IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 12, Issue 4 Ver. IV (Jul. – Aug. 2017), PP 11-18
www.iosrjournals.org

Electric Power Consumption Reduction in the University of Nigeria, Nsukka Power Network

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Abstract: *The paper addresses the power consumption profile of the University of Nigeria, Nsukka. The electricity bill of the institution which has existed for over fifty years is ₦14.4m on average which the University Administration sees as very excessive. The paper investigates the reasons for this high cost of electricity bills and seeks for ways to reduce these excessive bills. Load audit assessment has been adopted for the study. Audit result obtained shows that obsolete lighting loads were prevalent in the system, and non-lighting loads were based on very old technology which accounted for the high energy consumption. The result of this work shows 83% reduction for both lighting and non-lighting loads audit which translates to an average ₦11m cost savings for the monthly electricity bill. The paper shows 58.2% consumption in Staff Quarters, 27.77% in the Hostels while Faculties and the Administrative blocks take 11.85% and 2.18% consumption respectively.*

Keywords: *Consumption, Power, Energy saving, Distribution, Voltage.*

Date of Submission: 12-04-2017 Date of acceptance: 28-08-2017

I. Introduction

Energy plays the most vital role in the economic growth, progress, and development, as well as poverty eradication and security of any nation. Uninterrupted energy supply is a vital issue for all countries today. Future economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible, and environmentally friendly. Other aspects of human's life like security, climate change, and public health are closely interrelated with energy. Energy is an important factor in all the sectors of any country's economy. The recent world's energy crisis is due to two reasons: the rapid population growth and the increase in the living standard of whole societies [1].

Energy supports the provision of basic needs such as cooked food, a comfortable living temperature, lighting, the use of appliances, piped water or sewerage, essential health care (refrigerated vaccines, emergency, and intensive care), educational aids, communication (radio, television, electronic mail, the World Wide Web), and transport. Energy also fuels productive activities including agriculture, commerce, manufacturing, industry, and mining. It can also be said that lack of access to energy contributes to poverty and deprivation and can contribute to the economic decline. Energy and poverty reduction are not only closely connected with each other, but also with the socio-economic development which involves productivity, income growth, education and health.

II. Energy Situation in Nigeria

Nigeria is Africa's energy giant. It is the continent's most prolific oil-producing country, which, along with Libya, accounts for two-thirds of Africa's crude oil reserves. It ranks second to Algeria in natural gas. Most of Africa's bitumen and lignite reserves are found in Nigeria. In its mix of conventional energy reserves, Nigeria is simply unmatched by any other country on the African continent. It is not surprising therefore that energy export is the mainstay of the Nigerian economy. Also, primary energy resources dominate the nation's industrial raw material endowment. Several energy resources are available in Nigeria in abundant proportions. The country possesses the world's sixth largest reserve of crude oil. Nigeria has an estimated oil reserve of 36.2 billion barrels. It is increasingly an important gas province with proven reserves of nearly 5,000 billion barrels [2]. The oil and gas reserves are mainly found and located along the Niger Delta, Gulf of Guinea, and Bight of Bonny. Most of the exploration activities are focused in deep and ultra-deep offshore areas with planned activities in the Chad basin, in the northeast. Coal and lignite reserves are estimated to be 2.7 billion tons, while tar sand reserves represent 31 billion barrels of oil equivalent. The identified hydroelectricity sites have an estimated capacity of about 14,250 MW. Nigeria has significant biomass resources to meet both traditional and modern energy uses, including electricity generation. There has been a supply and demand gap as a result of the inadequate development and inefficient management of the energy sector. The supply of electricity, the country's most used energy resource, has been erratic. The electricity system in Nigeria centers on Power

Holding Company of Nigeria (PHCN), which accounts for about 98% of the total electricity generation [3]. Power generation by other agencies such as the Nigerian Electricity Supply Company relies on thermal power for electricity generation unlike PHCN, which relies on both hydro and thermal power generation. However, electricity generation is also a consumer of fuel and energy such as fuel oil, natural gas, and diesel oil. The importance of these sources of energy and fuel for generating electricity has been decreasing in recent years. However, hydropower that is relatively cheaper than these sources has grown to be more important than other sources [4]. However, more recently, the Power Authority has generated electricity through a mix of both thermal and hydro systems. All the power, distribution, and substations are specially interlinked by a transmission network popularly known as the national grid. The entire electricity generated nationwide is coordinated at the National Control Centre, Oshogbo, from where electricity is distributed to all parts of Nigeria.

III. Energy Consumption Pattern in Nigeria

Energy consumption patterns in the world today shows that Nigeria and indeed African countries have the lowest rates of consumption. Nevertheless, Nigeria suffers from an inadequate supply of usable energy due to the rapidly increasing demand, which is typical of a developing economy. Paradoxically, the country is potentially endowed with sustainable energy resources. Nigeria is rich in conventional energy resources which include oil, national gas, lignite, and coal. It is also well endowed with renewable energy sources such as wood, solar, hydropower, and wind. The patterns of energy usage in Nigeria's economy can be divided into industrial, commercial, agricultural, and household sectors [5]. The household sector accounts for the largest share of energy usage in the country which is about 65% of the total energy in supply. This is quite large due to the low level of development in the other sectors of the economy. The major energy-consuming activities in Nigeria's households are cooking, lighting, and use of electrical appliances. Cooking accounts for a staggering 49% of household energy consumption, lighting uses up to 43%, and the remaining 8% can be attributed to the use of basic electrical appliances such as televisions, radios, sound systems, computers etc. [6].

IV. Energy crisis in Nigeria

Energy crisis which has engulfed Nigeria for almost two decades has been enormous and has largely contributed to the incidence of poverty by paralyzing industrial and commercial activities during this period. Nigeria's energy need is on the increase, and its increasing population is not adequately considered in the energy development program. The present urban-centered energy policy is deplorable, as cases of rural and sub-rural energy demand and supply do not reach the center stage of the country's energy development policy. People in rural areas depend on burning wood and traditional biomass for their energy needs, causing great deforestation, emitting greenhouse gases, and polluting the environment, thus creating global warming and environmental concerns. The main task has been to supply energy to the cities and various places of industrialization, thereby creating an energy imbalance within the country's socio-economic and political landscapes. Comparing the present and ever increasing population with the total capacity of the available power stations reveals that Nigeria is not able to meet the energy needs of the people. The rural dwellers still lack electric power.

The second dimension of Nigeria's energy crises is exemplified by such indicators as electricity blackouts, brownouts, and pervasive reliance on self-generated electricity. This development has occurred despite abundant energy resources in Nigeria [7]. The electricity market, dominated on the supply side by the state-owned PHCN, has been incapable of providing minimum acceptable international standards of electricity service reliability, accessibility, and availability for the past three decades.

V. Energy and the Importance of Energy Efficiency and Conservation in Nigeria

About two-thirds of the fuel energy used in a thermal power plant is lost in generating electricity. About 9 percent of the generated electricity is lost during transmission and distribution of the electricity. So the other amount of electricity entering a building or facility represents only 30 percent or less of the original fuel energy [8]. Large energy savings are thus associated with standards for residential electronics products followed by higher efficiency standards for commercial refrigeration, lighting and air conditioning. The next largest savings in the residential sectors could come from higher standards for electric water heaters and lighting.

Improving energy efficiency across all sectors of the economy is an important national objective because of achieving a savings potential through energy efficiency could increase national energy security [9]. Greater energy efficiency would reduce the need for fossil fuels, which has been the mainstay of Nigeria energy supply, and would thereby enhance not only environmental quality but also national security.

Moreover, energy efficient and cost effective technologies are available today to supply services (such as lighting, heating, cooling, refrigeration, transport, industrial motor drive, and computing) that are integral to modern life and that constitute the underlying drivers of the demand for energy. Hundreds of technologies, some already available commercially and others just beginning to enter the market, can provide these services more efficiently than is the case today, and they can collectively save large amounts of energy [10].

Nevertheless, achieving greater energy efficiency in the country will take considerable time and effort because, among other impediments, long lived infrastructure, plants, and equipment such as buildings, automobile assembly lines, and industrial and residential boilers will have to be replaced or retrofitted[11].

6.1 University of Nigeria, Nsukka Distribution System

Power is supplied to the University of Nigeria, Nsukka from Enugu road Injection substation through UNN switch yard within UNN premises. The switch yard houses three 33/11kV, 5MVA step down transformers, metering equipment and oil circuit breakers that protect the transformers. One of the 33/11kV, 5MVA transformer supplies power to the UNN medical Centre while the other two transformers supply power to the rest of the University Community in Nsukka campus both residential and administrative buildings. It has 11kV Ring distribution network through two parallel 300mm^2 underground armored Ring feeder cables at 11kV.

The various 11/0.415kV secondary substations are fed from the switch substations through Ring Main Units (RMU) and 95mm^2 underground armored Feeder Lines. Each feeder begins and ends at a switch substation through oil circuit breakers (OCB). That is each Feeder is connected on either side through OCB and power can be fed from any side, depending on the load distribution required.

Each of these switch substations is equipped with South Wales Gear and uses sectionalized bus bar system with section switches (oil circuit breakers) and other switch ways for incoming and outgoing feeders as shown in Figure 1.

6.2 Major Components of the UNN 11kV Distribution Network

The major opponents of the network include the following:

(a) PHCN 33kV substation
(b) Switching substations (A,B,C) and the secondary Substations
(c) The Feeders (underground cables)
(d) The Ring Main Units (R.M.U.)

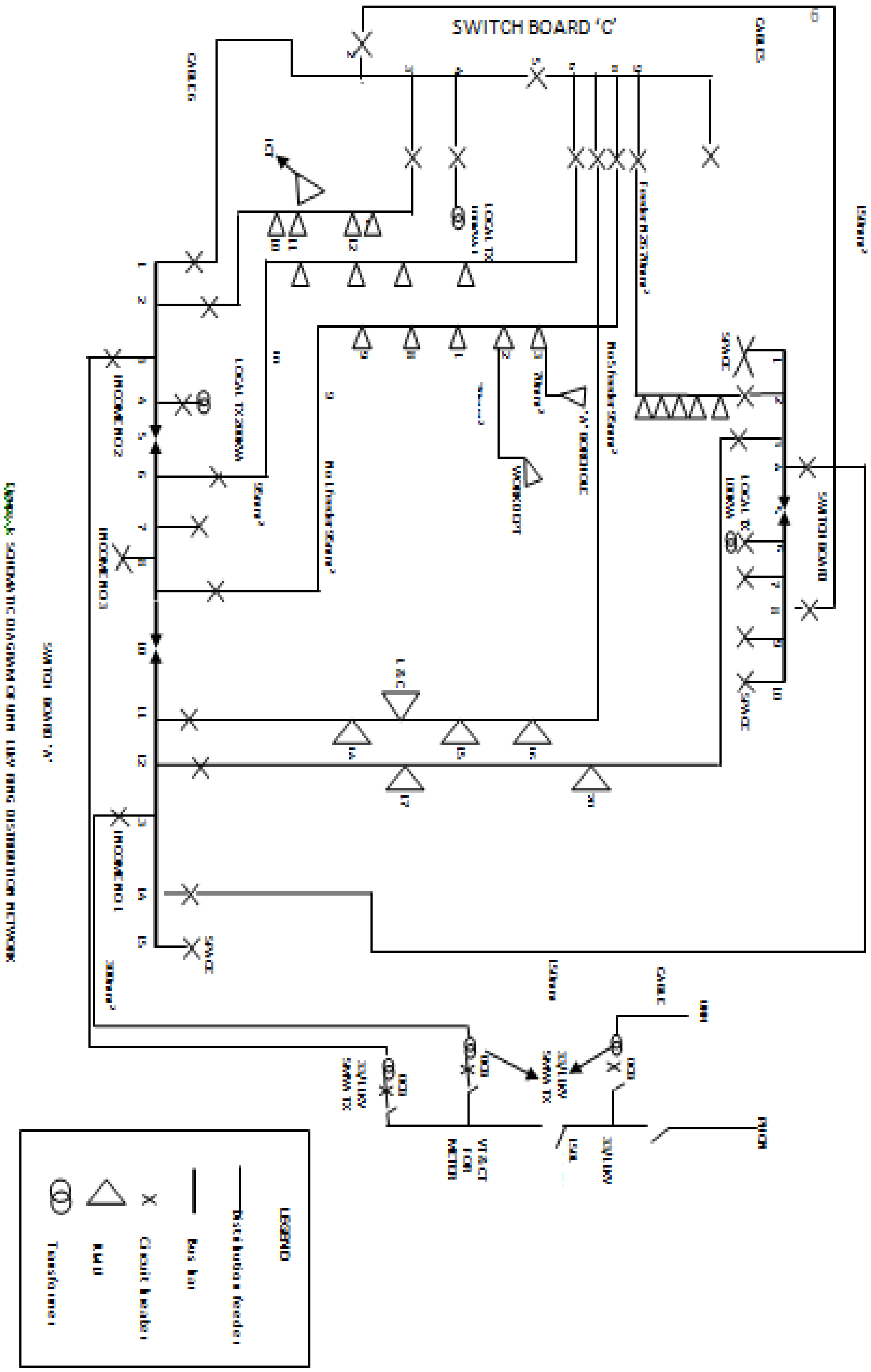
A detail description of these components are as follows:

PHCN 33kV Substation (UNN)

There are three 5MVA 33/11kV transformers in this substation. One of these transformers supplies power to the medical Centre and the other two are for the rest of UNN residential and administrative distribution network. The 11kV, secondary voltage of the transformer is supplied through two parallel 300mm^2 underground feeders to the switching sub-station ‘A’ as shown in figure 1.

The rating of each of the transformers is as shown below:

kVA	5000kVA
VOLTAGE	33kV H.V
NORMAL TAPPING L.V	11.61kV
CURRENT AT H.V	87.48 Amps
NORMAL TAPING L.V CURRENT	248.6 Amps
COOLING	ONAN



The single line diagram of the generation, transmission and distribution network is shown in figure 2.

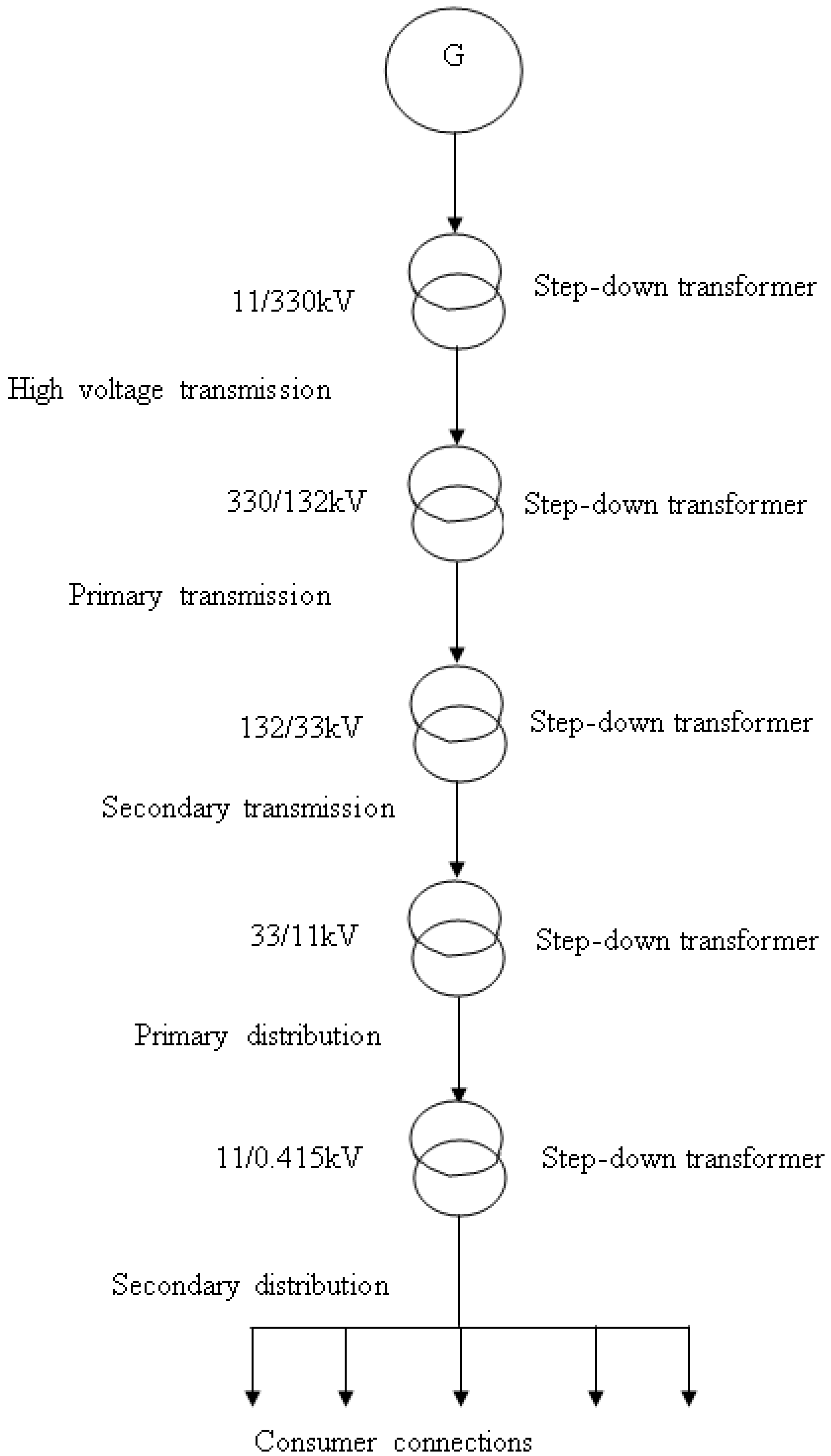


Figure 2: The single line diagram of the generation, transmission and distribution network

VI. Load Network

There are sixteen (16) Halls of residence for both the undergraduate and the post graduate students on campus, and the load network is shown in figure 3.

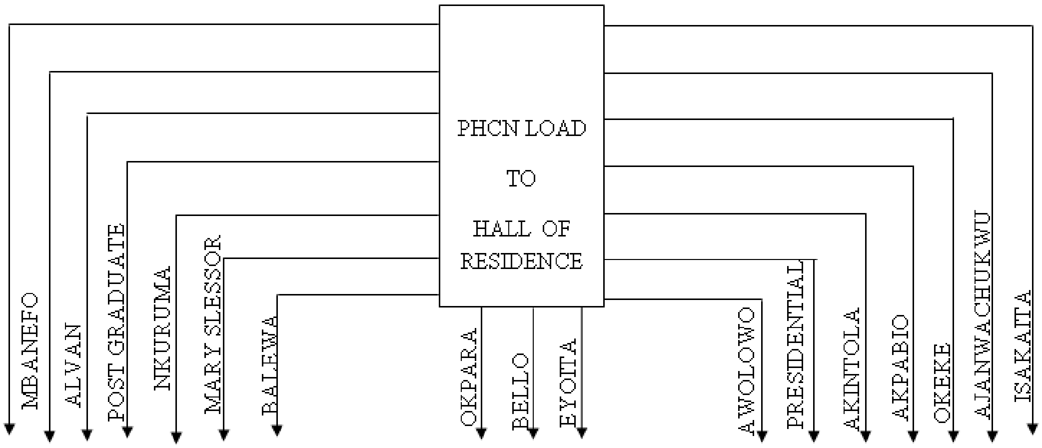


Figure 3: Load Network for students Hall of Residence in the University of Nigeria, Nsukka Campus

Table 1: Total Lighting Loads for the Students' Hostels, Staff Quarters, Administrative Blocks and Faculties

S/N	ITEMS	INCANDESCENCE ENERGY CONSUMED (kWh)	COMPACT FLUORESCENCE LAMP ENERGY CONSUMED (kWh)
1.	Students' Hostels	303,177.60	181,906.56
2.	Staff Quarters	635,385.60	381,231.36
3.	Administrative Blocks	23,760.00	14,256.00
4.	Faculties	129,340.80	77,604.48
	TOTAL	**1,091,664.00**	**654,998.40**

Table 2: Total Non Lighting Loads for the Staff Quarters, Students Hostels, Administrative Blocks and Faculties

S/N	ITEMS	ENERGY CONSUMED(kWh)
1.	Air Conditioner	368,106.24
2.	Electric Pressing Iron	1,163,970.00
3.	Electric Stove	373,800.00
4.	Electric Heater	186,900.00
5.	Miscellaneous Electric Appliances	629,550.00
	TOTAL	**2,722,326.24**

Table 3: Summary of the Monthly Average Energy Cost at the UNN Nsukka Campus

Energy Source	Energy Supplied(kWh)	Cost per Energy Unit (₦)	Total Cost of Energy (₦)
PHCN	744,296.38	19.36	14.4m
Diesel Generator directly operated by UNN Works Department	(264000 Litres)	160	4.22m
Average Monthly Cost	-	-	18.62m

Table 4: Comparism of illuminance of Light Sources

Light Source	Power Consumption (watts)	Illuminance(Lux)	Average life Span (hours)	Remarks
Incandescent Bulb	60	45	1200	Nominal
Conventional Fluorescent Tube	40	97	12000	Nominal
Compact Fluorescent Lamp	36	21	8000	Nominal
Telumina LED Tube	19.4	136	40000	Manufacturers Guarantee

Table 5: Savings and time to recover initial replacement cost

Yearly Savings of Energy	₦ 67.02m
Savings due to not replacing Conventional Lamps	₦ 3.75m
Total yearly savings	₦ 70.77m
Cost of Telumina LED Lamps	₦ 127.5m
Number of years to recover initial cost	₦ 127.5/-₦ 70.77 = 1.80 years
Manufacturers Guarantee	40,000 hours
Savings over a five-year period	₦ 353.85m

The following observations are made for the paper:

(a) The LED lamp produces more illumination and at a much lower power consumption, approximately ½ of power consumption of the most comparable 40W fluorescent lamp.

(b) The life span of the LED lamp is much more than that of any other lamp, at least more than 3 times the life span of the most comparable 40W fluorescent lamp. It should be added that in practice, most of the conventional fluorescent lamps rarely last a year in Nigeria due to the low quality of lamps that are imported into the country and the frequent low voltages and quality of the electricity supply. In most establishments, fluorescent lamps are replaced at least once a year.

VII. Cost Saving by Using LED Lamp

The following assumptions are made for the study:

1. Lighting load for the Nsukka Campus of UNN is 600kW (60% of the average supply of 1.033MW).
2. Lighting installation is represented by 40W fluorescent lamps.
3. Average monthly cost of energy (from table 3) is ₦ 18.62m.
4. From (1) and (2), the number of installation points is 15, 000 lamps.
5. From table 4, the power consumption of the LED lamp (Telumina) is approximately 50% that of the conventional fluorescent lamp (that is, 19.4W as against 40W).
6. From table 4, the manufacturer's guarantee is 40, 000 hours.
7. The conventional fluorescent lamps are changed once a year.
8. The cost of the conventional fluorescent lamps is ₦ 250.00 per lamp.
9. The cost of the LED (Telumina) is ₦ 8,500.00 per lamp.
10. From (1) and (3) above, the energy cost due to lighting installation is 0.6 x ₦ 18.62 = ₦ 11.17m.

I can now make the following calculations:

From (5) and (10) above, the energy savings due to lighting if LED lamps (Telumina) are used to replace all the conventional lamps will be,

0.5 x ₦ 11.17m = ₦ 5.59m

For a whole year, this translates to

₦ 5.59m x 12 = ₦ 67.02m in savings in energy bill.

From (8) above, the additional savings from not replacing the conventional fluorescent lamps is 15, 000 x ₦ 250 = ₦ 3.75m.

Therefore, the total yearly savings in energy cost and fluorescent lamp replacements is

₦ 70.77m

From (9) above, total cost of Telumina LED lamps = 15, 000 x ₦ 8,500.00 = ₦ 127.5m

From (6) and assuming the lamps are on 10hours every day, the life expectancy of the Telumina LED lamps is 40, 000/10 = 4000days = 11 years (approximately). Table 5. Shows the cost savings and time to recover initial cost of Telumina LED lamps.

VIII. Strategy for Load Reduction

From tables 1 and 2, the percentage reduction of energy consumed in kWh for the Students' halls of residence, Staff quarters, Administrative blocks, and Faculties on UNN campus can be calculated as:

% reduction = $(T_E - T_{CFE})/(T_E)\times 100$

% reduction = $(3{,}813{,}990.24-654{,}998.4)/(3{,}813{,}990.24)\times 100$

% reduction = 82.83%

From Table 3, The UNN average electricity bill from the months of July to December 2016 for six months including fixed charges and VAT is calculated to be ₦ 14,420,182.38 and using this amount, the percentage reduction is calculated as:

Reduction = (82.83/100) × 14,420,182.38 = ₦ 11,944,237.4

The amount above shows that lighting loads using compact fluorescence lamp (energy saving lamp) reduces power consumption in power system distribution network and also save cost.

With this level of supply, the average monthly energy bill is about ₦ 14.4m for the Nsukka Campus. If ₦ 4.22m which is the cost of diesel fuel used to run standby generators is added, the total monthly energy bill is ₦ 18.62m.

The LED lighting load will save ₦ 70.77m per annum and over a period of 5 years, the use of the LED lamps will save the university an estimated of ₦ 353.85m. The initial installation cost of ₦ 127.5m will be recovered in less than two years.

IX. Conclusion

The energy Consumption profile of UNN has been presented and this research work provides alternative means of reducing power consumption pattern in the University of Nigeria, Nsukka to 40% by direct replacement of incandescent bulbs with energy saving lamps. The reduction in both lighting and non-lighting loads audits is about 83% at constant reduction techniques for non-lighting load audits which translates to an average of ₦ 11m savings every months.

X. Recommendations

Some recommendations in the course of this research work to the power supply consumers/UNN Communities and the relevant authorities are as follows:

1 The security lights should be switched OFF during the day time.
2. The University Community should encourage the use of the energy saving light in all the Faculties, Administrative and the residential buildings.
3. There should be power supply operating manual with instructions on how to make use of the power supply.
4. Introduce energy saving lamps, fans, and air-conditioners to replace the conventional ones.
5. During bed time, some lighting loads should be switched OFF.
6. There should always be enlightenment programs or awareness to power consumers.
7. Faulty metering management should be discouraged by the PHCN.
8. Power consumers should stop vandalizing PHCN properties in order to encourage steady Power supply.
9. Sensitize the University Community about energy conservation (turning off switches of lightings, devices and equipment when not in use)

References

[1]. P. K. Nag, "Power Plant Engineering" (2nd Ed.), Tata McGraw Hill, pp. 10, 2004.
[2]. A. S. Sambo, "Renewable Energy for Rural Development" Scientific journal of Engineering Research. Vol. 3, No. 4, pp. 40-43, Dec. 2011.
[3]. F. B. Dayo,''Clean Energy Investment in Nigeria, the Domestic Context'' International Institute for Sustainable Development (IISD), pp. 5-7, August, 2008.
[4]. O. I. Okoro and E. Chikuni, "Power sector reforms in Nigeria: opportunities and Challenges", Journal of Energy in Southern Africa, Vol. 18, No. 3, pp. 20-25, 2007.
[5]. J. Engler and J. Jasinowski, "Efficiency and Innovation in U. S. Manufacturing", IEEE Vol. 9, No. 5, pp. 7-10, Nov. 2012.
[6]. Y. C. David Kuang, H. Chung-Hsuan and G. H Min-Hsien, ''Current Situation of Energy conservation in high-energy consuming industries in Taiwan'', Energy Policy 35, pp. 6, April, 2007.
[7]. A. Hepbasli and N. Ozalp**,** "Development of energy efficiency and management Implementation in the Turkish industrial sector", Dec. 2013.
[8]. A. Awad and A. Mohammed, "World Energy Road Map - A Perspective; WEC- 2007 Energy Future in an Interdependent World", pp. 14, March, 2007.
[9]. A. S. Sambo, "Energy Conversion and Management Strategic developments in Renewable energy in Nigeria", International Association of Energy Economics. Vol. 4, No. 3, pp. 10-13, Jan. 2009.
[10]. IEA, World Energy Outlook, International Energy Agency, Paris, France, pp. 5, 2006.
[11]. P. H. Jean and D. F. Marc, "From a forced dependency to positive cooperation in the Field of Energy"; WEC – pp. 33. 2007.

T.C.Madueme . "Electric Power Consumption Reduction in the University of Nigeria, Nsukka Power Network." IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE), vol. 12, no. 4, 2017, pp. 11–18.