Electric Load Consumption Profile of Female Students Hostels in Ahmadu Bello University Zaria, Nigeria

[a]Ode, O.M., *[a]Stanley, A.M., [a]Dadu, D.W., [b]Abah, A. M. and [c]Sani, I. F.
[a]Department of Building, Ahmadu Bello University, Zaria, Kaduna State Nigeria
[b]Department of Building, Niger Delta University, Amasoma, Bayelsa State, Nigeria
[c]Advanced Aircraft Engineering Laboratory, National Space Research and Development Agency, Gusau, Zamfara State, Nigeria
*Correspondence email: stanleywond@yahoo.com

Abstract

The study assessed electric energy consumption profile in female students' hostels of Ahmadu Bello University Zaria. Questionnaire survey method, energy audit and checklist were used in the study. Twenty four (24) different types of electric appliances were identified in the students' hostels. Electric pressing iron dominates with frequency of 61(9.79%), followed by handset charger 58(9.31%), electric fan 52(8.35%). The appliances with least frequency of 2(0.32%) were dishwasher and electric indoor grill. The study established that pressing iron has the highest energy consumption of 67,100W representing 18.7% total energy consumption of appliances in the hostels. This was followed by boiling ring with 60,000W representing 16.8% and hotplate with 57,600W representing 16.1%. The appliance with the least energy consumption was handset charger (232W) representing 0.1% of the total energy consumption. The total energy consumed by appliances in the hostels was 357,287W with a cost of ₦9, 289. 46 KWh. The frequency of use of appliances was ranked 1st as the major factor that determines energy consumption in the hostels, followed by room type and electric room heater. The study concluded that electric pressing iron, boiling ring and hotplates are the major energy consuming appliances in the students' hostel. The management should monitor the hostel energy consumption and sensitize the students on the importance of using energy efficient appliances to reduce the cost of energy.

Keywords: Electric Appliances, Electric Load Profile, Hostel, Ahmadu Bello University, Zaria

INTRODUCTION

Electric power supply in buildings has significant role in the productivity of the building occupants. Its availability is used as a yardstick to measure the development of a nation and the standard of living of its citizens (Muhammed, 2005). Its inadequacy is usually a setback to development especially in the developing countries. In the academic environment it facilitates academic activities and the well-being of staff and students. Its importance in the academic environment cannot be overemphasized.

Jukka and Lund (2006) observed that the academic environment consume significant amount of electricity due to its various activities particularly at the students' level. The cost of the electricity bill has been a major concern in most academic institution which can be reduced significantly by implementing good management and practicing energy conservation. Electric energy conservation has increasingly become a strong concerned across the globe due to its lack and the negative impacts on the environment at point of generation. Farzad and Neal (2003) have identified heating with the highest energy consumption in the building accounting for 63% while for lighting in hostels exceed the cost for heating.

Electrical load profile comprises of electric loads generated from appliances used in the building (Jukka and Lund, 2006). The load profile can be achieved through the audit of the energy consumption by the appliances. An electric energy audit of building is put into consideration in establishing the electrical consumption load which is performed in order to change energy use pattern of the building (Muhammed, 2005). It has been established in energy audit study that about 25% savings can be achieved through simple housekeeping measure.

High electric energy consumption has been characterized in the students' hostels of Ahmadu Bello University Zaria due to the various high load consuming appliances used in the hostels. Owing to the problems identified, there is need for the user to be aware of the rate at which the appliances used consume electricity especially in the female students' hostel. The need to device a means of minimizing the usage of electricity in the study area is inevitable. The study is therefore aim to develop an electricity load consumption profile of female students' hostels in Ahmadu Bello University Zaria, with a view to enhancing energy efficient in the hostel.

Energy Consumption Patterns in Building

Electrical load profile refers to the demand and consumption information of electricity (Elexon, 2013). The buildings sector alone accounts for about 60% energy consumption. This is characterized by user behavior, activities level and weather condition (Stanley, 2007). It includes the details of energy consumption generated from large to small equipment used in the building (Jukka and Lund, 2006).

A typical institutional energy consumption pattern according to Sustainability Network (2008) which is not far from what is obtainable in Nigeria are categorized into percentages as departments (27%), administrative blocks (1%), commercial (4%), hostels (17%), residential (10%), facilities (5%) and others (22%). The various electrical energy consuming equipment found in typical institution are; lightings, fan, scanner, air-conditioning, printer, electric kettle, electric coffee maker, photocopier and desktop computers. Others includes elevators, sterilizers, vacuum systems, steam systems, electric cooker, washing machine, vacuum cleaning, refrigerators, stabilizers, television, boiling ring, microwaves, toasters, hand driers, pressing iron, etc.

Consumption of electric energy of such nature translates into huge amount of money which is usually a challenge to management. In order to monitor such energy consumption, some establishments use statistical models to illustrate data for electricity consumption patterns (McLoughlin *et al.*, 2012). The pattern of consumption generated is based on detailed information appliances type, capacity, period/hours of use, number of the appliances and user behavior (Abdelbaset *et al.*, 2012). This process is referred to as electric energy audit. An electric load profile gives the expenditure period of usage across a day expenditure, and the pattern across the expenditure year, for the consumer (British Energy Suppliers, 2016). Electric energy consumptions are also monitored by the use of sense-analyze-respond switch via a smart meter and transmit collected data in real-time to servers, which analyze it to reveal detailed electrical usage and occupancy patterns, and finally respond by automatically controlling electrical loads to improve energy consumption (Sean *et al.*, 2013). These are measures to checkmate energy consumption in large organizations.

Factors that Determines Electric Load Consumption Profile

Steemers and Yun (2009) have identified the following factors that determine electric load consumption profile; location, geographic area, weather/climate characteristics, knowledge/awareness/attitude level on electricity consumption, room size, electrical heating type, type of room, stock of electrical appliances, frequency of use, the share of energy efficient appliances, cost of electricity, number in room and composition.

Room Size

The size of room is a factor that influences electricity demand and consumption. The number of students in a room also determines the number of electric appliances used which translate to the electric load consumption (McLoughlin *et al.*, 2012). The load profiles of two and three persons rooms look similar, but the morning peak (7.00–9.00 a.m.) and evening peak (4.00–10.00 p.m.), become more evident with an increasing electricity consumption (Yohanis *et al.*, 2008). The usage patterns of electric appliances usage differs, hot plates and lightings are used more frequently in bigger rooms. These frequent use of appliances and lights effects increases the extent of the load profile which will in the long run result in higher electricity consumption (Hayn *et al.*, 2014).

Time and Lifestyle

Working, leisure and sleeping time are activities associated with the indoors environments (Fahad and Arbab, 2014). Students spend most of their time indoors either in lecture (working), leisure or sleeping which are associated with electric load consumption. According to Fahad and Arbab (2014) the electric load consumption is usually low and steady from 12:00pm to 6:00am. It decreases from 7:00am till 9:00am and then steady till 1:00pm. After 1:00pm, it decreases till 5:00pm and starts rising till 8:00pm at leisure time. After 8:00pm the load gradually decreases again until 12:00am. It can be observed that the maximum load demand occurs at 8:00pm, and minimum load demand occurs after mid night which reflects the student's daily life style. At mid night 12:00am, most of the students are asleep, therefore the electric load consumption reduces. Similarly, at 8:00pm, students are at the common room watching TV, sitting beside heater, charging phones, laptops etc., so load is at the peak (Fahad and Arbab, 2014). The above is rule of load variation and has other rules of load variation with time. For example the start of semester of universities or school calendar also has the important impact on load consumption and thus changes the load profile. Similarly, day light saving can also decrease the average daily load also it changes the peaks from one time spot to the other (Fahad and Arbab, 2014).

Occupants Behavior

The building Occupant's behavior plays significant role in determining the energy consumption of the buildings (Steemers and Yun, 2009). Several studies (Derijcke and Uitzinger, 2006, Francis *et al.*, 2004, Gill *et al.*, 2010) have shown that building occupant's behavior is difficult to predict due to the diversity and complexity of user behavior. In order to obtain the full effects of user behavior, Yu *et al.* (2011) opined that it is necessary to abstract useful information corresponding from actual measured data.

METHODOLOGY

Quantitative research method was used for this study. A well-structured questionnaire and checklist were developed to generate information on the electrical load profile in the female students' hostels of Ahmadu Bello University Zaria. The female hostels studied were three which are; Amina Hall with eleven (11) blocks (533 rooms), Ribadu Hall with three (3) blocks (241 rooms) and Alexander hall with three (3) blocks (194 rooms).

The questionnaire generated data relating to; factors determining electricity consumptions, appliances used, duration of use, etc. A checklist was developed for walk through energy audit to establish the specification of the appliances used by the students.

A total of 968 rooms in all the hostels is the population of the study area. The sample size for the study was established from Yomen (2000);

$$SS = \frac{N}{1+N(e)^2}$$

Where:
SS = sample size from finite population
N = population size
e = tolerable error (the maximum error in the population that researchers are willing to accept)

N = 968, e = 0.1

$$SS = \frac{968}{1 + 968\ (0.1)^2} = 90.6367 \ \approx 91$$

Table 1 shows the room population and proportion of the sample size calculated across the three hostels.

Table 1: Population and Sample size

Hostels	Number of rooms	Sampled number of rooms
Queen Amina	533	35
Ribadu	241	33
Alexander	194	23
Total	968	91

The data obtained from the questionnaires were analyzed using statistical package for social sciences (SPSS) to determine the percentage and mean. The results were represented in tables and charts. Likert scale of scale 1 to 5 (where; 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree) was used to determine the factors responsible for the energy consumption.

Data obtained from the energy audit were used to calculate the consumption of electrical loads and the cost of energy consumption by the appliances. The equation used for the cost of energy calculations were used by Stanley (2007) as follow:

$$\text{Current (Amps)} = \frac{\text{Power (watts)}}{\text{Voltage (volts)}}, \text{ hence Watts = Volts x Amps}$$

Daily Energy Cost = $\frac{\text{Watts x ₦26/KWh}}{1000}$, but PHCN rate = N26/KWh, that is 1 unit = 1KWh = N26 tariff rate

RESULTS AND DISCUSSION

A total of Ninety One (91) structured questionnaires were administered to the respondents that resides in the females hostels. Seventy (70) completed questionnaires were collected and used for the analysis which gives a total of 72.16% response rate. According to the assertion of Asika (2006), response rate between 30-40% is valid and acceptable for a research conclusion. The result is shown below in Table 2.

Table 2. Questionnaire Administered

Questionnaire Administered	Frequency (No)	Percentage (%)
Returned	70	76.92
Not returned	21	23.08
Total	91	100

Table 3 shows the respondents' halls of residence, 37.1% with the highest frequency resides in Amina, 34.3% in Ribadu and 28.6% in Alexandra. This depicts that most of respondents were Amina residents. This was because Amina has the highest number of rooms and population amid the three halls. The number of occupants in a room was checked, 15.7% were in room of 1-2 with the lowest frequency, 22.9% were in room of 3-4, 35.67% were in room of 5-6 having the highest frequency and 25.7% were in room of more than 6. The table also shows the number of hours spent in room, 20% spent between 1-4 hours, 14.3% spent 5-8 hours, 17.1% spent 9-12 hours and 48.6% spent above 12 hours in the room which indicates that more than time are spent indoor.

Table 3. Respondent' Profile

S/N	Variable	Options	Frequency	Percentage (%)
1.	Hostels of Residence	a) Queen Amina	26	37.1
		b) Ribadu	24	34.3
		c) Alexandra	20	28.6
		Total	70	100
2.	Number of occupants in a room	a) 1-2	11	15.7
		b) 3-4	16	22.9
		c) 5-6	25	35.7
		d) Above 6	18	25.7
		Total	70	100
3.	Number of hours spent in room	a) 1-4	14	20
		b) 5-8	10	14.3
		c) 9-12	12	17.1
		d) Above 12	34	48.6
		Total	70	100

It could be observed from figure 2, that the pressing iron has the highest load of 67100W representing 18.7% of the total electrical load. This was followed by heater/boiling ring with a load of 60000W representing 16.8%, hot plates 57600W representing 16.1% of the total load, hand drier 47500W representing 13.3%, electric kettle 3600W representing 10.1%, toasters 16500W representing 4.6%, laptop 12000W representing 3.4%, microwaves 10500W representing 2.9%, room heaters representing 2.5%, flatteners 7500W representing 2.1%, stabilizer 6500W representing 1.8%, electric blenders 6000W representing 1.7%, fans 5200W representing 1.5%, refrigerator 3630W representing 1.0%, printers 2880W representing 0.8%, lamps representing 0.8%, griddles 2400W representing 0.7%, dishwashers representing 0.7%, mobile phones 900W representing 0.3%, electric indoor grills 500W representing 0.1%, reading lamps representing 0.1% of the total electrical load, television 420W representing 0.1%, CD/DVD player 245W representing 0.1% and handset charger 232W representing 0.1%. It could be seen that based on the analysis pressing iron, hot plates and heater/boiling ring consumes substantial amount electrical loads in hostels. The study observed that out of the appliances used in the hostels, pressing iron has the highest frequency of 61 representing 8.93% of the total appliances. Furthermore, the same pressing iron has the highest electrical load of 67100W with a percentage of 18.7% of the total electrical load. This means that pressing iron has a high power rating and contributes a lot to the electricity consumption and the utility bills.

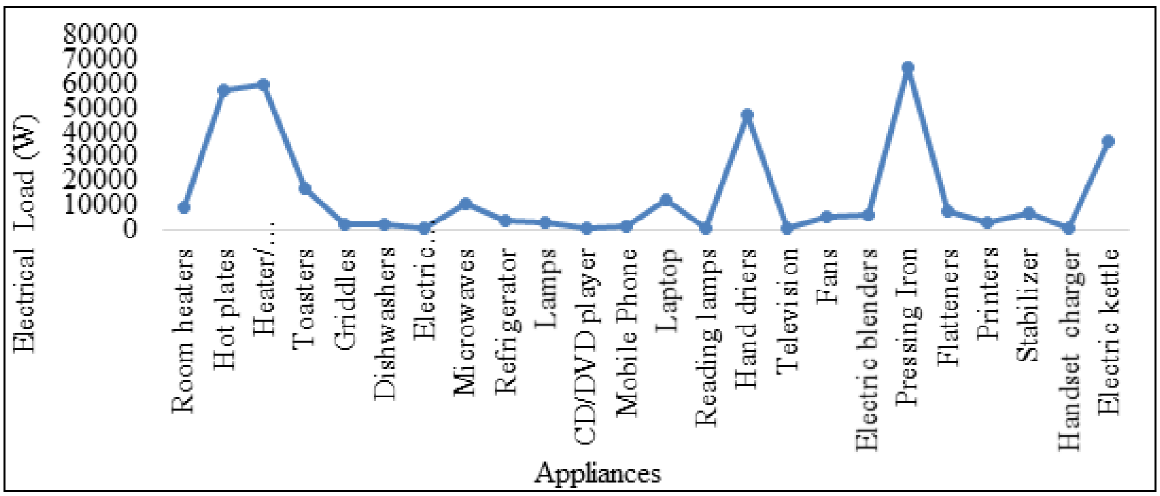

Figure 2. Electrical Load Profile for Hostels

Table 4 shows the factors that determines the electricity consumption in the hostels. The table indicates that respondents perceived that the frequency of use of appliances (3.74) rank 1st as area of energy consumption in the hostels, size of room (3.61) rank 2nd, electric heater (3.56) rank 3rd and number in the room (3.54) rank 4th. The respondents however ranked cost of electricity (2.93) 10th and geographical location (2.71) 11th as factors disagree and strongly disagree to determine electric load consumption in the hostels. The results are similar to the findings of Abdelbaset *et al.* (2012).

Cost of energy consumption

It could be seen from Table 5 that the total number of appliances is 623 and the total load of consumption by the appliances is 357,287W with a total cost of ₦9,289.46KWh running the appliances. In the audit, the rating of each appliance was recorded for the hostels and a simple calculation was done to attain the total electric load and cost for each of the appliance.

Table 4. Factors that Determine Electric Load Consumption

Factors	Frequency					∑f	∑fx	Mean	Rank
	1	2	3	4	5				
Frequency of use of appliances	5	8	15	14	28	70	262	3.74	1st
Location, geographic area	20	10	18	14	8	70	190	2.71	11th
weather characteristics	4	11	17	25	13	70	242	3.46	5th
Knowledge / awareness / attitude level on electricity consumption	8	10	23	17	12	70	225	3.21	7th
Stock of electrical appliances	12	11	15	18	14	70	221	3.16	9th
Electrical heating type	8	13	6	18	25	70	249	3.56	3rd
Type of room	7	15	23	9	16	70	222	3.17	8th
Room size	6	11	10	20	23	70	253	3.61	2nd
Sharing of energy efficient appliances among friends	4	11	19	27	9	70	236	3.37	6th
Cost of Electricity	9	22	17	9	13	70	205	2.93	10th
Number in room and composition	9	8	9	20	24	70	248	3.54	4th

1=Strongly Disagree, 2=Disagree, 3= Neutral, 4=Agree, 5=Strongly Agree

Table 5. Estimated Cost of Electric Load Consumption on Appliances

Appliances	Quantity (No)	Power (W)	Total load (W)	Cost ₦/KWh
Room heaters	18	500	9000	234.00
Hot plates	48	1200	57600	1,497.60
Heater/ boiling ring	50	1200	60000	1,560.00
Toasters	22	750	16500	429.00
Griddles	3	800	2400	62.40
Dishwashers	2	1200	2400	62.40
Electric Indoor grills	2	250	500	13.00
Microwaves	7	1500	10500	273.00
Refrigerator	33	110	3630	94.38
Lamps	45	60	2700	70.20
CD/DVD player	7	35	245	6.37
Mobile Phone	60	15	900	23.40
Laptop	48	250	12000	312.00
Reading lamps	48	10	480	12.48
Hand driers	19	2500	47500	1,235.00
Television	6	70	420	10.92
Fans	52	100	5200	135.2
Electric blenders	20	300	6000	156.00
Pressing Iron	61	1100	67100	1,744.60
Flatteners	12	625	7500	1,950.00
Printers	9	320	2880	74.88
Stabilizer	13	500	6500	169.00
Handset charger	58	4	232	6.03
Electric kettle	40	900	36000	936.00
Total	623	14284	357287	9,289.46

CONCLUSION

The study concludes that; several appliances were identified with pressing iron dominating in number and electrical load consumption of 67100W. The hourly cost of running the appliances in the hostels was ₦522953.02 (KWh). The study recommends that, the use of pressing iron should be properly monitored; there should be a reduction in the frequency of use of the appliances, the load profile should be used as a guide in decision making on energy saving strategies in the institution.

References

Abdelbaset, I, Rajamani, H. S., Read, A., Abd-Alhameed, A. and Mohamed, J, (2012). The Generation of Electric Load Profiles in the UK Domestic Buildings through Statistical Predictions. School of Engineering, Design and Technology University of Bradford, UK.

British Energy Suppliers (2016). Business Electricity Profile Classes. Britishbusinessenergy.co.uk https://britishbusinessenergy.co.uk/profile-classes/

Derijcke, E. and Uitzinger, J. (2006). Residential Behaviour in Sustainable Houses. In: User Behaviour and Technology Development -Shaping Sustainable Relations Between Consumers and Technologies. The Netherlands: Springer, 119-126.

Elexon, (2013). Load Profiles and their use in Electricity Settlement

Fahad, M.U. and Arbab, N. (2014): Factor Affecting Short Term Load Forecasting. *Journal of Clean Energy Technologies.* 2(4). 305 – 309.

Farzad, M. and Neal, D. (2003). Energy Analysis and Energy Conservation Option for the Warehouse Facility at the Human Services Centre Complex. Energy Efficiency Division, Texas Public Utility Commission Austin, Texas

Francis, J., Eccles, M., Johnston, M., Walker, A., Grimshaw, Foy, R., Kaner, E., Smith, L. and Bonetti, D., (2004). Constructing Questionnaires Based on The Theory of Planned Behaviour: A Manual for Health Services Researchers. Newcastle upon Tyne: Centre for Health Services Research, University of Newcastle.

Gill, Z., Tierney, M., Pegg, I. and Allan, N., (2010). Low-Energy Dwellings: The Contribution of Behaviours to Actual Performance. *Building Research and Information,* 38(5), 491-508

Hayn, M., Bertsch, V. and Fichtner, W. (2014). Electricity Load Profiles in Europe: The Importance of Household Segmentation. Elsevier*: Energy Research and Social Science*. 3, 30 – 45.

Jukka, V. P. and Lund, P. D. (2006). A Model for Generating Household Electricity Load Profile. International Journal of Energy Research. *Advanced Energy Systems,* Helsinki University of Technology, Finland 30 (5).

McLoughlin, F, Duffy, A, and Conlon, M. (2012). Characterising Domestic Electricity Consumption Patterns by Dwelling and Occupant Socio-Economic Variables: An Irish Case Study. Energy Build; 48:240–8

Muhammed, B. (2005) Checking the Odds, NEPA Review Magazine, (4). 10.1108/EJTD-11-2014-0077

Sean, B. Sandeep, K. David, I. and Prashant, S. (2013). Empirical Characterization and Modeling of Electrical Loads in Smart Homes. University of Massachusetts, Amherst

Steemers, K. and Yun, G., (2009). Household Energy Consumption: A Study of the Role of Occupants. *Building Research and Information,* 37 (5-6), 625-637.

Stanley, A.M. (2007). Energy Load Profile Analysis and Characterization of Electricity Demand in Institutional Buildings. *Journal of Construction Management and Engineering.* 1(3&4). 44 – 57.

Sustainability Network, (2008). *Power Consumption in IITM:* The Bulletin of the Energy Forum 1 (10).

Yohanis, Y. G., Mondol, J. D., Wright, A. and Norton, B. (2008). Real-life Energy Use in the UK: How Occupancy and Dwelling Characteristics Affect Domestic Electricity Use. Energy Build 40(6):1053–9.

Yu, Z., Fung, B., Haghighat, F., Yoshino, H. and Morofsky, E. (2011). A systematic Procedure to Study the Influence of Occupant Behavior on Building Energy Consumption: *Energy and Buildings (*4), 1409-1417.