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Energy savings opportunities at the University of Nigeria, Nsukka

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Abstract
This paper examines the potential for energy savings in Nigerian higher institutions with particular reference to the University of Nigeria, Nsukka. Electricity consumption and cost profiles for a period of 10 years indicate a steady rise attributable to marginal improvement in staff living standards, increasing students' enrolment, infrastructural development, preponderant use of inefficient electrical appliances and increasing business activities within the community. Investigations show that about 51% of the total electricity consumption occurs in staff housing units, 16% in students' hostels and the balance in academic and public buildings on the campus. An internal energy policy, awareness creation and establishment of an energy management unit in the University system are some of the measures that can guarantee good savings. This paper estimates electricity savings potentials of 10-20% in Nigerian higher institutions through well articulated and vigorously pursued energy efficiency programmes in the system.

Keywords: electricity, energy policy, energy efficiency, savings potentials

1. Introduction

Growing concern to improve electricity generation and supply in Nigeria over the years culminated in 2005 to the unbundling of the erstwhile National Electricity Power Authority (NEPA) and the encouragement of private sector participation in the electricity sector. Yet this action and all others earlier taken by successive governments have not improved the situation. Although the electricity reform agenda of government is yet to be felt in terms of steady power supply it has been observed that the current tariff regimes are too low to support a profitable operation of the electricity supply system (ECN, 2006). Activities in the electricity sector at present suggest that before long there may be an upward review of tariffs in order to sustain private sector investment and participation in electricity generation and supply in Nigeria. This is especially important for the universities where electricity is essential. Even though fully funded by the Federal government, universities in Nigeria should not remain unconcerned or detached from global issues as the increasing drive for rational energy consumption aimed at not only driving down costs but also reduction in greenhouse gas emissions from utilities.

Environmental externalities associated with energy consumption have continued to attract the attention of the international community. Since the rise in GHG emissions are heavily related to anthropogenic energy consumption, improving efficiency of energy use is seen as the key to reducing these emissions. Energy efficiency is a priority because a 10-30% reduction in GHG emission can be achieved for little or no cost by merely improving energy efficiency (Yin-Liang Chan *et al.*, 2007). Obviously this is very instructive to energy consumers in Nigeria particularly, institutions and industries.

In Nigeria, there are twenty seven federal universities (www.nuc.org) and several polytechnics, colleges of education and secondary schools that receive their funding from the federal government and have resident staff quarters and students' hostels. Because of their peculiar nature as knowledge-transfer-based institutions, the energy source predominantly in use in the universities and these other institutions for educational aids is electricity.

Therefore, the issues of electric energy availability, consumption and costs in universities with resident students and staff quarters can present a formidable challenge to any responsible administration. This is because its availability or otherwise can have profound effects not only on academic activities but also on the social and economic activities in the system. This is why university authorities in Nigeria make great efforts to compliment the generally unsteady electricity supply from the national grid with diesel generators albeit at a very high financial and environmental cost to fill the supply gap at the most critical moments.

Electricity consumption in the University of Nigeria, Nsukka, is mainly for lighting; comfort cooling; water heating; water pumping and general research activities. It is also the main driver in the provision of support services like operation of computers, photocopiers and other social activities. Electricity bills and fuel prices in the past did not present much concern to the University administration due largely to low tariff, low fuel prices and a low student population. The situation has however changed in the past few years. With a steady increase in students' enrolment, dwindling government subvention, energy price increases, growing infrastructural development and observed marginal improvement in the standard of living of university workers resulting from relatively enhanced emoluments, energy consumption and hence energy bills have continued to rise. The fallout from these is institutions saddled with enormous overhead costs. Therefore, the issue of how to minimize overhead costs in the face of rising energy prices and increasing students' population among other externalities is presently posing a formidable challenge to university administrators.

Energy efficiency measures are defined as 'all changes that result in decreasing the amount of energy used to produce one unit of domestic activity…..or to meet the energy requirements for a given level of comfort' (WEC, 2004) offers a window of opportunity for energy savings and hence lowering of energy bills in the university. Therefore, to effectively address the issue of rising energy bills, implementation of energy efficiency programs in all the universities in Nigeria presents the most reasonable and cost-effective means of achieving energy-bill reduction while maintaining quality service delivery. Furthermore, engagement in energy efficiency measures in the University will provide a source of compounding gain in reducing greenhouse gas emissions from utilities since every kWh of electricity consumed or saved is equivalent to the emission (or avoidance of the emission) of 0.44kg CO_2. Energy efficiency programs designed and implemented as part of the overall institutional development policy strategy will reduce energy bills as well as enhance environmental performance.

Again, an energy audit defined as 'a study to determine the quantity and cost of each form of energy to a building, process ... over a given period' and energy surveys 'a technical investigation of the control and flow of energy in a facility etc with the aim of identifying cost-effective energy saving measures' (Carbon Trust GPG 311) are both essential components of an energy efficiency program. They provide data required to make informed decisions on which are the most cost- effective measures of an energy efficiency program to be implemented. Generally, an energy audit provides an institution with better means for learning from past experiences: a platform for proper planning, policy formulation, resource allocation and improving energy consumption. Presented in this paper are the results of an energy audit and survey program carried out at the University of Nigeria, Nsukka Campus. The contribution of this work lies in the fact that this is the first attempt in the history of the institution to formally evaluate energy and cost savings opportunities in the University. The work will, in addition to creating the necessary awareness, engender improved environmental performance and all other incidental benefits as well as provide a reference point for planning, budgeting and future activities with respect to end-use energy efficiency and management measures in the University.

2. Electricity situation in Nigeria

Electricity generation in Nigeria rose from a mere 30 MW installed capacity in 1956 to 478 MW in 1968; 2441.6 MW in 1981 and about 6000 MW in 2005 with a mix of 28.5% hydro and 71.5% thermal (Emmanuel *et al*., 1986). Disturbingly the total electricity available capacity in Nigeria fell from about 4000 MW to less than 3000 MW in 2007 (NNCWEC, 2008). The generation, transmission and distribution losses in the grid over a decade (1991-2000) have been estimated to be about 38%. This in addition to ever increasing demand coupled with the general decay in the system explains the reason for the persistent load shedding and power rationing that has become almost endemic in the country. All these notwithstanding, end-use electricity in Nigeria are characterized with visible inefficiency due to lack of awareness and continuous use of obsolete and inefficient appliances among others.

Inefficient incandescent electric bulbs, for example, still adorn every home and institution in Nigeria. Electric lamps are still left to glow in broad day light along the streets and roads in major cities in Nigeria. Industries still run on old technology with inefficient electric motors, drives, outdated boilers and combustors which in many instances have initial low cost attraction but very high life-cycle costs with regard to energy consumption. On the whole, if proper attention is given to energy efficiency in

Nigeria the glamour for installation of new power plants may not be as pronounced as it is made to appear at the moment. There is an estimated 30-40% room for electricity savings opportunity in the industrial, commercial, institutional and domestic sectors of the Nigerian economy.

2.1 Electricity tariff structure

The electricity tariff in Nigeria is regulated by the utility charges commission of the Federal Government. By 1st February 2002 a new tariff structure was introduced by the commission which has remained in force since then. In this structure which has eight tariff groups, namely residential, commercial, industrial, street lighting, special class, welders, utility staff and pensioners, the Universities are placed under special class A2 with demand level of < 45 KVA < 500KVA. The Universities by government policy are exempted from payment of demand charges.

Energy charges by comparison are about 32% less than those in the same category (see Table 1). It is important to note that energy tariffs rose from ₦2.37/kWh in 1998 to ₦4.74 in 2001 and ₦5.80 by 2002. Presently another increase is being anticipated

2.2 Brief description of the University of Nigeria

The University of Nigeria, Nsukka established in 1960 lies on the North-West corner of the Eastern Region of Nigeria at a distance of about seventy kilometres from Enugu, the then regional capital, but now the capital of one of the states that make up the region. The population of the two-campus University has grown from 220 students at inception as (Emmanuel *et al*., 1986) to student enrolment at present, of about 30 000-35 000 annually. Statistics from the Academic Planning Unit show that in the 2006/2007 academic year the overall students' enrolment in both campuses was about 31 159 out of which 20 688 enrolled at the Nsukka campus. Furthermore, there are about 21 resident students' hostels with an estimated 2 220 rooms at the Nsukka campus of the university as at the 2007/2008 academic session. In addition, there are twelve faculties, sixty-two departments and several public and academic buildings in the Nsukka campus. The university also has about 642 senior staff housing units of various grades (flats, bungalows and duplexes) and 92 junior staff housing units. Information from the Students Affairs Unit of the University indicates a growing number of the population of officially recognized resident students over the years which now stands, on average, of about 9720 students /year. The University community is indeed a mini-township.

The University receives funding from the Federal Government through the National Universities Commission. However, due to continuing adjustments in government's economic policies, coupled with high students' enrolment, growing infrastructural development, and demand for better conditions of service etc, financial releases from government are no longer sufficient to meet the growing needs of the University. The situation therefore calls for every laudable measure that will reduce spending. One of such identified measures certainly is improving end-use energy consumption in the system.

2.2.1 Energy situation at the University

The primary energy types in use in the University are electricity from the national grid and diesel, used for electricity self-generation in diesel generating sets. Gasoline is also used to fuel official cars, but the volume of use has declined considerably due to government policies on the use of official vehicles.

The University buys electricity from the national grid and distributes same to faculties, research centres, offices, students' hostels, staff quarters and business units located within the community. A maximum demand meter located at the Odenigwe end of the Nsukka campus records the amount of electricity purchased each month from the Power Holding Company of Nigeria (PHCN). Apart from staff houses that are metered and billed for electricity usage, every other electricity consuming outfit in the University is not metered, including the guest-

Table 1: Aspects of new tariff structure effective from all bills production from 1st February, 2002
Source: PHCN (2002)

Customer demand level < 45 – < 500KVA							
End-use outfit	*Old tariff codes*	*New tariff codes*	*Fixed charge per month (Naira)*	*Meter maintenance charge per month (Naira)*	*Demand charge per KVA (Naira)*	*Minimum charge per month (Naira)*	*Energy charge per kWh (Naira)*
Residential	L3	R4	120.00	1 600.00	0.00	5 000.00	8.50
Commercial	L6	C3	240.00	1 600.00	230.00	5 000.00	8.50
Industrial	L9	D3	240.00	1 000.00	230.00	5 000.00	8.50
Special tariff class	-	A2	240.00	1 600.00	0.00	5 000.00	5.80

houses, the university micro finance banking complex and others. As earlier stated, due to frequent power outages that often lead to frustrating disruptions in services, the University and a number of the business outfits located within the campus maintain diesel generators to provide electricity during such interruptions.

3. Methodology

The methodology used in this work is the billing energy audit method for historical energy consumption analysis and facility walk-through for energy use survey. Electricity consumption data and costs for a period of about 10 years (1998-2008) were extracted from the utility bills and logbooks kept at the Works Unit of the University. The data was streamlined to indicate actual consumption within each month of the year. Statistics of resident students was obtained from the Students' Unit while information on annual students' enrolment was received from the Academic Planning Unit of the University.

The electricity tariff structure in Nigeria was obtained from the offices of the Power Holding Company of Nigeria (PHCN). The walk-through energy audit of students' hostels and staff offices was undertaken at night and during the day for physical observations of the different kinds of light fixtures and oral interview of energy end-users. There are about 2200 room spaces in the 21 students' hostels that accommodate an average of about 9 720 resident students per session. Electricity usage in the hostels is for lighting, water heating for comfort bathing, fan cooling, ironing, and supplemental cooking with hot plates and for playing musical sets. It is difficult to determine and isolate the exact quantity of electricity consumed by students from the overall consumption at any given period since the hostels are not metered.

An energy walk through of the students' hostels reveals that lighting is provided by mainly 60W and 100W incandescent bulbs while hot water heating is mainly by 1 000W rated resistant coil heaters. Also hot plates of various ratings are 'unlawfully' used for supplemental cooking in hostels. In order to arrive at a good estimation of electricity consumption profile of resident students, 1 000 copies of questionnaires detailing the major areas of electricity use by students were administered to about 1 000 rooms across the hostels out of which 929 inmates supplied answers to the questions posed. An aspect of the statistics relevant to study is shown in Table 3. The illuminance levels (lux/m^2) of light in students' rooms and some offices were measured using a TENMA 72-6693 light meter. Since the University has only one maximum demand meter that records consumption in the entire community, electricity consumption attributable to students living in the hostels was estimated from information in the questionnaire. Appropriate computer software was used for the analysis for trends and anomalies.

4. Results

4.1 Historical energy consumption

Table 2 details the monthly electrical energy consumption on the Nsukka campus of the University from January 1998 – June 2008, while Figures 1 and 2 show the average monthly consumption and the annual cost profile in millions of Naira respectively. The marginal increase in electricity consumption from 2004 as compared to the previous years is attributed to increasing population, growing number of public and academic buildings, increases in commercial activities, marginal improvement in staff salaries and a fairly steady power supply within the campus. What is however instructive is the astronomical rising in electricity bills from about ₦15 million in 1998 to over ₦60 million in 2007.

Table 2: Streamlined energy consumption at the University January: 1998 – June 2008 (kWh/month)

	1998	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*
Jan	666 400	308 500	290 100	855 400	773 000	N/A	565 500	490 600	747 920	629 760	792 240
Feb	436 100	479 800	229 100	1 060 900	730 200	-do-	716 300	1 024 400	991 830	943 550	980 640
Mar	326 800	653 100	335 900	645 200	849 800	-	1 043 100	605 380	1 023 030	940 300	971 890
Apr	581 400	615 900	443 400	263 100	695 400	-	683 800	920 570	1 087 430	833 440	920 630
May	390 400	524 100	594 200	485 100	492 500	-	1 011 000	797 840	1 071 970	793 160	529 450*
Jun	628 000	488 300	533 100	783 500	276 000	-	916 900	1 048 650	710 210	933 800	786 340*
Jul	559 100	530 200	451 100	774 300	425 300	-	999 800	987 530	758 420	1 113 880	
Aug	547 900	588 000	559 500	697 400	600 300	-	927 200	1 046 270	737 230	866 410	
Sep	617 400	420 200	485 500	752 000	832 300	-	1 056 000	660 270	928 290	1 203 530	
Oct	522 600	342 900	573 800	680 600	586 000	-	571 600	567 870	833 380	723 230	
Nov	647 400	622 600	539 900	666 000	N/A	-	655 500	748 870	652 510	777 110	
Dec	472 600	530 300	53 540	777 000	N/A	-	490 600	871 300	905 190	765 530	

* Witnessed frequent power outages due to installation faults

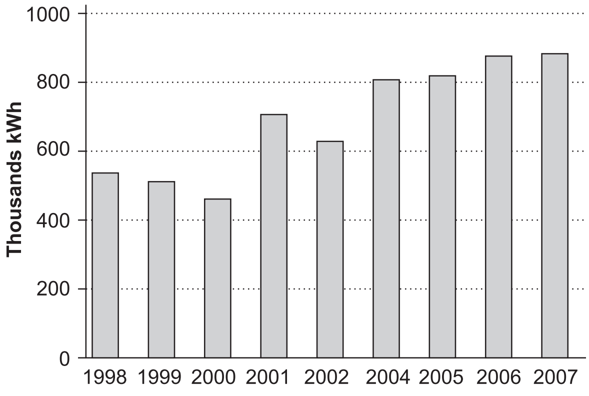

Figure 1:Average monthly electricity consumption (1998–2007)

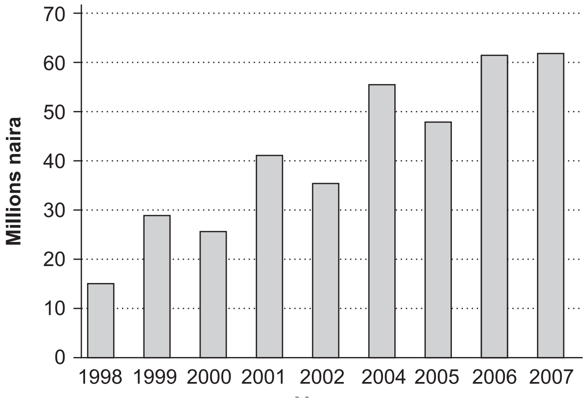

Figure 2: Annual electricity cost profile (Naira, 1998–2007)

Although the rise is partly due to the over 144% hike in tariff from ₦2.37/kWh in 1998 to ₦5.8 since 2002, the situation is altogether worthy of note when viewed against the backdrop of the fact that annual electricity supply to the University is only about 60 -70%.

It is therefore expected that with constant year round electricity supply, consumption and hence the energy bill will likely double the current figure. This information is very important as it will help policy makers to be aware of the desired need to reposition the University towards adopting energy efficiency measures that will not only save costs but minimize environmental fallouts from electricity generation.

4.2 Aspects of students energy consumption

4.2.1 Lighting use analysis

From Table 3 it can be seen that 44.2% of the total number of students sampled use 60W incandescent lamp bulbs in their rooms, while 44.9% use 100W bulbs – the rest use fluorescent lamps. Out of the number, only 42.8% remember to turn off lights when leaving a room while 57.5% do not, thus suggesting the need for awareness creation for energy efficiency promotion in the hostels in addition to replacement of the inefficient incandescent bulbs with CFLs.

4.2.2 Hot water use analysis

For hot water usage, 68.4% of the student popula-

Table 3: Aspects of survey results of electricity usage in the students' hostels

Hostel name	*Status*	*No rooms visited /re-spondents*	*Lighting analysis*				*Hot water use analysis*					*Electric appliances use*			
			Fixture rating		*Turn off light?*		*Bath hot water*	*Period*		*Reasons*		*Resistant coil*	*Elec kettle*	*Elec iron*	*Elec hot plate*
			60W	*100W*	*Yes*	*Other*	*Yes*	*Morning*	*Other*	*Cold*	*Other*	*Yes*	*Yes*	*Yes*	*Yes*
Okeke	F	32	20	12	10	22	25	25	10	18	14	17	10	23	10
Awo	F	21	19	1	11	20	17	18	8	17	4	12	2	14	2
Bello	,,	48	16	28	26	22	41	42	9	32	16	36	3	33	Nil
M/Slesor	,,	36	19	16	14	22	33	33	10	27	9	26	7	26	3
Isa	,,	37	14	20	13	24	28	29	8	27	10	21	2	22	Nil
Bel.	,,	47	25	17	21	26	35	35	12	18	18	40	1	36	9
Okpara	,,	58	28	18	19	39	40	36	4	35	17	36	9	42	13
Pr'dential	,,	49	26	15	12	37	39	35	10	37	12	28	3	33	5
Akin	,,	21	13	7	12	12	16	14	5	9	7	9	2	11	2
Akpab	,,	30	16	11	9	21	23	22	7	18	6	20	2	19	1
Flats A-C	,,	129	63	63	64	65	86	86	41	61	25	58	Nil	73	12
Flats D-E	,,	115	60	55	76	39	85	80	49	62	24	49	22	85	28
Subtotal		**623**	**319**	**263**	**287**	**339**	**468**	**455**	**173**	**361**	**162**	**352**	**63**	**418**	**85**
%			51.2	42.2	46.1	54.4	75.1	73	27.8	58	26	56.5	10.1	67.1	13.6
Nkurumah	M	51	13	28	14	37	23	23	Nil	14	9	20	Nil	9	17
Eni-Njoku	M	67	19	41	28	39	41	39	2	33	8	31	1	23	19
Mbanefo	M	69	24	28	28	41	38	38	Nil	30	8	37	Nil	32	36
Alvan	,,	119	36	57	41	78	65	65	Nil	52	13	65	Nil	74	70
Sub-Total		306	92	154	111	195	167	165	2	129	38	153	1	138	142
%			30.1	50.3	36.3	63.7	54.6	53.9	Nil	42.2	12.4	50	Nil	45.1	46.4
Grand total	M+F	929	411	417	398	534	635	620	175	490	200	505	64	556	227
%			**44.2**	**44.9**	**42.8**	**57.5**	**68.4**	**66.7**	**18.8**	**52.7**	**21.5**	**54.4**	**6.9**	**59.9**	**24.4**

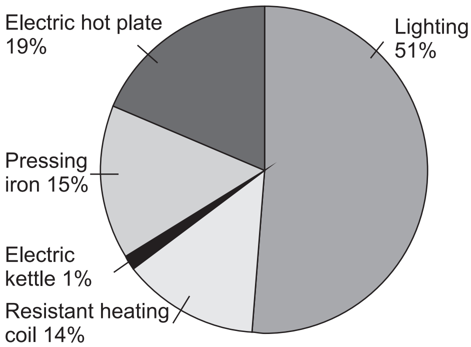

Figure 3: Percentage appliance use by students

tion bath in hot water while 31.6% do not. The peak period for hot water demand is in the morning hours when 52.7% of the student population bath in hot water due to the cold while the remaining 21.5% do so for medical reasons and as a habit. The statistics here shows a very good opportunity for the use of solar water heaters in the hostels or construction of 'refuse fuelled' incinerators for hot water generation.

4.2.3 Electric appliance use analysis
For hot water generation, 54.4% of the student population makes use of a 1 000 W rated resistant coil while 6.9% use an electric kettle. Furthermore, 59.9% of the students and 24.4% own pressing iron and electric hot plates respectively. On the basis of gender, the ratio of females to males that use resistant coils is almost 1:1 while for pressing iron it is about 1.5:1.

These findings are considered germane as they will aid in policy and planning purposes for alternative but cost- effective means of meeting students demand for hot water in the hostels should the University decide to adopt energy efficiency measures.

4.2.4 Estimation of energy savings potentials in the students' hostels
Using statistics from the energy use survey in the hostels and information obtained from the Students Affairs Department of the University, the potentials for energy savings in the hostels are estimated. For instance, the average number of resident students in the university is 9 720 per normal session of about 10 months (September – June of each year). Assuming an average of 9 000 resident students per session of the full academic year and an annual power supply factor of 0.6 from the national grid, electricity consumption by resident students is estimated using information from Table 3.

1. Lighting consumption (6 pm-11 pm; 5 am-6am:7hrs)

60 W x 7 hrs/day x (0.442 x 9000 students) x 305 days/yr x 0.6 = 304 749kWh/yr

100W x 7 hrs/day x (0.449 x 9000 students) x 305 days/yr x 0.6 = 517 652kWh/yr

2. Resistant coil consumption (1000 W)
Tests with the resistant coils show that it takes about 20 minutes to raise the temperature of 10 litres of water from an ambient of 20^0C to about 52^0C. To avoid over estimation of results, an average of 15 minutes is assumed to achieve a temperature level suitable for comfort bathing.

1000 W x 0.25 hrs/day x (0.544 x 9000 students) x 305 days x 0.6 = 223 992 kWh/yr

3. Electric kettle 2000 W
It is assumed that electric kettle generally takes about 5 minutes to boil water.

2000 W x 5/60 hrs/day x (0.069 x 9000 students) x 305 days/yr x 0.6 = 18 865kWh/yr

4. Pressing iron 1 000 W:
It is also assumed here that students iron their cloths for an average of 15 minutes a day.

1000 W x 15/60 hrs/day x (0.599 x 9000 students) x 305 days/yr x 0.6 = 246 638kWh/yr

5. Electric hotplate 1 000 W:
Students use electric hot plates for cooking food to supplement feeding since the government abolished the cafeteria system in the Universities. Survey results indicate that about 15% of the students actually use kerosene stoves. It is assumed that usage of a hotplate for cooking takes about 45 minutes.

1000 W x 45/60 hrs/day x (0.244 x 9000 students) x 305 days/yr x 0.6 = 301 401kWh/yr

From the computations, the students' electricity consumption by use of these 5 energy consuming appliances is estimated to be 1 613 297 kWh per annum. The percent share of each of the appliances is shown in Figure 3. As can be seen, two major areas present great opportunities for energy savings in the students' hostels. These are energy consumed in the use of incandescent light bulbs and that for water heating. For instance, 51% of the total energy consumed by students' resident in the hostels is expended on lighting by use of incandescent bulbs. With present technology more than ¾ of this quantity of energy can be saved by the deployment of the more efficient compact fluorescent bulbs which not only give higher lumens but lasts longer. Furthermore, the 14% energy consumption for water heating can be wholly saved by the installation of solar water heaters in the hostels. Further energy savings can be achieved by mounting intense awareness creation on the need for behavioural change in the use of energy in the hostels.

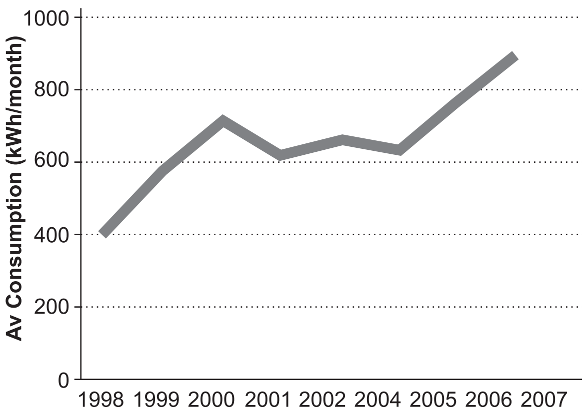

Figure 4: Monthly staff electricity consumption 2000–2007

4.3 Resident staff electricity consumption

As already stated, there are 642 senior staff and 92 junior staff houses on the Nsukka Campus of the University. The average monthly electricity consumption for a period of 8 years derived from staff billing records is shown in Figure 4.

If we assume an overall average consumption of 600 kWh/household/month, the total electricity consumption attributed to resident staff at the University is estimated to be 5 284 800kWh/year. Compared to an average consumption of 10 094 490 kWh/year (2004 – 2007) for the entire university community (hostels, staff houses, public and academic buildings) it becomes obvious that electricity consumption in staff houses is about 52% of the total consumption. Expectedly as in most homes of university employees, this quantity of energy is consumed mostly in electrical appliances such as air conditioners, deep freezers, fridges, washing machines, vacuum cleaners, water heaters, lighting, fans, and electric cookers in addition to avoidable wastes.

It is instructive to note that unlike in the cities, a tariff is not differentiated based on class of consumption at the University. The University buys electricity at a special rate of N5.80/kWh and sells to staff at a flat rate of N4.00/kWh. This is okay from point of view of social benefits. However, since government pays a monthly utility allowance to staff, the most plausible approach to achieve both energy and cost savings at the University is to allow staff to take responsibility for managing their energy use.

This can fully be achieved by the installation of pre-payment electricity meters in staff houses. The advantages of the pre-payment system are enormous. These include: no meter reading, no estimated billing, no crazy billing, no disconnections or payment of reconnection fees and above all it is pay as you consume which is central to proper energy management strategies especially in the homes. Other measures which can ensure energy savings in staff homes include awareness creation for attitudinal change, replacement of old inefficient air-conditioners with modern efficient ones and replacement of incandescent light bulbs with compact fluorescent lamps (CFL).

It is important to state here that a 20-25W CFL will give an equivalent lighting service to a 100 W bulb. Moreover not only do CFLs use less energy but they also last longer (8 000 hours compared to 500 – 2 000 hours) so that over their lifetime they pay for themselves (between 500 – 900 hours depending on the electricity price) and provide substantial cost savings in energy use avoided over its lifetime (about 10 – 20 times the initial cost over the life of the bulb) (*Joint Implementation Quarterly*, April, 2008).

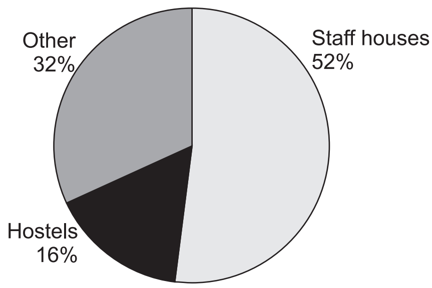

Figure 5: Estimated sectoral share of electricity consumption at the University

Based on the analysis, the percent share of staff, students' hostels and others in the overall electricity consumption in the University is shown in Figure 5. From the foregoing it is possible to achieve 10-20% energy savings yearly in all Nigerian universities if necessary measures are taken to ensure end-use energy efficiency including simple housekeeping measures. For the University of Nigeria, Nsukka, this will translate to an annual savings of about ₦6-9 million in addition to $C0_2$ emission avoidance from the utilities of about 700 metric tones per annum. These are conservative but very instructive figures.

The measured illumination levels in some locations are shown in Table 4. Illumination from diffused light at day-time is quite sufficient for any type of business in the offices. So, it is advisable to keep window blinds open during the day to let in diffused light. On the other hand, although this is typical of incandescent light bulbs where roughly only 5% of the energy is converted to light in the visible spectrum and the rest radiated as infrared and heat Smith (1981) the lux levels of 8 – 27 in the students' rooms are considered inadequate for reading purposes.

Table 4: Measured illumination levels in some locations

Location	*Time of measurement*	*Description of source light*	*Illumination level (lux)*	*ESI recommended Illumination level (lux)**
Hostels				
i	afternoon	1-100W-incandescent bulb	20-55	320
ii	,,	Diffused light	317-334	,,
iii	,,	Diffused light (Blind open)	289-547	,,
iv	night	1-100W-incandescent bulb	8-27	,,
Offices				
i	afternoon	Diffused light	318-554	320
ii	,,	1-100W-incandescent bulb	48-52	,,
iii	,,	6-40W-flourescent lamp	220-365	,,
iv	,,	4-40-flourescent lamp	105-165	,,
v	6.00pm	Diffused light	54-102	,,
Others				
Laboratory	afternoon	46-40W-flourescent lamp	534-680	500-750
Computing room	,,	Diffused light	317-325	320

* Craig B Smith copyright c 1981 Pergamon Press pg 155

Furthermore, a lot of energy savings can be realized by reducing the number of fluorescent lamps and ensuring task specific illumination in the laboratories.

5. Conclusion

The electricity situation in Nigeria is presently characterized with very low power generation capacity. Ironically the marginal quantity being generated is wasted through inefficient use in very many ways. Findings from this research indicate that opportunities for energy savings abound in the University system in Nigeria.

In the 1980s and 90s, electricity bills and fuel prices did not present much concern to the University administration due largely to a low tariff, low fuel prices and low student enrolment. However, the situation has drastically changed in the recent past. With steady increase in students' enrolment, dwindling government subvention, energy price increases, growing infrastructural development and observed marginal improvement in the standard of living of university workers resulting from relatively enhanced emoluments, energy consumption and hence energy bills have continued to rise. The fallouts from these are that universities are saddled with enormous overhead costs. Therefore, the issues of how to reduce costs in the face of rising energy prices and increasing student enrolment among other externalities are undoubtedly posing formidable challenges to university administrations across the nation.

Arguably the adoption of energy efficiency measures as part of the overall University developmental policy strategy will reduce energy bills and enhance environmental performance in the university system in Nigeria. Some of the policy options which the University can take to reduce energy spending include *inter alia:*

- A systematic replacement of incandescent bulbs with compact fluorescent lamps (CFLs), and obsolete and inefficient air-conditioners with modern efficient ones over a period of time.
- Disengagement of payment of electricity bills for resident staff by encouraging the installation of pre-payment meters in staff quarters to allow staff to take responsibility for their energy use.
- A policy of energy self accounting in all University owned enterprises encouraged by sub-metering of such business outfits for effective energy use surveillance.
- Institution of an annual competition with recognition and attached rewards for the most energy efficient hostels in the University.
- A policy to harness solar and other renewable energy sources for hot water generation in students' hostels.
- Creation of Energy Management Units in the University system.

A well articulated and vigorously pursued energy efficiency policy measures in Nigerian higher institutions can result in an estimated annual savings in electricity consumption of 10 – 20% if not more. This certainly will be a welcome development as it will ensure sustainable development of the sector and possibly eliminate the pressure for the installation of additional power plants as is the experience in some other countries across the globe. The additional benefit to the environment with respect to the climate change phenomenon cannot be overemphasized.

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