The effect of Climate on Solar Panels mounted on E-Vehicle

Shaleen Tripathi*1, Dr. Mukesh Pandey2, Anurag Gour3 and Pankaj Kumar Singh4

*1,4 Scholar of Department of Energy Technology UTD RGPV, Bhopal, M.P, India
2Head of Department of Energy Technology UTD RGPV, Bhopal, M.P, India
3Assistant Professor of Energy Technology UTD RGPV, Bhopal, M.P, India

ABSTRACT

The change in digital world raise the question of power- to chase such problems- renewable is a next generation to meet the context of power. The supply and demand of power in Indian market and environmental issue pushed all boundaries for human bounty. The major resources for power are petroleum and nuclear (excluding hydro power-renewable energy) but other solution to dilute negative environmental factors. An automobile is one of them, which are used, in large context to petroleum. This focus our idea to find a significant changes of electric power using polycrystalline solar panel at rest and in dynamic state of e-rickshaw and the difference in power generation. This paper presents the factors and effects on current, voltage and power due to environmental conditions and vehicle and factors responsible in power generation.

Keywords: Solar Panel, Fill Factor, Renewable Energy

I. INTRODUCTION

A solar cell is a device that converts the energy of sunlight directly into electricity by the photovoltaic effect. Sometimes the term solar cells is reserved for devices intended specifically to capture energy from sunlight. The most commonly known solar cell is configure as a large area p-n junction made from silicon. As a simplification, one can imagine bringing a layer of n-type silicon into direct contact with a layer of p-type silicon. In practice, p-n junctions of silicon solar cells are not made in this way, but rather by diffusing an n-type doping into one side of a p-type wafer (or vice versa).

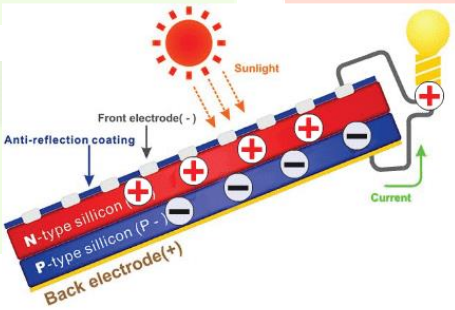


Fig 1: working of solar cell

When a photon hits a piece of silicon, one of three things can happen:

1. The photon can pass straight through the silicon this (generally) happens for lower energy photons,
2. The photon can reflect off the surface,
3. The photon can be absorbed by the silicon, if the photon energy is higher than the silicon band gap value. This generates an electron-hole pair and sometimes heat, depending on the band structure.

A. Characteristic Curves

An equivalent circuit can represent solar cell also. This circuit also includes the losses due to the solar cell manufacturing process [2]. In this circuit Rs is the series resistance associated with the cell, which is due to the grids above the solar cells and interconnection of solar cells. R_{sh} is the parallel resistance with cell, which represents the leakage current through the cell. Equivalent circuit of cell is as follows:

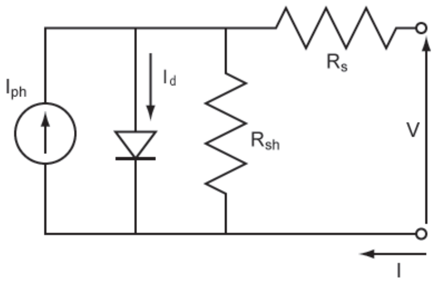
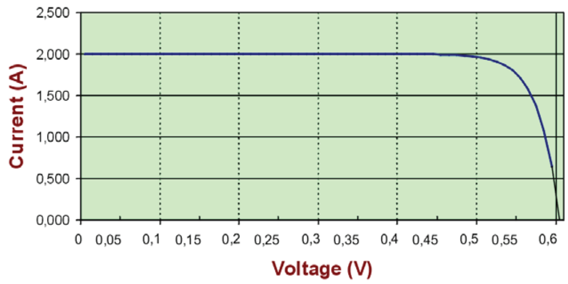
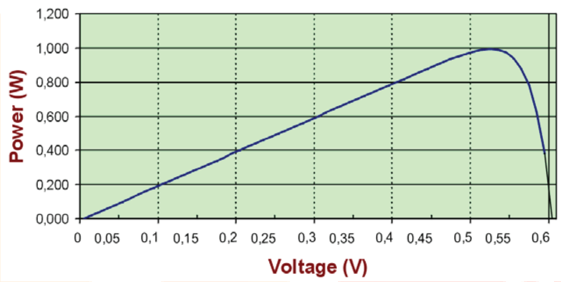


Fig 2: Equivalent Circuit of Solar PV Cell



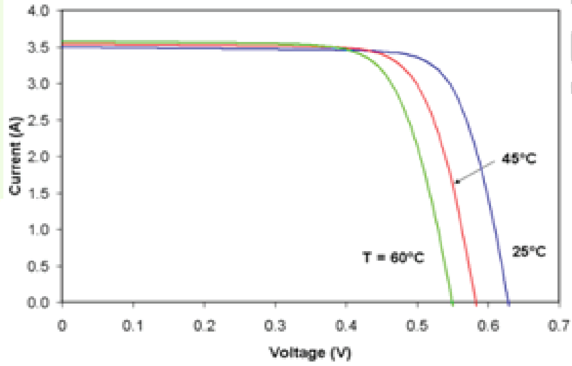
Graph 1: I-V Curve of Solar Cell



Graph 2: P-V curve of Solar Cell

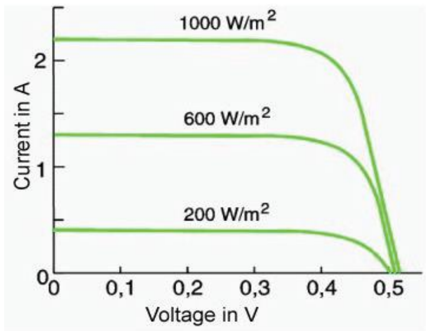
In these curves maximum current at the zero voltage is called short circuit current (I_{sc}) and the maximum voltage is known as open circuit voltage (V_{oc}). In P-V curves, the maximum power is achieved only at a single point, which is called MPP (maximum power point) [6], and the voltage and current corresponding to this point are referred as V_{mp} and Imp.

On increasing the temperature, V_{oc} of module decreases while I_{sc} remains the same, which in turn reduces the power.



Graph 3: Variation in V_{oc} with change in temperature

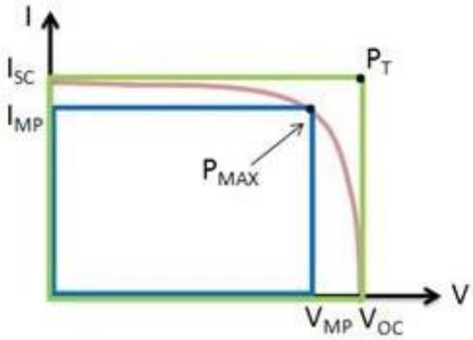
On changing the solar insulation, I_{sc} of the module increases while the V_{oc} increases very slightly



Graph 4: Variation in characteristic curve with Insulation

B. Fill Factor

The Fill Factor (FF) is essentially a measure of quality of the solar cell. It is calculated by comparing the maximum power to the theoretical power (PT) that would be output at both the open circuit voltage and short circuit current together. FF can also be interpreted graphically as the ratio of the rectangular areas depicted in following Fig. Larger fill factor is desirable, and corresponds to an I-V sweep that is squarer like. Typical fill factors range from 0.5 to 0.82. Fill factor is also often represented as a percentage.

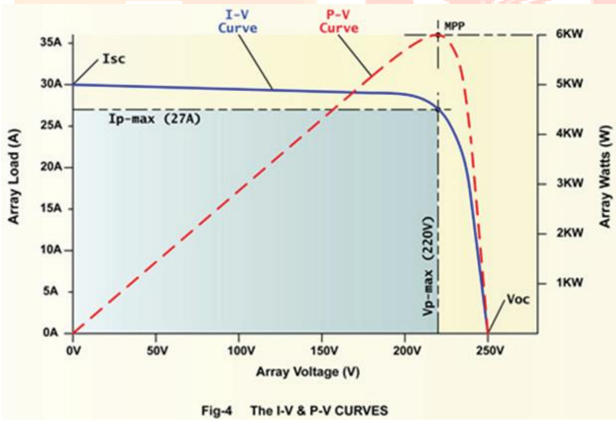


Graph 5: Fill Factor

$$FF=\frac{P_{MAX}}{P_T}=\frac{I_{MP}*V_{MP}}{I_{SC}*V_{OC}} \qquad - (1)$$

C. Maximum power point

Every model of solar panel has unique performance characteristics which can be graphically represented in a chart. The graph is called an "I-V curve", and it refers to the module's output relationship between current (I) and voltage (V) under prevailing conditions of sunlight and temperature [4]. Because of Ohm's Law (and the equation Power = Voltage x Current), the result of reduced voltage is reduced power output. The ideal position on any I-V curve—the sweet spot where we can collect the most power from the module—is at the "knee". That is the maximum power point (MPP), and can be observed that its position changes with temperature and irradiance



Graph 6: MPT

D. Efficiency of Solar PV Module

There are two main modes for charge carrier separation in a solar cell:

1. Drift of carriers, driven by an electrostatic field established across the device

2. Diffusion of carriers from zones of high carrier concentration to zones of low carrier concentration (following a gradient of electrochemical potential).

In the widely used p-n junction solar cells, the dominant mode of charge carrier separation is by drift. However, in non-p-n-junction solar cells (typical of the third generation solar cell research such as dye and polymer solar cells), a general electrostatic field has been confirmed to be absent, and the dominant mode of separation is via charge carrier diffusion.

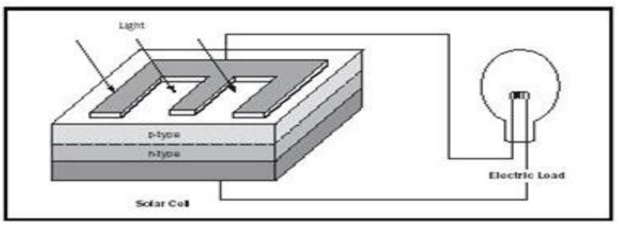


Fig 3: Block diagram of solar cell with external circuit

Generated holes goes in the direction of electric field while electron goes in the opposite direction of field and in this way all holes get gathered on p-type surface and electron gets gathered on n-type surface [5]. These charges at the surface make potentials, which will cause the flow of current on connecting these by load through a wire.

Following losses take place in solar cell [6]

1. *Reflection losses:* Occurs at top surface of the cell were light is incident. Reflection of light results in low absorption of photons in the solar cell.

2. *Recombination losses:* Occurs everywhere in the volume of the solar cells. Carriers generated get recombine with each other in order to maintain equilibrium condition. Areas were these losses occur in large magnitude are Bulk region (base region), Top surface, Metal to semiconductor contact areas, Junction region.

3. *Series resistance losses:* Resistance, contributed by the Metal fingers, Metal to semiconductor contact resistance, Bus bar, Emitter region and Bulk region, is called as series resistance. Voltage drop and power loss results due to high value of series resistance and hence reduce efficiency.

4. *Thermal losses:* A very small quantity of light absorbed by the cell is utilized in generation of power, remaining photon energy goes utilized in the form of heat, which increases the temperature of the cell. Cell parameters such as open circuit voltage (V_{oc}), short circuit current (I_{sc}) are functions of temperature. Isc increases with temperature but this increment is negligible but there is a 0.5 % drop in Voc with every degree rise above the 250C.

$$Efficiency\ (\eta, \%) = \frac{V_m * I_m}{Irradiance\left(W/_{m^2}\right) * Area\ (m^2)} * 100 \quad (2)$$

II. METHODS AND PROCESS

A. Position of Sun and Panel

Tilt is the angle between the plane surface under consideration and the horizontal plane. It varies between 0-900. PV arrays work best when the sun's rays shine perpendicular to the cells. When the cells are directly facing the sun in both azimuth and altitude, the angle of incidence is normal. Therefore, tilt angle should be such that it faces the sunrays normally for maximum number of hours.

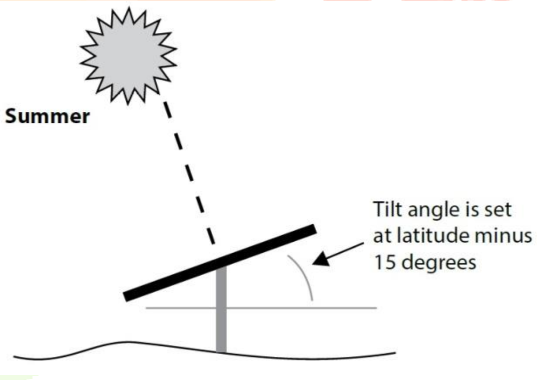


Fig 4.1: Tilt angle settings for summer

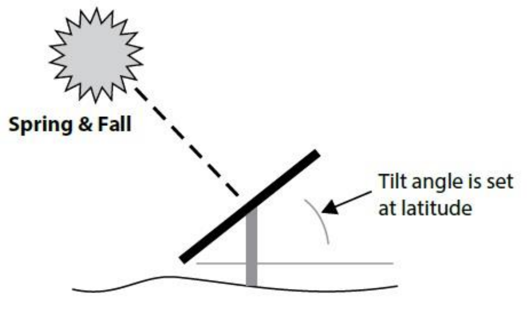


Fig 4.2: Tilt angle settings for Spring & Fall

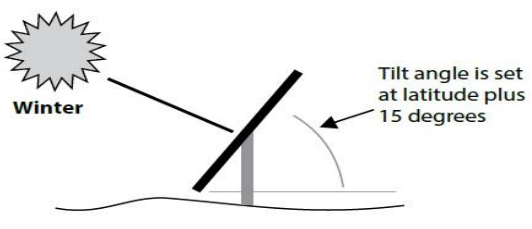


Fig 4.3: Tilt angle settings for winter

PV systems that are designed to perform best in the winter, array should be tilted at an angle of equal to latitude +15°. If the array is designed to perform best in the summer, then the array needs to be tilted at an angle of equal to latitude−15°. In this way, the array surface becomes perpendicular of the sunrays. For best performance throughout the year, tilt should be equal to the latitude angle [7].

B. Shadow Effect on PV Panel

There are 36 solar cells in a module, which makes the module as series connected solar cells. These cells are in series without bypass diode so shading of one cell will be sufficient to reduce the power to zero. This arrangement gives zero power if the entire row of cells gets shaded.

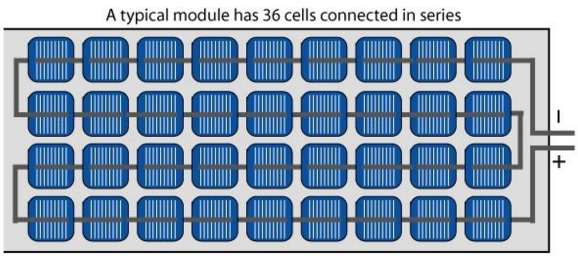
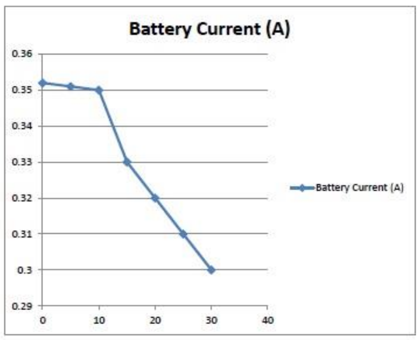


Fig 5: 36 solar cells connected in series [1]

C. Battery discharging

Battery discharging depends on magnitude of current drawn and the time for which this current is drawn. ate of charge flowing determined the steepness of discharge characteristic. At higher current i.e. at higher rate of discharge, voltage variation becomes more steeper and battery discharge up to much low voltage [8]. Similarly, at lower rate of discharging voltage variation becomes less steeper and battery discharge up to somewhat higher voltage. The typical 12V, 3Ah battery discharge characteristic is shown below.



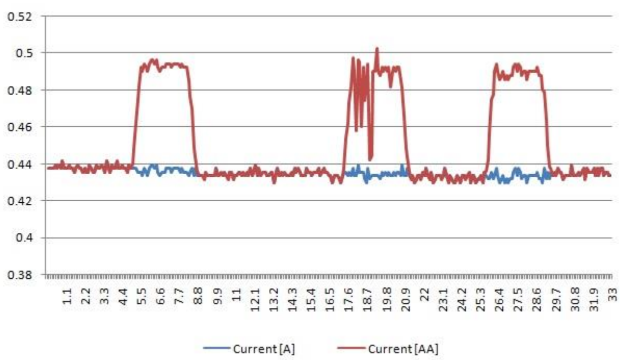
Graph 7: Battery discharging

D. Battery charging

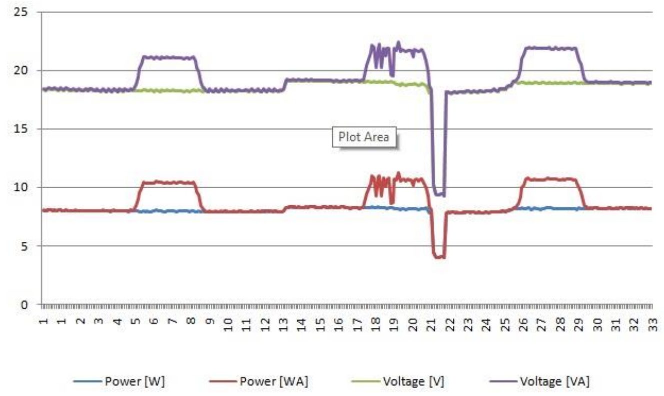
Starting current of charging is much higher because the voltage of the discharged battery is low [6]. Initially battery draws almost constant charging current while battery voltage increases rapidly, as soon as battery voltage reaches rated voltage, charging current start reducing rapidly and battery voltage becomes constant. After fully charging, the battery charging current reduces to vary low value required to trickle charge the battery.

E. DATA COLLECTION

A. First day (11-06-2018)



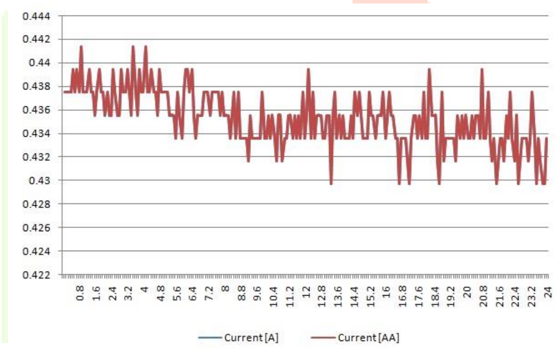
Graph 8: Actual Current to Apparent Current



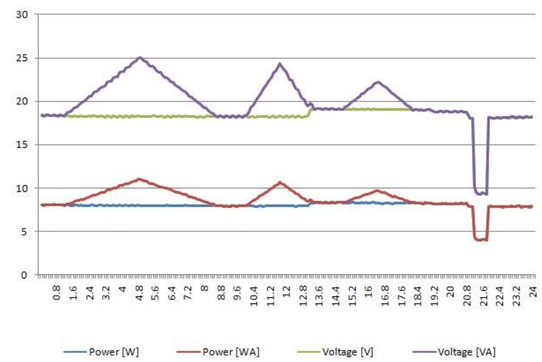
Graph 9: Actual Power and Voltage to Apparent Power and Voltage

During the college hour following data has been taken on the e-rickshaw and various things are observed i.e., at the start of the day when the rickshaw is at stand still there is normal generation and the sky is clear. Here the V refers to the voltage of panel and VA refers to the voltage of the e rickshaw. As the day progresses and the rickshaw speed are increased, there is change in the voltage and current output of the panel and the overall power is increased. As we can see that at following time, there is difference in the generation. The output of the panel also changed during the formation of cloud. There has been a significant change in the panel as the values of temperature and wind speed is increased or decreased. As we can see that, the power is decreases very much because of the formation of cloud and as soon as the cloud clears, the generation is again getting back to normal. The first change is due to motion of e-rickshaw. A slight change in power is due increase in wind velocity. The second round of e-rickshaw has lots of fluctuation due to cloud in our area. The volume of cloud work as objects (semi-transparent) and thickness of cloud define the intensity level of light to pass through a cloud-the instant drop and rocketed boost is before and after condition on panel due to cloud. A minor change also observed when wind speed and vehicle in integration increase the generation factors.

B. Second day (11-06-2018)



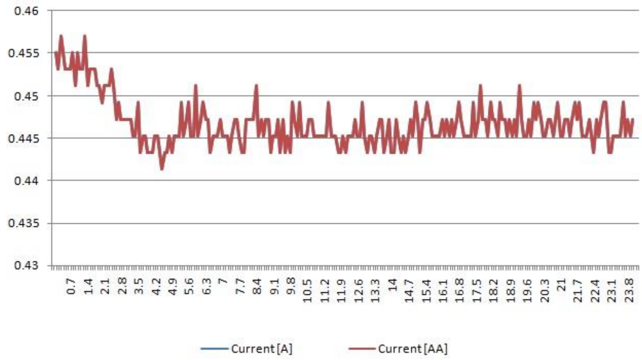
Graph 10: Actual Current to Apparent Current



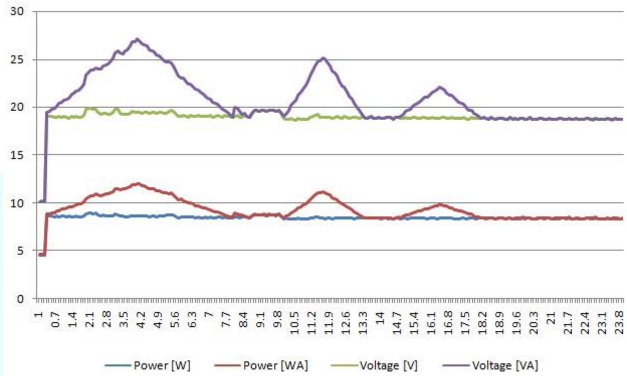
Graph 11: Actual Power and Voltage to Apparent Power and Voltage

On the second day, also, the same experiment is performing and we see a linear change in the values of voltage as the cloud formation was linear. During the start of the day the voltage was quite same but as the day progresses there is significant change in voltage whereas the current show a very drastic change in its values and we can see it changing quite often. So because of the values of current we see a linear change in power as well also the wind speed is good throughout this day so we can we got good peaks during the whole day only a slight downfall was observed at the end of the day because of the formation of cloud and was there for some time.

C. Third day (13-06-2018)



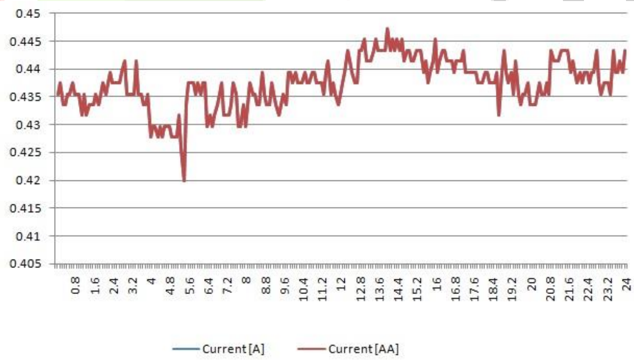
Graph 12: Actual Current to Apparent Current



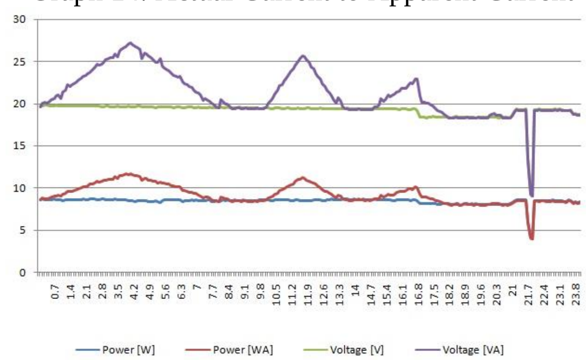
Graph 13: Actual Power and Voltage to Apparent Power and Voltage

On the third day of experiment, same observation was observe as the second day only change we are able to see is during the start of the day the voltage is at the negative maximum for quite a time but then it picks up its speed and reaches the normal generation. The voltage again shows a linear change during the day and the wind speed is very low at this point of time. A long time fluctuation is observe in the values of current and is changing quite often. But the values of power does not that kind of as current because of voltage and is low during the start of but then picks up and then is linear throughout the day. The sky is clear for the day so we do not much variation in the power generation on this day. The wind speed is normal so it does not have significant impact on the generation.

D. Fourth day (18-06-2018)



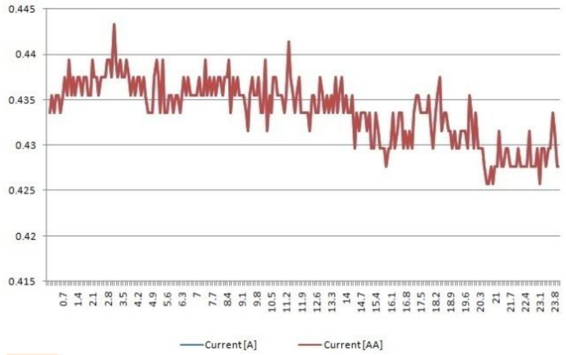
Graph 14: Actual Current to Apparent Current



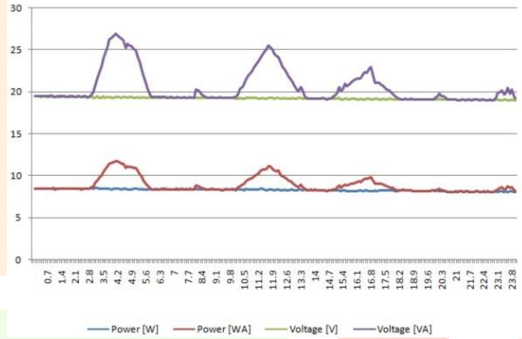
Graph 15: Actual Power and Voltage to Apparent Power and Voltage

On the fourth day we observed a very clear sky and the wind speed is also good so there is quite a good generation on the panel and because of this the graph of voltage shows a good slope and also linear increase for a long time and after this a decrease. The current graph shows a very nonlinear waveform and also it is moving up and down very frequently but the overall power graph is quite linear and we get a good power generation at this time. We also see a sudden decrease in voltage due to formation of cloud for a instant but after a few minutes as soon as the cloud disappeared the generation again got back to normal. The wind speed was also normal and was not much fluctuating throughout the day.

E. Fifth day (19-06-2018)



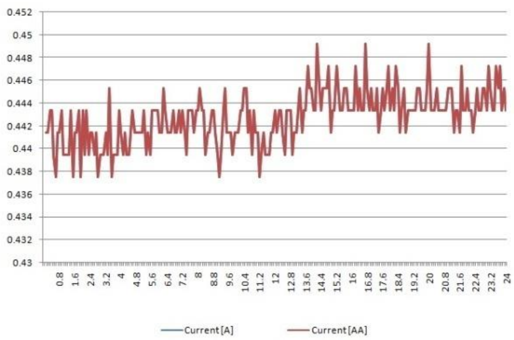
Graph 16: Actual Current to Apparent Current



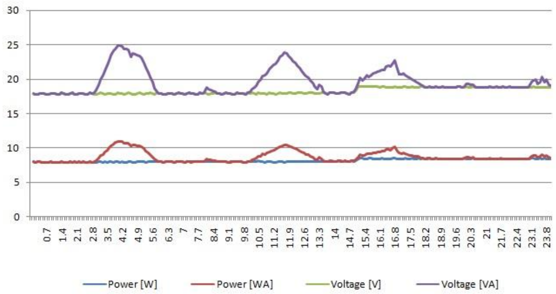
Graph 17: Actual Power and Voltage to Apparent Power and Voltage

On the fifth day, also, the same experiment is performing and we see a linear change in the values of voltage as the cloud formation was linear. During the start of the day the voltage was quite same but as the day progresses there is significant change in voltage whereas the current show a very slight change in its values. So because of the values of current we see a linear change in power as well also the wind speed is good throughout this day so we can we got good peaks during the day time and the peaks was occurring quite frequently. The peaks of power shows a slight downfall at the end of the because of the formation of clouds at the later time of the day.

F. Sixth Day (20-06-2018)



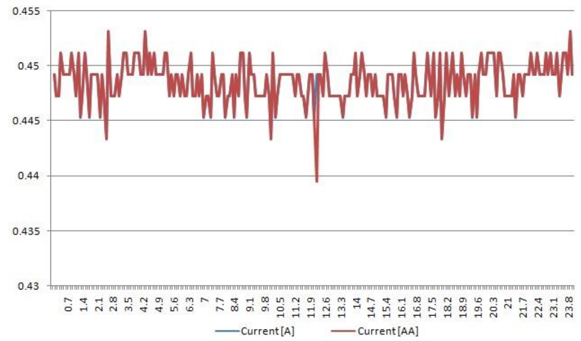
Graph 18: Actual Current to Apparent Current



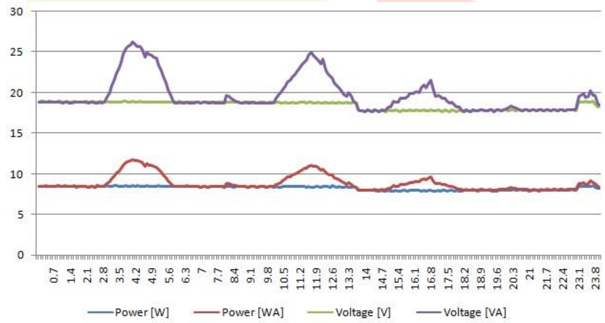
Graph 19: Actual Power and Voltage to Apparent Power and Voltage

On the sixth the reading and the outcomes were as follows, the voltage at the start of the day was exactly matching the voltage of the panel. In addition, as soon as the day progresses the voltage started showing linear change due to the temperature variation during the day the voltage peaks to a maximum value after few hours of the day and then started decreasing but as soon the wind speed increases the voltage increases to slightly greater value. The current is also showing slightly low values during the start but due to wind flow, it started to increase its value to a higher value. The overall power curve that was plotted shows the exact changes in the values of voltage and current.

G. Seventh Day (22-06-2018)



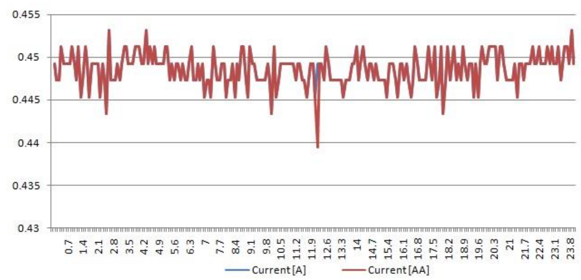
Graph 18: Actual Current to Apparent Current



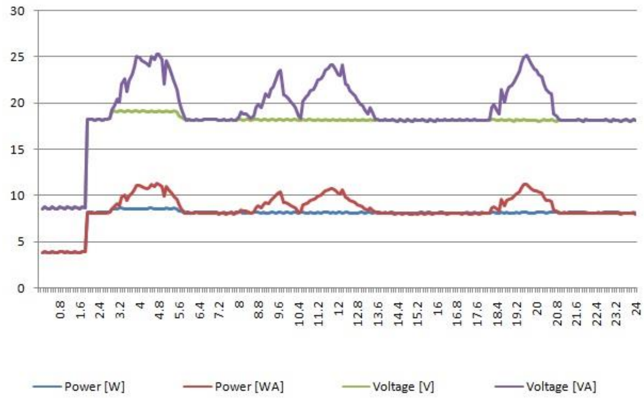
Graph 19: Actual Power and Voltage to Apparent Power and Voltage

On the seventh day the voltage was constant then started to show variation and it started to increase but a downside of the voltage was observed at the mid of the day. The current was constant throughout the day and did not show much of the variation. The voltage again started to increases at the end of the day and the generation reached to its normal value as observed at the start of the day. There was a change in the values of power as the wind speed started to decrease and there were variations throughout the day, which shown by the power curve

H. Eight Day (23-06-2018)



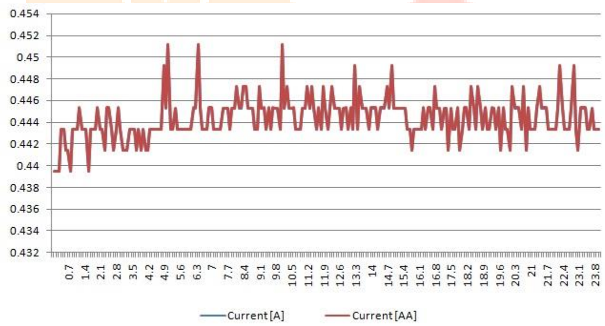
Graph 20: Actual Current to Apparent Current



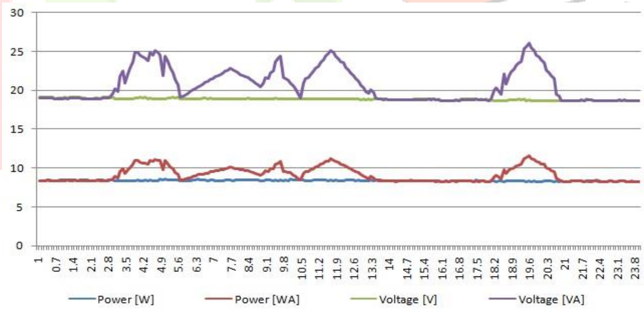
Graph 21: Actual Power and Voltage to Apparent Power and Voltage

On the eighth day at the start the values of voltage is constant for a long time but then as soon as the time increases there is sudden change of voltage due to increase in temperature and wind speed. We can see the change in values of voltage from the graph as the time is passed the graph shows a sudden increase in its values after sometime the voltage is made constant and then a linear change is observed. The voltage is stagnant for quite a time and then started to decrease. The change in voltage is observed for many time in a day. The current also shows slight changes in its values and remains constant at a point for quite a time and then begins to fluctuate. Now because of such sudden change in voltage the power curve also shows a drastic change in its values. We can see a sudden decrease in the actual power curve after sometime because of the decrease in wind speed.

I. Ninth Day (25-06-2018)



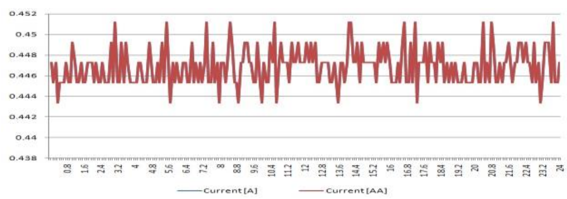
Graph 22: Actual Current to Apparent Current



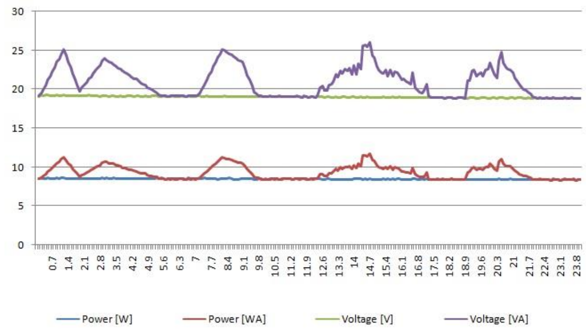
Graph 23: Actual Power and Voltage to Apparent Power and Voltage

On the Ninth day, the same experiment is performed and we see a linear change in the values of voltage. During the start of the day the voltage was quite same but as the day progresses there is significant change in voltage whereas the current shows change in its values at the mid of the day which did not came back to its original value. So because of the values of voltage we can see a frequent change in power as well as the wind speed is good throughout the day so we got good peaks during the whole day and which was repeated many time during the day.

J. Tenth Day (26-06-2018)



Graph 24: Actual Current to Apparent Current



Graph 25: Actual Power and Voltage to Apparent Power and Voltage

On the tenth day the values of voltage was very much flickering because of the change in the temperature and rainfall was observe on this day. The panel was cool because of the slight rainfall, which in turn led to more generation of the panel. The values of current did not show very much change and was nearly constant during the daytime. The generation was quite good on this day.

III. RESULTS

In the following research we had discovered that the orientation, wind speed, sun hours and the dynamic speed of vehicle are the variables responsible for to and fro of production of electricity. And in our climatic condition the wind speed increases the generation by adding extra cooling by dynamic state of vehicle. Hence mounting a panel on roof of vehicle looks bright in our experimental analysis.

IV. CONCLUSION

Although we can conclude that the successful result of our study gives a possible direction to move in electric vehicle to support environment and installation to solar charging station. By installing at point one at gate and another on side of library. This integrated effort of panel on roof and charging station will change the use of e-rickshaw and reduction in carbon pollution. So the promising world has lot of possible results and lot of scope in solar sector.

V. REFERENCES

[1] https://www.google.com/search?q=pv+cells+connectedi+n+series&source=lnms&tbm=isch&sa=X&ved=0ahUKEwiulLzX7IncAhVGcCsKHevSAoYQ_AUICigB&biw=1366&bih=662#imgrc=-M-OqxjwA99sSM

[2] Ajeet Singh, Dr. Mukesh Pandey and Anurag Gour - Experimental analysis of solar photo voltaic panel with air cooling system to maintain its efficiency- 2018, IJCRT Volume 6, Issue 2 April 2018 ,ISSN: 2320-2882

[3] Ecosense experimental kit

[4] http://www.yuvaengineers.com/solar-and-fuel-cell-technology-a-sai-pavani-t-tejovathi-k-s-n-avanthi

[5] Dhass. A.D.,Natarajan E and Lakshmi Ponnusamy Dept of EEE College of Engineering,Guindy Anna University, Chennai-Influence of Shunt Ressistance on the Performance of Solar Photovoltic Cell- 978-1-4673-4634-4/12©2012 IEEE

[6] Jubaer Ahmed and Zainal Salam-An improved perturb and observe (P&O) maximum power point tracking (MPPT) algorithm for higher efficiency- Applied Energy 150 (2015) 97–108

[7] Michael Mauk, Paul Sims, James Rand, and Allen Barnett -Thin Silicon Solar Cells- AstroPower Inc., Solar Park, Newark, Delaware, USA

[8] Wook Kim, Van-Huan Duong, Thanh-Tuan Nguyen and Woojin Choi-Analysis of the effects of inverter ripple current on a photovoltaic power system by using an AC impedance model of the solar cell- Renewable Energy 59 (2013) 150e157