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Technical Report on The Design and Installation of a 1KVA Solar Energy Powered Security Light in The Dora Akunyili and Stella Okoli Female Hostels of Nnamdi Azikiwe University, Awka, Using Monocrystalline Panels.

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Abstract:- Physicists seldom allow students in their courses to escape without understanding and being able to perform calculations pertaining to energy. Outside of science circles, however, "energy" generally refers not to an overall conserved quantity but rather to the large-scale conversion of stored energy into electricity, locomotion or manufacture. Physicists have much less contact with the conversion aspect of energy, though it is tremendously important to society. At some point in the near future, humankind must necessarily see a declining annual availability of fossil-fuel resources, given their finite nature and geological limitations to the rate of their extraction. That decline will be most sharply felt for petroleum, but it is also relevant for natural gas, less so for coal. The disappearance of global resources that are so important to our way of life is unprecedented. We have little choice but to adapt by reducing demand, migrating to alternative energy resources, or very likely, employing a combination of both strategies. It was with those concerns in mind that I decided to explore the practical side of photovoltaic energy with my students. We built a PV stand-alone system to power security LED lights at the two female hostels in our University. We used the monocrystalline panels, MPPT charge controller, Deep cycle lead-acid Trojan batteries, fuses, switches, conduct wires and 6 LED lamp heads. This had helped to drive away darkness at night since January 12, 2013 because of lack of supply from national grid and had sustained our environment.

Keynote:- Monocrystalline Panel, MPPT Controller, LED lamps and Alternative Renewable Source.

I. INTRODUCTION

Electricity generation from fossil fuels creates greenhouse gas emissions and air pollution. Photovoltaic (PV) systems provide a cleaner, environmentally friendly alternative. They convert solar radiation into electricity and are a great way to reduce environmental impact of our workplace, Nnamdi Azikiwe University, Awka, South East, Nigeria. PV systems allow electricity to be generated in between the two chosen female hostels very close to the source. This helped to avoid the significant energy losses associated with the transmission of electricity over long distances. PV systems are non-polluting, low maintenance and provide a very reliable source of power. They are relatively easy to install and have a long span of approximately 20 years. Fig. 1 shows the 1KVA monocrystalline connected in series to produce 150V used to power our battery bank. The work was basically on the harnessing and utilization of energy from the sun otherwise known as the renewable source of energy. Fig. 2, shows the block diagram of the design used for the installation.

Fig. 1: Monocrystalline panels

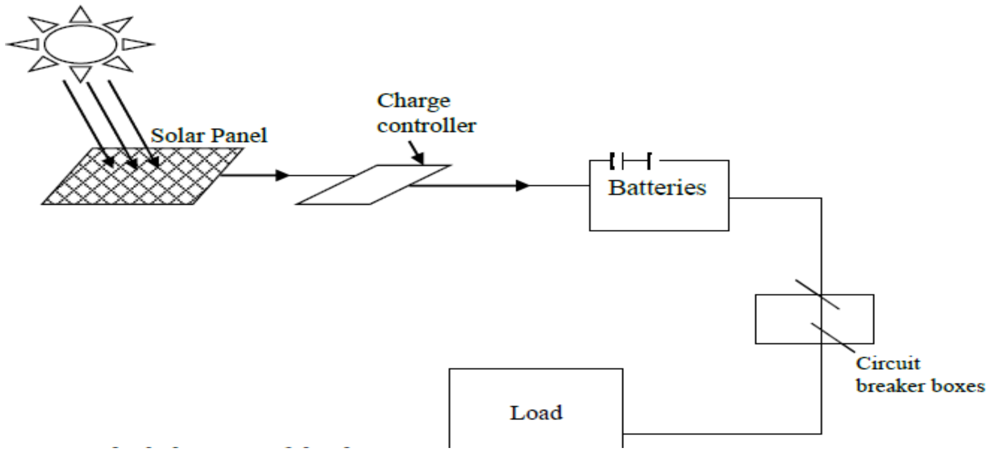

Fig. 2: Block diagram of the design.

II. SYSTEM DESIGN PROCEDURES

1) Load Profile

Since the first task in designing a PV system is to estimate the system load. We achieved this by listing the power demand of all the LED lamp heads and noting that the light was supposed to be on throughout the night that is dusk to dawn or for twelve hours in the night. We also decided to use a 6V Trojan battery of 435Amp-hr since we need more of the current in amperage than the voltage. All the LED lamp heads do function with the DC hence there was no need of an inverter.

2) PV array sizing

We selected the module based on the specifications provided by the manufacturer. We went for the monocrystalline silicon which is more efficient and lasts longer to about 25 years life time. We used four panels connected in series each rated 250W to give us a total of 1KW needed as shown in Fig. 1. The PV array was mounted at a fixed angle from the horizontal. We used the tilt angle of 6.2o to the South because the latitude of Awka, South East Nigeria is 6.1817o and it gives the most energy annually.

3) Battery Sizing

We noted the battery sizing which is the capability of a battery system to meet the load demand with no contribution from the photovoltaic system. We chose our battery the 6V Trojan lead-acid with 435Amp-hr so that our stand alone photovoltaic system must maintain a continuous energy supply at night when there is no solar energy as shown in fig. 3.

Fig.3: 6V Trojan Battery

Since the security lights require much current than voltage we did not go for 12V batteries since their amperage is usually between 101 – 110Amp-hr. Since batteries emit a corrosive and inflammable gas at the final stage of charging hence we installed them in a well-ventilated space away from the house inside our cubicle as shown in fig.5. Charge controllers are used in PV systems to protect the batteries from overcharge and excessive discharge. We used the MPPT (Maximum Power Point Tracker) 80 Amp charge controller to handle the maximum current product. One particular advantage of the MPPT charge controller is that it ensured that current does not flow from the battery to the array by night but only powers our security lights.

The MPPT charge controller was used because it operates the PV panels at the voltage that delivers maximum power. That voltage will generally be higher than the voltage required to charge the battery, so the excess voltage is converted into extra current at the voltage demanded by the battery. Therefore, MPPT controllers as shown in Fig.4 not only maximize power extraction from PV panels but also allow tremendous flexibility in PV configuration.

Fig. 4: The MPPT Charge Controller

We took proper care while installing the balance of system (BOS) components since making secure and durable connections is very essential to the lifetime of a PV system. The BOS components include:

i) Type of wire and size: We used copper wires for an increase performance and reliability of our PV system. We considered the total current carrying capability of the wire along with the fuses used to protect the conductors when choosing the type of wires to use. This was done to avoid overheating insulation breakdown and fire outbreak. We also considered the voltage drop and power loss before selecting the wire. Since both of these factors are dependent on the resistance of the wire, the amount of current and the length of wire.

ii) Switches and fuses: Fuses are used in PV systems to provide over current protection when ground faults occur and switches are used to manually interrupt power in case of emergency or maintenance. We connected a fuse between the array and the controller, since the battery is the major current source of concern in our stand-alone PV system. The function of the fuse is to ensure the protection of the modules from battery current should a ground fault occur when the controller is engaged. We also installed switches to isolate the array, battery, controller and load.

4) Connections: We took into consideration that poor connections are responsible for most problems in a stand-alone PV system. Also these poor connections may result to losses in system efficiency, system failure and costly troubleshooting and repairs. Hence we made our system connections secure and able to withstand extreme weather and temperature. We prevented our connections against corrosion by using copper conductors for system connections. Also we buried most of the wires with water pvc pipes for protection.

III. METHODOLOGY SYSTEM INSTALLATION

We employed structure mounting scheme whereby the arrays were mounted on a constructed six based galvanised pipes and screwed in tightly fitted into the structure as shown in Fig. 5. All the set up were mounted in a cubical located inside the open space between the 2 female hostels. Eight (8) galvanised pipes and some galvanised wires were used for the construction of the cubical. We mounted the four solar panels each sizing 16 by 9 inches 250W totalling 1000W or 1KVA on a constructed stand. It was elevated at 6.2 since latitude of Awka is 6.18o under the solar panel we mounted our batteries with the charge controller and the circuit breakers.

PV panels are rated for 25oC – far cooler than an actual panel in full sun. Increased carrier concentration at higher temperatures result in greater losses from recombination and concomitant power reduction. This was observed between January and March – and it results to very low production. Hence the stored energy in the batteries could not sustain the 6 LED security lights from dusk to dawn during the said period. But from April, till date when it started raining down here in the South Eastern Nigeria the PV panels were producing at its peak that do carry the load throughout the night.

While mounting our array we avoided shades for better output. Since the individual cells are arranged in series, so a shadow on one part of the panel can wipe out the panel output, essentially limiting the output current to that of the weakest cells. We located the panel as close to the charge controller and battery as possible to minimize wire length. The six different lamp heads were mounted on galvanised pipes located at the farthest measured 88.5m while the nearest measured 20.6m.

Fig. 5: The Cubicle

We had 2 lamp heads located inside the arena and four outside the 2 hostels. We did the wirings and passed the wires through PVC water pipes to avoid rusting. We used cement, sand mixed with stone to bury the conduits. The pictures below show the work in progress. The wirings were done by me with the assistance of my Professors and my post graduate students.

IV. SUMMARY

A properly designed PV system with adequate array, battery capacity and quality regulator can provide a power source many years of highly reliable energy.

In addition to PV modules, the components needed to complete a PV system include a battery charge controller, batteries; safety disconnects and fuses a grounding circuit and wiring. No PV system is maintenance-free. We scheduled regular inspections of our system to ensure that the wiring and contacts are free from corrosion, the modules are clear of debris and the mounting equipment has tight fasteners. We had been monitoring the power output of our PV modules, the state-of-charge and electrolyte level of our batteries, and the actual amount of power that our loads use. We had been writing this information in a NOTEBOOK as a good way of tracking our system's performance and this helps us to determine whether our system is operating as designed. Monitoring will also help us understand the relationships between our system's power production, storage capability, and local requirements. PV systems can be cost-effective options for providing electricity to our homes or remote site. PV can power our future in the South Eastern part of my country Nigeria. The very moment we switch unto PV systems, the power of the sun will take on a new meaning in our lives.

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