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Energy Auditing And Management

A Case Study of Student Hostel, A. B. U ZARIA, Nigeria.

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***Abstract*— Many Educational Establishments consumed a lot of electricity in order to perform their daily activities. The cost of the utility bill has been a major concern in the institution which can be manage and reduce significantly by implementing good energy audit. Energy efficiency and conservation can reduce the energy consumption and the resulting charges in the institution and provides a new platform for new investment in the educational institutes. Many reviews of energy auditing reveals in various student hostels shows that between 15-37% of their energy consumed can be adequately reduce to save the energy they consumed. This paper present a complete energy auditing for a student hostel (Suleiman Student Hostel) in Ahmadu Bello University, Zaria. The intensive effort of the paper is to realize energy management and efficiency. The study objectives to show numerous prospects to produce and instrument an energy developmental plan in institutions. The overall auditing was checked and appropriate approaches of regulating and enhancing energy efficiency were also recommended in order to decrease energy supplies along with the overall charges paid to the utility.**

Keywords—Energy efficiency; Conservation; Audit; Payback period; Tariff.

I. INTRODUCTION

Recently, the issue of conservation and saving of energy has increasingly become a strong concerned for many industries and public places in in almost every aspect and our day to day activities nowadays. Similarly, some of the development clearly indicates that subsidies in terms of energy may soon be gradually removed directly or indirectly in the public schools in Nigeria as the country is moving from

Government Driven Economy program (GDEP) to an independent Driven Economy program (IDEP). This means that some of the consumers will take care of electricity they consumed (kWh)[1]. The whole idea occurs, as a new strategy for energy conservation or energy saving which will definitely be a subject of discussion on the lips of every citizen in the country.

In Nigeria, electrical energy and petroleum products are subsidized by government by almost 65%. Therefore, there is a clear evidence of misappropriation in the energy sector as compared to other developed countries where they use little input to save energy instead of spending a lot to generate electricity. Due to the fact that government subsidized the energy sector, a lot of people does not care about paying the electricity bill on time on even focus on energy saving strategy for the electrical appliances[2]. Electrical Energy has been a crucial requirement for economic development and social activities. It has been the major constrain which affect the electricity supply and distribution since there is no any active plan on energy saving or any shift to renewable energy sources. Meanwhile, energy auditing potentials are to clear the gap which exist among adequate energy supply and accountability. Numerous methods for energy auditing are supposed to be considered. The energy auditing, saving and conservation is a good strategy when it is established properly. A single watt is cheaper to be saved than to increase the electricity supply by a single watt. Effective application of energy auditing in every resources can be environmentally friendly, and provide sound accountability[3]. Energy management or energy audit is the essential way of saving energy resources as every unit has to account, observed the amount of energy they consume, also they will be free from time to time to established good energy management and they will be indirectly forced to choose higher energy saving appliances. This leads to a simple culture of turning off all the electrical appliances while not in used and switching them on when they are only needed. This paper focus on energy auditing and energy management and cost implications. Therefore, a student hostel is choose as a case study where at the end it resulted that changing the conventional florescent with energy saving type will save a lot of energy.

II. METHODOLOGY

The methodology focuses on the consciousness on energy auditing, saving and its efficiency matters of a students' hostel. An energy audit as reported in[4]. It include a data of the amount of energy consumed base on each power rating of the electrical

appliances. The results obtained are used to approximate the amount of energy demand in the building, concentrating on a hostel occupied by the students. The attitude on how they utilized the energy is also considered. Majority of the appliances they used are conventional electric bulbs, incandescent, fluorescent and compact fluorescent bulbs. This analysis assumed that, some of the appliances especially lightning bulbs are used to be switched on for about 12 hours per day and are supplied by the institution generators not from the utility power supply which powered all the external lightings for security purposes. Therefore, the energy audit was carried out base on student's hostel.

III. Energy Supply in Ahmadu Bello University

Since the commencement of A. B. U. Zaria, there has been a thoughtful challenge in regards to electricity supply in the campus. The university authority provide power supply to both academic and student hostels from the generators due to inadequate supply from the power utility companies. These generators has to run for 8 to 12 hours every day and the university is losing a lot on cost of operation and maintenance. Almost 48% of recurring expenses directly goes to electricity supply. Therefore, the University find it difficult to continue with the un-voidable expenses on power supply. Electricity is considered to be an essential commodity in academic environment because it is used to power lightings in the building and research equipment. The University in December Last year constituted a committee of 10 members who will be responsible to look into the situation critically and provide a lasting solution to the problem. After several consultation and survey, the committee found out that on daily basis 80% of the external and internal lighting systems within the student hostels are incandescent bulbs which consumed a lot of energy. Incandescent bulbs does not save energy as only 25% is use to be converted and provide light which the remaining use to be converted directly to heat. One more thing about incandescent lamps is, you need to provide as many as possible in order to get good illumination. The main motive of this paper is make an energy auditing, management and provide an estimated way of saving energy with more efficient electrical appliances or energy saving bulbs. Table 1 shows a consumption pattern for a particular student hostel (Suleiman Hostel) in Ahmadu Bello University, Zaria.

TABLE I. DAILY ENERGY CONSUMPTION FOR SULEIMAN HOSTEL

S/N	Appliance	Qty	Power rating	Hrs/day	Total Load (W)
1	Lighting points	410	40	8	132,200
2	Electric Fan	124	60	8	24,000
3	Electric iron	51	1000	1	1052
4	Mobile phone	68	10	8	86
5	Laptops	46	65	6	117
	Total	**655**	**1210**	**37**	**1902**

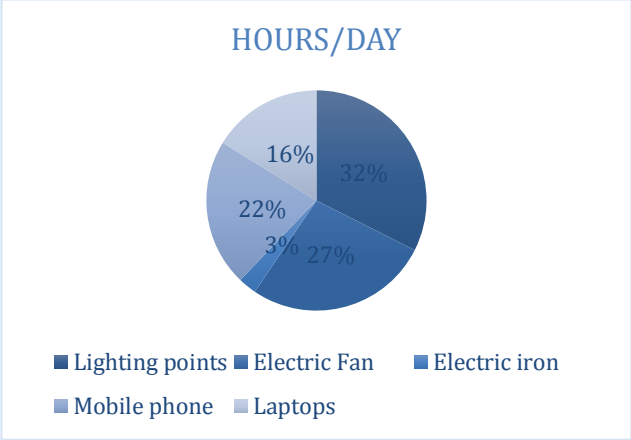

Figure 1: Daily energy consumption for Suleiman hostel

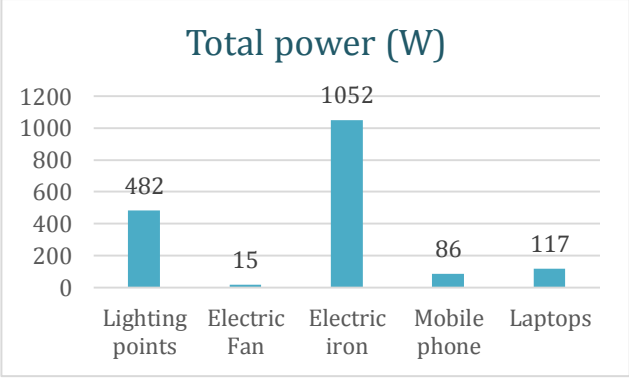

Figure 2: Daily energy consumption for Suleiman hostel

IV. Electricity Audit and Energy Tariff Order

Electricity tariff in Nigeria is regulated and control by a government regulatory body called National Electricity Regulatory commission (NERC). The idea of establishing this regulatory agent is to manage electricity bill in the country and promote energy auditing and efficiency. NERC is also responsible for licenced for establishing a power generation or distribution company. Most of the public places where place on a special discounted tariff. The figure below shows the electricity tariff for various categories from

2002 to 2014 where public schools fall under class A1 to A3 customer classification[5].

V. Data Analysis

The cost of a standard incandescent lamp is cheaper than the energy efficient type. Therefore, by considering both specification, which include life span, illumination quality, cost and longer period of usage one will realize that by replacing all incandescent bulbs with energy efficient type will definitely save more money and energy. By comparing 2 bulbs which consume the same amount of energy but produce difference amount of light and one is longer than the other in terms of life, definitely the cost and amount of energy they will consume will be different. A lot of people go for the cheaper ones and pay a lot for to the utility managers while others go for expensive and high efficient ones for less to the utility companies. Table 4 below shows a comparison between different types of lamps according to their specification[6].

TABLE II. NEW TARIFF UNDER 2012 TARIFF ORDER

New tariff classes under the 2012 Tariff Order		
Customer classification	Description	Remarks
Residential		
R1	Life-Line (50kWh)	A consumer who uses his premises exclusively as a residence-house, flat or multi-storeyed house
R2	Single and 3-phase	
R3	LV Maximum Demand	
R4	HV Maximum Demand	
Commercial		
C1	Single and 3-phase	A consumer who uses his premises for any purpose other than exclusively as a residence or as a factory
C2	LV Maximum Demand	
C3	HV Maximum Demand	
Industrial		
D1	Single and 3-phase	A consumer who uses his premises for manufacturing goods including welding
D2	LV Maximum Demand	
D3	HV Maximum Demand	
Special		
A1	Single and 3-phase	Consumers such as water bank, religious houses, agricultural and agro-allied
A2	LV Maximum Demand	
A3	HV Maximum Demand	

TABLE III. ENERGY FIXED CHARGE PER MONTH

Tariff code	2012	2013	2014	2015
Residential R1	-	-	-	-
Residential R2	500	800	1,280	2,048
Residential R3	25,018	40,029	64,046	102,474
Residential R4	156,356	250,170	400,271	640,434
Commercial C1	500	800	1,280	2,o48
Commercial C2	22,680	36,288	58,061	92,897
Commercial C3	141,748	226,797	362,875	580,600
Industrial 1	1,000	1,600	2,560	4,096
Industrial D2	139,466	223,146	357,033	571,253
Industrial D3	141,748	226,797	362,875	580,600
Special 1	500	800	1,280	2,048
Special 2	46,728	74,766	119,625	191,400
Special 3	62,500	100,000	160,000	256,000
Street Lighting 51	500	800	1,280	2,048

VI. Energy Auditing, Savings and Efficiency

Increase in demand of electricity and energy auditing is consider to be a global challenge, now a days due to huge amount of charges paid to utility companies monthly. It has been discovered that, energy auditing will surely improve every sector economically and will saved energy efficiently. When energy efficiency is achieved there will be environmental development because greenhouse gases will be reduced drastically. In the developed countries, energy auditing programs where initiated in order generate an attractive awareness to the public for saving energy in residential or public buildings. These programs can only be achieved if government or private companies handling the power sector will adequately fund the program through some incentives. Energy auditing is a widespread range of studies in the energy sector which clearly identifies major keys of energy which are difficult to understand and the implications in area of alternative energy supply of efficiency measures. It comprises the analysis and shows the actual demand and consumption of electricity and as well as the processes of conservation of energy. Energy Auditing aids in understanding further methods on how to utilize the use of electricity and clearly identify the scenarios where electrical energy can be saves[2].

VII. Recommendated Energy Saving Measures

Room's sizes and the respective electrical fittings such as lightings, Laptops, phone charges etc. were

considered. The analysis was conducted for both internal and external electrical fittings. It has been observed that if some measures were taking in terms of energy efficiency for Lightings and fans load, it will yield a profitable result. Therefore, the analysis carried out is based on three categories.

A. Audit 1

(a): By Replacing the 40W Fluorescent Lamp with 26W:-

(i) Existing Florescent Lamp is 40W

Daily operation = $8H_{rs}$

$\mathbf{T_D}$ = Duration of use / year / lamp days

= 8Hrs x 365_{days}

= $2920H_{rs}$/year

N = Total Number of lamps = 410

$\boldsymbol{NE_T}$ =Total energy consumed = **(Watts x T_D x N)**

= (40W x $2920H_{rs/year}$ x 410)

= 47,888 KW

Proposed Wattage = 26 W

$\boldsymbol{NE_T}$ =Total energy consumed = **(Watts x T_D x N)**

= (26W x $2920H_{rs/year}$ x 410)

= 31,217.2 KW

Amount of energy saved in terms of consumption = 14 W

TABLE IV. CHARACTERISTICS FOR DIFFERENT TYPES OF LAMPS

S/N	Type of Lamp	Design specificaion	Purpose	Advantage	Dis-Advantage
1.	Incandescent and Halogen Lamps	Lightning of building, external lighs, etc	Offices, residentials, hotels, hostels, etc	✓ Low cost ✓ Color enhancement ✓ Environmently friendly	✓ Very low life span (650h-1800h) ✓ The efficiency is low ✓ Generate a lot of heat
2.	Flurecent Lamps	Is used to be straight or circular in shape, etc	Hostels, toilets, corridors, entrance, etc	✓ Very efficient ✓ Come in variety of colors ✓ High life span (2800h-11800h)	✓ Very sensitive to tempreture ✓ It is not main for frequent switching (on and off)
3.	High intensity energy discharge lamp	HPS and LPS, Mercury or metal halide	Link tunnels, street lights, stadium lights	✓ Long life span (5400h-11800h) ✓ Very efficient ✓ Tempreture resistant	✓ Very expensive ✓ Delay return when it is suddenly switch off

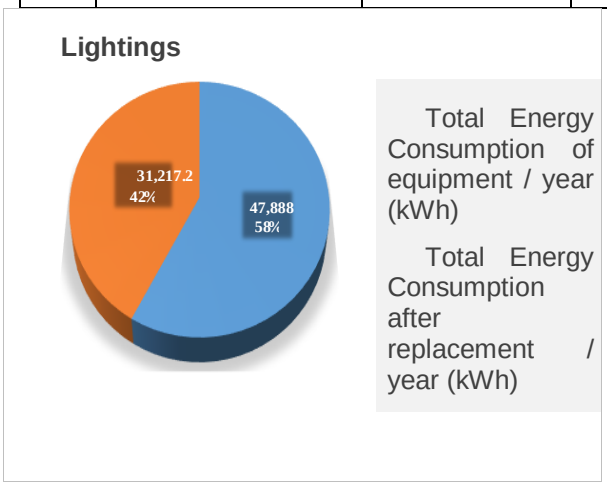

Fig. 3. Comparison between the existing and proposed lightings

B. Audit 1

(a) Electric Fan: Another item chosen in the analysis is to replace the existing 50W ceiling fans with 45W type.

$\mathbf{T_D}$ = Duration use fan / year /days

= 16Hrs x 276_{days}

= $4,416H_{rs}$/year

N = Total Number of lamps = 124

$\boldsymbol{NE_T}$=Total energy consumed= **(Watts x T_D x N)**

(50W x $4,416H_{rs/year}$ x 124)

= 27,359.2 KW

Proposed new Fans = 35W

$\boldsymbol{NE_T}$ =Total energy consumed = **(Watts x T_D x N)**

(35W x 4,416$H_{rs/year}$ x 124)

= 19,165.4 KW

The difference in energy consumption= 15W

= 27,359.2 – 19,165.4

= 8,213.8 KW

Savings in terms of energy Tariff:-

(1 unit = 1 KWh = 20.6 Naira) tariff rate

($1.00 US = N 184.00 Naira)

Amount of energy Saved is

(8,213.8 KW x 20.6)

= N 169,204.3 Naira, $ 919.59 US

TABLE V. OVERALL ENERGY CONSUMPTION FOR THE ELECTRICAL APPLIANCES

S/N	Description Of Appliances	Power Rating (Watt)	Qty	Total load of equipment (Watt)	P.F	Usage/ Year (in Hours)	Total energy consumption of equipment/ year (Kwh)	Total Energy Consumption After Replacement	Energy Saving (kwh)
1.	florescent Lamp	40	410	16,400	0.96	8 x 365=2,920	47,888	31,217.2	16,760
2.	External Lightings	26	28	728	0.98	12 x 365=4380	5,171.32	2,922.92	2,248.4
3.	Electric Fan	50	124	6,200	0.85	16 x 276=4,416	27,359.2	19,165.4	8,213.8
4.	Corridor Light	29	104	3,016	0.90	12 x 365=4,380	19,184.4	5472 (53.5%) Over lapping of luminous flux	3,485 Will be reduced Down to 53.5 %
5.	Water cooler	180	6	1,080		18 x 226 =4,068	4,393	Using the water from the cooler was checked during audit visit it requires little maintenance	The cooler is only made for occasional drinking 15 % wastage 235.6 Kwh
6.	Standing Refrigerator	115	1	115		18 x 297=5,346	614.8	It does not operate throughout the year	214 Kwh
7.	Lifter	5500	4	22,000	0.80	8 x 245=1,960	43,120	Un man operation	There is periodic maintenance
8.	Expeller Fans	32	45	1,440	0.80	12 x 365=5840	70,080	It operates during working hours	2,375

(b) Cost of 50W fan at ₦ 2100 each with devaluation cause of 50 %.

= 1,050 x 124

₦ 130,200.00, $707.61 US

Cost of installing energy efficient fans

₦ 2800 x 124

₦ 347,200, $1,886.96 US

Additional cost of new installation

₦ 347,200 - ₦ 130,200.00 =

₦ 217,700 Naira, $ 1,179.35 US

Pay Back per Annum

= ₦ 217,700 / 169,204

= 1.29 years

- Result of Auditing and Observation: the Life span of conventional ceiling fans is approximated to be 15 to 20 years. Therefore additional cost of the new installation will pay back within the period 1year 3 months.
- Henceforth, the suggestion made on the conventional ceiling fan can be substituted with the energy efficient ones although the payback period will be more than one years. Figure 4 below shows the comparison.

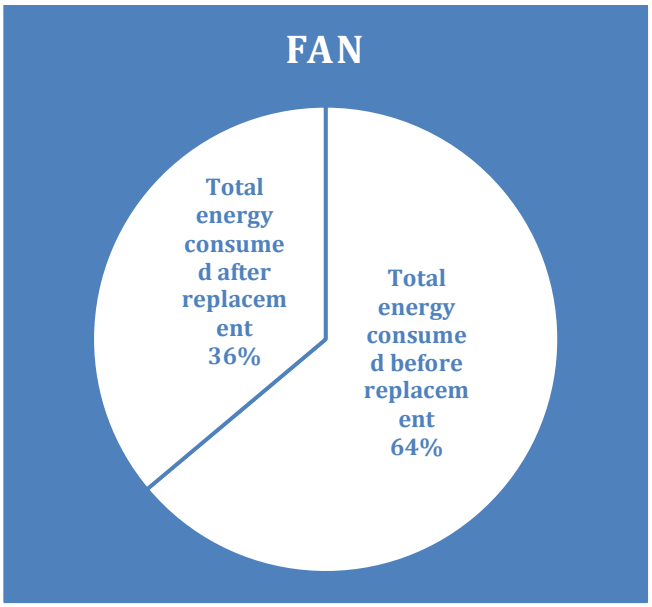

Fig. 4. Comparison between the existing and proposed fans

C. Audit 1

(a): By Replacing the 46W External Fluorescent Lamp with 26W:-

(i) Existing external Lamp is 46W

Daily operation = $11H_{rs}$

$\mathbf{T_D}$ = Duration of use / year / lamp days

= 11Hrs x 365_{days}

= $4,015H_{rs}$/year

N = Total Number of lamps = 28

$\boldsymbol{NE_T}$ =Total energy consumed = **(Watts x T_D x N)**

= (46W x $4,015H_{rs/year}$ x 28)

= 5,171.32 KW

Proposed Wattage = 26 W

$\boldsymbol{NE_T}$ =Total energy consumed = **(Watts x T_D x N)**

= (26W x $4,015H_{rs/year}$ x 410)

= 2,922.92 KW

Amount of energy saved in terms of consumption = 20 W

Amount of energy consumed after replacement.

= 2,922.92 KW

Difference in energy consumption

= 2,248.4 KW

Amount of energy Saved in terms of energy Tariff:-

(1 unit = 1 KWh = 20.6 Naira) tariff rate

($1.00 US, ₦184.00 Naira)

Amount of energy Saved

= (2,248.4 KW x 20.6)

₦ 46,317.04 Naira, $251.7 US

b) Cost of 46W Lamp at ₦ 1080 each with devaluation cause of 35 %. = 0.65 x 1080 x 28

₦ 19,656 $106.83 US

Cost of Installing of 26 W of Lamp

₦ 280 x 28

₦ 7,840 $ 42.6 US

Additional cost of new installation

₦ 19,656 - ₦ 7,840

₦ 11,816 Naira, $64.2 US

Payback period per Annum

=11,816 / 46,317.04

= 0 .255 years

- Audit Observation: The additional cost incurred towards the replacement will be paid back in 2 to3 months' time period. Life of CFL is approx. 4 to 5 years.
- Hence, it was suggested for replacement. The Comparison of existing energy consumption with recommended consumption in case of night lamp is shown in Figure 5 below.

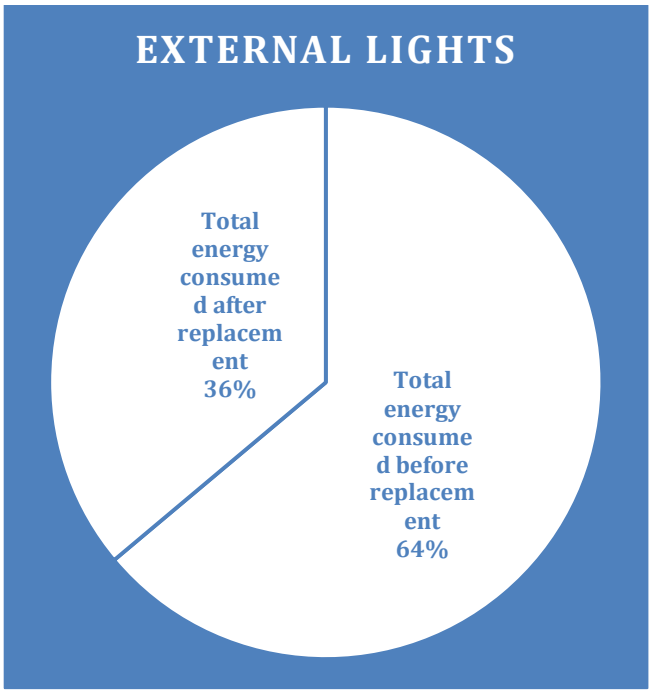

Fig.5. Between existing and proposed external lights.

VIII. Conclusion

Energy auditing program play a key role in terms of energy efficiency and energy conservation. It is only through energy audit one will be able to realized how energy saving will pay him back. Many technologies has been invented now a days in the area of energy auditing and energy management which brought about many innovations. Compact florescent lamps

provides a reasonable illumination and at the same time improved the efficiency when compared with the conventional incandescent lamp. It has testified that the auditing was designed at managing the consumption of electricity in the student hostels. From the result obtained based on energy auditing of the particular building, if implemented properly, there will be an efficient energy saving which will reduce their utility bills by almost 60%.

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