COMPARATIVE STUDY OF WEEKLY DISCHARGE RATE OF TWO SOLAR BATTERIES COMMONLY USED IN ANAMBRA STATE

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 need for better source of substitute clean energy and solar energy technology is one of the fastest growing forces in the world. Because of this sustainable source of energy is intermittent in nature, there is need for storage device to balance the load demand. Hence there is need for better choice of storage batteries to save cost and promote the use of this sustainable renewable source of energy in the country. This thesis undertakes a comparative study of weekly discharge rate of two solar batteries commonly used in Anambra State. The batteries considered were the Indian made battery with specification Luminous, Deep cycle sealed maintenance free batteries solar application, Lum 12V 100Ah 20hr and 3DGP161433 and Chinese made battery with specification Sun-Test std gel battery, 12V-100Ah, 010716w, Cycle use 14.4-15.0V, Stand by use; 13.5-13.8V and Initial current: less than 30A were 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 output voltages bihourly and estimation of weekly discharge rate of these batteries for a period of two months (eight weeks). From the analysis, the Indian made solar battery has insignificant discharge tendency for the first two months of its use whereas the Chinese made solar battery has a relatively high discharge rate of Voltage/hr per week within the first two months of its use. Also, while the Indian made battery is observed to be relatively stable, the Chinese made battery was observed to be very erratic and highly susceptible to discharge within the first two months of its use. Hence, it is concluded that Indian made battery is preferred to that of Chinese made battery for optimal performance of stand-alone PV system in Anambra State.

1. 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 energy storage device to balance the load demand. These storage devices are needed for 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.

Solar energy is the energy from the sun. According to Iftikhar, *et al.*, (2015), solar energy is derived from the sun and this energy is not only pollution free but also costless. 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 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. The load may require constant power supply, which may not be possible to provide by the PV modules or batteries in the system. Therefore, some kind of power conditioning may be required, which is referred to as the charge controller. In this way, in order to supply a reliable power to the load using PV module, several other components are required. The combination of all the components is referred to as solar PV system. Photovoltaic cells (solar cells) are placed under direct sunlight when the direct sunlight hits these cells; they convert the energy of light directly into electricity. (Bhutto *et al.*, 2012). Solar security lights are raised light sources which are powered by photovoltaic panels generally mounted on the lighting structure or integrated in the pole itself. The photovoltaic panels charge a rechargeable battery, which powers a fluorescent or LED lamp during the night.. Solar security lights are designed to work throughout the night. Many can stay lit for more than one night if the sun is not available for a couple of days. Older models included lamps that were not fluorescent or LED.

2. Background of the study.

Solar energy is the energy that is produced by the sun. Solar energy is also the energy produced by the sun in the form of heat and light. It is one of the most renewable and readily available sources of energy on planet earth. The fact that it is available in plenty and free and does not belong to anybody makes it one of the most important of the non conventional sources of energy (https://www.conserve-energy-future.com, 2018). A battery is an electric cell or a device that converts chemical energy into electricity. Batteries are basically the only method to store direct current (DC) power produced from sources like solar panels, wind generators, micro-hydro or generators. Batteries in PV systems are arguably the most

vulnerable component of the entire system. 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.

1. as a buffer store to eliminate the mismatch between the power available from the PV generator and the power demand from the load,
2. as energy reserve device and
3. to prevent large and possibly damaging voltage fluctuations (Nayak,2016).

Photovoltaic systems have been incorporated with different energy storage devices to increase the overall system performance where battery storage system seems to be paramount (Hon *et al.*, 2016). Some research works focus on the battery sizing while others studied the types of converter suitable for battery applications (Bazargan, *etal*, 2014). 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).

3. Materials

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

I. Rechargeable batteries: Indian technology with the following specifications;

Luminous Deep cycle sealed maintenance free batteries solar application. Lum 12V 100Ah 20hr, 3DGP161433 and Chinese technology with the specifications; Sun-Test std gel battery,12V-100Ah,010716w, Cycle use 14.415.0V, Stand by use; 13.5-13.8V and Initial current: less than 30A

II. Charge controller

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

III. Dc watt meter

IV. Cables

V. LED bulb(20W)

VI. metal galvanized poles

VII. Solar panels

Specification:

V_{OC} -20V

I_{SC} – 5A

V_{mp} _ 18V

I_{mp} – 4.44.

4. Methodology

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 the 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 different number of components are used in PV system depending on the requirements. Here, the two stand-alone PV security lights were installed. The stand-alone PV systems as stated before simply mean the self-dependent or autonomous solar PV systems. They do not depend on grid or any other electric power supply that is why they are also called off-grid PV systems. In this research, there were two types of Installations, the mechanical and the electrical. The mechanical involves installing the materials used for mounting our solar panel. The concrete base was laid with the depth of 2.5ft for mounting the galvanized aluminum steel that is 14ft tall. The solar PV module was mounted of the fixed structure pointing to the south direction. The battery cages were constructed for the safe keeping of our batteries. On the other hand, the electrical installation involves connecting the electrical components of the system with the wires. The charge controller used was rated 12/24V with six terminals for battery, panel and load connections. The battery was connected first to enable the charge controller 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 same wattage that is the 20W LED lamps each. The set up was monitored for a period of two months (eight weeks) with the specified readings taken at different intervals.

5. Results and Discussions

The data collected were analyzed graphically using Microsoft Excel. The data were collected from 19.00hrs to 7.00hrs of the immediate subsequent day from week one in January to week eight in February of 2017. These 19.00hrs to 7.00hrs of each subsequent day were transformed to 0-12hrs. That is 0, 2, 4, 6, 8, 10 and 12 hours respectively in order to carry out graphical analysis on the data. The output voltages of Indian made battery and Chinese made battery were recorded for each hour of the day and the average of the output voltages of each of the hours were calculated from the first day to seventh day of each week. That is, at different hours from 0^{th} hour to 12^{th} hour for each week starting from week one in January to week eight in February, the average voltage output were computed for both Indian made battery and Chinese made battery. For the eight weeks of the observation, table 1 shows the output average voltage discharge rate of the Indian made battery while table 2 shows the average output voltage discharge rate of Chinese made battery.

Table 1. The output voltage of Indian made battery with time

WEEK 1 DAYS 1-7	**HOUR**	**DAY 1**	DAY 2	**DAY 3**	**DAY 4**	**DAY 5**	**DAY 6**	**DAY 7**	**HR AVE**
19.00 HRS(GMT)	0	12.93	13.02	12.88	12.9	12.92	12.8	12.91	12.909
January	2	12.87	12.94	12.8	12.82	12.85	12.72	12.83	12.833
	4	12.81	12.86	12.73	12.74	12.77	12.66	12.76	12.761
	6	12.78	12.78	12.66	12.66	12.7	12.59	12.7	12.696
	8	12.75	12.73	12.6	12.58	12.62	12.51	12.62	12.630
	10	12.69	12.65	12.54	12.48	12.56	12.44	12.54	12.557
07.00(GMT)	12	12.63	12.57	12.48	12.42	12.49	12.36	12.45	12.486
WEEK 2 DAYS 8-14	0	13	12.8	12.91	12.82	13	13	12.9	12.919
	2	12.92	12.71	12.82	12.76	13.01	12.91	12.81	12.849
	4	12.84	12.64	12.75	12.68	12.94	12.82	12.74	12.773
	6	12.69	12.56	12.66	12.59	12.88	12.76	12.66	12.686
	8	12.77	12.49	12.56	12.49	12.79	12.68	12.57	12.621
	10	12.62	12.42	12.48	12.42	12.72	12.6	12.47	12.533
	12	12.56	12.36	12.4	12.36	12.64	12.5	12.38	12.457
WEEK 3 DAYS 15-21	0	12.95	12.9	12.91	12.8	13.1	13.13	12.97	12.966

	2	12.85	12.84	12.83	12.73	13	13.03	12.91	12.884
	4	12.76	12.78	12.75	12.67	12.91	12.94	12.84	12.807
	6	12.7	12.71	12.68	12.57	12.81	12.86	12.78	12.730
	8	12.62	12.64	12.59	12.48	12.7	12.67	12.7	12.629
	10	12.54	12.55	12.49	12.39	12.64	12.57	12.61	12.541
	12	12.44	12.46	12.41	12.33	12.55	12.51	12.53	12.461
WEEK 4 DAYS 22-28	0	12.8	12.92	12.75	12.94	12.9	12.8	12.85	12.851
	2	12.74	12.82	12.69	12.88	12.82	12.74	12.79	12.783
	4	12.67	12.72	12.62	12.82	12.73	12.67	12.71	12.706
	6	12.61	12.66	12.55	12.74	12.64	12.59	12.63	12.631
	8	12.52	12.59	12.46	12.67	12.56	12.52	12.54	12.551
	10	12.43	12.51	12.39	12.61	12.5	12.44	12.46	12.477
	12	12.37	12.42	12.33	12.52	12.41	12.35	12.4	12.400
WEEK 5 DAYS 29-35	0	12.9	13	12.97	12.9	12.9	12.8	12.85	12.903
	2	12.84	12.94	12.88	12.84	12.82	12.73	12.78	12.833
February	4	12.75	12.86	12.79	12.78	12.74	12.65	12.71	12.754
STARTS @ DAY 4	6	12.66	12.77	12.72	12.72	12.64	12.56	12.63	12.671
	8	12.6	12.69	12.64	12.62	12.57	12.49	12.54	12.593
	10	12.5	12.6	12.55	12.56	12.48	12.43	12.44	12.509
	12	12.4	12.5	12.45	12.5	12.39	12.36	12.36	12.423
WEEK 6 DAYS 36-42	0	13	12.97	12.9	12.95	12.85	12.8	12.8	12.896
	2	12.9	12.91	12.82	12.88	12.75	12.74	12.72	12.817
	4	12.84	12.63	12.75	12.81	12.67	12.68	12.64	12.717
	6	12.77	12.73	12.66	12.72	12.61	12.6	12.58	12.667
	8	12.67	12.64	12.58	12.64	12.55	12.53	12.5	12.587
	10	12.59	12.56	12.48	12.56	12.48	12.44	12.43	12.506
	12	12.52	12.47	12.42	12.47	12.4	12.38	12.37	12.433
									0.000
WEEK 7 DAYS 43-49	0	12.9	12.84	12.9	12.89	12.9	12.92	12.78	12.876
	2	12.82	12.7	12.82	12.83	12.82	12.84	12.72	12.793

	4	12.73	12.62	12.73	12.77	12.74	12.76	12.64	12.713
	6	12.66	12.54	12.66	12.69	12.66	12.67	12.57	12.636
	8	12.6	12.46	12.58	12.62	12.6	12.59	12.43	12.554
	10	12.51	12.39	12.51	12.55	12.53	12.52	12.36	12.481
	12	12.41	12.33	12.43	12.48	12.46	12.44	12.3	12.407
WEEK 8 DAYS 49-56	0	12.8	12.92	12.94	12.9	12.87	12.8	12.9	12.876
	2	12.73	12.84	12.86	12.84	12.8	12.73	12.83	12.804
	4	12.66	12.77	12.78	12.77	12.73	12.65	12.77	12.733
	6	12.58	12.7	12.71	12.69	12.65	12.59	12.69	12.659
	8	12.51	12.62	12.62	12.62	12.58	12.52	12.63	12.586
	10	12.42	12.53	12.52	12.53	12.51	12.44	12.54	12.499
	12	12.35	12.45	12.45	12.46	12.41	12.36	12.48	12.423

Careful observation of table 1 shows that the voltage discharge rate for the Indian made battery is relatively very low from 0^{th} hr to 12^{th} hr from week1 in January to the eight week in February. Apart from the very low discharge rate of the Indian made battery, the Indian made battery never tripped off throughout the period of the observation.

Table 2: The output voltage of Chinese made battery with time

WEEK 1 DAYS 1-7	**HOUR**	**DAY 1**	**DAY 2**	**DAY 3**	**DAY 4**	**DAY 5**	**DAY 6**	**DAY 7**	**HR AVE**
19.00 HRS	0	12.56	12.55	12.47	12.44	12.22	12.02	12.52	12.397
January	2	12.37	12.36	12.27	12.34	12.02	11.82	12.48	12.237
	4	12.17	12.16	11.97	12.14	11.83	11.62	11.92	11.973
	6	11.87	11.86	11.78	11.84	11.64	11.52	11.72	11.747
	8	11.77	11.76	11.58	11.74	11.54	11.42	11.52	11.619
	10	11.47	11.57	11.48	11.64	11.43	11.32	11.42	11.476
07.00HRS	12	Off	11.43	11.41	11.45	11.32	Tripped off	Off	6.516
WEEK 2 DAYS 8-14	0	12.35	12.39	12.44	12.55	12.49	12.38	12	12.371
	2	12.15	12.09	12.25	12.35	12.29	12.19	11.81	12.161
	4	11.95	11.89	11.95	12.19	12.09	11.99	11.61	11.953
	6	11.7	11.69	11.89	11.87	11.89	11.79	11.41	11.749

	8	11.5	11.49	11.69	11.97	11.69	11.59	11.31	11.606
	10	11.3	Off	11.44	11.65	11.49	11.29	11.11	9.754
	12	Off	Off	11.25	11.52	11.29	Off	11.01	6.439
WEEK 3 DAYS 15-21	0	12.48	12.74	12.9	12	12.7	12.54	12.56	12.560
	2	12.28	12.7	12.71	12.2	12.5	12.34	12.38	12.444
	4	12.09	12.5	12.51	12	12.25	12.15	12.18	12.240
	6	11.75	12.26	12.21	11.75	11.95	11.95	11.93	11.971
	8	11.7	11.9	12.01	11.55	11.75	11.7	11.74	11.764
	10	11.5	11.8	11.81	11.45	11.55	11.5	11.54	11.593
	12	11.3	11.5	11.51	11.25	11.35	11.3	11.34	11.364
WEEK 4 DAYS 22-28	0	12.57	12.58	12.37	12.09	12.08	12.15	12.8	12.377
	2	12.37	12.38	12.27	11.89	11.98	11.95	12.6	12.206
	4	12.18	12.08	12.07	11.79	11.79	11.7	12.54	12.021
	6	11.88	11.89	11.88	11.54	11.61	11.5	12.1	11.771
	8	11.68	11.69	11.68	11.34	11.41	11.34	11.96	11.586
	10	11.48	11.49	11.33	Tripped	11.31	Off	11.9	8.216
	12	11.29	Tripped	Tripped	Tripped	Tripped	Off	11.55	3.263
WEEK 5 DAYS 29-35	0	12.9	12.5	12.4	12.7	12.7	12.97	12.94	12.730
	2	12.7	12.31	12.2	12.56	12.86	12.71	12.84	12.597
February	4	12.4	12.11	12.01	12.36	12.61	12.47	12.64	12.371
STARTS @ DAY 4	6	12.21	11.81	11.71	12.19	12.26	12.28	12.34	12.114
	8	11.91	11.71	11.51	11.8	12.11	12.08	12.24	11.909
	10	11.71	11.61	11.31	11.7	11.65	11.98	12.14	11.729
	12	11.41	11.41	Off	11.47	11.45	11.91	11.95	9.943
WEEK 6 DAYS 36-42	0	12.72	12.52	12.75	12.7	12.79	12.94	12.65	12.724
	2	12.52	12.32	12.54	12.65	12.59	12.75	12.45	12.546
	4	12.33	12.26	12.34	12.45	12.39	12.55	12.07	12.341
	6	12.41	12.12	12.09	12.2	12.19	12.39	11.87	12.181
	8	12.04	12.02	11.83	12	11.99	11.94	11.6	11.917
	10	11.93	11.92	11.63	11.8	11.79	11.75	11.35	11.739

	12	11.82	11.72	11.3	11.6	11.59	11.35	11.35	11.533
WEEK 7 DAYS 43-49	0	12.74	12.8	12.5	12.28	12.58	12.2	12.05	12.450
	2	12.55	12.6	12.31	12.58	12.38	11.82	11.85	12.299
	4	12.34	12.35	12.11	12.38	12.16	11.62	11.65	12.087
	6	12.34	12.15	11.91	12.07	11.83	11.42	11.45	11.881
	8	11.83	11.91	11.81	11.92	11.65	0ff	Off	11.824
	10	11.63	11.71	11.61	11.68	11.43	Tripped off	Off	11.612
	12	11.43	11.51	11.51	11.48	Off	Tripped off	Off	6.561
WEEK 8 DAYS 50-56	0	12.4	12.56	12.57	12.58	12	12.59	12.08	12.397
	2	12.2	12.36	12.52	12.37	11.81	12.39	11.88	12.219
	4	11.9	12.11	12.12	12.12	11.61	12.2	11.68	11.963
	6	11.7	11.81	11.82	11.82	11.41	11.9	11.48	11.706
	8	11.4	11.61	11.62	11.62	Tripped off	11.7	Tripped off	11.563
	10	Tripped off	11.42	11.42	11.42	Off	11.51	Tripped	6.539
	12	Off	Off	Off	Off	Off	11.31	Tripped	1.616

For Chinese made battery, the output voltages were not steady, but observed to be erratic. From the first week of the study (Table 2), the Chinese made battery was observed to have started tripping off at 12^{th} hour of the daily observations. This characteristic of tripping off continued to be on the increase with the Chinese made battery for the rest of the weeks, the tripping off took place at earlier hours such as 12^{th}, 10^{th} and 8^{th} hours.

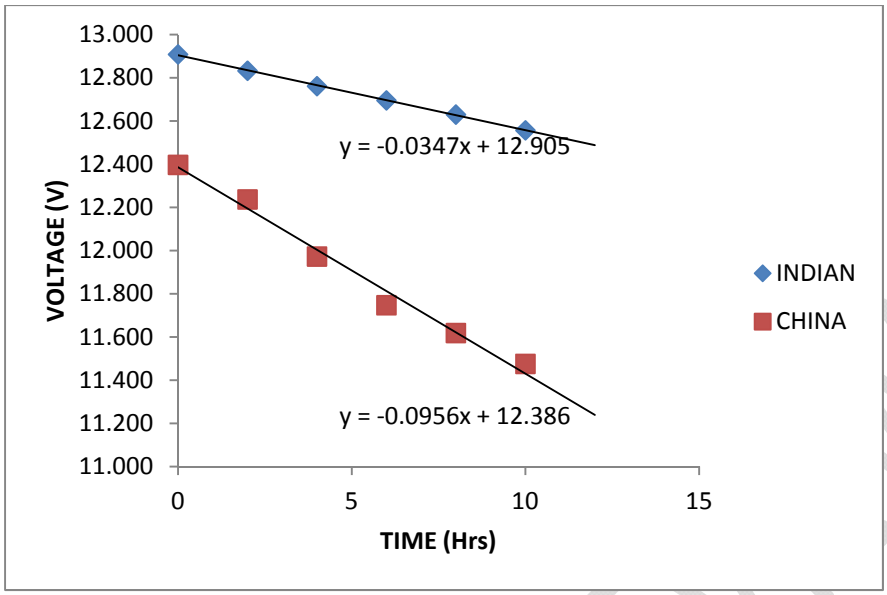


Fig. 1. Graph of average voltage against time in week one for Indian made battery and Chinese made battery.

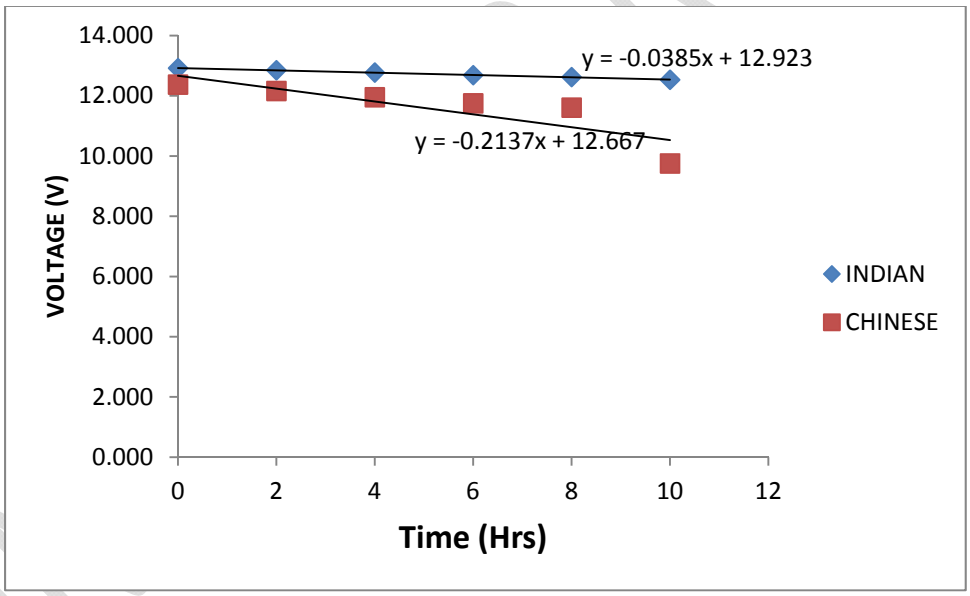
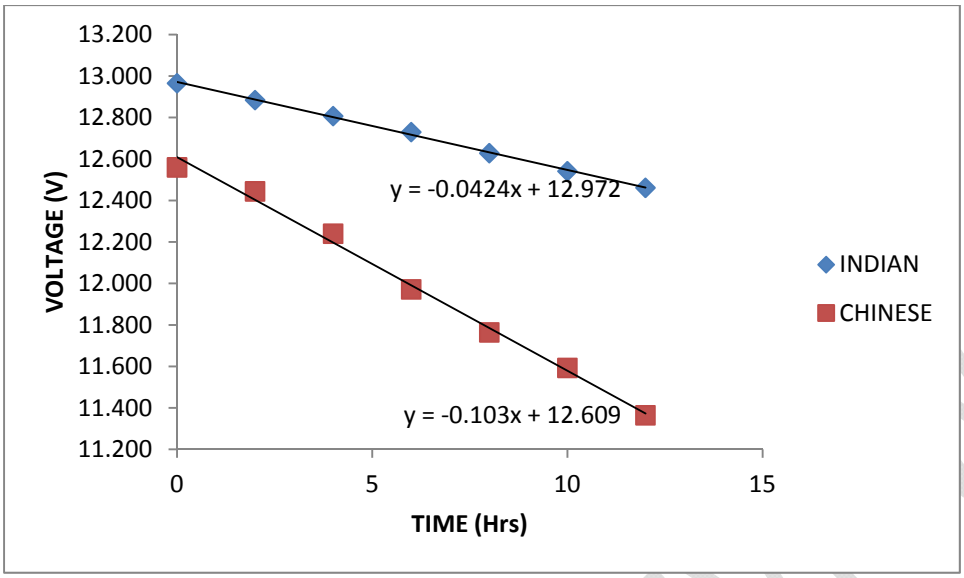


Fig.2. Graph of average voltage against time in week two for Indian made battery and Chinese made battery.



171

172 **Fig. 3. Graph of average voltage against time in week three for Indian made battery**
173 **and Chinese made battery**.

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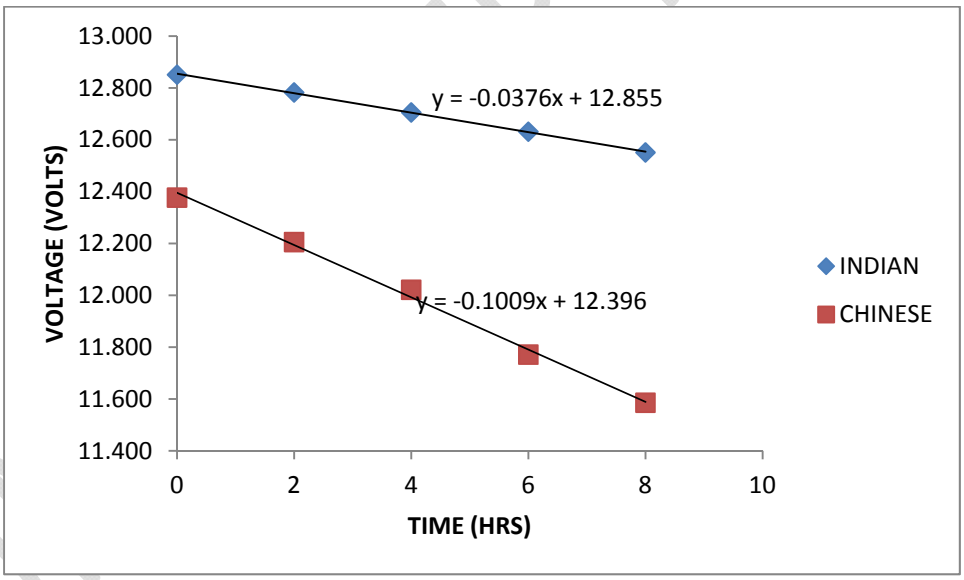

175

176 **Fig.4. Graph of average voltage against time in week four for Indian made battery**
177 **and Chinese made battery**.

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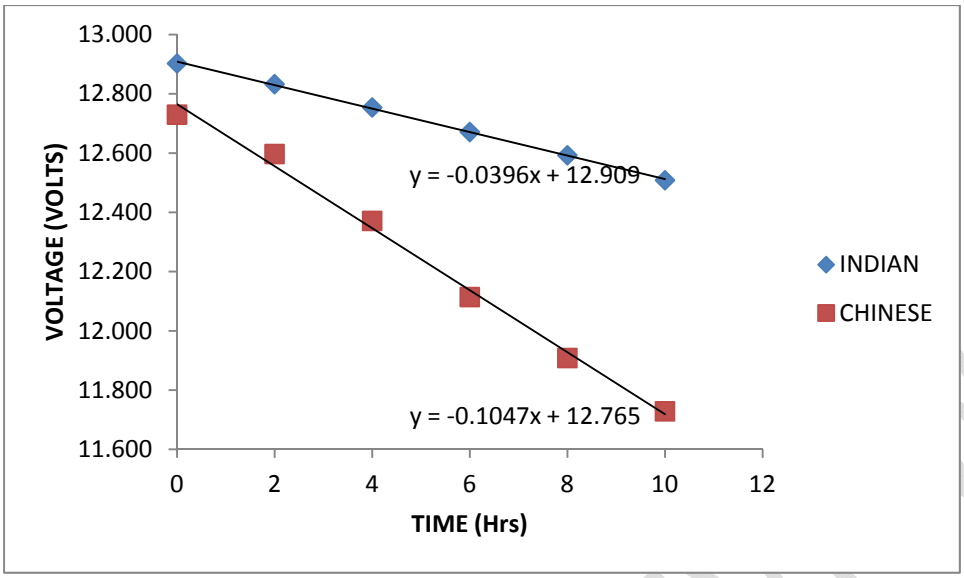

179

180 **Fig. 5. Graph of average voltage against time in week five for Indian made battery**
181 **and Chinese made battery**.

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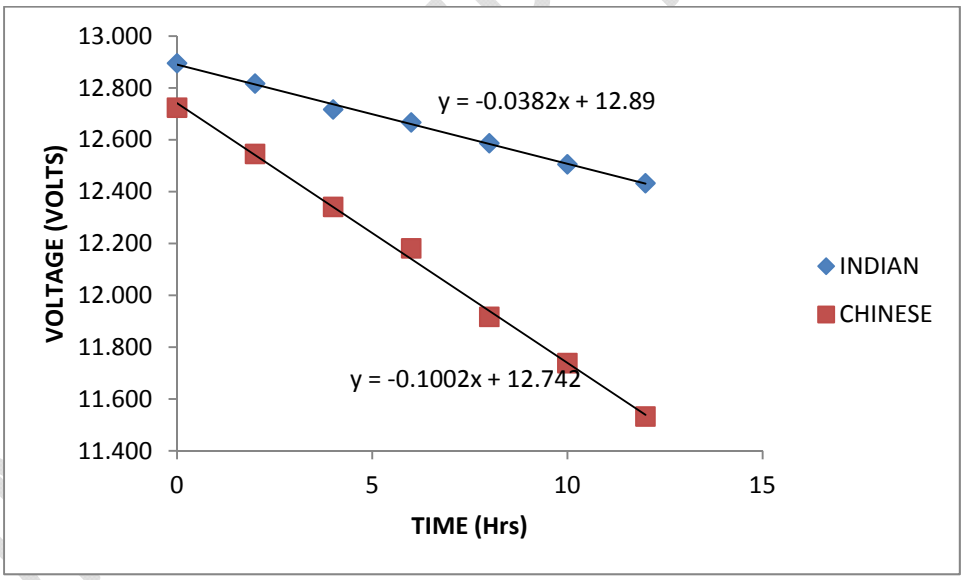

183

184 **Fig. 6. Graph of average voltage against time in week six for Indian made battery**
185 **and Chinese made battery**.

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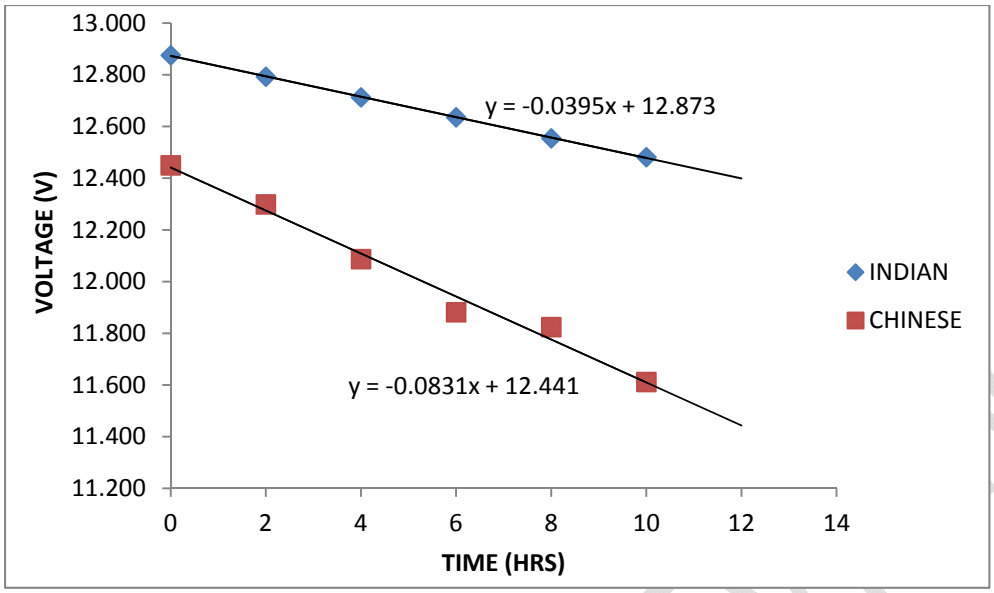

Fig. 7. Graph of average voltage against time in week seven for Indian made battery and Chinese made battery.

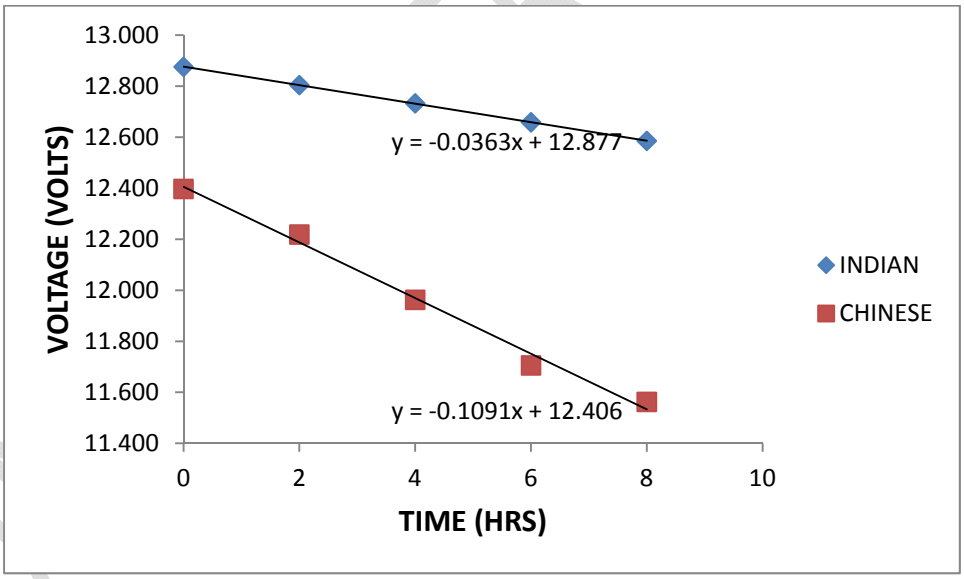

Fig. 8. Graph of average voltage against time in week eight for Indian made battery and Chinese made battery.

6. CONCLUSIONS

Based on the relevant steps taken on the foregoing research, the following conclusions are hereby drawn. Both the Indian and Chinese made solar batteries are usable in Anambra State metropolitan. In the first two months of the year, the Indian made Solar battery has insignificant discharge tendency and the Chinese made Solar battery has significant discharge tendency while in use. The erratic performance which characterizes the Chinese made battery is most likely owing to its poor charging capacity thereby completely off in some of its days of use hence the Indian made battery is preferable.

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