DESIGN AND ESTIMATION OF SOLAR PHOTOVOLTAIC POWER PLANT FOR DEPARTMENT OF ELECTRICAL ENGINEERING, GIRIJANANDA CHOWDHURY INSTITUTE OF MANAGEMENT & TECHNOLOGY, GUWAHATI

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*Abstract :*In Assam, although the per capita energy requirement is quite below the average per capita requirement of energy of the rest of India, yet due to industrialization and globalization the power requirement has increased significantly. This requirement of power can't not be met alone by conventional energy sources. The only alternative apart from biomass is therefore solar energy which can be harnessed and utilized for power generation. The average sunshine hours in Assam being four hours per day and the average insolation being around 500W/m^2, the photovoltaic power plant seems to be lucrative enough to choose for. It is environment friendly, free and renewable source of energy and thereby popular enough to find its utility in almost all over Assam. An effort has been made to design a standalone solar PV plant just to meet the power requirement of the Department of Electrical Engineering of Girijanada Chowdhury Institute of Management and Technology, Guwahati, Assam by considering only the working days of the year 2017 keeping all the loads ON as per the four seasons of the year. The calculations used in designing the mentioned power plant with the estimation of different loads connected during different seasons of the year have been put forward in the present paper.

IndexTerms – **Solar power, renewable energy, PV module, battery, inverter, charge controller, capacity calculation, installation cost, watt-hour, electricity.**

I. Introduction

The sun is regarded as one of the most powerful sources of energy. Solar energy is therefore needed to tap so as to meet long term global energy crisis. Mere capturing and then using just the sunlight which is incident on the earth in one day could provide enough energy for the entire world all year.

The electricity demand is increasing leaps and bounds throughout the world, STE (Solar Thermal) and SPV (Solar Photo Voltaic) technology have become more popular in this regard due to the availability of large wasteland areas worldwide which include rooftops of the houses, barren fields, across the railway lines etc..

India is a tropical country where sunshine is available for longer hours per day and in great intensity. Solar energy, therefore, has great potential as a sustainable energy source. It also gives us a scope for decentralized distribution of electric power and thereby empowering people at the grassroots level [1].

The main features of the radiation climatology of the state Assam of republic of India are as follows:

• About 2277hours [2] of bright sunshine are available in a year which is appreciably lower in comparison with the rest of India.

• About 4.29 kWh/m^{2}per day of solar energy is receivedduring winter and during summer, a reversal occurs with high values. [3]

• The mean daily global diffused solar radiation is 756 W/m^2 and the mean daily global radiation has been found to be around 1024 W/m^2 over southern part of Assam [3].

The total solar energy received by the subcontinent is over 60 x 10^{13} MWh [4]. There are between 250 to 300 days of usual sunshine per year in most parts of the country [5].

Assam has a total cumulative solar capacity of 11.18MW as in 31st March, 2017 [7]. With the average annual per capital consumption of electricity just 258kWh in the North Eastern part of India as compared to 779kWh consumption in the whole of the country, the demand for energy is not as high in NE states and therefore solar can easily become the primary energy source in the state. However the market of solar energy is set to grow significantly in the next ten years. Even under the 500MW Rooftop Subsidy scheme by the SolarEnergy Corporation of India (SECI), the NE states have been given a higher, 70% subsidy in order to encourage the installation of rooftop solar plants. The grid interactive net metering arrangement in Assam *was* formally announced in the month of May in 2015, allowing all the residents who wish to go solar to feedback the excessive produced electricity to the grid and be suitably rewarded for the same [6]. Encouraging the spread of solar mode of power generation (both CSP & PV) & aiming current status of grid parity at around Rs 5 / kWh by 2022 & coal power generation currently at around

Rs.4/kWh by 2030 forms the key element in India's comprehensive long term policy. In India solar power generation particularly for PV & solar thermal are Rs.8 &Rs.15 respectively per kWh [7].

II. MODELING OF SOLAR PV SYSTEM

For designing a PV system the following steps must be taken into consideration-

2.1 The total energy consumption for the whole year is calculated first.

2.2 Then the actual power demand required is determined by calculating the total watt hours per day of each appliance used. The total watt hours per day needed from the PV module is also calculated.

2.3 After calculating the overall energy consumption, the panel designing is done considering the following major components such as PV module, Inverter sizing, Battery sizing, Solar charge controller etc.

2.3.1 To find out the size the PV module, total watt peak (Wp) rating needed for the PV module and then number of PV panels required for the system are calculated.

2.3.2 Inverter designing is also important for the system where AC power output is desirable. For safety purpose, the inverter size should be 25-30%higher than the total watts of the appliances used.

2.3.3 Battery should be designed in such a way that it recharges fast and discharges to the low voltage and efficient enough to work in any environmental condition.

III. DESIGNING AND CALCULATION OF INSTALLATION COST

3.1Calculation of Solar Panel Requirement

In this technique, Total PV panels energy needed = Total energy per day x operating factor
(where operating factor is considered to be 1.3)

$$\text{Total watt-peak (Wp) of PV panel capacity needed} = \frac{\text{total PV panels energy needed}}{\text{Generation factor}} \quad \text{(i)}$$

(where generating factor is considered to be 3.4)

$$\text{No. of PV panels needed} = \frac{\text{total watt peak rating (Wp)}}{\text{PV module peak rated output}} \quad \text{(ii)}$$

3.2 Calculation of Inverter Sizing

Total watt of all appliances = 258070.00 W
Considering the inverter (25 -30)% bigger size
= 258070.00*30/100
= 77421.00 W
Therefore, rating of inverter=258070.00 W +77421.00 W
=335491.00 W or bigger
For cosϕ= 1
Inverter size should be of = 335491.00 VA = 335.491kVA

3.3Battery Sizing

Total watt-hour used by all appliances = 258070.00 W x 6 hr = 1548420Wh
Nominal battery voltage = 48 V
Days of autonomy= 3 days
Considering efficiency= 85% and depth of discharge= 60%

$$\text{Battery Capacity (Ah)} = \frac{\text{Total Watt-hours per day used by appliances x Days of autonomy}}{\text{Efficiency of inverter x Depth of discharge x nominal battery voltage}}$$

$$= \frac{4645260 \times 3}{0.85 \times 0.6 \times 48}$$

$$= 189757.35 \text{ Ah}$$

No of battery required = (189757.35 Ah)/1000 Ah = 190 (approx.)

3.4Solar charge controller Sizing

PV module specification, Pmax = 250 W
Vmp = 30.79 V
Imp= 8.12 A
Voc= 39.20 v
Isc = 8.71 A

Solar charge controller rating = 2389 x 8.71 x 1.3 A = 27051 A (approx.)

3.5Sizing of Solar Plant and Installation Cost of Solar Panel

Size of the plant = total no of modules x Wp rating of the PV module
= 2389 no of modules x 250 Wp = 597250 Wp = 600 kWp (approx.)

Considering cost of one solar module Rs.15000
Total cost for installation of solar panel = Rs.(2389 x 15000) = Rs.35835000.00
Considering cost of one unit Rs.8.00 per kWh
Total cost of electricity per annum = (219468.28 x 8)= Rs.1755747.00 (approx.)

IV. RESULTS AND DISCUSSION

In table 1, the electrical characteristics data of PV module considered are shown. In table 2, the estimated energy consumed by the different appliances including the sockets for all the rooms of the Department of Electrical Engineering have been show cased. This gives us an information of the energy demand for all the laboratories, class rooms, tutorial rooms, library, faculty room and conference room taking all the lights, fans and the connected sockets into consideration for 6hrs per day for all the working days of 2017. Moreover, table 3 presents the data which are obtained from equations (i) and (ii) involving the information from table 1. This gives us and information of required no of solar modules to meet the requirement of the daily energy requirement of the department. The figure 1 and figure 2 show the graphical representations of the total energy that can be consumed taking all the loads including the sockets into consideration in all the rooms of the department.

Table 1 Electrical characteristics data of PV module considered

Electrical Characteristics	PV module
Maximum Power (Pmax)	250 W
Voltage at Pmax (Vmp)	30.79 V
Current at Pmax (Imp)	8.12 A
Open circuit voltage (Voc)	39.20 V
Short circuit current (Isc)	8.71 A
Tolerance	± 2 W
Maximum system operating voltage	1000 VDC
NOCT (Normal Operating Cell Temperature)	47 ^{0}C

Table2 Calculation of energy consumption by the appliances of the department of Electrical Engineering for the year 2017

Room No.	Total Energy Consumption for a year (kWh)
104	22862.19
105	23275.2
106	4415.88
108	24580.92
109	55048.08
312	6810
313	2760.73
315	3966.36
316	6008.76
511	35378.4
519	34361.76
Total Energy Consumption of all rooms for a year (kWh)	219468.28

Table3 Calculation of modules required

Room No.	Total Watt Peak (Wp)	Total No. of Modules
104	81441.17	326
105	61023.52	244
106	11780	67
108	59542.09	238
109	143405.29	574
312	18238.24	73
313	7777.05	31
315	11115	44
316	16391.47	66
511	91994.12	368
519	89516.47	358
Total modules		2389

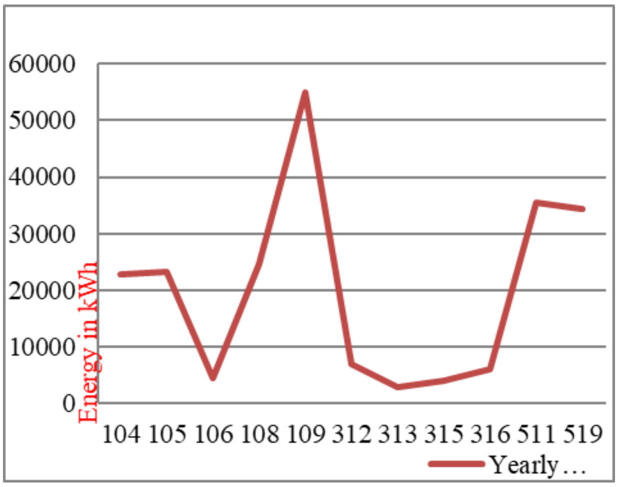

Fig.1Yearly Energy Consumption By The Different Rooms Of The Department

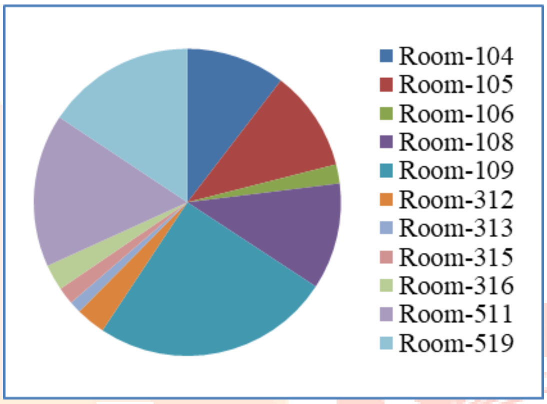

Fig.2Pi Chart Of The Total Energy Consumed By The Different Rooms Of The Department

IV. Conclusion

An attempt has been made to assess for a 600 kWp standalone solar PV plant having 3 days of autonomy for Department of Electrical Engineering at Girijananda Chowdhury Institute of Management and Technology, Guwahati. The described design of the system will produce the desired power of the project to supply all the appliances along with different AC and DC motors and different laboratory apparatuses and instruments together at the same time. Due to its promising potentials in Assam, solar PV although expensive can be adopted in the long run as mere a 600 kWp can be sufficient enough to meet all the power requirements of the department without accessing any power from the grid. Solar having zero global warming potential and almost zero ozone depletion potential can substantially reduce the carbon emission giving us clean and free sustainable energy for present and future power requirements.

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