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COMPARATIVE STUDY OF THE EFFICIENCY OF STORAGE BATTERIES (INDIAN AND CHINESE TECHNOLOGY) USED FOR SOLAR SECURITY LIGHTING APPLICATION IN ANAMBRA STATE, NIGERIA

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ABSTRACT

Presently in Nigeria, most of the power generated is produced using fossil fuels and hydropower. These not only emit enormous carbon dioxide into the environment but will eventually run out. In order to make the development of electricity in the nation less harmful and sustainable, there is a need for the better source of substitute clean energy and solar energy technology is one of the fastest growing forces in the world. All effort is geared toward making the world green. Because of this sustainable source of energy is intermittent in nature, there is a need for the storage device to balance the load demand. The photovoltaic system directly converts the solar energy into electrical energy which is stored in batteries for use at night times when there is no sunlight. Hence there is a need for better the choice of storage batteries to save cost and promote the use of this sustainable renewable source of energy in the country. In order to choose the right storage battery, we want to compare the Chinese and Indian technologies in Nigerian markets. This thesis undertakes a comparative study of two commonly available storage batteries that are used in Nigerian stand-alone solar PV systems. The batteries considered were the Indian battery technology with specification Luminous, Deep cycle sealed maintenance free batteries solar application, Lum 12V 100Ah 20hr and 3DGP161433 and Chinese technology with specification Sun-Test std gel battery, 12V-100Ah, 010716w, Cycle use 14.4-15.0V, Standby use; 13.5-13.8V and Initial current: less than 30A was used to power 2 stand-alone security lights at the Faculty of Physical Sciences, Nnamdi Azikiwe University, Awka. The technical assessment was based on measuring their voltages, current and determining their efficiencies for a period of two months. From the graphical analysis, we obtained the average efficiency of Indian battery as 97.7% and Chinese battery as 91.6%. The efficiency of Chinese battery which was lower than the expected 95% from literature leads to the frequent discharge of the Chinese battery before day breaks hence does not lasts for a two day autonomy when subjected to the same climate and weather condition as the Indian battery, the thesis concludes that Indian battery seems to be the optimal solution for stand-alone PV system in Nigeria.

KEYWORDS: *Harmful and Sustainable, Climate and Weather Condition, to Prevent Large and Possibly Damaging Voltage Fluctuations*

INTRODUCTION

The depleting nature of fossil fuels has led to the development of renewable energies that are sustainable like the wind and solar. In general, the stand-alone photovoltaic system is preferred in developing countries like Nigeria where there is non-availability of constant electricity supply even in the urban areas. Because these renewable energies are intermittent in nature, they need an energy storage device to balance the load demand. These storage devices are needed to guarantee energy supply during times of no sunlight like in the night and times when the intensity of the sunlight is not enough like on cloudy days. Here in Nigeria, batteries are the most commonly used storage device.

Batteries in PV systems are arguably the most vulnerable component of the entire system. Design and operation faults such as array under sizing and charge controller breakdown can lead to battery failure making the system unable to deliver the anticipated power. The capacity of a battery is not fixed but instead depends on the temperature, discharge current, state of life and other factors, which makes the complex electrochemical devices depend on a large number of material properties meeting a defined standard to function correctly. These batteries are mainly used to perform three main functions in PV systems.

- As a buffer store to eliminate the mismatch between the power available from the PV generator and the power demand from the load,
- As an energy reserve device.
- To prevent large and possibly damaging voltage fluctuations.

Photovoltaic systems have been incorporated with different energy storage devices to increase the overall system performance where battery storage system seems to be paramount. Some research works focus on the battery sizing while others studied the types of converter suitable for battery applications. The need for storage is particularly evident in relation to renewable energy technologies which generate electricity in haphazard daily patterns, dependent on natural resources. Storage, in this case allows the energy to be utilized as and when it is required and then stored when it is not, therefore reducing wasted energy as much as possible (Huggins, 2010).

BACKGROUND OF THE STUDY

Solar energy is the energy from the sun. According to Iftikhar & Soba (2015), solar energy is the most demanding energy source due to the fact that it is the most abundant and most effective energy source on earth. A system is defined as the set of things working together as parts of a mechanism or an interconnecting network to perform a specific task. A solar PV system is a system whose function is to generate electricity using sunlight and supply electricity to the load when required (Chetan, 2016). In order to achieve this objective, many components are connected together in the solar PV system, other than PV modules. For example, a solar PV module can convert sunlight into electricity. This electricity is available when sunlight is there. But the load may need electricity supply during non-sunshine hours. Therefore in order to make the use of electricity generated by PV modules by the load as per desire, there is need to store energy for night time applications hence batteries are required as energy storage device of direct current, DC, sometimes loads can use only alternating current, AC power, therefore, the conversion of DC power into AC power is required. This power conversion is done by a device called inverter. Discharge rate is a battery's ability to release the electricity that is stored. A battery's discharge is an extremely important feature for all applications as it determines how much and how quickly electricity is available to the load (Kaldellis, ed. 2010). Different applications require different discharge response times. For example, for grid stability, short-term discharge of less than one minute is required. On the other hand, when in use with renewable such as stand-alone PV systems, the discharge time needed can take between minutes and hours (Ford & Burns, eds, 2012).

MATERIALS AND METHODS

The following materials were used for the stand-alone PV security lights located at the Faculty of Physical Science Nnamdi Azikiwe University, Awka.

- Rechargeable battery

Specification: 100Ah

- Charge controller

Specification: Voltage - 12/24V, Current – 10A

- Dc watt meter
- Cables
- LED bulb(20W)
- 2 galvanized aluminum Poles
- 2 Solar panels

Specification:

V_{OC} -20V

I_{SC} – 5A

V_{mp} _ 18V

I_{mp} – 4.44A.

The Indian technology with the following specifications on the battery was used for the study;

Luminous

Deep cycle sealed maintenance free batteries solar application.

Lum 12V 100Ah 20hr

3DGP161433

And Chinese technology with the following specifications on the battery was used for the study;

Sun-Test std gel battery

12V-100Ah

010716W

Cycle use 14.4-15.0V

Standby use; 13.5-13.8V

Initial current: less than 30A

Two methods were used for this study;

Design Methodology for Stand-Alone PV Security Light

The design of a solar PV system is about determining the number of ratings of components used in solar PV system to supply reliable electricity to the load which in our own case is the 2 security lights. The design involves calculating the values of different components required to make the complete PV system (namely the PV module, battery, charge controller and the LED bulb) which is capable of supplying electricity to the connected load as required.

Installation Methodology for Two Stand-Alone PV Security Lights

Installation is a process in which the different components are connected in a systematic order to make a perfect working solar PV system to meet predefined demands. Different types and a different number of components are used in PV system depending on the requirements. Here we are set to install two stand-alone PV security lights. The stand-alone PV systems as we have stated before simply means the self-dependent or autonomous solar PV systems. They do not depend on the grid or any other electric power supply that is why they are also called off-grid PV systems. In this research, we had two types of Installation, the mechanical and the electrical. The mechanical involves installing the materials used for mounting our solar panel. We laid the concrete base with the depth of 2.5ft for mounting the galvanized aluminum steel that is 14ft tall. The solar PV module was mounted on the fixed structure pointing to the south direction. The battery cages were constructed for the safekeeping of our batteries. On the other hand, the electrical installation involves connecting the electrical components of the system with the flexible wires. Our charge controller was rated 12/24V with six terminals for battery, panel and load connections. The battery was connected first to enable the charge controller to dictate the right voltage configuration. Then the two wires from the panel were connected to the charge controller and the load of 20W LED lamps was also connected to the charge controllers. The first installation was labeled A which contained the 12V Chinese battery while the second installation B contained the Indian battery also. Both were connected to loads of the samewattage, which is the 20W LED lamps each. The set up was monitored for a period of two months with the specified readings taken at different intervals.

RESULTS AND DISCUSSIONS

The data collected was analyzed using graphical methods with the aid of statistical package by name MINITAB 20

Table 1: Rate of Discharge of Indian and Chinese Batteries in the Month of March and April

Days	March				April			
	Indian battery		Chinese Battery		Indian battery		Chinese Battery	
	Current (A)	Voltage (V)	Current (A)	Voltage (V)	Current (A)	Voltage (V)	Current (A)	Voltage (V)
1	1.83	12.69	1.83	12.09	1.83	12.70	1.80	11.98
2	1.83	12.76	1.91	11.92	1.83	12.66	1.87	11.92
3	1.83	12.60	1.76	12.10	1.83	12.58	1.83	11.91
4	1.83	12.58	1.82	12.03	1.83	12.62	1.83	11.83
5	1.83	12.55	1.87	11.94	1.82	12.76	1.83	11.91
6	1.83	12.67	2.00	11.64	1.83	12.73	1.91	11.72
7	1.83	12.62	1.84	11.99	1.83	12.66	1.87	11.84
8	1.82	12.79	1.86	11.88	1.83	12.57	1.67	11.95

Table 1: Contd.,

9	1.81	12.86	1.77	12.08	1.83	12.63	1.75	12.19
10	1.83	12.65	1.84	11.97	1.83	12.61	1.83	11.97
11	1.83	12.57	1.83	12.03	1.83	12.59	1.85	11.96
12	1.83	12.69	1.87	11.92	1.83	12.67	1.75	12.21
13	1.83	12.72	1.87	11.97	1.83	12.66	1.71	12.21
14	1.83	12.66	1.89	11.80	1.83	12.65	1.81	11.92
15	1.83	12.71	1.79	12.22	1.83	12.62	1.79	12.00
16	1.83	12.65	1.76	12.25	1.83	12.67	1.81	11.95
17	1.83	12.57	1.91	11.94	1.83	12.68	1.89	11.70
18	1.83	12.72	1.83	12.00	1.83	12.69	1.91	11.77
19	1.83	12.78	1.84	11.99	1.83	12.58	1.90	11.93
20	1.83	12.80	1.84	11.95	1.83	12.69	1.85	12.01
21	1.82	12.83	1.87	11.97	1.83	12.66	1.92	11.61
22	1.83	12.74	1.92	11.86	1.81	12.78	1.92	11.90
23	1.83	12.61	1.88	11.94	1.83	12.67	1.88	11.70
24	1.83	12.54	1.94	11.70	1.83	12.74	1.78	12.03
25	1.83	12.59	1.93	11.69	1.83	12.66	1.88	11.71
26	1.83	12.62	1.91	11.86	1.83	12.70	1.86	12.01
27	1.83	12.59	1.82	12.07	1.83	12.57	1.88	11.71
28	1.83	12.58	1.79	12.17	1.83	12.62	1.89	11.70
29	1.83	12.59	1.82	11.97	1.83	12.66	1.78	12.03
30	1.83	12.68	1.84	11.86	1.83	12.65	1.83	11.97
31	1.83	12.68	1.81	12.03				
	1.828667	12.667	1.855	11.96	-	-	1.836	11.9083

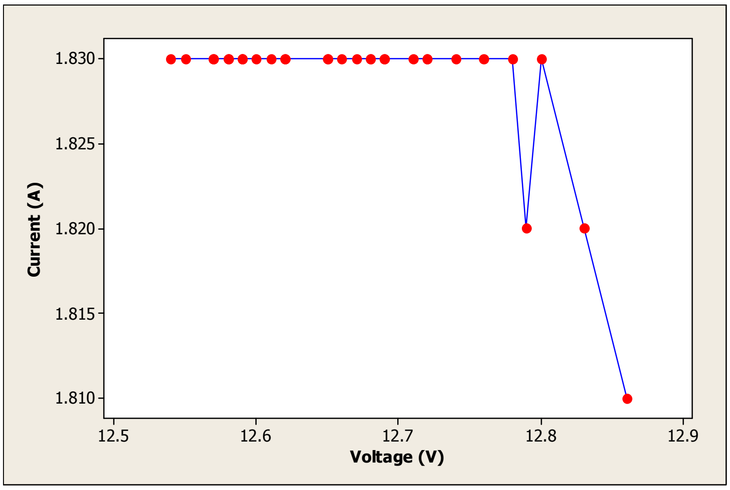

Figure 1: Graph of Current Verse Voltage of Indian Battery in the Month of March

(**Source:** Chetan, 2016). Since discharging time and charging time is the same thing, we neglected it.

From the analysis above, because the graph does not give us a rectangular shape because the current fluctuates and is not constant then, the efficiency of the battery is calculated using the formula below.

$$\eta = \frac{Discharging\ voltage \times discharging\ current \times discharging\ time}{charging\ current \times charging\ current \times charging\ time} \times 100$$

Discharging voltage = 12.667V

Discharging current = 1.828667A

Charging time = 12hours

Charging voltage = 12V

charging current = 2A

Chagrining time = 12 hours

$$\eta = \frac{1.828667 \times 12.667}{12 \times 2} \times 100$$

$$\eta = \frac{23.163}{24} \times 100 == 96.5\%$$

From the analysis, it shows that the efficiency of Indian battery in the month of March is high (96.5%).

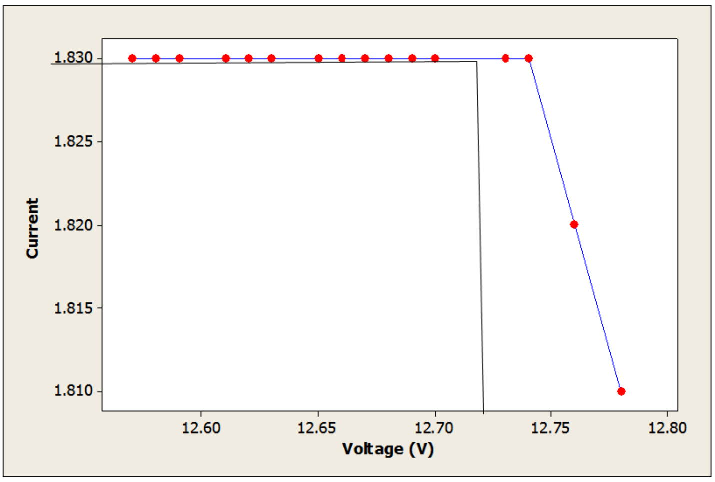

Figure 2: Graph of Current Verse Voltage of Indian Battery in the Month of April

(Source: Ikeh, 2003)

From the analysis above, because the shape of the graph gave us a rectangular shape, the efficiency of the battery is calculated using the formula below

$$\eta = \frac{area\ of\ the\ internal\ rectangle}{area\ of\ the\ external\ rectangle} \times 100$$

$$\eta = \frac{V_m \times I_m}{V_{oc} \times Isc} \times 100$$

Where V_m is maximum voltage = 12.74

I_m is maximum current = 1.829

I_{sc} is short circuit current = 1.830

V_{oc} is open Circuit voltage = 12.79

$$\eta = \frac{12.74 \times 1.829}{12.79 \times 1.830} \times 100 = \frac{23.26488}{23.424} = 98.9\%$$

From the analysis, it shows that the efficiency of Indian battery in the month of April is high (98.9%). The average efficiency for Indian battery is 97.7%

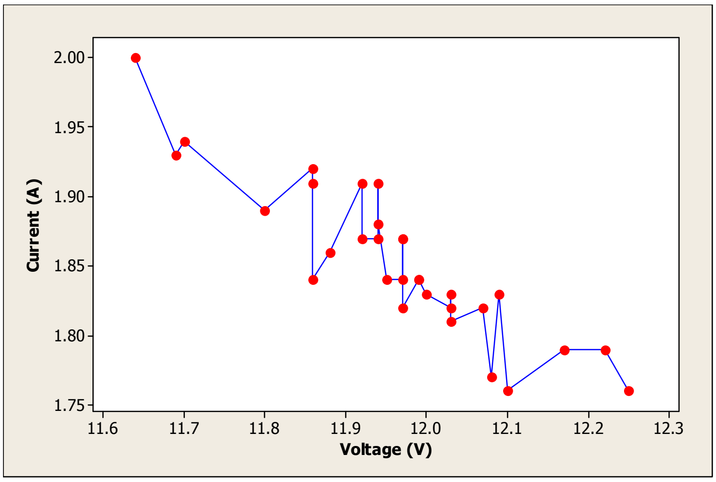

Figure 3: Graph of Current Verse Voltage of Chinese Battery in the Month of March

From the analysis above, the efficiency of the battery is calculated using the formula below

$$\eta = \frac{Discharging\ voltage \times charging\ current \times discharging\ time}{charging\ voltage \times charging\ current \times charging\ time} \times 100$$

$$\eta = \frac{1.855 \times 11.96}{12 \times 2} \times 100$$

$$\eta = \frac{22.18}{24} \times 100 == 92.2\%$$

From the analysis, it shows that the efficiency of Chinese battery in the month of March is lower than Indian battery (92.2%).

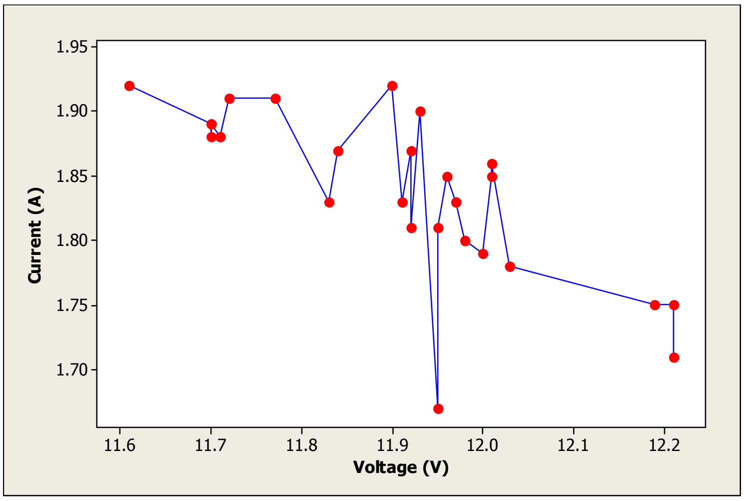

Figure 4: Graph of Current Verse Voltage of Chinese Battery in the Month of April

From the analysis above, the efficiency of the battery is calculated using the formula below

$$\eta = \frac{Discharging\ voltage \times discharging\ current \times discharging\ time}{charging\ voltage \times charging\ current \times charging\ time} \times 100$$

$$\eta = \frac{1.836 \times 11.9083}{12 \times 2} \times 100$$

$$\eta = \frac{21.86}{24} \times 100 == 91.0\%$$

From the analysis, it shows that the efficiency of Chinese battery in the month of April is lower than Indian battery (91.0%). The average efficiency for Chinese battery is 91.6%

CONCLUSIONS

Having done the analysis, it was observed from the analysis that Indian battery technology with this specification Luminous, Deep cycle sealed maintenance free batteries solar application, Lum. 12V 100Ah 20hr and 3DGP161433 have an average efficiency of 97.7%, last longer and longer lifespan than Chinese battery technology with specification Sun-Test std. gel battery, 12V-100Ah, 010716w, Cycle use 14.4-15.0V, Standby use; 13.5-13.8V and Initial current: less than 30Awith efficiency 91.6%. This analysis will help a lot of people in making choice of the battery to be used in solar security lightening application. The research showed that this Indian battery technology, Luminous, Deep cycle sealed maintenance free batteries solar application, Lum 12V 100Ah 20hr and 3DGP161433 last longer; it is more durable and more stable when powering a load into Nigeria. From the comparative study, this particular Chinese battery imported in Nigeria has high internal resistance and drops voltage faster in comparison with Indian technology.

RECOMMENDATION

The experiment can as well be carried out with other technologies i.e. German, American and Japanese technologies to know the overall best. The manufacturers of Chinese battery should improve on this particular battery with this specification Sun-Test std gel battery, 12V-100Ah, 010716w, Cycle use 14.4-15.0V, Standby use; 13.5-13.8V and Initial current: less than 30A for high demand. The use of security lights should be encouraged as we now have the battery that is cheap and easily affordable.

REFERENCES

1. *Chetan S.S. (2016). Solar photovoltaic Technology and Systems. A Manual for Technicians, trainers and Engineers. PHI learning Private Limited.*
2. *Ford, R.M and Burns, R.M. eds, (2012). Energy Storage Technologies for Power Grids and Electric Transportation, Nova science Publishers, Inc., New York.*
3. *Huggins, R.A.(2010). Energy Storage, Springer, New York*
4. *KHEMARIYA, M., & MITTAL, A. (2012). OPTIMAL DESIGN OF A SOLAR PHOTOVOLTAIC AND PEM FUEL CELL INTEGRATED ENERGY SYSTEM FOR RURAL AREA'. International Journal of Electrical and Electronics Engineering Research, 2(4).*
5. *Iftikhar J.K &Soba, E.R (2015). Installation of solar power system used for street lights and schools in Khyber Pakhtunkhwa, Pakistan. International journal of multidisciplinary sciences and engineering, Vol.6 No.10.*
6. *Kaldellis, J.K, ed.(2010). Stand-alone and Hybrid Wind Energy Systems. Oxford Cambridge, Woodhead Publishing limited, New Delhi.*