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Design and Performance Analysis of a Grid Connected Solar Photovoltaic System

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Abstract: A solar photovoltaic system is a technology that converts sunlight into direct current electricity by using semiconductors. Designing a 100kWp grid-connected solar photovoltaic system many components are used like as a solar photovoltaic module, inverter, earthing protection, cable, grid protection and mounting structure. This solar system is installed at integral university which is placed in Lucknow. Latitude of the Lucknow is 26.85degree N and longitude of the Lucknow is 80.94 degree. Annual average isolation is 4.27kwh/m2/day. PVSYST is a simulation software which is used in designing of a solar photovoltaic system.

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I. INTRODUCTION

The tendency for India's energy consumption out of conventional sources is establish to increase with improved industrialization and civilization features of the society. The estimated electricity consumption increased from 882,592GWh during 2013-14 to during 1,122kwh/capita 2016-17. The increase in electricity consumption is 7.07% from 2013-14 (882,592GWh) to 2016-17 (1,122kWh/capita) of the total consumption of electricity in 2016-17, industry sector accounted for the largest share (40.01%), followed by residential (24.32%), agriculture (18.33%), traction (1.61%) and commercial sectors (9.22%).[1] The electricity consumption in the Industry sector and commercial sector has increased at a much faster pace compared to other sectors during 2013-14 to 2016-17. India is the world's third largest consumer of electricity and third largest producer of electricity.

A solar photovoltaic is a power system that is considered to supply efficient solar energy with the help of photovoltaics. A Solar PV System may also use a solar maximum power tracking system to improve the system's overall performance and include an integrated battery solution, as prices for storage devices are expected to decline. Grid-connected PV system, Rooftop PV system, off-grid PV system is the type of solar photovoltaic system. In a grid-connected photovoltaic system power generated from the system is exported to the grid through the inverter and export-import meter. Power generated from a solar module is Direct Current which is converted to Alternating Current using Inverter before feeding it to a grid. During maximum load period like holidays, the weekend the extra power produced from solar systems could be fed to the grid. Off-grid solar PV system consists of the roof or ground-mounted solar panels, a battery bank to collect energy and an inverter or charger to act as an interface between the different inputs.

1.1Abbreviations and Units

AC	Alternative Current
DC	Direct Current
BOS	Balance of System
PV	Photovoltaic System
AM	Air Mass
PR	Performance Ratio
PSH	Peak Sun Hours
SPV	Solar Photovoltaic
Tamb	Ambient temperature
TMY	Typical Metrological year
STC	Standard Test Condition (1000W/m2)
FF	Fill Factor
Voc	Open Circuit Voltage
Isc	Short Circuit Current

GHI	Global Horizontal Irradiance
MPPT	Maximum power point tracker
MPP	Maximum Power point

II. PHOTOVOLTAIC SYSTEM COMPONENTS

2.1 Solar Photovoltaic Module:

Solar PV module absorbs the solar radiation and directly convert solar energy into electricity. Solar PV module uses solar radiation from the sun to produce electricity through the photovoltaic effect. A module is generated by 30-36 cells in series, which produces 15-18 volts, enough to charge a 12V battery. Modules are interrelated in parallel to form arrays to attain higher current. A single module can generate the only a limited amount of power. PV module is connected in series the voltage potential is increased. When the PV module are connected in parallel current potential is increased. The output from a solar panel depends upon some conditions such as fill factor, ambient temperature and intensity of incidence light.

2.2 Inverter:

An inverter is an electrical converter which is used to adapt the variable direct current output of PV solar module into a utility frequency AC that can be fed into a commercial electrical grid and off-grid electrical network. Solar inverters have various utility reformed for consumption with photovoltaic arrays, including maximum power point tracking (MPPT) and anti-islanding protection. [2] The PV module generates DC at a voltage, which depends on the design and solar energy. Inverters generally used in big scale applications are significant inverters that offer easy installation and high efficiency.

2.3 Charge controller and Batteries:

Charge controllers are included in most photovoltaic systems to protect the batteries from overcharge or avoidable discharge. Overcharging can boil the electrolyte from the battery and cause failure. Allowing the battery to be discharged too much will cause impulsive battery failure and possible damage to the load. The charge controller is a critical element in the Photovoltaic system. [3]

Batteries are commonly, used as a backup source in such application. Batteries are used to reduce the cost of the system. Batteries feed the load when photovoltaic output energy is less the load demand.

III. PVSYST

PVsyst integrates simulation of a PV system with evaluation of its pre-feasibility, sizing and financial analysis, no matter whether it is a grid-connected, stand-alone, DC grid system. Mainly meteorological stations in PVsyst are referenced to the definite ones, otherwise the data is inserted between 3 closest stations. PVsyst is a simulation tool which was developed by André Mermoud.[4]

3.1 LOCATION DETAILS AND METEOROLOGICAL DATA FOR THE PROPOSED LOCATION:

In PVSYST, the renewable source input can be the coordinates of the place.Based on place coordinates, data can be retrieved from NASA website dealing with Meteorological data. The usual solar energy in proposed locationi.e in Lucknow which is at latitude 26.85 North and longitude80.94‘Eastis 4.27kW/m2 day. Solar radiance is high (above the normal) from March to May, with a highest in the month of April, while solar radiance (below the normal) from June to December.Fig 1.Shows the solar irradiation data at the proposed site which is used in the simulation.

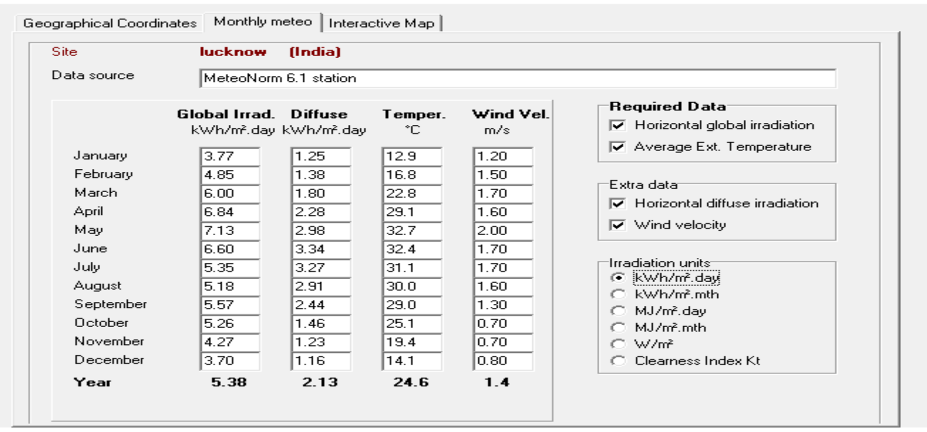

Fig.1 Monthly Meteorological data for the proposed location

IV. SIMULATION RESULT:

4.1 Design of PV Panel:

PVSYST deals a database of photovoltaic module based on power, the technology and the constructer. The electrical parameters such as MPPT and Temperature coefficient, efficiency and the FF are considered while choosing a photovoltaic module. The maximum watt peak of a certain array is considered. Simulations were run for a panel at Standard Test Conditions(STC) 1000w/s2 and Nominal Operating Collector Temperature (NOTC) of 25degree C, mounted modules with an air mass 1.5 .The I/V characteristics of the selected module are shown in fig 2.

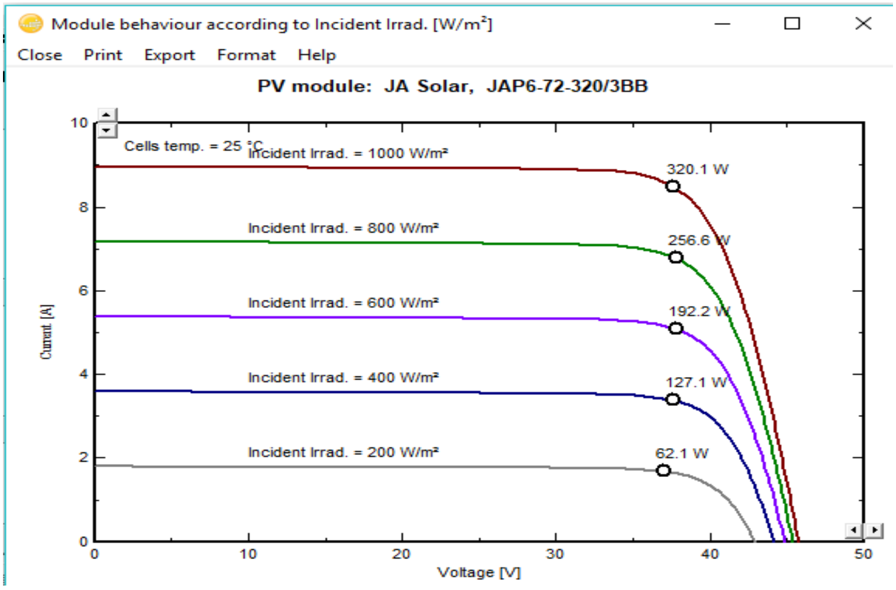

Figure 2. I/V characteristics at different Irradiance level

4.2 Design of Inverter:

Optimization technique is used to reducing the losses, the mismatch losses for the inverter are to be reduced the cost of the system. For a 50kW inverter the mismatch losses are high compared to that of a less nominal voltage. Therefore in this study 20kW inverters are used with the operating voltage of 330-800V. Maximum efficiency of inverter is 97.8%.the efficiency curve as a function of the output is shown in the fig 3. The inverter irradiance distribution is shown in figure 4.

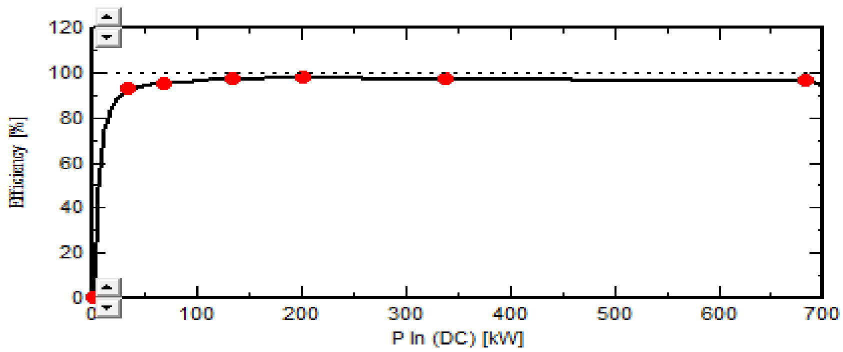

Figure 3. Efficiency Curve of the Inverter

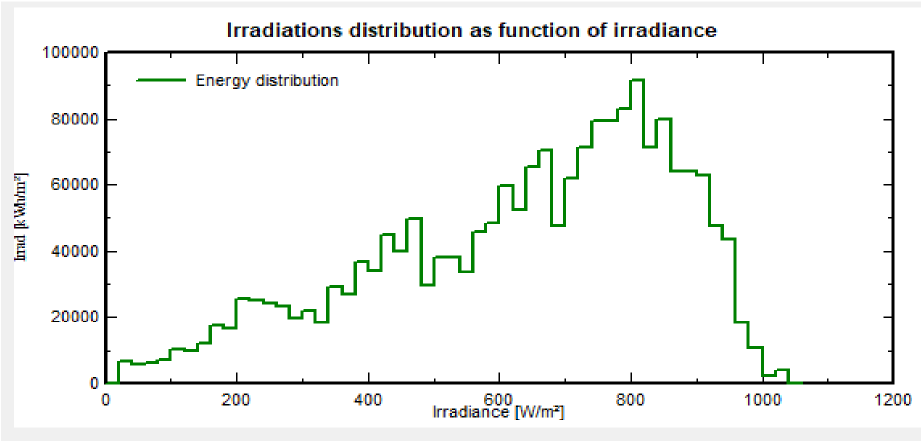

Figure 4 Inverter Irradiation distribution

V. RESULT:

The losses have been reduced by different combinations of strings, modules and also the inverter capacity. The detailed losses have been described in fig 5 and fig 6. However the Energy injected into the grid per year was found to be about 210MWh with an array virtual energy of 210MWh. Fig 7 shows the effective power at output of array , percentage efficiency of the array and percentage efficiency of the photovoltaic system, which was found to be 205381kWh, 13.40% and 13.75% respectively.

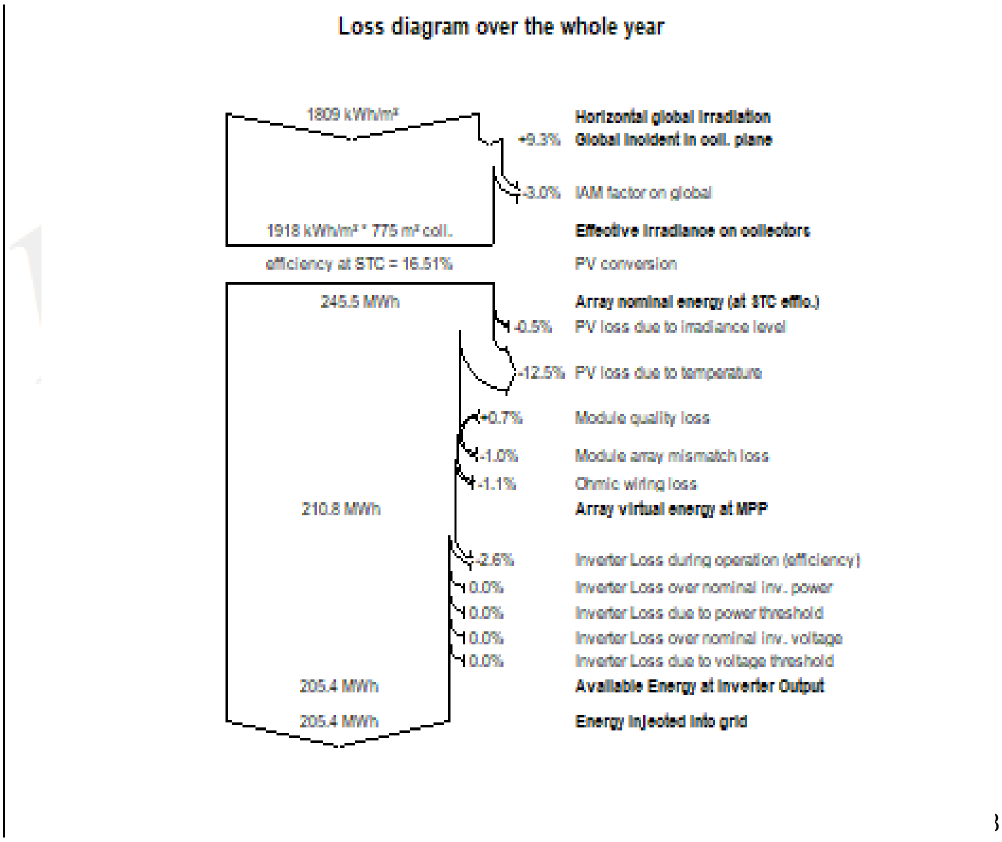

Fig 5. Yearly Loss diagram of PV array and Inverter

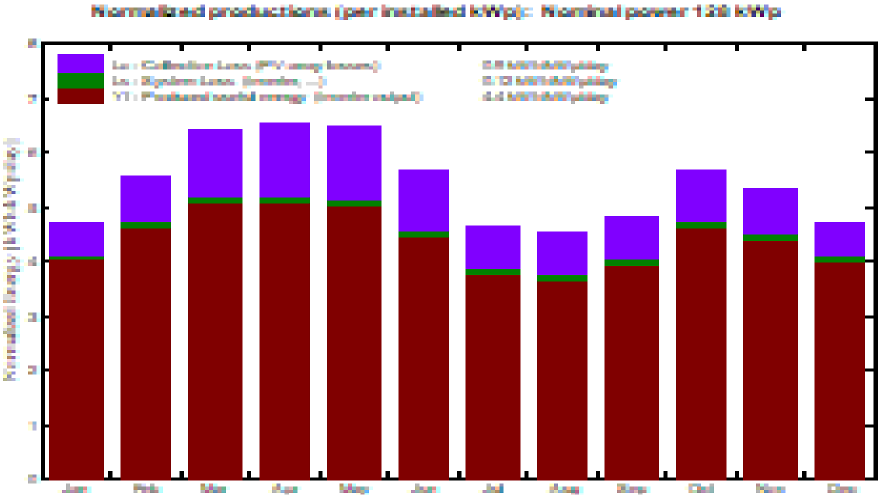

Fig 6. Monthly Loss Diagram of PV Array and Inverter

New simulation variant
Balances and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	EffArrR %	EffSysR %
January	115.3	15.80	145.6	141.0	16455	16060	14.58	14.23
February	130.8	19.40	156.0	151.5	17086	16656	14.13	13.77
March	178.2	25.50	198.2	192.9	20789	20246	13.53	13.17
April	189.6	30.60	196.6	191.1	20087	19547	13.18	12.82
May	203.7	32.10	200.3	194.4	20431	19891	13.15	12.81
June	177.3	31.30	170.9	165.4	17676	17212	13.34	12.99
July	148.8	29.00	144.6	139.8	15352	14931	13.69	13.31
August	138.9	28.00	139.6	135.0	14924	14514	13.79	13.41
September	135.6	26.90	144.5	140.0	15524	15127	13.86	13.50
October	151.0	24.80	175.4	170.4	18768	18310	13.80	13.47
November	128.1	21.10	160.4	155.7	17458	17018	14.04	13.68
December	111.6	16.90	144.9	140.3	16287	15870	14.49	14.12
Year	1808.8	25.14	1977.0	1917.6	210838	205381	13.75	13.40

Fig 7. Simulation Results

VI. CONCLUSION:

For the renewable energy system mainly solar energy system the major feature in reducing the cost and optimally sizing the system. In implementation and sizing of grid connected photovoltaic system several methods like PVsyst, RCTscreen are used. In this paper optimal size of PV, inverter of a grid-connected PV system for proposed location in Lucknow has been examined by using PVSYST as a software tool.

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