation, which directly converts solar radiation into electricity, contains a lot of significant advantages such as inexhaustible and pollution-free, silent and with no rotating parts, and size-independent electricity conversion efficiency. Positive environmental effect of photovoltaic is replacing electricity generated in more polluting way or providing electricity where none was available before [1].

Nowadays, energy is very important in every aspect of development since it is one of the criteria in order to support population growth and to be one of the world developed countries. Presently, the Indian Government is starting to prepare to search and possibly implement several alternative green energy sources as energy consumption is gradually increasing (e.g. Increasing oil price issues, depleting conventional fossil fuel energy sources, etc.).

The purpose of such efforts is to seriously take into consideration the need to fulfill the future energy demands of India. Consequently, the Indian Government has seen that renewable energy sources such as solar energy can be one of the alternatives to confront the problems related to the ever increasing demand for energy

Sun hours is one of the parameters used in Photovoltaic system design in determining whether installation of a solar system would be recommended for a particular region, with a minimum of 5 sun hours per day being a recommended standard. As a result, photovoltaic systems are preferably installed in areas with long sun hours and these invariably have high temperatures. However, studies carried out on the performance of photovoltaic modules have shown a considerable decrease in their power output at temperatures above their optimum operating temperature 25$^o$C. Figure 1 shows solar resources at different states of India.

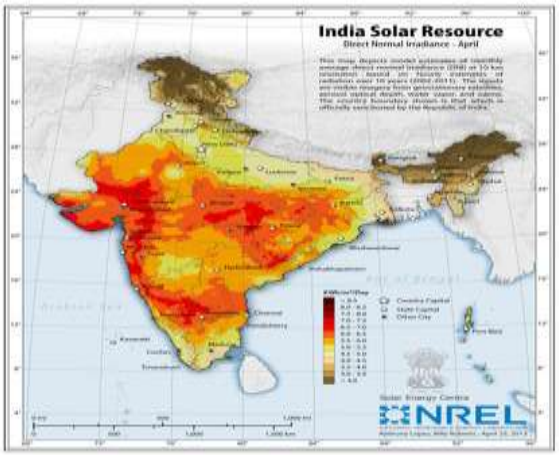


Fig. 1. Indian Solar Resources

## II. Impact of Temperature on Solar Module

The cell performance (efficiency) usually varies inversely with the operating temperature. Two competing factors are at play:

1) As temperature increases, the band gap of the intrinsic semiconductor shrinks, and the open circuit voltage decreases, PV cells therefore have a negative temperature coefficient of $V_o$. Here, the lower output power results due to the same photocurrent or the charge carriers which are liberated at a lower potential.

2) As temperature increases, again the band gap of the intrinsic semiconductor shrinks meaning more incident energy is absorbed because a greater percentage of the incident light has enough energy to raise charge carriers from the valence band to the conduction band. A larger photocurrent results; therefore, I, increases and PV cells have a positive temperature coefficient of $I_{sc}$,

Given short-circuit current and open-circuit voltage at some reference temperature (often 25°C), I, and V, respectively; one can evaluate quantitatively the effects of temperature on Pmax. Short-circuit current and open circuit voltage varies with temperature as follows:

$$I_{sc} = I_o (1 + \alpha \Delta T) \quad (1)$$

$$V_{oc} = V_o (1 + \beta \Delta T) \quad (2)$$

So, the theoretical maximum power is:

$$P_{max} = I_{sc} V_{oc} (1 + \beta \Delta T) (1 + \alpha \Delta T) \quad (3)$$

And, ignoring the quadratic term,

$$P_{max} = I_{sc} V_{oc} [1 + (\beta + \alpha) \Delta T] \quad (4)$$

Because the temperature coefficient of open-circuit voltage ($V_{oc}$) is negative and usually larger than the temperature coefficient ($\alpha$,$\beta$) of short-circuit current ($I_{sc}$) (a terms is normally negative). Small rise in temperature will decrease the output voltage and power [2].

## III. Experimental Verification

The functioning of PV modules at any time is not only dependent on the module temperature but also on other environmental aspects subjected modules operate under. The other ambient variables that have been found to affect PV performance are radiation, humidity, dust, cloud cover and clearness index. However, humidity and wind speed is only significant, only if ambient temperature and not the module temperature is taken into consideration [3] [4].

The average temperature of Ahmadabad is higher than the optimum operating temperature and therefore may result in a significant reduction in PV power generation as the power output of photovoltaic cells decreases with increasing temperature above the optimal. The PV panels under investigation are located at the top of different buildings of the SAC-ISRO campus in Ahmadabad, Fig. 2 shows the site.

Fig.2.50 kWp solar PV plant

The Data is taken from the SCADA system for 6 months analysis report (10kW Inverter). Here, a one parameter studies was carried out under controlled conditions on the performance of photovoltaic modules and the results showed a considerable decrease in their output power at high temperatures. The power output slowly rises and reaches its peak at about 25oC and thereafter slowly decreases, indicating that the heat had caused the panel to age prematurely. In a study of Power output of PV solar panels at different temperatures, the effect of temperature on the performance of solar panel is given in Fig. 3,4, and 5.

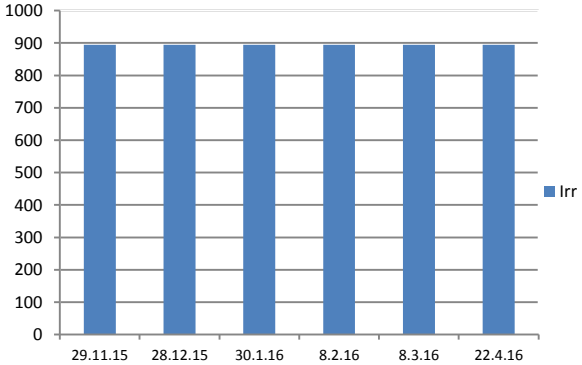


Fig. 3 Irradiation

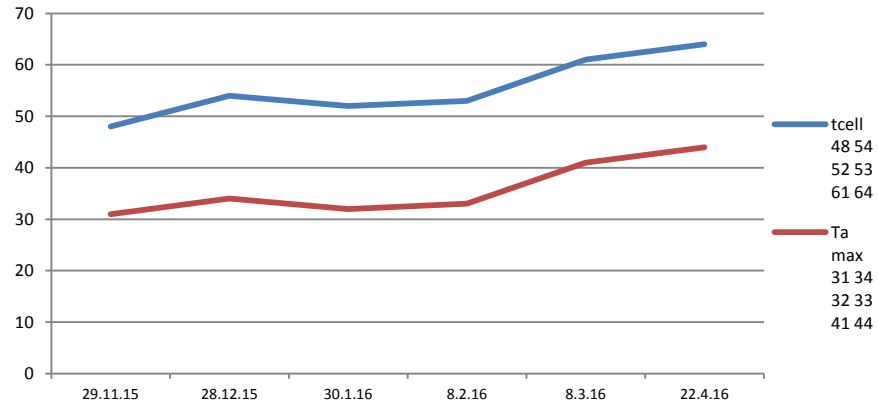


Fig.4. Curve of Ambient and Cell Temperature

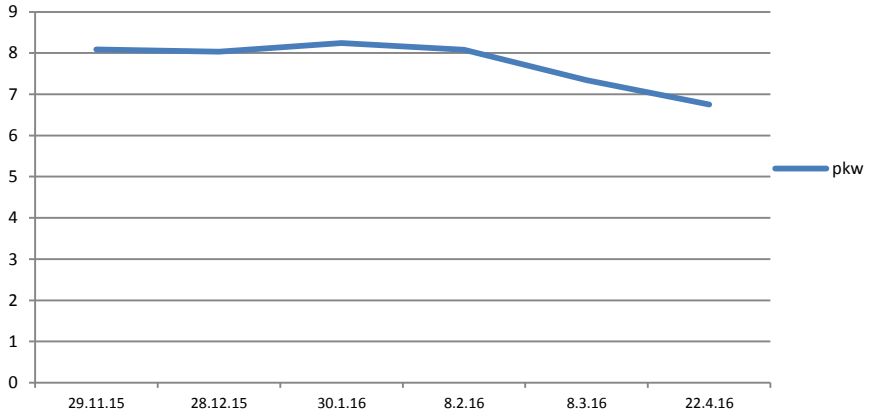


Fig.5. Power Output

The average temperature in different areas of Ahmadabad is classified in Table I and summarized as cold, medium and hot temperatures. As the temperature will affect solar panel performance, then the average temperature is needs to be considered.

Table 1 Average temperature at Ahmadabad

| ***Seasons*** | ***Ambient temperature $^0C$*** |
|---|---|
| Cold | 15 |
| Medium | 32 |
| Hot | 45 |

## IV. System Modeling and Simulation

The simulation is carried in SAM Software for 10kW inverter as per experimental study for respective months as shown in Fig.6

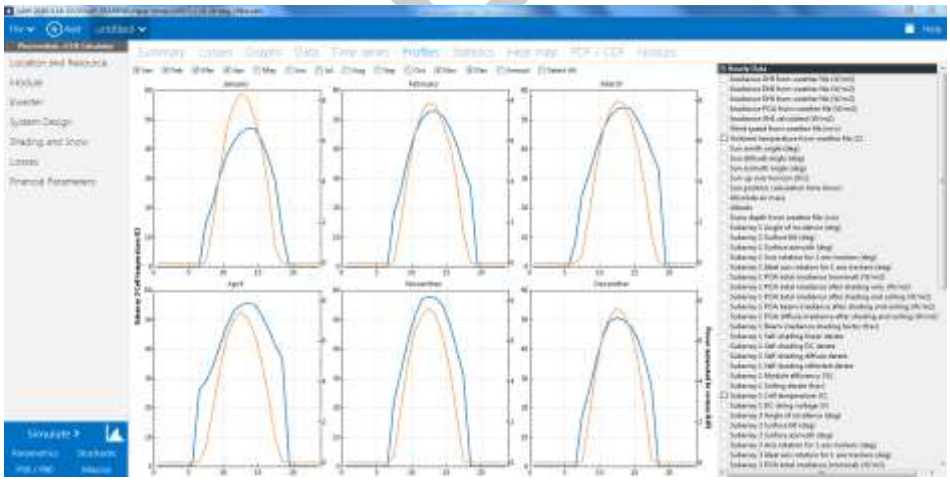

Fig. 6. Simulation Results

The simulation results clearly show, as ambient temperature increase, cell temperature increases, which results to reduce power output of PV panels.

## V. Conclusion

The research has confirmed, through simulation in SAM software for SAC-ISRO Campus' PV system, that the power output of a PV system is dependent on both the Isolation received by the systems modules and on the operating temperature of the modules .As per our experimental validation ,Power output at different cell temperature and ambient temperature is noted at a fixed Irradiation ,which shows a decrease in output power with increase in operating temperature .The experimental and simulation results show that the electrical parameters change with a variation in temperature.

## VI. Acknowledgment

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