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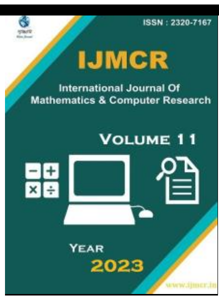

Energy Audit and Power Usage for Oleh Campus, Delta State University, Abraka: A Case Study

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ARTICLE INFO	ABSTRACT
Published Online: **25 May 2023** Corresponding Author: **Eyenubo O.J**	Energy audit process including the computation of energy per hour, day, week and calendar month used in Oleh campus of Delta State University Abraka, was discussed in this paper. Energy waste and valuation and capability of savings were ascertained through walk-through energy audit. Similarly, comprehensive assessment of the data point compiled was ensured by proposing gainful methods for energy usage. The outcomes and other essential knowledge engendered were recorded. The energy auditing for a day is the indicator of the utilization that regulates crises by making available maintenance arrangements. The campus needs 20530.95 kW of electricity per hour costing N1, 113, 598.728. The running charges for a 4 hours power supply for Engineering and Law faculties and other areas in a year will amount to N53, 452, 738.944 resulting in the following break-down 34.7%, 20.5%, 17.3%, 11.7%, 15.8% engineering, law, hostels, administrative block and lodges consumption respectively.

KEYWORDS: energy audit; building energy demand; load profiling; power system; load modelling; Compact Flourescent Lamp

1.0 INTRODUCTION

Currently the set-up of the power system has been distorted due to fast development in electrical energy demand, implementation of new know-how, operating functioning of electricity trading floor, and the enormous advancement resulting from renewable power. Adding to the prevailing variations, electrical mediums, distributed ideas, and smart grid views technique causing the scheme to be very complicated. Thus, it is a demanding undertaking to sustain the protection and permanence sectors of the transmission system [1,2]. To achieve this task, keep in check and safety acts need to be enhanced. From a safety view point, distance relay in large connected power arrangement supports various functioning coordination so that security and examining task can be done in an efficient method. The distance security arrangement offers basic standby safety measures commonly used for protection of high voltage transmission cables established on magnitude of obvious electrical resistance for computing current and voltage data [3,4]. On the contrary, both fault and technique essential working requirements can trigger the load resistance to interrupt the protective regions and this can initiate sudden failing of line breakers. Thus, distance relay is susceptible to strained actions that may cause cascading outcomes resulting in system shutdowns. With the new technological advancements made by power engineers in collaboration with the other field experts, is seen that all-inclusive stoppage of these devastating effects is not probable but their gravity, after-effects, and influence on end users can be decreased to some level. Provision is aim at a detailed account on the existing literature of past serious brownout events initiated due to protecting relay maloperation.

2.0 REVIEW OF RELATED WORKS

Buildings are different in their corporal magnitude, type, geometry, shroud and functioning features (arrangements, habitation, mechanical, and electrical). When varied factors and weather situations touches building, energy usage is intricate. Benchmarking a building alongside its peer assemblage to regularize energy usage for all influential viewpoints is to facilitate a reasonable performance measurement. There are standard procedures occurring with variable intricacy levels. The most straightforward techniques

Energy Use Intensity (EUI) regulates structures' energy usage for variances example in floor area [5-7]. It is stated total energy utilized/unit floor area (e.g., kWh/m^2). The EUI is similarly computed built on important causes of distinct types, e.g., energy use/member of staff in office buildings (e.g., kWh/employee). On the contrary, whole-building energy models, according to [8, 9], can quantitatively justify varied persuading things. Though, erecting and standardizing these replicas takes substantial period, exertion, and know-how, which put restrictions on their scalability for an ample number of edifices; benchmarking rests in sundry components expended for evaluating regularized energy used and their importance.

2.1 Measurable Data and Techniques

Data gathered for the audit power utility Delta State University, Abraka, Oleh-Campus including Law and Engineering faculties was done for the interval of 1 October 2020 to 30 November 2021. The audit intendment is establishing a beneficial and reliable technique of dropping energy utilization and proffering an easier procedure of energy administration [8]. The review improved energy-proficient applications for day-to-day activities for general usage providing ease for energy expenses data were garnered from all sectors. The work put together how many fluorescent tubes, fans, air-conditioners, electronic gadgets. The overall contribution of each equipment in the total electricity consumption was considered. Nigeria, a leading economy in the African continent has a considerable production capability 13.6 GW when contrasted to the peak load demand 8.32 GW; authority have a duty to attend to the domestic demand [10-13]. By 2019 the accessible power has reduced to 3.6 GW; agreeing with the World Bank index, only 45.6% are connected to the national grid yet supply is more erratic as at 2022. The school electricity audit handles both faculties. The survey of the over-all resources of the fiscal investment on electricity generation even from diesel generators were considered. Furthermore, the overall saving on electric energy was examined showing the rates contributed by fluorescent bulbs, fans, computers and other appliances obligation. The sum-up of the study in the school shown in Figure 1.

3.0 MATERIAL AND METHODS

Data collected for energy audit for Delta State University, Abraka, Oleh – campus was conceded by the team; the audit target audience shows a healthy and safe technique for energy use and proffer simpler approach of energy management. This audit eased the energy-proficient uses. Besides, common appliances have been provided to facilitate saving energy expenditure. Data were collected from each unit, sections and offices. Consideration will be how many tubes, fans, A. Cs, electronic instruments, etc. in locations; how much was the participation of each component in total electricity consumed? Policies were instituted to explore other energy means. Nigeria, with the largest economies, has a sizeable set up generation capability of 13.5 GW compared to country’s peak demand 8.25 GW. It is essential that the government should attend to the general demand; yet in 2019 the on-hand capacity is 3.7 GW. In harmony with to the World Bank, assemblage of developmental statistics is 55.4%. Nigerian population access to electricity supply is still not adequate as at 2022. Thus, the University electricity audit has been conducted considering necessary areas of concern. The total budget of the school, the total economic investment of the institute on electricity generation from the solar and other electricity generation units were also looked into. Also, the total saving on electricity was considered this showed the exact contribution of bulbs, fans, computers and other instruments needing electricity usage.

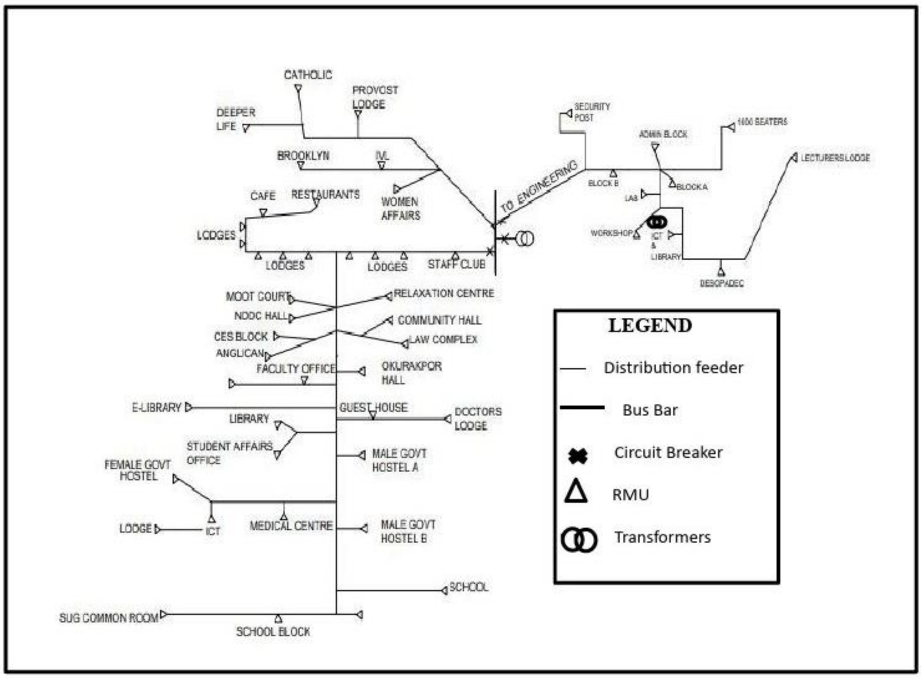

Figure 1. Layout of Delsu Ole-campus

The power rating of all of this equipment were collected from the survey. From the 1 kVA generator in the law faculty, we have an 11 kVA transformer that follows a grid line through old Olomoro road then back of Damotech hotel area to the generator house in engineering power station. entering another 11 kVA transformer into two different generators 500 kVA and 200 kVA.

3.1. Diesel generator

The load demand of the entire school was found to be 245,325 Watt, and with a p.f 0.8, the load in kVA is 314.19 kVA. For the intent of this consideration, F.G Wilson generator: 3-phase, 415-V, 50- Hz diesel engine generator of 350 kVA and fuel (automotive gas oil) consumption rate of 65 L/h, with a lube oil capacity of 39 liters was selected.

Amount of procurement and fixing = 30,600,000 Naira

Price of diesel with annual price increase = 243.8 Naira/L

Day-by-day fuel utilization = 650 liters

Everyday fuel charges = 62 × 10 × 243.8 = 151,156 Naira

Aggregate day-to-day energy usage = 2,234,700 Watt-h/day

Per hour energy use for a 10-h work day = 2,254,800/10 = 225,480 Watt-h

Yearly repair price = N 650,000

Factorization all charges over 10 years = 30,600,000 + (149,916 × 2610) + (650,000 × 10) = 428,380,760 Naira

Daily cost of generator usage

$$= \frac{427,780,760}{2610} = N163,900.674$$

Part rate

$$\frac{\text{Daily cost of energy}}{\text{Total daily consumption (kWh)}} = \frac{163,900.674}{2,234.7} = 73.34N/kWh$$

A probable general investigation was employed by to transform diesel usage into corresponding kWh for ease of analysis. A cubic decimeter of diesel is 38.6 MJ, and since 1 kWh is equal to 3.6 MJ, therefore a liter of diesel will amount to 10.72 kWh.

3.2 Load computation

Energy assessment is basically the first phase in auditing, an evaluation of data-based for building an energy managing plan or model for the system, to reduce utilization devoid of any undesirable effect on usage. Secondly, deductions were built on information gotten from the review for cost-effective energy efficiency.

A load survey was conducted on Delsu Oleh campus power use monthly bill for six months. This record was categorized showing the unit electricity consumed per hour, the charges paid and the over-all amount of price for the period under consideration as shown in in Table 1.

Table 1. Delsu Oleh Campus Power Use Monthly Bill for Six Months

S/N	Meter Reading	kVA	Unit Consumed (kWh)	Amount per unit (₦)	Total amount (₦)	P.F.
1	30/03/2022	2065	3000	33.36	147,091	0.65
2	17/04/2022	2065	3002	33.36	150,071	0.70
3	02/05/2022	2065	3010	33.36	155,310	0.68
4	07/06/2022	2065	2985	33.36	145,210	0.79
5	03/07/2022	2065	2800	33.36	140,091	0.66
6	11/08/2022	2065	3000	33.36	147,091	0.78

Official working hour for most companies in Nigeria is 8 am - 5 pm; for the intent of this task, assumption that the offices last for a consistent 9 hours daily from Monday - Friday. This connotes that a 5-day work per workweek is used up. Thus, 261 work-days/year over 9 period, there are 2,349 days, taking into awareness the normal public vacations per annum. Analysis of energy cost from alternative power sources for Oleh-campus gives a comparative consideration established on a 9-year running period. The unit cost of energy can be determined using thermo-economic method. The unit of electricity from a renewable source is defined by the cost-balance equation as follows in Equation (1)

$$A^{\alpha}E^{\alpha}_{\beta} + \sum A_{\gamma} = A_{\sigma}E^{\sigma}_{\rho} \qquad (1)$$

The terms are defined as follows:

A^{α} = Fuel price per unit

E^{α}_{β} = Fuel consumption rate

A_{γ} = Components of the investment cost

A_{σ} = Unit rate of electrical power

E^{σ}_{ρ} = Rate of electric energy produced

For renewed energy bases without fuel (e.g., solar energy), the cost-balance equation is defined in Equation (2) as follows:

$$\sum A_{\gamma} = A_{\sigma}E_{\varepsilon}P^{\alpha}_{\beta} \qquad (2)$$

$$S_{\varepsilon} = \frac{\text{Electric power produced by energy set-up per annum}}{\text{Annual bulk of the energy arrangement}} \qquad (3)$$

The capacity factor S_ε can be written as in Equation (4):

$$U_\mu = \frac{\text{Overall number of operational hours yearly}}{365x24} \quad (4)$$

3.3 Load Model and its Features

Many electric appliances and devices have an electrical load that varies as the supply voltage changes. The loads are categorized as a function of voltage, constant power (demand is constant regardless of voltage) or as a constant impedance (power varies as square of voltage). The load at a particular point might be a mixture of some proportion of all these.

It is quite important in both planning and engineering to model the voltage sensitivities of load correctly. For example, incandescent lighting, resistive water heaters cooking loads shunt compensation and many other loads are constant impedance loads. On a feeder with a 7.5 % voltage drop from substation to feeder end will vary up to 14.5% depending upon location of the feeder. The same set of incandescent light that creates 1 kW of load at the feeder head would produce only 844 watts. Induction motors, controlled power supply tap changing transformers in power systems (PS) are relatively constant. In general, these load static models can be written as:

$$P = P^\alpha \left(V / V^\alpha\right)^{K1}; \; Q = Q^\alpha \left(V / V^\alpha\right)^{K2}$$

Where P^α , Q^α = Nominal values of real and reactive loads

And V^α = Voltage at nominal load

3.4 Load Factor (LF)

Power supply authorities generates revenue by selling their product, viz.., units of the electric energy by those granted with the right of using energy as per their requirements at any hour. The average load ratio to maximum demand (MD) is LF as depicted in Equations (5) and (6).

$$\text{Load Factor} = \frac{\text{Average Laod}}{\text{Maximum Demand}} \quad (5)$$

If generator is operated for a period T

$$\text{Load Factor} = \frac{\text{Average Laod*T}}{\text{Maximum Demand*T}}$$

$$\text{Load Factor} = \frac{\text{Units generated in T hours}}{\text{Maximum Demand*T}} \quad (6)$$

The LF may be daily, monthly or annually; the factor is lesser than 1 since LF is smaller than the MD.

4.0 RESULT AND DISCUSSION

Energy Cost

The present BEDC energy cost for Delsu Oleh Campus is N33.36per kWh. Neglecting the fixed charges and VAT, this translates to a monthly average energy bill of; ₦33.36kWh x 2,966.2kWh = ₦98,951.43

Works Department of Delsu Oleh Campus consumes 15 liters of diesel per hour and it run for 7 hours in a day all through the week. Therefore providing 2,940 liters of diesel per month to run generator on campus to power the hostels. Pump price of diesel is N750/liter, the running cost of generators is 2,940 litres x ₦750/litre = ₦2.205 million.

Equivalent Number of Lighting Points (lamps) and Comparison of Light Sources

For ease of analysis, assumption for standard lamp used for lighting installation is the conventional FL of 40W rating. Thus, an equivalent number of lamps can be calculated as:

50kW/40W = 1250 lamps (that is, 1,250 x 40W FLs)

The incandescent lamp, the conventional fluorescent lamp and the CFL, which is popularly known as "energy saving lamps", consumes less energy as the conventional ones if the same level of lighting is to be achieved. These lamps when compared with a newly patented LED lamp, Sunco LED bulbs. (Sunco LED is a trademark). The following observations are made for the study:

(a) The LED lamp produces more illumination and at a much lower power consumption, approximately more than half of power consumption of the most comparable 40W fluorescent lamp as shown in Table 2 while Table 3 the outcome of the this is as shown in Figure 3 gives the areas where usage of the lights is needed.

(b) The life span of the LED lamp is about 4 times comparable to 40W FL, practically, most of the conventional FLs hardly last a year in Nigeria resulting from substandard quality of lamps that are imported into the country and the recurrent low voltages and quality of the electricity supply, Table 4 summarizes the various devices that consumes power, this is depicted in Figure 4.

Cost Saving by Using LED Lamp

The following assumptions are made for the study:

1. Light load for the Delsu Oleh is 50 kW
2. Lighting installation is represented by 40W fluorescent lamps.
3. Average monthly energy cost is ₦2.303 million
4. From (1) and (2) above, installation points are 1,250 lamps.
5. LED lamp (Sunco LED bulbs) is approximately 65% CFL (that is, 11W as against 40W).
6. Manufacturer's assurance is 25, 000 hours.
7. The conventional FLs are changed once a year.
8. The worth of conventional FLs (Osram Fluorescent Tube) is ₦2000.00 per lamp.
9. The amount for LED (Sunco LED bulbs) is ₦5,400.00 per lamp.
10. From (1) and (3), the energy cost due to lighting installation is 0.05 x ₦2.303m = ₦115,197.

We can now make the following analysis:

From (5) and (10) above, the energy savings due to lighting if LED lamps (Sunco LED bulbs) replaces all the conventional lamps will be, 0.65 x₦115,197= ₦74,878.4

For a whole year, this translates to ₦74,878.4 x12 = ₦898,541 in savings in energy bill.

From (9) above, sum rate of Sunco LED bulb = 1,250 x ₦5,400.00 = ₦6.750m

11. From (6) and assuming the lamps are on 12 hours every day, life expectation of Sunco LED bulbs is 25,000/12 = 2,083days = 5years and 7 months (approximately).

Strategy for Load Reduction

Percentage reduction in kWh of consumed energy in Student's halls of residence in Oleh Campus can be calculated below as:

$$Percentage\ reduction\ = \frac{Total\ energy\ supplied - total\ compact\ flourescent\ energy}{total\ energy\ supplied} x100$$

$$Percentage\ reduction\ = \frac{17.797 - 9.340}{17.797} x100 = 47.5\%$$

From time t of power consumption monthly bill, the Delsu Oleh Campus average electricity bill from the months of March to August 2022 for six months including fixed charges and VAT is calculated to be ₦147,091 and using this amount, the percentage reduction is:

$$\text{Reduction } = \frac{47.5}{100} x147,091 = N69,868$$

The amount above indicates that lighting loads using compact FL (energy saving lamp) reduces power consumption in PS distribution network and also save cost. With this level of supply, the average monthly energy bill is about $N147,091$ for Oleh Campus. If $N2.025\ million$ is the price of diesel used to run standby generators is added, the total monthly energy bill is ₦2.35m.

Using the LED bulbs, which is brighter and consumes less energy can serve as replacement. Assuming the initial cost is spent, it will take another 5 years to replace them which is cost effective since almost 1.8 million (average monthly billing times 12) will be spent on just yearly billing. Therefore, in 5 years, only lighting loads will consume 9 million in electrical billing this is without considering their replacement. Therefore, we can say that using LED bulbs as suggested will help save cost at a long run. Suppose at 11 watts, 176 bulbs were energized for 6 hours in one month, we will have that 387.2 KWh as energy used in student room in IVL Hostel. As compared to where 1,140.48 kWh was consumed using CFLs of 36 Watts. Table 4 gave a comparison of luminance of light sources and this is displayed in Figure 5. Table 5 contrast between total lighting loads with CFL 36W vs lighting of Sunco bulbs 11W, and the result is given in Figure 6

Table 2. Total lighting Loads for both Incandescent and (40W) CFL at the Student Hostels

S/No	Hall	Incandescent Energy Consumed (kWh)	CFL Energy Utilized (kWh)
1	Brooklyn	3,792	2,047.68
2	Women Affair	5,052	2728.08
3	IVL	5,665.6	2,721.6
4	Government (Male)	1,428	771.12
5	Government (Female)	708	382.32
TOTAL		16,645.6	8,650

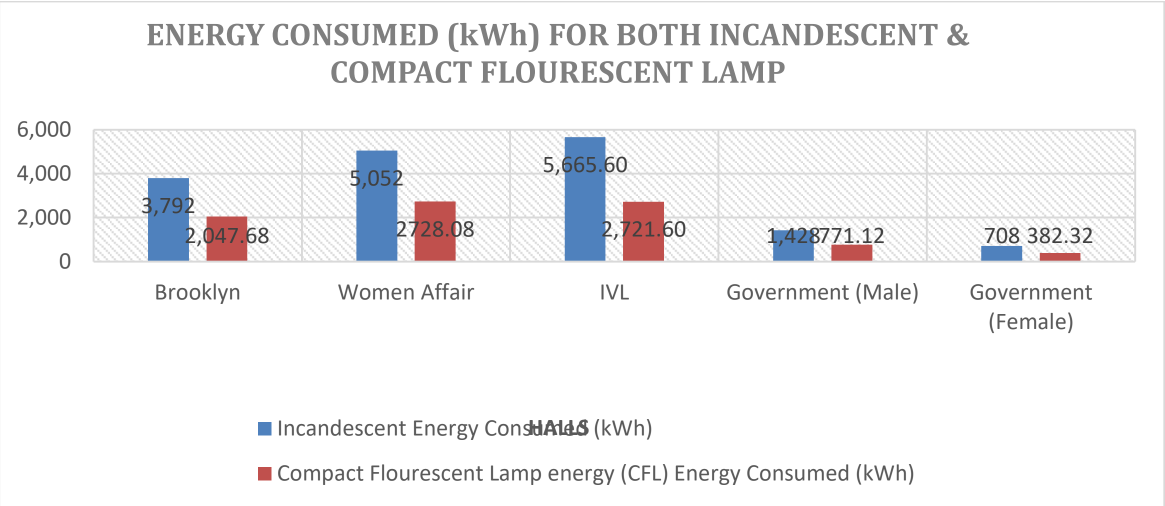

Figure 2. Total lighting Loads for both Incandescent and CFL at the Student Hostels

Table 3. Total lighting load for Offices, staff Quarters, libraries, classrooms, and Laboratories with (CFL)

S/No	Location	No. of CFT Bulbs	CFL Energy Utilized (kWh)
1	Staff quarters (lodges)	250	1, 620
2	Classrooms	734	4, 756.32
3	Offices	400	2, 592
4	Laboratories	120	777.6
5	Libraries	32	207.36
TOTAL		1, 536	9, 953.28

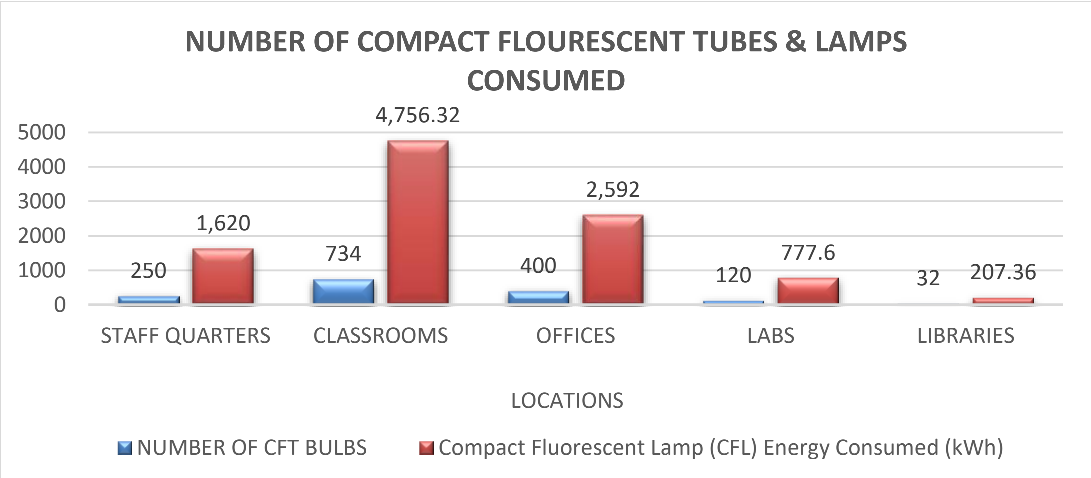

Figure 3. Total lighting load for Offices, staff Quarters, libraries, classrooms, and Laboratories with (CFL)

Table 4. Total load for student's hostels, staff quarters, and administrative block

S/N	Items	No. of devices	Energy used (kWh)	Hours calculated	Days
1	Air conditional	44	4, 336	6	15
2	Electric pressing iron	66	6, 534	6	15
3	Water pump	10	1, 350	6	15
4	Fans	500	3, 150	6	15
5	Electric stove	4	360	6	15
6	Water heater	36	3, 240	6	15
7	Miscellaneous	------	10, 670	1	1

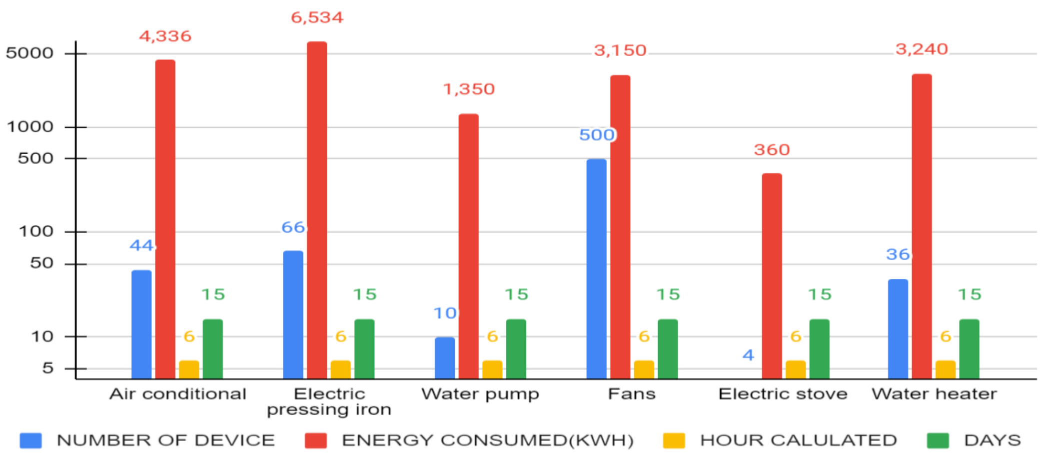

Figure 4. Total load for the student's hostel, staff quarters, and administrative block

Table 5. Summary of the Monthly Average Energy Cost in Delsu Oleh Campus

Energy Source	Energy Supplied (kWh)	Cost/Energy Unit (N)	Total Cost (N)
BEDC	2,966.2	33.36	98,951
Diesel Generator	2,940	750	2.205 million
Average monthly Cost			2,303,951

Table 6. Comparison of Luminance of Light Sources

Light Source	Power consumption (Watts)	Illuminance (lux)	Ave. Life Span (hours)
Incandescent bulb	60	45	1, 200
CFT	40	97	12, 000
CFT (Energy-saving lamp)	36	21	8, 000
Sunco LED bulbs	11	110	25, 000

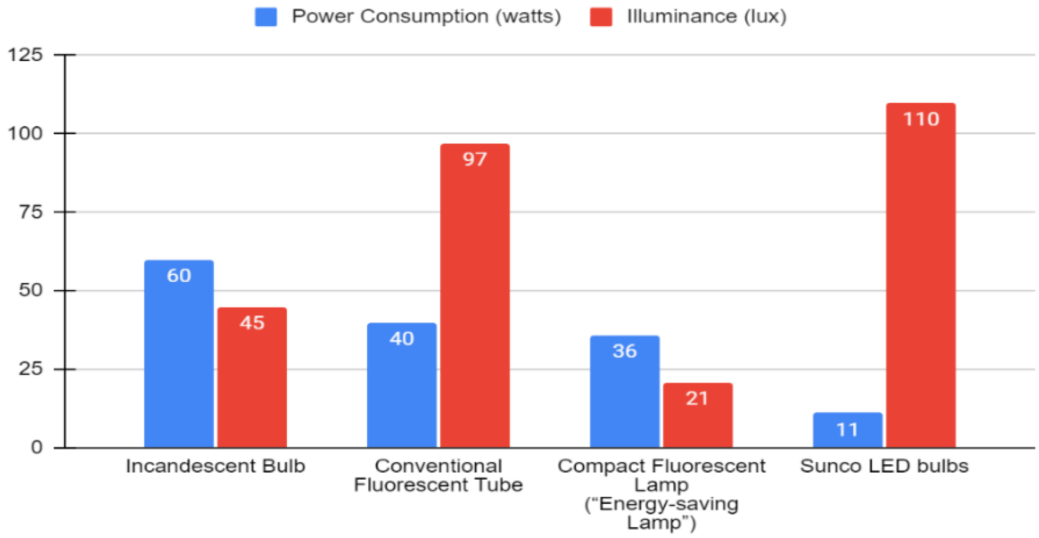

Figure 5. Comparison of luminance of light sources

Table 7. Total lighting Loads with CFL (36W) vs lighting of Sunco bulbs (11W)

S/N	Location	No. of Bulbs	CFL Energy Used (kWh)	Sunco Bulbs (kWh)
1	Staff quarters	250	1, 620	495
2	Classrooms	734	4, 756.32	1, 453.32
3	Offices	400	2, 592	792
4	Laboratories	120	777.6	237
5	Libraries	32	207.36	63.36
	TOTAL	1, 536	9, 953.28	3, 040

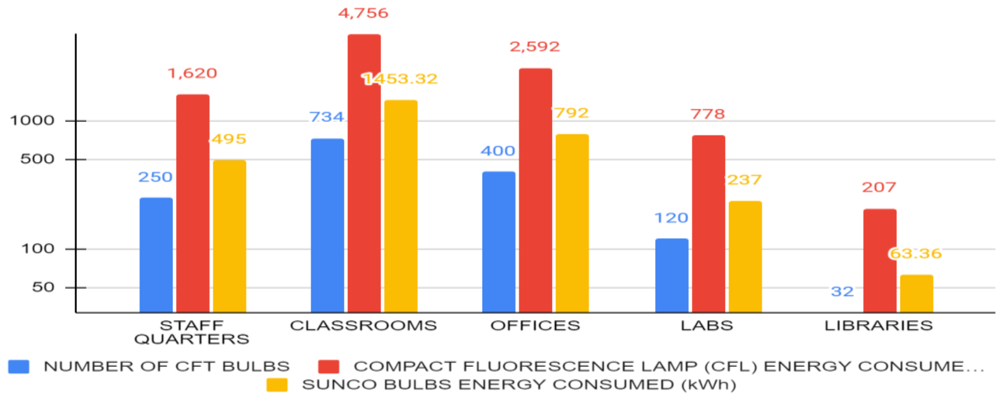

Figure 6. Total lighting Loads with CFL (36W) vs. lighting of Sunco bulbs (11W)

5.0 CONCLUSION

Energy audit is a valuable means characterizing to pay particular attention to a far-reaching energy managing set-up. A precise audit of any class will give an establishment idea which it can efficiently oversee the corporation energy scheme at lowest energy rate. Consequently, a comprehensive investigation has been crafted to look into the electric power use in Oleh campus of the Delta State University, Abraka. It focuses on the savings to be obtained thereby cutting energy crunch significantly.

Consequently, strong caution to users not only in terms of the energy costs, but also the energy predicament in upcoming to all sectors of people; by applying the proposals recommended in this work, will lead a reduction of around 41.66 % of the energy and 30.6 % of cost decrease. The total savings needed to put into operation would be about ₦53,452,738.944 and the various lighting features and other appliances have also been calculated. Energy auditing is an endless procedure and administrations ought to carry it out regularly.

Energy exigency and establishing the cost-effective methodology for operating electric burden for Oleh campus; two starting point of electrical power were taken into consideration and these are Benin Electricity Distribution Company public grid supply and diesel apparatus. The price for the two energy sources was ascertained by means of initial system capital and the functioning running cost over definite time frame. Load-sharing probabilistic ratio method is then used to decide the rate of fueling the buildings over-all electrical loads using proportion arrangements of alternate energy provisions. The outcome made known that energy from the general BEDC grid is low-cost, but this is defied by network unpredictability and instabilities in supply which interrupt business bustles. Diesel equipment is a probable substitute to the erratic public source, but the ignition of fossil fuel is a main basis of Greenhouse gas worldwide, and attempts are continuously being made to safeguard the ozone layer by lowering the suppliers of ozone-depleting constituents. Thus, as contained by this research, stability amongst these functioning authenticities guaranteeing a cost-effective umph supply exclusive of a significant damage to the ecosystem. An additional area of study will be the inclusion of other renewable sources such as wind and solar energy.

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