Simulation Analysis of Solar Photovoltaic Array Installation on Roof Top of an Academic Institution by Using Helioscope

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Abstract:
The Solar energy based harvesting technologies are gaining enormous interest now-a-days. It has been estimated that, the generation of electricity based on available renewable energy sources shall predominantly increase in the range from 35% to 40% by the year 2040 which was stated by International Energy Agency recently. Furthermore, according to Ministry of new and Renewable energy, India has already been setup a huge target of energy expansion which is likely to be reached nearly about 175 Giga Watt capacities by 2022. This clearly indicates that, Solar energy based energy generation techniques has become an essential means in order to reduce several vital issues related to energy demand needs and environmental aspects especially owing to the reduction in harmful emissions. There are several software's available to simulate and analyze the installation methodologies of Solar energy based roof top mounted system or ground based installation systems. Among the existing software packages, helioscope basically provides many user friendly options to investigate the installation process with the help of Google map and adopting cloud computing technique in particular. It emphasizes on commercially as well as residentially viable installations. This paper more specifically explains about the simulation study of mounting a roof top based Photovoltaic system on our Institution itself and illustrates the energy generation and efficiency view points by estimating the losses in the system.

Keywords:*Google Map, Helioscope, Photovoltaic system, Roof top mounted system*

I. INTRODUCTION

With the increase in energy demand, it has become a need for everyone to look forward for adopting renewable energy resources and technologies for survival and sustainability of mankind. Depletion of fossil fuels is one of the most important confronting issues that the world is facing now. In order to mitigate the ever increasing energy needs, it is the right time to switch over to several non-conventional technologies like solar energy, wind energy, Bio-gas etc. Among the available renewable energy resources, the solar energy is found to be abundant and it has proven to be one of the better energy sources for harvesting purpose.

The solar energy based photovoltaic systems can be installed either by grid connection mode or in standalone mode. Even in the hybrid mode i.e. combining the grid and standalone modes, one can install the solar photovoltaic (PV) array systems either on ground mounted system or on roof top related systems [1]. For Grid mode, there is no need of battery backup but for standalone mode, it is of utmost important to add battery option to store the energy. Roof top systems are more convenient for commercial buildings, residential purposes, as it saves the ground space [2]. In this paper, we have considered roof top installation of

our academic institution and analyzed the simulation of 20.5kW energy generation.

There exist many solar energy related softwares like PVsyst, PVsol, Homer, google sketchup etc in order to simulate and analyze the solar PV installations [3]. But helioscope is considered to be a unique option and facilitates the cloud computing technology. It basically appends the Google map and depicts the exact location where the solar PV panels should be installed. It allows the user to visualize the installation area clearly and also generates the simulation report comprising of performance ratio, energy generated and statistical solar radiation data day wise or monthly wise.

II. HELIOSCOPE

This paper has given much emphasis on explaining the features available in helioscope and also the simulation methodology in step by step.

Step1: In this cloud computing server based software, one should create an individual login account. After logging in, the software asks for creating a new design project where one can identify the location based on Google map wherein the solar PV array to be installed. After specifying the location, the process of simulation can be initiated by creating new project as depicted in Fig. 1 below respectively
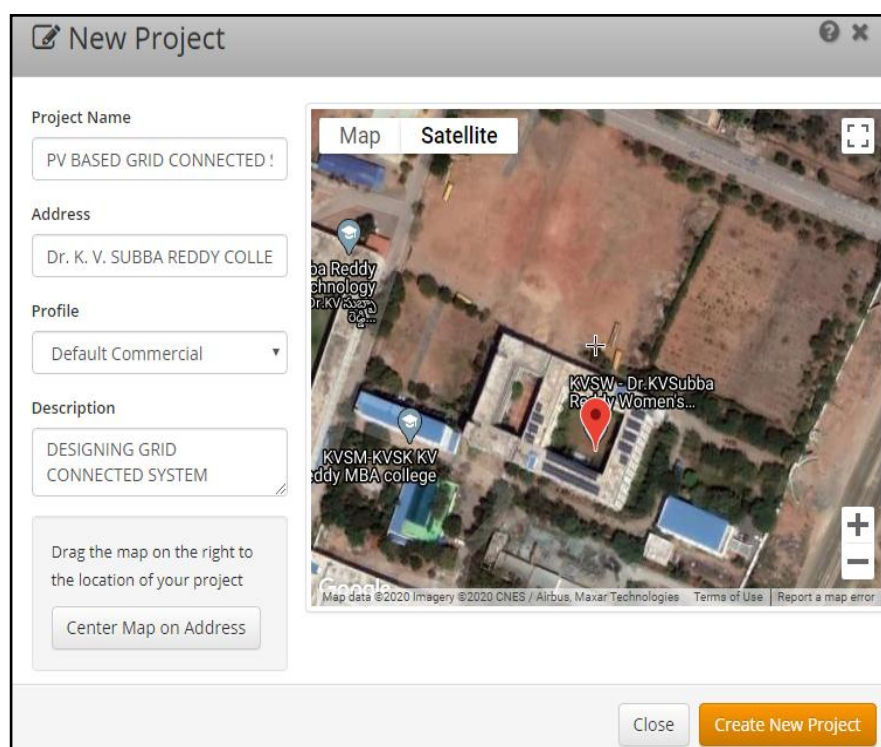

Fig: 1 Creating new project

Step2:
The location details of latitude and longitude has to be specified as shown in Fig. 2.

Location	(15.740247, 78.008265) (GMT 5.5)
Profile	Default Commercial

Fig: 2 location details of project

Step3:

The software provides 5 options such as design parameter, analyzing conditions, shading analysis, sharing option and generating reports of projects. The screen shot of the five specific parameters are represented below in Fig. 3.
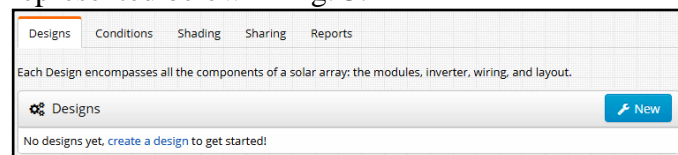

Fig: 3 Design parameters of project

Step4:

Now entering into the design section in particular, there exist again 4 different options like mechanical, keep outs, electrical and advanced criteria.

In Mechanical section, the software specifies to draw the segments where the panels need to be installed. It also tells to draw the area to be considered for installing the PV panels. The area will be represented with the help of dimensions clearly in terms of feet. In this simulation analysis, we have considered two field segments namely, segment 1 and 2 respectively. The field segment 1 consisting of 27 modules and can generate energy of around 8.6kWp.

The field segment 2 consists of 37 PV modules and   can generate energy of 11.8 kWp. The Fig. 4 and 5, the two field segments can be visualized.
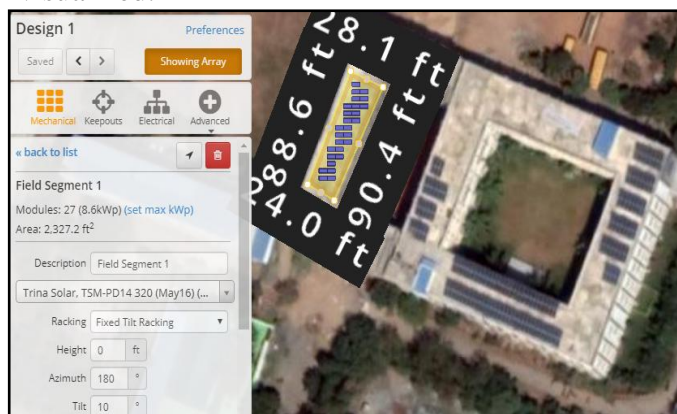

Fig. 4 Field segment 1 of PV array installation

Fig. 5 Field segment 2 of PV array installation

The yellow colored portion could be clearly seen in Fig. 4 and 5 which have been highlighted to represent the newly designed PV array. The tilt angle of 10^0 and azimuth angle of 180^0 has been taken as default in installation of PV modules.
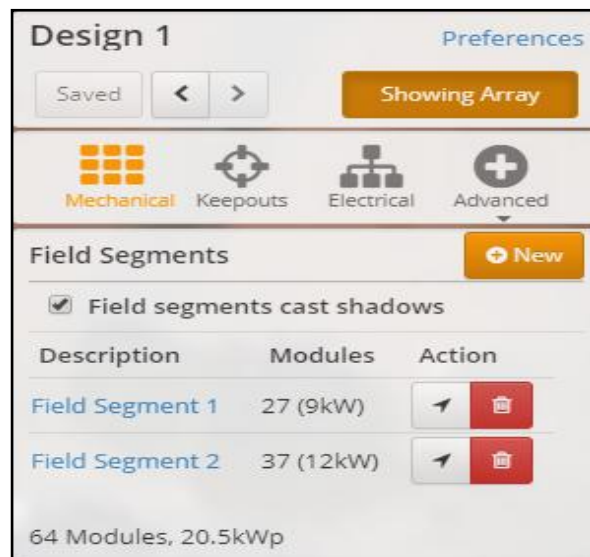

Fig. 6 Final Design parameters

The Fig. 6 shows the final specifications of field segments 1 and 2. Trina Solar based manufactured PV panels are considered for installation and specifications like row spacing, setback spacing were mentioned clearly as shown in Fig. 7 and 8 respectively.
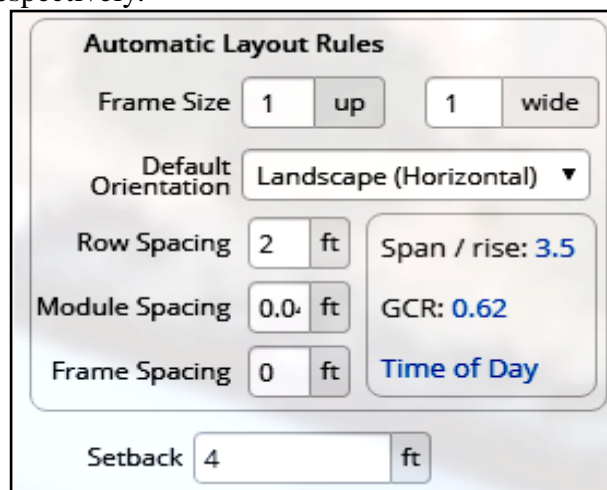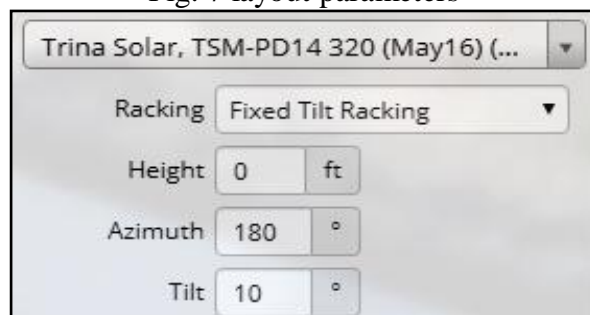

Fig. 7 layout parameters

Fig. 8 Tilt angle and type of solar Panel selected

Step5: In this step, the electrical wiring system should be analyzed. There are DC and AC wiring possibilities. The Fig. 9 depicts the wiring of the panel setup.

Fig. 9 Wiring diagram representation of Panels

Step6: Selection of inverter module for the existing Panels. Sunny Tri-power 24000 TL-US type inverter has been chosen for this simulation analysis.

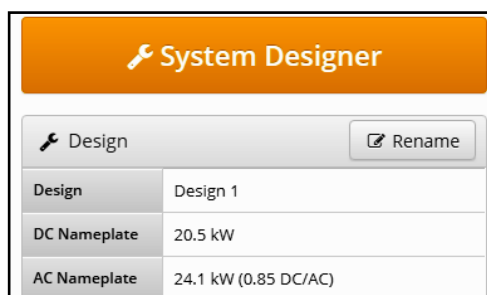**Step7:** System design view of components is shown in Fig. 10 and 11 given below.

Fig. 10 System overall design

Fig. 11 System inverter selection

The final layout of the field segments 1 and 2 are depicted in Fig. 12 given below.
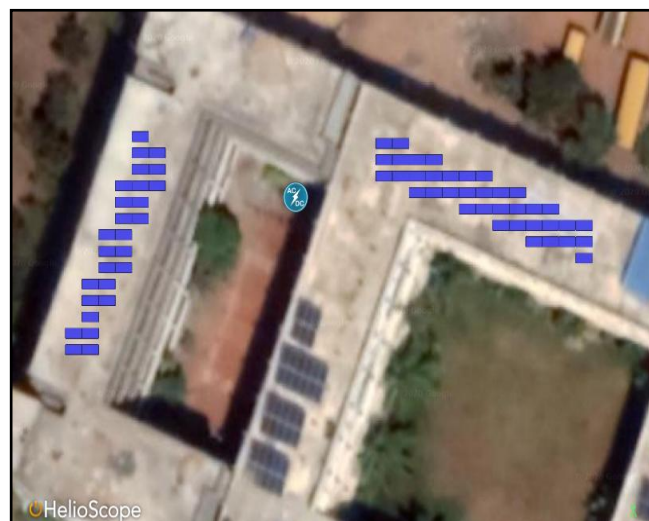

Fig. 12 Final layout view of field segments

The software also provides an option to view the entire project in two different viewing angles like south western angle view and south eastern angle view point which is shown in Fig. 13 and 14.

Fig. 13 South Western angle viewing point

Fig. 14 South eastern angle viewing point
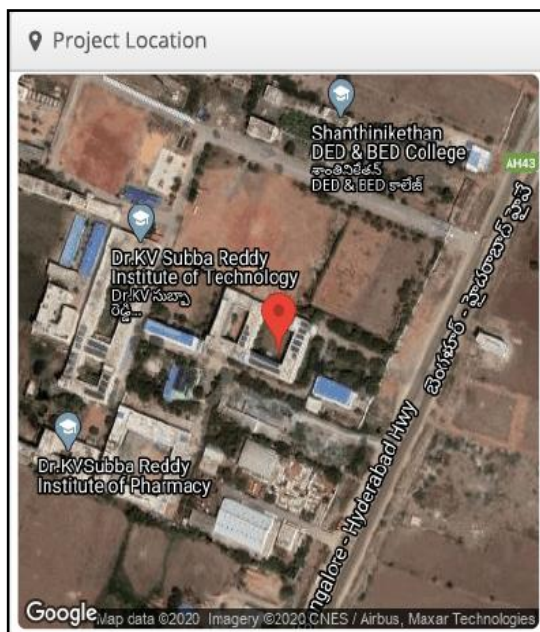
III. SIMULATION RESULTS

a. PROJECT LOCATION:

Fig. 15 Project location shown by software

b. PROJECT SYSTEM METRICS:

System Metrics	
Design	Design 1
Module DC Nameplate	20.5 kW
Inverter AC Nameplate	24.1 kW Load Ratio: 0.85
Annual Production	34.24 MWh
Performance Ratio	79.0%
kWh/kWp	1,672.1
Weather Dataset	TMY, 10km Grid, meteonorm (meteonorm)

Fig. 16 System metrics

c. WIRING ZONE:

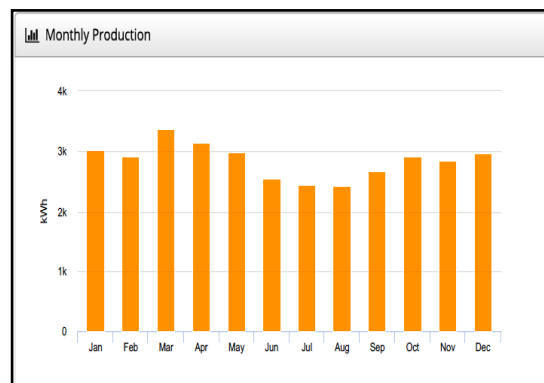| Wiring Zones			
Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	5-21	Along Racking

Fig. 17 System Wiring

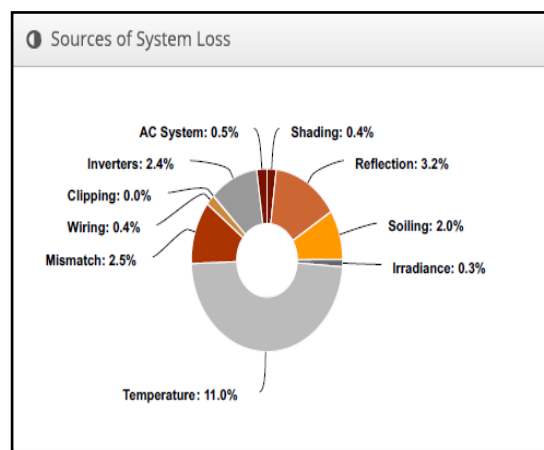### a. MONTHLY PRODUCTION:

Fig. 18 Monthly energy generated

b. SYSTEM LOSSES:

Fig. 19 System losses percentage

c. ANNUAL ENERGY PRODUCTION:

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	2,039.1	
	POA Irradiance	2,116.4	3.8%
	Shaded Irradiance	2,106.9	-0.4%
	Irradiance after Reflection	2,039.0	-3.2%
	Irradiance after Soiling	1,998.2	-2.0%
	Total Collector Irradiance	**1,998.3**	**0.0%**
Energy (kWh)	Nameplate	40,946.5	
	Output at Irradiance Levels	40,822.5	-0.3%
	Output at Cell Temperature Derate	36,326.8	-11.0%
	Output After Mismatch	35,402.8	-2.5%
	Optimal DC Output	35,250.6	-0.4%
	Constrained DC Output	35,250.5	0.0%
	Inverter Output	34,416.8	-2.4%
	Energy to Grid	**34,244.8**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		30.3 °C
	Avg. Operating Cell Temp		43.1 °C

Fig. 20 Annual production of energy

d. Solar radiation conditions report

Condition Set				
Description	Condition Set 1			
Weather Dataset	TMY, 10km Grid, meteonorm (meteonorm)			
Solar Angle Location	Meteo Lat/Lng			
Transposition Model	Perez Model			
Temperature Model	Sandia Model			

Temperature Model Parameters	Rack Type	a	b	Temperature Delta
	Fixed Tilt	-3.56	-0.075	3°C
	Flush Mount	-2.81	-0.0455	0°C

Soiling (%)	J	F	M	A	M	J	J	A	S	O	N	D
	2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Module Characterizations	Module	Uploaded By	Characterization
	TSM-PD14 320 (May16) (Trina Solar)	Folsom Labs	Spec Sheet Characterization, PAN

Component Characterizations	Device	Uploaded By	Characterization
	Sunny Tripower 24000TL-US (SMA)	Folsom Labs	Modified CEC

Fig. 21 Solar insolation simulation details

IV. CONCLUSION

The present simulation work mainly illustrated the installation procedure of a solar PV array system especially on roof top of our academic institution. The PV array installation analysis has been accomplished with the help of helioscope which is web-technology based software and explained the design process in detail. The conclusions regarding the kWh/kWp energy generated, performance ratio and the energy actually estimated are mentioned in the table given below.

Parameter	Simulation result obtained
kWh/kWp	1672.1
Performance ratio	79%
Energy generated	34.2MWh

This paper shall be considered as a reference tool for the solar practitioners those who are willing to develop and install further the solar based roof top systems.

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