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50 kW$_p$ Rooftop PV System: A Case Study

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Abstract:
This paper presents on experimental analysis of the solar module (230W$_p$) installed of existing 50 kW$_p$, Solar Photovoltaic Station at KIIT campus, Bhubaneswar. Different characteristics of output current (I) *vs.* voltage (V) and output power (P) *vs.* voltage (V) at difference irradiance level have been validated. Again, a study on the output voltage of inverter of 50kWp solar PV station has been made annually. It was found that Solar PV station not only gives supply to campus but also it connects with the online grid.
Keywords: Irradiance, Insulation, Output Current, Output Power, Output Voltage of inverter and Solar Photovoltaic Station

1. Introduction:

The solar cell technologies based on Si-wafer are generally referred as the first generation technologies while the cell technologies based on thin film are referred as the second generation technologies. The primary objective of development of thin film technologies is to reduce the cost of PV Modules. In this work Cd-Te thin film solar cell will be fabricated with the cheapest technique to get efficient and low cost solar cell.

The state of Odisha receives an average solar insolation of about 5.5 kW per sq. meter. At this rate the average capacity utilization factor is expected to be about 19%. Keeping this in view the State offers a levelized tariff of Rs 17.80 per kWh over a period of 25 years. Again the solar cell technologies can be categorised to Si- Wafer solar cell and heterojunction solar cell (thin film solar cell).

3 Block Diagram of Grid Integrated Solar Power Plant:

The basic components of grid integrated solar power plant are as follows: PV arrays, Inverter, Transformer, Load, Meter, Protective devices, Other devices etc.

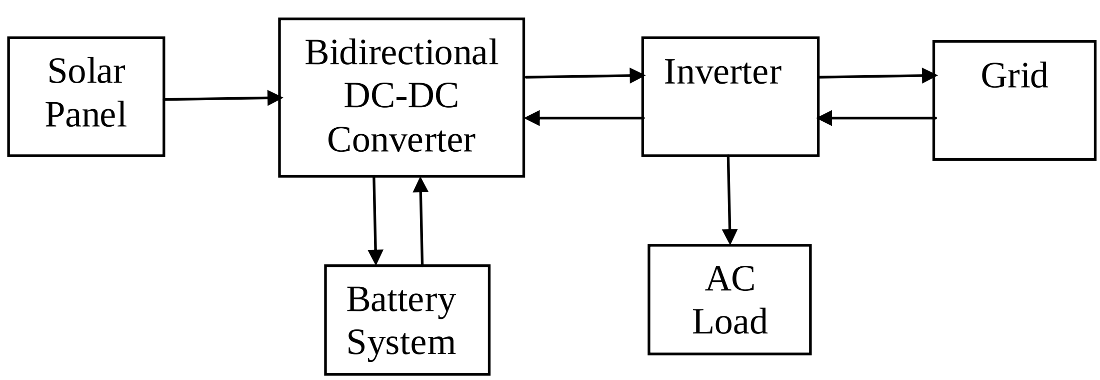

Figure 1: Block diagram of Grid connected PV System

3. Solar Photovoltaic Station: A Case Study.

.Figure 2, represents a roof top Solar PV station of 50KW$_p$ at KIIT Campus, Bhubaneswar.

Figure 2: 50kW$_P$ roof top PV system of KIIT

4 Module Specification: HSTBF24230P (Poly Crystalline Solar Module)

Figure 3: Polycrystalline solar module

Table 1 (Solar PV specification)

Company	**HHV Solar PV**
Type	Standard
Model No.	HSTBF24230P

Technology	Polycrystalline
Maximum Power, P_k	$230W_p$
Open Circuit Voltage, Voc	36.90V
Short Circuit Current, Isc	8.15A
Rated Voltage	30.55V
Rated Current	7.53A
Maximum System Voltage	1000V
Output Tolerance	± 3%
Cell Temperature	25˚C
Dimension of Module	1650mm x 987mm x 42

5 PV Array Designing:
Number of Solar Photovoltaic modules is calculated as per load demand. The no. of inverter, combiner box and other equipments is needed to complete the whole designing. It is required to find the followings.

a) The no of module to be accommodated on both roof top and facade can be calculated by the following formula,
No. of module accommodation = (Total usable area) ÷ (area of a selected PV module).
b) To design the array there are some parameter to check. The most important thing to choose proper inverter and combiner box. So that, they can withstand the PV modules' voltage and current.

6. Calculation:
(a) Maximum Current in Inverter calculation:
MPPT voltage range of the Inverter = 425V to 875V
Power rating of inverter = 50kW
Inverter rated voltage =900V
So maximum current in the inverter=50,000/900=5505b Amp
Open circuit voltage of the Module = 36V
There are 20 modules in series. So open circuit voltage of the series combination
= 36.0 × 20 = 720V.
As 720V is within MPPT voltage range of the inverter, So Maximum voltage of the Module = 30.55 V
Inverter MPPT voltage range: 425V-875V
(425V-875V)/ 20= 21.25-43.75 (Maximum power voltage of the Module = 29.60V)
So, maximum power voltage is in the voltage range of the Inverter.
50kW inverter current rating: Inverter rated voltage = 900V
Maximum Current= (50000/900)= 55.55A
(b) Number of inverter calculation
No of inverter = Total no of module/(no. of module in series in a string × no. of parallel string) = 220/(20 × 11) = 1
(c) Number of combiner box
As combiner box is equal to the number of inverter, So, only one combiner box is required.
(d) Plant Capacity

It may be calculated by= No. of modules × Maximum Power = 220 × 230Wp = 50,600Wp

(e)Power Generation

It may be calculated by:

Total Calculated Energy = [No. of Modules × Max. Power (Wp) × Solar irradiance (in kWph/m^2/day) × No. of days] ÷ 1000.

Table 3 (Total Calculated Energy in kWph)

Month	No. of Modules	Max. Power (Wp)	Solar irradiance (in kWph/m^2/day)	No. of days	Total Calculated Energy in kWph
January	220	230	4.5	31	7058
February	220	230	5.2	28	7367
March	220	230	5.7	31	8941
April	220	230	6.2	30	9411
May	220	230	6.1	31	9568
June	220	230	4.4	30	6800
July	220	230	3.8	31	6054
August	220	230	3.7	31	5803
September	220	230	4.09	30	6208
October	220	230	4.5	31	7058
November	220	230	4.4	30	6679
December	220	230	4.6	31	7215
Total Power generated					80946

7. Extra Power Generated

Extra power generated is the difference between total power generated and field power or power consumed.

= (80946 – 4890) kWph = 76056 kWph

% power generated= (Extra Power Generated ÷ Total power generated) × 100

= (76056 ÷ 80946) × 100 = 93.9%

The total extra power generated is about 93.9%. The reason behind this is the losses occurred in the system. The loss may be occurred due to dust on the module or copper loss/wire loss or shading or increase in temperature or change in intensity etc.

8. Experimental Analysis:

An experiment was done at KIIT campus by considering one PV module from the 50kWp plant. The experiment was done by considering difference irradiance level.

The I-V (current-voltage) curve of a PV string (or module) describes its energy conversion capability at the existing conditions of irradiance (light level) and temperature. Conceptually, the curve represents the combinations of current and voltage at which the string could be operated or 'loaded', if the irradiance and cell temperature could be held constant. Figure 4 and figure 5 shows the I-V characteristics and PV characteristics in different irradiance level. The fill factor is approximately 0.75 which is use in the calculation above. The maximum power obtained from the solar cells varies between 29V to 30V when solar irradiation changes from 600 W_p/m^2 to 1200W_p/m^2.

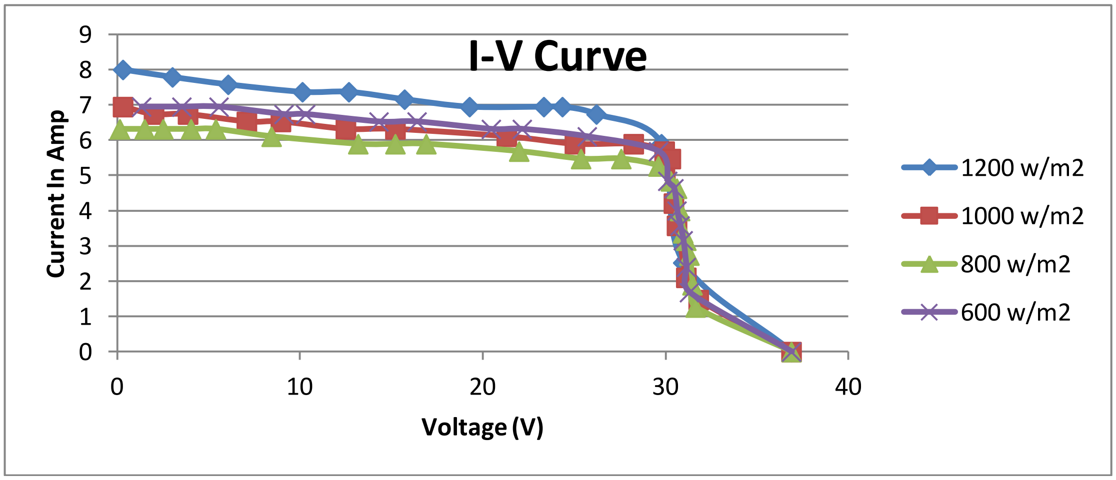

Figure 4: I-V Characteristics of solar module installed

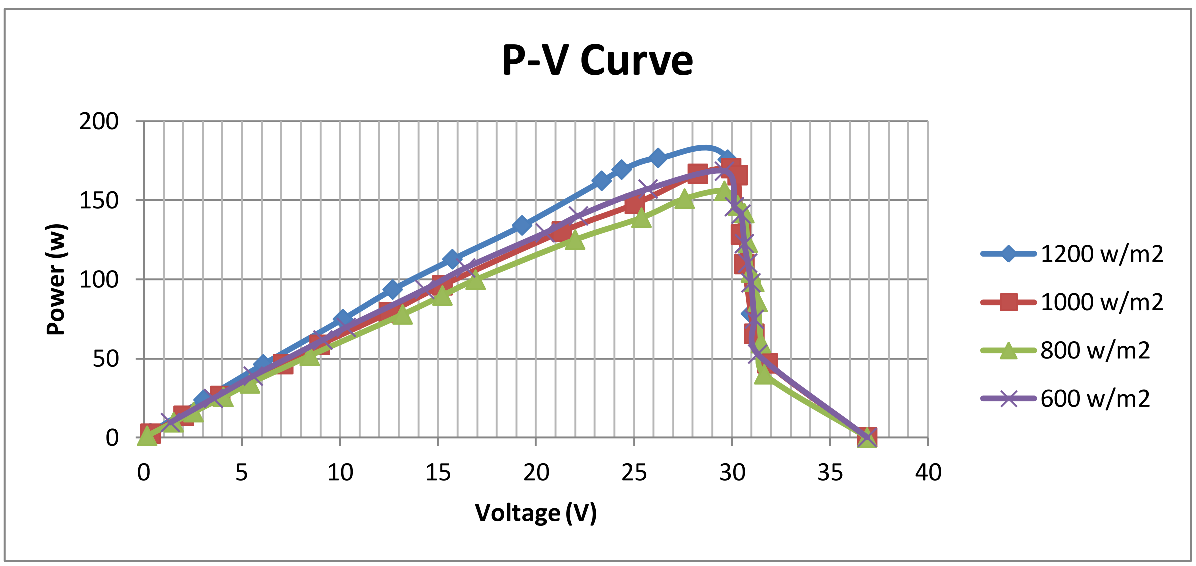

Figure 5: P-V Characteristics of solar module installed

9. Characteristics of Energy Generation of Inverter in Rooftop Solar PV Station:

The load curve for Rooftop power generation from the different Inverter for the month of January is given below. The inverters are placed in different hostel buildings, academic building, vocational building etc.. The figure shows from 6 to 14, that the output from each inverter with respect to solar generation for the load connected to it.

Figure 6 shows a no load on 13th January and maximum load of 95kWh occurs on 24th January in Hostel 1.

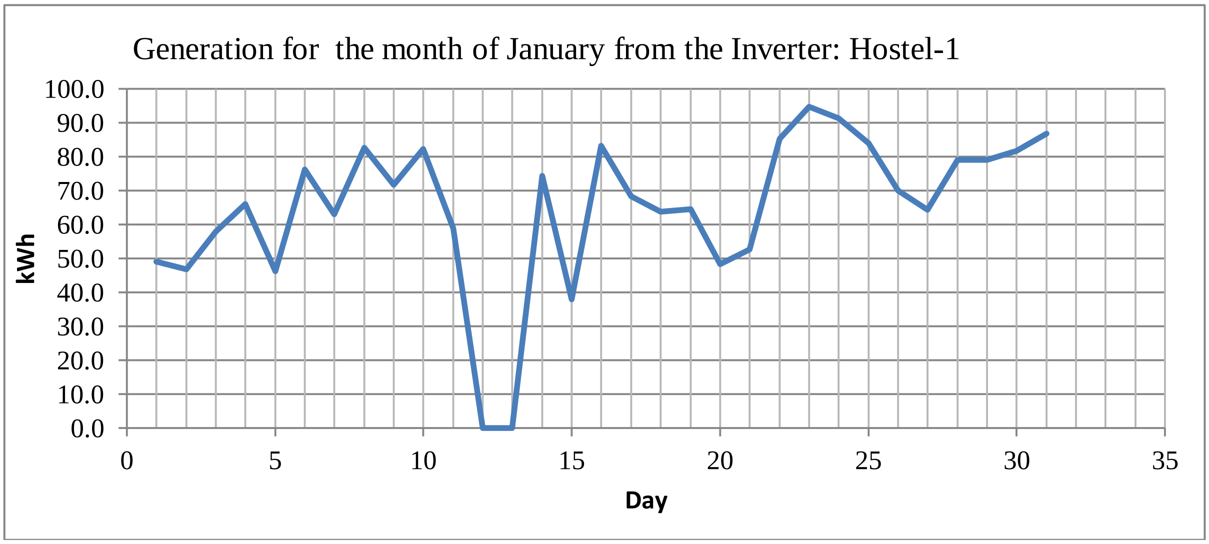

Figure 6: Power generation for the Month of January from the inverter Hostel-1

Figure 7 shows a minimum load of 42kWh on 15th January and maximum load of 95kWh occurs on 24th January in Hostel 2.

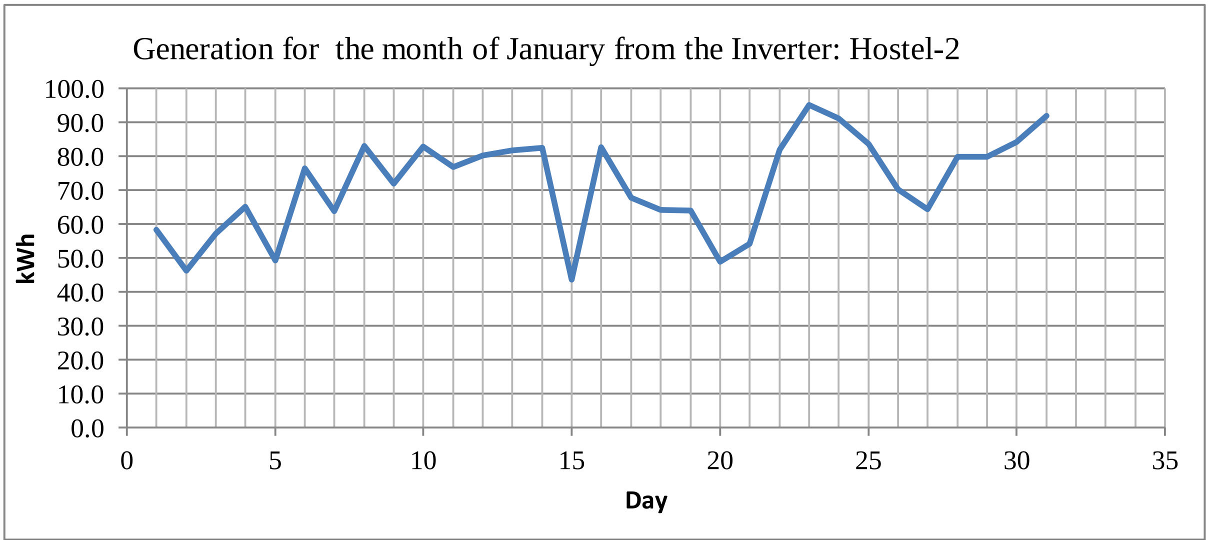

Figure 7: Power generation for the Month of January from the inverter Hostel-2

Figure 8 shows a minimum load of 35kWh on 15th January and maximum load of 82kWh occurs on 24th January in Hostel 3.

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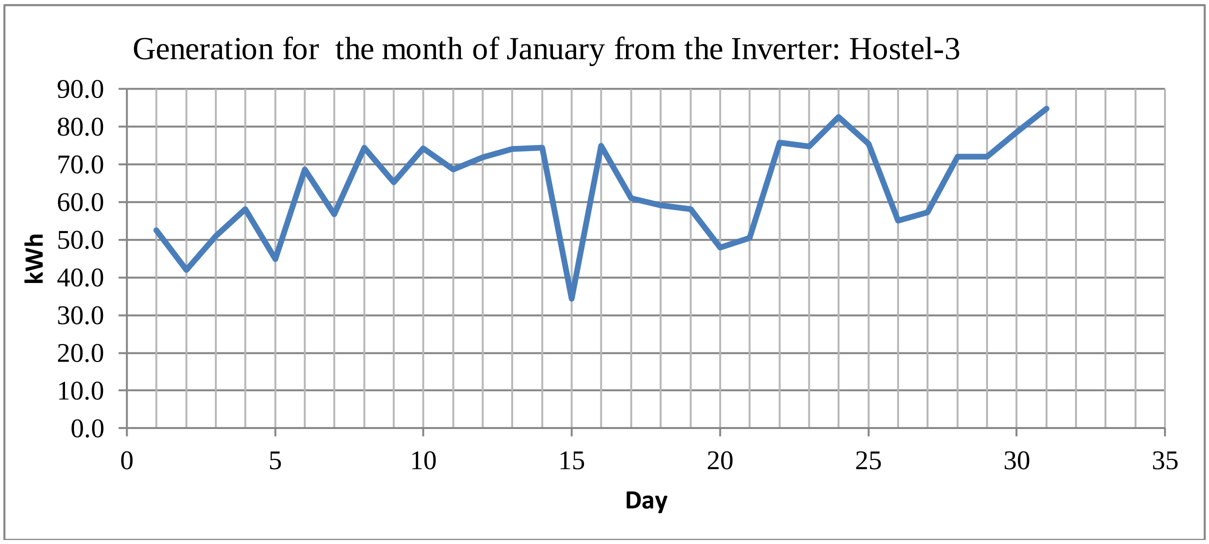

Figure 8: Power generation for the Month of January from the inverter Hostel-3

Figure 9 shows a minimum load of 27kWh on 20th January and maximum load of 71kWh occurs on 12th January in Hostel 4.

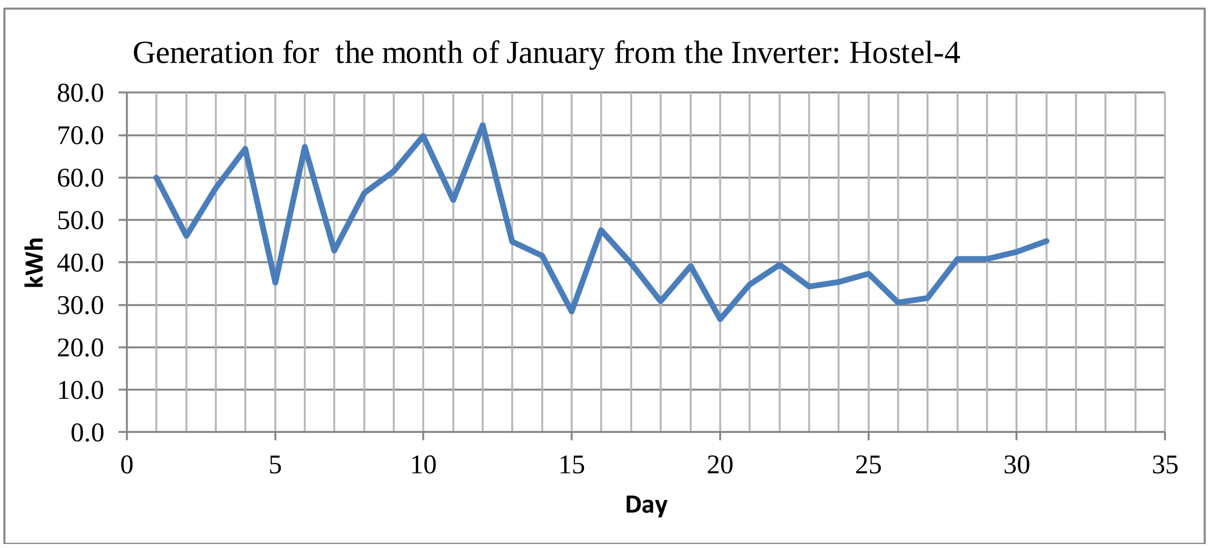

Figure 9: Power generation for the Month of January from the inverter Hostel-4

Figure 10 shows a minimum load of 29kWh on 15th January and maximum load of 78kWh occurs on 23th January in Dining Hall 1.

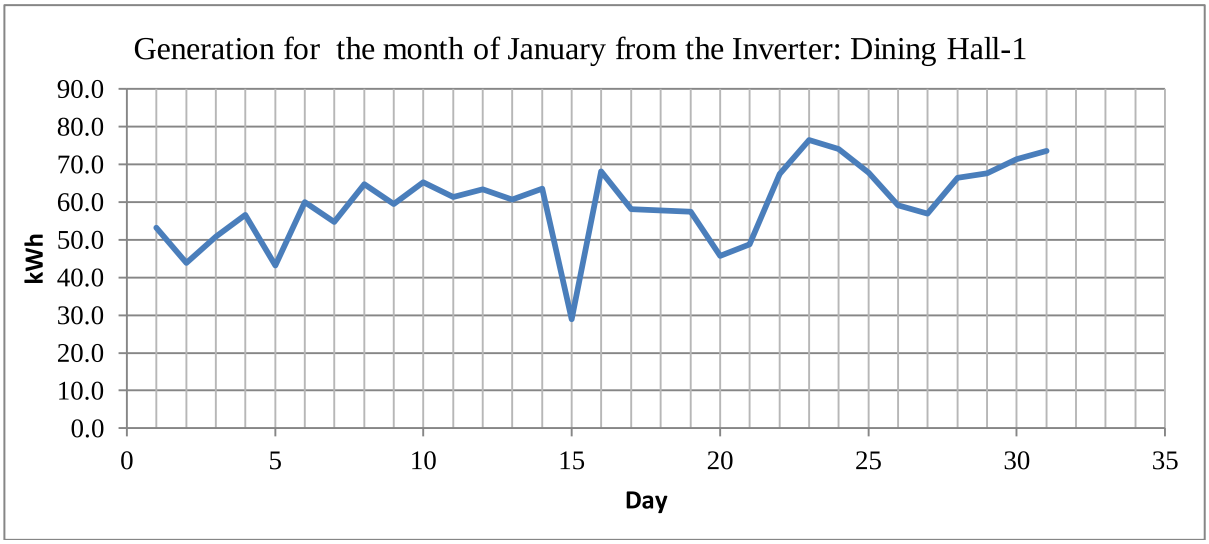

Figure 10: Power generation for the Month of January from the inverter: Dining Hall-1

Figure 11 shows a minimum load of 30kWh on 15th January and maximum load of 73kWh occurs on 24th January in Dining Hall 2.

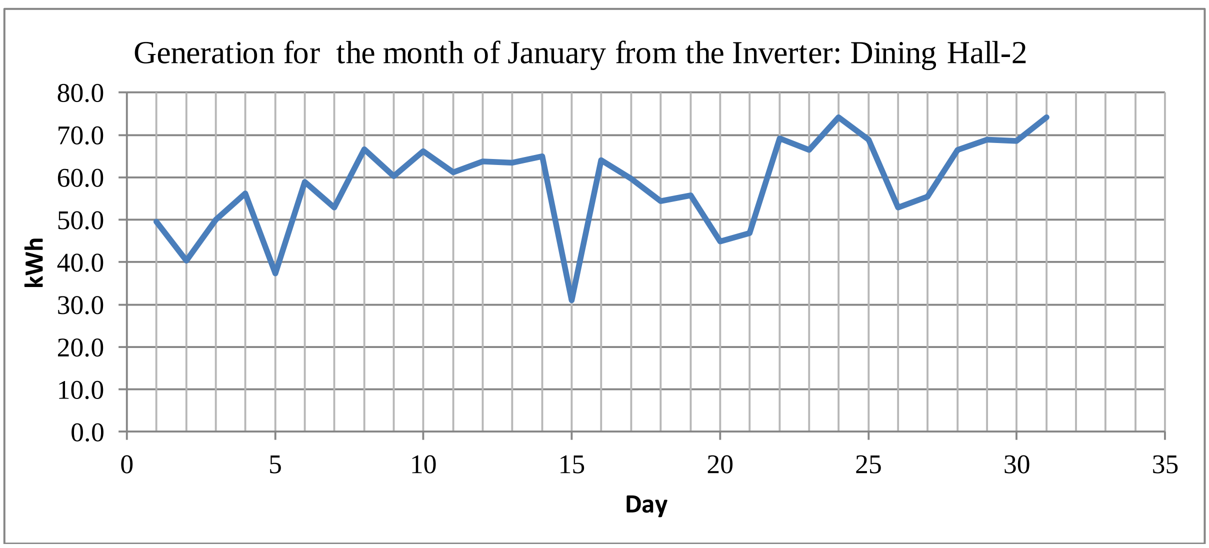

Figure 11: Power generation for the Month of January from the inverter: Dining Hall-2

Figure 12 shows a minimum load of 35kWh on 15th January and maximum load of 78kWh occurs on 16th January in Vocational Building.

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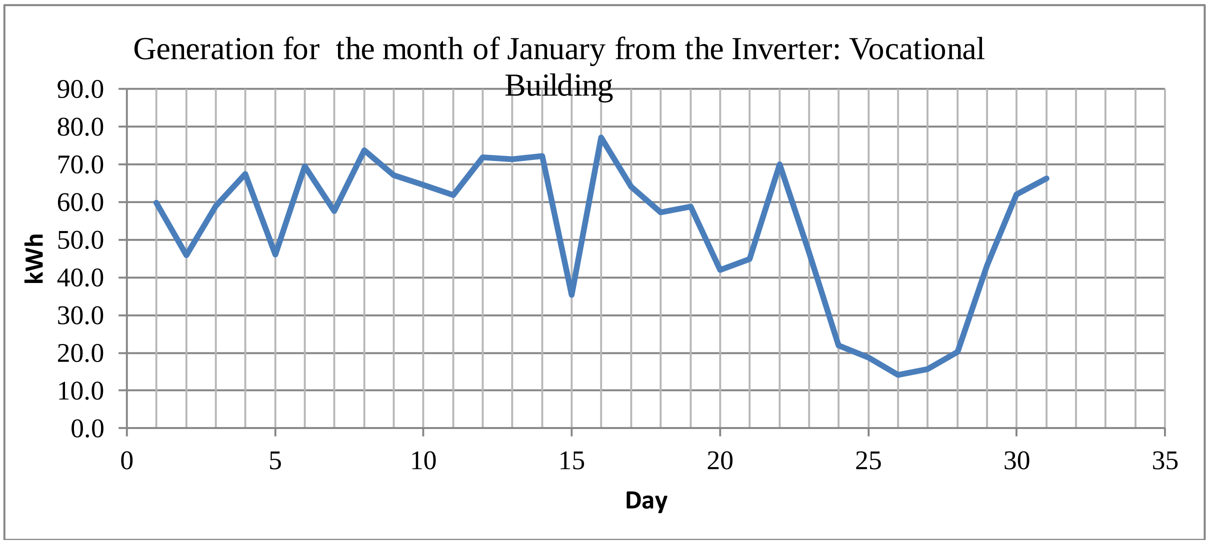

Figure 12: Power generation for the Month of January from the inverter: Vocational Building

Figure 13 shows a minimum load of 14kWh on 27th January and maximum load of 73kWh occurs on 12th January in Academic Building.

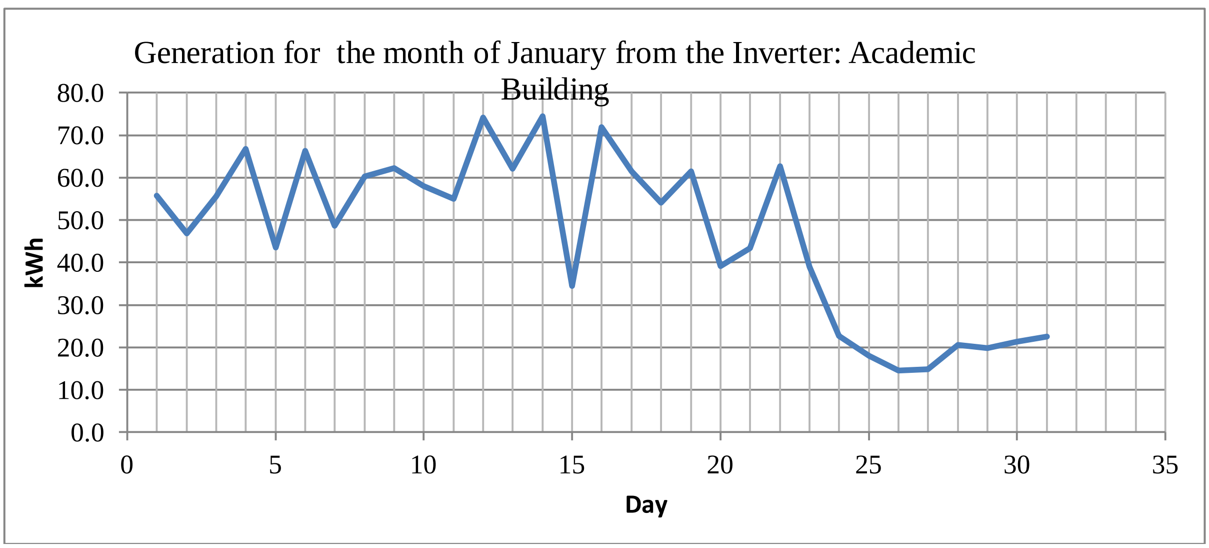

Figure 13: Power generation for the Month of January from the inverter: Academic Building

Figure 14 shows a minimum load of 12kWh on 27th January and maximum load of 69kWh occurs on 12th January in Academic Building 1.

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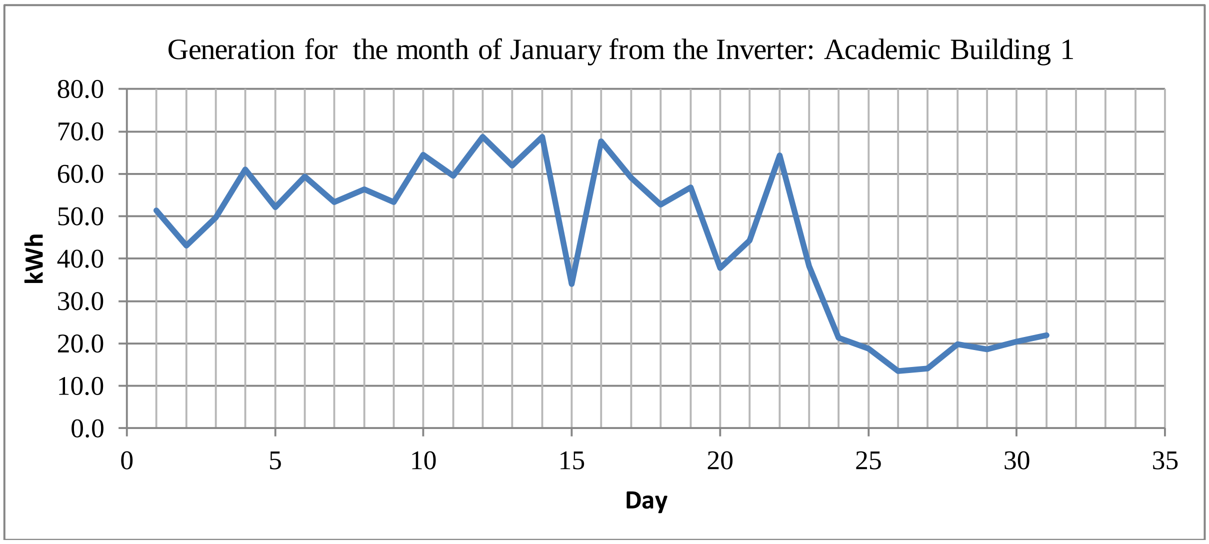

Figure 14: Power generation for the Month of January from the inverter: Academic Building-1

10. Conclusion:

In this paper, different characteristics of output current (I) *vs* voltage (V) and output power (P) *vs* voltage (V) of the module (230W_p) installed at 50 kW_p Solar PV Station at KIIT campus has been drawn to realize the energy conversion capability of the module in the existing conditions of the module. Again, a study on 50kWp solar PV station at KIIT campus has been made incorporating the output voltage of inverter annually. From the case study at KIIT Campus it was found that Solar PV station not only gives supply to campus but also it connects with the online grid. It was concluded that there has been most significant role of solar PV system in India by connecting utility grid in which more amount of energy can be generated and consumed.

References

[1] T. Markvart, L.Castaner, Practical Handbook of Photovoltaic: Fundamentals and Applications, Oxford: Elsevier Science Ltd, 2003, pp. 72-455.

[2] D.P. Hohman, and M.E. Roop, “Comparative study of maximum power point tracking algorithms,” Progress in Photovoltaic: Research and Applications vol. 11, pp. 47-62, November 2002.

[3] Cho, B. H. (1985). Modelling and Analysis of Spacecraft Power Systems, PhD Thesis. Virginia Polytechnic Institute and State University.

[4] Slobodan M. Cuk “Modelling, Analysis and designing of switching converters” Ph. D thesis of California Institute of Technology, Pasadena, California.

[5] Muhammad Syafei Gozali, “Comparison of ĆUK and SEPIC Converter Applied in Maximum Power Point Tracking for PV System,” IJEERI, Vol. 2, No. 1, March 2013.

[6] Diva Catherine, Kavitha Bhaskar, “Simulation of a Solar Mppt Charger Using Cuk Converter for Standalone Application” International Journal of Electrical, Electronics and Computer Systems (IJEECS), ISSN (Online): 2347-2820, Volume-1, Issue -1, 2013.

[7] Ankur Bhattacharjee (2012) "Design and Comparative Study of Three Photovoltaic Battery Charge Control Algorithms in MATLAB/SIMULINK Environment", International Journal of Advanced Computer Research (ISSN (print): 2249-7277 ISSN (online): 2277-7970), Volume-2 Number-3 Issue-5.

[8] Zameer Ahmad and S.N. Singh (2012) "Extraction of the Internal Parameters of Solar photovoltaic Module by developing Matlab / Simulink Based Model", International Journal of Applied Engineering Research, ISSN 0973-4562 Vol.7 No.11.

[9] Pandiarajan.N and Dr. Ranganath Muthu (2011)"Development of Power Electronic Circuit Oriented Model of Photovoltaic Module", International Journal of Advanced Engineering Technology, E-ISSN 0976-3945 Vol.II/ Issue IV.

[10] P. Geethanjali, P. Vijaya Priya, M. Kowsalya, J. Raju," Design and Simulation of Digital PID Controller for Open loop and Closed Loop Control of Buck Converter," IJCST Vol. 1, Issue 2, December 2010.

[11] Villalva.M.G , and Ruppert.E, "Dynamic analysis of the input controlled buck converter fed by a photovoltaic array" Revista Controle & Automação/Vol.19 no.4/Outubro, Novembro e Dezembro 2008,pp 463-474

[12] A.K. Sinha, and J. Pal, "Simulation based reduced order modelling using a clustering technique," Jr. Computer and Electrical Engg., vol. 16, no. 3, pp. 159-169, 1990.

[13] E. Durán, M.B. Ferrera, J.M. Andújar, M.S. Mesa (2011) "I-V and P-V Curves Measuring System for PV Modules based on DC-DC Converters and Portable Graphical Environment" IEEE, 978-1-4244

[14] Sung-Jun Kang et,al, "A Novel MPPT Control of photovoltaic system using FLC algorithm," 2011 11th International Conference on Control, Automation and Systems, pp. 26-29, October 2011.

[15] Hairul Nissah Zainudin and Saad Mekhilef (2010) "Comparison Study of Maximum Power Point Tracker Techniques for PV Systems" 14th International Middle East Power Systems Conference (MEPCON'10), Cairo University, Egypt, Paper ID 278.

[16] D. Sera et, al. "Teaching Maximum Power Point Trackers Using a Photovoltaic Array Model with Graphical User Interface," Institute of Energy Technology, Aalborg University, December 2008.

[17] A.N.K. Nasir, M.A. Ahmad and M.F. Rahmat, "Performance comparison between LQR and PID Controller for an inverted pendulum system" International Conference on Power Control and Optimization, Chiang May, Thailand, 18-20, July 2008.