International Journal of Engineering Research
Volume No.5 Issue: Special 6, pp: 1129 - 1254
ISSN: 2319-6890)(online),2347-5013(print)
20 May 2016

# Estimation of solar potential of grid connected Photo-voltaic system for 100m$^2$area

**Santhosh Somashekar**
Department of Mechanical Engineering, JSSATE, Bengaluru-560060
E-mail-santhoshangadi888@gmail.com

**Abstract--- Conventional (fossil) fuels are depleting fast. As a result, the non-conventional (renewable) energy sources, such as solar, wind and biomass are receiving a lot of attention from researchers all over the world. A major advantage of renewable sources is that, in general, they do not cause any pollution and most of them are available in abundance.PV systems do not cause any noise pollution and incur nearly zero maintenance and running costs, which adds to its popularity. However, due to higher initial investment and limited life span, it is important to utilize the PV array as effectively as possible and extract maximum possible power. The objective of this work is to estimate the potential of grid quality SPV power. Diurnal variations, monthly and peak variations are calculated and plant rating is made**

**Keywords--- Diurnal variations, Daily Energy Output, Monthly Energy Output, Grid Connected Photovoltaic (PV) System, PWM Inverters, Solar Radiation, Yearly Energy Output**

## I. Introduction

Electricity is obtained from the PV array most efficiently during daytime. But at night or during cloudy periods, independent power systems use storage batteries to supply the electricity needs. With grid interactive systems, the grid acts as the battery, supplying electricity when the PV array cannot. The energy storage devices viz. battery has been avoided in this work. This approach reduces the capital as well as the running cost. We have tried to develop a grid connected photovoltaic system. Grid connected photovoltaic system is well known in various parts of world, and several technologies are used. There have been efforts to develop the power electronics circuitry involved. Several types of inverters have been designed. But our focus is to obtain the potential of grid connected photovoltaic system using weather-station data installed within the premises of plant and an establishment of this type of system is tried out with the existing methodologies and equipment available.

## II. Materials and Methods

To find out the solar photovoltaic generation potential of Patiala, the solar radiation over 9 months (August 2015-April 2016) is recorded from the weather-station installed within the premises of plant. Then the diurnal variations, average monthlyoutput, yearly output have been found out and relatedgraphs are plotted for showingthe variation in different seasons and time. For better understanding of the methodology, the measured radiation data for the month of April 2015 has been given as a sample. The diurnal variations for different months are plotted. From that the monthly output and yearly outputs are calculated. Also observing the peak value in different days, the monthly average peak is calculated and variation of the monthly peak is plotted and the average annual peak is calculated. For calculating the output the efficiency of the photovoltaic module is taken as 14.3%. Finally a grid connected photovoltaic system is designed with the available technologies for the estimated plant capacity on 100 m$^2$area. The novelties of this approach lies in the fact of assessing the solar photovoltaic generation potential and thereby obtaining the possible plant capacity. The method of design is shown with the existing equipments available in the market.

## III. Results and Discussion

Solar radiation is recorded with the help of weather-station installed within the premises of plant for the time period August 2015 to April 2016. The results for the month of April at 9AMhave been shown as a sample in Table 1. The diurnal variation for April 2016 is then shown in Table 2. Graph showing the diurnal variations of the different month ofApril 2016 are then drawn and similar graphs are plotted. Daily, monthly and yearly energy outputs are calculated as shown in Table 3. Graphs for daily and monthly energy outputs are obtained as shown in 2 and 3. Using the peak values for the different months thepossible plant capacity is estimated as shown in Table 4. Monthly peak variations are also plotted in graph 4.

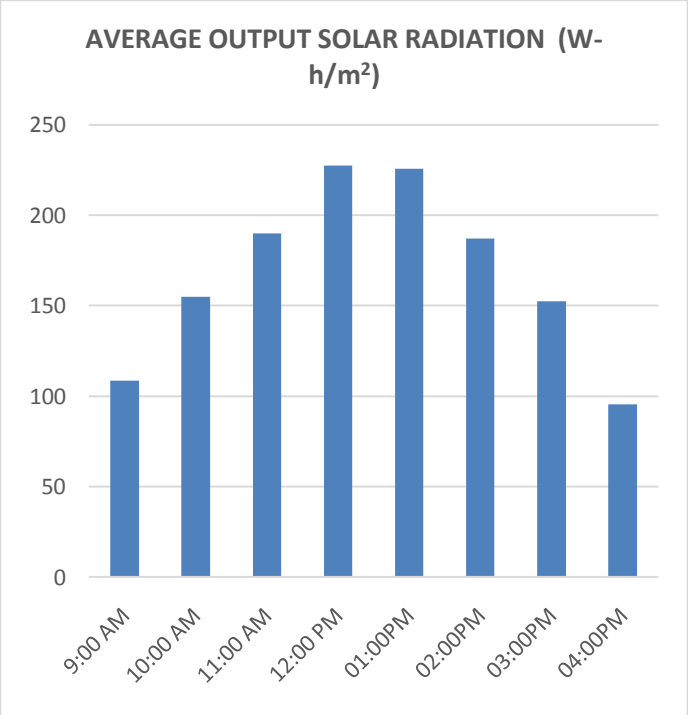
ISSN: 2319-6890)(online),2347-5013(print)
20 May 2016

Table 1: Solar Radiation Data & Calculation of Average Output April 2016 (Time: 9 AM)

| Date | Input Solar Radiation(W-H/M$^2$) | Output Solar Radiation(W-H/M$^2$) |
|---|---|---|
| 1/4/2016 | 812.75 | 116.22325 |
| 2/4/2016 | 827.875 | 118.386125 |
| 3/4/2016 | 782.25 | 111.86175 |
| 4/4/2016 | 752.375 | 107.589625 |
| 5/4/2016 | 867 | 123.981 |
| 6/4/2016 | 915.625 | 130.934375 |
| 7/4/2016 | 791 | 113.113 |
| 8/4/2016 | 784.875 | 112.237125 |
| 9/4/2016 | 733.25 | 104.85475 |
| 10/4/2016 | 710.375 | 101.583625 |
| 11/4/2016 | 778.125 | 111.271875 |
| 12/4/2016 | 723.5 | 103.4605 |
| 13/4/2016 | 740.625 | 105.909375 |
| 14/4/2016 | 824.375 | 111.271875 |
| 15/4/2016 | 844 | 120.692 |
| 16/4/2016 | 886.875 | 126.823125 |
| 17/4/2016 | 897.25 | 128.30675 |
| 18/4/2016 | 892 | 127.556 |
| 19/4/2016 | 732.625 | 104.765375 |
| 20/4/2016 | 819.125 | 117.134875 |
| 21/4/2016 | 836 | 119.548 |
| 22/4/2016 | 827.625 | 118.350375 |
| 23/4/2016 | 786 | 112.398 |
| 24/4/2016 | 925.125 | 132.292875 |
| 25/4/2016 | 852.25 | 121.87175 |
| 26/4/2016 | 814.75 | 116.50925 |
| 27/4/2016 | 786.375 | 112.451625 |
| 28/4/2016 | 820.25 | 117.29575 |
| 29/4/2016 | 817.125 | 116.848875 |
| 30/4/2016 | 783.125 | 111.986875 |

Table 2: Diurnal Variations for the month of April 2016

| Time | Average Output Solar Radiation (W-H/M$^2$) | Daily Energy Output (W-H/M$^2$) | Monthly Energy Output (W-H/M$^2$) |
|---|---|---|---|
| 09:00 AM | 108.5388500 | 1341.015526 | 40230.46579 |
| 10:00 AM | 154.9120192 | | |
| 11:00 AM | 189.9172771 | | |
| 12:00 PM | 227.4552042 | | |
| 01:00PM | 225.4812375 | | |
| 02:00PM | 186.9251759 | | |
| 03:00PM | 152.2753375 | | |
| 04:00PM | 95.51041500 | | |




Graph 1: Average output solar radiation for the month of April 2016

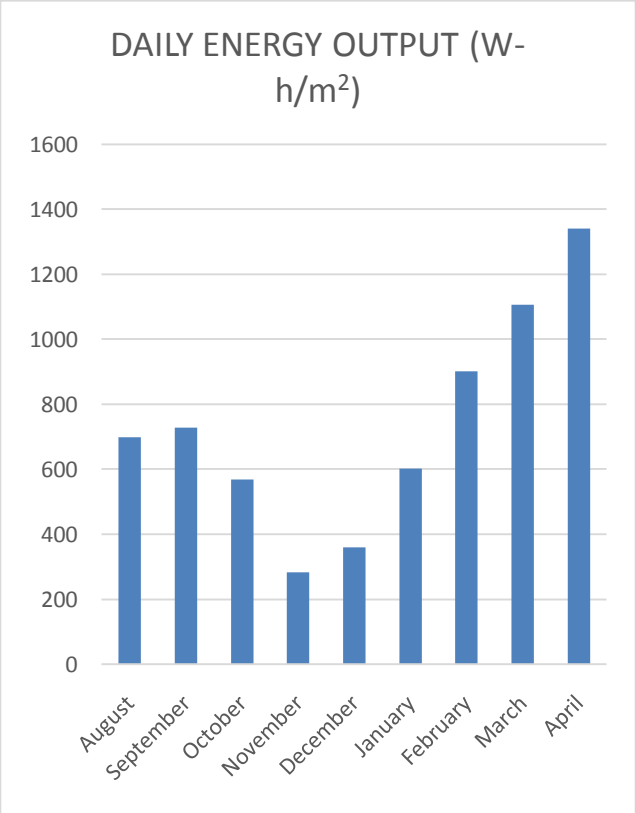

doi: 10.17950/ijer/v5i6/021

ISSN: 2319-6890)(online),2347-5013(print)
20 May 2016

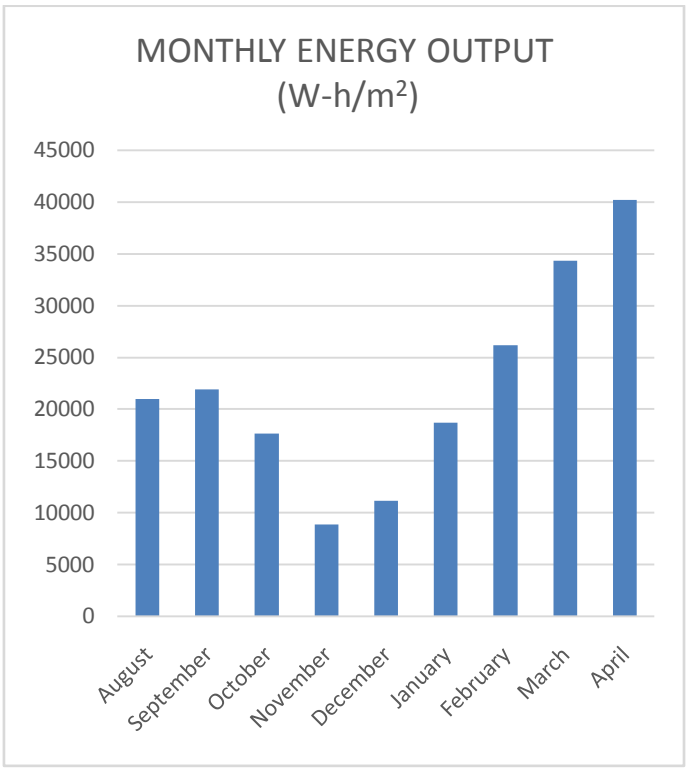
Table 3: Total Energy Output

| Months | Daily Energy Output (W-H/M$^2$) | Monthly Energy Output (W-H/M$^2$) |
|---|---|---|
| Aug | 700.3972782 | 21011.91835 |
| Sep | 729.4847083 | 21884.54215 |
| Oct | 568.8679759 | 17634.90725 |
| Nov | 284.6676219 | 8824.696279 |
| Dec | 359.6377400 | 11148.76994 |
| Jan | 602.7380089 | 18684.87828 |
| Feb | 903.1113334 | 26190.22867 |
| Mar | 1107.896930 | 34344.80483 |
| Apr | 1341.015526 | 40230.46579 |

Average Monthly Energy Output (W-h/m$^2$)-22217.24572
Average Yearly Energy Output (W-h/m$^2$) - 266606.9486




Graph 2: Daily energy output




Graph 3: Monthly energy output

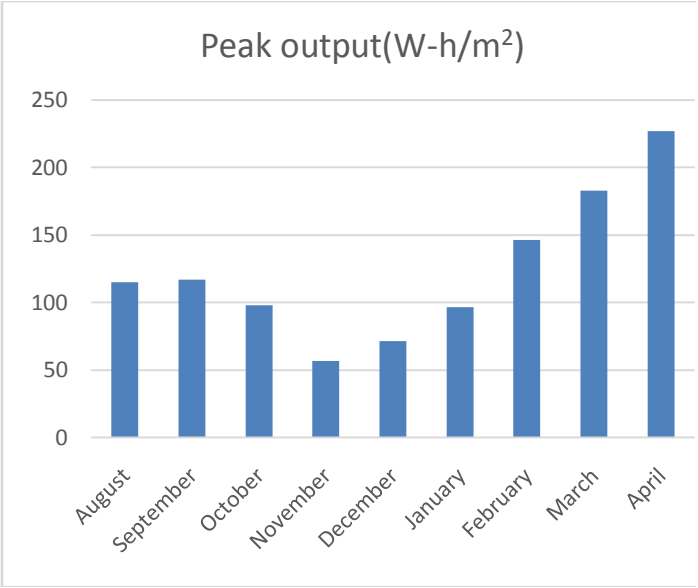
Table 4: Peak Variation & Possible Plant Rating

| Months | PEAK OUTPUT (W-h/m$^2$) |
|---|---|
| August | 115.0835 |
| September | 117.2510 |
| October | 98.17016 |
| November | 56.93546 |
| December | 71.41933 |
| January | 96.67253 |
| February | 146.7395 |
| March | 183.1408 |
| April | 227.4552042 |

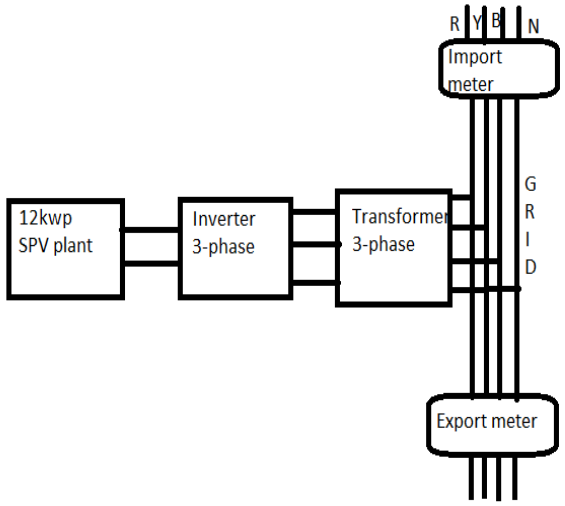
AVG PEAK OUTPUT (W-h/m$^2$) -123.73553
AVG PEAK OUTPUT/100m$^2$ AREA (W-h) - 12373.55363
POSSIBLE PLANT CAPACITY (kW-h) - 12


doi: 10.17950/ijer/v5i6/021

ISSN: 2319-6890)(online),2347-5013(print)
20 May 2016




Graph 4: Peak output




12Kwp Grid Connected Solar Photovoltaic Power Plant

## IV. System Design

Grid connected PV system can be designedin various ways, like with battery, without battery, with or without transformer etc. Here without battery grid interconnected system is used, because of short life time, large replacement cost, and increased installation cost. A transformer is used for boosting the ac output voltage and feeding to grid. There are two meters connected-one is called the import meter, the other is called the export meter. Thus the difference between the two meter readings gives the power fed to the grid from solar photovoltaic power plant. So using these meters we can easily determine what amount of energy is fed to the grid from solar power. From the results obtained, we find that a 12KWp solar photovoltaic power plant can be developed on 100 $m^2$area. Corresponding system sizing and specifications are provided along with the system design. For the 12kWp plant required no. of PV modules = (12000 /200) =60. Now to form a solar photovoltaic power plant 60 modules are connected in series parallel combination. 10 modules are connected in series and there are 6 parallel paths of 10 modules each. It also supports the fact that these 60 PV modules can be accommodated within 100 $m^2$ area. Now each module produces 24.5 Volts. So total 10 series connected module will produce = 24.5×10 =245Volts. So there are six 245 Volts combinations are connected in parallel. Therefore total output from solar photovoltaic structure= 245 Volts. This

 doi: 10.17950/ijer/v5i6/021 

ISSN: 2319-6890)(online),2347-5013(print)
20 May 2016

## V. System Sizing and Specifications

The system sizing and specifications for the 12 KWp power plant unit is shown below

| **Grid Specification** | |
|---|---|
| No. of Phases | Three phase |
| Voltage rating | 400 Volts AC |
| Frequency | 50 Hz |
| **Solar Photovoltaic Power Plant Specification** | |
| Plant Capacity | 12KW |
| Voltage Output | 245 Volts dc |
| Current Output dc | 50 A dc |
| Area | 100$m^2$ |

- PWM inverters are used here for suppressing the harmonics produced after DC to AC conversion.
- The calculation for finding the output voltage of inverter is shown below:

Phase voltage= $V_{ph}$=0.4714× $V_{dc}$ =0.4714×245 =113.136Volts

Line voltage = 0.779× $V_{dc}$ =0.779×245= 186.96Volts

| **Inverter Specification** | |
|---|---|
| KVA rating | 11.5 - 12 KVA |
| Input DC voltage | 245 Volts DC |
| Input dc current | 50 A |
| Output AC voltage | 1135.36 V ac (phase voltage)<br>186.96 V ac (line voltage) |
| No. of Phases | Three |
| Type | PWM (for suppressing 3rd harmonics) |
| Efficiency | Almost 90-93% |
| Total harmonic distortion | < 5% |
| **Transformer Specification** | |
| KVA rating | 12 KVA |
| No of phases- | Three |
| Frequency rating | 50 Hz |
| Primary voltage rating | 240 V |
| Secondary voltage rating | 400 V |
| Primary current rating | 90 A + (10-15% extra) |
| Secondary current rating | 55 A + (10-15% extra) |
| Efficiency | Almost 95 % |
| Extra features | Air cooled |

| **Solar Panel Specification** | |
|---|---|
| Watt | 200 Watt |
| Voltage | 24.5 Volts |
| Current | 8A |
| Type | Polycrystalline |
| Efficiency | 14.3% |
| Temperature | 25 deg C |
| **Protection** | |
| Protective device | 400 Volts under voltage relay |

Others: Junction boxes, meters, distribution boxes, wiring materials, mounting materials etc.

## VI. Conclusion

Solar photovoltaic generation potential during the period August 2015-April 2016 is assessed. It is found that the month of November produced the lowest solar radiation. Monthly and yearly outputs were calculated on the basis of 100 $m^2$ area. Considering the monthly peaks, the average peak output is calculated from where an estimate of the possible plant rating is made. The methodology adopted seems satisfactory for determining the possible plant capacity chosen area. The design described is based on the potential measured. System sizing and specifications are provided based on the design made. Cost analysis of this photovoltaic plant can be taken up as a future scope of work.

## Acknowledgement

The author of current work wish to thank KPCL, Bangalore for their facilities and financial support.

## References

i. Prakasit Sritakaew and others, "On Reliability Improvement of Distribution systems Using PV Grid Connected Systems"

ii. A.S. Elhodeiby and others, "Performance analysis of 3.6KW Rooftop grid connected photovoltaic system Egypt. International Conference on Energy Systems and Technologies (ICEST 2011) 11-14 March 2011, Cairo, Egypt.

iii. D. Picault and others, "Guidelines for evaluating grid connected PV system topologies". IEEE International Conference on Industrial Technology. Page(s): pp. 1-5, 2009.

iv. Phil Bolduc and others, "Performance of a grid connected PV system with energy storage". IEEE Photovoltaic. Page(s): 1159 – 1162, 1993.

v. [http: Energy Scenario] "Solar PV Industry 2010: Contemporary scenario and emerging trends"

ISSN: 2319-6890)(online),2347-5013(print)
20 May 2016

vi. [http: Energy Scenario] “the solar PV landscape in India” available atwww.teicontrols.com/.../FinalReport- .pdf.