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Performance Evaluation of Solar Powered Battery Charger

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Abstract- The electricity needs of the college (Yaba College of Technology), Lagos state and in general Nigeria is at disturbing rate and the power demand has been at an alarming increasing rate. Generators are also expensive to run over a period of time consistently. This has led to sourcing for alternative means of energy generation to perform day to day. The solar powered battery charged was assembled, tested and found to be reliable, environmental friendly and above all efficient when compared to the national grid which is very epileptic in this part of the world. Three different test were conducted using the assembly solar battery charger. These tests include the charging rate and discharging or self-discharging rate of the sample battery that was charged. The initial voltage of the sample battery to be charged was taken, (11.20V) before charging; similar battery was then charged of eight (8) hours using solar energy, generator and the national grid (PHCN). The charging rate results obtained were 13.14V, 13.16V and 13.16V. the fully charged sample battery was then left for seven weeks (49 days) before the voltage was then taken in order to determine the self-discharging rate of the battery. The self-discharging rate results obtained from the sample battery charged using solar energy, generator and the national grid (PHCN) were 12.75V, 12.77V and 12.77V respectively. From these result, it can be said that battery charged powered by solar energy is as effective as one powered by generator set or the national grid (PHCN). This form of energy (solar) is a good alternative for local technician who are into the business of charging batteries as they are guaranteed up to 8hours backup time daily needed for charging their batteries.

Indexed Terms- Generator, Solar Energy, National Grid.

I. INTRODUCTION

There are about a dozen forms of renewable energy available on earth, and solar energy is one of these many forms. Solar energy conversion is one of the discussed topics in renewable energy field. Solar radiation can be converted into two forms of energy, electrical and thermal energy. Solar electricity has been in applications in numerous system such as powering rural area, water pumping and satellite communications. Solar power had been used large-scale grid connected system and small remote photovoltaic or stand-alone systems (Bica &Cristian, 2008).

Recent advancement in technological development in thin-film photovoltaic (PVs) is leading to new generation consumer portable and mobile solar panels. These newer solar powers are light in weight, durable, flexible, and have reported to be power efficient even up to 10% portable solar panels make solar power readily available for mobile power needs such as outdoor events, excursions and camping activities. It also provides portable solar power for laptops, computers and other mobile device which require electricity to perform its basic functions etc. The earth receives about 1x10^12 MW of energy from the sun every year. This is more than enough to cover earth`s energy demands for over 1000 times. Capturing sunlight and turning it into electrical for daily usage is a very good way to minimize expenditure and pollution. Solar energy has proven to be a clean and safe form of energy for our daily living. and is made available naturally around most part of the world, therefore; solar power is expanding beyond it`s traditional applications. Solar power is harnessed and stored by charging rechargeable batteries, using photovoltaic cells (Bioco et al.,2007).

- Battery charger

A battery charger is a device used to input energy into a secondary cell or rechargeable battery by forcing electric through it. It is a system design to convert AC current power source of 240V to DC current power source ranging from 3.5V to 24V.depending on the voltage rating of the battery. This simply means battery chargers do not generate electricity but rely on a power source which can either national grid, generator set and any renewable power source. In a charging system the battery charger must deliver a voltage high enough to keep the battery from discharging and low enough to avoid battery over charging which will drain and spoil the battery in both cases. An industrial battery charger is an electric unit used to charge up lead acid batteries. It is usually used in batteries or devices that have no independent charging system or a battery that is totally run down, to boost it back up (liping, 2010).

1.0 Battery Charging Techniques

Constant Voltage A constant voltage charge provides a high initial charge to the battery then it slowly decreases until the voltage level is lowered again. The constant charging of the battery with this method will cease once the full voltage of the battery is reached. Constant Current Using a constant current charger is one of the more effective ways to charge different types of batteries. The most common types that are best charged with a constant current include lithium-ion, nickel-metal-hydride and nickel-cadmium.

Not all types of these batteries require a constant charge. Many different constant current chargers are also not available for lithium cell batteries. These types of batteries require a certain voltage and a constant voltage charging requirement.

Trickle charge There are regulated and unregulated taper chargers available. A better choice of charging such batteries as a sealed lead acid battery is the regulated taper charger. These regulated taper chargers do not allow the voltage to reach more than a trickle charge. This, in turn, will allow the charger to be used to maintain the battery as well as charge the battery.

Pulsed Charges A pulsed charge is said to be used to provide any type of battery with an additional charge. This includes lead acid batteries as well as even car batteries. A DC charge is used to provide constant pulse of energy to the cells of the battery until it is fully charged. A pulse charger can also be used as a sort of trickle charger to maintain a charge once full capacity is met.

1.1 Problem Statement

The major problem solved by this project is the irregular power supply that is being experienced in the country. The solar panel converts the energy from the sun to a DC current constantly charged the battery during the day and the charged battery in turn be used for commercial charging purpose.

1.2 AIM AND OBJECTIVES

1.2.1 AIM

To carry out performance evaluation of a solar powered industrial battery charger.

1.2.2 Objective

- To assembly an industrial battery charge
- To assemble a 1.2 KVA solar powered renewable energy source
- To compare the charging rate and self-discharging rate of a battery charged by the solar
- powered industrial battery charger with that of generator and the national grid (PHCN)

1.3 Scope and Limitation

This project is limited to the performance evaluation of an assembled solar battery charge other applications of solar energy will be neglected.

II. LITERATURE REVIEW

2.0 Solar Energy

Solar energy is a clean, inexpensive, renewable energy source that is harnessed almost everywhere around the world, any point where the sunlight touches the surface of the earth is a potential solar generation location (George, 2009). Since solar energy is gotten from the sun this simply implies it is a limitless source of power generation. Renewable energy technologies are used to generate electricity with renewable is preferable to using fossil fuel. It took hundreds of years for oil and coal to form which is finite so every time this resource is burned to generate electricity this reduces the deposit of this resources. There would always be constant sunlight shining on the surface of the earth because of its readily availability and environmentally friendly characteristics, this form of energy should be used to reduce greenhouse effect.

2.1 Solar Panel Technology

This is the most important component of a solar energy system; it absorbs the sun energy which is in form of heat and converts this energy into electrical current. In this conversion process light (photons) to electricity (voltage) is called the solar photovoltaic (PV) effect. Photovoltaic solar cells convert sunlight directly into solar power (electricity). They use a thin layer of semi-conducting material that is charged differently between the top and bottom layers semi-conducting material can be encased between a sheet of glass and or a polymer resin. When exposed to daylight, electrons in the semi-conducting materials absorbed the photons, causing them to become highly energized. These move between the top and bottom surfaces of the semi-conducting materials. This movement of electrons generates a current known as a direct current (DC).

2.1.1 Types of solar panel

i. Mono crystalline panels
ii. Polycrystalline panels
iii. Thin film

Mono crystalline panels: As the name suggest are created from single continuous crystal structure. They can be identified by appearance as they appear as a single flat colour. They possess the highest efficiency rate since they are made from highest grade silicon; occupy less space and a life span of 25years.

Polycrystalline Panel: polycrystalline cells were previously thought to be inferior to mono crystalline because they were slightly less efficient. However, because they are cheaper to manufacture, they have now become dominant in the solar technology market. Thin Film Panels: Unlike mono and polycrystalline panels, they are new technology, they have solid black appearance they are bad when it comes to efficiency. But because they are cheaper to manufacture and occupy less space, they have less space they have taken over the solar technology market because they can be flexible which makes them appealing.

2.2 Battery

A deep cycle battery was chosen to power the system. The battery is a 12V and has a 200 Amp-hour capacity. Battery for PV system batteries gradually must discharge a smaller current for a longer period of time, and night or during the day. Deep cycle batteries are designed for the purpose of discharging to a lower capacity, between 20% and 50% than a conventional battery. The most used cycle batteries are lead-acid batteries and nickel-cadmium batteries, both of which have pros and cons. The deep-cycle batteries can be easily charged and discharged many times and can last for several years due to the thicker plate materials utilize. Batteries in PV systems can also be very dangerous because of the energy they store and the acid electrolytes they contain, so you`ll need a very well-ventilated, nonmetallic enclosure for them (Bioco, et al., 2007).

2.2.1 Types of Batteries

Batteries can be categorized in terms of the materials used to build them. They define in terms of capacity, cost and area of usage. In this categorization there are four major types.

- Nickel-cadmium (Ni-Cd) battery
- Nickel-metal hydride (Ni-Mh) battery
- Lead-acid battery
- Lithium-iron (Li-ion) battery
- Lithium polymer

2.3 Charge Controller

A charge controller is a device that can connect and disconnect the charger to the battery, and it take control over charging and stop charging at correct voltage. This helps to protect the batteries from damage, over charged and regulate the power from the solar panel to the batteries. A microcontroller in the circuit reads the level of the batteries and then cuts off the solar panel supply to the battery, once it sees the batteries fully charged. If this is not in place, the solar panel will keep feeding the battery energy and the batteries will become overheated and damage the internal component. The advantage of having a microcontroller in the system is that will enable the adding of features to the system. An example of such features is the LCD which displays the battery level of the system. It also ensures the adequate power available charge the battery, if they are insufficient power; it will prevent the system from being used until the sufficient power has been achieved. The microcontroller also aids solar efficiency (Gonzalez et., al 1998).

2.4 Inverter

An inverter is an important component to the solar battery charger system. It will convert the DC voltage generated from the solar panels to an AC voltage. An inverter can produce square wave, modifies sine wave, pulsed sine wave, or pure sine wave depending on circuit design, the two dominant commercialized wave form type of inverter of 2007 are modified sine wave and pure sine wave. There are two basic designs for producing household plug-in voltage from a lower voltage DC source, the first of which a switching boost a converter to produce a higher voltage DC are convert them to AC. The second method is converting DC to AC at battery level and use a line-frequently transformed to create a output voltage (Boico, et al 2007).

2.5 Battery Charger

A battery charger is a device used to put energy into a cell or (rechargeable battery) by forcing an electric current through it. Battery chargers typically have two task to accomplish.

- To restore battery capacity, often as quickly as possible
- To maintain capacity by compensating for self-discharged

A key factor prolonging battery life and obtaining optimum performance from it proper charging environment. This is only possible if the charging and voltage are properly controlled and matched to the battery temperature.

The circuitry to recharge the batteries in a portable product is an important part of any power supply design. The complexity and cost of the charging system is primarily dependent on the types of battery and the recharge time (Bioco et,.al 2007)

III. MATERIAL AND METHODOLGY

The battery charger was logically built. The solar panel and the battery were sourced from a local battery shop at alaba international market here in Lagos state. The installation was done using SCI-TECH E15625 Aluminum wire.

3.1 Material Specification Used

Table 1: show the material and its specification used for the project

S/N.	MATERIAL	SPECIFICATIONAS	QUALITY
1	Solar module	280W	1
2	inverter	1200V	1
3	Charge controller	12V	1
4	wire	E156525	1
5	Battery (lead acid)	200AH	1
6	Battery charger	250W	1
7	Voltmeter	MAS 830L	1
8	Clips (battery terminal)	copper	2
9	Screwdriver `	Flat & Star	1
10	Battery (Sample)	75AH	1

3.2 MATERIAL SIZING

3.2.1 Battery Sizing

The size of the battery was calculated with the formula

Bc (Ah) $= \frac{\text{Total watthour per day}}{Blc \times BDd \times NBV}$ …………………………………………..(1)

Where;

Bc = battery capacity in ampere hour.

Total Watts hour per day = Battery charger capacity x No. hrs

=150W x 9hrs=1350W

Blc = battery loss constant = 0.80

BDd = battery depth of discharge=0.75

NBV=nominal battery voltage=12V

Battery Capacity (Ah) = $\frac{1350 \times 1}{0.80 \text{ x } 0.75 \text{ x } 12}$ = 187.5 ≈ 200Ah

3.3 BATTERY BACKPUP TIME

The backup time for batteries in an inverter depends on the number of batteries as well as their capacity in Amp-hours.

Backup time= $\frac{\text{battery power in watt hour (Wh)}}{connected\ loads\ in\ Watts\ (W)}$…………………………………………….(2)

Battery Power (Watts)= Battery capacity (AH) x Battery Voltage (V) x No of batteries.

Backup time = $\frac{C\ Ah \times V\ Volt \times N\ (no\ batt)}{Connected\ Loads\ in\ Watts\ (W)}$………………………………………….(3)

Backup time = $\frac{2000\ X\ 12\ X\ 1}{150\ (w)} = \frac{2400}{150\ (w)}$ = 16

Backup time = 16hrs.

3.4 INVERTER SIZING

Inverter capacity (Ic) = $\frac{TW}{PF}$ …. (4)

Where; TW= Total wattage= 1350 W PF= power factor = 0.8

Ic= $\frac{1350}{0.8}$ = 1687.5

The inverter capacity can be estimated as 2000Va = 2.0KVA

3.5 SOLAR PV MODULE SIZING

Total watt hour needed from module= Inverter capacity=1687.5

The panel generation factor is to be considered for the estimation of the solar module requirement. It depends on the climate conditions and location of where the panel is to be used. The power generation factor in Nigeria is 3.41.

Peak watt needed for PV modules.

Wp = TWh/dPGF……………………………………………………………(5)

Where; Wp = peak watt

TWh = total watt hour per day = 1687.5

PGF(d) = power generator factor=3.41

Wp = $\frac{TWh}{d}$= $\frac{1687.5}{3.41}$ = 1687.5

= 494.86

Wp = 500

3.6 DESIGN OF THE TRANSFORMER

The transformer capacity needed to carry load of the batteries of one terminal. The rating was arrived at using the power formula for a single phase transformer.

P = $\frac{V\ X\ 1}{1000}$………………………………………………………..…………………………………………….. (6)

= $\frac{16}{9.8} = 0.1568$

= 16KVA

Where P is the power in KVA

V = output voltage of the transformer (16.0V)

I = Current of the transformer (9.8)

3.7 NUMBER OF TURNS REQUIRED FOR THE OUTPUT VOLTAGE

Using the formula $\frac{NS}{NP} = \frac{VS}{VP}$ ………………………………………………….. (7)

The number of turns required for the output voltage which is at the secondary coil was determined, given that primary turns (Ns) is 140.

$\frac{NS}{140} = \frac{16}{220}$

Ns = $\frac{140\ X\ 16}{220}$ = 10.18

Ns = 10 turns.

4.1 RESULT AND TESTING CARRIED

The battery charger, after being assembled was tested and found out to be able to charge 12 volts batteries of a rate capacity up to 200Ah. Theoretically, a 12 volt battery charger should be able to charge any volt battery as long as it produce an output of 13-14.4 volt, but the charging current is what determine the charging duration of the battery. The following test were carried out on the solar battery charger after assembling.

4.2 Charging Test using Solar Power

After the unit has been assembled, three different was conducted using the assemble solar battery charger. This test include the charging rate; discharging rate and self-discharge rate of a sample battery was charged. The initial voltage of the sample battery to e charged was taken using a digital voltmeter (MAS830L) and recorded (10.8V) before charging process commenced. The subsequence reading ware taken at an interval of 1hour for the nest eight(8) hours till the battery was fully charged. It should be noted that the charging level indicate became green after 15th hours but the battery it`s self was not upto 12.8 volt until about 25mins after.

Table 2: show the charging rate result after when using solar energy

Time (hrs)	0	1	2	3	5	4	5	6	7
Battery (V)	11.20	11.75	11.98	12.23	12.50	12.75	12.98	13.01	13.14

4.3 Self discharged test carried out on Battery Charge Using Solar Power

The voltage of the sample battery charge using the assembled solar powered energy was measured after it has been left for seven days the subsequence voltage was taken after a period of fourteen days and twenty one days in order to determine the self discharged rate of the shelf life of the sample battery.

Table 3: Show the discharging rate result obtained from the battery charge using solar

Time (days)	0	7	14	21	28	35	42	49
Battery (v)	13.01	12.95	12.95	12.92	12.92	12.88	12.82	12.75

4.4 Charging Test carried out using 2.4KVA Generator

The sample battery was discharged to the initial voltage of 11.20V before it was connected t the battery charger and then charge using a 2.4KVA generator. The battery voltage then taken at one hour interval and then recorded

Table 4: show the charging rate results obtained from battery using a 2.4kva generator.

Time (days)	0	1	2	3	4	5	6	7	8
Battery (v)	11.20	11.75	12.01	12.25	12.52	12.77	13.00	13.02	13.16

4.5 discharging test carried out on battery charged using 2.4Kva Generator.

The battery using the 2.4KVA generator was also left for a period of seven days before the initial voltage was taken and the subsequence reading were taken at an interval of fourteen (14) days and twenty one (21) days. The results were tabulated in table 5.

Table5: Shows The Discharging Rate Results Obtained From Battery Charged Using Generator

Time (days)	0	7	14	21	28	35	42	49
Battery (v)	13.02	13.01	12.98	12.94	12.90	12.86	12.83	12.77

4.6 : Charging Test Carried Out On The Battery Using The National Grid

The Sample battery was discharged to an initial Voltage of 11.20V before it was connected to the battery charger and then charged using the national grid. The battery voltage were then taken at one hour interval for eight (8) hours and then recorded.

Table 6: Shows the Charging Rate Result Obtained from Battery Charged Using National Grid

Time (days)	0	1	2	3	4	5	6	7	8
Battery (v)	11.2	11.75	12.02	12.28	12.52	12.77	13.01	13.02	13.16

	0									

4.7 Discharging Test Carried Out on Battery Charged using The National Grid

The sample battery charged using the national grid was left for a period of seven days before the initial voltage was taken and the subsequence reading was taken at an interval of fourteen (14)days and twenty one(21) days. The result were tabulated in table.

Table 7: shows the discharging rate result Obtained From battery charged using national grid

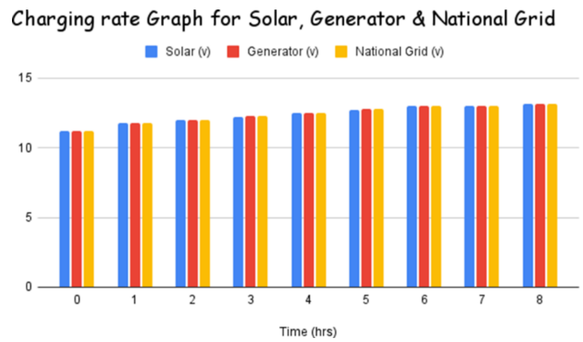
Time (days)	0	7	14	21	28	35	42	49
Battery (v)	13.02	13.02	13.00	12.96	12.90	12.88	12.85	12.77

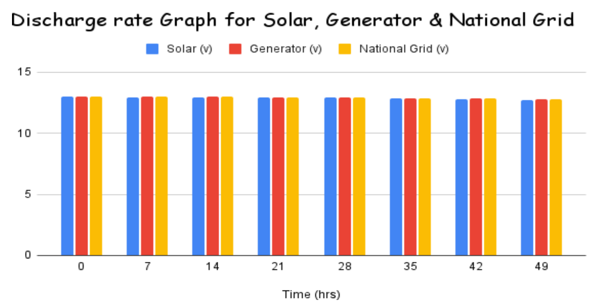
Table 8: Show tabulated charging rate for Solar, Generator and National Grid

Time (hrs)	Solar (v)	Generator (v)	National Grid (v)
0	11.20	11.20	11.20
1	11.75	11.75	11.75
2	11.98	12.01	12.02
3	12.23	12.25	12.28
4	12.50	12.52	12.52
5	12.75	12.77	12.77
6	12.98	13.00	13.01
7	13.01	13.02	13.02
8	13.14	13.16	13.16

Table9: shows tabulated discharging Rate for Solar, Generator and National Grid

Time (hrs)	Solar (v)	Generator (v)	National Grid (v)
0	13.01	13.02	13.02
7	12.95	13.01	13.02
14	12.95	12.98	13.00
21	12.92	12.94	12.96
28	12.92	12.90	12.90
35	12.88	12.83	12.85
42	12.82	12.83	12.85
49	12.75	12.77	12.77





4.8 DISCUSSION

A 200ah battery was used for the project backup power, and 70ah was used to carry out the charging and discharge test (sample battery). A 280watt mono crystalline solar panels was used because it possess the highest efficient rate since they are made from highest grade silicon; occupy less space and have a life span of 25years. A 1.2Kva Mpower inverter was used because of the ability to produce pure sine wave and still perform ultimately even at battery voltage, A Gpower solar module was chosen due to its cost and market availability.

After the unit had been assembled, three different test was conducted using energy from solar, generator are national grid to change the sample battery. This test include the charging rate, discharging rate and self discharging rate of the sample battery that was charged. The initial voltage of the sample battery to be charged was taken using a digital voltmeter(MAS830L) are recorded(10.8V) before charging process commenced. The subsequence reading ware taken as an interval of one hour for the nest eight(8)hours till the battery will be fully charged. It was noted that the charge level indicator on the battery charger became green after the 5th hour but the battery itself was not up to 12.8 volts until about 25mins after.

From table (8) it could be observed that both generator are national grid gave an equal voltage value of 13.16V after the sample battery was charged for 8hrs while solar solar power gave a value of 13.14V.

From table (9) it could be seen that the discharging rate of the charged sample battery after been charged for 8hrs and left for 49days, both generator are national grid gave an equal voltage value of 12.77V while solar power give a value of 12.75V.

4.9 MAINTENANCE SYSTEM

Do not allow the battery to stand idle for a long time, this may cause inactivation of the battery cell. After every complete discharge, the battery should be immediately charged. A battery cell should be charged at a normal rate with temperature check to make sure it does not exceed 40oC while can damage the battery cell. Due to high temperature. Voltage at each battery terminal should be checked before conclusion of the battery cell

4.9.1 SAFETY PRECAUSIONS

- Do not smoke near the battery
- Do not bring flame near the battery
- Wear splash proof clothing when working with the battery
- During preparing electrolyte always add the concentrated acid little by litle
- Never pour water into the concentrated acid

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The solar powered battery charger was assembled and tested. The result from table(8 &9). Show that the solar powered battery charger is reliable, cheaper, environmentally friendly and efficient; from this, the aims and objective of the project has been met.

5.2 RECOMMENDATION

Solar powered battery charger is as effective as when generator or the national grid is been used as sources of power, it is therefore recommended that

1. Solar power can be used as an alternative energy source for charging batteries.
2. When there is no available solar energy source, the backup battery should not be used more than 80% of system backup time.

REFERENCES

[1] C.E.Kennedy and H.Price “Progess In Development of High Temperature Solar Selective Coating”, Proceeding of ISEC2005, August 6-12 2005, Orlando, Florida, USA.

[2] C. Hua, J.Lin and C.Shen, “Implementationof a DSP-controlled photovoltaic system with peak power tracking”, IEEE Transaction on Industrial Electronics, Vol. 45, No. 45, february 1998

[3] Coker, J.O. (2004). Solar energy and its applications in Nigeria. Global Journal of pure acid Applied Sciences 10:pp 223-225.

[4] D. Bica. D. Cristian. “ photovoltaic laboratory for study of renewable solar energy”, 43 rd International Universities Power Engineering Conference . pp. 1-5, Sep 2008

[5] Erusiafe, N.E. and Chando, M.A.C (2010). Size – predication analysis for stand-alonephotovoltaic system.

[6] Nigeria Jounal of Renewable Energy,10:pp 15-27.

[7] F. Boico, B. Lehman and K.Shujaee, “ Solar battery chargers for NiMH Batteries”, IEEE Transacation on power Electronics, Sept 2007,Vol. 22, No.5,pp. 1600-1609

[8] George johnson “Piugging into the sun, National Geographic magazine, Sept. 2009.

[9] LipingGuodesign and and implementation of a Solar battery charger. American Society for Engineering Education2010

[10] M. Gonzalez, M.A Perez, J.C. Campo and F.J. Ferrero, “Accuratedetection algorithm of battery full- capacity under fast- charge”, Proceeding of Instrumentation and Measurement Technology Conference, 1998, Vo12,pp755-759

[11] M.A.S Masoum S.M.M Badejani and E.F. FUCHS, Microprocessor-controller new class of optimal battery charger for photovoltaic application,”IEEE Transaction on energy Conversion. Vol. 19, NO. 3, september 2004

[12] s.armstrong ,M.E Gilavin and W. G. Hurley, “Comparison of battery charging alogorithms for standalone

[13] photovoltaic system, “2008 IEEE Power Electronics Specialists Conference, pp. 1469-1475, june 2008