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Original Article

Analysis of Electrical Energy Consumption Pattern and Audit for Improved Electricity in Owerri Urban “A Stepwise Approach”

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Abstract *- Nigeria is blessed with abundant natural resources to reform its power sector, but despite this enormous wealth, the sector is confronted with chronic power outages. Currently, the installed capacity is 12,522MW, but the availability is less than 5,000 MW. This capacity is grossly insufficient and unhealthy for the socio-economic growth of the nation, which requires about 180,000 MW. The energy consumption survey conducted in Owerri Urban revealed that 11.3 MW is required, but the power allocated by the utility is 6.3 MW. Load shedding has become a norm rather than an exception to balance demand and supply of electricity. Most frustratingly, consumers are issued with outrageous estimated bills, not considering the fact that they experience power outages for over 16 hours daily. An energy audit investigation was conducted using a stepwise approach to mitigate energy consumption and realize energy savings opportunities to assuage exorbitant electricity bills. The results obtained showed satisfactory performance with the drastic reduction in value energy consumption from 11.3MW to 5.1MW while the annual electricity bill dropped significantly from ₦156, 925,532.30 to ₦ 57,409,115.00 and total cost savings was ₦ 99,516,417.30. It was deduced that the survey actualized the objective of the research in line with the sustainable development target.*

Keywords *- Energy audit, Energy demand, Fossils fuel, Load shedding, Load survey.*

1. Introduction

Electricity is considered one of the major drivers of the economy of any nation. Electricity demand relies on diverse socio-economic factors like industrialization, government policies, and technological, economic and population growth, respectively [1-4].

The Nigerian power industry is plagued with epileptic power supply despite the enormous gift of natural resources. Out of the 12522 MW installed capacity, the availability is less than 5,000 MW [5]. The capacity is grossly insufficient and unhealthy for the most populated black nation that requires about 180,000 MW [6]. This intractable situation has severely constrained the nation's economic and industrial development. The load consumption survey conducted in Owerri Urban revealed that 11.3 MW is required, but the power allocated by the utility (Enugu Electricity Distribution Company) is 6.3 MW. Load shedding has now become a regular practice in the Nigerian Power industry order than the exception to reduce demand. This is not only a result of corruption or obsolete grid equipment but also because demand surpasses availability.

This paper adopts a stepwise approach to conduct energy consumption and Audit surveys in various customer classifications, e.g. Residential and commercial in Owerri urban. Commercial comprises of Hotels, Industries, Hospitals, Banks and offices etc.

The exponential increase in electricity demand makes it absolutely necessary to conduct energy Audits within the study area to identify losses and achieve energy-saving measures to mitigate extreme consumption and cost of billing. An energy audit is a tool adopted for careful examination of the electrical loads. It not only determines when, where, why and how electricity is utilized but also gives a comprehensive idea of total energy consumption in various facilities without any negative impact on the system's well-being [7]. It helps utilities to make judicious use of energy, enhance efficiency and maximize profit. It is sacrosanct to ensure strict compliance with energy audit recommendations to manage available resources effectively and efficiently.

2. Literature Review

To assess the robustness and relevance of this research, the twenty most recent publications in journals, conferences and technical papers on residential and commercial electricity consumption were reviewed.

Saoud et al. [8] developed a methodology for forecasting power consumption. The proposed technique utilized machine learning models of the stationary wavelet transform (SWT) and transformers to predict household power consumption in different resolutions. The paper presented by Bani et al. [9] centered on an electricity consumption survey trajectory in Jordan under variable weather conditions based on an annual historical dataset. Mahdavi et al. [10] suggested the introduction of incentive measures by utility companies to motivate electricity consumers to change their attitude towards energy consumption systems for a specific load pattern to mitigate wastage.

The amount of energy usage and its associated power features in UNDIP College investigated by Windarta et al. [11] highlighted the importance of power system security in supporting sustainable national development. Adamu et al. [12] identified different sources of electricity for residential usage. They scrutinized the consequences of their reliance on customary power sources, the energy steps model adopted, and their choices. Understanding the residential energy demand journal, Barrella et al. [13] explained the importance of energy consumption patterns in various customer classifications using a bottom-up model approach. The emphasis was on residential and household consumption required to meet Spanish- households' energy requirements.

A journal presented by Czosnyka et al. [14] analyzed power demand and electricity consumption during the period of the economic recession. The statistical comparison was drawn with features from the previous periods. An investigation of mean energy consumption with an emphasis on residential appliances was presented by Kim et al. [15]. Ali et al. [16] developed a communication interface to monitor the performance and behavior of power system configuration for ease of electricity data consumption analysis. Alam [17] defined energy as the essential force driving all economic activities. It plays a fundamental role in any nation's economic and industrial development.

Much attention was devoted to residential building consumption in the reviewed publications. Non-residential customers were not considered. Secondly, the reviewed papers did not address the disparity between the rising energy demand and availability, and no long-term future expansion plans were considered in the reviewed papers; hence, further research is needed to fill these gaps. One of the efficient and effective ways to achieve this is to conduct energy audits in all the facilities.

3. Materials and Methods

The load assessment is a vital section of energy auditing. They are tools normally used to understand the status of energy consumption patterns. The research proposed a stepwise method. The method outlined the details of a distinct step-by-step approach adopted to determine energy consumption survey and energy Audit. The study was conducted in Owerri Municipal L.G.A, comprising Douglas Road, Royce and Umezuruike axis. The areas are interconnected to one utility feeder (Township Feeder). It is fed on an 11kV voltage level from a 33kV injection substation located at the Fire services Bus stop, Egbu Road Owerri. The substation is fed on a 33 kV transmission line from the Egbu transmission substation and stepped down with 2x15MVA Transformers via four feeders: GRA, New Owerri, Naze and Township feeder [18]. The schematic diagram of the existing injection substation is shown in Figure 9 below.

3.1. Data Collection for the Study

The data collection source was achieved using the focus group method. It involved surveys and interviews conducted by selected individuals and consumers drawn from the group of university undergraduates and young professionals, mainly Engineers. This survey was classified into load consumed in Residential, Hotels, Hospitals, Industrial, and Banks/Offices. The under-listed factors were put into consideration during the electrical load survey.

Population, number of electricity customers(both metered customers and estimated billing customers), number of households with electricity, average number of persons per household, annual growth rate of consumers, current grid capacity, load consumption, power demand consumption demand, available utility bills for un-metered consumers, future load, average daily electrical energy consumption, hours of electricity availability and outage. The data collected were compared with the official records obtained from NBS on electricity report, National Population Commission [20-21], and the geographical information system department of Enugu Electricity Distribution Company (EEDC).

3.2. Load Consumption Survey

The first stage is to make a comprehensive list of all the electrical appliances and their power capacity to be ascertained, and this first step is called an energy consumption survey. The power requirement is ascertained by multiplying the operating hours of such by the rating of such device. The energy consumption survey of various facilities comprising residential Commercial (Hotels, Hospitals, Industrial, Banks and offices are determined and shown in Tables 3.1 to 3.5.

Table 3.1. Actual residential energy consumption

Description	Rating (W)	Qty	Run (Hrs)	Total load(KW)	Daily energy(KW)
Lightening points a. Internal b. External 1 c. Street Light points	40 40 100	10000 1000 200	10 12 10	400 40 20	4,000 480 200
Fans	80	500	5	40	200
Refrigerators	120	100	24	12	288
Pressing Iron	1000	100	1	100	100
Air Conditioners (1Hp) Air conditioners (1.5Hp)	746 1119	100 10	5 5	74.6 11.19	373 55,.95
TV	60	100	5	6	30
Blender	500	100	0.5	50	25
Laptop	80	100	2	8	16
Cooker unit	1500	10	5	15	75
Radio	40	1000	5	40	200
Desktop Computer	100	50	5	5	25
Vacuum cleaner	500	50	1	25	25
Printer	50	50	2	2.5	7.5
Kettle	1000	5	1	5	5
Bore Holes (1Hp) Bore Holes (1.5Hp)	746 1119	100 10	1 1	74.6 11.19	74.6 11.19
Total energy in a day				**940.08**	**6,191.24**
Total energy in a Mon(31days)				29,142.48	191,928.44
Total energy in a Yr(365 days)				343,129.2	2,259,802.6

Table 3.2. Actual energy usage for banks and offices

Description	Rating (W)	Qty	Run (Hrs)	Total load(KW)	Daily energy(KW)
Lightening points a. Internal b. External	40 40	300 100	10 10	12 4	120 40
Fans	80	50	10	4	40
Refrigerators	100	20	10	2	20
Water dispensers	580	10	2	5.8	11.6
Air Conditioners (1Hp) Air conditioners (1.5Hp)	746 1119	15 10	10 10	11.19 11.19	111.9 111.9
TV	60	100	10	6	60
Photocopiers /Printers	1000	10	5	10	50
ATM Machines	120	20	24	2.4	57.6
Laptop	80	100	10	8	80
CCTV Cameras	10	20	10	2	20
Internet router	10	100	10	1	10
Desktop Computer	100	20	10	2	20
Security doors	500	10	10	5	50
Printer/Scanners	50	50	10	2.5	25
Bore Holes (1Hp) Bore Holes (1.5Hp)	746 1119	10 5	10 10	74.6 11.19	74.6 11.19
Total daily energy				174.87	913.79
Monthly (20 days)				3,497.40	18,275.8
Annual energy (261 days)				45,641.1	238,499.2

The actual and audited energy consumption was computed for offices and banks. The official work hour for various companies in Nigeria is usually from 8 am to 5 pm. On paper, it is assumed that offices run for an average of 10 hours daily from Monday through Friday.

Table 3.3. Actual energy consumption for Hotels

Description	Rating (W)	Qty	Run (Hrs)	Total load(KW)	Daily energy(KW)
Lightening points a. Internal b. Central light c. Desk Light	 40 60 40	 300 20 20	 10 10 2	 12 1.2 0.8	 120 12 1.6
Fans	80	20	10	1.6	16
Refrigerators	180	10	10	1.8	18
Elevator	52,000	1	10	52	520
Air Conditioners (1Hp) Air conditioners (1.5Hp) Central Air conditioner	746 1119 5000	10 10 2	10 10 10	7.46 11.19 10	74.6 111.9 100
TV	60	50	10	6	60
Photocopiers /Printers	1000	10	5	10	50
ATM Machines	120	2	24	0.24	5.76
Laptop	80	10	10	0.8	8
CCTV Cameras	10	20	10	2	20
Internet router	10	5	10	0.05	0.5
Desktop Computer	100	5	10	0.5	5
Security doors	500	2	24	1	24
Printer/Scanners	50	2	10	0.01	1
Bore Holes (1.5Hp)	1119	5	10	5.595	55.95
Total energy in a day				124.335	1,204.300
Total energy in a Mon(31days)				3,854.385	37,333.300
Total energy in a Yr(365 days)				45,382.3	439,569.5

The current energy consumption for all the hotels in the study area is in Table 3.3, with a total daily energy consumption of 1,204.3kW and a total load of 124.335kW.

Table 3.4. Actual energy consumption for Hospitals

Description	Rating (W)	Qty	Run (Hrs)	Total load(kW)	Daily energy(kW)
Lightening points a. Internal b. External 1	 40 40	 300 100	 10 10	 12 4	 120 40
Fans	80	50	10	4	40
Vaccine refrigerators	100	20	10	2	20
Centrifuge	580	10	2	5.8	11.6
Air Conditioners (1Hp)	746	10	10	7.46	74.6
Incubator	400	10	10	4	40
Autoclave	1564	10	5	15.64	78.2
Oxygen concentrator	300	10	10	3	30
CCTV Cameras	10	10	10	1	10
Spectrometer	575	10	10	5.75	57.5
Desktop Computer	100	5	10	1	10
Tissue culture	475	10	10	4.75	47.5
Printer/Scanners	50	5	10	0.25	2.5

Hematology mixer	28	5	10	0.14	1.4
X-ray machine	3000	2	6	6	36
Ultrasound	1440	2	6	2.88	17.28
Dialysis machine	575	2	6	1.15	6.9
Bore Holes (1Hp)	746	10	10	74.6	74.6
Total energy in a day				15.42	718.08
Total energy in a Mon (31 days)				478 .02	22,260.48
Total energy in a Yr(365 days)				5,628.30	262,099.20

The industrial electrical consumption of the area under study includes the energy consumption 5 laundry shops, 3 fuel stations and 10 refrigeration storage facilities outlets (cold rooms). The energy consumption and running periods are items in Table 3.5

Table 3.5. Actual industrial energy consumption

Description of equipment	Rating (W)	Qty	Run (Hrs)	Total load(kW)	Daily energy(kW)
Lightening points a. Internal b. External 1	 60 100	 500 200	 10 12	 30 20	 300 240
Fans	80	50	5	4	20
Refrigerators	120	100	24	12	288
Pressing Iron	1200	20	2	24	48
Air Conditioners (1Hp) Air conditioners (1.5Hp)	746 1119	50 20	5 5	74.6 11.19	37.3 22.38
TV	100	20	8	2	16
Washing machine	850	10	4	8.5	34
Cloth dryer	3000	3	2	9	18
Fuel dispenser	1120	100	10	112	1,120
Laptop	80	10	2	8	16
Radio	40	10	5	0.4	20
Desktop Computer	100	20	5	2	10
Printer	50	20	2	2.5	5
Bore Holes (1Hp) Bore Holes (1.5Hp)	746 1119	10 5	2 1	7.46 5.595	14.92 5.595
Total energy in a day				333.245	2,215.195
Total energy in a Mon(31days)				10,330.595	68,671.045
Total energy in a Yr(365 days)				121,634.425	808,546.175

Table 3.6. Energy audit computation for residential

Description	Ratings (W)	Qty	Run (Hrs)	Total load(kW)	Daily energy(kW)
Lightening points a. Internal b. External c. Street Light points	 5 10 20	 10000 1000 200	10 10 10	 50 10 4	 500 100 20
Fans	50	500	5	25	125
Refrigerators	80	100	20	8	160
Pressing Iron	500	100	1	50	500
Air Conditioners (1Hp) Air conditioners (1.5Hp)	746 1119	100 10	3 3	74.6 11.19	223.8 33.57
TV (Plasma)	40	100	5	4	20
Blender	500	100	0.5	50	2.5
Laptop	50	100	2	5	10

Cooker unit	1200	10	3	12	36
Radio	20	1000	5	20	100
Desktop Computer	50	50	5	2.5	12.5
Vacuum cleaner	500	50	1	2.5	2.5
Printer	50	50	2	2.5	5
Kettle	1000	5	1	5	5
Bore Holes (1Hp) Bore Holes (1.5Hp)	746 1119	100 10	1 1	74.6 11.19	74.6 11.19
Total energy in a day				808.08	1,491.66
Total energy in a Mon(31days)				25,050.480	46,241.46
Total energy in a Yr(365 days)				294,949.2	544,455.9

3.3. Energy Audit Investigation

A detailed energy audit analysis was conducted to evaluate the energy consumption in various sectors using the available records of consumers' electricity bills. Energy-saving devices like LED bulbs, inverter Refrigerators, Air-Conditioners, Smart televisions and inverter welding machines were recommended to replace obsolete heavy-duty analog electrical appliances to reduce consumption rate. Switching off appliances and reducing the running hours of appliances not in use was equally recommended. The energy audit computation of residential and commercial consumers (e.g. Hospitals, Hotels, Industrial, Banks/offices based on the above recommendations are shown in Tables 3.6 to 3.10.

Table 3.7. Energy audit computation for Banks/ Offices

Description	Rating (W)	Qty	Run (Hrs)	Total load(kW)	Daily energy(kW)
Lightening points a. Internal b. External 1	5 10	300 100	10 10	12 4	120 40
Fans	80	50	10	4	40
Refrigerators	80	20	10	2	20
Water dispensers	500	10	2	5.8	11.6
Air Conditioners (1Hp) Air conditioners (1.5Hp)	746 1119	15 10	10 10	11.19 11.19	111.9 111.9
TV	60	100	10	6	60
Photocopiers /Printers	1000	10	5	10	50
ATM Machines	65	20	24	2.4	57.6
Laptop	50	100	10	8	80
CCTV Cameras	5	20	10	2	20
Internet router	5	100	10	1	10
Desktop Computer	100	20	10	2	20
Security doors	500	10	10	5	50
Printer/Scanners	50	50	10	2.5	25
Bore Holes (1Hp) Bore Holes (1.5Hp)	746 1119	10 5	2 2	7.46 5.595	14.92 111.90
Total energy in a day				102.135	854.11
Total energy in a Mon (20 days)				2,042.70	17,082.20
Total energy in a Yr (261days)				26,657.3	222,922.7

Table 3.8. Energy audit computation for hotels

Description	Rating (W)	Qty	Run (Hrs)	Total load(kW)	Daily energy(kW)
Lightening points a. Internal b. Central light c. Desk Light	 5 20 5	 300 20 20	 10 10 2	 1.5 0.4 0.1	 15 4 0.2
Fans	40	20	10	0.8	8
Refrigerators	80	10	10	0.8	8
Elevator	52,000	1	5	52	260
Air Conditioners (1Hp) Air conditioners (1.5Hp) Central Air conditioner	746 1119 5000	10 10 2	5 5 2	7.46 11.19 10	37.3 55.95 100
TV	50	50	10	2.5	25
Photocopiers /Printers	500	10	5	5	25
ATM Machines	100	2	24	0.2	4.8
Laptop	40	10	10	0.4	4
CCTV Cameras	10	20	10	0.2	2
Internet router	10	5	10	0.05	0.5
Desktop Computer	80	5	10	0.4	4
Security doors	500	2	24	1	24
Printer/Scanners	50	2	10	0.1	1
Bore Holes (1.5Hp)	1119	5	2	5.595	11.19
Total energy in a day				99.695	589.94
Total energy in a Mon(31 days)				3,090.55	18,228.14
Total energy in a Yr(365 days)				36,388.68	215,328.10

Table 3.9. Energy audit computation for hospitals

Description	Ratings (W)	Qty	Run (Hrs)	Total load(kW)	Daily Energy(kW)
Lightening points a. Internal b. External 1	 4 10	 300 100	 10 10	 1.2 1	 12 10
Fans	40	50	10	2	20
Vaccine refrigerators	80	20	10	1.6	16
Centrifuge	500	10	2	5	10
Air Conditioners (1Hp)	746	10	2	7.46	14.92
Incubator	400	10	5	4	20
Autoclave	1564	10	1	15.64	15.64
Oxygen concentrator	300	10	5	3	15
CCTV Cameras	10	10	5	1	5

Spectrometer	575	10	5	5.75	28.75
Desktop Computer	100	5	5	1	5
Tissue culture	475	10	5	4.75	23.75
Printer/Scanners	50	5	2	0.25	0.5
Hematology mixer	28	5	5	0.14	0.7
X-ray machine	3000	2	1	6	6
Ultrasound	1440	2	2	2.88	5.76
Dialysis machine	575	2	2	1.15	2.3
Bore Holes (1Hp)	746	5	2	3.73	7.46
Total energy in a day				67.55	218.78
Total energy in a Mon (31 days)				2,094.05	6,782.18
Total energy in a Yr(365 days)				24,655.75	79,894.70

Table 3.10. Energy audit computation for industries

Description of Equipment	Rating (W)	Qty	Run (Hrs)	Total Load(kW)	Daily Energy(kW)
Lightening points a. Internal b. External	 18 40	 250 150	 5 10	 4.5 6	 22.5 60
Fans	10	50	3	4	12
Refrigerators	80	100	10	8	80
Pressing Iron	500	20	2	10	20
Air Conditioners (1Hp) Air conditioners (1.5Hp)	746 1119	50 2	2 2	74.6 11.19	37.3 22.38
Smart Television	60	20	5	1.2	60
Washing machine	800	10	2	8	16
Cloth dryer	3000	3	1	9	9
Fuel dispenser	1120	60	5	112	560
Laptop	80	10	2	0.8	1.6
Radio	10	10	5	0.1	0.5
Desktop Computer	100	20	5	2	5
Printer	50	10	2	0.5	1
Bore Holes (1Hp) Bore Holes (1.5Hp)	746 1119	5 3	2 1	3.73 3.357	7.46 3.357
Total energy in a day				258.99	918.10
Total energy in a Mon(31days)				8,028.91	28,461.01
Total energy in a Yr(365 days)				94,553.91	335,105.41

3.4. Analysis of the Unit Cost Energy

The electricity bill computation between the actual and audited energy consumption of various classes of customers will be performed with the approved tariff template released by the Nigerian Electricity Regulatory Commission for Distribution Company. The tariff charge per kWh for Residential (R2T), Commercial (C2) and Industrial (D2) customers are ₦34.28, ₦45.24 and ₦45.67 [19].

Table 3.11. Electricity bill calculation for various customers

Electricity bill calculation for Residential (₦)	
a_1: Yearly = $\frac{2,259,802,600}{1000} x \frac{34.28}{1} = 77,466,033.1$	b_1: Yearly = $\frac{544,455,900}{1000} x \frac{34.28}{1}$ =18,663,948.3
Electricity bill calculation for Banks and offices (₦)	
a_2: Yearly = $\frac{238,499,190}{1000} x \frac{45.24}{1} = 10,789,703.4$	B_2: Yearly = $\frac{222,922,710}{1000} x \frac{45.24}{1}$ =10,085,023.4
Electricity bill calculation for Hotels (₦)	
a_3: Yearly = $\frac{439,569,500}{1000} x \frac{45.24}{1} = 19,886,124.2$	b_3: Yearly = $\frac{215,328,100}{1000} x \frac{45.24}{1}$ =9,741,443.2
Electricity bill calculation for Hospitals (₦)	
a_4: Yearly = $\frac{262,099,200}{1000} x \frac{45.24}{1} = 11,857,367.8$	b_4: Yearly = $\frac{79,894,700}{1000} x \frac{45.24}{1} = 3,614,436.2$
Electricity bill calculation for Industry (₦)	
a_5: Yearly = $\frac{808,546,175}{1000} x \frac{45.67}{1} = 36,926,303.8$	B_5: Yearly = $\frac{335,105,405}{1000} x \frac{45.67}{1} = 15,304,263.9$

Table 3.12. Summary of actual and audited energy usage

Description	Actual energy consumption		Energy audit calculations.	
	Total load(kW)	Daily energy(kW)	Total load(kW)	Daily energy(kW)
Residential	940.08	6,191.24	808.08	1,491.66
Banks & Offices	174.87	913.79	102.135	854.11
Hospitals	15.42	718.08	67.55	218.78
Hotels	124.335	1,204.30	99.695	589.94
Industries	333.245	2,215.20	258.997	918.097
Total	**1587.95**	**11,242.61**	**1336.457**	**4,072.59**
Future load (50%)	793.98	5,621.31	668.23	2,036.30
Ground Total	**2,381.93**	**16,863.92**	**2,004.69**	**6,108.89**

4. Results and Discussion

Investigation of electrical load consumption pattern and energy audit for improved electricity in Owerri urban was performed. The results are presented and discussed herewith in figures and tables:-

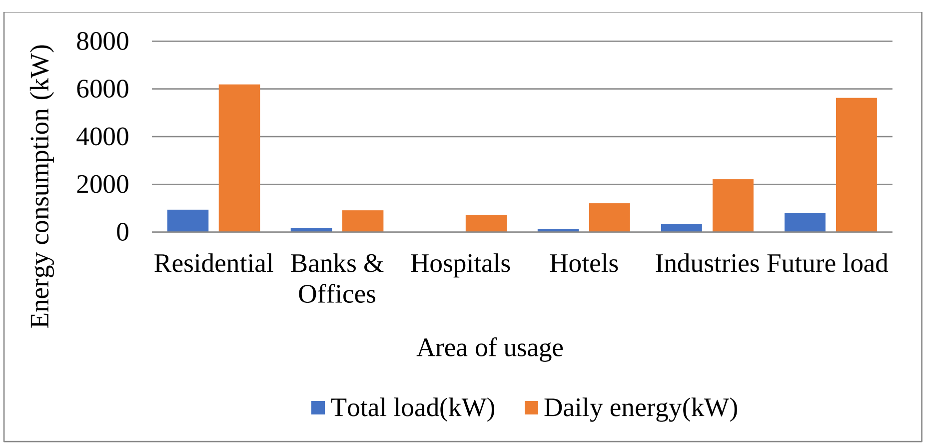

Fig. 1 Barchart of actual load consumption

The computed load and daily energy consumption are shown in Figure 1. From the barchart, it was deduced that residential buildings recorded the highest energy consumption with a value of 6,191.24 kW, while a total of 5,621.31 kW was allocated to future load consumption. Similarly, figure 2 shows the bar chart of audited load and energy consumption. The value of residential energy consumption recorded a value of 1,491.66kW, while that of future energy consumption was 2,036.30. The difference between the actual and audited residential energy consumption was 4699.58 kW, while that of future load was 3585.01 kW. The reason for the drop in value was because of the energy audit examination.

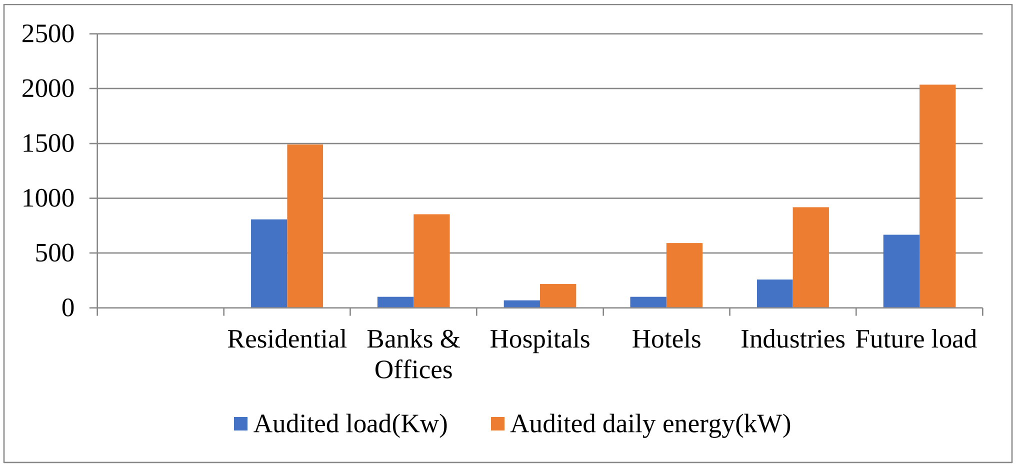

Fig. 2 Bar chart of audited energy consumption

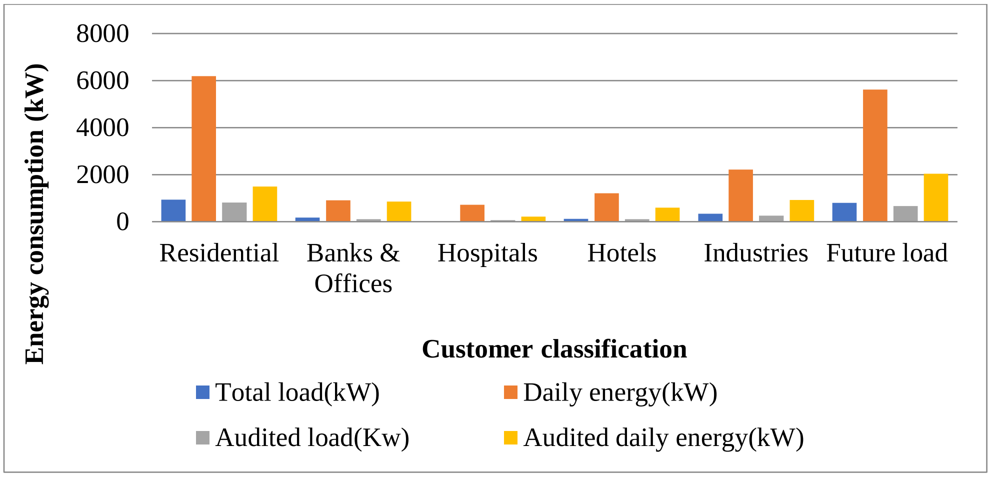

Fig. 3 Comparison of energy consumption

A comparison barchart of actual and audited energy consumption is shown in Figure 3.

Table 3.13. Percentage of actual and audited energy

Description	Actual energy consumption		Energy audit calculations.	
	Total load(kW)	**Daily energy(kW)**	**Total load(kW)**	**Daily energy(kW)**
Residential	142.13	132.16	145.11	87.90
Banks & Offices	26.40	19.51	18.35	50.33
Hospitals	2.33	15.33	12.13	12.89
Hotels	18.78	25.71	17.90	34.77
Industries	50.36	47.29	46.51	54.11
Future load	120.0	120	120	120

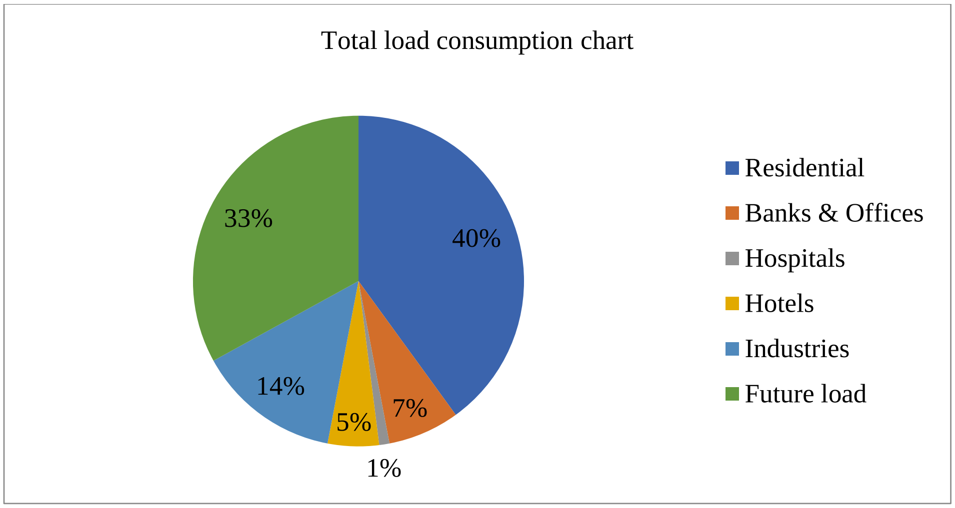

Fig. 4 Piechart of total load consumption

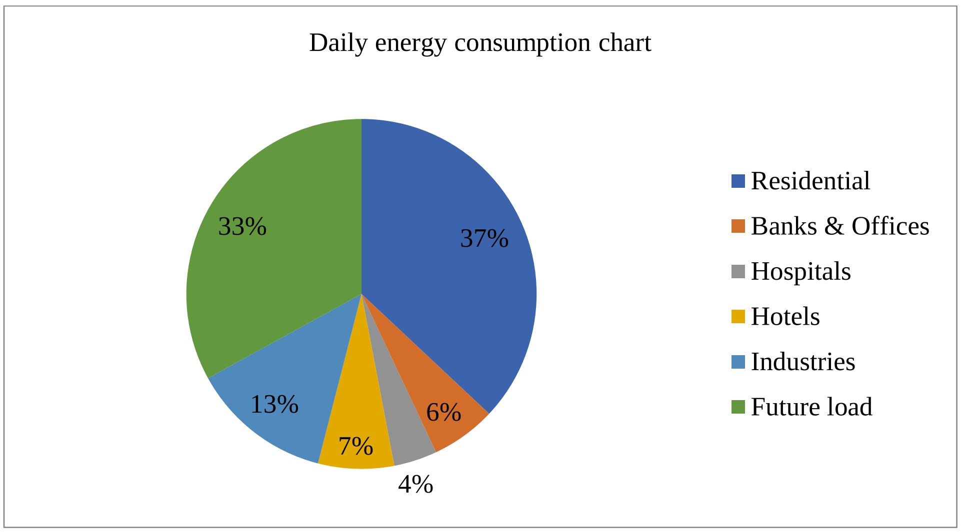

Fig. 5 Piechart of total load consumption

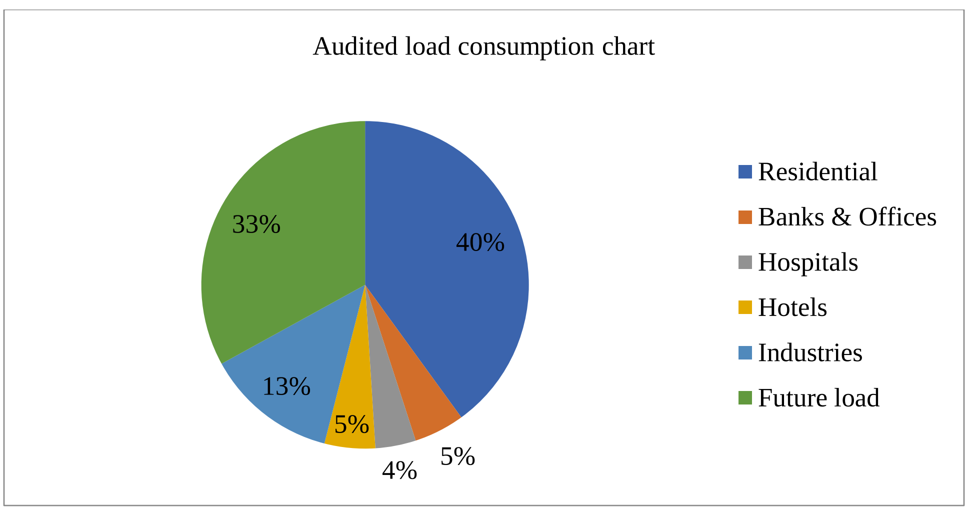

Fig. 6 Piechart of total load consumption

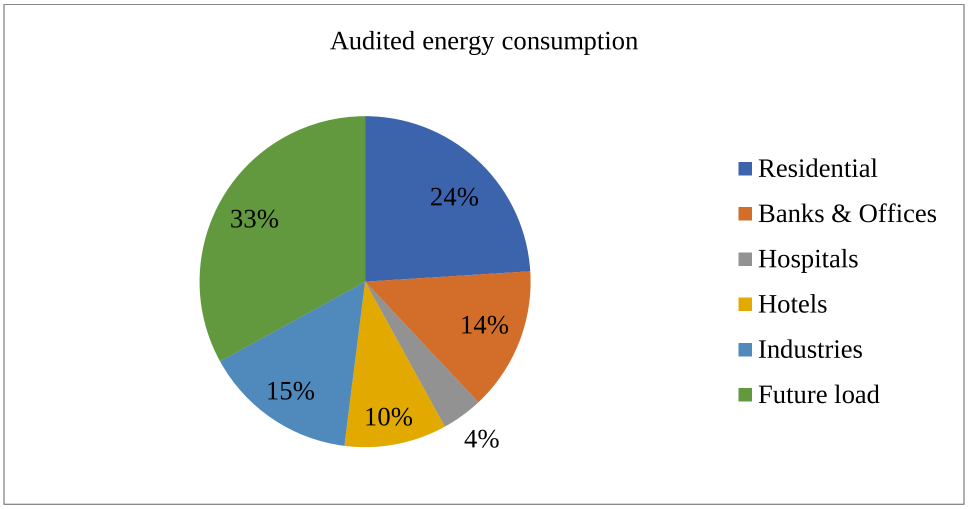

Fig. 7 Percent of audited energy consumption

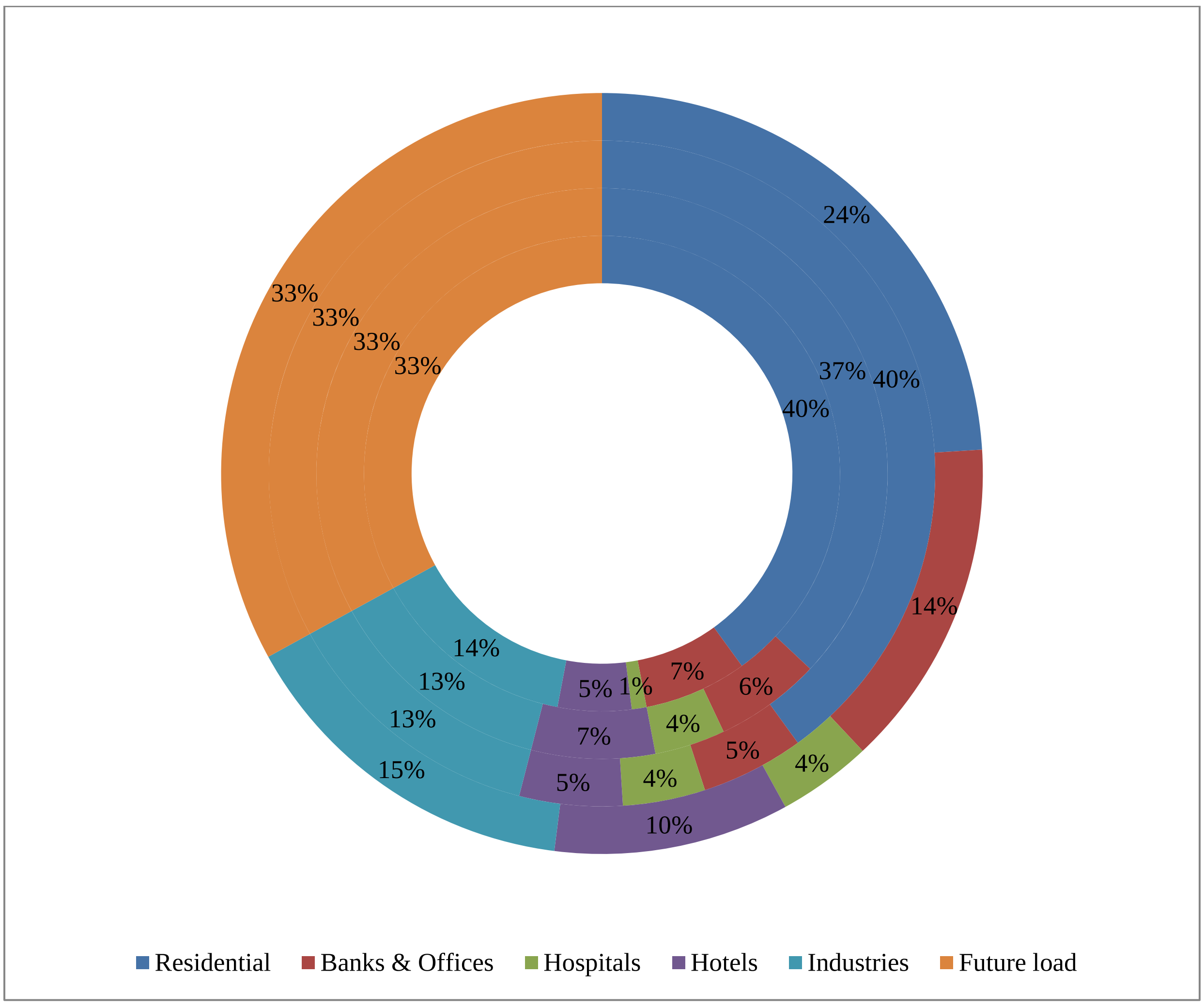

Fig. 8 Multiple contributions of various users

The pie chart of Figure 4-7 displays the percentage contribution of the actual load, energy and the audited energy and load of energy consumption of various facilities. Residential and future consumers recorded the highest percentage of consumption, 40% and 33%, respectively.

The doughnut chart in Figure 8 shows the multiple contributions of each consumption in various customer categories. The highest energy consumption occurred in residential buildings, with a 40% value, while the lowest was in hospitals, with a 4% value.

The cost of the calculated electricity bills between actual and audited energy consumption is shown in Figure 9. The computed bills were based on the approved tariff plan released by NERC. The disparity in columns of various customers' categories resulted from an energy audit investigation.

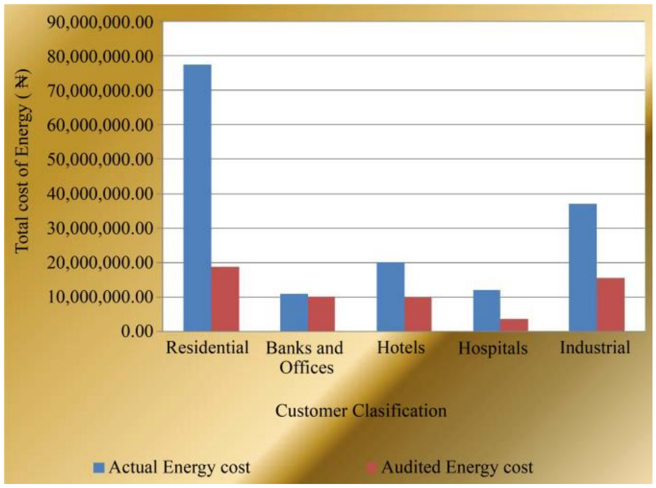

Fig. 9 Cost of energy computation

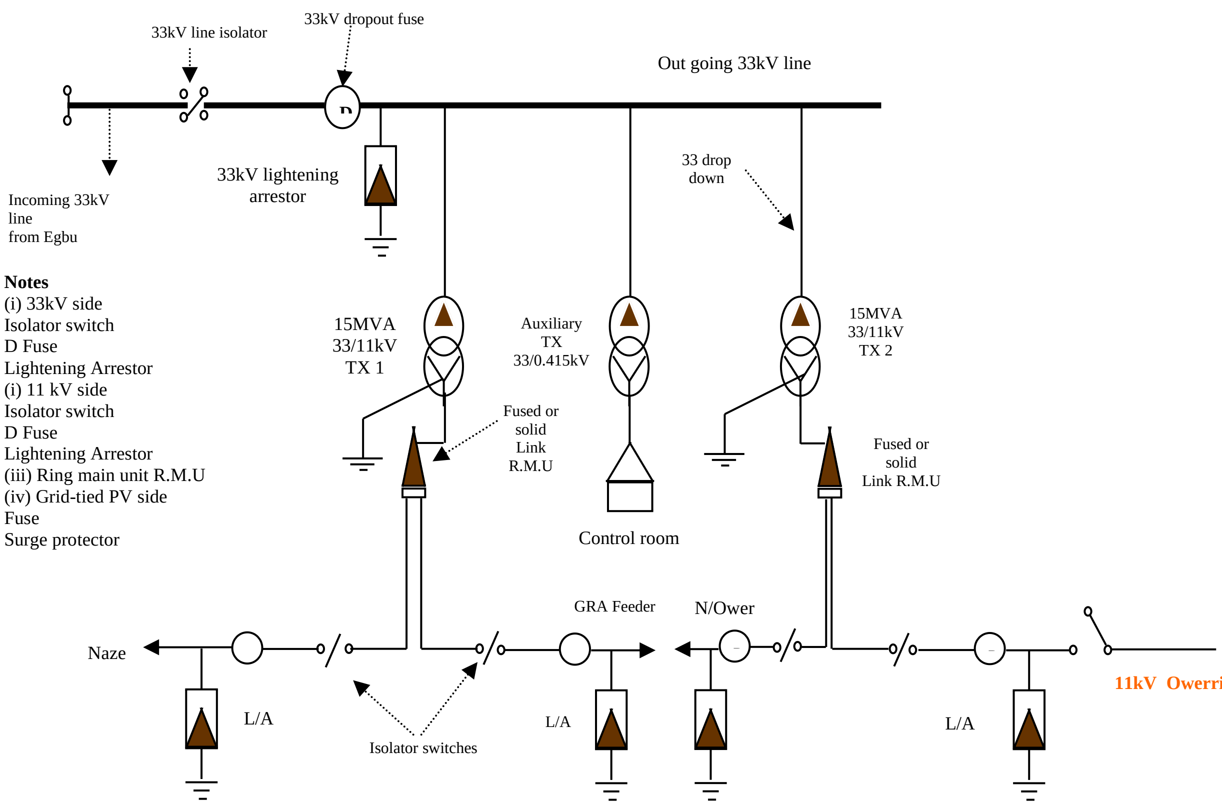

Fig. 10 Schematic diagram of the existing injection substation

5. Conclusion

The electrical energy consumption and Audit investigation in Owerri Urban was successfully conducted. The load survey revealed that 11.3 MW is required, but the power allocated to Owerri Urban by the utility is 6.4 MW. The energy audit investigation was also performed to ascertain accurate energy consumption and measures to mitigate energy consumption, wastages, and exorbitant electricity charges. The energy audit gave a satisfactory performance with a drastic reduction in value load consumption from 11.4MW to 5.1MW, while the annual electricity bill dropped significantly from ₦156, 925,532.30 to ₦ 57,409,115.00. This shows that if the recommended energy audit report is implemented, it will enhance electricity supply and save the cost of ₦ 99,516,417.30 from the electricity bill.

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