Estimation & Design of Possible Solar Photovoltaic Generation Potential for U.I.E.T, K.U.K

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ABSTRACT

The depletion of fossil fuel resources on a worldwide basis has necessitated an urgent search for alternative energy sources to meet up the present day demands. Solar energy is a clean, inexhaustible, environment friendly and a potential resource among the various renewable energy options. Solar radiation is the key factor determining electricity produced by photovoltaic (PV) systems. This paper reports a novel method to estimate the solar photovoltaic generation potential for U.I.E.T, K.U.K on the basis of Mean Global Solar Radiation data available for Kurukshetra and finally develop a system design of possible plant capacity for available area. The specifications of equipments are provided based on the availability of the components in India.

Keywords : Solar Photovoltaic (PV) System, Insolation, Solar Radiation

I. INTRODUCTION

It is anticipated that photovoltaic (PV) systems will experience an enormous increase in the decades to come. However, a successful integration of solar energy technologies into the existing energy structure depends also on a detailed knowledge of the solar resource. Therefore solar radiation is a key factor determining electricity produced by photovoltaic (PV) systems which is usually obtained using Geographical Information System (GIS). The calculation of electricity generation potential by contemporary PV technology is a basic step in analyzing scenarios for the future energy supply and for a rational implementation of legal and financial frameworks to support the developing industrial production of PV. Electricity is obtained from the PV array [1- 4] most efficiently during daytime. But at night or during cloudy periods, independent power systems use storage batteries to supply the electricity needs. With grid interactive systems [5], the grid acts as the battery, supplying electricity when the PV array cannot. The energy storage devices viz. battery has been avoided in this work. This approach reduces the capital as well as the running cost. We have tried to develop a grid connected photovoltaic system. Grid connected photovoltaic system [6-7] is well known in various parts of world, and several technologies are used. There have been efforts to develop the power electronics circuitry [8-10] involved. Several types of inverters [11-17] have been designed. But our focus is to estimate the potential of grid connected Solar photovoltaic system for U.I.E.T K.U.K and an establishment of this type of system is tried out with the existing methodologies and equipments available.

II. METHODOLOGY

To find out the possible solar photovoltaic generation potential, the solar radiation over one year (Jan - Dec 2012) is taken based on the data of mean global solar radiant exposure over Kurukshetra district of Haryana and following the methods discussed in [18-19]. Then the related graph is plotted for showing the variation in different seasons. Also For calculating the output the efficiency of the PV module is taken as 14.3% [20]. Finally a grid connected photovoltaic system is designed with the available technologies for the estimated plant capacity on available area. The novelties of this approach lies in the fact of assessing the solar photovoltaic generation potential in kurukshetra and thereby obtain the possible plant capacity. The method of design is shown with the existing equipments available in the market.

III. RESULTS & DISCUSSIONS

The mean global solar radiant exposure varies from 3.34 KWh/m²/day in the month of December to 7.35 KWh/m²/day in the month of May. We can take these readings from HAREDA, Sec-26 Chandigarh & solar data sites available. The month wise mean global solar radiant exposure in Kurukshetra district of Haryana for year 2012 is given in Table 1.

The Graph showing the variation for different months (Jan - Dec 2012) is shown in Fig. 1. Further step involve the calculation of total load of campus & is illustrated well in tables 2- 5. Then using the value for average annual solar insolation, the possible plant capacity is estimated considering the PV module efficiency as 14.3% and is integrated in table 6. We have assumed in our study that the solar energy is available for about 6 hours during the normal day. After estimating the potential, the design of grid connected solar PV power plant is made. The methodology adopted seems satisfactory for determining the possible plant capacity for a chosen area.

Month	Daily Solar radiation in KWh/m^2/day
Jan.	3.41
Feb.	4.41
March	5.77
April	6.77
May	7.35
June	6.81
July	6.29
Aug.	5.78
Sep.	5.45
Oct.	5.30
Nov.	4.16
Dec.	3.34
Annual	5.40

Table 1: Mean Global Solar Radiant Exposure at Kurukshetra.

So, Average annual solar insolation in Kurukshetra
= 5.40 kWh/m^2
= 900 W/m^2/day.

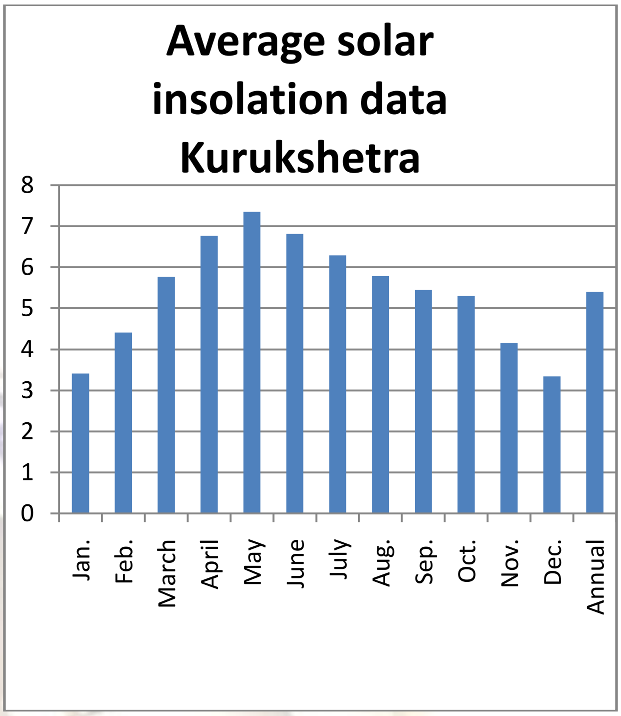

Fig.1: Variation of Mean Global Solar Radiant Exposure at Kurukshetra (in kWh/ m^2/day)

Load Calculation of U.I.E.T Block

Table 2: Load Calculation for Ground Floor **(Abbreviations: L. H- Lecture Hall, T. R- Teacher's Room)**

Room No.	Fans (80W)	Tube Lights (40W)	6A/3Pin socket (40W)	Computers & Accessories (300W)	Exhaust fan (50W)
100 (L.H)	22	27	2		
101 (L.H)	22	27	2		
102 (T.R)	1	2	1		
103 (T.R)	1	2	1		
104 (T.R)	1	2	1		
105 Chemistry lab1	6	9	2		1
106 Chemistry lab2	6	9	2		1
107 Instrumentation Lab, chemistry	6	8	2		2
108 Project lab(BT)	3	4	3		
109 Biochemistry lab	5	7	2		
110 R/DN lab	5	7	2		

111 Animal cell/Culture lab	5	7	2		
112 Microbial fermentation lab	5	7	2		1
113 Plant tissue Culture lab	3	4	2		
114 Store Room	3	6	1		
115 Store room	3	6	1		
116 F/I BIOTECH	4	6	1	1	
117 Bio-informatic lab	6	16	2	18	
118 (T.R)	1	2	1		
119 (T.R)	1	2	1		
120 (T.R)	1	2	1		
121 Library	18	24	4	3	
122 Mech. W/S	30	36	6		2
123 (T.R)	1	2	1		
124 (T.R)	1	2	1		
125 (T.R)	1	2	1		
126 Exam centre	6	9	2		
127 Thermodynamic lab	4	6	2		
128 (T.R)	1	2	1		
129 (T.R)	1	2	1		
130 Photostat shop	1	2	2	1 photostat m/c	
131 (T.R)	1	2	1		
132 DOM/KOM lab	12	16	2		
133 Electrical lab (instrumentation)	6	12	2		
134 (L.H)	6	8	2		
135-136 Research lab	8	16	2		

137 (L.H)	6	9	2		
138 (L.H)	9	12	2		
139 (L.H)	6	9	2		
140 (T.R)	1	2			
141 (T.R)	1	2			
142 (T.R)	1	2			
Corridors	3	36	2		
Others (wash rooms)		2*4			2*4
TOTAL	234*80 =18720 W	384*40 =15360 W	72*40 =2880 W	22*300 + 2000 =8600 W	15*50 =750 W

Total load of Ground floor = 46.31 KW

Table 3: Load Calculation for 1st Floor

Room No.	Fans (80W)	Tube Lights (40W)	6A/3Pin socket (40W)	Computers & Accessories (300W)	Exhaust fan (50W)
200 (L.H)	22	27	2		
201 (L.H)	22	27	2		
202 (T.R)	1	2	1		
203 (T.R)	1	2	1		
204 (T.R)	1	2	1		
205 Digital electronic lab	6	9	2		
206 Microwave lab	6	9	2		
207 (L.H)	6	8	2		
208 Electronic design lab	3	4	4		
209 Audio visual Engg lab	6	8	2		
210 (L.H)	6	8	2		
211 Micro processor lab	6	8	4		
212 (L.H)	6	8	2		
213 (L.H)	6	8	1		
214 (T.R)	1	2	1		
215 (T.R)	1	2	1		
216 (T.R)	1	2	1		

217 Store stationary	1	2	1		
218 F/I ECE	4	6	2	1	
219 Conference room	6	9	4		
220 (T.R)	1	2	1		
221 (T.R)	1	2	1		
222 (T.R)	1	2	1		
223 M.tech electrical lab	6	8	2	18	
223-A Reading hall	12	17	2	1	
224 Engg drawing hall	15	18	1		
225 UIET Office	15	18	8	6 P.C 1 photostat m/c	
226 TEQIP-II	1	2	2	1	
227 Refreshment	1	2	2		
228 Steno to director	1	2	2		
229 Director Office	6	9	3	1	
230 T & P cell	4	6	2	3 P.C 1 photostat m/c	
231 (T.R)	1	2	1		
232 (T.R)	1	2	1		
233 (T.R)	1	2	1		
234 (T.R)	1	2	1		
235 Cad/cam lab	6	8	2	29	
236 (L.H)	6	8	2		
237 Dsp lab	6	8	3	24	
238 (L.H)	6	8	1		
239 ET lab1	6	8	2		
240 ET lab2	6	8	2		
241 (L.H)	6	9	2		
242 (L.H)	9	12	2		
243 (L.H)	6	9	2		

244 (T.R)	1	2	1		
245 (T.R)	1	2	1		
246 (T.R)	1	2	1		
247 (T.R)	1	2	1		
248 E.D.Cell	1	2	2		
Corridors	2	34	2		
Others (wash-room)	-	2*4			2*4
TOTAL	244*80 =19520 W	379*40 =15160 W	95*40 =3800 W	84*300 +4000 =29200 W	8*50 =400 W

Total load of 1st floor = 68.08 KW

Table 4: Load Calculation for 2nd Floor

Room No.	Fans (80W)	Tube Lights (40W)	6A/3Pin socket (40W)	Computers & Accessories (300W)	Exhaust fan (50W)
300 (L.H)	22	27	2		
301 (L.H)	22	27	2		
302 (T.R)	1	2	1		
303 (T.R)	1	2	1		
304 (T.R)	1	2	1		
305 (L.H)	6	9	2		
306 (L.H)	6	9	1		
307 (L.H)	6	8	2		
308 Internet lab	3	4	8	30	
309 S/W project lab	5	8	4	30	
310 (L.H)	6	8	2		
311 Project lab	6	8	4	30	
312 (L.H)	6	8	2		
313 (L.H)	6	8	1		
314 (T.R)	1	2	1		
315 (T.R)	1	2	1		
316 (T.R)	1	2	1		
317 (T.R)	1	2	1		

318 Hardware lab	5	8	1		
319 (T.R)	1	9	1		
320 (T.R)	1	2	1		
321 (T.R)	1	2	1		
322 (T.R)	1	2	1		
323 (T.R)	1	2	1		
324 (T.R)	1	2	1		
325 (T.R)	1	2	1		
326 Common room (boys)	6	9	1		
327 (L.H)	4	6	1		
328 (T.R)	1	2	1		
329 (T.R)	1	2	1		
330 (T.R)	1	2	1		
331 (T.R)	1	2	1		
332 Physics lab-1	6	8	2		
333 DBMS lab	6	8	2	30	
334 Dark room	6	8	4		
335 Linux lab	6	8	8	30	
336 Physics lab-2	6	8	4		
337 Thin client lab	6	8	4		
338 (L.H)	6	9	1		
339 Software lab	6	9	8	30	
340 (L.H)	6	9	2		
341 (T.R)	1	2	1		
342 (T.R)	1	2	1		
343 (T.R)	1	2	1		
344 (T.R)	1	2	1		
345 Server room	1	2	2		
Corridor	2	35			

Others (wash-rooms)	-	2*4			2*4
TOTAL	188*80 =15040 W	318*40 =12720 W	92*40 =3680 W	180*300 =54000	100 W

Total load of 2nd floor = 85.54 KW

Table 5: Energy Consumption of Each Floor

Name of Floor	Total Load (KW)	Energy Consumption per day (KWh)	Energy Consumption per month (KWh)
Ground	46.31	277.86	8335.8
1st	68.08	408.48	12254.4
2nd	85.54	513.24	15397.2

Total load of U.I.E.T (as calculated) = 199.93 ≈ 200 KW

Roof Area of U.I.E.T Block

Total Roof area=3400 m^2

IV. Energy Calculations

Table 6: Energy generated from U.I.E.T Block

Name of Block	Available Area (m^2)	Effective Area (m^2)	Average Peak Output (W/m^2)	Possible Plant Capacity (kW)	Energy Generated per day (kWh)	Energy Generated per month (kWh)
U.I.E.T	3400	2380	900	306	1836	55080

Effective area = $3400 \times 0.70 = 2380$ m^2

System Sizing

Grid connected PV system can be designed in various ways, like with battery, without battery, with or without transformer etc. Here without battery grid interconnected system is used, because of short life time, large replacement cost, and increased installation cost. From the results obtained, we find that a 306 KWp solar photovoltaic power plant can be developed on 2380 m^2 area. Corresponding system sizing and specifications are provided along with the system design. For the 306 KWp plant, required no. of PV modules = (306000 /180) = 1700. Now to form a solar photovoltaic power plant 1700 modules are connected in series-parallel combination.34 modules are connected in series and there are 50 parallel paths of 34 modules each. Now each module produces 24 Volts. So total 34 series connected module will produce $34 \times 24 = 816$ V. So there are fifty 816 Volts combinations are connected in parallel. Total output voltage from solar photovoltaic structure is = 816 Volts. This 816 Volts dc output from solar photovoltaic structure is the input of 3 phase inverter and it will convert the dc voltage into ac voltage. After the inverter a 3 phase transformer is connected, this will boost up/step down the ac voltage and feeds it to the grid.

SYSTEM SIZING & SPECIFICATIONS

The system sizing and specifications for the 306 KWp power plant unit is shown below:

Grid Specification

No. of Phases	3-φ
Voltage rating	400 Volts AC
Frequency	50 Hz.

Solar Photovoltaic Power Plant Specification

Plant Capacity	306 KW
Voltage Output	816 Volts dc
Current Output	375 A
No. of Modules	1700
Area	2380 m^2

PWM inverters are used here for suppressing the harmonics produced after DC to AC conversion. The calculation for finding the output voltage of inverter is shown below:
Phase voltage = Vph = 0.4714 × Vdc = 0.4714× 816 = 384.66 Volts.
Line voltage = V_L = 0.779 × Vdc = 0.779× 816 = 635.66 Volts.

Inverter Specification

KVA rating	330 KVA
Input DC voltage	816 Volts DC
Input dc current	375 A
Output AC voltage	384.66 Vac (phase voltage) 635.66 V ac (line voltage)
No. of Phases	3-φ
Type	PWM (for suppressing 3rd harmonics)
Efficiency	Almost 90-95%
Total harmonic distortion	< 5%

Transformer Specification

KVA rating	330 KVA
No of phases	3-φ
Frequency rating	50 Hz
Primary voltage rating	635.66 V
Secondary voltage rating	400 V
Primary current rating	519.14 A
Secondary current rating	825 A
Connections	Primary – delta (for suppressing3rd harmonics) Secondary – star 10 to 25 taps in secondary
Efficiency	Almost 95 %
Extra features	Air cooled

Solar Panel Specification

Watt	180 Watt
Voltage	24 Volts
Current	7.5 A
Type	Polycrystalline
Efficiency	14.3%
Temperature	25 deg c
Dimensions (mm)	1593 × 790 × 50 Area of single panel = 1258470 (mm) Area of single panel = 1.259 meter²
Tilt angle(slope) of PV Module	29°52´ and 30°12´ N
Mounting	Fixed Type

Others: Junction Boxes, Meters, Distribution Boxes, Wiring Materials, Mounting Materials etc.

V. CONCLUSIONS

Solar photovoltaic generation potential during the period Jan – Dec 2012 is assessed for Kurukshetra district of Haryana. It is found that the month of December produced the lowest solar radiation. With greater available area higher capacity plant can be set up. Moreover, the possible plant capacity has been estimated from the average output results available from the solar radiation readings of each month. No optimised approach has been carried out which can be taken up as a future scope of work. Maximum Power Point Tracking (MPPT) has not been employed for the calculation which could have produced better results. Had calculations been available for the months of May and June which offers the highest solar radiation, the result would have been far more accurate and yielded higher capacity plant. Relative comparison with the other districts of Haryana can be taken up for future studies. The methodology adopted seems satisfactory for determining the possible plant capacity for chosen area. The design described is based on the potential measured. System sizing and specifications are provided based on the design made. Environmental impact of this photovoltaic plant can be taken up as one the important issue in near future.

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