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PLACEMENT, PLANNING & PERFORMANCE ASSESSMENT VIA "PVSYST" OF A 25KWP GRID-SYNCHRONIZED PV SYSTEM FOR THE RESIDENTIAL PROPERTIES, MP, INDIA

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ABSTRACT

Currently, solar energy becoming versatile choice of each industry person or engineer to fulfil the consumer's energy demand. Numerous experiments and researches are progressing to shift the dependency from coal based energy system towards the green and clean energies. Recently, a feasible performance survey and design of a 100 kWp solar grid-tied PV system has been carried out for installation purpose via "PVsyst" for green city "Jatani" in Bhubaneswar, India. In current study, a simulation based planning, sizing, placement and performance examination of a 25 kWp solar grid synchronized PV system is carried out by using PVsyst, version 7.1.8, for 50 residential houses. These habitations are located around the "Rawan Park" in Jabalpur district of Madhya Pradesh, India. The coordinates of the site are 23.21^0 N, 80.00^0 E as latitude and longitude respectively. Further, the suggested system has the performance ratio of 71.64 % for fixed tilt angle i.e. 27°. Additionally, the placement and operational features for 30 years of life span have been discussed in the following study. The PV system produces 35.89 MWh/year energy with specific energy production i.e. 1477 kWh/kWp/year. Later on, analysis of CO_2 emission reduction has been done for the suggested system and explained in upcoming sections of this analysis. Based on study, it is found that, the suggested PV system has the potential to fulfill the societal load efficiently. Further, this type of system is a futuristic method of energy generation as well as requirement of our society.

Keywords: Pvsyst, CO_2 Emission, Smart Grid, On-Grid PV System, Performance Ratio, Micro-Grid Design.

I. INTRODUCTION

Today, India is developing fresh technologies, to make it global hub of state of the arts. Primary focus of this is to make it's an energy efficient country for their citizens. Because, in India there are lots of places are still present, where availability of energy is not feasible. Indian government is continuously proposing new policies and regulations for public utility companies to diminish the above stated issues. Due to rapid growth in population in last few decades, it is become a quite complex task to fulfill each residents energy needs by the conventional ways of energy generation i.e. coal fired plants, hydro-electric energy, and nuclear energy etc. Currently, numerous researches have been done regarding latest and innovative methods of power generation. According to latest research of scientists and researchers, it will be a quite satisfactory step, if we shift the dependency for energy requirements from conventional resources towards the green and clean energies. Existing energy plants are damaging the environment. Further, they are in-reliable and in-efficient to satisfy the drastically increasing load demands. Recent trend is adopting renewable energy resources as a backbone for energy generation hub. India has the potential to fulfill the energy requirement of individuals by using solar energy. In latest work, the planning & sizing of a grid-synchronized solar cell system has been studied for 50 habitations for their domestic load requirements. The whole simulation based study is done via PVsyst system software. According to PVsyst, the selected site has satisfactory value of solar insolation i.e. 5.648 kWh/^{m2}/day. The yearly based average temperature for selected site is 25.5°C. By using PVsyst, many simulation based analysis has been carried for numerous geographical locations, globally. The current study is based on a grid-tied solar PV system principle which satisfies the community load consumption at the chosen site location. Additionally, all the performance parameters with various load analysis is also elaborated in tabular format for the suggested system. Behind this, carbon dioxide emission analysis is carried out, for the selected site along with PV on-grid system and explained in upcoming sections of this study.

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II. LITERATURE SURVEY

Globally, PVsyst is known for its tool, which allows user to design an efficient system based on solar energy. Many study based analysis have been done for numerous geographical locations around world by using PVsyst approach. Recently, performance analysis of a 100 kWp on-grid system has been done via PVsyst in terms of optimization. It is designed for green and smart city Jatani, Bhuvneshwar. This is explained in work of [1]. In work of [2], performance survey of a 3 kWp grid connected photovoltaic system for location in Thailand. This was designed for the university of Pathumthani sector. A financial and technical performance analysis has been carried out by using PVsyst of a solar on-grid solar system having capacity of 625 kWp and explained in work of [3]. The pre-installation analysis of an 8.3 kWp solar grid synchronized solar cell system for an urban smart city in Bhuvneshwar via PVsyst system programme has been done in work of [4]. In study of [5], preparation of a model, which is a solar-wind system, designed by using MATLAB simulink feature has been carried out. A performance evaluation of a grid-connected solar energy system via HOMER PRO & PVsyst for MMMUT, Gorakhpur has been studied and explained in [6]. Further, all the required system information and technical terms are also discussed in the paper. In [7], analysis of a hybrid standalone energy system has been completed via PVsyst and Homer-pro, for communal & administrative load at three different regions of Maluku, Indonesia. A simulation based design of an off-grid solar PV system to fulfill the requirements of energy demand of a school, located in chennai, has been done and given in work of [8]. Further, an on-grid PV system is analysed by using PV*SOL premium software in terms of design and performance evaluation, for campus hostels of Kota, Rajasthan Technological University, which is represented in [9]. Based on work of [10], design and analysis of a solar rooftop PV system has been carried out by using PV*SOL software for faculty of electrical & electronics engineering at Istanbul Technical University.

III. METHODOLOGY

This analysis is based on the principle of grid-connected solar photovoltaic system. This concept is utilizing here to electrify the 50 residential houses to feed their daily load consumption. Further, the site is located at centre point, around which all the houses are present. Additionally, the site is present at the urban region of Jabalpur district, Madhya Pradesh, India. The whole analysis is done by using solar PV system design tool i.e. PVsyst (version- 7.1.8). It is simulation based design of an on-grid PV system, which has the potential to satisfy the domestic load in appropriate manner. In next parts of this study the whole working performance of the suggested methodology and CO_2 calculation for 25-30 years of life span are explained in detail. Further, the required data to design an efficient PV system via PVsyst is given below;

PVsyst version 7.1.8

PVsyst is a special purpose tool, to design and analysis the varieties of solar cell system. i.e. solar on-grid PV system, solar off-grid photovoltaic system, solar water pumping system etc. It is use by many engineers, research scholars and industry persons to prepare the simulation based PV models in an efficient manner. This software is also utilizes by numerous school students around the globe for the same objective. It gives results which is consists of so many data related to PV system, in tabular format as well as pie charts or bar plots. It has the feature of whether calculation of any geographical location, globally. i.e. meteonorm, solar cast etc. Additionally some important parameters knowledge are needed during simulation process, which elaborated in below given segments-

a. Tilt angle

It is an angle through which a solar panel faces itself, towards the direction of incoming sun light or solar energy. Generally, PVsyst has an adjustable tool, to manage the tilt angle according to the site and atmospheric conditions of the system location. Under study, 27^o is considered as a tilt angle for the proposed on-grid system. Based on simulation, it is found that, the suggested system shown maximum feasibility with least system loss, for chosen site at 27^o. This is shown in table-1.

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Table 1. Tilt angle

PV system type	Tilt angle in degree
25 kWp solar grid-tied PV system	27^{o}

b. Azimuth Angle

The angle between the true south and solar irradiance is known as azimuth angle. Further, a negative angle represents a position West of South, while a positive angle represents a position East of South. In current study, 0 degree is considered as an azimuth angle.

c. Albedo Value

The part of solar radiation that gets reflected by the earth is measured by an albedo value. Further, its value lies in between 0.1 to 0.2. In icy regions, value of albedo is higher. In current study, 0.2 is considered as an albedo value, due to texture features of the working site, and obtained by PVsyst.

d. Solar Energy

The total energy solar energy receives by the earth's surface is known as solar insolation. As per study, it is observed that, the chosen geographical location has enough value of solar insolation i.e. 5.648 kWh/m^2/day according to PVsyst database. On site, maximum solar energy captures by the PV panels in July month, while during august month, minimum solar energy is receives by the solar cells.

Site survey

The site is located at Rawan Park in Jabalpur district of Madhya Pradesh state of India. This park is present at urban region of Jabalpur. It is 8 km away from the railway station. Around this ground, 50 residential apartments are present. The site has enough availability of solar irradiance i.e. 5.648 kWh/m^2/day, which is obtained via PVsyst tool. The average temperature availability on yearly basis is around 26.8^{o}C, which is quite satisfactory from power generation prospectus. The site is represented in fig. 1.

Figure 1: Satellite View of Rawan Park

Load Estimation

Subheading should be 10pt Times new Roman, The planned system designed to fulfill the societal load requirements in efficient and reliable manner. The proposed system is an on-grid type solar photovoltaic system of capacity 25 kWp. The load calculation is completed through the physical survey at the site. The whole domestic load is divided into two sections i.e. summer and winter loads. At starting, load computation has been done for 10 houses for distinct seasons. AS per load analysis, per house energy consumption during summer and winter months are 3.973 kW & 2.453 kW respectively. Further, per house energy utilization is multiplied with 50 to obtain total energy consumption in summer and winter seasons respectively i.e. 198.65 kWh/day in summer season, while 122.65 kWh/day in winter months. Total load of fan is eliminated for winter load estimation. Additionally, Oct, Nov, Dec, Jan, Feb, Mar etc. months are considered for winter load evaluation while April, May, Jun, Jul, Aug, Sep etc months are considered for summer load.

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Table 2: Community load computation

S. no.	Light (Q x W x H)	Fan (Q x W x H)	T.V. (Q x W x H)	Freeze (Q x W x H)	Water Pump (Q x W x H)	Mobile Charger (Q x W x H)	Washing Machine (Q x W x H)
1	4x15x8= 480	2x90x8=1440	1x80x4=320	1x350x12=4200	1x1000x0.5	1x7x2 =14	1x255x2 =510
2	2x15x9= 270	2x90x8=1440	1x80x5=400	NA	NA	1x7x2 =14	NA
3	4x15x10=600	2x90x12=2160	1x80x5=400	NA	1x1000x0.5	1x7x2 =14	1x255x2 =510
4	5x15x6= 450	1x90x10=900	1x80x3=240	NA	NA	1x7x2 =14	NA
5	6x15x8= 720	1x90x10=900	1x80x4=320	NA	NA	1x7x2 =14	1x255x2 =510
6	4x15x8= 480	3x90x7=1890	1x80x6=480	1x350x12=4200	1x1000x0.5	1x7x2 =14	NA
7	2x15x12=360	4x90x5=1800	1x80x4=320	NA	NA	1x7x2 =14	NA
8	5x15x6= 450	2x90x6=1080	1x80x5=400	1x350x12=4200	1x1000x0.5	1x7x2 =14	NA
9	4x15x10=600	2x90x8=1440	1x80x4=320	NA	NA	1x7x2 =14	NA
10	2x15x8= 240	2x90x12=2160	1x80x5=400	NA	NA	1x7x2 =14	NA
Total	4650 Wh/day	15210 Wh/day	3600Wh/day	12600 Wh/day	2000 Wh/day	140Wh/day	1530 Wh/day
Summer Load				Winter Load			
Total Wh/day for 10 habitations=39.73 kWh/day kWh/day/house=39.73/10=3.973 kWh/day Overall kWh/day for 50 houses= 50 x 3.973 = 198.65 kWh/day				Total Wh/day for 10 habitations=24.53 kWh/day kWh/day/house=24.53/10= 2.453 kWh/day Overall kWh/day for 50 houses= 50 x 2.453 = 122.65 kWh/day			
Average daily energy consumption= (198.65 + 122.65) / 2 = 160.65 kWh/day							

IV. RESULTS AND DISCUSSION

The proposed 25 kWp solar grid-synchronized PV system is designed by PVsyst, to supply necessary energy to the domestic loads of the urban society in Jabalpur, Madhya Pradesh. The society has 50 residences and located around a park known as Rawan Park. The components data with technical details are explained in this section, obtained via "PVsyst" simulation report. Furthermore, operational survey of the system has been studied in next segments of this paper;

Solar Cell System

Based on analysis, it is observed that, 90 units of PV panels of capacity 270 Wp each are required for the suggested PV system. Total 18 strings of PV panel are used for current system, in which each string contains 5 panels and connected in series. Other technical specifications are given in tab.3

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Table 3: PV cell specifications

Manufacturer	Generic
Model	Eldora VSP.60.270.05_U
Unit Nominal Power	270 Wp
Modules	18 strings x 5 in series
No. of PV, modules	90 units

Solar Inverter

As per study, 6 units of inverter circuit are required to design a 25 kWp solar PV system with capacity of 4 kWac each. The ratio of DC to AC for current inverter circuit is 1.01, which is a quite satisfactory value. Further, inverter specifications are given in tab.4.

Table 4: Solar inverter specifications

Manufacturer	Generic
Model	PS 5000i-MV
Unit Nominal Power	4.00 kWac
Operating Voltage	100- 350 V
No. of Inverter Circuit	6

Performance Analysis

In this section, detailed explanation regarding operational specifications of the proposed on-grid system is given. This information is elaborated by various graphs i.e. pie chart, bar plot and scatter plot etc, obtained from PVsyst simulation report and database. These are explaining below

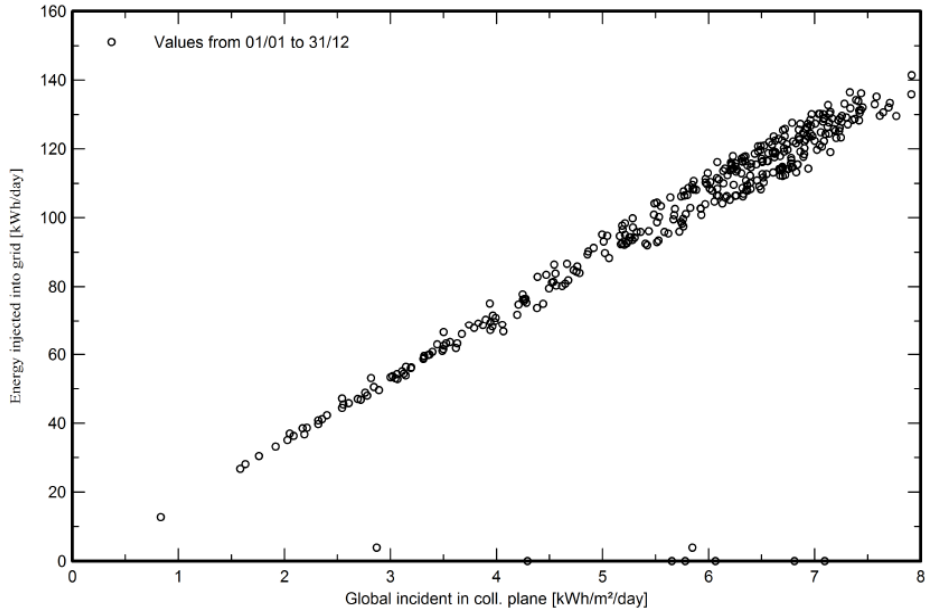

Figure 2: Daily Input-Output Graph

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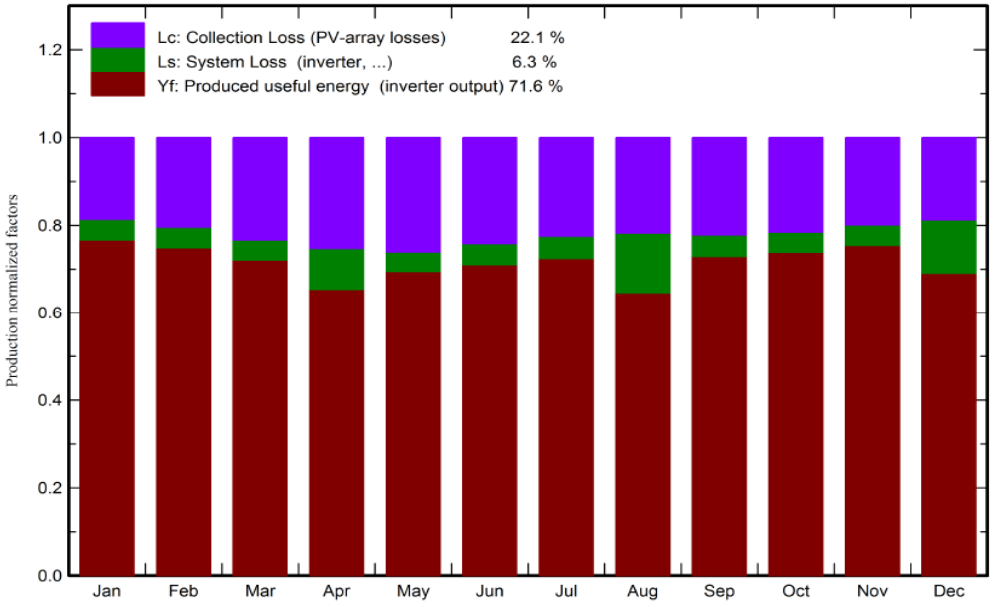

Figure 3: Normalized Production and Loss Factor

Normalized Production & Performance ratio

The normalized production per installed kW is 4.05 kWh/kWp/day obtained for the stated methodology. It gives maximum value during March month, while during August month minimum production per installed kW is observed.

At standard testing condition, the ratio of actually obtained output to the anticipated output is known as performance ratio (PR). The stated photovoltaic system has quite satisfactory value of performance ratio i.e. 71.64%.

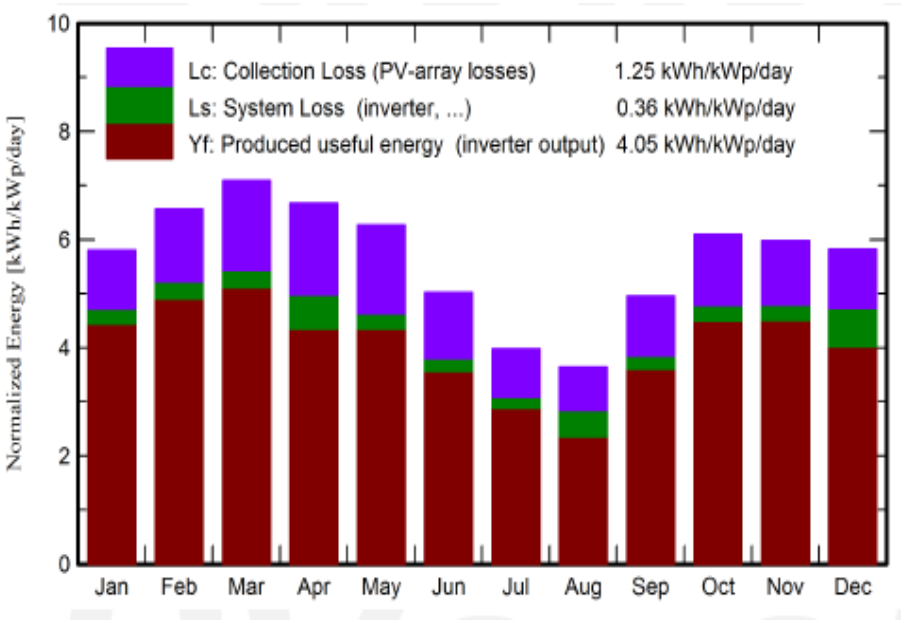

Figure 4: Normalized Production Per Installed Capacity

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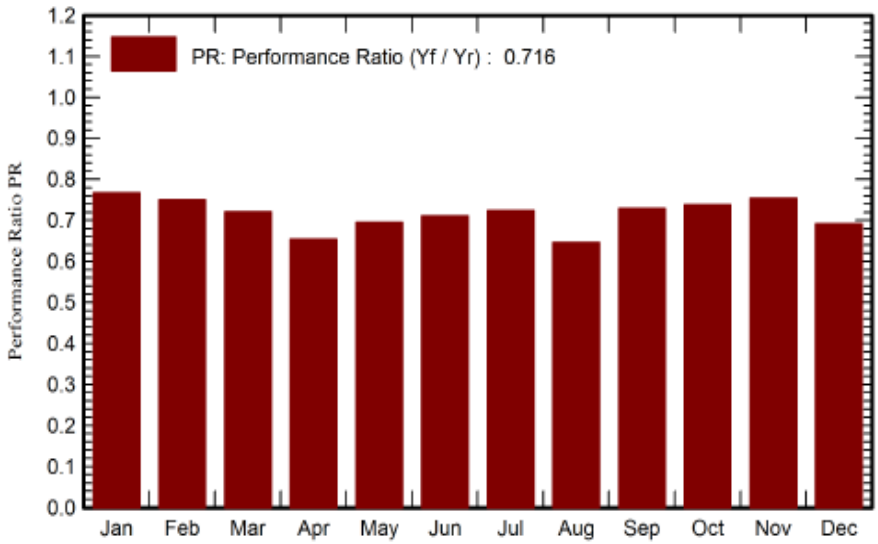

Figure 5: Performance Ratio of a 25 kWp PV System

CO² Emission Analysis

The proposed PV system is designed for 30 years of life cycle. Since, solar energy harvesting system is an eco-friendly technique of energy generation. Due to which, huge quantity of carbon dioxide (CO_2) is reduced to considerable extent. Based on simulation results, it is found that, the stated PV system reduces 823.4 tCO_2 during 30 years of operation of the grid-tied solar plant according to IEA India, which is an excellent benefit of installing this type of system in rural and urban regions of India. Additional details regarding CO_2 emission are explained in figure-6.

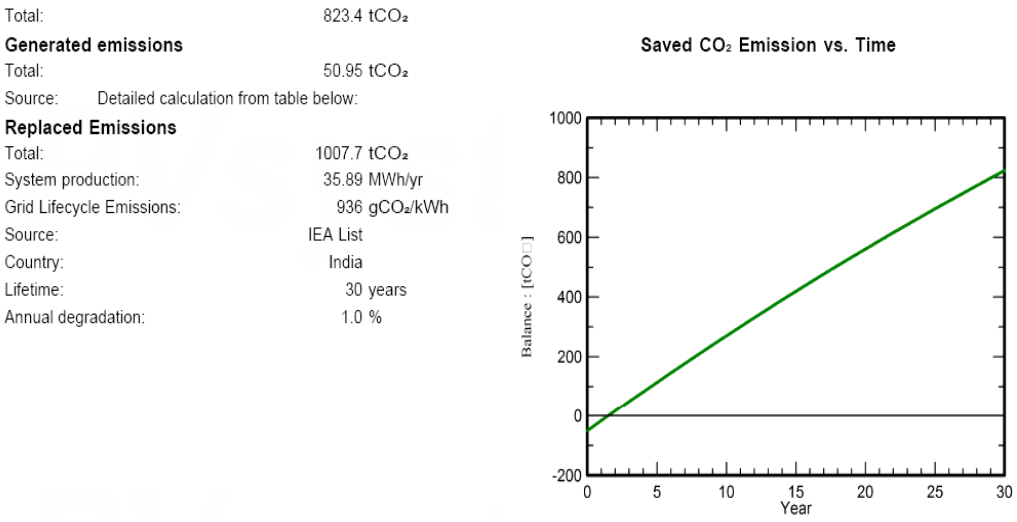

Figure 6: CO_2 Emission Study

V. CONCLUSION

The proposed methodology is designed to satisfy the domestic loads of the society, located around the Rawan Park, Jabalpur, India. The overall design analysis of an on-grid PV system has been carried out by using PVsyst tool. The capacity of the designed plant is 25 kWp. The performance ratio of the suggested PV system is 71.64%, for 27° tilt angle which is enough from satisfactory performance for the chosen site. This system produces 35.89 MWh energy per year with specific energy production i.e. 1477 kWh/kWp/year. Under study the considered azimuth angle is 0 degree. The average solar irradiance and average temperature for geographical location are 5.648 kWh/m²/day and 26.8°C, respectively. Further, the proposed grid-connected PV system reduces the significant amount of CO_2 emission, during 30 years of life cycle of the PV system i.e. 823.4 tCO_2. Based on study, it is found that the proposed system has efficiency and reliability to fulfill the energy

requirements of the societal load in proper manner. This system can be used for those reasons, where enough grid availability is present. It is also beneficial to use this type of system in rural zones of India, for energy requirements.

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