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Experimental analysis of rooftop solar PV modules installation in educational premises

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ABSTRACT

Photovoltaic module solar energy is a renewable source of energy that uses solar radiation to produce electricity. It is worked on the so-called photoelectric effect, by which semiconductor materials are able to absorb photons (light particles) and release electrons, generating an electric current in form of Direct Current. Which then converted into Alternative current with the help of alternator. There is notable research is going on to use various Straight PV Modules and their types of System on the basis of their operation as alternative of electricity. Solar power systems derive clean, pure energy from the sun. Traditional electricity is sourced from fossil fuels such as coal and natural gas. Installing solar panels on home, Educational Institute and open spaces helps combat greenhouse gas emissions and reduces our collective dependence on fossil fuel. In present assessment Installation of roof top solar PV modules for reducing Electricity bill by using On-grid power system by net metering. Here energy generated by this solar pv module solar plant is transmitted to the electricity power grid and on compensation from electricity board Electricity bill reduces to minimum or extra arears provided to consumer. In traditional way to production of electricity fossil fuels is used which continues to rise producing high levels of carbon dioxide (CO2) which climatologists believe is a major cause of global warming. Similarly, electricity from various Electricity Boards and manufactures hikes their prices by day by day which is affect the unbalanced in the cost and profits of the individuals and its show the impact on social economic life of the persons. Whereas solar energy which is get from Sun is in bulk and its cost nothing. Initial Cost and maintenance cost is low as compare to other source energy.

Keywords— *Net metering, On-Grid System, PV Module, Solar energy*

1. INTRODUCTION

The installation of on-grid solar plant serves several advantages in commercial complexes, educational institutions whereas off-grid solar installations have been proved successful in remote areas.

Alamuri Ratnamala Institute of Engineering, Shahapur spread over a geographical belt of 12.5 acres has single educational institutions of which the connected load is 52 KW. The institute receives electricity from an express feeder at 11 kV through a step-down transformer 11 kV/0.44 kV, 200 kVA. The annual electricity consumption is approximately 1,80,000 kWh (average monthly consumption 15,000 kWh) which costs around Rs. 22 lacs annually. The energy charges were Rs. 10.8 (August 2015). The cost of energy generation using solar was Rs. 6.4. This has necessitated bringing down the electricity consumption from the grid and extract as much as possible from the solar installation. Since the installation was grid connected, it saved quite a large expenditure which would have been otherwise spent on energy storage using batteries and its maintenance. The planning of rooftop solar installation needs careful study of the site information, plant architecture, layout, structural analysis and its economic benefits. The institute is situated in Sapgaon area with latitude: 19.45 N, Longitude: 73.35 E, Altitude: 46 m (151 feet). The annual average wind speed is 3.98 meter per second (source: www.synergyenviron.com). Annual average solar radiation is 5.5 kWh/m2/day. Though the area is surrounded by industrial belt but is has no such problem of fumes, smoke, dust etc. This has necessitated to go for solar PV plant as the maintenance would be minimum. The initial survey was performed by the author on all buildings T1 and T2, after careful survey of all the buildings, structural analysis and feasibility study, finally T1 buildings were selected for rooftop installation. The average shadow free space requirement for solar installation in 12 m2/kW. Thus, the rooftop requirement for a 20-kW solar PV plant is approximately 240 m2. The area is estimated considering the sufficient space between the solar panels between the row arrays for maintenance purpose. The panels have been installed with a tilt angle of 17° on the buildings. The inverters were installed on fourth floor of T1 building which was easily accessible.

2. METHODOLOGY

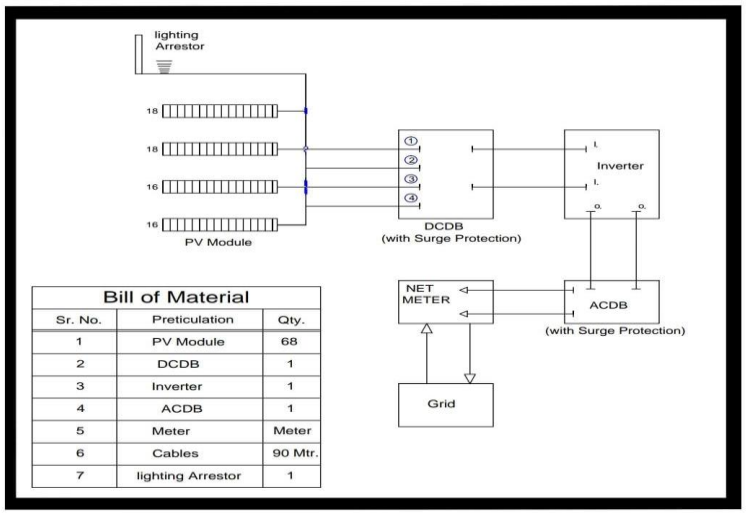
2.1 Selection of location and site

Site is selected on the basis of

1. amount of radiant solar energy,
2. which is quite away from polluted environment.
3. Which is accessible in transportation.
4. near to power grid

2.2 Designing of solar PV module Solar Power Plant

As per requirement and utilization designing of Solar PV module solar power plant is designed.
The required space is considered before installation.



Bill of Material

Sr. No.	Preticulation	Qty.
1	PV Module	68
2	DCDB	1
3	Inverter	1
4	ACDB	1
5	Meter	Meter
6	Cables	90 Mtr.
7	lighting Arrestor	1

Fig. Designing of 20KW solar PV module power plant

2.3 The Installation OF SOLAR PV Plant Process in 7 Steps

2.3.1 Erecting the scaffolding

The first step in the process in the installation of PV module roof top is to erect the scaffolding. In this civil operation of building structure will ensure safety for the installation team when they are on the roof

2.2.2 Attaching Roof Anchors

After the scaffolding is set, the installation is done by attaching the roof anchors, which will hold the base for the solar panels. The types of anchors used depends on the type of roof tile fitted on the roof.

2.2.3 Attaching the Frame

The next step is to attach the frame, which is made up of aluminum bars. The bars must be fitted in a straight direction and parallel to one another.

Fig. 1 Attaching the Frame

2.2.4 Installing the Panels

Once the frame has been attached, the installation of the solar panels themselves can begin. The panels are clamped to the aluminum frame, but initially not too tight so as to permit adjusting on the frame. Once they are set up at the desired position, these will be firmly anchored.

Fig. 2 Installing the panels and wiring

2.2.5 Wiring the Solar Panels

Now that the panels are fastened securely on the frame, the next step is to wire them. In most of the cases the panels come wired from the manufacturer, however, these need to be connected to the inverter, which would typically be in the attic of the household. The inverter is a component of the panel system which converts absorbed energy from the panels into AC electricity, which can be used by the household appliances. Be prepared to replace your solar PV inverter every 5-10 years, as these machines tend to have shorter lifespans than solar panels.

2.2.6 Final Connections to the Consumer Unit

After the panels are wired to the inverter, the final connections to the consumer unit will be made. A generation meter will also be connected, whose purpose is to monitor how much electricity the solar panels actually produce. During the time of the wiring installation, the electricity supply to the household will need to be shut off.

2.2.7 Testing the Solar panels

After the wiring is set up to the inverter, together with the generation meter, the installation is nearly finished. Now the only thing left is to switch the power on and test the system. Once this is complete, the installation is officially over and the system can start working.

Pre-Data collection

Date	Time	Temperature (^{o} C)	Irradiation (Kwh/m^2/Day)	Wind Speed (Km/hr)
15-03-2018	08.00 AM	27.1	3.2	4.2
	10.00 AM	29.2	3.8	3.9
	12.30 PM	30.8	4.6	3.6
	02.30 PM	32.4	4.8	3.6
	06.00 PM	29.7	4.4	4.1
22-03-2018	08.00 AM	27.4	3.1	3.0
	10.00 AM	29.5	3.9	3.0
	12.30 PM	31.8	3.8	2.9
	02.30 PM	32.7	5.2	3.4
	06.00 PM	29.9	4.8	4.0
30-03-2018	08.00 AM	28.4	3.1	2.9
	10.00 AM	32.5	5.0	3.4
	12.30 PM	36.7	5.4	4.0
	02.30 PM	38.8	5.5	4.0
	06.00 PM	34.2	4.8	4.2
06-04-2018	08.00 AM	28.7	3.2	3.4
	10.00 AM	30.2	3.7	4.0
	12.30 PM	32.8	3.8	4.0
	02.30 PM	33.9	5.2	4.2
	06.00 PM	28.4	3.8	4.4
13-04-2018	08.00 AM	27.9	3.2	2.9
	10.00 AM	30.8	3.6	3.4
	12.30 PM	32.1	5.1	4.0
	02.30 PM	33.2	5.2	4.0
	06.00 PM	28.4	4.1	4.2
20-04-2018	08.00 AM	27.7	3.1	3.2
	10.00 AM	28.9	3.5	4.0
	12.30 PM	30.8	4.9	4.0
	02.30 PM	32.9	5.2	4.2
	06.00 PM	29.4	3.9	4.4

3. MODELING AND ANALYSIS

3.1 Photovoltaic modules inclination angel design

The best inclination angel of the photovoltaic power systems varies considerably. If the most electric generation production in winter is required, the inclination angel of the photovoltaic panels should be larger than the latitude degree. If it needs the most electric generation production in summer to supply some loads like air conditions, the inclination angel of the photovoltaic panels should be smaller than the latitude degree.

Tilt Angle = (Latitude X 0.9)
= (19.45 x 0.9)
= 17.50 degree

3.2 Solar PV System Design

A solar PV system design can be done in four steps:

- Load estimation
- Estimation of number of PV panels
- Estimation of battery bank

- Cost estimation of the system.

3.3 Solar Panel Calculation

The number of solar panels that can source the current required to charging the battery.
Where,
Ipv, photovoltaic current = total current required to charge the battery from the solar panel
Ei= input energy to the inverter
V = system voltage = 12V
H = peak sunshine hour, the average number of hours the solar energy can be captured.
H = 5hrs.

Thus

$$Ipv= 4395.06/ (12 \times 5) = 73.25 \text{Amperes.}$$

In order to compensate for the losses due to the inefficiency of the solar panel, 20% of Ipvis added so that:

$$Ipv= 73.25 + (0.2 \times 73.25) = 87.9A.$$

With a solar panel of the above rating, the peak or open circuit voltage,

$$VP = 230 \text{ V Peak power,}$$

$$\text{Total Capacity} = Ipv \times VP = 87.9A \times 230V = 20677W$$

20 W SOLAR PV SYSTEM CALCULATIONS

Numbers of units consumed per months = 2400 Units

Numbers of units consumed per day = 2400/30 = 80 Units
1 Unit = 1 KW = 1000W
So, 80 units = 8 KW = 8000 W

System to be installed = Units consumed per day/4 = 80/4 =20 = 20 KW = 20000 W

Number of Panels to be used of 300 W each = 20000/300 = 66.67 = 68 panels

Thus, the number of solar panels required is approximately 68 panels.

Cost of System installation = 20 KW × ₹42991/- = ₹ 8,59,832/-

Power generation =20KW×4hr/day×300days/yrs. = 24000Units/yrs.

Cost Without solar = 24000Unit/yrs. × ₹ 10.63 / units = ₹ 2,25,677

Returns of Investment (ROI) = Total Cost of System/Total Cost without solar
= ₹ 8.59,832/₹ 2,25,677 = 3.81 = 3 year 8 months.

1) Unit Cost of Electricity = (Annualised Capital Cost + Annual Cost of Maintenance and Operation) ÷ Annual Amount of Electricity Produced

Annualized Capital Cost = Capital Cost + Capital Recovery Factor

$$\text{Capital Recovery Factor} = [\{d(1+d)^{25}\} / \{(1+d)^{25}-1\}]$$

$$\text{Unit Cost} = [8, 59,832 \times \{0.125(1+0.125)/(1+0.125)^{25}-1\}+1] / (20KW \times 4 \times 300)]$$
$$= 2, 17,056 / 24,000$$
$$= 7.98 \text{ Rs / Unit}$$

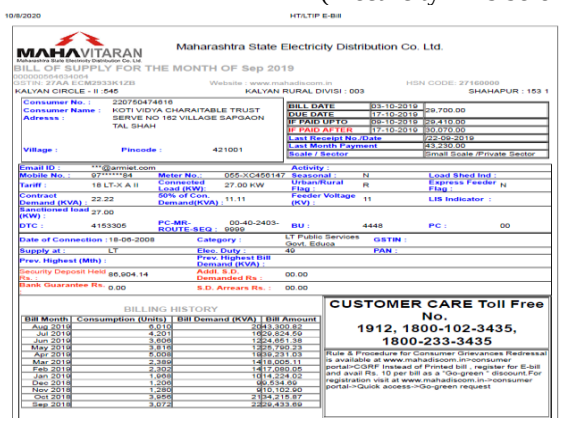
2) Simple Pay Back = [Capital Cost (Co) / (Benefits-AMC)]

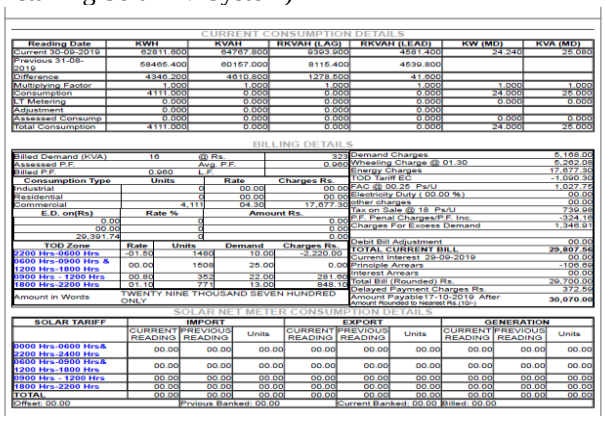
$$\text{Simple Pay Back} = Tsp = 8, 59,832 / (20 \times 4 \times 300)-(0.0125 \times 8, 59,832) \times (8)$$
$$= 8, 59,832 / 2,26,271$$
$$= 3.8 \text{ Years}$$

4. RESULTS AND DISCUSSION

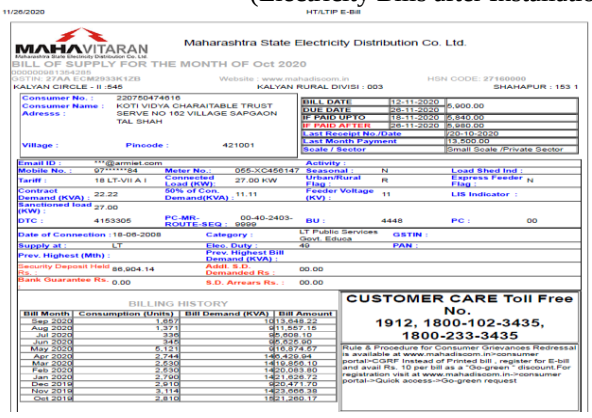
On the basis experimental Analysis and Electricity bills of MAHADISCOM its clear evidence that bills of electricity is reduces and the objects of the project is completed.
Following Results are carried out on the basis of various calculations drawn:
1) Tilt Angle of Solar Pv Panel is 17 degrees.
2) For Production of 20 KW Electricity generations 68 Panels requires.
3) Unit Cost of electricity per Unit is 7.98 Rs
4) Simple Pay Back period for project is 3.8 Year i.e., approximately 4 years.

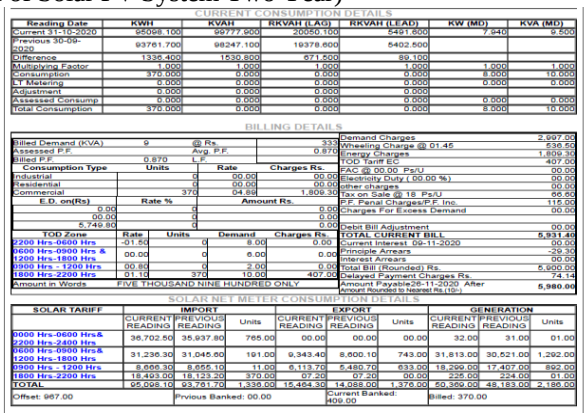
(Electricity Bills before Installing Solar PV System)





(Electricity Bills after Installation of Solar PV System Two Year)





5. CONCLUSION

The installation of 20 kW solar power generation plant at Alamuri Ratnamala Institute of Engineering, Shahapur not only provides a self-sustaining way of producing power from renewable energy source (i.e. sun) but also provides economic benefits. From the bill assessment, it was found that the energy demand as well as the energy charges decreased after the installation of solar panel. There is a considerable amount of savings and the payback period has been estimated to be about 6-7 years. Net metering enables the user to sell the excess energy back to the utility grid. Thus the installation of such a renewable power generation plant not only helps in achieving economic benefits but also reduces impact on the environment by reducing pollution, and implications due to climate change. The energy generated through solar system, its utilization for local load and feeding back to the grid is recorded by net metering (bidirectional) installed by the utility after careful assessment of protection system and ensuring that no part of the utility is affected by the solar generation. In case of any fault within the solar system, it has to be disconnected from the main bus so as to prevent any harmful effects to the utility. Installation of such plants not only benefits the consumer but also augments the solar generation of the nation. It thus benefits both utility in terms of solar power capacity addition and the consumer with reduced energy charges

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