Standalone Rooftop Technology in the Design of Solar Power Plant

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Abstract : Electricity has become a key role in mankind. So, it is necessary to provide electricity to all the individual. Because of energy crisis demand, the usage of renewable energy has become a best method for the electricity generation. This paper presents the designing of solar stand-alone roof top for household applications. And also the design of a 5.8MW grid connected system is shown. The method involves the simple calculation of the load. The solar energy is extracted using the photovoltaic cells which produce direct current when it is connected to the grid. The entire system consists of battery, grid tie inverter, power conditioning unit, charge controller etc. The different solar photovoltaic technologies are also discussed. The factors affecting the solar power are also seen in the paper**.**

IndexTerms **- Photovoltaic (PV), Solar standalone rooftop, grid tie inverter, Power conditioning unit, Direct current, Photovoltaic technologies**

I. INTRODUCTION

Being a universal energy resource, electricity is obtained from methods such as solar power, hydropower, wind power, natural gas, etc[1]. Electricity is a different kind of energy from any kind of energy. It is an energy which cannot be produced without consuming. It means that consumption is required for production.

Electricity is one of the most important blessings that science has given to mankind. It has also become a part of modern life and one cannot think of a world without it. Electricity has many uses in our day to day life. It is used for lighting rooms, working fans and domestic appliances like using electric stoves, A/C and more. All these provide comfort to people. In factories, large machines are worked with the help of electricity. Essential items like food, cloth, paper and many other things are the product of electricity. Modern means of transportation and communication have been revolutionized by it. Electric trains and battery cars are quick means of travel. Electricity also provides means of amusement, radio, television and cinema, which are the most popular forms of entertainment, are the result of electricity. Modern equipment like computers and robots have also been developed because of electricity. Electricity plays a pivotal role in the fields of medicines and surgery too such as X-ray, ECG [3]. The use of electricity is increasing day by day. This is an indicator of how much electricity is important in our lives. Therefore, it is essential to provide electricity to each person on this earth. Yet, this has become a very farfetched dream because, there are 1.3 billion people in the world without the access to power, out of which about 300 million people live in India.

II. METHODOLOGY

When rays of sunlight hit the solar cell electrons as shown in figure 1 are ejected from the atoms. Electrons are knocked loose from their atoms, which allow them to flow through the PN Junction to produce electricity. PV modules generate electricity by energizing electrons inside their material system. PV modules are made from semiconductor materials, which have the ability to absorb sunlight and create electric energy. When sunlight is absorbed in a semiconductor, the optical energy of the light is transferred to the electrons inside the material [4]. The energized electrons can then be extracted from the semiconductor into an electrical circuit, yielding electricity. As the amount of absorbed sunlight increases, so does the number of high-energy electrons, which then creates a flowing electric current. The energy difference between low-energy electrons and high-electrons, i.e. the size of the energy gap, determines the voltage output by the PV module.

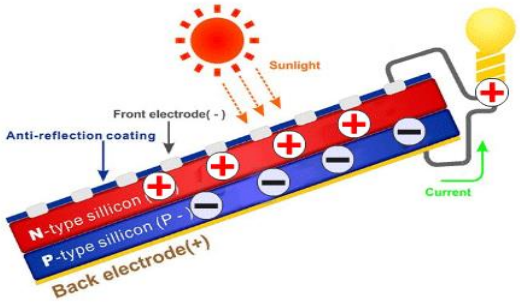

Figure 1.1: Electricity produced by PV cell

III. DESIGN OF SOLAR PV ROOFTOP

A rooftop PV system is a photovoltaic system that has its electricity-generating solar panels mounted on the rooftop of a residential or commercial building or structure. The various components of such a system include photovoltaic modules, mounting systems, cables, solar inverters and other electrical accessories.

Rooftop mounted systems are small compared to ground-mounted photovoltaic power stations with capacities in the megawatt (MW) range. Rooftop PV systems on residential buildings typically feature a capacity of about 5 to 20 kilowatts (kW), while those mounted on commercial buildings often reach 100 kilowatts or more.

These systems can generate, store and deliver power without depending on the electricity supply Small stand-alone SPV systems can power systems like:

1) Home lighting and Street lights
2) Garden lights and Illuminated hoardings
3) Water pumps
4) Depending on the nature of the load, stand-alone SPV systems are designed with or without storage battery

3.2 Salient features of 1KW Solar PV Grid Connected Power Plant

1. Investment Cost per KW is 70,000 without battery and 90,000 with battery.
2. Area required for 1KW is 10/10 sq. feet area.
3. Generation is 5-6 units/day/KW.

Before designing the standalone roof top, its necessary to know the load details at residential.

Energy Consumption per Day					
Sl No.	**Item**	**Power (watts)**	**Number**	**No. of hours of operation**	**Wh per day**
1	Tube light	40	4	5	800
2	Fan	80	4	6	1920
3	Television	125	1	9	1125
4	Refrigerator	150	1	2	300
5	Laptop	65	1	3	195
6	Mixer grinder	500	1	0.08	40
7	Washing machine	500	1	1.5	750
8	Miscellaneous	15	-	-	15
Total watts		**1475**	**Total Wh per day**		**5145**

The details of energy consumption per hour in a house are given below.

Energy Consumption per Hour					
Sl No.	**Item**	**Power (watts)**	**Number**	**No. of hours of operation**	**Wh per day**
1	Tubelight	40	4	1	160
2	Fan	80	4	1	240
3	Television	125	1	1	125
4	Laptop	65	1	1	65
			Total Wh per hour		**670**

Calculations:

STEP-1 Load calculation

1. Daily Load = 5.145 kWh
2. Hourly Load = 670Wh

STEP-2 Selection of Inverter

Inverter is selected based on hourly load

1. 25% of hourly load =0.25 X 0.670=0.1675kWh
2. Load on inverter =0.590 + 0.1475= 0.8375 kWh

STEP-3 Selection of Battery

Battery is selected based on daily load

We choose 12V, 120 Ah battery for the design

1. Daily load = 5.145 kWh

Let the deep discharge value be 70 %

Therefore, we need 30 % more energy storage

=0.3 X 5.145=1.5435 kWh

2. Total energy to be stored by the battery
   =5.145 + 1.5435= 6.6885 kWh
3. Number of batteries=6.6885/1.44=5 No.s

We need 8 batteries of 12 V, 120 Ah capacity

4. DC input voltage=48 V
5. AC output voltage=230 V, 50 Hz, 1-ϕ

STEP-4 Solar Module Specification

1. Module type = RI 240
2. Model Capacity = 240 Wp
3. Open Circuit voltage (Voc) = 43 V
4. Short Circuit Current (Isc) = 7.31 A
5. Maximum voltage (Vmax) = 36 V
6. Maximum current (Imax) = 6.86 A

1 kW capacity of solar module generates 5 kWh energy per day

To generate 5.145 kWh, the solar module capacity needed is = 5.145/5 =1.029Kw

25% extra module capacity =0.25 X 1.029=0.2572kW

Total solar PV requirement = 1.029 + 0.205 = 1.2862kW

Number of solar panels required = 1286.2/240= 6 panels

We need 6 solar panels of 240 Wp capacity

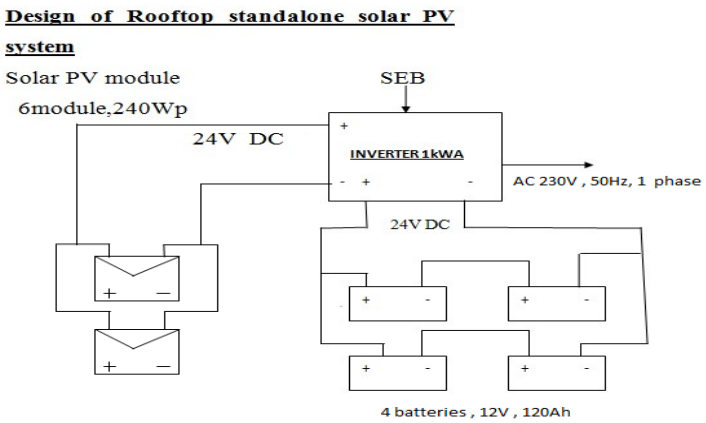

Figure 3.1: Design of Rooftop Standalone Solar PV System

3.3 Salient features of 1MW grid connected solar power plant

1. Investment Cost for 1MW is about 4 Crores.
2. Area required for 1MW each is 3.5 - 4 acres
3. Life of the equipment is 25 years.
4. Tariff as per Karnataka Electricity Regulatory Commission is 6.51Rs.
5. Generation/Annum/MW is about 1.5 million units.
6. Subsidy facilities are also available as per individual policy.
7. 10 years tax holiday is available for the revenue generated.
8. CDM benefits are available.
9. Whatever the Power generated can be used for capital purpose or selling to third party or to the government.
10. Government lands are also available to set up solar or any other renewable energy power plant.

3.4 Solar Photovoltaic Technologies

1. Mono-Crystalline: These types of solar panels uses solar cells which are made from a very pure single large crystal,cut from ingots. They are the most efficient type of solar panels but are also the most expensive. Their performance is somewhat better in low light conditions (but not as good as some advertising hype would have you believe). Overall efficiency on average is about 12-15%. Most panels of this type are warranted for 20-25 years. They are usually blue-grey in color and have a fairly uniform consistency.

Figure 3.2: Mono crystalline solar panel

2. Poly-Crystalline Block: With most poly-crystalline solar panels the silicon in the solar cells is cast from large blocks of silicon which may contain many small crystals. Some manufacturers use a slightly different approach for creating poly-crystalline solar cells. Currently, poly-crystalline solar panels are the most common. They are slightly less efficient than single crystal, but once set into a frame with 35 or so other cells, the actual difference in watts per square foot is not much. Poly-crystalline cells look somewhat like shattered glass and have a dark blue to almost black color. Overall efficiency on average is about 11-13%.

Figure 3.3: Poly-Crystalline Block

2. **Poly-Crystalline String Ribbon:** String ribbon photovoltaic use a variation on the polycrystalline production process, using the same molten silicon but slowly drawing a thin strip of crystalline silicon out of the molten form between two strings. These strips of photovoltaic material are then assembled in a panel with the same metal conductor strips attaching each strip to the electrical current. This technology saves on costs over standard polycrystalline panels as it eliminates the sawing process for producing wafers. Some string ribbon technologies also have higher efficiency levels than other polycrystalline technologies. Overall efficiency on average are from 11-14%. Evergreen is the primary provider of string ribbon solar panels.

3. **Amorphous :** Amorphous solar panels are also referred to as "thin film" solar panels. In these types of panels the silicon is spread directly on large plates, usually of something like stainless steel. The thin film type of solar cells can also be spread on to more flexible plastic materials to make very flexible solar panels. These types of solar cells are much cheaper but also much less efficient than mono crystalline or poly-crystalline solar panels. Therefore in order to provide as many watts as the other types of solar panels they must be much bigger in size. However, because they can be put on to flexible backings they have proven very valuable in certain types of applications Where flexibility is more critical than power. For example, these types of solar panels are often used in portable products such as solar backpacks and solar bags. Overall efficiency on average is about 5-6%.

4. **Concentrating Photovoltaic Solar Panels :** These types of panels employ a lens or mirror to concentrate the sun's energy on to the individual solar cells. In theory these types of panels will be more efficient because by concentrating the sun's energy fewer solar cells are needed to create the same amount of energy. Many of the concentrating panels use a type of plastic lens, called a Fresnel lens, to concentrate the sun's energy. Another type of concentrating solar panel called a Helio tube uses a series of troughs which track the movement of the sun to provide greater solar exposure to the solar cells. Concentrating solar panels reduce the amount of photovoltaic needed to produce electricity, and also reduce the amount of space needed for a photovoltaic installation. Their main disadvantage is that they depend solely on direct light to produce electricity, while stand-alone photovoltaic panels can use both direct and diffuse light. Many regions do not receive enough direct light throughout the year for these systems to make these types of panels practical. Another disadvantage is their complexity of their construction, which makes these systems more difficult to build and install than conventional PV panels. Concentrating panels are also considerably heavier than conventional PV panels and have a number of moving parts which makes them more susceptible to failure than conventional panels. These types of panels are not widely used in residential solar PV systems.

IV. FACTORS AFFECTING THE SOLAR POWER RADIATION

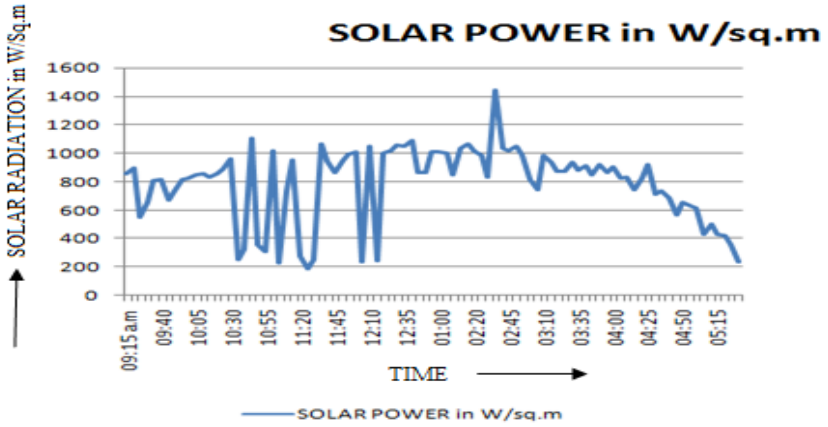

Figure 4.1: Solar power radiation measured at different time

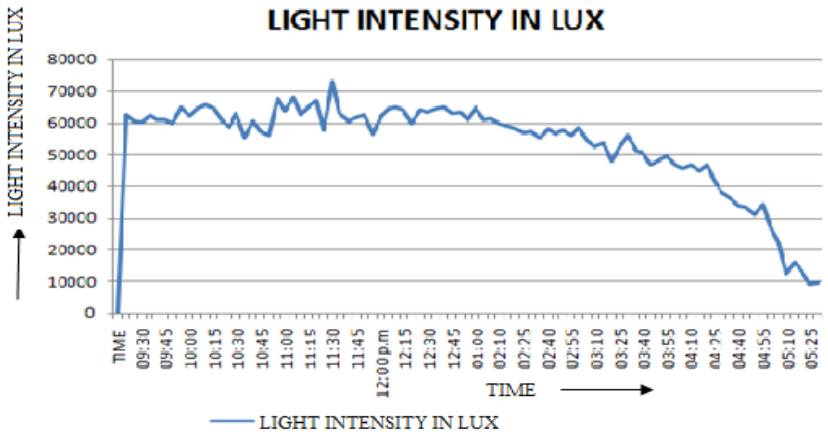

Figure 4.2: Light intensity measured at different time

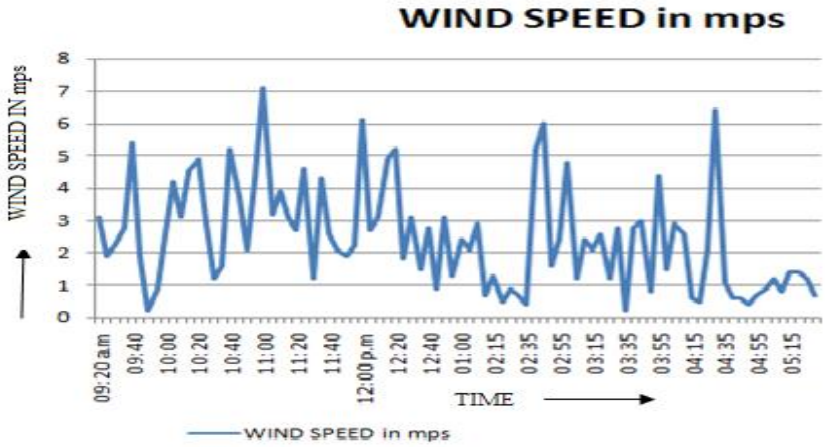

Figure 4.3: Wind speed measured at different time

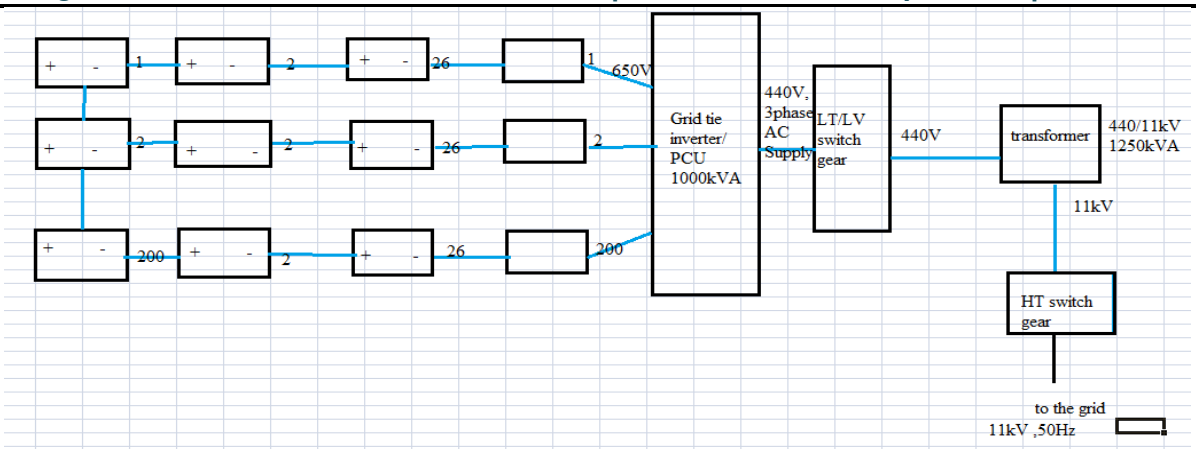

Fig 4.4: Design of 5.8 MW Grid-connected solar PV power plant

V. APPLICATIONS OF PHOTOVOLTAIC SYSTEM

1) Water pumping and Radio beacons for ship navigation at port ,
2) Community radio and television sets, Cathodic protection of oil pipe lines .
3) Battery charging and Telecommunication
4) **Cooking:** solar cookers are commercially available and can be conveniently used for the purpose of cooking food.
5) **Heating:** solar water heaters and air heaters are being used for a variety of applications both in industrial sector and domestic sector
6) **Distillation:** solar stills can be used for the production of portable water in remote areas
7) **Lighting:** solar photovoltaic lighting system can be effectively used in remote rural areas for both domestic lighting and street lighting.
8) **Process heating:** cylindrical parabolic collectors can be used for the production of low-pressure steam for industrial application. These systems are still in the developmental stage.
9) **Refrigeration:** solar energy can be used for the purpose of cold storage as well as air conditioning application. Vapour compressor system using solar photovoltaic panels and vapour absorption system using thermal collectors can be used for these purposes.

VI. CONCLUSION

This paper presented the designing of Solar stand-alone roof top for household applications. And also the design of a 5.8MW grid connected system was seen. The method involves the simple calculation of the load. The solar energy is extracted using the photovoltaic cells which produce direct current when it is connected to the grid. The entire system consists of battery, grid tie inverter, power conditioning unit, charge controller etc. The different solar photovoltaic technologies are also discussed. The factors affecting the solar power are also seen in the paper

REFERENCES

[1] E.H. Camm, S. E. Williams, “Solar Power Plant Design and Interconnection”, IEEE Power and Energy Society General Meeting, July, 2011

[2] Retno Aita Diantari, Isworo Pujotomo, “Calculation of Electrical Energy with Solar Power Plant Design”, International seminar on Intelligent Technology and its Applications (ISITIA), July 2016

[3] Adolf Goetzberger, Joachim Knobloch, Bernhard Voβ, “Crystalline Silicon Solar Cells” Johnwiley & Sons, Ltd PP. 87-229.1998

[4] J. Singh, “Study and Design of Grid Connected Solar Photovoltaic System at Patiala, Punjab”, no. July,

[5] 2010Ritwik Chattopadhyay, Kishore Chatterjee, “PV Based Stand Alone Single Phase Power Generating Unit”, in 38th Annual Conference on IEEE Industrial Electronics Society, PP. 1138-1144 IECON 2012

[6] National Renewable Energy Laboratory, PVWatts Calculator (2013. Sep). Estimates the Energy Production and Cost of Energy of Grid Connected PV Energy System Throughout the World [Online]. Available: http://pvwatts.nrel.gov

[7] Antoni Martiniano A. Acuzar, Ian Paulo E. Arguelles, Jim Cedric S. Elisan, Jason Kevin D. Gobenciong, Alexandra M. Soriano, and Josyl Mariela B. Rocamora, “Effects of Weather and Climate on Renewable Energy Resources in a Distributed Generation System Simulated in Visayas, Philippines”, IEEE 9th conference on HNICEM, Dec 2017

[8] Solar power hand book by Dr. H. Naganagowda , Director, National training centre for solar technology KPCL, Govt of Karnataka, Bengaluru.