Energy Audit And Standalone Solar Power Generation Design For Akwa Ibom State University Main Campus

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***Abstract*— An energy audit is the key to a methodical approach for decision-making in the area of energy management. Energy management and energy audit is conducted to use energy wisely, this leads to reduction in money spent on energy at a given institution, if the techniques recommendations given by the energy audit team are used. Through efficient energy management and auditing methods, environment can be protected, energy and money can be saved without affecting the quality work in any sector. This work briefly describes the importance of energy audit and energy management in Akwa Ibom State University (AKSU) main campus. Also, Off-grid (stand-alone) photovoltaic (PV) systems have become widely adopted as reliable option for electrical energy generation. In this paper, the electrical energy demand (load) of Akwa Ibom State University's main campus was estimated based on watt-hour energy demands. The estimated load is 6021 kWh/ day, and 4380kwh/day when energy management techniques are applied. An off grid PV system was designed based on the estimated load, where the PV components: PV modules, number of batteries, a voltage regulators and an inverter were sized accordingly. The cost estimate of the PV system is relatively high when compared to that of the fossil fuel generator used by the University. The payback period of the system is estimated to be 6.4 years and 4.6 years (when management techniques are applied), which is obviously much shorter than the lifespan of the selected PV module which is 30 years.**

Keywords—energy audit; solar energy; payback period; load demand; sizing

I. Introduction

Across residential areas in Nigeria, the consumption of electricity is about 55.4 percent of the total electricity consumption, according to data published in 2018 and 2019 [2][20][22]. This could be a result of the Development in the social-economic sector, which has made energy an indispensable resource [4][5][6][8] . However, with the increase in development and population, the energy demand far exceeds the supply. Electricity, which represents 40% of the total energy used in many countries and is primarily used to run equipment in industrial, commercial, residential, and utility applications, is required as an input. A lot of industrial machine drives are powered by electricity, where various speed controls for varieties of industrial processes and applications are enhanced.[8][14][16] [17] In developing countries like Nigeria, where electrical energy resources are scarce and the production of electricity is very costly, energy conservation studies are of great importance. In order to reduce energy consumption for sustainable and energy-efficient manufacturing, continuous energy audits and process tracking of industrial machines are essential [6]. An energy audit involves proper planning, directing, and controlling the supply and input-output ratio of energy consumption to maximize productivity and minimize energy costs.

In a quest to minimize the cost and environmental impact of electricity generation, renewable energy has been the best alternative, and the best in terms of availability and simplicity is solar energy.[1] [3][19]. Solar irradiation varies in Nigeria according to season, but it recorded about 5.25 kWh with an average sunshine hour of 6.5 hours. Also , depending on the location, it receives an average of 20 M/m2 [9][10][11][12]. Several works have been done to maximize the efficiency of the solar system: [11] worked on the best angle placement of the solar panel for maximal irradiation at south-south Nigeria; [14] also compared the onshore and offshore solar potential, which informed the actual design parameters at both locations; This paper involves an energy audit of Akwa Ibom State University main campus and a solar energy system stand-alone design for the load demand.

II. Methodology

The electrical appliances (loads) available at the University were first itemized with their power ratings and time of operation during the day to obtain the total energy demand in Watt-hours per day by the university. The average yearly radiation of AKSU was gotten from the National Aeronautic and Space Administration (NASA) Website. The total energy demand obtained was then used to determine the proposed off-grid photovoltaic system components sizes.

A. *The daily load profiles*

The daily load profiles were determined by calculating the power demand (kWh/day) for all load types of appliances in the

the study area and the value of average solar radiation in the same location. The sizes of its components were carefully determined using approved electrical laws that guide a standard circuit design. Also, the sizes of cables and wire are a major decision in PV system design; hence, the National Electrical Code was used in wire and cable sizing [12]

Table 1: Daily load demand

Hour(hi)	Facility 1 l_{1hi}	Facility 2 L_{2hi}	Facility 3 L_{3hi}	……….	Facility n, l_{nhi}
0	P(1,0)	P(2,0)	P(3,0)	………	P(n,0)
1	P(1,1)	P(2,1)	P(3,1)	……….	P(n,1)
2	P(1,2)	P(2,2)	P(3,2)	……….	P(n,2)
………	…….	……….	……….	………	……….
23	P(1,23)	P(2,23)	P(3,23)	………	P(n,23)
Daily demand	$\sum_{ki=0}^{23} P(1, ki)$	$\sum_{ki=0}^{23} P(2, ki)$	$\sum_{ki=0}^{23} P(3, ki)$	………	$\sum_{ki=0}^{23} P(n, ki)$

University main canpus. The total daily load demand, lnd is calculated from hourly load demand.

$$lnd = \sum_{i=1}^{24} \ln ki \quad \text{(I)}$$

Where; L_{nd} = Daily load demand of facility l_n, n=1,2,3,4,5,6…….nth

l_{nhi}* = *Hourly load demand of facility ln, hi = 0,1,2,3,4………..23th hour

From the above expression, table format for the hourly load profile is shown Table 1.

Where P(n,hi) = power consumed by facility l_n at *hi* hour

Also, total hourly load is given as, $\sum(p(ln, hi))$, where n= 1,2,3,4…… and

hi = 0,1,2,3….23th hour, where the highest value is the peak load. Hourly load demand for Akwa Ibom State University has been given as Table 3.1 and Table 3.2, respectively. The energy audit was carried out in the study area, where the load demand of each appliance was investigated using Table 1 as a guide. The energy demand of each appliance was known by its total hourly energy consumption. It has been found that this study area's site consumes energy at a rate of around 6021 kWh per day, with a load demand of nearly 993 kW. Based on the audit, when the load demand of each appliance was given a more energy-efficient product and the lower load was used to give the same performance, the energy demand was reduced by almost 30%.

B. *Meteorogical Date*

The meteorological data was gotten from the latitude of 4.7575°N and longitude of 7.7205°E at Akwa Ibom State University in the Mkpat Enin Local Government Area. The data includes monthly and daily solar radiation and ambient temperature

C. *PV system design considerations*

The system voltage, number of solar panels and connection type, size of inverter, number of batteries, and overall capacity depend on the load demand in

The design is described in detail in the subsequent sections.

D. *Determination of PV Array size*

The PV array output power is realized from by equation 1 [7].

$$P_{pv\ array} = \frac{E_l}{\eta_{bo} * K_{loss} * H_{tilt}} * PSI \quad (2)$$

E_L = Estimated average daily load energy consumption in kwh/day

Where, E_L = Estimated average daily load energy consumption in kwh/day

H_{tilt} = Average solar radiation in peak sun hour's incident for specified tilt angle.

PSI = Peak solar intensity at the earth surface (1kW/m^2)

η_{bo} = Efficiency of balance of system

K_{loss} = A factor determined by different losses such as module temperature, losses, dust, etc.

$$\eta_{bo} = \eta_{inverter} \times \eta_{wire\ losses} \quad (3)$$

In this design $\eta_{inverter}$ and $\eta_{wire\ losses}$ are taken as 95% and 90% respectively[3] [7][15].

$$K_{loss} = f_{man} \times f_{temp} \times f_{dirt} \quad (4)$$

f_{man} = manufacturer's tolerance , f_{temp} = Temperature de-rating factor ,f_{dirt} = De-rating, an acceptable de-rating would be 5% [w]

f_{temp} , according to is given by equation 5

$$f_{temp} = 1 - [Y(T_{cell.eff} - T_{STC})] \quad (5)$$

Y = Power temperature co-efficient , $T_{cell.eff}$ = Average daily temperature in oC , $T_{cell.eff}$ = can be determined by equation 5 [7]

$$T_{cell.eff} = Ta.day + 25 \quad (6)$$

Since in AKSU is a busy with a lot of academic activities, f_{dirt} is taken as 95%. From equation 3,

E. *Number of modules in series*

The number of modules in series N_{ms} and parallel is given in equations 6 and 7. This is done using the design parameters [1][3]

$$Nms = \frac{V_{system}}{V_{module}} \quad (7)$$

$$Nmp = \frac{P_{Pv\,array}}{Nms \times P\ modules} \quad (8)$$

Total number of modules is given by equation 8 [44]

$N_{mt} = N_{ms} * N_{mp}$ (9)

F. Determination of Battery bank capacity

The capacity of the battery bank is determine from equation (12) [12] [13]

$$C_x = \frac{N_c * E_l}{DOD_{max} * V_{system} * \eta_{out}} \quad (10)$$

C_x = Required battery capacity, N_c = Number of days of autonomy , E_L = Estimated load energy in Wh

DOD_{max} = Maximum depth of discharge, η_{out} = Battery loss

1) Determination of the required battery bank capacity

The battery capacity was sized based on all the recommended standard conditions from the manufacturers. In this design, the allowable maximum depth of battery discharge and the day of autonomy is taken as 75% and 4 days respectively . The battery bank capacity required (Cx) is given by equation (10) [16][3].

2) Specification of Batter

The battery has a capacity of 325AH and a nominal voltage of 12V. From equation 10, number of batteries required (N_{breq}) is got from equation (10);

$$N_{breq} = \frac{C_x}{C_{selected}} \quad (11)$$

Number of batteries in series is given by equation (11)

$$N_{bs} = \frac{V_{system}}{V_{battery}} \quad (12)$$

Number of batteries in parallel is given by equation (12)

$$N_{bp} = \frac{N_{breq}}{N_{bs}} \quad (13)$$

G. Determination of Inverter and voltage regulator sizes

In sizing the inverter, equation 60 is used, where the Power of appliances running simultaneously, the Power of large surge current appliances, and the safety factor of 1.25 are considered. The PV array and battery are two major factors that influence the choice of voltage regulator. The number of voltage regulators and rated currents are determined by equations (14) and (15), respectively.

$$P_{total} = (P_{RS} + P_{LSC}) * 1.25 \quad (14)$$

P_{total} = Inverter power rating (size) , P_{RS} = Power of appliances running simultaneously

P_{LCS} = Power of large surge current appliances

$$N_{vreg} = \frac{I_{rated}}{I_{selected}} \quad (15)$$

H. Payback Period (PB)

The payback period [16][1] is given as

$$PB = \frac{OC}{TEC} \quad (16)$$

Where OC is overall cost of the PV system, TEC is total estimated cost of the diesel generator for the first year

III RESULTS AND DISCUSSION

This section deals with the data on the load demand of the study area and the energy management strategy, as well as the results of the PV energy system design for Akwa Ibom University's main campus.

I. Load Demand Profile

The hourly load demand profile and load demand profile of Akwa Ibom State University's main campus are shown in Table 1 and Fig. 1. From Table 1, the peak load is 993 kW, while the hourly daily load demand is 6021 kW/day. The energy consumption was duly investigated, and it turned out that some of the appliance ratings can be replaced with a lower economy wattage and will produce even better than what is obtainable presently. When these ratings were replaced, we had the load demand presented in Table 2 and the hourly load profile in Fig. 2. Hence, 30% of the energy was saved.

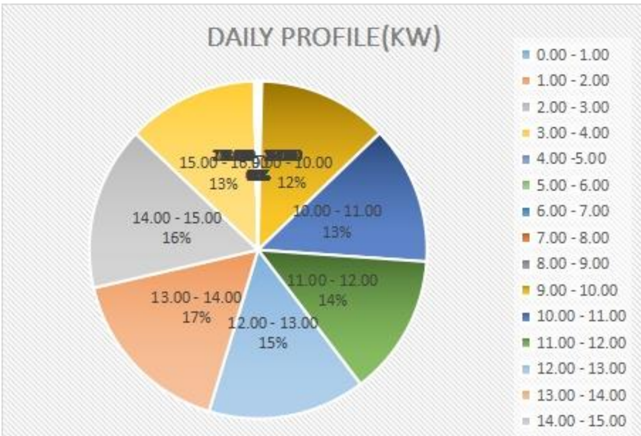

Fig. 1: Daily load demand profile 2

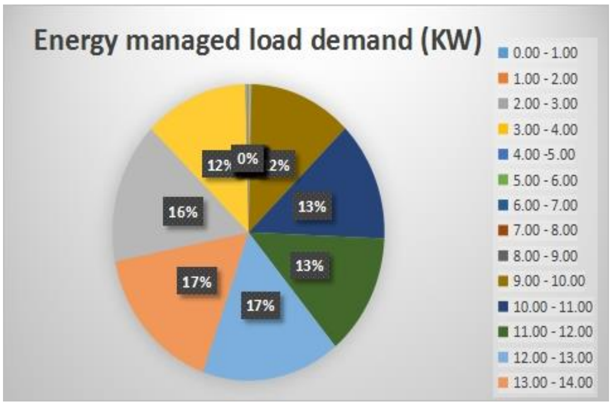

Fig. 2: Daily load demand profile after energy audit

From the results obtained, we have been able to save up to 30% of energy from the previous consumption, and a summary table of the energy management measures applied is shown below in Table and 2.

J. Determination of PV Array

From equation (2) and (3)

$$Ppv\ array = \frac{El}{\eta bo * Kloss * Htilt} * PSI$$

$\eta_{bo} = \eta_{inverter} \times \eta_{wire\ losses}$

In this design $\eta_{inverter}$ and $\eta_{wire\ losses}$ are taken as 95% and 90% respectively [3][7].

$\eta_{bo} = 0.95 \times 0.90 = 0.855$

Table 2: summarised daily load profile of AKSU main campus

S/N	APPLIANCES	RATING(W)	QUANTITY	TOTAL LOAD(W)	LOAD IN (KW)
1	BULB	10	664	6640	6.64
2	BULB	30	119	3570	3.57
3	BULB	100	26	2600	2.6
4	SECRITY LIGHTING	15	239	3585	3.585
5	AIR CONDITIONER	1350	254	342900	342.9
6	AIR CONDITIONER	4000	62	248000	248
7	FRIDGE	100	157	15700	15.7
8	COMPUTER	100	505	50500	50.5
9	FAN	75	801	60075	60.075
10	PRINTER	60	93	5580	5.58
11	TELEVISION	65	16	1040	1.04
12	PHOTOCOPIER	1320	33	43560	43.56
13	LABORATORY	187151		187151	187.151
13	WATER DISPENSER	85	8	680	0.68
14	LAPTOPS	65	91	5915	5.915
15	PROJECTORS	800	24	19200	19.2
	TOTAL			996696	996.696

Table 3: Electrical Energy Management daily load profile of AKSU main campus

S /N	APPLIANCES	RATING(W)	QUANTIT Y	TOTAL LOAD(W)	LOAD IN (KW)
1	BULB	10	809	8090	8.09
2	SECRITY LIGHTING	15	239	3585	3.585
3	AIR CONDITIONER	1119	316	353604	353.604
4	FRIDGE	75	157	11775	11.775
5	COMPUTER(DESKTOP)	75	505	37875	37.875
6	CEILING FAN	33	801	26433	26.433
7	PRINTER	60	93	5580	5.58
8	PHOTOCOPIER	1320	33	43560	43.56
9	TELEVISION	65	16	1040	1.04
10	LABORATORY			187151	187.151
11	WATER DISPENSER	85	8	680	0.68
12	LAPTOPS	45	91	4095	4.095
13	PROJECTORS	400	24	9600	9.6
	TOTAL			693068	693.068

f_{temp} , according to [8] is given by equation 4.

$f_{temp} = 1 - [Y(T_{cell.eff} - T_{STC})]$ (17)

$T_{cell.eff}$ = can be determined by equation 5 [7]

$T_{cell.eff}$ = Ta.day + 25 (18)

The minimum peak sun hour per day (H_{tilt}) for AKSU is 4.2 kWh/m2/day .

The peak solar intensity (*PSI*) at the earth surface is 1KW/m2

From equation (17),

$f_{temp} = 1 - [Y(T_{cell.eff} - T_{STC})]$

Based on the manufacturer specification for the selected module, $T_{cell.eff}$ = 45°c,

Y = 0.48%/0C, T_{STC} = 250C and f_{man} = 97%

$Ftemp = 1 - [\frac{0.48}{100}(45-25)] = 0.904$

Since there is high rate of dustiness in AKSU, f_{dirt} is taken as 95%.

$$P\ pvarray = \frac{6021.293}{0.855 * 0.833 * 4.20} * 1 = 2013kw$$

Pv array using the energy management from table 2

$$P\ pvarray = \frac{4380.434}{0.855 * 0.833 * 4.20} * 1 = 1464kw$$

J. Number of modules in parallel

From equation (7) and (8), we have

$$N_{mp} = \frac{P_{pv\ array}}{N_{ms} * P_{module}}$$

$$N_{mp} = \frac{2013 * 10^3}{2 * 180} = 5592\ modules^3$$

For energy management, table 2

$$N_{mp} = \frac{1464 * 10^3}{2 * 180} = 4067\ modules^3$$

Total number of modules is given by equation 8 [7]

$N_{mt} = N_{ms} * N_{mp}$ = 2*5592 = 11184 modules

$N_{mt} = N_{ms} * N_{mp}$ = 2*4067 = 8134 modules (for energy management)

K. Determination of Battery bank capacity

These batteries were configured were sized based on the load demanded and from the manufacturer's data. Batteries are considered as a major cost factor stand alone power systems. The storage battery capacity can be calculated using equation (10) [3] . Determination of the required battery capapcity for the study area is as follows, using the parameters from the design in equation (10).The result of the number of battery required are presented in table 4.

$$C_x = \frac{N_c * E_l}{DOD_{max} * V_{system} * \eta_{out}}$$

η_{out} = 0.85

$$C_x = \frac{2 * 6021.293 * 10^3}{0.75 * 48 * 0.85} = 393549Ah$$

Battery bank determination using the energy management table

$$C_x = \frac{2 * 4380.434 * 10^3}{0.75 * 48 * 0.85} = 286302\ Ah$$

Using the battery that has a capacity of 325AH and a nominal voltage of 12V. From equation 11, number of batteries required (N_{breq}) is;

$$N_{breq} = \frac{C_x}{C_{selected}}$$

$$\boldsymbol{N_{breq}} = \frac{393549}{325} = 1211\ batteries$$

Specification for energy management table 3

$$\boldsymbol{N_{breq}} = \frac{286302}{325} = 881\ batteries$$

Number of batteries in series is given by equation 12

$$N_{bs} = \frac{V\ system}{V\ battery}$$

$$N_{bs} = \frac{48}{12} = 4\ batteries$$

Number of batteries in parallel is given by equation 13

$$N_{bp} = \frac{N_{breq}}{N_{bs}}$$

$$N_{bp} = \frac{1211}{4} = 303\ batteries$$

Number of batteries in parallel for energy management

$$N_{bp} = \frac{881}{4} = 220\ batteries$$

(from table 3)

L. Determination of Inverter size

Converter: inverter is used in converting the Dc from the battery bank to AC, to feed the AC load. In the present instance, the size of the inverter used is by the expression from equation (14) [3].

$P_{total} = (P_{RS} + P_{LSC}) * 1.25$

. $P_{total} = (P_{RS} + P_{LSC}) * 1.25$

In this design, P_{LSC} = 0

P_{RS} = 996.696 KW from Table 4.4

P_{total} = (996.696 + 0) * 1.25 = 734KW = 1246KVA

For P_{RS} = 693.068 KW from Table 4.6

P_{total} = (693.068 + 0) * 1.25 = 866KW =866KVA (for energy management)

The inverter to be used for this system should have capacity not less than 1246kVA for normal usage and 866KVA for energy management and a nominal voltage of 48VDC.

M. Determination of Voltage Regulator Size

Voltage regulators: a voltage regulator is a system designed to automatically maintain a constant voltage. The expressions on determining a regulator is given equation (14). From table 2 and 3.

$I_{rated} = N_{mp} * I_{sc} * f_{safety}$

In this design, f_{safety} = 1.25 [3][7]

I_{rated} = 5592 * 5.38 * 1.25 = 37606.2 A

I_{rated} = 4067 * 5.38 * 1.25 = 27350.6 A

Using a charging load/current of 240A .Number of voltage
regulator required is given by equation 15.

$$N_{vreg} = \frac{I_{rated}}{I_{selected}}$$

$$N_{vreg} = \frac{37606.2}{240} = 157\ voltage\ regulatorS$$

$$N_{vreg} = \frac{27350.6}{240} = 114\ voltage\ regulatorS$$

The design results for the propose off grid PV system, is shown in table 4

J. Cost Estimate of the System

The cost estimate of the system's components is summarized in Table 4. Table 5 and 6, show the price comparison when energy management techniques are applied in solar energy system component sizing.
Cost per Component = Quantity× Unit price
Other Balance of System Component (BOS) Cost = 20% of subtotal [3].
The operating costs for solar PV installations are negligible, but the annual maintenance cost may amount to 0.5% to 1% of the capital cost of the system. Maintenance cost of
the PV system = 1% of Overall cost of the system.
Maintenance of the PV system = 0.01 * 1,556236800 = ₦ 1,5562368
Total cost for the first year = 1,5562368+ 1,556236800 =1,571799168
Cost per Component = Quantity× Unit price
Other Balance of System Component (BOS) Cost = 20% of subtotal [3].
The operating costs for solar PV installations are negligible, but the annual maintenance cost may amount to 0.5% to 1% of the capital cost of the system. Maintenance cost of
the PV system = 1% of Overall cost of the system.
Maintenance of the PV system = 0.01 * 1125842400 = ₦ 11258424
Total cost for the first year = 11258424 + 1125842400 = 1,137100824

K. *Estimated Cost of the Diesel Generator used by Akwa Ibom State University*

Using 550 KVA
Hours used = 8 hours per day.
Total estimated hours used per annum = 8* 365 = 2920 hours
Total estimated fuel (diesel) consumption per hour = 65 litres
Total estimated fuel consumption per annum = 65 * 2920= 189800 litres
Cost of diesel = ₦ 650 per litre
Total estimated cost of fuel used per annum = 650 * 189800 = ₦ 122,370,000

Table 4: Parameters of the PV modules of the system

S/N	COMPONENT	DESCRIPTION OF COMPONENT	RESULT
1	Load Estimation	Total Estimated Load	996kw / 693kw
2	Pv array	Capacity of PV array	2013Kw/ 1464kw
3		Number of modules in series	2
4		Number of modules in parallel	5592 / 4067
5		Total number of Modules	11184/ 8134
6	Battery bank	Battery Bank capacity	393549Ah/ 286302Ah
7		Number of batteries in series	4
8		Number of batteries in parallel	303/ 220
9		Total number of batteries required	1212 /880
10	Voltage Regulator	Capacity of voltage regulator	240A
11		Number of voltage regulator required	157/114
12	Inverter	Capacity of the Inverter	1246KVA/ 866KVA

Table 5: cost of PV components

Components	QTY	Unit Price(Naira)	Cost of Components(Naira)
Modules	11184	92,000	1028928000
Batteries	1212	186,000	225432000
Voltage Regulators	157	84,000	13188000
Inverter	1	31500000	31500000
Sub Total			1,299048,000
Other components (Wires, Fuses, Circuit Breakers etc.)			257,188,800
Total Cost			1,556236800

Table 6: cost of PV components after energy audit

Components	QTY	Unit Price(Naira)	Cost of Components(Naira)
Models	8134	92,000	748,328,000
Batteries	880	186,000	163,680,000
Voltage Regulators	114	84,000	9576000
Inverter	1	18,200,000	18,200,000
Sub Total			939784000
Other components (Wires, Fuses, Circuit Breakers etc.)			186,058,400
Total Cost			1125842400

Total estimated cost of maintenance per annum = 10% * ₦ 122,370,000 = ₦ 12,237,000

Cost of purchase of the diesel generator = ₦ 62,000,000

Total estimated cost of the diesel generator for the first year = ₦ 196,607,000

For 100Kva

Hours used = 14 hours per day.

Total estimated hours used per annum = 14* 365 = 5110 hours

Total estimated fuel (diesel) consumption per hour = 12 litres

Total estimated fuel consumption per annum = 12 * 5110= 61320 litres

Cost of diesel = ₦ 650 per litre

Total estimated cost of fuel used per annum = 650 * 61320 = ₦ 39,858,000

Total estimated cost of maintenance per annum = 10% * ₦ 39,858,000 = ₦ 3,985,800

Cost of purchase of the diesel generator = ₦4,000,000

Total estimated cost of the diesel generator for the first year = ₦ 47,843,800

Total sum of both generator cost for first year: (550kva and 100 kva) = ₦ 47,843,800 + ₦ 196,607,000 = ₦ 244,450,800

L. Estimated Cost of the Utility used by Akwa Ibom State University

Total estimated hours used per annum = 22* 365 = 8030 hours

Cost of utility = ₦ 55kwh

Total estimated cost of utility used per annum = 55 * 6021*365 = ₦ 120,871,575

Cost of registering for utility = ₦150,000

Total estimated cost of the utility for the first year = ₦ 121,021,575

For energy Management;

Hours used = 22 hours per day.

Total estimated hours used per annum = 22* 365 = 8030 hours

Cost of utility = ₦ 55kwh

Total estimated cost of utility used per annum = 55 *4380*365 = ₦ 87,928,500

Cost of registering for utility = ₦150,000

Total estimated cost of the utility for the first year = ₦ 88,078,500

N. Payback Period

The payback period of the PV system can be found using equation as:

$$\text{Payback period} = \frac{1{,}571799168}{244{,}450{,}800} = 6.4\ years$$

Payback period for energy managed table.

$$\text{Payback period} = \frac{1{,}137100824}{244{,}450{,}800} = 4.6\ years$$

(using the energy management table)

M. Comparison Of Solar Pv System, Diesel Generator And Utility(PHCN)

It is of great importance to compare the generation of energy from the three factors considered which is more suitable, also considering environment and location of site of installation and the possible danger it might incur on the lives of the occupant and even plants. The comparison of the system is shown in Table 7 .

Table 7: cost comparison of the three source of electrical energy

System	Pv system)	Diesel	Utility
Cost of purchase (₦)	1,556236800	66000000	150000
Cost of running (₦)	1,5562368	178450800	120871575
Estimated cost for first year (₦)	1,571799168	244450800	121021575

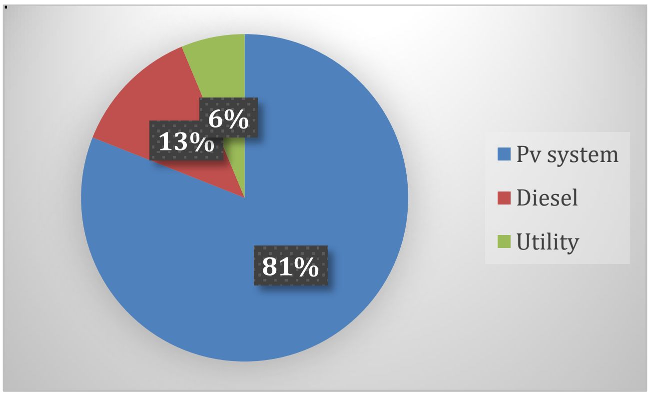

Fig. 3: Cost comparison of the three souces of energy

Cost comparison for energy management table is represented below as table 8 shows that, and represented in fig. 3, 4 and 5 respectively

Table 8: comparison between the normal usage and the energy management

System	Normal usage	Energy managed usage
Pv system	1,571799168	1,137100824
Diesel	244450800	244450800
Utility	121021575	88078500

IV. Conclusion

In this paper, an electrical energy audit was carried out, and key energy management decisions were discovered as a result of the audit. The energy usage of the main campus of Akwa Ibom State University, Nigeria, was studied, and ways of reducing the cost of energy were analyzed. At present, a 500 kVA diesel generator is used to power the facilities within the university, and when the audit was concluded, we found out that the peak energy demand is between 9 a.m. and 4 p.m., and between 3.50 p.m. and 8.50 a.m., load demand is very low compared to the peak demand. Also, the energy demand on weekdays is considerably lower compared to weekdays. During this off-peak period, instead of using 500 kVA to power the facilities between 3.50 p.m. and 8.50 a.m., 100 kVA can do the same function at a low cost. Also, some of the appliances with a very high rating were not economical, so when the lower-rated ones with even better performance were replaced, the electrical energy demand was reduced by 30%, as was the cost. Furthermore, there is an abundance of sunlight in Akwa Ibom State; hence, the design of a solar energy system was incorporated into this research to power the facilities within the university. The components of the PV system were adequately sized. The design using an approved electrical formula and the value are stated in the results sections. The payback period when compared with the diesel generator is 6 years, and when the key energy management decision was used, according to the audit, the payback was reduced to 4 years, which is lower than the lifespan of the selected PV modules, which is 30 years.

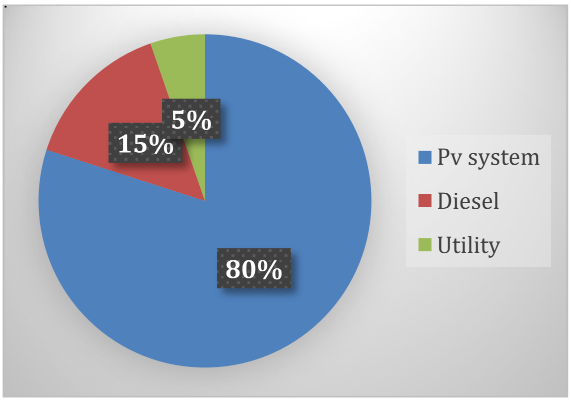

Fig. 4: Cost comparison of the three souces of energy with energy management measures

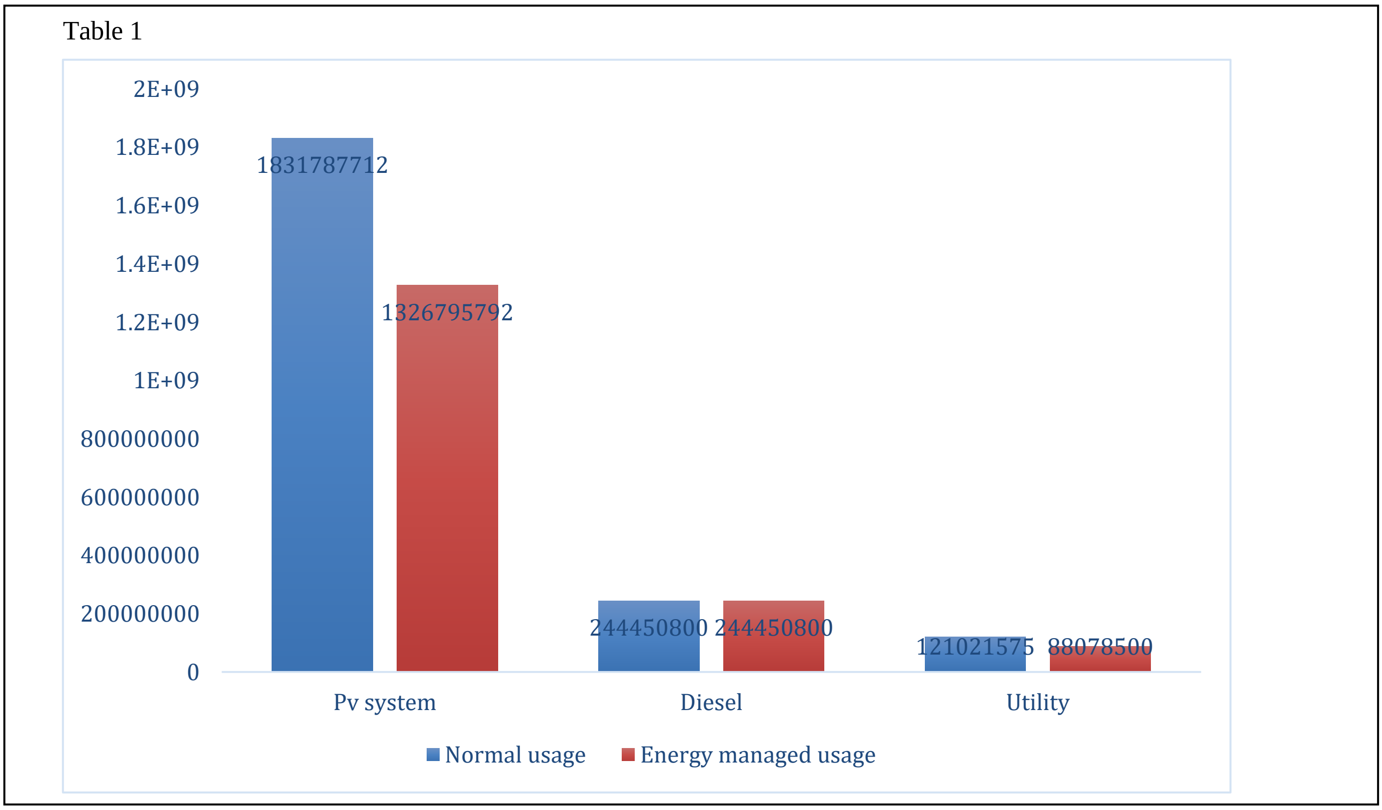

Fig. 5: Cost comparison of the three souces of energy, normal and manage usage

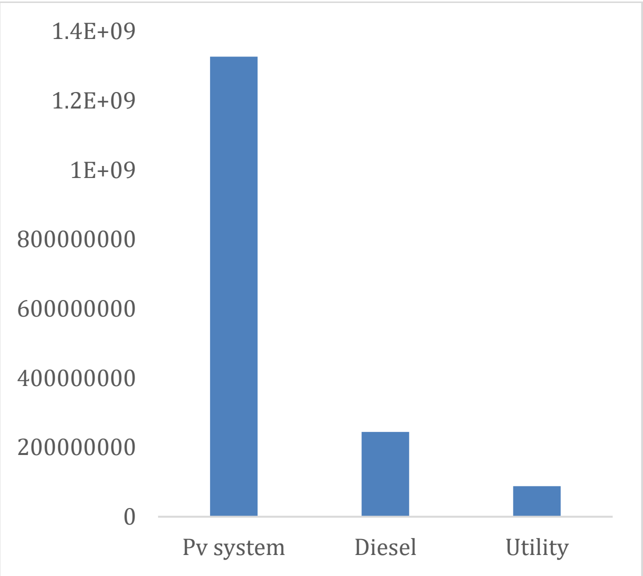

Fig. 6: Cost comparison of the three souces of energy

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