DESIGN AND ESTIMATION OF SOLAR PV SYSTEM FOR EDUCATIONAL CAMPUS

Panchal Kaushal Piyushkumar, Siddhant Shinde,Preyash Shah
Institute of Technology, Nirma University,Ahmedabad
kppanchal2805@gmail.com, shindesiddhant370@gmail.com, 15bee097@nirmauni.ac.in

I.

***Abstract*— This paper discusses the potential of implementing solar panels at rooftops of the blocks at Institute of Technology, Nirma University (ITNU) to harvest solar energy. The design is conducted using HelioScope simulation tool, specifying all the mechanical parameters and the electrical components used in the proposed PV system.The expected system power is estimated to be at least 2 times the campus energy demand and around 8% decrease in AC consumption due to shadowed rooftops.**

Keywords-component; Renewable Energy, PV system, Nirma University, HelioScope.

I.Introduction

In the present era oil has been the major conventional source for fulfilling the energy demands. Since the past few decades this conventional resources have been depleting substantially and are bound to get exhausted in upcoming decades. An excellent alternative which has been trending in recent years is renewable energy. India's target is to achieve 175 GW of renewable energy production by 2022[1]. The reliability of consumer based decentralized system yields more economic benefits and reliability compared to centralized system [2].Modern universities require huge amount of energy, which increases the energy bill of the institute.Ultimately, this increases the financial burden on the institution.

A major portion of India passes through the equator so it will be an added advantage of harvesting solar source of energy. According to Indian meteorological Department there are on an average 3020 sunny hours in Ahmedabad, Gujarat[3]. As shown in figure I, this abundance of sunshine in Ahmedabad makes harvesting of solar panels an ideal choice for power generation. Moreover the campus of Nirma University comprises of largish 115 acres. Grid connected and standalone are the two possible configurations for PV system. Grid connected system is more suitable for the problem under study due to availability of the grid in NU campus. In the forthput PV project the generation exceeds the demand. Different programmes are offered by university in different buildings. The estimated energy generation of the considered building is greater than the energy demand of the foresaid building ,hence excessive energy can be distributed to the other institutes This reduces the dependency of the university on the grid.

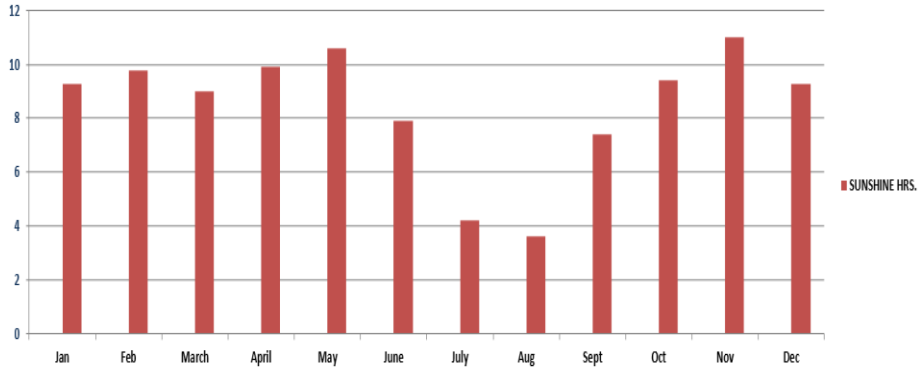

FIG.I Sunny hours in Ahmedabad

Moreover, there is an additional benefit of reduction on the loading of Air Conditioning in the classrooms of the top floor due to decrease in ambient temperature due to mounting of panels on rooftop.

II PV SYSTEM DESIGN

The description regarding the type of PV panels, inverters, conductors, combiners and the physical layout of each block of ITNU is given in this paper. The simulation and design software used for the estimation of generation of power in the forthput PV system using PV panel in this paper is helioscope[4], which yields accurate results.The ITNU consists of 7 blocks; A, B, C, D, K, PG, W. The total combined area of all the blocks is 225863.1 Ft^2 and available average radiation per day is 5.22 KWh/m^2/day[5]

A. Mechanical system design

Mechanical design of PV system includes calculations for the tilt angle, azimuth angle ,intrarow-spacing, physical dimension of the module,total number of modules and their power output for respective blocks.In the forthput PV system design the mechanical unit comprises of stating the tilt angle 10^o, azimuth is 180^o, intrarow-spacing is 2Ft. Table II shows the mechanical parameters.

TABLE I. MECHANICAL SYSTEM DESIGN PARAMETERS

BLOCKS	ORIENTATIONS	Modules	Module size	Total no. of cells	Power(KWh)
A	Horizantal	48	10*6	2880	288
B	Horizantal	39	10*6	2340	234
C	Horizantal	46	10*6	2760	276
D	Horizantal	36	10*6	2160	216
K	Horizantal	17	10*6	1020	102
PG	Horizantal	19	10*6	1140	114
W	Vertical	29	5*6	870	87

B.Electrical system design

In the forthput PV system, the electrical system design comprises calculation of the electrical parameters, i.e power rating of PV modules, inverters,connecting wires(strings), combiners. The forthput type of PV modules are 100W, 12V polycrystalline and inverters are 20KVA, 260V sukam hi-Cap colossal, 3-phase. String size is chosen as 10AWG (copper) with maximum 0.4% loss and various inputs combiners are used[6]. The simulation tool recommendstotal 234 PV modules for all the blocks, 57 inverters, 56-(4input combiners), 2-(3input and 1input combiners), 1-(2input combiners).Table III shows the electrical parameters.

TABLE II. ELECTRICAL SYSTEM DESIGN PARAMETERS

Blocks	4-input combiner	3-input combiner	2-input combiner	1-input combiner	Inverter	Strings
A	12	0	0	0	12	10 AWG Cu, 0.3%
B	9	1	0	0	10	10 AWG Cu, 0.4 %
C	11	0	1	0	12	10 AWG Cu, 0.3%
D	9	0	0	0	9	10 AWG Cu, 0.3%
K	4	0	0	1	5	10 AWG Cu, 0.3%
PG	4	1	0	0	5	10 AWG Cu, 0.3%
W	7	0	0	1	4	10 AWG Cu, 0.2 %

III RESULTS

This section discusses the results obtained for the proposed PV system.

As shown in table III the system metrics for the system is calculated under Standard Test Condition (STC). The temperature of the cell is 25。C, solar irradiance 1000W/m^2 and air mass is 1.5. The weather dataset is TMY, 10 km Grid, meteonorm.

TABLE III. RESULTS OBTAINED FOR THE SYSTEM

BLOCK	Annual production (MWH)	Performance ratio (%)	Kwh/Kwp	DC MODULE NAME PLATE (KWH)	AC MODULE NAME PLATE (KWH)	LOAD RATIO
A	445.8	75.1	1547.9	288	240	1.2
B	357.6	74.2	1528.1	234	200	1.17
C	427.8	75.2	1550.1	276	240	1.15
D	334.6	75.2	1548.9	216	180	1.2
K	158.5	75.4	1554	102	100	1.02
PG	176.7	75.2	1549.9	114	100	1.14
W	132.5	73.9	1522.6	87	80	1.09

As shownin figure II in the double bar graph of generation and demand[7]. The generation and demand keeps on fluctuating as per the change in months.

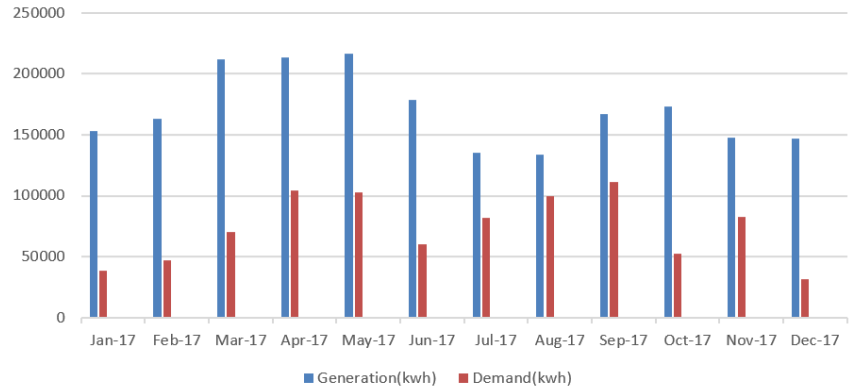

FIG.IIDouble bar graph of generation and demand

IV. SYSTEM LOSSES

System incorporates various types of losses as shown in table IV such as Inverters -2.1%, clipping-0%, wiring-0.3%, mismatch-4.4%, soiling-2%, irradiance-0.2%, reflection-3.2%, shading-3.7%.

TABLE IV. SYSTEM LOSSES

CONTRIBUTION OF DIFFERENT LOSSES	(%)
Inverters	2.1
Clipping	0
Wiring	0.3
Mismatch	4.4
Soiling	2
Irradiance	0.2
Reflection	3.2
Shading	3.7

V. REDUCTION IN AC CONSUMPTION

This section discusses the additional benefits of reduction in AC consumption at the topfloor classrooms due to shadowed terrace .There are air conditioners on the top most floor classrooms of the blocks of ITNU and as the PV panels are mounted on the rooftops it would cast shadows on the rooftops leading to decrease in ambient temperature of the top most floor by up to 3^{o}C of rooms which leads to the less operation of the air conditioners than under the roof without PV panels and hence there would be ultimately savings in consumption of power and electricity bill [8]. Figure III shows the temperature scenario for Ahmedabad[9].

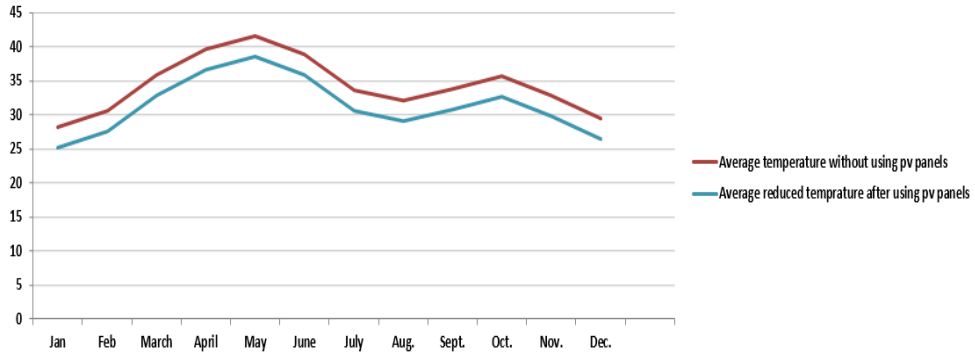

FIG. III Temperature scenario for Ahmedabad

The Air conditioner installed in all blocks are of 1.5 tonnes and of power rating 1500 watts.
There is 3% decrease in ambient temperature of room due to harvestation of solar panel.
For 1^{o}C there is 3% decrease in power consumption of Air condition.
For 1st degree 1500W x 0.03=45 W

So total decrease in consumption is 1500-45=1455W.

For 2nd degree 1455 W x 0.03=43.65W.
So total decrease in consumption is 1455-43.65=1411.35W.

For 3rd degree 1411.35W x 0.03 =42.34 W.
So total decrease in consumption is 1411.35-42.34=1369 W.

So, in total decrease in consumption per AC 1500-1369=131W
% Decrease in consumption is 131/1500=8.733%.

Considering 9 rupees rebate per unit we get
0.08733x1500x9=1.17 rupees rebate per AC per hour
Now, per room there are 6 AC. So, savings per room is of 1.17x6= Rs.7.02 per hour and as topmost floor of D- block comprises of 12 rooms. So total reduction in consumption per hour for D block is 12x7.02= Rs.84.24 per hour.

The duration of operation per day is 9hours. So, total rebate per day for D block is 84.24x9= Rs.758.16 per day.

Considering 25 working days on an average per month and 9 working months per year, the net annual saving can be calculated as 758.16x25x9= Rs.1,70,586 per year.

TABLE V ANNUAL SAVINGS PER BLOCK

	BLOCKS	NO.OF AC	ANNUAL SAVINGS (Rs.)
	A	9	21,323.25
	B	8	18,954
	C	16	37,908
	D	72	1,70,586
	K	14	33,169.50
Total	5	119	2,81,940.75

VI. CONCLUSION

The university offers various courses on renewable energy and resources. This project serves as facility for the budding students as source of erudition. Moreover, the university curriculum involves several industrial visits and this project can serve as a facility for learning. Moreover, there are many universities in fringes of Ahmedabad city .Also this project can serve as an instance for implementing in other universities. From the double bar graph demonstrated in the forthput project the generation is greater than demand and the excess amount of generated power can be distributed to other institutes of the university as well; thereby reducing the overall dependency of the university on grid, making this project as feasible and lucrative endeavour.

REFERENCES

[1] “Report of the Expert Group on 175GW RE by 2022”[Online].Available:http://niti.gov.in/writereaddata/files/writereaddata/files/document_publication/report-175-GW-RE.pdf
[2] “Renewables and Storage in Distribution Systems:Centralized vs. Decentralized Integration”[Online].Available:https://arxiv.org/pdf/1601.02315.pdf
[3] “Current Results”[Online].Available https://www.currentresults.com/Weather/India/annual-sunshine.php
[4] “Helioscope,”[Online].Available: https://www.helioscope.com/
[5] “NASA Surface meteorology and Solar energy” [Online].Available:https://eosweb.larc.nasa.gov/cgi-bin/sse/retscreen.cgi?&email=rets@nrcan.gc.ca&step=1&p=&lat=23.1296&submit=Submit&lon=72.54
[6]“Urjakart” [Online].Available:https://www.urjakart.com/
[7] Archives of NU substation.
[8]A. Dominguez, J. Kleissl, J. Luvall“Effect of solar photovoltaic panels on roof heat transfer” [Online].Available:https://www.sciencedirect.com/science/article/pii/S0038092X11002131.
[9]“Current Results”[Online]. Available:https://www.currentresults.com/Weather/India/average-india-weather.php