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Design of an On-grid Photovoltaic system

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Abstract: The exhaustion of conventional resources and its effect on climate requires an urgent call for the substitute power resources to convene up the current power requirement. Solar energy is an endless, unsoiled and prospective energy source among all other nonconventional energy options. As more concentration is being done on focal point for the development of Renewable energy capital globally. To ascertain their viability, it is necessary to do the economic and technical assessments of these resources. This paper presents designing aspects and assessments of solar PV system based on field and actual performance. The study is based on design of solar PV system and a case study based on Panel Sizing & cost analysis of 20 kW off-Grid photovoltaic energy system.

***Index Terms* - Solar Panel, Solar Panel Calculation, Photovoltaic, Basics of Solar, Solar Calculator**

I. INTRODUCTION

Photovoltaic is a technology that reliably converts solar radiation into electricity. There are different types of modules depending on power ratings. Every module has a number of solar cells. Solar cells are fabricated by means of semiconductors such as silicon. Photovoltaic cells generate electricity in clean and reliable manner which is the prime concern for today's environment. Variation in temperature affects the efficiency of solar module greatly.

Due to these variations this technology faces enormous challenges in its power quality performance. Solar photovoltaic standalone systems have better power quality as compared to grid integrated systems. In standalone systems batteries connected with MPPT charge controller tolerates all fluctuations of temperature and radiation associated with environment.

In this paper, 20kW PV system is designed for 5th floor of engineering building. This is small roof top system and its performance based on cost analysis has evaluated using PVsyst software. PV system software uses the information of total load to calculate generated power, used power and unused power.

The PV system has different categories such as On Grid system, Off Grid system and Hybrid system. These use to save the energy and reduction of electricity bill.

1. PV Technology:

The basic unit of a photovoltaic system is the photovoltaic cell. Photovoltaic (PV) cells are made of at least two layers of semiconducting material, usually silicon, doped with special additives. One layer has a positive charge, the other negative. Light falling on the cell creates an electric field across the layers, causing electricity to flow. The intensity of the light determines the amount of electrical power each cell generates.

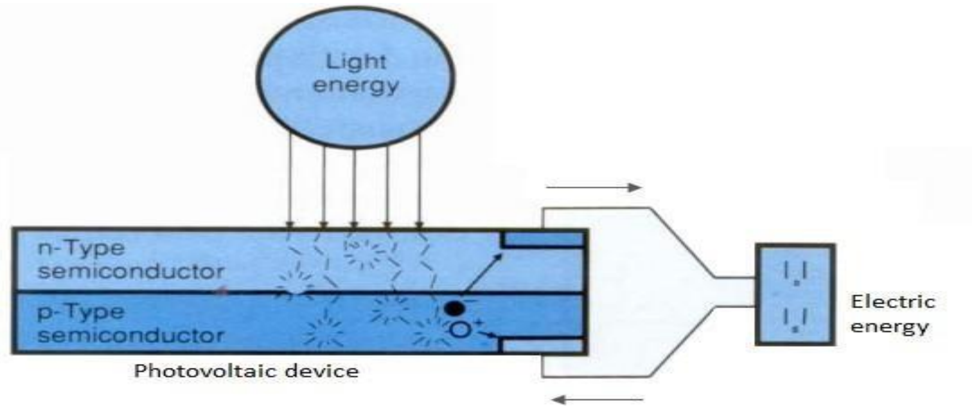


Figure no 1: PV Process

2. Solar Cell:

The solar cell is the basic unit of a PV system. A typical silicon solar cell produces only about 0.5 volt, so multiple cells are connected in series to form larger units called PV modules. Thin sheets of EVA (Ethyl Vinyl Acetate) or PVB (Polyvinyl Butyral) are used to bind cells together and to provide weather protection. The modules are normally enclosed between a transparent cover (usually glass) and a weatherproof backing sheet (typically made from a thin polymer or glass). Modules can be framed for extra mechanical strength and durability.

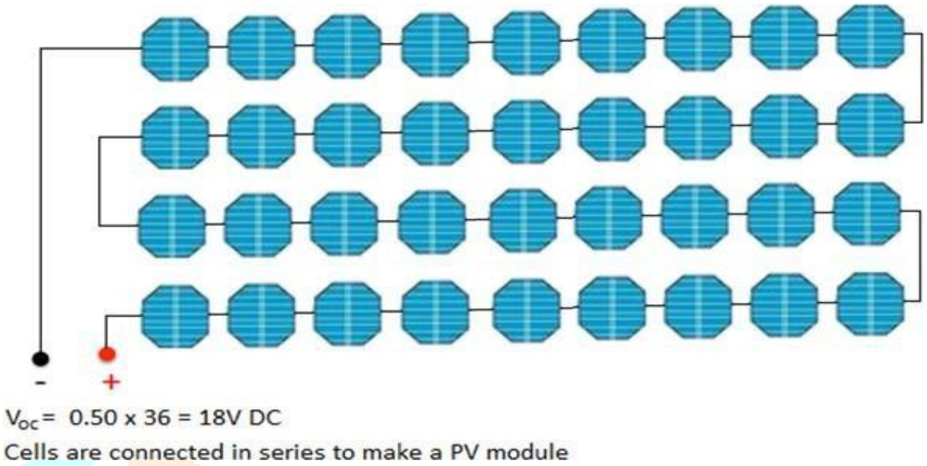


Figure no 2: Solar cell

3. PV Array:

The power that one module can produce is seldom enough to meet requirements of a home or a business, so the modules are linked together to form an array. Most PV arrays use an inverter to convert the

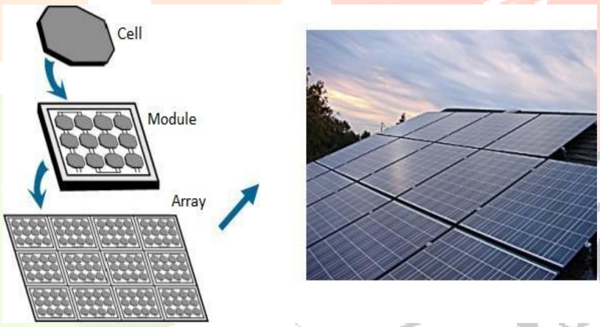


Figure 3: PV array

DC power produced by the modules into alternating current that can plug into the existing infrastructure to power lights, motors, and other loads. The modules in a PV array are usually first connected in series to obtain the desired voltage; the individual strings are then connected in parallel to allow the system to produce more current. Solar arrays are typically measured by the electrical power they produce, in watts, kilowatts, or even megawatts.

4. PV Types:

The three general types of photovoltaic cells made from silicon are:

a. Mono-crystalline Silicon – also known as single-crystal silicon
b. Poly-crystalline Silicon – also known as multi-crystal silicon
c. Thin Film Silicon.

5. Conversion Efficiencies of Various PV Module Technologies:

PV type	Description (Color and texture)	Module efficiency	Surface area for 1kWp system (m^2)
Monocrystalline (m-Si)	Blue, grey, black, high light absorption	14-19%	7
Polycrystalline (p-Si)	Bright bluishspeckled tone	12-15%	9
Thin film Amorphous silicon	Reddish-black, very flexible/durable	6-8%	17

6. Photovoltaic I-V Characteristics Curves*:*

Manufacturers of the photovoltaic solar cells produce current-voltage (I-V) curves, which gives the current and voltage at which the photovoltaic cell generates the maximum power output and are based on the cell being under standard conditionsof sunlight and temperature with no shading.

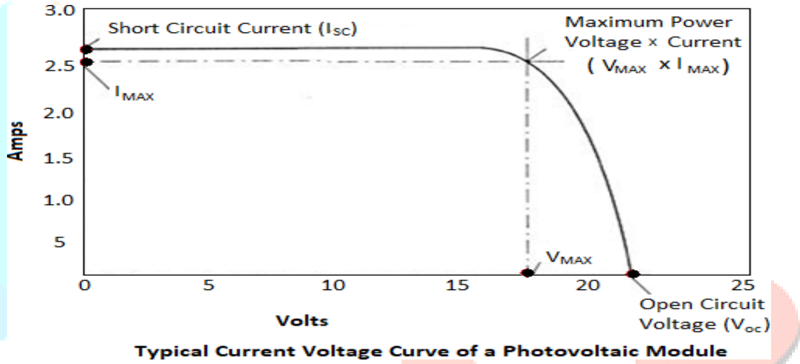


Figure No 4

Voltage (V) is plotted along the horizontal axis while Current (I) is plotted along thevertical axis. The available power (W) from the PV, at any point of the curve, is the product ofcurrent and voltage at that point.

7. PV Module Output

For a specific load, PV module output depends on two major factors:

a. Irradiance or light intensity
b. Temperature

8. Solar Intensity:

The amount of sunlight falling onto the face of the PV cell affects its output. The more sunlight entering the cell, the more current it produces. The voltage will remain the same. Figure below shows that under different test conditions, when day light is 1000 W/m^2 v/s 600W/m^2, the power out from the PV module varies in proportion.

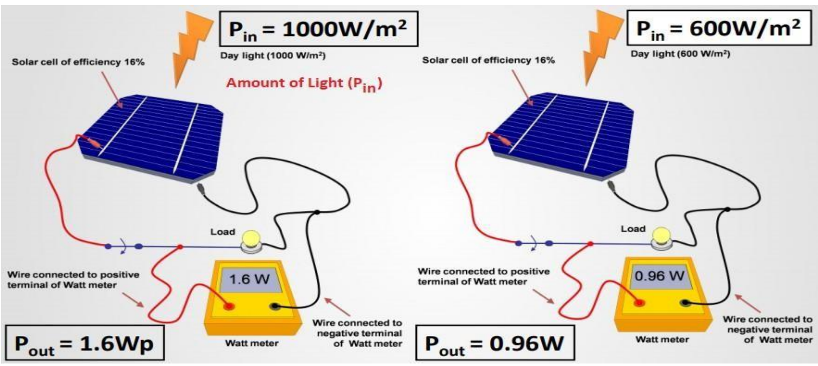


Figure No 5:

Dirt and dust can accumulate on the solar module surface, blocking some of the sunlight and reducing output. Although, rigorous maintenance will clean off the dirt and dust regularly, it is more realistic to estimate system output considering the reduction due to dust buildup in the dry season. A typical annual dust reduction factor to use is 93% or 0.93. So, the –100- watt module operating with some accumulated dust may operate on average at about 79 Watts (85 Watts x 0.93 = 79 Watts).

9. Temperature:

PV cell performance declines at higher cell temperatures. The operating voltage drops with increasing cell temperature. So, in full sun the output voltage reduces by about 5% for every 25°C increase in cell temperature. Then photovoltaic panels with more solar cells are recommended for very hot climates than would be used in colder ones in order to offset power output losses due to high temperatures.
Most thin film technologies have a lower negative temperature coefficient compared to crystalline technologies. In other words, they tend to lose less of their rated capacity as temperature rises. Refer graphical representation below: As the temperature of a solar cell increases, the open circuit voltage Voc decreases but the short circuit current Isc increases marginally.

10. Calculation:

A. Connected Load:

Fifth Floor of Engineering Building												
Sr No.	Room Space	No. of Room	Fan	Fan Wattage	Tubelight	Tube Wattage	Other Equipments	Other Wattage	Total Wattages	Total Wattages	Working Hr.	Watt Hr.
1	Classroom	19	4	75	6	20			420	7980	6	47880
2	Staffroom	2	6	75	9	20			630	1260	8	10080
3	Washroom	8		75	1	20			20	160	8	1280
4	HoD Office	2	2	75	3	20			210	420	4	1680
5	Corridor	1		75	30	20			600	600	8	4800
6	Computer Room	1	4	75	6	20			420	420	4	1680
7	Camera's	1					5	5	25	25	24	600
8	Machine Lab	1	12	75	18	20			1260	1260	4	5040
								Total		12125		73040

Table no 2

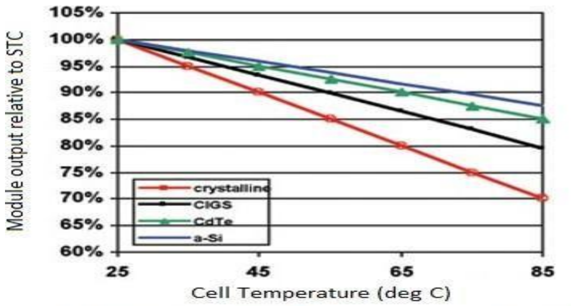
Here, we have total connected load of 5th floor. In that we calculate for classroom, staff room, corridor lights & many other rooms light, fan & computers we got total 12125W & the 73040 kwh which is energy used per hour.

B. Calculation of Load:

12.125 KW – Total Power
73.04 KWh/day – Total Energy
For monthly total Energy are 73.04 X 30 = 2191.2 KWh
But, our college aren't working on Sunday & as well 25% working on Saturday
So, we consider 22 days are properly working ie 4 days of Sunday & 4 days are Saturday (25 % x 73.04) (i.e18.26)
73.04 X 22 = 1606.88
1606.88+73.04 (25% of 4 Saturdays) = 1679.92 KWh
Total Energy required to generate = 1679.92 KWh

C. Solar Panel Sizing:

Here, we know
For **Polycrystalline**
1 kw = 3.2 unit/day
For **Monocrystalline**
1 Kw = 3.8 unit/day



Effects of a negative temperature coefficient of power on PV module performance

Figure no 6

Here We Select Polycrystalline Panel
For 30 days, 1 KW panel generate 96 unit.
So Total panel required. 1679.92/96 = 17.49 KW

D. Inverter Selection:
An inverter converts the DC voltage to an AC voltage. In most cases, the input DC voltage is usually lower while the output AC is equal to the grid supply voltage of either 120 volts, or 240 Volts depending on the country.
In other words, a device that converts direct current electricity to alternating current either for stand-alone systems or to supply power to an electricity grid.
We required **Inverter of 20 KVA** which is equal to size of solar panel or you selected 20% extra of recent solar panel size.
E. Battery Selection:
For Battery,
All energy stored in battery is not available to use i.e DOD (Depth of Discharge)
Lead - acid have 50% DoD
Li - ion have 90% DoD
Energy that battery should supply = 73.04 Kwh/day
Then, Battery Storage= 73.04 / DoD
If we select Lead Acid battery then 73.04/0.5 = 146.08 Kwh Storage
Here we choose,
24 v * 200 Ah = 4800 wh/4.8 kWh
Thus, No. of batteries required
Battery storage/Size
146.08/ 4.8=30.43
= 32 batteries

F. Payback Period:
This is clearly stated and seen above that we have generated 1679.92 units per month. The price of installation is 13 lakhs. Hence the payback period can be calculated by the following steps
Cost of 1unit= 11.82Rs
Hence total savings for months = 1679.92×11.82 = Rs 19856.65
Hence total savings for 12 months = Rs 238279.85
Payback period= 13 lakhs /19856.65 = 65.47 month ~ 5-6 years.

G. Price List of 20kW Solar System

The price of a 20kW solar system depends on its type or category. The price of any solar system is measured in terms of solar price per watt, hence the price of a 20kW solar system ranges from Rs.47 to Rs.80 per watt, depending on the type of solar system.

Solar System	Selling Price
On-Grid System	Rs 9,40,000
Off-Grid System	Rs 13,40,000
Hybrid System	Rs 16,00,000

11. Software Used:

ECLIPSE IDE
❖ **Features**
➢ Open Source
➢ IDE (Integrated Development Environment)
➢ Widely use JAVA IDE
➢ Multi-Language
Development Application

12. Result & Conclusion:

Figure no 7: Prototype Model

The main conclusion that derived from this case study was that, today the solar power is the global need. The consumption of energy is increasing day by day and so follows with creating the burden for energy generation hence these results into burning of large amount of fossils fuels leading them to depletion. Hence to overcome all this solar energy is the best source of energy since it mainly achieves advantages like- use of the free renewable energy source that is the sun, reduction in the CO2 emissions, reduction in electricity bills which makes it economical and reduces the payback period. This makes it more vital among all the other renewable energy sources. The research for the enhancement of solar panel was conducted, in order to utilize the solar panels after their warranty period finishes and are on the verge of replenishing it stated that the solar panels can be recycled and can be utilized back and works with almost the same efficiency.

Hence it's better to installed On-grid PV system rather than the Off-grid PV system. In On-grid system we saves the energy and in the maintenance and payback period point of view On-grid system is cost effective, hence we preferred On-grid PV system for our college.

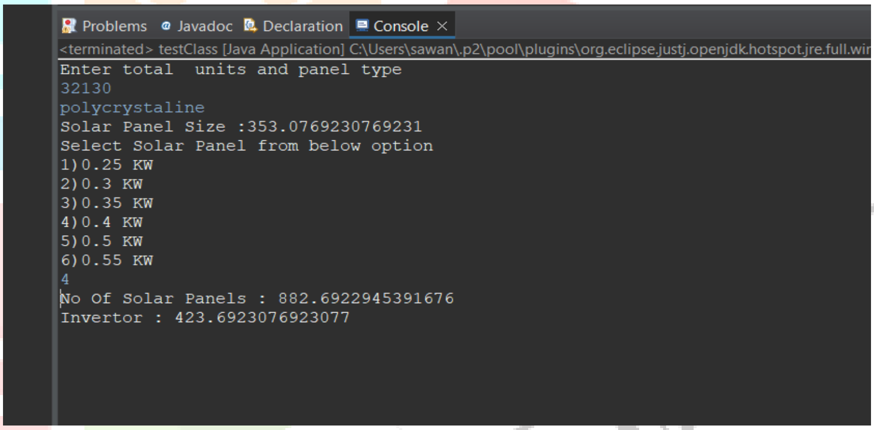


Figure no 8: Output window

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