Performance Analysis of 5MW Solar PV Grid connected Power plant

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***Abstract*— The increased energy demand in the developing nations has increased the requirement of energy security. This has made essential to utilize the renewable energy resources. Solar energy is a inexhaustible, clean and environment friendly potential resource among all other renewable energy. One of the best alternatives at large scale in renewable energy is grid connected solar photovoltaic system. To assess the real time behavior of the grid connected solar PV plant performance analysis is the most important aspect to be considered. Performance analysis will help in designing, operating and maintaining of a grid connected solar PV system. In this study performance analysis of 5MW solar PV grid connected power plant situated in a place called belakawadi in mandya district in the state of Karnataka, established by Karnataka Power Corporation limited, is presented and its performance is evaluated.**

In this paper, the solar photovoltaic plant design aspects, performance ratio, solar radiation, capacity utilization factor (CUF) and annual performance is elaborated. The performance results of 5MW solar PV plant are also compared with the simulation values obtained from PV watt calculator and PV Syst software.

Based on the comparison of the above parameters it is possible to improve the performance of the existing power plant. Power demand always increases especially during summer seasons, so the power generated from other renewable resources like coal based power plants, hydel power plants or wind power plants are not sufficient. Hence it becomes necessary to demand more on a non- exhaustible energy source like solar energy.

Keywords— solar energy; grid connected; SPV system; photovoltaic; solar radiation;

I. INTRODUCTION

.There is a pressing need to accelerate the development of advanced clean energy technology in order to address the global challenges of energy security, climate change and sustainable development. The demand for electric energy is increasing day by day hemce generation needs to be increased to fulfil the needs. Hence developing countries are moving towards renewable resources to generate energy.Solar energy is the most efficient, clean and environment friendly. Hence here we have considered solar power plant.

Photovoltaic is a device which directly converts sunlight into electricity. Solar cell is a building block of photovoltaic technology; these are made of semiconductor material such as silicon. The most useful property of these semiconductors is that by increasing impurities conductivity can be varied.

1. PV System Types and Their Components

PV systems can be divided into two categories: Grid-connected PV Systems and Stand-alone PV Systems. Grid-connected PV Systems are further divided into two categories: Bimodal PV systems are those that are Directly Connected to the utility and these are without storage system as shown in figure 1. Stand-alone PV Systems can be divided into three categories: Without Battery, With Battery, and Hybrid PV Systems. Direct-Coupled are without battery systems, and With Battery systems may include Self-Regulating DC Systems or AC Systems with a charge controller for the battery and load. Hybrid PV Systems include systems with wind turbines, with hydro turbines, with diesel generators, or with fuel cells or other sources.

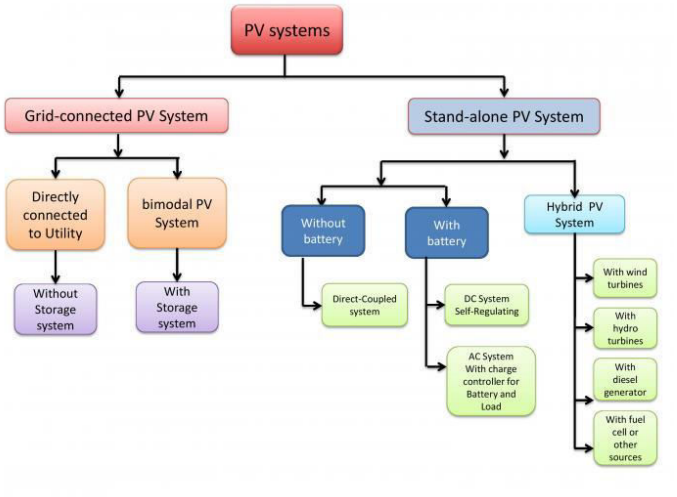

Fig. 1 PV system types.

2. Objectives

The main objectives of this work is to estimate the performance and evolution of grid connected to 5MW solar PV PLANT using PVWATT and PVSYST software in shivanasamudra mandya district of Karnataka. Performance ratio of 5MW solar plant, rating of plant for 25 sq meters of area, annual energy generation from 5MW grid connected SPV is calculated.

The objectives of this study are summarized below:

- To estimate the performance of solar power plants;
- Various parameters that affect the performance of SPV plant;
- To review design criteria for better performance of power plants;
- Analysis of Solar PV plant using PV Syst software.
- Analysis of Solar PV plant using PV Watts calculator.
- Compare actual data and data obtained from PV Syst software and PV Watts calculator.

II. SITE AND TECHNICAL DETAILS

The proposed site is located at Belakavadi village in Shivansamudram project in Malavalli taluk of Mandya district (Survey No's 369,370 and 371).

Latitude 12.3^0 and Longitude 77.16^0

Fig. 2 **:** 5MW Solar Plant Location

TABLE – 1 **:** Technical Details Of PV Module at Shivanasamudram plant.

Sl. no	DESCRIPTION	DETAILS
I	Type of SPV module	Poly crystalline
2	PV module power output	Min 235 Watts 30.8 V
3	Total no. of module used	22560
4	No. of Module per MW	3584
5	Array rating	259.5 KW
6	Details of series/parallel combination	24 Nos. in series 940 parallel string
7	Tilt angle	15^0
8	Temperature	Min 15 ^{0}C Max 40 ^{0}C

Schematic diagram of power plant is as shown in figure 3. The technical details are specified in the block diagram it is based on the theoretical calculations obtained.

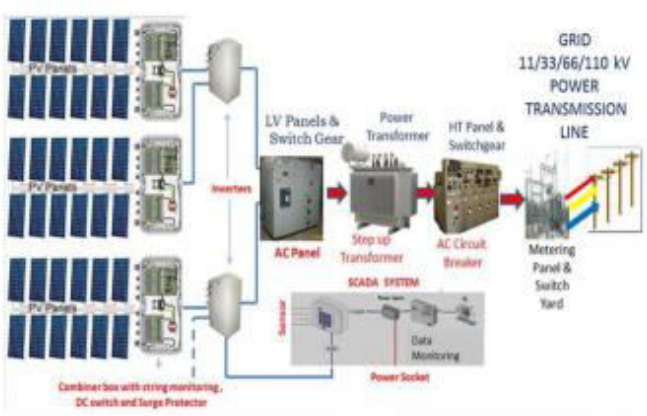

Fig 3 : Schematic diagram of solar PV grid connected plant

III. METHODOLOGY

A. *PV Syst Software*

PV Syst is a PC software package for the study, sizing and data analysis of complete PV systems. This software is designed according to the needs of architects, engineers, researchers. It is also very helpful for educational training. Simulation input files can be created from measurements of production modules under various conditions of temperature and irradiance. While some manufactures create their own files. PV Syst offers 3 levels of PV system study, roughly corresponding to the different stages in the development of real project.

B. *PV Watts calculator*

PV Watts is a useful map based free online software for international photovoltaic sites analysis. It will provide the global annual energy output of PV systems connected to the grid, in many parts of the world. It can also provide PV energy output hourly values and provide international solar maps.

PV Watts calculator provides energy production and cost savings of PV system across the world. Totally free it allows anybody to easily estimate the performance of worldwide PV plant. It also provides estimated monthly and annual irradiation and energy production. Users can select a location and enter their own system parameters for size, electric cost, array type, tilt angle and azimuth angle.

IV. PERFORMANCE EVALUATION

Performance evaluation of Grid Connected Solar PV Plant is based on the parameters namely solar radiation, Performance ratio, CUF, Annual yield, Energy Production on daily and monthly basis.

1. *Actual results*

Actual results obtained from 5MW shivanasamudra plant is tabulated below

Table 2: 5 mw solar PV power plant shivasamudram-kpcl

Capacity	5	MW
Amsl	672	Mtr
Latitude	**12° 18′ 2.81" N**	DEGREE
Longitude	**77° 9′ 47.84" E**	DEGREE
Solar radiation	5.26	kWh/Sq.mtr/day
Wind speed	3.02 to 5.58	M/S
Temperature - min (15)	15.00	^{o} C
Temperature - max (40)	40	^{o} C
Tilt angle (15)	12° 18′ 2.81" N	DEGREE
Average temperature	27.5	^{o} C
Ground mounting	Fixed type	SOUTH FACING
Material	GI and Aluminium Structures	
Area required @ 5 acres/mw	25	ACRES
Guaranteed generation	8.3224	MU/YEAR (19%)

Performance ratio is 77.3%

Total annual energy generation 7.70 MU

2. *Results obtained from PV Watts calculator*

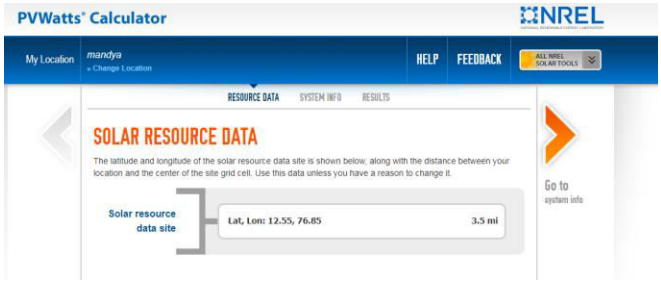

Fig 4 : Screenshot of PV Watt simulation

Table 2 : Results obtained from PV Watts calculator

	Fixed (Open rack) Kwh/year	1-Axis tracking Kwh/year	2-axis tracking Kwh/year
standard	8090735	9769646	9951142
premium	8352738	10151317	10394312
Thin film	863861	10206393	11303016

3. *Simulation using PV Syst*

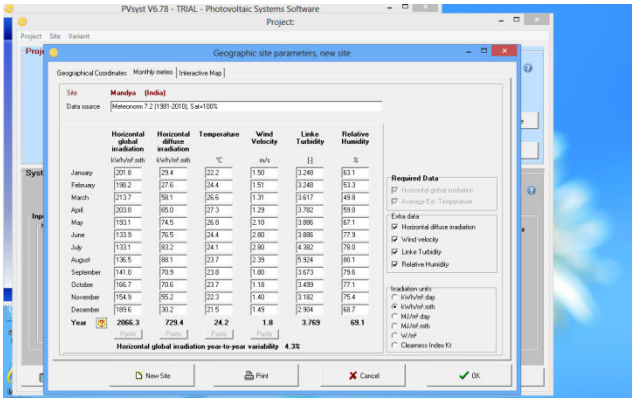

Fig 5 : Screenshot of PV Syst Simulation entering site details

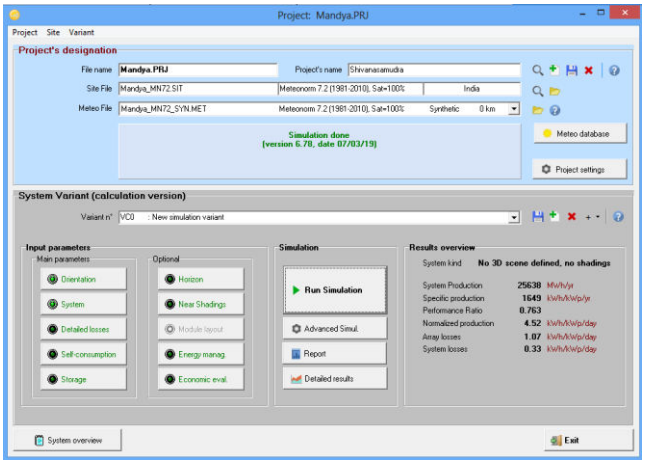

Fig 6 : Screenshot PV Syst Simulation

4. *Comparison of PV Syst, PV Watts and Actual data*

Table 3 : Comparison of PV Syst , PV Watt and Actual data

parameters	PV Syst	PV Watts	Actual
Annual production (kwh/yr)	7925638	8081544	7696766
Solar radiation (w/sq m)	5.58	6.09	5.20
CUF	18%	16%	19%
Performance ratio	76.03	74.61	77.09

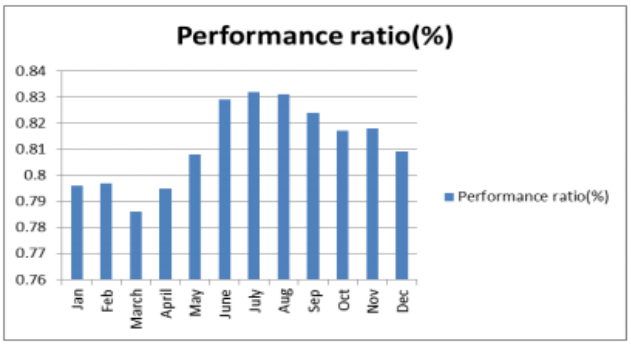

Fig 7: Performance ratio for the theoretical values

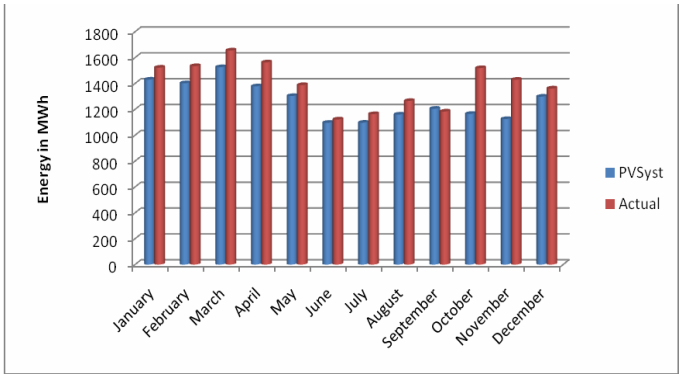

Fig 8 : Comparison of PVSyst and actual energy (DC) generation Month wise during year 2018

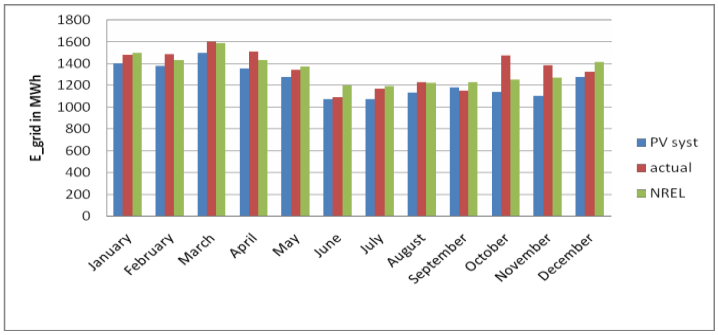

Fig 9: Comparison of PVSyst, PVWatts calculator and actual energy (AC) generation month wise during year 2018

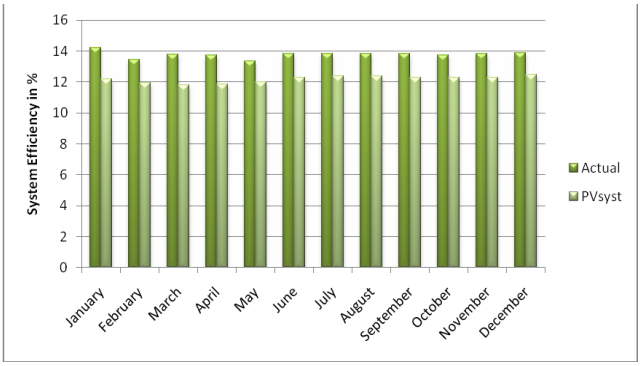

Fig 10: comparison of PVSyst and actual efficiency month wise during year 2018

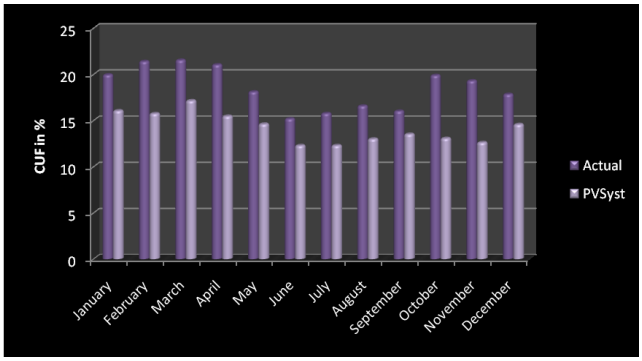

Fig 11: comparison of PV Syst and actual CUF month wise during year 2018

V. CONCLUSION

Performance analysis of 5 KW solar PV system installed at belakawadi, mandya district had been investigated. Following observations were drawn:

1. Average annual energy generation 2018 is 7.70 MU.
2. Average daily performance ratio (PR) in 2018 is 77.03%.
3. The average capacity utilization factor (CUF) in September 2017 is 18.10%.

Solar PV generation during the period from January 2018 to December 2018 is assessed in Shivasmaudram, Mandya District, Karnataka state. The performance of the plant can be analyzed by the polycrystalline PV panels, Performance ratio and other parameters like solar insolation, wind velocity and ambient temperature of the plant. The performance ratio of 5MW Solar PV plant is 116.21% for 6 months average value, which gives overall performance of the plant. Here capacity utilization factor (CUF) considered is 18% because of techno commercial aspects. It can also be verified by considering cable losses, transmission losses by using the simulation software PVSYST. Here PR is showing as 76.3%. The comparison between PR of actual and theoretical is not matching. Hence the capacity utilization factor need to be reevaluated based on the six months actual performance of the plant and PV Syst simulation values. Energy Conservation is the Best Reservation for the Future Generation.

Today's clean environment is tomorrow's safe environment and today's world is yesterday's creation, tomorrow's world will be today's conservation.

VI. RESULTS

It's clear that the PV Syst shows the smaller energy output when compared with Actual generation. Whereas grid side output NREL shows more accurate values compared withthe PV Syst software

Actual Irradiation values are more nearer to PV Syst software hence it is more accurate than the NREL software and measured temperature is greater than the PV Syst output temperature.

Efficiency of the system remains almost same during all the months and PV Syst efficiency is lesser when compared with the actual SCADA output.

ACKNOWLEDGMENT

It is my pleasure to express my sincere gratitude to my guide DR. J S Rajashekar , Professor and Head of the Department in the Department of Electronics and Instrumentation Engineering and Dr. H. Naganagouda, Director, National Training Centre for Solar Technology, KPCL, Bangalore, for his help, suggestion, co-operation and valuable guidance in preparing the industrial training report.

I wish to express my sincere gratitude to Prof. Meharunnisa, professor and PG coordinator in department of Electronics and Instrumentation Engineering for her guidance, suggestion, moral support and encouragement.

I am grateful to Dr.C P S Prakash, Principal, Dayananda sagar college of Engineering, Bengaluru, for having supported me in my academic endeavors.

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