International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 06 | June-2018 www.irjet.net p-ISSN: 2395-0072

Design of Solar Rooftop Plant for JSSATEN

Aparupa Shenoy[1], Vishal Bhadauria[2], Sujay Singh[3], Rohit Kumar[4], Rajendra Gond[5]

Department of Civil Engineering, JSS Academy of Technical Education Noida , APJAKTU Lucknow, India

---

Abstract - *Solar Power a clean renewable resource with zero emission has tremendous potential of energy which can be harnessed using a variety of devices. With current developments, solar energy systems are easily available for industrial and domestic use with the added advantage of minimum maintenance. Solar energy could be made financially viable with government tax incentives and rebates. For designing we take JSSATEN College as our plant location .JSSATEN College is always using large amounts of energy. Consuming large energy in terms of electricity means our college is spending huge sum of money to power corporation every year. JSSATEN has many buildings having open roof which gives us fair chance to utilize it for implementing solar panels over there .Thus, by implementing rooftop solar power plant we can reduce the electricity consumption from the outside source .The purpose is to convert our college campus into clean green and smart campus under energy conservation by utilizing roof top solar power plant. With the help of software we calculate rooftop area of the buildings and consider for the designing. We can calculate total power generation after designing and compare with Electric consumption bill. Considering all the expenses and profits, at the end we are able to calculate the Payback Period of the project .We also consider the net metering .This step of our college is an excellent move towards sustainable energy conservation and will contribute to the progress of our nation.*

***Key Words*: Solar Energy, Payback period, Net Metering, Total Power Generation, Smart Campus, Photovoltaic.**

1. INTRODUCTION

The Sun is a reliable, non-polluting and inexhaustible source of energy. Since the beginning of life on earth, the energy that was received by all living forms was radiated from the sun. It is the time now when the mankind is on a standpoint to again depend and rely upon the sun as the main source of energy

With rapid rise in energy prices, concern over pollution, depletion of resources and environment degradation the awareness for limited resources around the world has increased dramatically. Use of fossil fuels which causes green house emissions, inefficient use of energy and release of harmful pollutants to the atmosphere causing threat such as acid rain must be addressed seriously in new buildings. Governments with vision have come to realise that generation of electrical power through non renewable sources of energy is not enough. The power of the future must be environmentally friendly as well.(George et.al, Vol-1 2016;Environment impact of Solar Energy Technology)

Photovoltaic is a way by which energy from the sun can be directly used for power generation. This method for electricity generation causes no environmental pollution, has no rotating or moving parts, and causes no material depletion . Photovoltaics are also multifunctional. It can generate and operate illuminations, pump water, operate any house hold equipments and appliances, can operate any electrical gadgets and communication equipment. The photovoltaic finds its wide application in village electrification in the developing countries and electricity production for the buildings, commercial areas and industrial sector in cities.(Parida et.al, Jan 2011; The Review of Photovoltaic Technology)

2. INSIGHTS FROM PREVIOUS STUDIES

Mehdi Hajian [1] explained solar energy can be exploited through the solar thermal and solar photovoltaic (PV) routes for various applications. He explored various method of using solar energy for number of purposes Power generated is not just relatively simpler but is also much more environmental friendly compared to power generation using non-renewable sources like the fossil fuels and coals.

Annie Meyer et.al [2] find that Stonehill College is currently building one of the U.S.A. 's largest college campus solar fields. It is a 2.7 MW field that will contain 9,000 solar PV. The solar field is expected to save about $185,000 a year on energy costs and account for 20% of the campus electrical usage. In addition, the carbon offset is ~521,702 lbs per year, which in turn equivalent to the amount of carbon 10,869 trees can absorb in a year or is the same as taking 46 Cars off the road for the year (Tree Facts, 2014; Greenhouse Gas, 2011).

S. Rodrigues et.al [3] explain the methodology to develop an application tool that is useful, flexible, and adaptable for providing technical support to decision making for the implementation of PV investments in the most suitable locations in full respect of other uses of the territory. It is basically a Portuguese case study to acess the lans suitability for a installation of solar farm.

Tanima Bhattacharya et.al [4] find the effects of temperature on PV module output performance were investigated.The ambient temperature has a positive correlation with the efficiency of the photovoltaic system which indicates that ambient temperature plays an important role in performance analysis. Also, there is a direct proportionality between the ambient temperature of the locality and efficiency of the PV system. They have concluded that the ambient temperature can be preferred for predicting the performance of photovoltaic module compared to wind speed for the present area of study.

Bhubaneswari Parida et.al [5] gives review of major solar PV technologies comprising of PV power generation, Hybrid PV generation, various light absorbing materials, performance and reliability of PV system, sizing, distribution and control is presented. The different applications of solar PV system such as desalination plant, building integrated system, space, solar home systems and pumps are also presented.

Andreas Poullikkas et.al [6] gives an overview of the net metering mechanism for renewable energy sources for power generation (RES-E) systems is carried out. In particular, the net metering concept is examined with its benefits and misconceptions. In the USA, any customer's net excess generation is credited to the customer's next electricity bill for a twelve month billing cycle at various rates or via a combination between rates.

Shruti Sharma et.al [7] reviewed a progressive development in the solar cell research from one generation to other, and discussed about their future trends and aspects. The article also tries to emphasize the various practices and methods to promote the benefits of solar energy. Technology based on nano-crystal QD of semiconductors based solar cell can theoretically convert more than 60% of the whole solar spectrum into electric power. However, their degradation over time is a serious concern.The main outcome of the article is the comparison of various PV panels.

B. Shiva Kumar & K. Sudhakar [8] did a performance study of 10 MW peak grid connected solar photovoltaic power plant installed at Ramagundam by NTPC was evaluated on annual basis. A peak power output of 10.34 MW and 40.83 kW of minimum power output were observed during the year round operation. Lowest total energy generation of 950.228MWh was observed in the month of July & Maximum total energy generation of 1511.003 MW h was observed in the month of January.

Roni George & Arun Ouseph Babu [9] deals with Environmental Impact Assesment of Solar Energy Technologies (SETs). SETs on the whole provide significant environmental benefits when compared to the conventional energy sources, contributing to the sustainable development.

3. MATERIALS AND METHODOLOGY

3.1 MATERIALS

3.1.1 CRYSTALLINE SOLAR CELLS

Most solar cells are made of a single crystal or multi-crystalline silicon material. Silicon ingots are made by the process of crystal growth, or by casting in specially designed furnaces. The ingots are then sliced into thin wafers. Single crystal wafers are usually 125 × 125 mm or larger sizes with "pseudo square "shape; multi-crystalline wafers are typically square-shaped with a dimension of 100 × 100 mm or larger. Using high temperature diffusion furnaces, Impurities like boron or phosphorous are introduced into the silicon wafers to form a p-n junction. The silicon wafers are thus converted into solar cells. When exposed to sunlight, acids are generated in each cell. Contact is attached to the top and bottom of each cell to enable inter-connections and drawing of the current

3.1.2 THIN-FILM SOLAR CELLS

Thin-film solar cells are made from amorphous silicon (a-Si), copper indium selenide / cadmium sulphide ($CuInSe_2$/ CdS) or cadmium telluride/cadmium sulphide (CdTe/CdS),by using thin-film deposition techniques. These technologies are at various stages of development and have not yet reached the maturity of crystalline silicon. Production of thin-film PV modules is also limited.

3.1.3 PV MODULE

PV modules are usually made from strings of crystalline silicon solar cells. These cells are made of extremely thin silicon wafers (about 300 um) and hence are extremely fragile. To protect the cells from damage, a string of cells is hermetically sealed between a layer of toughened glass and layers of ethyl vinyl acetate (EVA). An insulating tedlar sheet is placed beneath the EVA layers to give further protection to the cell string. An outer frame is attached to give strength to the module and to enable easy mounting on structures. A terminal box is attached to the back of a module; here, the two ends (positive and negative) of the solar string are welded or soldered to the terminals. This entire assembly constitutes a PV module. When the PV module is in use, the terminals are connected either directly to a load, or to another module to form an array. Single PV modules of capacities ranging from 10 Wp to 120 Wp can provide power for different loads. For large power applications, a PV array consisting of a number of modules connected in parallel and/or series is used.

Fig 1: Solar Photovoltaic Cell

3.2 METHODOLOGY

There are two methods for implementing solar energy.

i) Directly using PV or photovoltaic- it is the method of establishing solar power panels on the roofs thus, obtaining electricity directly from sun.

ii)Indirectly by CSP or concentrated solar power- this is actually an indirect method in which power is not obtained directly by sun and require various process to obtain electricity.

Due to requirement of more power, large area, poor running on cloudy days,high maintenance and construction cost in concentrated solar power we will not use CSP method. So, we use photovoltaic method.

3.2.1 CONSUMPTION ANALYSIS

Access to the various information from the college like electricity bill of each department of the college, electricity bill of the hostel, MPH, food court, ISH, library ,etc. i.e. area where we want to establish roof top solar panel.

So we take Electric Consumption bill for JSSATEN College for 2016-17

TABLE 1: Electric Consumption Bill of JSSATEN

SL. NO.	Bill Month	Unit(KWH)	Rates(Rs.)	Amount(Rs.)
1	June 2016	2,51,935	7.95	20,02,884
2	July 2016	1,94,979	7.95	15,50,078
3	August 2016	1,43,518	7.95	11,40,971
4	September 2016	1,94,209	7.95	15,43,967
5	October 2016	2,46,821	7.95	19,62,227
6	November 2016	2,00,373	7.95	15,92,967
7	December 2016	1,57,967	7.95	12,55,838
8	January 2017	1,57,504	7.95	12,52,161
9	February 2017	1,48,139	7.95	11,77,711
10	March 2017	1,66,654	7.95	13,24,900
11	April 2017	1,66,672	7.95	13,25,050
12	May 2017	1,87,788	7.95	14,92,920
Average	June 2016 to May 2017	1,84,713	7.95	14,68,472

3.2.2 SOFTWARE

Obtaining available utilizable roof top areas in campus with the help of software (GOOGLE MAPS)and visiting there.

3.2.3 TOTAL POWER GENERATION

To analyze the data from the solar panel, to calculate the total power generation by the pair of solar panels. By this data we can estimate the possible power generation

3.2.4 PAYBACK PERIOD

Considering all the expenses and profits, At the end we are able to calculate the *Payback Period* of the project.

We also consider *the Net Metering*[10].

3.2.4.1 NET METERING

For electric customers who generate their own electricity, net metering allows for the flow of electricity both to and from the customer – typically through a single, bi-directional meter. When a customer's generation exceeds the customer's use, electricity from the customer flows back to the grid, offsetting electricity consumed by the customer at a different time during the same billing cycle. In effect, the customer uses excess generation to offset electricity that the customer otherwise would have to purchase at the utility's full retail rate.

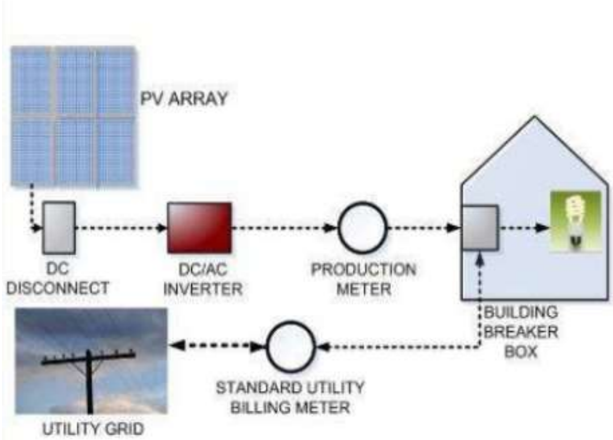

Fig. 2: Block Diagram of Net Metering

Advantages of net metering are Financial Credit for Extra Solar Power Produced , No Battery Storage System Needed , No Backup Generator for when Solar Power is Not Available , Seasonal Storage – Solar Power Produced in Summer Saves on Winter Costs , No Maintenance – Solar Power Without Hassles .

3.3 DESIGNING OF SOLAR ROOFTOP PLANT

3.3.1 INTRODUCTION

As per figure NOIDA(near New Delhi) comes in orange belt which is 5.8-6.0 KWH/sq.m./day gives us fare opportunity to implement rooftop solar power plant in our college. Location of college as per GOOGLE MAPS: JSS Academy of Technical Education , Noida (U.P. , India) 28.614425,77.358773 (Geographical Coordinates)

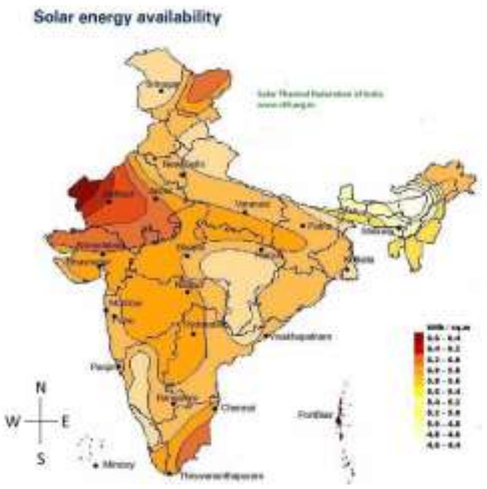

Fig. 3: Solar irradiance in INDIA

3.3.2. ROOFTOP AREA CONSIDERED

i. Total area of the college is 1,13,312 sq.m

ii. According to our requirement we have considered only Academic Blocks i.e. Academic Block-1, Academic Block -2, Academic Block -3, Academic Block -4& Academic Block -5 of JSS Academy of Technical Education , Noida .

Fig. 4 : Rooftop area calculated by Google Maps

Table 2 : Calculated Rooftop Area

BUILDING	ROOFTOP AREA (Sqm)
Academic Block -1	1694.05
Academic Block-2	1573.04
Academic Block-3	2133.69
Academic Block-4	671.41
Academic Block-5	5115.17
Total	11,186

3.3.3 CALCULATION

The global formula to estimate the electricity generated in output of a photovoltaic system is :

E = A * r * H * PR

E =Energy (kWh)

A =Total solar panel Area (m2)

r =solar panel yield or efficiency(%)

H =Annual average solar radiation on tilted panels (shadings not included)

PR = Performance ratio, coefficient for losses

r is the yield of the solar panel given by the ratio : electrical power (in kWp) of one solar panel divided by the area of one panel.

i. Total area of college = 11,186 sq.m

ii. Total area covered by panels = 5,867 sq.m (52.45%)

iii. Area of one 1kw solar panel = 8 sq m (Source- http://solarcalculator.co.in)

iv. Total no. Of panels required = 550

v. Thus, 550 panels of 1kw rating with 75% area efficiency cover 5,867 sq.m

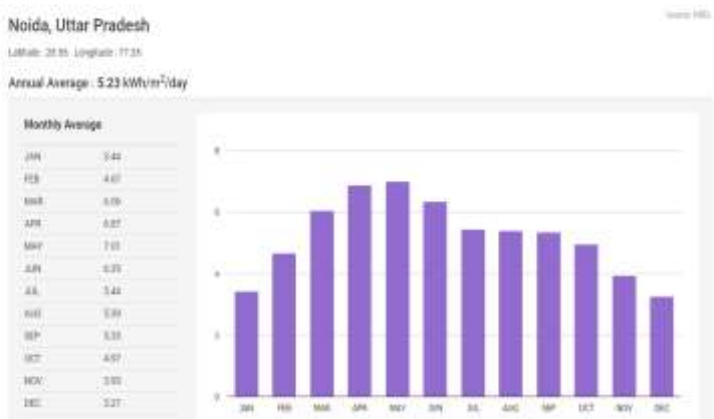

Fig.- 4 Solar Radiation in Noida (National Renewable Energy Laboratory, U.S.A)

3.3.4. PANEL DISTRIBUTION

Table 3 : Panel Distribution

Blocks	No. of panels (1 KW)	Power generation (KWh)
ADMINISTRATIVE BLOCK 1	83	10,707
ADMINISTRATIVE BLOCK 2	77	9,933
ADMINISTRATIVE BLOCK 3	105	13,545
ADMINISTRATIVE BLOCK 4	33	4,257
ADMINISTRATIVE BLOCK 5	252	32,508
TOTAL	550	71,995

Sample Calculation For January

Irradiation = 3.44

Annual average irradiance in Noida = 5.23 KWh/sqm [12]

Annual average production of 1kw panel = 4.3KWh [13]

Thus, Efficiency of panel = 82% [4.3/5.23]

Therefore,

Production of electricity = panel rating * efficiency * irradiation * no. Of panels * no. Of days

Production of electricity = 1 * .82 *3.44 * 550 * 31 = 48,558.4 units

consumption of electricity in January = 1,57,504 units.

SAVINGS = units produced * charge per unit = 48558.4 * 7.95

= Rs. 3,86,039.28

Table 4 : Electricity production by solar plant

MONTH	ELECTRIC BILL UNITS	IRRADIATION*82% (4.3/5.23 =.82)	PRODUCTION BY SOLAR	SAVINGS In Rupees
JANUARY 2017	1,57,504	2.848	48,558.4	3,86,039
FEBRUARY 2017	1,48,139	3.866	59,536.4	4,73,314
MARCH 2017	1,66,654	4.980	84,909.0	6,75.026
APRIL 2017	1,66,672	5.650	93,225.0	7,41,138
MAY 2017	1,87,788	5.760	98,208.0	7,80,753
JUNE 2016	2,51,935	5.220	86,130.0	6,84,733
JULY 2016	1,94,979	4.470	76,213.5	6,05,897
AUGUST 2016	1,43,518	4.430	75,531.5	6,00,475
SEPTEMBER 2016	1,94,209	4.400	72,600.0	5,77,170
OCTOBER 2016	2,46,821	4.100	69,905.0	5,55,744
NOVEMBER 2016	2,00,313	3.230	53,295.0	4,23,695
DECEMBER 2016	1,57,967	2.688	45,830.4	3,64,351
AVERAGE	1,70,819	4.3	71,995.4	5,72,362

4. COST ESTIMATION

4.1. COST OF PANEL

According to guidelines of Ministry of New and Renewable Energy (Govt. Of India)

1KW Solar Panel Available At Rs. 42000 (with 30% subsidy on Rs. 60000).

Cost of panels= no. of panels*cost of 1 panel

No. of panels= 550

Cost of 1 panel= Rs.42,000

Cost of panels = 550*42,000

= Rs.2,31,00,000

4.2. TOTAL COST

It includes

i) Cost of Panel

ii) Installation Cost

iii) Electrical equipments and wires

Total Panel - 550

Table 5 : Cost Estimation

Components	Percentage of total cost	Amount in Rs.
PV modules (poly-crystalline)	52%	2,31,00,000
Inverters	23%	1,02,17,300
Balance of system (plugins, cables,etc.)	17%	75,51,900
Installation charges	8%	35,53,900
TOTAL	100%	4,44,23,100

According to *Ministry of New and Renewable Energy*- Benchmark cost of systems with 5 year warranty for all components (inverters , switchgears ,etc.) other than PV module.

PV module are warranted for 90% of output at the end of 10 years.

It came down to atleast 80% of output at the end of 25 years.

4.3. PAYBACK PERIOD

Considering efficiency of panel to be reduced at a constant rate of 1% each year till first 10 years.

Total amount to be spent in installing rooftop solar pant is Rs. 4,44,23,100 in a single lumpsum amount

Total amount saved annually when operational is Rs. 68,68,000 (From Table- 4)

Let the payback period be N

Now, according to the definition of Payback Period-

Investment = savings each year * depreciation 4,44,23,100 = 68,68,000*(99+98+97+……..)/100=(N(198+(N-1)(-1))/200 = 6.468

=N*(199-N) = 1293.6

On solving above equation we get,

=N = 6.7 years

which is approx 7 years equal to Payback Period

Note- Here, we have not considered the maintenance cost of plant as it comes out to be very small as compared to the size of project. Thus, considered negligible. And the major defects in equipments if might occurs shall covered under warranty thus, the maintenance cost will be very small and that is why it is neglected.

Here, we have not considered Tax Benefit in above calculation. Doing so, will reduce the Payback period depending upon the Tax rates as per latest Financial & Taxation Rules.

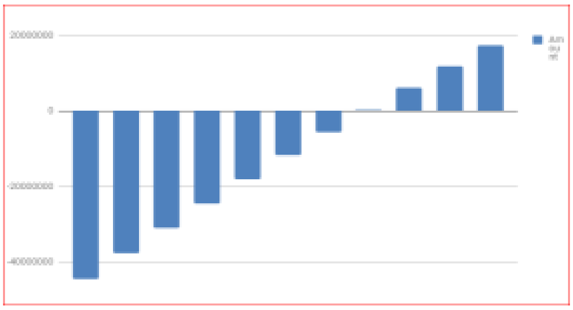

Fig. 5 : Payback period representation

5. CONCLUSION

- By this project we convert our campus into smart campus.
- By this project we can make our college energy efficient.
- By this project we can contribute to the Initiative of Government of India
- Also we can minimize the electricity bill of the campus.
- Make environment more healthy.
- According to MNRE (Govt. of India) for 550 KW solar plant
  - Carbon dioxide emissions mitigated is 15560 tonnes.
  - This installation will be equivalent to planting 24895 Teak trees over the life time.
- We can save about Rs. 68 lac per year in initial working years of plant which can useful to get the amount we invested in our plant.

On an average we can save 71,995.4 units per month .

REFERENCES

[1]Mehdi Hajian, " Various Aspects of Solar Energy Utilization: Review", International Journal of Advanced Science and Technology Vol.58, (2013), pp.41-50 http://dx.doi.org/10.14257/ijast.2013.58.04

[2]Annie Meyer, "A case study- solar pannel at boston college", Boston College Environmental Studies Senior Seminar, published on 1 APRIL 2014.

[3]Sara Rodrigues el al, "Suitability Analysis of Solar Photovoltaic farms: A Portuguese Case Study", International Journal Of Renewable Energy Research S. Rodrigues et al., Vol.7, No.1, 2017

[4]Tanima Bhattacharya el al, "Effects of Ambient Temperature and Wind Speed on Performance of Monocrystalline Solar Photovoltaic Module in Tripura, India", Hindawi Publishing Corporation Journal of Solar Energy Volume 2014, Article ID 817078, 5 pages, http://dx.doi.org/10.1155/2014/817078

[5]Bhubaneswari Parida el al, "Renewable and Sustainable Energy Reviews", Renewable and Sustainable Energy Reviews 15 (2011) 1625–1636, published on 12 january 2011.

[6]Andreas Poullikkas el al, "A review of net metering mechanism for electricity renewable energy sources", International journal of energy and environment, Volume 4, Issue 6, 2013 pp.975-1002,Journal homepage: www.ijee.ieeFoundation.org

[7]Shruti Sharma el al, "Various Aspects of Solar Energy Utilization: Review", International Journal of Advanced Science and Technology Vol.58, (2013),00 pp.41-50, published on December 2015.

[8] B.Shiva kumar & K.Sudhakar " Performance evaluation of 10 MW grid connected SPV Power Plant at NTPC" 4 dec 2015 Elsevier Publications

[9]Roni George ,Arun Ouseph Babu, "Environmental Impacts Of Solar Energy Technologies", Imperial International Journal of Eco-Friendly Technologies, Volume-1,Issue-1 2016,pp-75-79

[10]Akshay Kumar Sahoo el al, "Exploring the impact of net metering with hybrid solar-wind-grid based distribution generation", International Reasearch Journal of Engg. And Technology, Volume-03, published on 5 MAY 2017

[11]Abhinav malhotra,"solar energy plant to power iit kanpur", the times of india,article 27 march 2014(https:// aruna kumarankandath "modi government sets revised timesofindia.indiatimes.com/city/kanpur/Solar-energy-plant-to-power-IIT-Kanpur/articleshow/32768937.cms http://indiatoday.intoday.in/education/story/solar-panels-in-educational-institutions/1/658717.html)

[12]Google maps application(https://googlemaps.co.in)

[13]Ministry of New and Renewable Energy(Government of India)