Design and Construction of 10kw Solar Based Power Supply

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ABSTRACT

Electricity generation using renewable energy is used to power an inverter. These can be called Photovoltaic system because it consists of solar modules, solar controller, 24V d.c battery inverter. Photovoltaic comprises of a two words Photo" means Light, and "Voltaic" means electricity. Photovoltaic is the scientific term used to describe what we use to convert solar energy into electricity generates electricity from light. The solar module serves as a source of charger through the solar charge controller to the battery and inverter are used in converting the direct current into alternating current for the domestic appliance. The uses of a battery are to store energy for future use. A battery is designed especially for solar applications with lifetimes for 15 years are available. A cost-effective application needs to be identified before the system design can begin, the potentials that designate a chance for photovoltaic power are remoteness, critical load, low voltage, Noise or pollution, modularity and high insulation. It needs less maintenance, it does not use fuel, it is not heavy, and it is noiseless.

Keywords: Solar photovoltaic, Solar energy, Alternative to electricity, Solar Spectrum.

1. INTRODUCTION

Light is crucial in everyday activity for the continuity of normal life. From plants to animals, from human beings to domestic insects, from technology to science, nothing seems to maximize its existence without the availability of light (Kaur et al., 2000) Even the human eye requires some amount of light to function well (Perlin, 1999) Light from the sun is natural and it is called sunlight. This sunlight can serve as a source of solar power which is converted to electric power for both household and industrial utilization. Solar power is the generation of electricity from sunlight. This can be direct as with photovoltaic (PV) or indirect as with concentrating solar power (CSP) (Holladay et al., 2016) where the sun's energy is focused to boil water which is then used to provide energy. Solar power is a predictably intermittent energy source, meaning that while solar power is not available at all times, we can predict with a very good degree of accuracy when it will not be available. One area of application of solar energy is found in the construction of solar-powered on a building. This is the equipment that is paramount to meet the needs of the beneficiary when there is an interrupted power supply from IBEDC. Harnessing of non-polluting renewable energy resources to control Duro Global Communication Enterprises. The solar mission, which is part of the National Action Plan on Climate Change has been set up to promote the development and use of solar energy in for power generation and other uses with the ultimate objective of making solar energy competitive with fossil-based energy options (Ahmed et al., 2019).

The solar photovoltaic device systems for power generation had been deployed in the various parts in the country for electrification where the grid connectivity is either not feasible or not cost-effective as also some times in conjunction with diesel-based generating stations in isolated places and communication transmitters at remote locations. With the downward trend in the cost of solar energy and appreciation for the need for the development of solar power, solar power projects have recently been implemented (Asmus, P. 2008). A significant part of the large potential of solar energy in the country could be developed by promoting grid-connected solar photovoltaic power systems of varying sizes as per the need and affordability coupled with ensuring an adequate return on investment. It has been proposed to set up a 10KW grid-connected solar photovoltaic power plant on the rooftop terrace of the Duro global communication office as a pilot project.

Solar Photovoltaic is beneficial in the day to day running and maintenance costs are reduced, save energy, environment-friendly and convenient to install. There are automatic

changes overbuilt which need no manual operation of switching ON and OFF. The system itself detects whether there is a need for light or not. When there is a power failure, then automatically it switched ON and when there is another source of light, it switched OFF. This is done by a sensor called light-dependent resistor (LDR) which senses the light actually like our eyes (Beverungen & Schmid, 2003). This vital use of light gives rise to the idea of using solar energy into building power system as an alternative to electricity (Carr et al., 2016).

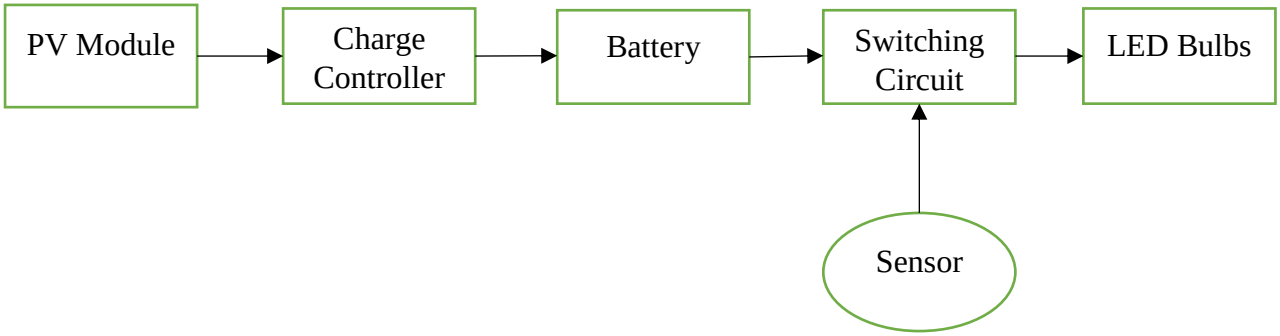

Fig .1. The block diagram of the system

The aim of this project is to design and construct 10KW solar-based uninterrupted power supply (UPS). This solar power source makes it possible to provide a clean reliable supply of alternative electricity free of sags or surges which could be found in the line voltage frequency.

2. PRINCIPLE OF OPERATION OF SOLAR ENERGY

Solar energy is available in abundance in most parts of the world. The amount of solar energy incident on the earth's surface is approximately1.5 x 1018 kWh/year, which is about 10,000 times the current annual energy consumption of the entire world. The density of power radiated from the sun (referred to as solar energy constant) is 1. 373 kW/m2.

A solar cell is a device which converts photons in Solar rays to direct-current (DC) and voltage. The associated technology is called Solar Photovoltaic (SPV). A typical silicon PV cell is a thin wafer consisting of a very thin layer of phosphorus-doped (N-type) silicon on top of a thicker layer of boron-doped (P-type) silicon. An electrical field is created near the top surface of the cell where these two materials are in contact (the P-N junction). When the sunlight hits the semiconductor surface, an electron springs up and is attracted towards the N-type semiconductor material (Gao et al., 2019). This will cause more negatives in the n-type

and more positives in the P-type semiconductors, generating a higher flow of electricity. This is known as **Photovoltaic effect**. The figure below shows the working mechanism of a silicon solar cell.

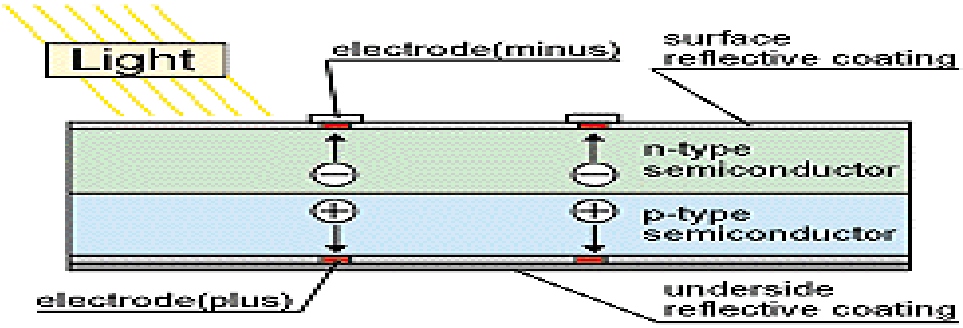

Fig. 2. Silicon Solar Cell and its working mechanism (Source: global.kyocera.com)

The amount of current generated by a PV cell depends on its efficiency, its size (surface area) and the intensity of sunlight striking the surface. For example, under peak sunlight conditions a typical commercial PV cell with a surface area of about 25 square inches will produce about 2 watts peak power.

3. SOLAR IRRADIANCE

The Sun is the fundamental driving force for energy in the Earth's climate system. It is of crucial importance to understand fully the conditions of its arrival at the top of the atmosphere and its transformation through the earth. The amount of solar power available per unit area is known as **Irradiance**. Irradiance is a radiometric term for the power of electromagnetic radiation at a surface, per unit area. It is used when the electromagnetic radiation is incident on the surface. Irradiance fluctuates according to the weather and the sun's location in the sky (Pikra et al., 2013; Panchenko, 2019). Figure 3 below illustrations the dual angles (Sun's Compass Angle and Sun's Elevation Angle).

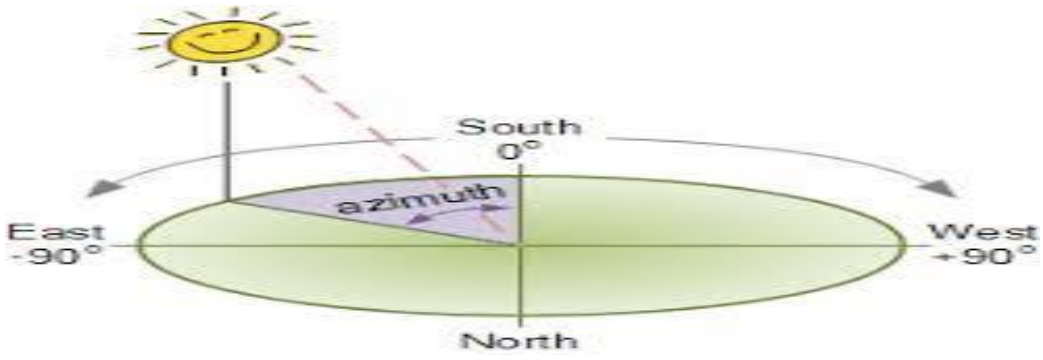

Fig. 3. Sun's Position in the Atmosphere

4. SOLAR BAND

The sun radiates power over a continuous band or spectrum of electromagnetic wavelengths. Various wavelengths levels in the solar band are not the same.

4.1 Ultraviolet, Visible and Infrared Radiation

The entire sun's energy is collected of 7% electromagnetic energy, 4% visible energy and 46% ultraviolet (heat) energy. Ultraviolet (UV) energy is the reasons why many materials to damage and is meaningfully cleaned out by the layer of ozone in the upper sky. Photovoltaic cells mainly use visible energy (Mouli et al., 2018). The spreading of colours within the light is vital, because, a photovoltaic cell will produce different quantities of current contingent on the several colours shiny on it.

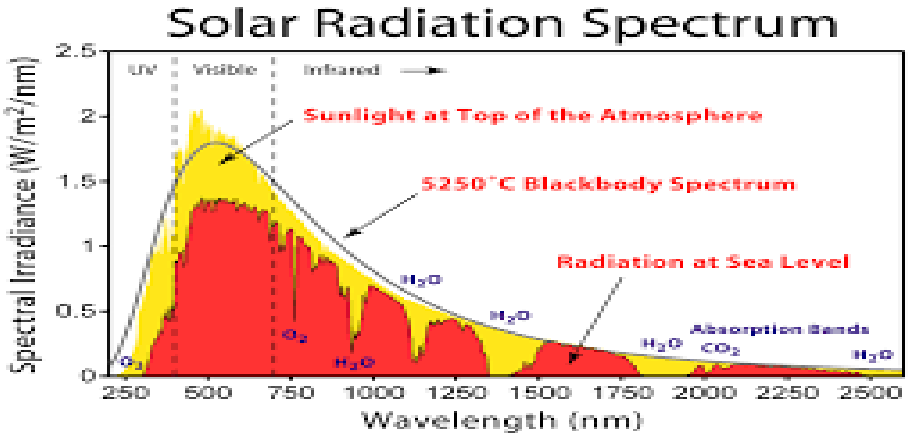

Fig. 4. Solar Range (Source: www.juliantrubin.com)

5. PV TECHNOLOGY

The most important parts of a PV system are the CELLS which form the basic building blocks of the unit which collects the sun's light, the MODULES which bring together large numbers of cell into a unit, and, in some situations, the INVERTERS used to convert the electricity generated into a form suitable for everyday use. PV CELLS AND MODULES PV cells are generally made either from thick CRYSTALLINE SILICON, sliced from ingots or castings or from grown ribbons, or THIN FILM, deposited in a thin layer on a low-cost backing. Most cell production (93.5% in 2005) has so far involved the former, while future plans will also have a strong focus on the latter. Thin film technology based on silicon and other materials is expected to gain a much larger share of the PV market in the future (Wenzl et al., 2004).

This technology offers several advantages such as low material consumption, low weight and a smooth appearance (Mouli et al., 2018).

6. CELL TYPES CONCENTRATOR CELL

It focuses light from a large area onto a small area of photovoltaic material using an optical concentrator (such as a Fresnel lens), thus minimizing the number of PV cells required. The two main drawbacks with concentrator systems are that they cannot make use of diffuse sunlight, and must always be directed towards the sun with a tracking system (Seshie et al., 2018). Below are the types of concentrator cells.

6.1 Spheral Solar Technology

It uses minute silicon beads bonded to an aluminium foil matrix. This offers a big cost advantage because of the reduced requirement for silicon. Two companies, from Canada and Japan, are planning to commercialized modules with sphere solar cells, with one of them ready predicting a module efficiency of 11%. This represents an excellent example of the rapid technical progress in photovoltaic (Tawfik et al., 2018).

6.2 Modules

Modules are clusters of PV cells incorporated into a unit, usually by soldering them together under a sheet of glass. They can be adapted in size to the proposed site, and quickly installed. They are also robust, reliable and weatherproof. Module producers usually guarantee a power output of 80% of the nominal power even after 20-25 years. When a PV installation is described as having a capacity of 3 kWp (peak), this refers to the output of the system under standard testing conditions (STC), allowing comparisons between different modules. In central Europe, a 3 kWp rated solar electricity system, with a module area of approximately 27 square metres, would produce enough power to meet the electricity demand of an energy-conscious household (Tawfik et al., 2018).

6.3 Inverters

Inverters are used to convert the direct current (DC) power generated by a PV generator into alternating current (AC) compatible with the local electricity distribution network. This is essential for grid-connected PV systems (Tawfik et al., 2018).

7. COMPONENTS FOR STAND-ALONE PV SYSTEMS

The stand-alone (off-grid) PV systems comprise a BATTERY, often of the lead-acid type, to stock the energy for future usage. Though, the period of the battery powerfully is contingent on battery management and the user's behaviour (Tawfik et al., 2018). The battery is connected to the PV array via a CHARGE CONTROLLER. The charge controller protects the battery from overcharging or discharging, and can also provide information about the state of the system or enable metering and pre-payment for the electricity used. If AC output is needed, an INVERTER is required to convert the DC power from the array.

8. TYPES OF PV SYSTEM

8.1 Grid Connected

This is the most popular type of solar PV system for homes and businesses in the developed world. Connection to the local electricity network allows any excess power produced to be sold to the utility (Tawfik et al., 2018). Electricity is then imported from the network outside daylight hours. An inverter is used to convert the DC power produced by the system to AC power for running normal electrical equipment.

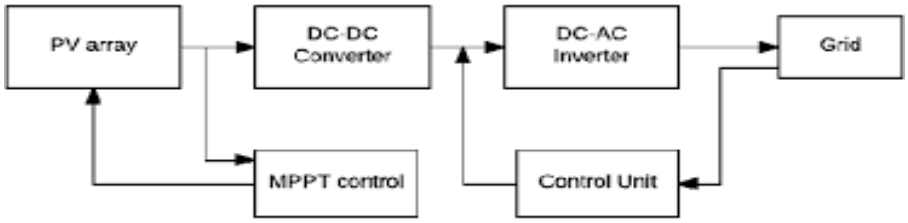

Fig. 5. Block diagram of a basic grid-connected PV system (Source: www.semantischolar.org)

In countries with a premium feed-in tariff, this is considerably higher than the usual tariff paid by the customer to the utility, so usually, all electricity produced is fed into the public grid and sold to the utility. This is the situation in countries such as Germany or Spain.

8.2 Off-Grid

Completely independent of the grid, the system is connected to a battery via a charge controller, which stores the electricity generated and acts as the main power supply. An inverter can be used to provide AC power, enabling the use of normal appliances without mains power. Typical off-grid, applications are industrial applications such as repeater stations for mobile phones or rural electrification (Flesch et al., 2015). Rural electrification means either small

solar home systems (SHS) covering basic electricity needs or solar mini-grids, which are larger solar electricity systems providing electricity for several households.

8.3 Hybrid System

A solar system can be combined with another source of power - a biomass generator, a wind turbine or diesel generator - to ensure a consistent supply of electricity. A hybrid system can be grid-connected, stand-alone or grid support.

9. METHODOLOGY

This method used for carrying out research made is surfing the web/internet to facilitate the circuit diagram that can assist in the design of the task ahead i.e. construction of 10KW solar-based uninterrupted power supply.

9.1 Charge Controllers

Battery charge regulation and control of the energy produced by the PV array is a critical function in the PV system. The most important functions of charge controllers are listed below.

- Avoid overcharge battery
- Avoid over-discharge battery
- Make available load regulator functions
- Make available position information to system users
- Control back up energy sources and Interface
- Divert PV energy to an Auxiliary load
- Serve as wiring centre

9.2 Characteristic of System Design

Expectations in Arrangement Design:

- Considered the solar PV system.
- Latitude of (CEO OFFICE)-23.2°N is considered for the site.
- Longitude of (CEO OFFICE)-$9 21°E is considered for the site.
- Day-to-day solar insolation at 30° slope - 4.98 kWh/m2/day (high at 30 0C)

- PV module of MBPV 125 was considered.
- Battery of LMS400 was considered
- 0.8 depth of discharge was considered
- 2 days of autonomy was considered
- 85% of array output efficiency was considered
- 90% of inverter efficiency was considered
- 85% of battery efficiency was considered

9.3 Battery Design

- 300Ah, 48V battery output was required
- 375 Ah at 80% depth of discharge, capacity was required
- 720Ah at 48V capacity required with 2 days self-sufficiency
- Exide LMS750, 2V, 750 Ah battery was selected
- 24 nos of batteries in series was selected
- 1 no. of batteries in parallel was selected
- Number of batteries = 24 x 1 = 24 nos.

9.4 PV Array Design

- 16.5 kWh, 48V of PV array output was required
- 19.4 kWh of array output considering losses of 15% was required
- 3.89 kWp of solar insulation of 4.98 hours capacity was considered
- MBPV125 (130Wp, 28.5Vmp, 4.5 Imp) of module was selected
- Modules is series = 48/28.5 = 2
- Modules in parallel = 70/4.5 = 16

9.5 Charge controller

- Battery bank Solar PV modules inverter was required
- 1.38 kW connected load was considered
- 85% 300 Ah + 75Ah + 300 Ah + 75 Ah = 750 Ah 48 Volts efficiency was considered
- 85% 19.4 kWh 3.89 kWp efficiency was considered
- 16.5 kWh 48 Volts, 70 Amps was considered
- 34 Amps 13.33 kWh was considered
- 10 kWh, 15.7 kWh, 13,33kWh was considered
- 90% 2kVA 48V/230V efficiency was considered

9.6 Inverter Capability

2kVA, 1 phase, and 48V/230V inverter capacity was required

10. TASKS AND OBJECTIVES

PV hybrid systems consist of two or more power-generating and supply units, such as PV and wind turbine systems, hydroelectric power plants, or combustion gensets. Frequently, several such generators are connected in parallel. With the exception of combustion gensets, the generators can only be controlled under certain conditions, or not at all. For this reason, a battery is always integrated into a hybrid system to act as energy and power buffer. The storage battery performs certain key functions. When not enough energy is being produced to meet demand, the battery releases this energy. However, there are limits to the amount of storable energy and power. Furthermore, the battery is subject to ageing processes which are highly dependent on the charging technique employed. Therefore, this makes battery management a crucial factor in the entire process of operational control. Without intelligent charge control and effective protection against total discharge, typical lead-acid storage batteries only provide a very short service life. The service life and efficiency of combustion gensets also exhibit a strong dependence on prevailing and frequently occurring operational conditions. Thus, typical diesel engines for electricity generation, as a rule, reach maximum efficiency at 100 % of their nominal power. At around 50 % of nominal power, efficiency is already 20 % less. At generator loads below 50 %, efficiency drops off very steeply. The operational control of hybrid systems has the following three basic tasks:

- To keep the system securely operational so that the loads can be reliably supplied with electric power
- To minimize fuel and maintenance costs
- To optimize the life of the battery and generator

11. RESULTS AND DISCUSSION

The solar panel was installed employing a fixed rack method. And six pieces of solar panel was mounted on it. The voltage rating of each solar panel is 35.8V, 300w and 8.2 Amps while the fusing circuit rating is 10A. We connected 6 panels in series and the voltage was

taken, it gives us 237V. We observed that the voltage was much than the required voltage, so we divided to connect 3 panels in parallel to form a pair of parallel connection so as to produce two repeated and similar out-put voltage.

We took the voltage reading of one side of the 3 panels which was connected in parallel and its give 35.8V. We wired the panel cable from the panel to the building using 2.5mm industrial flexible cable with 20mm conduit pipes. The paired cable 35.8V each was connected to the provision made for solar Panel on the solar charge controller which was mounted on the wall before the connection was made.

We wired sized pieces of 5W d.c bulbs in parallel and 2 pieces of two twin socket which were taken to the load provision on the first charger controller at the Rector's office and 2 pieces of 5W d.c bulbs was also wired in parallel and on pieces of twin socket which were taken to the load provision on the second charge controller meant for secretary office. We connected each of the two available batteries (12v, 200A) to the battery provision on each charge controller. That is one battery for each controller. Then we assemble 3 pieces of 12v, 15W rechargeable standing fan which was connected to the 15A d.c socket. Then we powered the available inverter (12V, 1KVA) from the battery placed at the secretary office to supply 1 piece of tower P.C (Personnel Computer).

The following reading was taken after installation:

(1) Battery Voltages reading on No Load we derived 14.2V

(2) Solar Voltage reading on No Load, we derived 24.1V

(3) Battery Voltage reading on load, we derived 14.2V

(4) Solar voltage reading on Load, we derived 18.5V

The significance of this study is that the solar-based uninterrupted power supply does not give room for electricity surge that is fluctuation in power supply. It can last for many years say, 20-25 years without failure, therefore it is very reliable.

12. CONCLUSION AND RECOMMENDATION

12.1 Conclusion

The production of electricity from renewable energy technologies is growing much faster than the electric power supply as a whole. Solar power is among the fastest-growing segments of the renewable energy market. Centralized solar power is produced on large farms and fed into an electrical grid a network of wires and a transformer that allows electricity produced by multiple Sources to be transported to industrial, commercial and residential consumers. Globally, grid-connected solar capacity increased an average of 60 per cent annually from 2004 to 2009, faster than any other energy source. Solar electricity production grew by 15.5 per cent in 2009 alone. Today, however, solar power still accounts for less than one-half of one per cent of the world's electric power output.

Despite its impressive growth, and even with significant subsidies, solar power is substantially more expensive than conventional power sources in most locations. This is true of solar thermal systems that use lenses or mirrors and tracking systems to focus sunlight into a small beam to heat a fluid that turns steam-powered turbines. It is also true of solar photovoltaic power, in which panels or modules of cells fabricated from semiconducting materials generate electrical power by converting solar radiation into direct-current electricity. This study focuses on solar photovoltaic ("solar"), the more mature, more widespread and historically easier to build a form of solar generation. Analysts agree that if solar is to become a significant power source, it must compete with other energy sources in markets without subsidies to any form of energy, barriers to the entry of new producers or discriminatory price regulations. When the price at which customers in a particular area can purchase electricity generated by solar power is about the same as the average price of electricity generated by conventional sources, it is said to have reached grid parity.

Photovoltaic power systems offer many unique benefits above and beyond simple energy delivery. That is why comparisons with conventional electricity generation and more particularly compared with the unit energy costs of conventional generation are not always valid. If the amenity value of the energy service that PV provides, or other non-energy benefits, could be appropriately priced, the overall economics of PV generation would be dramatically improved in numerous applications, even in some grid-connection situatıons.

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