Design and Cost -Analysis of an integrated photovoltaic system for a multipurpose building (A case study)

[1] Mandeep Kaur, [2] Gursewak Singh Brar
[1] M.tech Scholar, [2]Associate Professor
Electrical Engineering Department
BBSBEC, Fatehgarh Sahib, Punjab, India

***Abstract* - The day by day demand of electricity is rising and fossil fuels are depleting continuously. So there is an urgent need of renewable energy sources to meet up the current days demand. Solar energy is the most rich endless and clean of all the renewable energy resources till date. Photovoltaic technology is one of the most excellent ways to harness the solar power. Due to seasonal and periodic variations neither a standalone solar photovoltaic system nor a wind energy system can provide a continuous supply of energy. Thus, in order to satisfy the load demand, grid connected energy systems are now being implemented that unite solar and conventional conversion units. The grid connected SPV project would be a demonstration plant to exploit renewable energy and the data on generation would be utilized for study of the various aspects of operation as also that of availability of power. The objective of the work is to estimate the potential and cost analysis of grid quality solar photovoltaic plant of a girls hostel, at an educational institute and finally build up a system based on the potential estimations made for an available rooftop area of 1770 m^2. Equipment specifications are provided based on the accessibility of the components in Indian market. Annual energy output by proposed Grid quality SPV power plant is calculated.**

***Keywords* - Grid Connected Photovoltaic (PV) System, Solar Photovoltaic (SPV), Annual energy output, Renewable energy sources**

I. INTRODUCTION

Photovoltaic system offers the consumers the capability to produce electricity in a hygienic, silent and reliable way. Photovoltaic systems are comprised of photovoltaic cells, devices which converts light energy directly into electricity. It is feasible that photovoltaic systems will experience an huge increase in the decades to come. However, a successful integration of solar energy technology into the existing structure depends also on a exhaustive knowledge of the solar resources [4][7]. It is essential to state the amount of literature on solar energy, the solar energy system and PV grid utility system is enormous[1]. Grid interconnection of photovoltaic power generation system has the benefit of more effective consumption of generated power. However, the technical requirements from both the grid utility power system side and the PV system side need to be satisfied to make sure the safety of the PV installer and the reliability of the utility grid[5]. Net metering system is used which is a billing mechanism that credits solar energy systems owners for the electricity they add to the grid. It is a notion which accounts net energy between export of electrical energy and import of electrical energy .The electrical energy exported to the grid is deducted from the electrical energy imported from the grid by using import/export energy meters[6].

II. PRESENT WORK

The load requirement for the chosen site is 85 KW as per the connected load. To find out the potential and cost estimation for 85 KW grid connected solar PV plant , the solar radiation over different months were calculated for this place using solar position calculator. Then the average monthly and yearly energy outputs are found out and related graphs were plotted for showing the variations. So. we measured value of solar radiation from April, 2014 to march ,2015 month after that we calculated the diurnal variations, average monthly energy output for twelve months (April 2014 to march 2015) ,also took help of PEDA regarding daily sunshine hours to get average sunshine hours. Then the average yearly energy output is calculated by multiply the average monthly energy output with the total number of months taken that is 12 months [2]. Input solar radiation means how much amount of solar radiations are coming from sun and Output solar radiation means how much amount of solar radiation we can consume to generate electricity which depends upon the efficiency of the PV module [1]. For calculating the output the efficiency of the PV module is taken as 22.7%. The area chosen for the estimated plant capacity is considered as 1770 m².Finally the cost analysis and payback period is carried out[10][11]. Additionally, the concept of export of electrical energy from solar panel to the grid by using Import /Export energy meter for additional revenue generation has been introduced [9].

III. ANNUAL ENERGY DATA

Solar radiation is recorded with the help of solar position calculator for the time period April 2014 to March 2015.The data of daily sunshine hours to get average sunshine hours is taken from PEDA which is 7 hours/day basis. From the solar radiation data daily and monthly energy output is calculated. Graph showing the diurnal variation of different months from April 2014 to March

2015 are as drawn in figure 1 to figure 12. Table 1 shows the daily and monthly outputs of energy. Monthly peak variations are also plotted in figure 13.Then from daily and monthly energy outputs, the average monthly and yearly energy outputs are calculated.

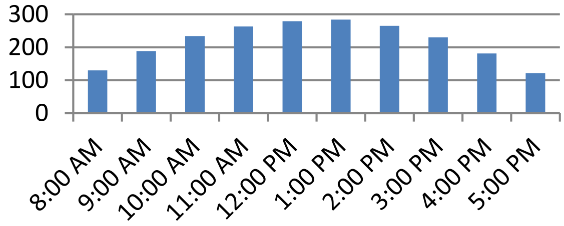

Figure 1: Diurnal variation for April

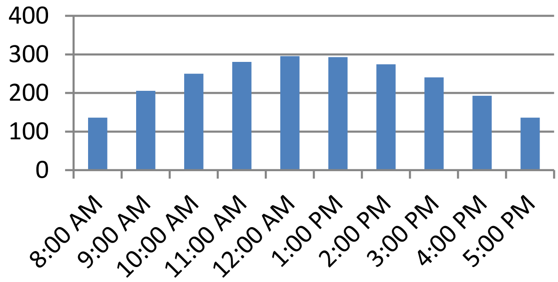

Figure 2: Diurnal variation for May

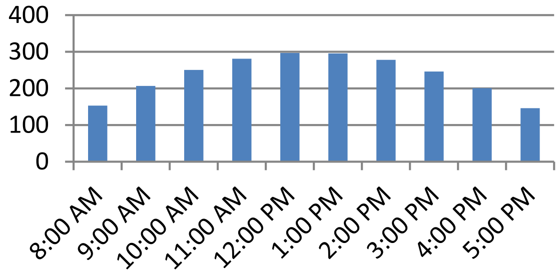

Figure 3: Diurnal variation for June

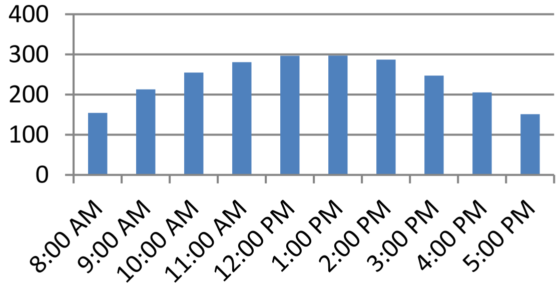

Figure 4: Diurnal variation for July

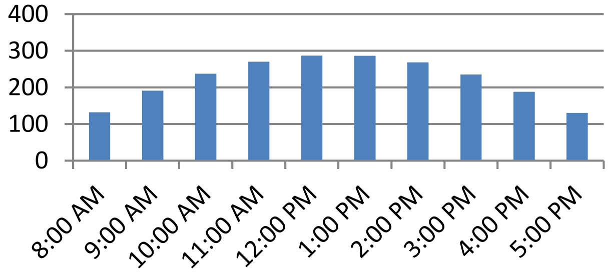

Figure 5: Diurnal variation for August

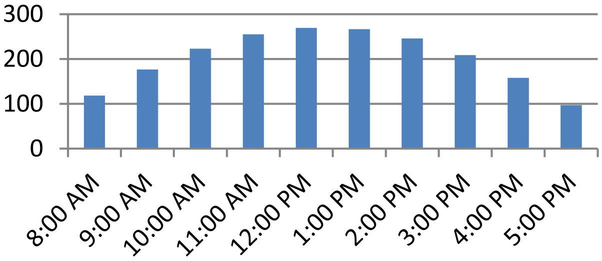

Figure 6: Diurnal variation for September

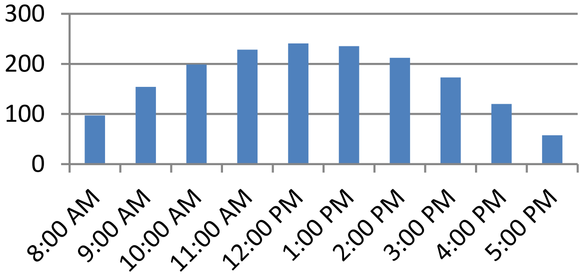

Figure 7: Diurnal variation for October

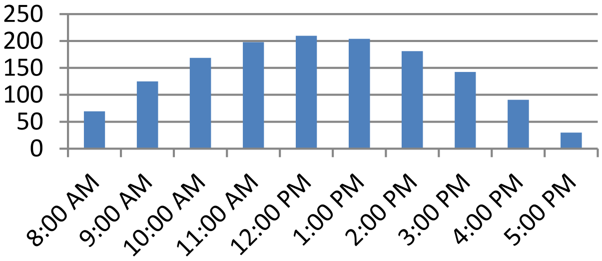

Figure 8: Diurnal variation for November

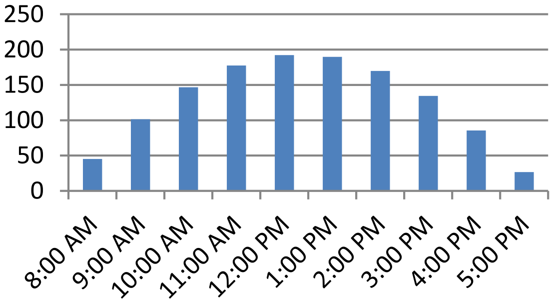

Figure 9: Diurnal variation for December

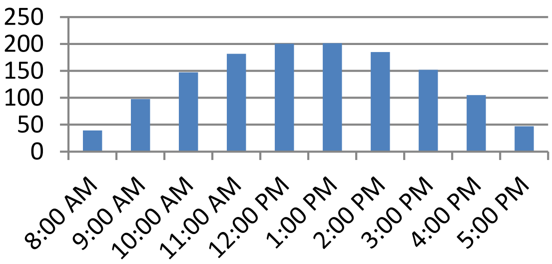

Figure 10: Diurnal variation for January

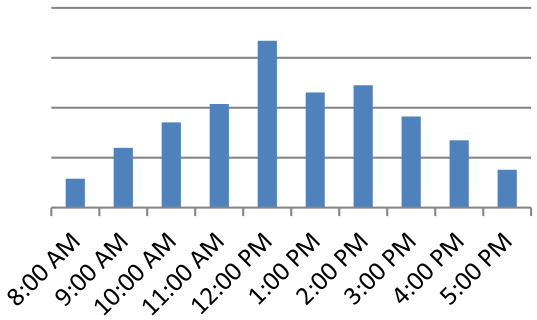

Figure 11: Diurnal variation for February

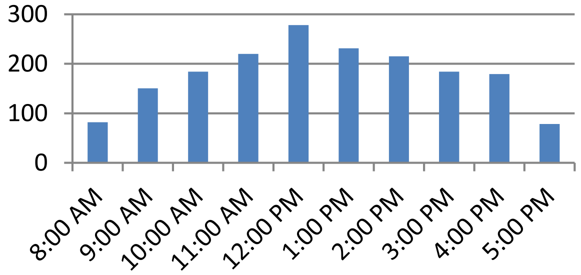

Figure 12: Diurnal variation for March

Table 1: Daily and monthly energy output

Months	Daily energy output (W-h/m^2)	Monthly Energy Output (W-h/m^2)
April(2014)	2267.58	68027.4
May(2014)	2304.49	71439.19
June(2014)	2352.61	70578.3
July(2014)	2388.64	74047.84
August(2014)	2223.16	68917.96
September(2014)	2019.06	60571.8
October (2014)	1717.75	53250.25
November(2014)	1419.09	42572.7
December(2014)	1270.53	39386.43
January(2015)	1456.19	42029.49
February(2015)	1659.45	46464.6
March (2015)	1803.25	55900.75

Average monthly energy output= 56717.13 W-h/m^2
Average yearly energy output= 680605.62 W-h/m^2

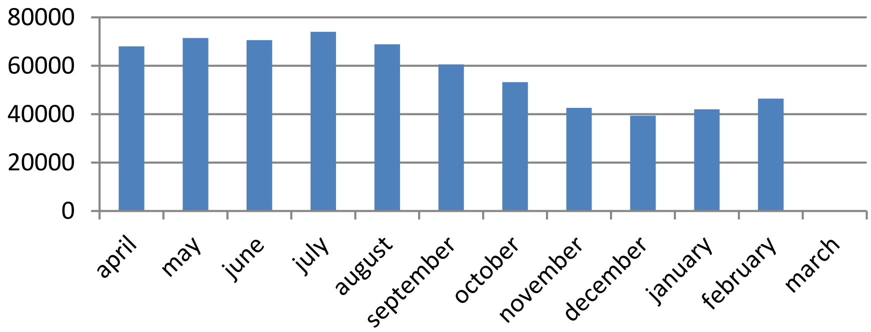

Figure 13: Monthly peak variation

The July month gives maximum monthly energy output and December gives minimum monthly energy output out of 12 months.

IV. SYSTEM DESIGN AND RESULTS

Grid connected PV system can be designed with battery or without battery. Here without battery grid connected system is used, due to reasons like short life time, large replacement cost, and increased installation cost. A transformer is used to boost up the AC output voltage and feed it to grid [3]. The two meters are connected one is called the import meter and the other is called the export meter. Thus the difference between the two meter readings gives the power fed to the grid from solar photovoltaic power plant. So, by using these meters we can easily verify what amount of energy is fed to the grid from solar power. From the results obtained, we find that a 85 KW solar photovoltaic power plant can be developed on according to total connected load of building that is 83,875 KW on 1770 m^2 rooftop area. For the 85 kW plant no. of PV modules required are 355. Now to form a solar photovoltaic power plant 165 modules are connected in one group and 190 modules are connected other group . Now in group of 165 modules, 11 modules are connected in series and 15 in parallel and in group of 190 modules ,10 are connected in series and 19 are connected in parallel. Therefore, the total output from solar photovoltaic system is 85.47928 KVA or 76.93 KW. This output from solar photovoltaic system is the input of three-phase inverter which convert the dc voltage into ac voltage. After the inverter a 3 phase transformer is connected which will boost up the ac voltage and feeds it to the grid[8]. The annual energy gain is 196556.15 KWh. Revenue generated after exporting surplus energy to the grid@ Rs.4.90/- per kWh is Rs 385250.05[9].

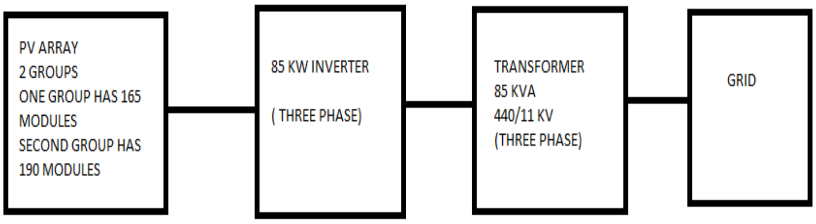

Figure 14: Grid connected photovoltaic plant

Cost analysis of grid connected solar PV plant

1. Cost of solar panels: The cost of Panasonic HIT power 240s solar panel is Rs 110 per watt.
   Cost of 240 watt panel is= 240 x 110 = Rs 26400
   Total cost of solar panel =355 x 26400 =Rs 9372000
2. Cost of 3 phase inverter: 85 KW inverter is used and multiplies the size of the inverter by Rs 25 per watt.
   Cost of inverter = 25x 85000 =Rs 2125000
3. Cost of 3 phase step up transformer: 85 KVA 440volts /11KV step up transformer is used and multiply the size of transformer by Rs 20 per rated watt.
   Cost of transformer = 20x 85000 = Rs 1700000
   Subtotal: Rs 1,31,97,000
4. Total cost: Multiply the subtotal above 0.2(20 %) to cover balance of system cost (wires, fuses, switches etc)
   Cost Estimate of system= Rs 26,39,400
   Total estimate PV cost = Rs 1,58,36,400
   Subsidy (30%) = Rs 4,750,920
   Net capital cost = Rs 1,10,85,480
   Operating cost = 1% of the total capital cost =Rs 1,58,364
   Total Plant Cost = Rs 11,243,844

V. CONCLUSION

The design of BIPV system is based on the solar potential measured.The designed system is capable of fulfilling the load during day time thereby reducing the burden on utility transformer and the consumption cost of electricity. System sizing and specifications are provided on the basis of design made. The energy available from the SPV power plant thus varies from a minimum of 39386.43 W-h/m^2 during the December month to a maximum of 74047.84 W-h/m^2 during the April month. The annual energy gain is 196556.15 KWh. Finally, cost analysis is carried out for the proposed design. Estimated PV System Cost is Rs.11243844 as calculated. Payback period of 85 KW solar power plant is 9.5 years.

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