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The Use of Renewable Energy as an Alternative Power Supply to New Faculty of Management Science Building Rivers State University, Port Harcourt Nigeria.

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ABSTRACT: *The commonest alternative Source of Electric Power Supply is the use of Renewable Energy.Nigeria has a daily horizontal solar radiation ranging from 6.7kwh/m^2/day to 4.42 kwh/m^2/day during the month of August.Rivers State University, Portharcourt is strategically positioned within the Latitude of 4.4638N and Longitude of 7.0482E which means that it has sunshine all year round considering the Faculty of Management Science as a focal point. The Total Load of the Faculty of Management Science was accessed to be 354,473 Kilo-Watts,and the alternative Power Source was considered based on the required Load of the Faculty, The results obtained using Microsoft excel and PVsyst V6.55 software indicates that the comparative analysis between the 400KW solar panels and batteries, PHED and the 500KVA generator set, for duration of 25 years. Generator set and solar system has N210,595,420.00, PHED and solar system has N503,111,815.39, Generator set and PHED has N292,518,395.10. With some of the recommendation raised in this project research work it can be seen below that the solar system in Nigeria could be developed as viable means of achieving our electricity demand to meet up for office needs. (i). Government, independent power producers (IPPS), Schools, Colleges, polytechnics and Universities should align into solar energy courses and productions system, on solar Energy in our various institutions (ii) The PHCN should see solar energy system as another alternative means of meeting up our electricity demand in this global world.*

KEYWORDS:*Battery Sizing, Solar Panel sizing, Cable sizing, Cost Analysis, Cost Comparism, Inverter sizing. PVsyst V6.5 Software,*

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I. INTRODUCTION

The best alternative method of supplying electricity to the final consumers in this modern era is the non-conventional sources of energy also known as the renewable energy sources which are constantly sourced by natural process such as solar energy, wind energy, bio energy, wave and tidal hydro-powers, and thermal energy are some of the renewable energy sources[1]. The renewable energy converts the energy of the system into electrical energy such as sunlight, wind falling water from a higher potential area to a lower potential areas.[12]

Acknowledging the persisting power failure which the new faculty of management science has suffered over years now considering the increase in various appliances and inductive loads which also increases the load across the departments and to provide reliable power supply as an alternative means of electricity supply to the new faculty of management sciences building.[7]

II. LITERATURE REVIEW

2.1 Solar Energy Generation

Solar energy is the most cleanest and abundant renewable energy resources available, which could be refers to as the technology used to harness or extract the energy from the sun and make it useable.[20] "The renewable energy as well as solar energy in the developing areas is more affordable energy sources that offer means of power generation.[1]

2.2 Monocrystalline PV

There are monocrystalline PV modules that has the tendency to have the space effectiveness meaning that it has a minor space consumption. The cells are made with solitary silicon stones[13].The proposed most common plausible design of sun oriented PV system with design generator as back up for rural or localized area electrifications.[3]

2.3 Polycrystalline PV

The polycrystalline PV modules are produced using cell containing heaps of little silicon stones. It is less experience in function and less effective than the monocrystalline modules.[16]. The solar cell are mostly mounted or installed on a roof tops in other that it will convert the sunlight directly to coherent electricity.[4]The inverter plays a conical roles in any solar energy system and are often considered to be the brain of a projects.[12].

The solar cell are mostly mounted or installed on a roof tops in other that it will convert the sunlight directly to coherent electricity, and they are often used to power calculators and watches they are made up of some conductor materials similar to those used in computer chips.[18] "The renewable energy as well as solar energy in the developing areas is more affordable energy sources that offer means of power generation and added that as a result of the changing energy around the world[5]. Alternative energy store added that solar batteries are quite different from motor car batteries, and are called deep cycle Batteries which is capable of surviving prolonged, repeated and deep discharges which are off grid, the solar Batteries are key component in a standalone renewable energy system.[14].

"The solar lighting system for domestic uses is a fixed installation for domestic applications, it comprises of solar photovoltaic PV modules (solar cell) charge collectors, battery and lighting system (Lamp and fans)"[17].

In this system the solar cells are employed for supply of power, where the electrical energy is installed in batteries cells and are used for the lighting purposes when fully needed.[19] Through this system of lighting are useful in non- electrified rural area and as reliable emergency light system for important domestic, commercial and industrial application. Below are some solar lighting system which its modules needs a periodic dishing for effective and efficient performance.[15]

2.4 Solar Batteries

Solar batteries are really deep cycle batteries that provides energy storage for solar, wind and other renewable energy systems.[18]

Alternative energy store added that solar batteries are quite different from motor car batteries, and are called deep cycle Batteries which is capable of surviving prolonged, repeated and deep discharges which are off grid, the solar Batteries are key component in a standalone renewable energy system.[14] In the renewable energy systems, deep cycle batteries provides the energy storage for the system unlike the car battery, and to maintain heating batteries and prolong batteries life, the deep discharge is limited or limiting to 20% meaning that the deep cycle battery will be at 80% capacity better.[18]

2.5 Solar Inverter

A solar inverter or PV inverters is a kind of electrical converter which converts the variable direct current (DC) output of a photovoltaic (PV) solar panels into a utility frequency alternating current (DC) that can be fed into commercial electrical grid or used by local of-grid electrical network.[13]

2.6 Solar Charge Controller

A charge controller or charge regulator is basically a voltage and/or currents regulator to keep the solar batteries from overcharging. Its vital function is to regulate the voltages and currents coming or flowing from the solar panels to the batteries.[13]

2.7 Solar Energy Cables

The solar Energy photovoltaic cable or panel cables are PV cables used to interconnect solar panel arrays which is suitable for internal and external installation and connect the solar cells to the inverter or the direct current (DC) main cable, through the range of the photovoltaic cables can be roof mounted or buried directly in the earth. One good characteristic of photovoltaic cables is that they are halogen free flame retardant with low smoke properties ensuring the safety of the inhabitant in the event of fire source.[19]

III. MATERIALS AND METHOD

3.1 Materials

Nigeria has a daily horizontal solar radiators ranging from a higher of 6.70kwh/m^2/day to a lower of 4.42 kwh/m^2/day and receives abundant sunshine during the months of August.[2] Though the scientist measures the amount of sun light falling in a specific locations in a different time interval of the year by estimating the amount of sunlight falling on region at the same Latitude with similar climate measurement of the solar energy.[6] The solar radiation reaching the Rivers State University is enough since its local Latitude and longitude as 4^o, 4638.7N and $7^{0,}$ 048.24E.**[7]**

Therefore the materials used are;

- Backup generator
- PHED
- Inverter
- PV panels
- Batteries
- Charge controller

3.2 The Comparative Approaches

Using Microsoft Excel

PV Syst V6.5 Software as simulation approache.

3.2.1 Calculations on Electrical Components in each Department

Calculating on each of the electrical components in the departments using this formular.[15]

$$W_T = I_{sup} \times Q \times W \quad (1)$$

Where I_{sup} = start-up current

Q = quantity of each components

W = wattages

W_T = total wattages

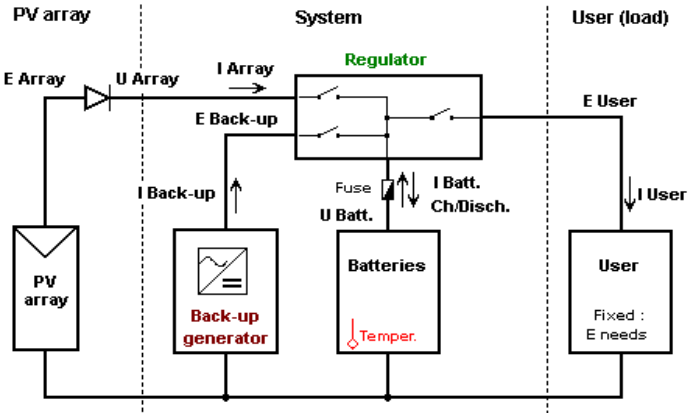

Figure 1: A Schematic Diagram for Solar PV and Battery System

3.3 Sizing of Generator System

To obtain the KVA of the generator, we divide the overall load in kilo-watts by the power factors of 0.8 [8]

$$KVA = KW/Pf \quad (2)$$

$$= \frac{355\text{KW}}{0.8} = 443.750 \backsimeq 500\text{KVA}$$

Which is approximately 500KVA generator set.

3.4 Inverter and Regulators Sizing

The inverter is primarily concerned with the proper conversion of the direct current (DC) into alternating current (AC) Inverter sizing is done by dividing the load demand by power factor of 0.8.[8]

$$= \frac{355000}{0.8} = 443750KVA \approx 5000KVA$$

3.5 Five (5) Days of Autonomy, Calculation for 9 Hour Per Day.

(Brito mc 2009) he stated that the measurement of rough energy storage required is the same as the result at the aggregate energy required by the hours in use.[9]

The statement is mathematically represented as;

$$Er = E \times H \quad (3)$$

E is the rough energy storage

E is the total energy

H is the total hours

Then E has the value of 400,000 watts

H has the value of 9 hours

Therefore $Er = E \times H$ (4)

= 400,000 x 9 =360,000

Er = 360000whd

So calculating for five (5) working days

$$Er = E \times H \times D \quad (5)$$

Where D is the Days of autonomy in the week

Er = 40000 x 9x5 = 1800000 whd.

3.6 The Safe Energy Storage (Es)

The safe energy in definition is the number of rough energy storage over the maximum depth of discharge.[9]

$$Es = \frac{Er}{DOD} \quad (6)$$

Where

Es is the safe energy

Er is the rough storage Energy

DOD is the max depth of discharge

$$Es = \frac{Er}{DOD} = \frac{1800000}{0.9} = 20000000whd$$

3.7Number of Series Connection (NS)

The system connection emerge both series and parallel.[9]

$$N_s = \frac{V_{DC}}{V_s} \quad (6)$$

Where N_s = Number of series connection

V_{DC} = Direct current voltage = 96

V_s = System voltage Assumed to be 12 volts

$$N_s = \frac{96}{12} = 8$$

3.8 Number of Parallel Connection (N_p)

Using this formula

$$N_p = \frac{P_{max}}{P_{mc} \times N_s} \quad (7)$$

Where N_p = Number of parallel connection

N_s = Number of series connections

P_{max} = Maximum power of the system

P_{mc} = Rated max power capacity of the system

$$Np = \frac{800000}{345 \times 8} = \frac{800000}{27CD} = 289855$$

3.9 Number of Photovoltaic Arrays or Number PVA Array System

Npvarrays = $N_p \times N_s$ (8)

= 289,855 x 8

= 2318.84

≈ 2500 modules

3.10 The Cost of Photovoltaic Panel for 400KW

Using this relationship between number of PV arrays, the unit price of PV panels and the cost of PV panels for 400KW monocrystal line is N65,000.[9]

$$C_{PV} = N_{p\,varrays} \times U_{ppv} \quad (9)$$

$$C_{PV} = 28985 \times 65{,}000 = 18{,}845{,}50$$

Where Cpv = cost of PV panels Uppv = unite price of PV panels, Npvarray = Number of PV arrays.

3.11 Batteries Size, Output and Input System Calculations.

The kinds of battery to be used mostly depends on the capacity of the battery and the time of the load considering its level of discharge and recharge.

3.12 Battery Bank Capacity.

The battery Bank capacity is measured in complex hours which is equivalent to the safe energy storage (Es) over the rated voltage of each battery (Vb).[9]

Battery capacity Cbb = $\frac{Es}{Vb}$ (10)

Cbb = $\frac{2000000}{2} = 10000Ah$

Where

Es = Safe Energy in whd

Vs = Battery voltage in Ah

Cbb = Battery Bank Capacity measured in ampere hour.

3.13 Batteries in Series/Parallel Paths.

The connection of batteries are either done by series connections or in parallel paths connections.

$$N_{bs} = \frac{V_{dc}}{V_b} \quad (11)$$

$$N_{bs} = \frac{360}{2} = 180$$

Now note that

N_{bs} = Number of batteries in series

V_{dc} = Voltage of the Direct current of input voltage

V_b = Battery voltage of the system

Number of Parallel paths (NPP) can also be calculating using the numbers of batteries to divided by the batteries connected in series.[9]

$$N_{pp} = \frac{V_b}{V_{bs}} \quad (12)$$

$$N_{pp} = \frac{718{,}75000}{180} = 3993055556$$

3.14 Number of Batteries

Since the system has a voltage of 360 volts and the system batteries is in multiple of 180 (Ah) ampere hours, then the number of batteries will be given as below.[10]

$$N_b = N_{pp} \times N_{bs} \quad (13)$$

$$N_b = 3993055556 \times 180$$

N_b = Approximately 719Ah

Where

N_b = Number of batteries

N_{pp} = Number Parallel Paths

N_{bs} = Number batteries in series

3.15 Cost of Batteries for 400KW Solar PV Panel System.

The cost of batteries depends mostly on the unit price of batteries and the number of batteries. Using this formula [8]

$$U_{pp} = \frac{C_b}{N_b} \quad (14)$$

$$C_b = U_{pp} \times N_b$$

$$C_b = 205000 \times 719$$

C_b = N14,739500

The cost of battery = N 14739500

Where

C_b = Cost of battery

U_{pp} = Unite cost or price of battery

N_b = Numbers of batteries

Table 1 Cable Size and Cost

S/N	Cable Types	Cable speci.	Quantity	Amount (N)	Total Amount (N)
1	PV TUV	$75mm^2$	7 Roll	27,000	189,000
2	Solar	$16mm^2$	2 Rolls	18,000	32,000
3	Cables	$10mm^2$	2 Rolls	12,500	25,000
4		$6mm^2$	2 Rolls	9,200	18,400
5		$4mm^2$	4 Rolls	6,000	24,000
6	Nigerian Cable	$25mm^2$	4 Rolls	3,000	12,000
	Total				300,400

3.16 The Cost of Energy from the Port Harcourt Electricity Distribution company (PHED).

The cost of one unit of power also known as 1 kwh or per kwh as at Feb 9th 2018 is N46.23 for commercial houses which is falls on category C_1 to C_3 in their tariff list 2018.[11]

Recall that 1 unit = 1Kwh = N46.23

Total kwh =Tkwh = watts x hours x numbers of days

Tkwh = w x H x Ndays

Where Tkwh is the total kilowatts hours

W = wattage of each component

H = Hours per day

Ndays = Number of days

Again to calculate the total cost of energy using this relationship

$T_{kwh} = Kw \times Kwh_c$ (15)

Where: TC_{kwh} = total cost of kilowatts hour

Kw = kilowatts in unit

Kwh_c = cost of kilowatts hour

Now using this equation (14and 15) above to develop table 2 below

Kwh/days = kw x Nhr

Where: Kwh/day is the kilowatt hour per day

Kw = kilowatts

Nhr= number of hours.

IV. RESULTS AND DISCUSSION

4.1 Results

The detail of the full load analysis of the entire building was done by putting in consideration all the necessary technical, durability and economical aspect of the solar photovoltaic energy.

Table 2.Shows the Result on the total Full load Analysis on each Appliances in the Entire Faculty. Official Building on the Ground Floor, First Floor Second Floor and the Third Floor.

S/N	Appliances	Quantity	Wattage	Total Load
1	A/C (Air condition 3hp/ 1.5 hp)	146	1117.5/2235	99368
2	Computers	174	100	17400

3	Fan	412	75	30900
4	Television	34	100	3400
5	Fridges	41	120	4920
6	Printer	20	30	600
7	Photocopiers	3	475	425
8	Lighting Point	945	11	10395
9	Projectors	5	300	1500
0	Standing Fan	3	60	80
11	Water dispersers	2	140	280
12	Decoders	7	21	147
Total Load				**354,473**

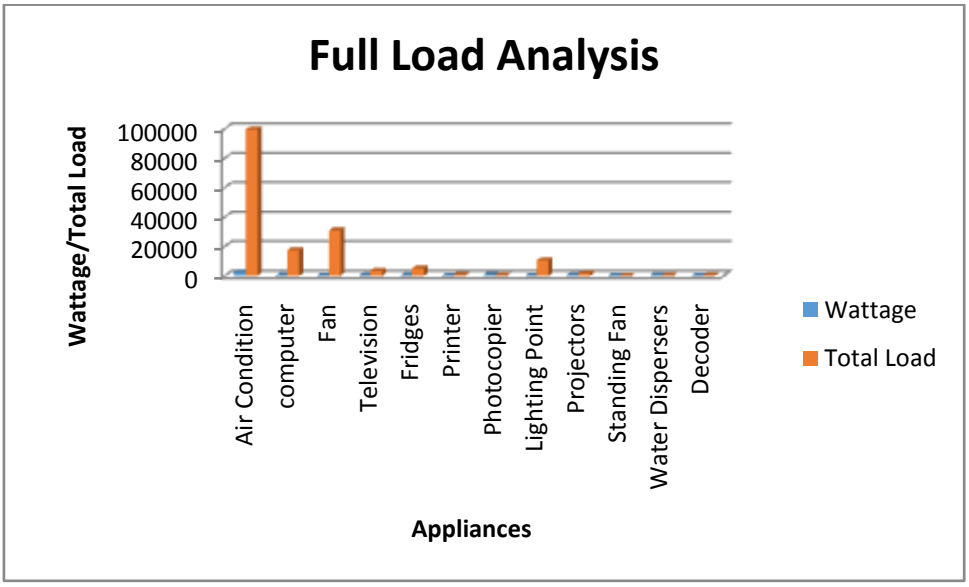

Figure. 2:The Graphical Representation of the total Full Load in the Entire Faculty of Management Science Building

Table 3: The Comparative Cost Analysis Between 400KW Solar Panel, PHED and 500KW Generator Set for 25 Years.

	400KW Solar/500KVA Gen	400KW Solar/PHED	500KVA Gen/PHED
	Generator set 471229892.00	PHED 763748287.39	PHED 763748287.39
	Solar PV 260636472.20	Solar PV 260636472.20	Gen. 471229892.00
Diff/Comp.	210595420.00	503111815.39	292518395.10

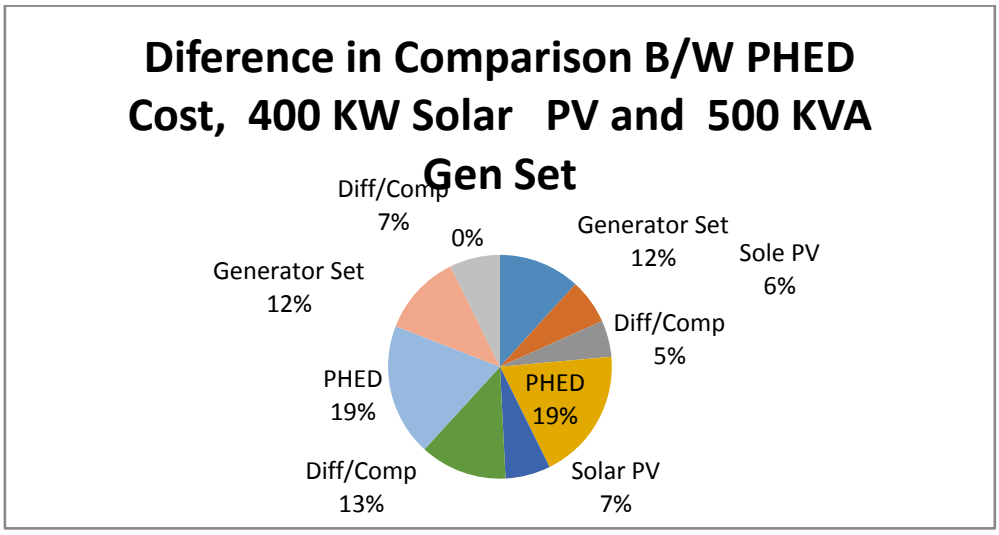

Figure 3: This Pie Chart Shows the Percentage in Comparison between PHED Cost, 400 KW Solar PV and 500 KVA Generator.

4.2 Discussions

The table 2 and table 3 above is the comparison difference in cost on operation and maintenance for 400KW solar PV/battery and the 500KW generator set for 25 years duration. The PV solar battery has a value of N354,036,287.00 (three hundred and fifty four million, thirty six thousand two hundred and Eighty seven naira. While the generator set is N744,969,15.00 (seven hundred and forty four Million, nine hundred and sixty nine thousand, one hundred and fifteen naira) with comparison difference of N390,392,828 (Three hundred and ninety million, three hundred and Ninety two thousand, Eight hundred and twenty Eight naira) Showing that the maintenance of the generator set is more expensive.

V. CONCLUSION AND RECOMMENDATIONS

5.1Conclusion

A comparison analysis was done, between the 400KW PV solar system, PHED and the 500KVA generator set for technical and economic reasons. The results obtained using Microsoft excel and PVsyst V6.55 software indicates that the comparative analysis between the 400KW solar panels and batteries, PHED and the 500KVA generator set, for duration of 25 years.

i. Generator set and solar system has N210,595,420.00
ii. PHED and solar system has N503,111,815.39
iii. Generator set and PHED has N292,518,395.10

The above results show that the 400KW solar PV/ battery and the 500KVA generator set has lesser amount and it is more better for power supply consideration the economic advantage

5.2Contribution to Knowledge Gap

The knowledge gap would help in planning and harnessing of energy demand, and cost of energy supply by PHED.

1. The expression in equation (1) was developed to calculate the electrical appliances in the entire faculty
2. The expressions in equation (15) (16) (17) was developed to calculate the cost energy supply by the PHED.

Therefore the above reasons and calculation will enhance the performance of the system of supply.

5.3Recommendations

1. Government, independent power producers (IPPS), Schools, Colleges, polytechnics and Universities should align into solar energy courses and productions system, on solar Energy in our various institutions
2. The PHCN should see solar energy system as another alternative means of meeting up our electricity demand in this global world.

REFERENCES

[1]. N. Alrikabi, and M. A., Kh. Renewable e Energy Types, Journal of Clean Energy Technologies. 2(1) (2014),. 61- 64.
[2]. Solar Energy – National geographic https://www. National geographic. Com
[3]. Girama. Common plausible design of sun oriented PV system (2013).
[4]. Jump up – New world record achieve in solar cells Technology (Press release 2016). 5-6.
[5]. RGS Energy (2013)
[6]. H. Aslaksen, and S. Y. Teo, (nd).The Analemma for latitudinal - Chnlleme1 People. Department of Mathematics National University of Singapore, Singapore 117543, 1-48
[7]. D. C. IdoniboyeobuandDumkhana. Research work on inverters (2010).
[8]. P.Amalu. Material on calculations of solar panels, Batteries, and inverters (2018).
[9]. M. C., Brito,.Energia SolarEotovoliaica.[Available] online:https://www.docplayer.net/3556743-energia-solar fotovotaica-mc-pv-systems-3-11-1009.html(2009), 1-25.
[10]. Jump up-E/A Electricity data www.ciagov. Retrieved 2016
[11]. PHED information.com. (www.PHED information.com)
[12]. D.Dergamini .The Universe usage of solar system.
[13]. E. Engineering. A Guide to photovataic (PV) System Design and Installation. Version 1.0, (2001).14
[14]. Energy Sources: Solar department of energy retrieved April 2011.
[15]. I.E.E Industrial electronics Magazines in March (2010).
[16]. G. Jonathan. A brief history of Solarpower. Available (online) https://eziniearticales.com, (2010)
[17]. M., Kolhe, K. M. I., Ranaweera, and A. G B. S., Gunawardana. Techno-Economic analysis of off-grid hybrid renewable energy system for SriLanka. (Available) online https://www.researchgate.net/publication/28173175(2015)
[18]. R. Margolis andJ. Zuboy. Nontechnical Barriers to Solar Energy Use: Review Recent Literature', National Renewable Energy Laboratory (NREL). Innovation for Our Energy Future, Technical Report NREL/TP-520-40116, Availableelectronically at http www.osti.gv/bridge, (2006).1-30.
[19]. M. M., Moulfson (2000).The Original and Evaluation of Universe and solar system.Pred Holy – Creation research society quarterly 1967.
[20]. T. J. J., The past History of earth as inferred from the mode of formation of solar system (1909).

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