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# Investigation of Variation in Temperature on the Performance of the Solar Cell

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***Abstract*—**The power generation through PV cells is now popular everywhere in the world and we are the leading one in the world but the solar output is affected by increasing panel temperature. In the backside of the solar panel, temperature increasesupto40$^0$C– to 50$^0$CinJaipur.Inthisexperiment, we have taken a parameter ‘current’ to analyze the temperature effect on the solar photovoltaic (PV) power generation. The photovoltaic (PV) cell’s power generation is reduced as their temperature increases in the surrounding especially under high insolation levels and cooling is beneficial. Here we have an aim of this paper to analyze the thermal effect on a solar plant on a rooftop to compare efficiency in case of with and without thermal management. The test results clearly show that the standard test condition boundaries don’t address the genuine working states of PV panels for open air conditions. Less yield power wasdelivered influenced by barometrical factors like sun based irradiance and surrounding temperature. The two factors firmly influenced the PV panel temperature conveyance. To put it plainly, the raising of PV panel temperature added to the adverse consequence on the yield execution of the panel.

***Index Terms*—**PV panel, Solar irradiance, Ambient Tempera- ture, PV Panel Temperature, Insolation

## I. INTRODUCTION

.In most cases, when installing a photovoltaic system, the investment cost of photovoltaic modules is the highest compared to any other modules. Therefore, the return on investment of a photovoltaic system mainly depends on the energy output of the photovoltaic module. Unfortunately, due to some degradation factors, photovoltaic modules usually operate with low conversion efficiency. The temperature of the PV module is regarded as the key point for predicting power generation. For example, the long-term high tempera- ture operating conditions of photovoltaic modules will cause irreversible degradation of their electrical output power. The high temperature is caused by the waste heat generated by the absorption of solar radiation. The radiation falling on photovoltaic modules, only up to 20% of incident solar energy is converted into electrical energy [1]. Most of the rest isconverted into heat. As a result, the accumulated thermal energy will increase the operating temperature of the photovoltaic module, resulting in a decrease in electrical efficiency. Under STC, the conversionefficiencyofphotovoltaicmoduleswilldecrease by about 0.40-0.50% for every 1 degree increase in temperature. However, all data rarely correspond to real solar conditions, because it depends on the specific climatic conditions of the corresponding location.

## II. EFFECT OF HEAT ON PV CELL

In addition, the temperature we consider of sun powered panels will rely upon factors like air temperature, geographic area, level of direct daylight, and roofing material. The most generally utilized PV module innovation is Polycrystalline, and this material has a negative temperature coefficient. This implies, with an increment in temperature, the age proficiency of the module (which is normally 15-16%) will diminish. Commonly, this temperature coefficient is near -0.4%/° C, this demonstrates with every degree ascend from 25°C (which is the cell temperature at STC) the proficiency of the module will lessen by 0.4% [2]. As per climate conditions in India, Polycrystalline modules are liked in the greater part of the districts. Consequently, according to the functioning standard of polycrystalline modules one can't expect higher age num- bers during high temperature days. Consequently, temperature adjustmentissignificantwhileassessingproducedunits.

## III. FORMULA FOR CALCULATION

The efficiency of solar photovoltaic panel is the ratio of power output to energy absorbed by solar PV panel. Photo Electric conversion efficiency (*n*e) is calculated using the following equation.

$$n(\%) = \frac{I_{sc}.v_{oc}.FF}{P_{in}} \quad (1)$$

$$P_{max} = I_{mp} V_{mp} \quad (2)$$

$$FF = \frac{P_{max}}{I_{sc}V_{oc}} = \frac{I_{mp}\, V_{mp}}{I_{sc}V_{oc}} \quad (3)$$

$$\eta = \frac{P_{max}}{P_{in}} \quad (4)$$

Where

- P max = maximum power point
- η = efficiency
- FF = fill factor

Voc = Open circuit voltage normalized to thermal voltage (V)
k = Boltzmann's constant 1.3806488 $10^{-23}$JK$^{-1}$ ×
T = Temperature of Solar PV cell (K)

q = Elementary electron charge 1.602×10−19 Coulomb
The typical I-V curve of a solar PV panel is indicated infigure

## IV. METHODOLOGY

Data and information from a wide assortment of sources have been utilized in this paper, which incorporates hypothetical information on sun based energy innovation, for both sunlight based PV and sun oriented nuclear energy stations, accessible in different on the web and disconnected devices. Information for sunlight based radiation has been dissected from sources like the Handbook of Solar Radiation for India (Anna Mani, Allied Publishers) India Meteorological Depart- ment (IMD), National Renewable Energy Laboratory (NREL), MinistryofNewandRenewableEnergy(MNRE) [2].

## TEMPERATURE CONTROLLING TECHNIQUE

The most simple and low cost method is to remove heatfrom around PV module using natural air circulation, but othercoolingmethodsareusedtokeepthetemperatureatacceptable level of PV modules. The most popular method for cooling PV modulesisHybridPhotovoltaic/Thermal(PV/T)solarsystem [8]. These systems consist of solar photovoltaic panels for the electric power generation with a cooling system. The cooling agent of the cooling system is circulated around the heated PV modules for the cooling the solar cells. Water or air can beusedasthecoolingagent.Thethermalenergyofheatabsorbed water or air (cooling agent) can be used. It can be found that, from the hybrid PV/T solar system with water cooling can be increased the solar cell power output by most 50%. A cooling method by spraying water using a fan, It was found that the solar panel with the cooling system generates more poweroutputthanwithoutthecoolingsystem.

## V. SOLAR MODULES

The grid-tied Solar PV module consist of 25 Crystalline Silicon Solar cell modules with each capacity of 100Wp, with RFID tag & as per IEC 61215/IS 14286 standards with installedcapacity . The module mounting structure on RCCrooftops- Hot Dip Galvanized (80 micron) is used.The observed locations was Vivekananda Global University, Japur

(Rajasthan), India. The parameters are determined by changing the module's temperature by spraying the water at ambient temperature state when irradiation is constant.

## VI. PV SYSTEM DETAILS

A 2.5 kW peak (KWp) rooftop grid-tied PV system was installed under**GenerationQualityImprovementProgramme (GQIP**) of **Vivekananda Global University in march2021** on the rooftop ofLibrary building. The DC-side of 3Ph, 2.5 kW grid connected inverter is connected to the PV array. The system is installed to insert the produced energy directly into the existing electrical network. It includes of 3major components that are Solar Panels, Grid connected Inverter &Energy Monitoringsolution [4].

## VII. INVERTER

It is the vital part of any grid tied system. The outputs of the PV modules are linked to Delta RPI M10A, 3Ph Grid Tied Solar Inverter which convert DC energy into AC & directly connected to utility system. The Inverter is switched ON all day & synchronized to the electric grid automatically. The Inverter stops its service for operator protection if grid faces issues such as shut down or irregular issues [3]. This Inverter have dual MPP tracker, wide voltage range (200-1000V DC), Transformer less, reactive power manage, Ergonomic grip devise, Ultra compressed volume, Build in power logger, IP65 security point, Build in AC/DC Switch & Peak efficacy up to 98.3%.

Data logger is as follows :

## VIII. PV MODULE DETAILS

| sensor | DSP version | HCL version | Rated power |
|---|---|---|---|
| 0507 | 001D | 0030 | 2.5 kw |
| Date | Safety country SN | | |
| 24/3/2021 | 054AA1195200057/IEC 1727L | | |
| Min temp | 17 $^{0}$C | Max temp | 31 $^{0}$C |

| | |
|---|---|
| Solar | Polycrystalline Silicon as per IEC 61215 / IS 14286 |
| No of Modules | 25 |
| SPV Module Capacity in (Wp) | 100 |
| RFID tag | y |
| System capacity | 2.5 kw |
| Avarage Height | 3.3 |
| Tilt Angle | 19 |
| Azimuth | True south |
| Voltage@ Max. Power (Vmpp) | 36.8 |
| Current @Max. Power (Impp) | 8.7 |
| Open Circuit Voltage (Voc) | 45.3 |
| Efficiency of Panel (%) | 9.42 |
| Cell Type | Polycrystalline Silicon |
| panel dimension | 1960*990*40 |

| | |
|---|---|
| (mm) | |
| panel weight (Kg) | 22.50KG ± 5% |

**Earthling:** The Earthling system is used for array, distribution system & SPV power plant. Each array structure is grounded properly as per IS: 30431987. The GI strip of 25*3 mm is utilized for earthling [5].

**Lightning:** The Lightning arrester with conventional type earth pit is provided for the protection against lightning as per IEC 62305 standards [6].

**Cables-**

- Single core,Multistrand, 4sq.mm TUV approved solar cable for DC side
- Multi strand cable for AC side
- MC4 connectors suitable for 4 sq.mm cable
- UV protected cable ties for solar cables

**Table 1: DC GENERATION compared with and without temperature control**

| Time | DC current | DC current with temp control |
|---|---|---|
| 7:34:00 AM | 0.8 | 0.9 |
| 8:06:23 AM | 1.9 | 2.1 |
| 8:12:45 AM | 2.1 | 2.3 |
| 8:38:59 AM | 3.1 | 3.3 |
| 8:48:58 AM | 3.4 | 3.5 |
| 9:00:16 AM | 3.9 | 4.1 |
| 9:11:01 AM | 4.2 | 4.5 |
| 9:21:09 AM | 4.6 | 4.8 |
| 9:26:32 AM | 4.8 | 5 |
| 9:40:40 AM | 5.1 | 5.4 |
| 10:05:39 AM | 6 | 6.3 |
| 10:26:58 AM | 6.5 | 6.7 |
| 10:36:40 AM | 6.8 | 6.9 |
| 11:02:02 AM | 7.3 | 7.7 |
| 11:23:49 AM | 7.7 | 8.1 |
| 11:36:30 AM | 7.7 | 8.4 |
| 11:41:56 AM | 7.8 | 8.4 |
| 12:02:59 PM | 8.6 | 8.1 |
| 1:09:54 PM | 8.8 | 8.2 |
| 2:31:06 PM | 6.4 | 7.3 |
| 3:00:31 PM | 5.6 | 6.7 |

| | | |
|---|---|---|
| 3:32:57 PM | 5.5 | 5.5 |
| 3:59:52 PM | 4.4 | 4.1 |
| 4:32:33 PM | 3 | 3.2 |
| 5:03:20 PM | 1.3 | 19 |
| 5:36:51 PM | 0.5 | 1.1 |
| 6:08:14 PM | 0.1 | 0.4 |
| 6:30:50 PM | 0.1 | 0.1 |

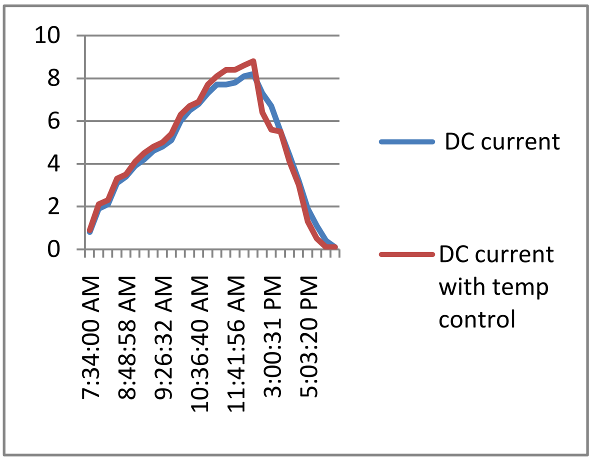


**Figure 1: Graphical representation of DC current with without temperature control**

**Table 2: AC GENERATION compared with and without temperature control**

| Time | AC Current T/W/C(A) with temperature control | AC Current T/W/C(A) with temperature control |
|---|---|---|
| 7:34:00 AM | 1.2 | 1.4 |
| 8:06:23 AM | 2.9 | 3.1 |
| 8:12:45 AM | 3.2 | 3.6 |
| 8:38:59 AM | 4.8 | 4.8 |
| 8:48:58 AM | 5.5 | 5.0 |
| 9:00:16 AM | 6.3 | 6.6 |
| 9:11:01 AM | 7 | 7.3 |
| 9:21:09 AM | 7.6 | 7.7 |

| | | |
|---|---|---|
| 9:26:32 AM | 8 | 8 |
| 9:40:40 AM | 8.5 | 8.7 |
| 10:05:39 AM | 9.8 | 10.5 |
| 10:26:58 AM | 10.7 | 11.4 |
| 10:36:40 AM | 11.1 | 11.5 |
| 11:02:02 AM | 12.2 | 12.5 |
| 11:23:49 AM | 12.3 | 13.1 |
| 11:36:30 AM | 12.7 | 13.6 |
| 11:41:56 AM | 12.7 | 13.5 |
| 12:02:59 PM | 12.9 | 13.7 |
| 1:09:54 PM | 12.3 | 13.3 |
| 2:31:06 PM | 11.4 | 10 |
| 3:00:31 PM | 10.6 | 9.4 |
| 3:32:57 PM | 8.4 | 8.2 |
| 3:59:52 PM | 6 | 5.7 |
| 4:32:33 PM | 3.4 | 3.5 |
| 5:03:20 PM | 2 | 1.3 |
| 5:36:51 PM | 1.1 | 0.7 |
| 6:08:14 PM | 0.6 | 0.6 |
| 6:30:50 PM | 0.7 | 0.7 |

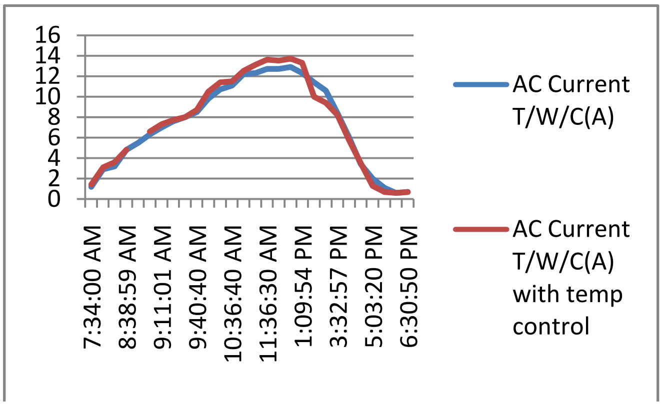


**Figure 2: Graphical representation of AC current with without temperature control**

## IX. RESULT

All the results obtained which have been shown in this paper are taken from a solar plant established on rooftop of VIVEKANANDA GLOBAL UNIVERSITY, JAIPUR . From the continuous observation of that plant, we have found that with the increase in temperature, there is an improvement in the efficiency and the voltage and current level up to a level. But when the temperature increases beyond a limit, there is a continuous reduction or decrease in the voltage and current from the conclusions obtained from the result .Max DC generated with temperature maintained near room temperature is about 8.8 A while it is normally 8.2 A as shown in table . so Diff of Imax = 8.8 – 8 .2 = 0.6 A% increment in current generation = ( 0.6 x 100 ) / 8.2 = 7.3 %Similarly, Max AC generated with temperature control is 13.7A and normally it is 12.9A. so difference in Imax = 13.7 – 12.9 = 0.8 A% increment = ( 0.8 x 100 ) / 12.9 = 6.2 %Graphically it is presented and verified too along with data .

## CONCLUSION

The performance parameters of 2.5KWp Solar plant installed on roof top of library building of Vivekananda Global University, Jaipur, India is presented here. The parameters like AC & DC Current are shown here.As we have made observation on 2.5 kw solar panel , 12 hrs morning to evening and data collected by specified system details given in data table. Next day again we keep our eyes on power generation with the tool to manage temperature surrounding solar panel. We observed improvement in current generation. Thus we have come to the conclusion that quality temperature in and out of the system may improve quality of generation or impact system output positively or negatively. So there is lot of scope in formulating and fabrication of system in this previews. Also there is lot of factor to look after which have magnificent role to affect temperature increment or decrement.

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