International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 07 | July 2018 www.irjet.net p-ISSN: 2395-0072

Simulation Based Performance Evaluation of 10MW Grid Connected Solar Power PV Plant

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Abstract - *The favorable weather condition and effective use of non-conventional energy sources for the place called Shivanasamudra located at Mandya district, Karnataka state, provide a considerable incentive for installed grid connected PV system. In this paper simulation of 10MW grid connected solar PV plant established by KPCL (Karnataka Power Corporation Limited) is presented and performance is evaluated on the annual basis by using PV syst. The various losses and performance ratio are also calculated. The performance results of the PV plant are also compared with simulated values.*

***Key Words*: PV syst, Grid Connected, Performance ratio, Inverter.**

1. INTRODUCTION

In Today's world the non renewable energy resources are gradually decreasing due to the increased cost and pollution. On other hand, the usage of renewable energy resources are rapidly increasing because India has an enormous potential for these energy sources particularly in solar power and these solar energy technologies are playing an important role in the field of electricity because of their pollution free, recyclable and abundant nature.

1.1 Description of Grid connected PV plant

Grid tied PV Systems consists of solar panels that provide necessary power during the day time, though it is connected to the local electrical grid in the night time. During summer season the Solar PV plant produces more electricity. This surplus electricity is either stored in the batteries or fed back to grid. Grid connected system can also known as Grid-tied and On-grid system. Grid connected PV system consists of solar arrays, several combiner boxes, inverters, transformers, switchyard and grid.

The installed solar PV power plant at Shivanasamudra site would use the approximate 50 acres of land. The installed solar photovoltaic power plant will be having a rating of 10MW and would be connected to the grid.

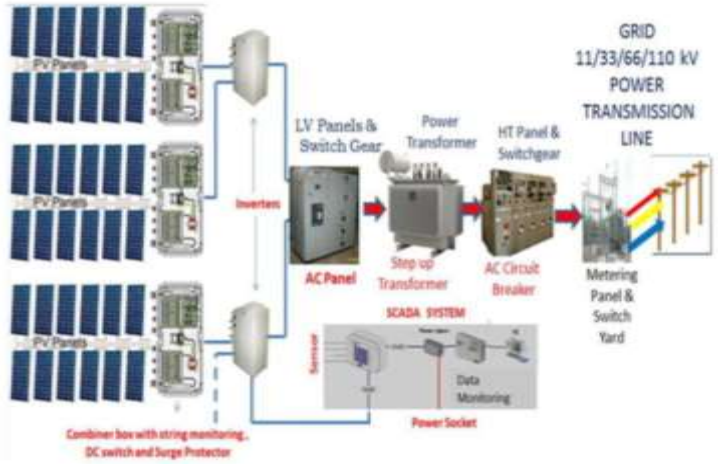

Fig -1: Schematic diagram of grid connected PV system

1.2 Objectives of the System

The objective of system is as follows

- To study the seasonal variations in PV plant output from the monitored SCADA data system.
- Performance evaluation of 10MW PV power plant based on actual generation.
- To compare the actual performance data with simulated data of PVSYST.
- To analyze the various losses occurring at various terminal points and identify the causes for losses.

1.3 Geographical area of the place

The installed KPCL 10 MW solar power plant will be located at latitude of 12.30^0 N, longitude 77.17^0 E and at a height of 90 meters. The Karnataka Power Corporation Limited (KPCL) opted this site for their construction of its 10MW Solar power plant as it positioned at geographically good location, where it can absorb more solar radiation for the whole year.

1.4 Layout of Plant

The entire rating of the plant is 10MW and it covered about 50 acres of land. The plant consists of of a total of 35840 modules in which 20 modules will be in series and 1792 strings will be in parallel. The modules of the system are fixed type, a 630kW inverter used for conversion of DC to AC which will be directly supplied to the grid.

1.5 Solar Panel Specification

PV Module	Specification
Module number	L24270P
Total number of module used for 10MW	35840
Module per MW	3584
Open circuit voltage	42V
Short circuit current	8.5A
Maximum voltage	35V
Maximum Current	8.2A
Type of mounting	Fixed

1.6 Inverter Specification

KVA rating	630
Input voltage of DC	874Volts
Input current of DC	854A
Number of Phases	3 phase
Type	Grid export condition(GEC)
Efficiency	96-98%
No of inverters required	16

1.7 Specification of Transformer

MVA rating	1.6
No of phases	3 phases
High voltage side	11kV
Low voltage side	440V
Type of cooling	ONAN
Efficiency	Almost 95%
No of Transformer required	8
Vector group	Dyn11

1.8 Grid Specification

No of phase	3phase
Grid Voltage	440V
38System Frequency	50Hz

2. METHODOLOGY

The performance of grid tied solar PV plant work in this paper is divided into following two stages:

(1) Manually collect the power generation parameters such as temperature, wind speed, and solar irradiation data through SCADA system.

(2) Compare the performance with the PVSYST software.

The performance of a power plant can be analyzed by considering the parameters like Performance ratio, Capacity Utilization Factor (CUF) with respect to energy production, system losses and solar resources of a plant.

2.1 Performance Ratio

The performance ratio of a PV plant can be defined as it is the ratio of actual power to the target power of the plant. Performance ratio can be calculated by considering the factors of irradiation, panel temperature, availability of grid, size of the aperture area, nominal power output.

PR=Actual power generation/Target Power Generation

2.2 Capacity Utilization Factor

It is defined as actual output of the plant compared to theoretical maximum output of the plant.

CUF = Energy measured (kW h)/(365 *24 * installed capacity of the plant).

2.3 Simulation using PV syst

PV syst software is PC simulation software developed to estimate the performance of the solar power plant. This software import meteo data from many different sources as well as personnel data. PV syst software is capable of evaluating the performance of grid-connected, stand-alone and pumping systems based on the specified module selection. The program accurately predicts the system yields computed using detailed hourly simulation data.

3.0 RESULT AND DISCUSSION

3.1 Estimation of Actual and Target generation for the year 2017

The Target energy can be calculated from known value of the CUF (Capacity Utilization Factor).The total target generation of 10MW PV plant for one year is given by

Target energy=Installed capacity of the PV plant*Number of days in a year*Number of hours in a day*known value of CUF

=10MW*365*24*0.186

Target energy=16293.6MU/Annum

Target energy of a day is obtained by dividing the annual energy of the PV plant by number of days present in a year (365days) and total Target energy generation can be obtained by number days in that particular month is multiplied by Target energy of that related month as shown in the table 1.

Month	Monthly energy output(actual) in MWh	Avg daily energy generation in MWh	Target power (MWh)	PR=(A/T)*100
Jan-17	1496.67	48.27	1382.6	108.25
Feb-17	1569.86	56.06	1249.92	125.59
Mar-17	1616.02	52.12	1383.84	116.77
Apr-17	1557.62	51.92	1339.2	116.77
May-17	1491.06	48.09	1383.84	107.74
Jun-17	1227.88	40.26	1339.2	91.68
Jul-17	1155.08	37.26	1383.84	83.46
Aug-17	1172	37.80	1383.84	84.69
Sep-17	1220.25	40.67	1339.2	91.11
Oct-17	1273.09	41.06	1383.84	91.99
Nov-17	1204.38	40.14	1339.2	89.93
Dec-17	1381.79	44.57	1382.6	99.85
Total				95.67

Table -1: Estimation of performance ratio

From the above table we can conclude that February month shows the highest performance ratio and monthly sum of energy generation and July month shows the lowest performance ratio and monthly sum of energy generation. This is all because of seasonal tilt of the solar arrays and the amount of solar radiation received from sun. Overall performance ratio of 10MW PV plant is 95.67%.

3.2 Simulation using PV syst

Fig- 2: Specification of system obtained by using PV syst

3.3 BALANCE AND MAIN RESULTS

The above table gives the Balance and Main results of Grid connected PV plant for the entire year. The yearly global horizontal irradiation is 2050kWh/m^2.The annual global incident energy on the collector plane is 2070

kWh/m².The total amount of energy injected to the grid is 17863 MWh.

Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR
January	202.9	25.52	22.98	232.5	226.5	1955	1920	0.809
February	189.4	36.15	24.97	207.3	202.2	1728	1697	0.801
March	223.1	52.18	27.13	231.6	225.7	1906	1873	0.792
April	200.7	66.31	27.71	198.2	192.5	1639	1610	0.795
May	187.4	71.63	27.21	177.3	171.3	1483	1455	0.804
June	132.4	86.30	24.95	125.7	120.8	1084	1062	0.827
July	131.5	82.94	24.80	125.4	120.6	1083	1060	0.828
August	137.8	87.01	24.41	134.3	129.3	1159	1135	0.828
September	142.3	70.42	24.45	143.9	139.3	1228	1204	0.819
October	165.1	72.53	24.39	174.7	169.7	1489	1461	0.819
November	165.4	50.38	23.10	172.2	167.5	1473	1445	0.822
December	182.3	35.23	22.20	209.9	204.5	1793	1761	0.821
Year	2050.4	736.60	24.87	2133.0	2070.0	18020	17683	0.812

Table -2: Balance and main result

3.4 Performance Ratio

The yearly average performance ratio value obtained from PVSYST is 81.6% hence the PR value obtained from simulated results closely matches to the actual PR value of the SCADA system.

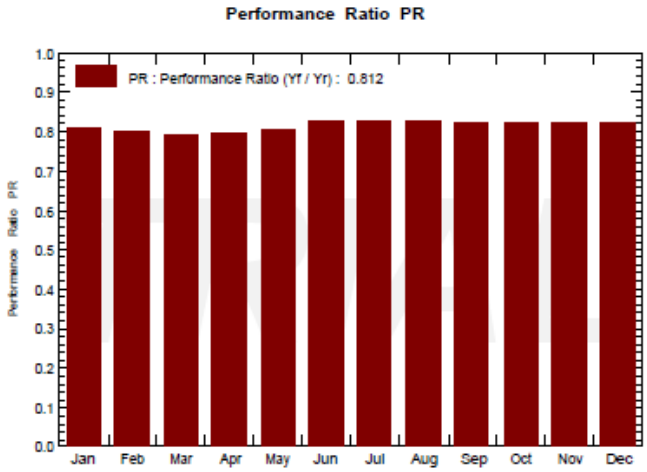

Fig-3: Annual Performance Ratio

3.5 Loss Diagram

The loss diagram shows the effective irradiation on the collector plane is 2070kW h/m2 and the global horizontal irradiance is 2050kW h/m2.The solar radiation incident on the solar panels will convert into electrical energy. After the PV conversion, the nominal array energy is 21617MW h. The efficiency of the PV array is 15.02% at standard test condition (STC). Array virtual energy obtained is 18020 MW h. After the inverter losses the available energy obtained at the inverter output is 17863 MW h.

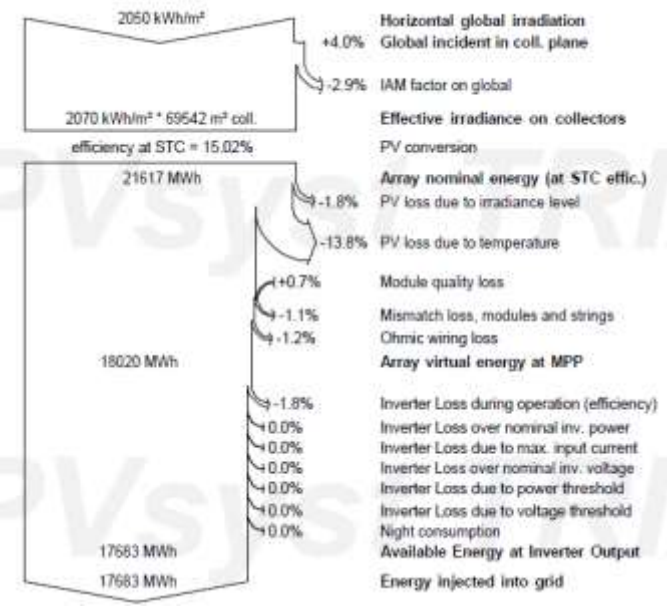

Fig-4 Loss diagram of a year

3.6 Performance Comparison

Month	Generation data from SCADA (MWh)	PV syst result (MWh)
Jan-17	1457.856	1920
Feb-17	1524.577	1697
Mar-17	1566.414	1873
Apr-17	1510.091	1610
May-17	1447.922	1455
Jun-17	1195.546	1062
Jul-17	1124.594	1060
Aug-17	1141.201	1135
Sep-17	1185.724	1204
Oct-17	1236.461	1461
Nov-17	1174.918	1445
Dec-17	1343.805	1761
Total	15909.109	17683

Table -3: Performance comparison

4. CONCLUSION

A performance study of 10 MW peak grid connected solar photovoltaic power plant installed at Shivanasamudra was evaluated on yearly basis. The following conclusions are drawn from the study.

- Maximum total energy generation of 1616.02 MW h was observed in the month of March and lowest total energy generation of 1155.08MW h was observed in the month of July.
- The comparison of generation data with PVsyst simulation results shows, plant is operating closer to the predicted generation of energy modeling software.

- 10 MW solar power plant has been operating with good amount of PR and CUF. The plant has been in operation and feeding energy to grid at an available percentage of almost 90%.

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