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Design Study and Performance Evaluation of 198kW$_P$ Grid Connected SPV System at Academic Block I, Integral University, Lucknow

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Abstract: In this paper the performance study of 198kW$_P$ grid connected SPV System installed at Academic Block I, Integral University, Lucknow has been done with help of software tool PV*SOL. PV*SOL is software design tool for simulating photovoltaic system performance. These systems are designed to work with grid. Solar array and grid, both are connected to the AC Distribution Box (ACDB) through system controller and inverter. This type of system is installed at Integral University Lucknow which is the scope of this study. The simulation results of existing system as well as optimized system are compared to study the performance of a Academic Block I, Integral University, Lucknow.

Keywords: Grid connected SPV system, Tilt Angle, Production Forecast, Renewable Power.

I. INTRODUCTION

In compliance to 'Paris Climate Accord' and to deal with greenhouse gas emission mitigation, Govt. of India has taken big initiative for expanding the use of clean energy in all sectors in the country. The most serious problem of today's based future of earth is pollution and decreasing fuels for the production of power. The world is already joining in-hand and working together or distributed on making earth as green as possible. To overcome the problem of burning earth and diminishing fuels, this plant is one of stepping stone towards the common global goal of green earth. The significance of this plant is to make the university as eco-friendly & green university as possible by reducing the power consumed from grid and using as much renewable power (solar) as possible.

II. RELATED APPROACH

Performance analysis of a 3 MWp grid connected solar photovoltaic power plant in India, K. Padmavathi , S. Arul Daniel, Department of Electrical and Electronics Engineering, National Institute of Technology, Tiruchirappalli, 2013 International Energy Initiative. Published by Elsevier[1].
In this paper renewable energy is projected to meet a significant portion of the future energy needs of India. With solar energy, being abundantly available in most parts of the country, grid connected solar photovoltaic (SPV) power plants are assuming increasing importance. Energy fed into the grid by a solar power plant depends upon seasonal variation of the solar resource, losses due to temperature variation, system losses and losses due to condition of the grid. This paper presents performance analysis of a 3 MW grid connected SPV plant located in Karnataka State, India as per International Electro-technical Commission (IEC) Standard 61724, using monitored data. Normalized technical performance parameters of the plant are evaluated for the year 2011.Inverter failure losses and grid failure losses are estimated for two years of plant operation. Daily and seasonal variations in the SPV plant output are shown using monitored data at five-minute intervals. The SPV generation in relation to load duration curve of the substation is observed. A comparison of normalized performance parameters of the plant with similar parameters of other plants is given. Annual average energy generated by the plant was 1372 kWh/kWp of the installed capacity. Performance of the plant is satisfactory in comparison with that reported from other countries. A detailed performance analysis based on monitored data and operating experience of PV systems is required for large scale integration of grid PV systems in future. An investigation on the performance of a3 MWp grid connected PV plant in India is presented. The performance ratio (PR) was found to be less than 0.6 from August to November2010 due to high inverter failure losses estimated to be 818 MWh. Avoiding delay in attending to inverter failure will result in increased system output. However, PR values improved in the next year giving an annual average value of 0.7 and inverter failure losses were reduced to 409 MWh. Performance trend is positive. The annual average reference yield and final yield were 5.36 [kWh/(kWp-day)] and 3.73[kWh/(kWp-day)] respectively. It is observed that load demand due to irrigation pump sets in the surrounding region of the PV plant is dependent on the availability of 3-phase ac supply. Further studies on this network are required towards achieving PV generated energy catering to the peak load demand.

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Feasibility study and Performance evaluation of a grid-connected Rooftop Solar PV system, Jaya Vasita, Querie Shakhiya, 2017 IEEE International Conference on Information Communication, Instrumentation and Control[2].
In this paper, the potential and cost-effectiveness of a solar photovoltaic (SPV) power plant for meeting the energy demand of educational Institute at Ahmedabad, Western India is analyzed. With the rapid depletion of fossil fuels resources on a worldwide basis has necessitated an exigent search for alternative energy resources with maximum conversion efficiency to meet up the present day energy demands. Renewable energy technologies(RET) presents an emission free means of energy harvesting in the current energy scenario demanding sustainable needs. However, the production process of RETs especially SPV is the most suitable environmental friendly technique to welcome a better tomorrow. So it is essential to develop a new methodology and techniques for an abridged cost of solar power plant. The actual design of a system is based on a predefined load pattern to be supplied, the pertinent weather data, relevant market prices,and the applicable recent economic rates. In this paper, we have studied the design of solar power plant as well as the calculation of power production and its performance evaluation. The resultsare analyzed and compared by using PVSyst software. The research paper focus on solar PV energy generation from a grid-connection installed using PVsyst. It is observed that the proposed grid connected solar PV power plant gives acceptable results and it is cost effective as no provision of battery storage is planned for the plant due to high initial cost of battery. The maintenance cost of the plant will also increase because of batteries so it is not preferable and even not advised due to short life span of batteries. From the outcomes, it is reasoned that the proposed plant will work dependably. Block B and Block D experience the same fluctuation in temperature and radiation but have different tilt angles. Block B is at 6° tilt angle and Block D is at 10°tilt angle. The performance ratio of the proposed grid connected solar PV plant is observed to be 79.3% for Block B and 78.3% for Block D. Final Yield (Yf) of the proposed plant for Block B went from a lower value of 3.37 h/d in the month of August to 5.35 h/d in the month of April and for Block D went from a lower value of 3.32 h/d in the month of August to 5.28 h/d in the month of April. The various experimental results are also qualitatively and quantitatively depicted in various sections of the research paper. This simulation result will further help in analyzing and comparing the actual field generation results. The payback analysis shows the cumulative saving of an Institute which may get return on investment near around 46 months from the date of commissioning. The final outcome may vary as per the workmanship but it can be summarized that the institute will get good return on Investment.

III.PERFORMANCE ANALYSIS

Design Details of Academic Block I

- Installed Capacity of rooftop: 198kWP
- Rooftop height of Academic Block I 12m
- Total number of Modules: 720
- Inverters: 66kVAx3
- Wattage of module 320W_P
- Latitude of Integral University 26.57° N
- Altitude of Sun at solar noon on equinox @ I. U. L

When there is 90° angle between Sun and module then maximum energy will be collected.
γ_c = 90-latitude (equinox, Mar 21st/Sep 23$^{rd)}$
γ_c = 90- 26.57° = 63.43° S

Altitude of the Sun is 63.43º S

- Tilt Angle (β) = 180-90-Altitude of Sun

β = 180 – 90 - 63.43° = 26.57°

Rooftop height of Civil Block is 12 m, due to expected high wind pressure Tilt of Module kept at 15°

- Tilt Angle: 15°
- Orientation: South

PV Module Specification

- Polycrystalline
- Wattage of Module: 320W_p
- Maximum Power Point Voltage (V_{MPP}) 37.65V
- Open Circuit Voltage (V_{OC}) 45.96V
- Short Circuit Current (I_{SC}) 9.03A

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- Efficiency 16.67%
- Temperature Coefficient of V_{OC} -0.310%/C
- Temperature Coefficient of V_{MP} -0.409%/C
- Temperature Coefficient of I_{SC} +0.052%/C

Inverter Specifications (66kVA Schneider Inverter):

- Max DC input Voltage 1000 V
- MPPT Voltage range 570-850 V
- Max array short circuit current 140A
- AC output Power 66KW
- Output Voltage range 310-480V
- Max output current 96 A

The overall parameters of the PV system at academic block I are shown in Table 1.

PV System		
PV Generator Output	226.8	kWp
Spec. Annual Yield	1,537.23	kWh/kWp
Performance Ratio (PR)	81.6	%
Grid Feed-in	348,643	kWh/year
Grid Feed-in in the first year (incl. module degradation)	348,643	kWh/year
Standby Consumption (Inverter)	58	kWh/year
CO_2 Emissions avoided	2,09,186	kg / year

Table 1. PV System's Overall Parameters for Academic Block I

Energy production forecast of existing system during a year is simulated and is given below in Fig.1

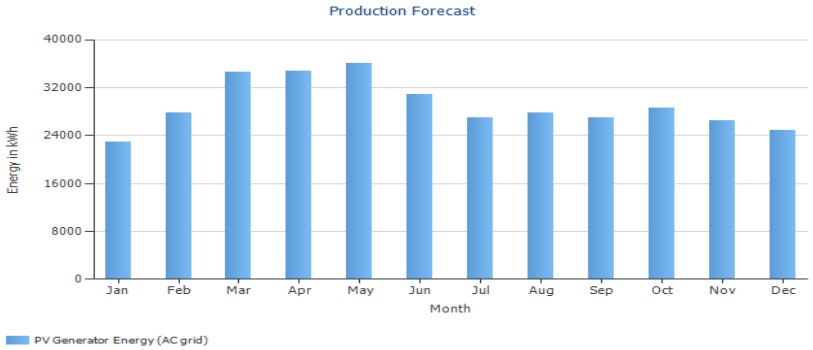

Figure 1 Production Forecast of the PV System

Simulation results of optimized system are discussed below. The module is kept 27º which is the optimum tilt angle for the Integral University, Lucknow. Overall parameters of the PV system of Academic Block I are shown in Table 2.

PV System		
PV Generator Output	226.8	kWp
Spec. Annual Yield	1,546.71	kWh/kWp
Performance Ratio (PR)	81.8	%
Grid Feed-in	350,794	kWh/year
Grid Feed-in in the first year (incl. module degradation)	350,794	kWh/year
Standby Consumption (Inverter)	59	kWh/year
CO_2 Emissions avoided	2,10,476	kg / year

Table 2 PV System's Overall Parameters

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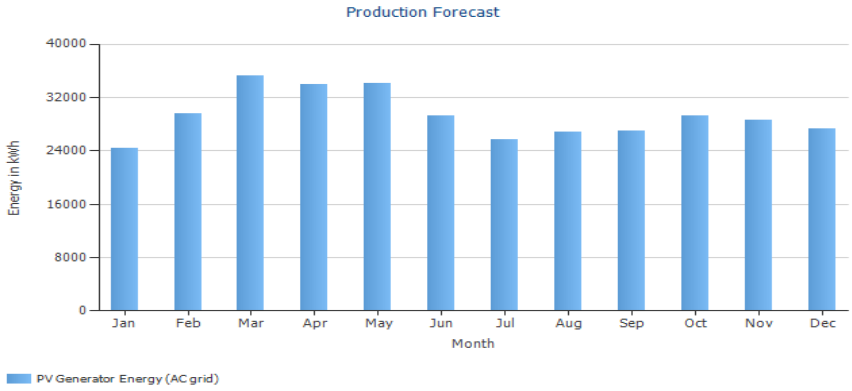

Fig. 2 Production forecast Of the PV system

IV. CONCLUSION

The following Conclusions are drawn from the study of performance analysis of 198kW$_p$ grid interactive rooftop solar PV system installed at Academic Block I, Integral University, Lucknow

- The module's tilt angle in existing system is 15º which is not the yearly optimum tilt angle for the installation site, i.e.; Integral University, Lucknow, India. Due to non optimal tilt angle of PV array, it is observed from PV*SOL simulations that various performance parameters of the PV system such as grid feed-in, performance ratio, annual specific yield, carbon emissions avoidance, etc have been reduced compared with the optimized PV system.
- Comparison of final results of the existing system as well as optimized system is given below in tabular form in table 3.

Parameters	Results Highlights of existing system	Results Highlights of optimized system
Grid feed-in	348,643kWh/year	350,794kWh/year
Specific Annual Yield	1,537.23kWh/kW$_P$	1,546.71kWh/kw$_P$
Performance Ratio	81.6%	81.8%
CO_2 Emission Avoided	2,09,186kg/year	2,10,476kg/year
Global Radiation at Module	1882.5kWh/m^2	1891.2kWh/m^2

Table 3

REFERENCES

[1]http://wgbis.ces.iisc.ernet.in/biodiversity/sahyadri_enews/newsletter/issue45/bibliography/Performance%20analysis%20of%20a%203%20MW%20grid%20connected%20solar.pdf
[2] http://ieeexplore.ieee.org/document/8279067/