EasyChair Preprint

№ 6749

Application of "PVsyst" to Simulate the 100 kWp Rooftop Solar Grid-Tied PV System at College Campus Jabalpur Engineering College, India

Abhishekh Sawner and Shailja Shukla

October 3, 2021

Application of "PVsyst" to Simulate the 100 kWp Rooftop Solar Grid-Tied PV System at College Campus: Jabalpur Engineering College, India

Abhishekh Sawner
Department of Electrical Engineering
Jabalpur Engineering College, Jabalpur
Jabalpur, Madhya Pradesh, India-482011
sawner.abhishekh@gmail.com

Dr. Shailja Shukla
Department of Electrical Engineering
Jabalpur Engineering College, Jabalpur
Jabalpur, Madhya Pradesh, India-482011
shailja270@gmail.com

***Abstract*- So many remote or rural regions in India have energy crisis with limitations of existing coal based power generating units. With ever growing demand for electricity in India, new and renewable forms of electricity generation methods are needed. To overcome this problem, many researchers are trying to find alternate ways to generate electricity without harming the environment. One such way is to utilize the open roof tops of large govt building for installation of roof mounted solar panels. Generating electricity via solar PV system is a clean, renewable and sustainable as well as environment friendly .This paper is a case study and modelling of 100 kWp solar photovoltaic rooftop grid-tied systems at the site of Jabalpur engineering college, Jabalpur in Madhya Pradesh state of central India. Site has the coordinates 23.19317761200415, 79.98711859871126. "PVsyst" software package is employed to study and simulate the performance ratio (PR), efficiency and various losses occurring during the operation of the PV system.**

Keywords- Rooftop PV system, Renewable, Pvsyst Software, Performance Ratio, PV array characteristics, Loss Diagram, Array losses.

I. INTRODUCTION

Electricity is very essential part of day to day life. From simple phone charging to electric vehicle, electricity has made our life easy. Being a developing country with a big population, demand for electricity in India also growing. To satisfy the demand for electricity in a way that it does not impact the environment we have to go for renewable sources of electricity.

The most common forms of renewable electricity generation are wind energy and solar energy. Solar power is one of the most prominent answers for the growing demand of electricity as it is clean and sustainable. Solar photovoltaic (PV) system has emerged as the best way to generate electricity for the masses. India receives sun light for the most part of the year. More than 300 clear sunny days makes India one of the best places to install solar energy system. About 5000 Petawatt-hour per year (PWh/year) solar energy is incident over the lands of India. The average energy per square meter is 4-7 kWh/ m^2/day. In this study, we are analysing the performance of solar on-grid system, which is installed on Jabalpur engineering college campus on the department of civil engineering building. This installed system basically a rooftop type, which provides necessary power requirement of various departments load in college campus.

II. PREVIOUS WORK

Previous work has led the way for software based simulation to predict the preplanning study, economic analysis and generation capacity of the PV plant at the planning step. 1kWp system was designed and studied by Priya Yadav et al. in 2015 [1]. This plant was installed in hilly region of Himachal Pradesh. Its data of over a year was taken for simulations by PVsyst system to get results. In Malaysia, 1 kWp PV plant along with 1kWp inverter is installed. This was later studied by Y.M Irwan et al. in 2015. [2] For geographic location impact, studies were done at multiple locations that showed that solar power generation defer according to the location. The cost based analysis for solar generation was done by Kandasamy et al. in 2013, [3] on a plant that is installed in southern state of Tamilnadu. Allouhi et al. 2016, [4] performed study on monocrystaline and polycrystalline PV modules. Jabalpur Engineering College has large building with empty rooftop, thus a very good choice for installation of solar rooftop panel.

III. METHODOLOGY

In this study, a simulation based analysis of 100 kWp solar grid tied rooftop system for an academic institute, located at the coordinates of 23.19 (longitude), 79.98 (latitude) is given. Operation of the installed system is depends on the various elements. I.e. geographical location of site, materials used for making system component, qualities of auxiliary accessories and environmental factors like wind speed, solar irradiance, temperature, object shadow etc. In this work, analysis of the working system is done by PVsyst software package version 7.2, is

examined. . In this section, we are going to analyse the performance, efficiency and systemic losses of 100kWp solar photovoltaic system (PV), installed at Jabalpur Engineering College, Jabalpur, Madhya Pradesh in India using PVsyst software package version 7.2. All possible departmental electrical computation is done through physical survey. In load calculation it is found that, the whole load of college before installing the PV system is 300kWh/day which is supplied by the Madhya Kshetra Vidyut Vitran Company Limited (MPPEB), a state government enterprise. Several performance parameters of the system are analysed through PVsyst software in which many losses and execution data are given in upcoming segments of this paper. This huge data is explained by different pictorial diagrams for easy elaboration of the system performance i.e. Bar-plots, Scatter plot, Histogram, Pie-chart, Table etc.

Fig-1 Site Location: Top View

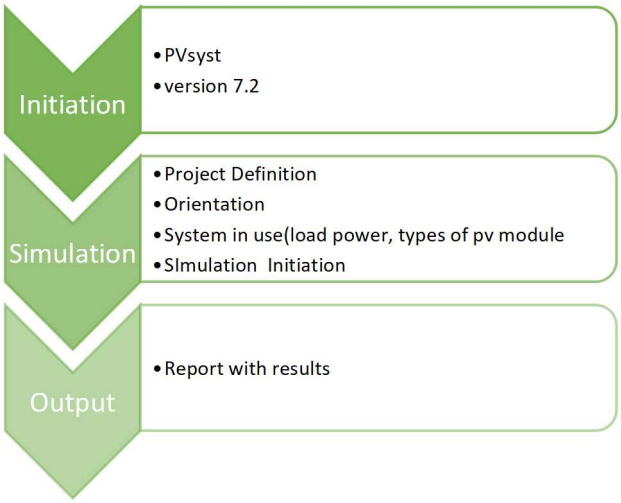
A. PVsyst Software

This software is specially designed for Research scholars, Engineers and industry persons to design and study of economy, reliable and robustness of PV systems. PVsyst 7.2 is personal computer software which is utilized in the study, design and conceptualization of solar photovoltaic systems. It can analyse systems linked to power-grid, individual solar system, solar water pump system and DC based (mass transit system I.e. metro) PV systems. PVsyst consists of vast amount of meteorological data for many sites. Some of the key features of the PVsyst software are as follows:-

- System Design Board: - The system design is based on required/designed power, available empty space, PV module, and inverter.
- System Sizing: - A specific feature for the visual tool to gather all parameters and limits for the sizing of the system.
- 3D shading scene
- Reports of simulations that shows total power generation, performance ratio, specific energy etc.
- Storage in a grid. Meteonorm: - Location searching using GeoNames and OpenLayer.
- Aging for multi-year batch simulation.
- Economic Evaluation: - The total cost of the system, billing methods, advanced cost analysis, revenue and profitability analysis.

B. Inputs for the system

Since every location has a unique geography, the design of the PV system varies according to the location. The position of the sun causes the design change for every location. A schematic diagram is shown below for better explanation about the inputs of the system.



1. Geographic Location

Jabalpur Engineering College is located in Jabalpur city of Madhya Pradesh of India at latitude 23.19317761200415 and latitude 79.98711859871126. The area is full of rock basins and low hills that contain many small lakes. The system is designed for Department of Civil Engineering, Jabalpur Engineering College, Jabalpur to meet the load of the college such as load of CFLs, tube lights, ceiling fans, wifi routers, water coolers etc. Figure 1 show areal image of the site taken from Google Maps.

The location site of PV solar plant is shown in table 1.

Table 1 Address details of Jabalpur Engineering College

Parameters	Jabalpur Engineering College, Jabalpur
Latitude	23.19317761200415
Longitude	79.98711859871126
Altitude	407 m
Seasonal tilt Angle	6 degree for summer 44 degree for winter
Azimuth Angle	0 degree
Albedo	0.2

2 Leaning Angle

Leaning angle is the gradient between the solar panels and the ground. This is the angle at which the panels are fixed towards the sun. The position of the Sun changes on a day to day basis. Usually leaning angle is similar to the

latitudes. Leaning angles are taken by Abhishekh sawner.

3 Azimuth Angle

India is situated in the northern hemisphere of earth. So the mounting panels are south facing and the azimuth angle is taken as zero.

4 Albedo

Earth surface reflectivity measure is known as Albedo. It is location specific. The value ranges between 0.1 to 0.9. For Jabalpur we have taken albedo as 0.2 since it is plane.

5 Load

For Jabalpur Engineering College, the daily requirements for electrical load is estimated at 300 kWh per day. A monthly energy use and user's need data is given in the table 2.

Table 2 Energy use and User's needs

Month	E_Grid(kWh)	PR ratio
January	14544	0.731
February	13494	0.715
March	13686	0.685
April	11244	0.572
May	12434	0.613
June	10735	0.697
July	9165	0.722
August	9198	0.731
September	10795	0726
October	12205	0.700
November	12755	0.714
December	14049	0.724

6 Inverter and Module specification

For the installed capacity of 100 kWp, we have considered Generic Solarmax 50TS. The capacity of the inverter is 50 kWac of which two units are installed. The operating voltage range is between 430-800 V. Details of rooftop panels are given in table 3.

Table 3 Details of rooftop panel.

Solar panel producer	**Generic**
Model	**Eldora VSP.72.325.03.04**
Panel capacity	**325 Wp**
Total panels	**308 units**
	22 strings × 14 in series
Operating temperature (50 C)	
Maximum peak power	89.8 kWp
Maximum peak voltage	472 V
Maximum peak current	190 A
Total installed capacity	
Nominal (STC)	100 kWp
Total	308 modules
Module area	598 sq. m.
Inverter Producer	Generic
Model	Solamax 50TS
Per unit power	50.0 kWac
Inverter units	2 units
Total capacity	100 kWac
Operating Voltage	430-800 V
Pnom Ration (DC:AC)	1.00
Seasonal tilt adjustment	
Azimuth	0
Summer tilt	6
Winter	44

6 Defused solar radiation

Diffused solar radiation is also an important parameter for design and simulation. This phenomenon includes solar radiation coming to atmosphere and after being dispersed by particles, molecules of dust, gases etc. The amount of solar diffusion depends mainly on solar tilt angle, moisture and cloud presence in atmosphere as well as presence of dust particles. PVsyst software also takes temperature and wind data as input for system simulation.

IV. RESULTS AND DISCUSSION

A through report consisting Loss Diagram details, Performance Ratio, Balance and Main Result and Array losses by PVsyst software is presented in this section. The report contains both tables and graphs.

1. Performance Ratio

The performance ratio of the proposed system is that the ratio of the net energy used with respect to the energy that would have been produced at standard temperature and conditions (STC) while working constantly.

The proposed system has 69 % of performance ratio (PR) which is good enough for power production through solar radiation. Fig. 2 shows the performance ratio for over a year.

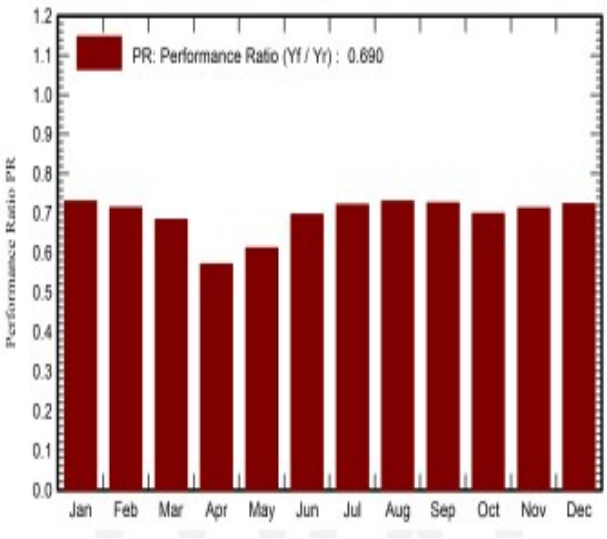


Fig-2 Performance Ratio

2. Balance & Main Results

Fig. 3 shows the main result for every month of the year for the PV system. The Abbreviations are shown in fig 4

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR ratio
January	136.1	43.56	16.75	198.8	184.6	15.15	14.54	0.730
February	147.7	43.83	20.47	188.6	177.0	14.07	13.49	0.714
March	186.7	65.11	26.13	199.6	185.0	14.28	13.68	0.685
April	193.6	73.05	31.10	196.4	187.2	13.75	11.24	0.572
May	203.6	88.54	35.01	202.6	193.3	13.90	12.42	0.612
June	155.5	91.82	31.55	153.8	145.9	11.25	10.73	0.697
July	127.9	81.84	27.73	126.7	119.8	9.63	9.16	0.722
August	125.5	85.96	26.66	125.7	118.6	9.66	9.19	0.731
September	145.3	75.22	26.93	148.5	140.6	11.30	10.79	0.726
October	149.5	62.13	25.92	174.2	161.5	12.75	12.20	0.699
November	129.5	46.74	21.40	178.5	166.0	13.31	12.75	0.714
December	127.0	39.72	17.62	193.8	179.4	14.65	14.04	0.724
Year	1828.0	797.54	25.63	2087.3	1958.9	153.71	144.21	0.690

Fig-3 Balance and Main Result

GlobHor	Global horizontal irradiation
DiffHor	Horizontal diffuse irradiation
T_Amb	Ambient Temperature
GlobInc	Global incident in coll. plane
GlobEff	Effective Global, corr. for IAM and shadings
EArray	Effective energy at the output of the array
E_Grid	Energy injected into grid
PR	Performance Ratio

Fig 4 Abbreviations

3 *PV Array Characteristics and losses*

The PV array characteristics and array losses for the PV system are shown in the following fig 5.

PV Array Characteristics

PV module		Inverter	
Manufacturer	Generic	Manufacturer	Generic
Model (Original PVsyst database)	Eldora VSP.72.325.03.04	Model (Original PVsyst database)	Solarmax 50TS
Unit Nom. Power	325 Wp	Unit Nom. Power	50.0 kWac
Number of PV modules	308 units	Number of inverters	2 unit
Nominal (STC)	100 kWp	Total power	100 kWac
Modules	22 Strings x 14 In series	Operating voltage	430-800 V
At operating cond. (50°C)		Pnom ratio (DC:AC)	1.00
Pmpp	89.8 kWp		
U mpp	472 V		
I mpp	190 A		
Total PV power		**Total inverter power**	
Nominal (STC)	100 kWp	Total power	100 kWac
Total	308 modules	Nb. of inverters	2 units
Module area	598 m²	Pnom ratio	1.00

Array losses

Array Soiling Losses		**Thermal Loss factor**		**DC wiring losses**	
Loss Fraction	2.0 %	Module temperature according to irradiance		Global array res.	42 mΩ
		Uc (const)	20.0 W/m²K	Loss Fraction	1.5 % at STC
		Uv (wind)	0.0 W/m²K/m/s		
Serie Diode Loss		**LID - Light Induced Degradation**		**Module Quality Loss**	
Voltage drop	0.7 V	Loss Fraction	2.0 %	Loss Fraction	-0.8 %
Loss Fraction	0.1 % at STC				
Module mismatch losses		**Strings Mismatch loss**		**Module average degradation**	
Loss Fraction	2.0 % at MPP	Loss Fraction	0.1 %	Year no	10
				Loss factor	0.4 %/year
				Mismatch due to degradation	
				Imp RMS dispersion	0.4 %/year
				Vmp RMS dispersion	0.4 %/year

Fig 5 PV array characteristics and losses

4. *Loss Diagram*

In the following tabular format, information regarding various losses in the proposed PV system designed by using PVsyst software and details of the losses which helps in improving the performance and quality as well as efficiency of the system is explained. Loss diagram details are shown in fig 6.

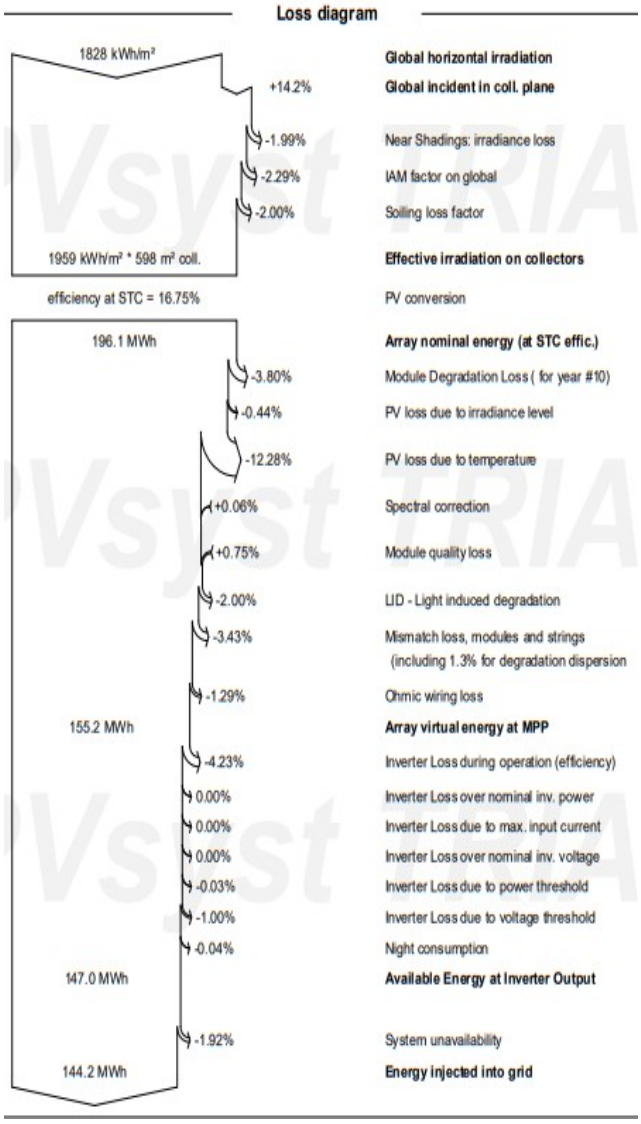


Fig 6 Loss Diagram

V. CONCLUSION & FUTURE SCOPE

The PVsyst software based assessment of 100 kWp Si-monocrystaline PV system was performed for Jabalpur Engineering College, Jabalpur in Madhya Pradesh State of India, and the following conclusion were drawn and shown in table no 4.

Table 4 Result Summery

Electricity provided to grid (yearly)	**144.2 MWh/year**
Average PR (yearly)	**69.02 %**
Electricity to the grid **Maximum** **minimum**	 **14.544 MWh (January)** **9.165 MWh (July)**
The total saving of electricity bill for the whole year	**144.306 MWh/year.**

The results of the analysis show that the PV system plan will work for the installer. The daily input output diagram is shown below in fig. 4.

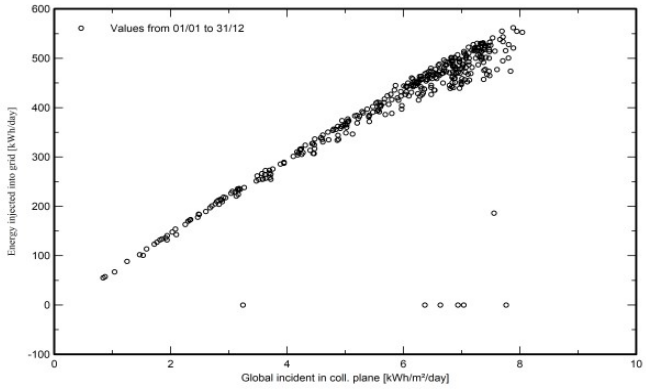


Fig-4 Daily input/output Detail

VI. ACKNOWLEDGMENT

This work is administered as performance analysis of the PV solar system installed on the rooftop on the building of Department of Civil Engineering, Jabalpur Engineering College, Jabalpur. I also acknowledge the support and assistance provided by Department of Electrical Engineering as well as my guide Professor Dr. Shailja Shukla.

VII. REFERENCES

[1] P. N. K. a. S. C. Yadav, "Simulation and performance analysis of a 1kWp photovoltaic system using PVsyst," *International Conference on Computation of Power Energy Information and Communication(ICCPEIC),* 2015.

[2] A. ,. M. ,. F. ,. W. ,. N. ,. I. Y.M.Irwana, "Stand-Alone Photovoltaic (SAPV) System Assessment using PVSYST Software," *International Conference on Alternative Energy in Developing Countries and Emerging Economies,* 2015.

[3] C. P. P. P. a. N. K. Kandasamy, "Solar potential assessment using PVSYST software," *International Conference on Green Computing, Communication and Conservation of Energy (ICGCE). (IEEE 2013),* 2013.

[4] R. T. R. A. M. A.Allouhi, "Grid-connected PV system installed on institutional buildings: Technology comparison, energy analysis and economicperformance,," 2016.