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Design Study and Performance Evaluation of 111kW$_P$ Grid Connected SPV System at Integral University, Lucknow

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Abstract: In this paper we are working to determine the performance of 111kW$_P$ grid connected SPV System installed at Civil Block, Integral University, Lucknow. To determine the performance of the system a software tool PV*SOL is used. PV*SOL is software design tool for simulating photovoltaic system performance. The simulation results of actual system and optimized system are compared to study the performance of a civil block.

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

I. INTRODUCTION

A photovoltaic power system is carbon negative over its lifespan, as any energy produced over and above that to build the panel initially offsets the need for burning fossil fuels. Even though the sun doesn't always shine, any installation gives a reasonably predictable average reduction in carbon consumption. With the background Integral University has taken the initiative for installation of 500kW Rooftop Grid Interactive Solar Power Plant in the University as per Solar Corporation of India bid. The plant is set up using a number of identical solar panels that work on the principle of solar photo voltaic effect. It uses solar inverters, ACDB's, DC cables, AC cables, Flat earth cables with Light arrester, Grid interactive meter called Net meter. The design study part constitute the study of basic technology involved, type of the plant, basic constructional details of the plant, steps of plant set up, and working of the plant.

II. RELATED APPROACH

Techno-economic analysis of solar photovoltaic power plant for garment zone of Jaipur city, M. Chandel et al , Centre for Energy and Environment, Malaviya National Institute of Technology, Jaipur 2013 The Authors. Published by Elsevier Ltd[1].

In this paper, the potential and the cost-effectiveness of a solar photovoltaic power plant for meeting the energy demand of garment zone at Jaipur (India) is analyzed. Also, the energy demand of garment zone for year 2011has been estimated (2.21 MW) and the design of the solar PV power plant of 2.5MW capacity has been proposed, which requires about 13.14 acres of land area. Looking at the scarcity and cost of the land near the city, an off-site proposal for the power plant has also been considered and compared with the on-site option. For the on- site solar PV power plant internal rate of return (IRR) is 11.88%, NPV @ 10% discount rate is 119.52 million INR, simple payback period is 7.73 years and discounted payback period @10% is 15.53 years, while for the off-site power plant IRR is 15.10%, NPV is 249.78 million INR, simple payback period is 6.29 years and discounted payback period is 10.14 years. Levelized cost of energy is Rs. 14.94 and Rs. 11.40 per kW h for on-site and off-site solar PV plants respectively @ 10% discount rate, which is quite attractive. Study has been carried out to assess the technical feasibility and economic viability of a 2.5 MW capacity solar photovoltaic power plant for meeting the energy demand of garment zone, Jaipur considering on-site and off-site options. For this power generation total 22,230 PV modules are required with 16 modules in each row. Seven inverters with MPPT controller of 3.5 MW capacity and battery bank of 431,781 Ah are required to supply the power and the total land area required is 13.11 acres. In on-site power plant PV modules are placed also on the roof of industries and modules are connected to a centralized battery bank and inverter. For off-site SPV power plant no battery bank is required as all the power generated is supplied to the grid simultaneously and a centralized inverter is used with a step-up transformer. The power plant can generate 10.03 GWh electricity in first year at 35.23% plant capacity factor. After 25 years, considering cumulative degradation of 11.01%, electricity generation from the plant will be i.e. 8.96GWh. Levelised cost of energy (LCOE) is Rs. 14.94/kW h and 11.40/kW h for on-site and off-site PV power plants respectively, considering 25 years of plant life @ 10% discount rate. Financial performance indicators (internal rate of return (IRR), net present value (NPV) and payback periods) are analyzed for four financial cases i.e.

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pre-tax analysis, post-tax analysis, equity analysis pre-tax and equity analysis post-tax. Financial analysis shows that the off-site PV power generation option is better because of land scarcity near the city.

Simulation and performance analysis of 110 kWp grid-connected photovoltaic system for residential building in India: A comparative analysis of various PV technology, Akash Kumar Shukla, K. Sudhakar , Prashant Baredar, Energy Centre, Maulana Azad National Institute of Technology Bhopal, 2016 The Authors. Published by Elsevier Ltd[2].
In this paper a study is done to evaluate the feasibility of grid connected rooftop solar photovoltaic system for residential Hostel building at MANIT, Bhopal, India (Latitude: 23° 16′ N, Longitude: 77° 36′ E). system simulation is necessary to investigate the feasibility of Solar PV system at a given location. The study focuses on the use of Solarism PV Planner software as a tool to analyse the performance a 110 kWp solar photovoltaic rooftop plant and also compares the performances of different PV technologies based on simulated energy yield and performance ratio. Solaris proves to easy, fast, accurate and reliable software tool for the simulation of solar PV system. This paper has evaluated the technical performance of a110 kWp grid connected roof top solar PV-system to supply electricity and energy for the Hostel building. Four types of PV modules have been simulated to determine performance ratios and Energy yield. The following conclusions are drawn from the study. The PR of the PV systems varies from 70% to 88% and their energy yields range from 2.67 kWh/kWp to 3.36 kWh/kWp.• Among the four types of PV systems considered here, two PV systems a-Si and CdTe PV system have their PRs higher than75%.• From the annual energy yield of the PV systems, it is observed that all the four technology perform satisfactory under the tropical weather conditions. The electricity generated by PV systems can be used to power the water pumps, lighting and other electrical appliances of the Hostel building.

III.PERFORMANCE ANALYSIS

Simulation results of existing system are discussed below. In this grid connected solar PV system tilt angle of the modules are kept at 15º from the horizontal which is not the optimum tilt angle for the site, i.e. Integral University Lucknow. Due to excessive wind pressure tilt angle of the modules are kept at 15º. The overall parameters of the PV system at civil block are shown in Table 1.

PV System		
PV Generator Output	131.4	kWp
Spec. Annual Yield	1,531.20	kWh/kWp
Performance Ratio (PR)	81.3	%
Grid Feed-in	201,130	kWh/year
Grid Feed-in in the first year (incl. module degradation)	201,130	kWh/year
Standby Consumption (Inverter)	24	kWh/year
CO_2 Emissions avoided	1,20,678	kg / year

Table 1. PV System's Overall Parameters for Civil Block

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

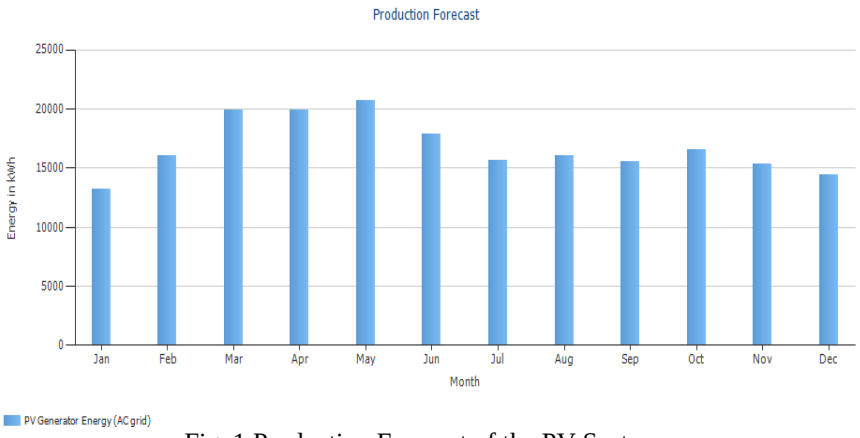

Fig. 1 Production Forecast of the PV System

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Energy output forecast of the PV system for a period of 21 years is simulated and is given in Fig.2

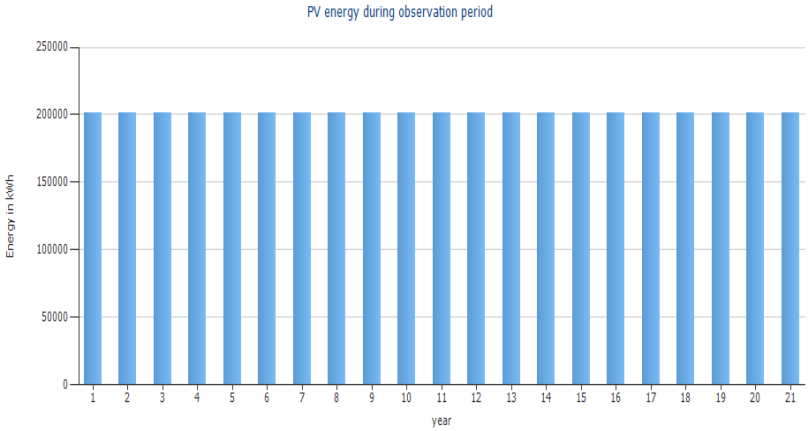

Fig. 2 PV Energy Output forecast for a Period of 21 Years

Production forecast per inverter is simulated of existing system and is given below in figure 3.

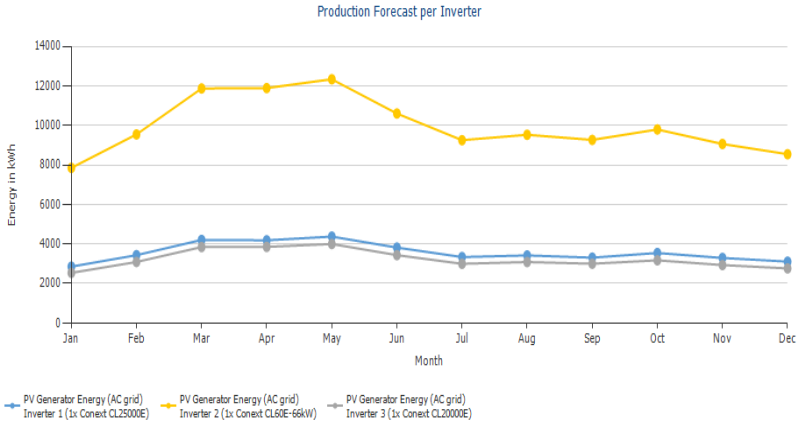

Fig. 3 Production Forecast Per Inverter

Simulation results of optimized system are discussed below. In this grid connected SPV system tilt angle of the module is kept 27º which is the optimum tilt angle for the installation site i.e. Integral University. . Overall parameters of the PV system at civil block are shown in Table 2.

PV System		
PV Generator Output	131.4	kW_P
Spec. Annual Yield	1,540.38	kWh/kW_P
Performance Ratio (PR)	81.4	%
Grid Feed-in	202,337	kWh/year
Grid Feed-in in the first year (incl. module degradation)	202,337	kWh/year
Standby Consumption (Inverter)	24	kWh/year
CO_2 Emissions avoided	1,21,402	kg / year

Table 2 PV System's Overall Parameters

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Energy production forecast of optimized system during a year is simulated and is given below in Figure 4.

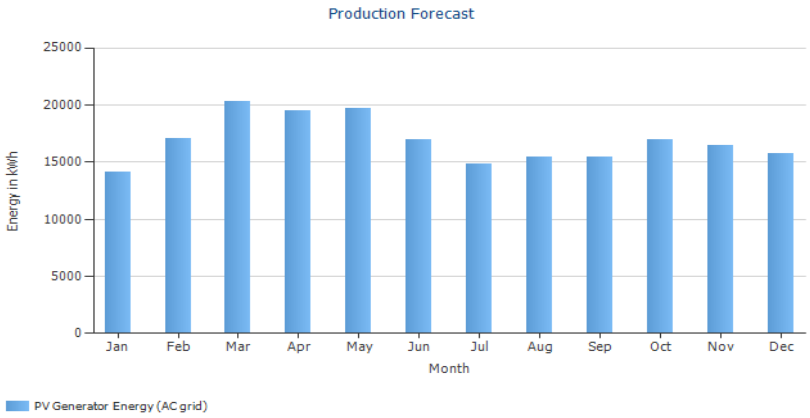

Fig. 4 Production Forecast of PV System

Energy output forecast of the pv system for a period of 21 years is simulated and is given in Figure 5.

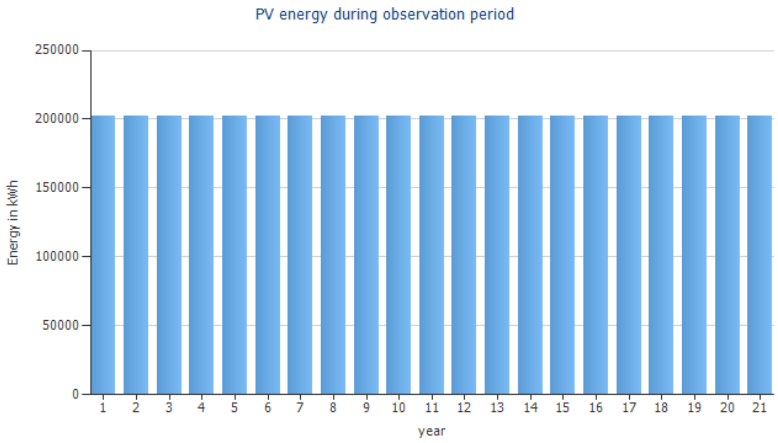

Fig. 5 PV Energy Output forecast for a Period of 21 Years

Production forecast per inverter is simulated of optimized system and is given below in figure 6.

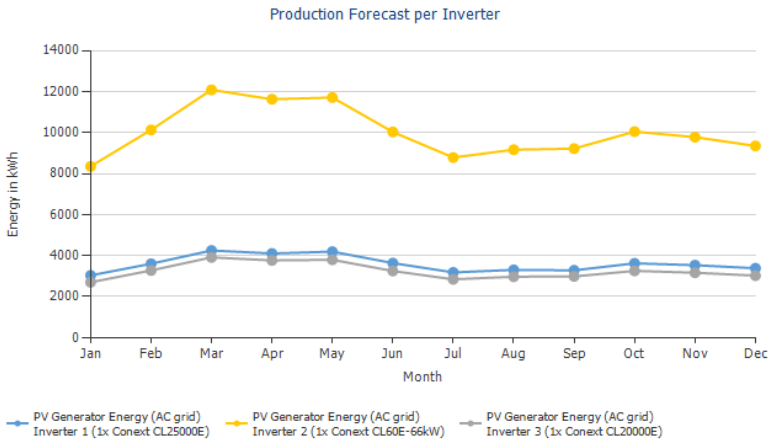

Fig. 6 Production Forecast per Inverter

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IV. CONCLUSION

Design study and performance analysis of 111kW$_p$ grid interactive rooftop solar PV system installed at Civil Block, Integral University, Lucknow has been done. The following Conclusions are drawn from the study.

- Maximum energy feed-in to the grid is observed for the month of May while minimum energy feed-in to the grid is for the month of January.
- 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, etchave been reduced compared with the optimized PV system.
- Form PV*SOL simulations of existing system and optimized system, it is ascertained that the variation between results of performance parameters of both the systems are as follows:
  i) Grid feed-in is 2,01,130 kWh/year, specific annual yield is 1531.20 kWh/kW$_p$, performance ratio is 81.3 %, CO_2 emissions avoidance is 1,20,678 kg/year and global radiation at the module is 1851.6 kWh/m^2 for existing system installed at Civil Block, Integral University, Lucknow.
  ii) Grid feed-in is 202,337 kWh/year, specific annual yield is 1540.38 kWh/kW$_p$, performance ratio is 81.4 %, CO_2 emissions avoidance is 1,21,402 kg/year and global radiation at the module is kWh/m^2 for optimized system.

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