International Journal of Innovation and Applied Studies
ISSN 2028-9324 Vol. 20 No. 2 May. 2017, pp. 661-674

http://www.ijias.issr-journals.org/

ELECTRIC POWER GENERATORS USED IN SELECTED BUILDINGS IN IBADAN METROPOLIS, NIGERIA

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ABSTRACT: Inadequate supply of power by the service provider has been an unresolved national issue which affects occupants of buildings in performing tasks indoor. This study was carried out to assess generator audit in selected residential and commercial buildings in Ibadan Metropolis, Nigeria. The study area was divided into core, transition and suburban residential zones. Multistage and quota sampling techniques were used to select respondents sampled in residential and commercial buildings respectively. Descriptive and inferential statistical techniques were used to analyse data collected. The findings revealed that the average supply of power to residential and commercial buildings in the core, transition and suburban zones were 4.37, 5.31 and 7.6 hrs; 4.00, 4.45 and 5.86hrs respectively. The study showed that regardless of the zone, occupants of residential and commercial buildings sampled depended on varying types of brand of generating sets for either comfort need or occupational purpose. Also, 47.79%, of respondents in the residential buildings in the suburban zone used generating sets that were of higher output ratings than those used in either core or transition zone. Across the zones, 71.43% of respondents in the residential buildings could not use their generators to power all their electrical devices. However, in the commercial buildings across the zones, 93.75% of respondents were able to use their generators to power all their electrical appliances indoor. The study recommended that the myriad of poor power supply that forced building occupants to procure various types of generating sets and also run generator economy should be addressed by harnessing environmentally friendly and alternative sources of energy that will foster power security.

KEYWORDS: Supply of Electricity, Electric Power Generators, Generator Audit, Buildings.

1 INTRODUCTION

Buildings are constructed to serve as a unit of environment, meet housing and shelter needs and have much influence on the health and efficiency of the occupants. It is also considered as one of the three most fundamental human needs (Mabogunje, 2007; Adedokun *et al*., 2011). Buildings are really meant to provide shelter for the occupants, but there is need for the procurement and installations of engineering and service systems to give the occupants the required comfort. These installations depend mostly on the use of one form of energy or the other to power them (Komolafe, 2011). Energy is fundamental for the provision of basic needs of the populace. It is considered to be a very important substance for development and has been a vital and indispensable input for the economic needs of the present age. It is undoubtedly the driving force of industrialization (Onyegegbu, 2003); and a powerful engine of economic and social opportunity, such that no nation can manage to develop without ensuring access to the required amount of energy to power service systems to be used in buildings (Steer *et al*., 2000).

In spite of Nigeria's huge resource endowment in energy and enormous investment in the provision of energy infrastructure, performance of the power sector has remained poor in comparison with other developing economies. According to World Bank (2005), Nigeria had the highest percentage of system losses at 33 to 41% with the lowest generating capacity factor at 20%, the lowest average revenue at US dollars of 1.56 KWh, the lowest rate of return at 8%, and the longest average accounts receivable period of 15 months when compared with those of 20 other developing countries. As a result of this fundamental problem, households, businesses and industrial premises rely on their self-procured electricity from generators that have attendant operating and capital costs (Idiata *et al., 2010*; Awofeso, 2011).

A constant power supply is a critical component of every successful modern business, and where power failure happens more often and takes more time to fix, a reliable standby generator is really essential to power all the equipment and systems (Pabla, 2003; Gross, 1986). Today, the most common form of off-grid electricity supply are generators running on diesel or gasoline. Generators are used not only by rural households, but also by the grid-connected households and industries as a more stable supplement to the grid power. The rural incidence of diesel generator in Nigeria is difficult to estimate, but 96 to 98% of the grid-connected firms are known for the ownership of private generators (Tyler, 2002). Previous studies on generators usage in Nigeria such as Ahmad and Abubakar, 2012; Ana *et al.* 2014; Sonibare *et al*. 2014 especially in residential and commercial buildings in Ibadan Metropolis did not focus on generator audit. The study provided answer to research questions that considered characteristics of electric power generators used by the building occupants as alternative source of energy and thus assessed generator audit on the types, brand, ratings and cost of the use of generators in both residential and commercial buildings in Ibadan Metropolis, Nigeria.

2 Research Methodology

The scope of this study was limited to residential and commercial buildings that existed in Ibadan Metropolis. Ibadan metropolis was chosen because the study was urban based. Ibadan is the capital of Oyo State in the southwestern part of Nigeria (Ayeni, 1994). Ibadan is an urban centre located in the humid southwest of Nigeria and is the capital city of Oyo State. The geographical location of Ibadan falls between coordinates $7^{o}\ 22^{'}\ 47^{''}$ North of the Equator and $3^{o}\ 53^{'}\ 0^{''}$ East of the Greenwich Meridian. The total population of Ibadan according to FGN (2009) is 2,559,853 including population of the surrounding towns and villages. The entire area of Ibadan is largely well-drained, though many of its rivers are seasonal. Developed land increased from only 100 ha in 1830 to 12.5 Km^2 in 1931, 30 Km^2 in 1963, 112 Km^2 in 1973, 136 Km^2 in 1981 and 214 Km^2 in 1988 (Mabogunje, 1968).

The study population was made up of residential and commercial buildings occupied for residential and commercial purposes; where generating sets were used that existed in each of the three residential zones; core, transition and suburban respectively in each of the five local governments that made up Ibadan Metropolis. A reconnaissance survey was carried out and the study area was divided into a list of different residential/political wards determined and used for the purpose of the 2011 general elections by the (Oyo State Independent Electoral Commission, 2013). Multi-stage sampling technique was used which led to the sampling of 736 residential buildings The first stage involved delineation of residential areas in Ibadan Metropolis into different zones based on age and other criteria. The technique of delineating residential areas in Nigeria involves the use of historical and physical attributes. It takes into consideration, period of the emergence of a city or a section of a city, housing characteristics, environmental qualities and population per square kilometer (density) among others (Afon, 2008; Wojuade, 2012; Adigun 2013). Faniran (2012) among other authors had identified three (3) residential zones in Ibadan. These are: core, transition and suburban residential zones and were thus adopted for this study. The stratification made the heterogeneous nature of the study population to be reduced into residential/political wards of similar and homogeneous features. In the second stage, stratified random sampling technique was used. According to Singleton *et al*. (1988), stratified random sampling technique requires fewer cases because each stratum is homogeneous. Out of the 59 residential/political wards in all the local governments, a 25% sample, representing 15 political/residential zones and 3 political wards (representing core, transition and suburban area respectively) in each of the selected local governments were used for the study. In the third stage, systematic sampling technique was used whereby 2% of the total number of buildings in the selected wards was sampled in accordance with Singleton *et al*. (1988) which stated that the greater the heterogeneity of the population, the larger the sample needed to achieve a given level of reliability.

Pockets of commercial buildings that were along the road networks and close to the residential buildings were purposively selected as its sample population. According to Esan and Okafor (1995), quota sampling has no definite probability law associated with the selection procedure which is aimed at providing some “balance” in the selected sample. In view of this, quota sampling technique was used to determine number of commercial buildings sampled and it served as representation of the stock of commercial buildings that existed in the study area. Thus, ten commercial buildings were selected in each of the three residential zones in the study area. Hence, a total of 150 commercial buildings were sampled.

In all, 886 residential and commercial buildings were selected (Table 1). The first building sampled was selected randomly between the 1st and the 20th building and starting with that number, every 20th building was subsequently selected following the line of accessibility. This technique eliminates bias of the researcher and gives each unit of investigation equal chance of being chosen in the complete list of the population (Blalock, 1969). One occupant was taken in each of the residential and commercial buildings sampled in each of the zones of the local governments of the study area. The data collected were analysed by using descriptive and inferential statistical techniques such as ANOVA, Chi-square, frequency distribution and Duncan Multiple Range Test.

3 FINDINGS AND DISCUSSIONS

Table 1 showed that out of the 886 questionnaires administered on the users of generators in the residential and commercial buildings sampled, 537 questionnaires were returned and found useful. This indicated a return rate of 60.61%. According to Babies (2005), a response rate of 40% was adjudged adequate for studies in built environment related researches, and this implies, that the 60.61% return rate should be adequate to uphold the results.

Table 1: Response Rate of the Questionnaires Administered

Respondents/ Users of Generator	Number Administered by Building Type	Number Collected by Building Type	Percentage Collected by Building Type (%)	Percentage Collected in All Buildings Sampled (%)
Residential Building	736	443	60.19	
Commercial Building	150	94	62.67	60.61
Total	886	537		

CHARACTERISTICS OF THE RESPONDENTS SAMPLED

Table 2 showed the characteristics of respondents sampled in residential buildings in the study area. The age distribution of the respondents showed that bulk of respondents in the residential buildings across the zones belonged to the 31-40 age group (37.50%) and was followed by the 41-50 age group (33.80%) while the age group that was greater than 60 years (4.70%) had the least number of respondents. Table 3 showed that majority of respondents in the commercial buildings across the zones belonged to the 21-30 age group (52.20%) and was closely followed by the 31-40 age group (24.40%). This implies that bulk of the respondents sampled in the residential and commercial buildings were in their youthful ages and ought to be in possession of service items needed for comfort needs and performance of tasks indoor. It is shown in Table 2 that in the residential buildings, 55.88% of the users were self-employed, 35.05% were employed and 9.07% were senior citizens who had retired from either private or public service. It was obtained that employed respondents existed across the three residential zones of the study area as there were 24.84% in the core, 38.46% in the transition and 45.30% in the suburban residential zone. However, majority of respondents (100.00%) in the commercial buildings were self-employed since they used the facilities they occupied as means to earn their livelihood (Table 3). The educational status of respondents in residential buildings as shown in Table 2 revealed that 61(44.20%) of respondents in the transition zone had senior secondary education, 60(43.50%) had post-secondary education and 10(7.20%) had postgraduate qualification. In the suburban residential zone, 41(34.70%) had post graduate education which indicated that they were mostly educated. Comparably, in the core residential zone, 25(14.70%) and 108(63.50%) of its respondents had adult/primary and senior secondary school education respectively. Since it was found that it was in the suburban residential zones where the respondents were mostly educated, this indicates that the level of education of respondents which was most significant in the suburban residential zone in the study area would affect their socio-economic characteristics, particularly on the type and rate of the use of generating sets in their buildings. Contrastingly, Table 3 showed that majority of respondents in commercial buildings, 59(66.30%) across the zones had senior secondary school education and 23(25.80%) had post-secondary school education. Similarly, 23(74.20%), 24(66.70%) and 12(54.55%) of respondents in the core, transition and suburban zone respectively had senior secondary school education. The Table further indicated that a large proportion of the commercial buildings' respondents did not possess post graduate education. This could have effect on their socio-economic status.

Table 2 showed that bulk of respondents in the suburban residential buildings 32(29.09%) earned more than 120,000 naira monthly while respondents in the transition residential zone had reduced response rate of 4(2.94%). It also indicated that, it was in the core residential zone, where its majority, 111(63.07%) of its respondents earned below 30,000 naira monthly, and 65(36.93%) earned between 30,000 to 60,000 naira monthly. However, in the transition and suburban zones, 69(50.74%) and 14(12.73%) of their respondents respectively earned between 30,000 to 60,000 naira. This implies that earning power of respondents in the suburban residential buildings was significantly higher than others in the transition and core residential zones. Contrastingly, Table 3 showed that 23(62.16%) of respondents in commercial buildings in the transition zone earned most with a monthly income range of 61,000 and 90,000 naira followed by 16(72.72%) and 21(61.76%) of respondents in the suburban and core residential zone that earned 61,000 to 90,000 and below 3,000 naira respectively. There was unequitable occupancy status of respondents sampled in the residential buildings as bulk of respondents in all the zones were landlords in their personal buildings with response rate of 94(52.81%), 91(65.47%) and 71(57.72%) for core, transition and suburban residential zone respectively (Table 2). It further revealed that fewer number of respondents were tenants in the buildings selected as the core zone had the highest frequency rate of 84(47.19%) followed by suburban 52(42.28%) and transition zone 48(34.53%) respectively. It is thus expected that, with the majority of the respondents being landlords in the selected buildings, their propensity to use building service items ought to be very high. However, tenancy status of respondents of commercial buildings in the study area varied disproportionately from what obtained in the residential buildings. It is shown in Table 3 that majority of the respondents, 64(68.82%) in commercial buildings in different zones of the study area were tenants in the facilities/buildings used based on the terms stated in their tenancy agreement.

Table 2: Characteristics of Respondents Sampled in the Residential Buildings

Characteristics	Residential Buildings							
	Core Zone		Transition Zone		Suburban Zone		Total	
	F	(%)	F	(%)	F	(%)	F	(%)
Age (Yrs)								
21-30	22	(12.50)	22	(16.40)	5	(4.20)	49	(11.40)
31-40	73	(41.50)	50	(37.30)	38	(31.90)	161	(37.50)
41-50	56	(31.80)	41	(30.60)	48	(40.30)	145	(33.80)
51-60	18	(10.20)	15	(11.20)	21	(17.60)	54	(12.60)
> 60	7	(4.00)	6	(4.50)	7	(5.90)	20	(4.70)
Total	176	(100.00)	134	(100.00)	119	(100.00)	429	(100.00)
Employment								
Employed	40	(24.84)	50	(38.46)	53	(45.30)	143	(35.05)
Self Employed	107	(66.46)	70	(53.85)	51	(43.59)	228	(55.88)
Retired	14	(8.70)	10	(7.69)	13	(1.11)	37	(9.07)
Total	161	(100.00)	130	(100.00)	117	(100.00)	408	(100.00)
Education								
Adult/Primary	25	(14.70)	4	(2.90)	0	(0.00)	29	(6.80)
Junior Secondary	23	(13.50)	3	(2.20)	0	(0.00)	26	(6.10)
Senior Secondary	108	(63.50)	61	(44.20)	19	(16.10)	188	(44.10)
Post Secondary	14	(8.20)	60	(43.50)	58	(49.20)	132	(31.00)
Post Graduate	0	(0.00)	10	(7.20)	41	(34.70)	51	(12.00)
Total	170	(100.00)	138	(100.00)	118	(100.00)	426	(100.00)
Income								
< N30,000	111	(63.07)	49	(36.03)	13	(11.81)	173	(40.99)
N30,000-N60,000	65	(36.93)	69	(50.74)	14	(12.73)	148	(35.08)
N61,000-N90,000	0	(0.00)	12	(8.82)	24	(21.82)	36	(8.53)
N91,000-N120,000	0	(0.00)	2	(1.47)	27	(24.55)	29	(6.87)
> N120,000	0	(0.00)	4	(2.94)	32	(29.09)	36	(8.53)
Total	176	(100.00)	136	(100.00)	110	(100.00)	422	(100.00)
Occupancy								
Landlord	94	(52.81)	91	(65.47)	71	(57.72)	256	(58.19)
Tenant	84	(47.19)	48	(34.53)	52	(42.28)	184	(41.81)
Total	178	(100.00)	139	(100.00)	123	(100.00)	440	(100.00)

Table 3: Characteristics of Respondents Sampled in the Commercial Buildings

Characteristics	Commercial Buildings							
	Core Zone		Transition Zone		Suburban Zone		Total	
	F	(%)	F	(%)	F	(%)	F	(%)
Age (Yrs)								
21-30	21	(61.80)	15	(44.10)	11	(50.00)	47	(52.20)
31-40	5	(14.70)	12	(35.30)	5	(22.70)	22	(24.40)
41-50	5	(14.70)	5	(14.70)	6	(27.30)	16	(17.80)
51-60	2	(5.90)	2	(5.90)	0	(0.00)	4	(4.44)
> 60	1	(2.90)	0	(0.00)	0	(0.00)	1	(1.10)
Total	34	(100.00)	34	(100.00)	22	(100.00)	90	(100.00)
Employment								
Employed	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)
Self Employed	32	(100.00)	33	(100.00)	23	(100.00)	88	(100.00)
Retired	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)
Total	32	(100.00)	33	(100.00)	23	(100.00)	88	(100.00)
Education								
Adult/Primary	3	(9.70)	1	(2.80)	0	(0.00)	4	(4.50)
Junior Secondary	1	(3.20)	1	(2.80)	0	(0.00)	2	(2.20)
Senior Secondary	23	(74.20)	24	(66.70)	12	(54.55)	59	(66.30)
Post Secondary	4	(12.90)	10	(27.80)	9	(40.90)	23	(25.80)
Post Graduate	0	(0.00)	0	(0.00)	1	(4.55)	1	(1.10)
Total	31	(100.00)	36	(100.00)	22	(100.00)	89	(100.00)
Income								
< N30,000	21	(61.76)	10	(27.03)	3	(13.64)	34	(36.56)
N30,000-N60,000	13	(38.24)	3	(8.11)	3	(13.64)	19	(20.43)
N61,000-N90,000	0	(0.00)	23	(62.16)	16	(72.72)	39	(41.94)
N91,000-N120,000	0	(0.00)	1	(2.70)	0	(0.00)	1	(1.07)
> N120,000	0	(0.00)	0	(0.00)	0	(0.00)	0	(0.00)
Total	34	(100.00)	37	100.00)	22	(100.00)	93	(100.00)
Occupancy								
Landlord	14	(41.18)	6	(16.67)	9	(39.13)	29	(31.18)
Tenant	20	(58.82)	30	(83.33)	14	(60.87)	64	(68.82)
Total	34	(100.00)	36	(100.00)	23	(100.00)	93	(100.00)

ASSESSMENT OF GENERATOR AUDIT IN THE SELECTED BUILDINGS

The identification and examination of the types of generating sets used by respondents in the buildings sampled is presented in this section. The interrelated issues of the availability of power supply to the buildings; generator audit that focuses on the years of use (age) of the generators, type, ratings of generators used, brand, cost of the use of generators (fuelling) and the capacity of generators to power all appliances used indoor relative to electricity supply by the Ibadan Electricity Distribution Company (IBEDC) are discussed.

RATE OF SUPPLY OF ELECTRICITY BY IBEDC TO BUILDINGS

The study determined rate of supply of electricity to the selected commercial and residential buildings in the study area with a view to using it to power appliances used indoor. The rate of supply of electricity to the buildings sampled is shown in Table 4. There was disproportionate supply of power by IBEDC to the various residential zones in the study area. The result revealed that the average duration of supply of electricity to residential buildings was 4.37, 5.31 and 7.63 hours daily in the core, transition and suburban zones while average daily supply of 4.0, 4.45 and 5.86 hours were found in the core, transition and suburban zone's commercial building's respectively. The result substantiated findings of Baker Institute of Technology (2008), Subair and Oke (2008), World Bank (2005) that most cities in Nigeria rarely had stable power supply from the power authority. Also, according to NERC (2015), the daily supply of power to buildings in the country dropped to an average of 5.86 hours daily. This implies that the dire need of building occupants in residential and commercial buildings in the study area was significantly affected by the epileptic power supply. It was also found during interview and observation carried out that the time of supply of electricity to both residential and commercial buildings in the study area was never constant and this epileptic nature of power supply informed their dependence on generators as a more reliable form of energy.

The ANOVA test established a variation of F = 44.599, $p < 0.05$; F = 6.380, $p < 0.05$ for residential and commercial buildings respectively. By implications, the ANOVA test established a significant variation between the average number of hours of availability of electricity to zones and buildings in the study area. Further examination carried out using Duncan Multiple Range Test (DMRT) revealed that there were significant differences in the average rate of supply of electricity in the core, transition and suburban zones through the differences in the mean rate of supply of electricity to buildings across the zones of the study area (Tables 5 and 6). The study also showed that the supply was quite erratic in some zones as it was found that they were not supplied with electricity which made their neighbourhood to be in a state of blackout.

Table 4: Rate of Supply of Electricity by IBEDC to Buildings Sampled

Buildings Sampled	Core Zone Hrs	Transition Zone Hrs	Suburban Zone Hrs
Residential Buildings	4.37	5.31	7.63
Commercial Buildings	4.00	4.45	5.86

Table 5: Duncan Multiple Range Result of Supply of Electricity to Residential Buildings

	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Core Zone	168	4.3750a	1.68006	.12962	2.00	8.00
Transition Zone	136	5.3162b	2.46066	.21100	2.00	12.00
Suburban Zone	123	7.6341c	4.41731	.39830	.00	22.00
Total	427	5.6136	3.22885	.15625	.00	22.00

Note: Alphabets a, b and c indicate significant differences at 0.05 level of significance.

Table 6: Duncan Multiple Range Result of Supply of Electricity to Commercial Buildings

	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Core Zone	34	4.0000a	2.07437	.35575	.00	9.00
Transition Zone	34	4.4559b	2.14040	.36708	1.00	8.00
Suburban Zone	23	5.8696c	1.51671	.31625	3.00	10.00
Total	91	4.6429	2.09137	.21923	.00	10.00

Note: Alphabets a, b and c indicate significant differences at 0.05 level of significance.

YEARS OF USE (AGE) OF GENERATORS IN THE BUILDINGS SAMPLED

The generator audit on the determination of the years of use of generators in the buildings sampled is analysed in this section. It is shown in Table 7 that about 45% of respondents, 61 (46.92%), 56 (45.16%) and 53 (45.30%) in residential buildings of the core, transition and suburban zones respectively had been using their generating sets for an average of 3 years. In the same fold, it was found that across residential buildings of the study area, 45.82% of the respondents had been using their generators for 3 years, 25.88% (2 years), 14.82% (1 year) and 6.74% (4 years). Contrastingly, in the commercial buildings across zones of the study area, 26 (30.95%) of the respondents had been using their generating sets for 2 years, 29.76% (3 years) and 17.86% (1 year). The Chi-square test indicated that there was significant relationship in the years of use of generators in residential and commercial buildings (χ^2 = 11.427, p = 0.325; χ^2 = 6819, p = 0.742). It was also found during the interview that a large number of the respondents in either residential or commercial buildings across zones of the study area had used different generating sets for an average of 3 years which is comparable to the results of the questionnaires administered. The implication of this is that the dependence of majority of the respondents on generators running for years shows that they run generator economy as found in the works of (Ibitoye and Adenikinju, 2007; Ahmad and Abubakar, 2012; BBC Africa, 2013).

The One-sample binomial test carried out on the years of use of generating sets in residential buildings sampled shown in Table 8 revealed that at P-value of 0.50, there was probability of 0.45 of those that had used their generating sets for 3 years. However, in the commercial buildings, the use of generating sets across the zones for 2 years had probability of 0.31. The years of use of the generating sets could have implication on the type and brand being procured by the building occupants as alternative source of energy supply.

Table 7: Years of Use (Age) of the Generating Sets

Years of Use (Yrs)	Residential Building				Commercial Building			
	Core Zone F %	Transition Zone F %	Suburban Zone F %	Total F %	Core Zone F %	Transition Zone F %	Suburban Zone F %	Total F %
1 Yr	18 13.85	23 18.54	14 11.97	55 14.82	5 16.13	7 21.21	3 15.00	15 17.86
2 Yrs	36 27.69	28 22.58	32 27.35	96 25.88	9 29.03	8 24.24	9 45.00	26 30.95
3 Yrs	61 46.92	56 45.16	53 45.30	170 45.82	12 38.71	9 27.28	4 20.00	25 29.76
4 Yrs	8 6.15	6 4.84	11 9.40	25 6.74	4 12.90	6 18.18	2 10.00	12 14.29
5 Yrs	4 3.08	9 7.27	2 1.71	15 4.04	1 3.23	2 6.06	2 10.00	5 5.95
> 5 Yrs	3 2.31	2 1.61	5 4.27	10 2.70	0 0.00	1 3.03	0 0.00	1 1.19
Total F %	130 100.00	124 100.00	117 100.00	371 100.00	31 100.00	33 100.00	20 100.00	84 100.00

Table 8: One-Sample Binomial Test on the Years of Use of the Generating Sets

	Years of Use of Generator	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
Residential Buildings	1 Yr	55	.15	.50	.000
	2 Yrs	96	.26		
	3 Yrs	170	.45		
	4 Yrs	25	.07		
	5 Yrs	15	.04		
	> 5 Yrs	10	.03		
	Total	371	1.00		
Commercial Buildings	1 Yr	15	.18	.50	.000
	2 yrs	26	.31		
	3 Yrs	25	.30		
	4 Yrs	12	.14		
	5 Yrs	5	.06		
	> 5 Yrs	1	.01		
	Total	84	1.00		

TYPE OF FUEL AND OUTPUT RATING OF GENERATORS USED BY THE RESPONDENTS

Table 9 showed that 12(9.68%) of respondents in residential buildings in the suburban zone used diesel engine generators while 9(6.37%) and 4(2.94%) in transition and core zone respectively used it. This indicated that socio-economic level of the respondents in the suburban zone which was significantly higher than respondents in other zones' residential buildings accounted for this prevalence. As depicted in Table 9, petrol engine generators were significantly used by 132(97.06%), 133(93.66%) and 112(90.32%) of respondents in residential buildings in the core, transition and suburban zone respectively. It was found that various brand of petrol engine generators were procured by the respondents for their use in the residential buildings. The results of the Chi-square tests revealed that there was a significant association between the type of fuel of generating sets used in the residential zones and occupancy status of the respondents in Ibadan ($\chi^2 = 19.009$, $p < 0.001$).

However, diesel engine generating set was partly used in the transition zone by 4(15.38%), while 2(5.71%) and 1(4.55%) of respondents in the core and suburban zone's commercial buildings respectively. A large proportion of respondents in the study area, 33(94.28%), 22(84.62%) and 21(95.45) in the core, transition and suburban zone respectively of the commercial buildings used petrol engine generators. It was found that fair compliance with environmental laws which stipulated types of equipment used by building occupants that could generate noise informed why the use of diesel engine and higher output ratings generators by respondents in commercial buildings in the suburban zone was much more reduced.

The one-sample binomial test revealed that at a 2-tailed significance level, there was significant probability of the use of petrol engine generators in either residential buildings (0.94) or commercial buildings (0.92) in the study area (Table 10). Largely, the findings of the study showed significant and wide use of petrol engine generators in both residential and commercial buildings across zones of the study area and the paltry use of diesel engine generators was dependent on the socio-economic level of the respondents based on its economy of use. These findings were in line with BBC Africa (2013) which concluded that more than 60% of businesses in Nigeria depend on generators. Also, Tyler (2002) in his study found that 96 to 98% of outlets in the country have private generators used as alternative source of power supply. From these, there was wide use of various types of generators and thus underpinning the statement, that many geographical locations in the country run "generator economy".

Table 9: Type of Fuel of the Generators Used in the Buildings

Type of Fuel of the Generator Used by the Respondent		Residential Building			Total	Commercial Building			Total
		Core Zone F (%)	Transition Zone F (%)	Suburban Zone F (%)	F (%)	Core Zone F (%)	Transition Zone F (%)	Suburban Zone F (%)	F (%)
Petrol	F	132	133	112	377	33	22	21	76
	%	97.06	93.66	90.32	93.78	94.28	84.62	95.45	91.57
Diesel	F	4	9	12	25	2	4	1	7
	%	2.94	6.37	9.68	6.22	5.71	15.38	4.55	8.43
	F	136	142	124	402	35	26	22	83
Total	%	100.0	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 10: One-Sample Binomial Test on the Type of Generating Sets Used in the Buildings

	Type of Generator	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
	Petrol	377	.94	.50	.000
Residential Buildings	Diesel	25	.06		
	Total	402	1.00		
	Petrol	76	.92	.50	.000
Commercial Buildings	Diesel	7	.08		
	Total	83	1.00		

The respondents were asked to indicate output rating of their generating sets based on the standardized ratings and classifications that existed in the sales outlet during the preliminary survey. The findings on this are contained in Table 11. The respondents in the suburban residential buildings, 54(47.79%), significantly used petrol generating sets of rating limits (2.8-5.5 KVA) than those in other zones and the use of diesel engine generators was also most prominent than what obtained in the other two zones (Table 11). However, the study also revealed that respondents in commercial buildings in the transition zone (31.57%) significantly used generating sets of rating (2.8 -5.5 KVA), (21.21%) in the core zone and (31.57%) in the suburban zone respectively. The rate of usage of diesel engine generators was also most prominent in the transition zone than other zones (Table 11). This implied that output rating of the generators used in the transition zone was significantly higher than those of other zones and this would have much relationship with the likely use of generating sets by the respondents. The Chi-square test indicated that there was significant relationship in the ratings of petrol and diesel engine generators used in the buildings ($\chi^2 = 82.048$, $p < 0.001$; $\chi^2 = 30.857$, $p < 0.001$).

Table 11: Ratings of Generators Used by the Respondents

Ratings of the Generator	Residential Building				Commercial Building			
	Core Zone	Transition Zone	Suburban Zone	Total	Core Zone	Transition Zone	Suburban Zone	Total
KVA	F (%)	F (%)	F (%)	F (%)	F (%)	F (%)	F (%)	F (%)
Petrol Engine (KVA)								
0.65 - 1.2	102 60.36	40 29.63	8 7.08	150 35.97	14 42.42	5 14.71	8 42.11	27 31.40
1.2 – 2.8	53 31.36	54 40.00	51 45.13	158 37.89	12 36.36	14 4.18	5 26.32	31 36.05
2.8 – 5.5	14 8.28	41 30.37	54 47.79	109 26.14	7 21.21	15 44.11	6 31.57	28 25.55
Total	169 100.00	135 100.00	113 100.00	417 100.00	33 100.00	34 100.00	19 100.00	86 100.00
Diesel Engine (KVA)								
7.5 – 10	1 100.00	5 83.33	13 92.86	19 90.48	2 100.00	4 100.00	1 100.00	7 100.00
10 – 15	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00
15 – 20	0 0.00	1 16.67	1 7.14	2 9.52	0 0.00	0 0.00	0 0.00	0 0.00
> 20	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00
Total	1 100.00	6 100.00	14 100.00	21 100.00	2 100.00	4 100.00	1 100.00	7 100.00

The one-sample binomial test (Table 12) also indicated that there was significant probability (0.68) of the use of petrol engine generators of 0.65-1.2 KVA in the core zone (0.34) of 1.2-2.8 KVA in the transition zone and (0.49) of 2.8-5.5 KVA in the suburban zone's residential building's respectively. The observed probability of the use of various output ratings of petrol engine generators in residential and commercial buildings sampled was 0.95 and 0.92 respectively while diesel engine generators had 0.05 and 0.08 respectively.

Table 12: One-Sample Binomial Test on the Output of Types of Generating Sets

		Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
Residential Buildings	Group 1	Petrol	417	.95	.50	.000
	Group 2	Diesel	21	.05		
	Total		438	1.00		
Commercial Buildings	Group 1	Petrol	86	.92	.50	.000
	Group 2	Diesel	7	.08		
	Total		93	1.00		

Brand of Generators Used by the Respondents

As shown in Table 13, it was found that in residential buildings in the core zone, a large number of the residents 32(24.06%) used Tiger brand, 23(17.29%) used Elemax brand, while in the transition zone, a sizeable number of the respondents, 29(22.14%) used Elemax brand followed by Tigmax brand 27(20.61%). However, in the suburban zone of the study area, an almost similar result was found with a large proportion of the respondents 26(22.03%) used Elemax brand and closely followed by 24(20.34%) that used Elepaq brand of generator set. In another fold, in the commercial buildings of the study area, an almost similar result was obtained. Table 13 showed that respondents of commercial buildings in the core zone of the study area, 14(45.16%) used Tiger brand of generator, in the transition zone, a sizeable number 9(27.27%) used Tigmax brand while in the suburban zone, Tigmax brand was used mostly by 5(22.71%) of the respondents.

Thus, as shown in Table 13, in the residential buildings across zones of the study area, Elemax brand of generator was largely used by the respondents 78(20.42%), followed by 65(17.01%) that used Tiger brand of generator. However, in commercial buildings across zones of the study area, a sizeable number of the respondents, 23(26.74%) used Tiger brand of generator. The brand of generators procured and used by the respondents in either residential or commercial buildings of the study area was found to depend largely on their perception about their failure rate and efficiency and this informed the variation in the brand used. The Chi-square test indicated that there was significant relationship in the brand of generators used in residential and commercial buildings (χ^2 = 30.803, p = 0.06; χ^2 = 21.171, p = 0.271). In view of the procurement and use of different brand of generating sets by the respondents, the result of this study substantiated findings of Ahmad and Abubakar, 2012 and World Bank, 2005 that the country is a market hub for generating sets evident in the importation of different types and make of generating sets massively used by the populace in the face of poor power supply.

Table 13: Brand of Generating Sets Used in the Buildings Sampled

Brand of Generating Sets	Residential Building				Commercial Building			
	Core Zone F %	Transition Zone F %	Suburban Zone F %	Total F %	Core Zone F %	Transition Zone F %	Suburban Zone F %	Total F %
Yamaha	5 3.76	2 1.53	2 1.69	9 2.36	0 0.00	0 0.00	0 0.00	0 0.00
Thermocool	4 3.00	3 2.29	8 6.79	15 3.93	0 0.00	2 6.06	1 4.55	3 3.49
Honda	9 6.78	2 1.53	4 3.39	15 3.93	1 3.22	2 6.06	2 9.09	5 5.81
Tiger	32 24.06	17 12.98	16 13.56	65 17.01	14 45.16	5 15.16	4 18.18	23 26.74
Tigmax	14 10.53	27 20.61	12 10.17	53 13.87	8 25.82	9 27.27	5 22.71	22 25.58
Elemax	23 17.29	29 22.14	26 22.03	78 20.42	3 9.68	1 3.03	4 18.18	8 9.30
Elepaq	15 11.28	19 14.50	24 20.34	58 15.18	4 12.90	7 21.21	2 9.09	13 15.12
Sumec	12 9.02	14 10.68	8 6.78	34 8.90	1 3.22	4 12.12	1 4.55	6 6.98
Firman	7 5.26	3 2.29	7 5.93	17 4.45	0 0.00	2 6.06	1 4.55	3 3.49
Lutian	5 3.76	6 4.58	5 4.24	16 4.19	0 0.00	1 3.03	1 4.55	2 2.33
Imex	7 5.26	9 6.87	6 5.08	22 5.76	0 0.00	0 0.00	1 4.55	1 1.16
Total F %	133 100.00	131 100.00	118 100.00	382 100.00	31 100.00	33 100.00	22 100.00	86 100.00

The one-sample binomial test based on the 2-tailed level (Table 14) also indicated that there was significant probability (0.20) of the use of Elemax brand of generating sets in the residential buildings. It was followed by Tiger brand with probability (0.17) and Elepaq (0.15). However, in the commercial buildings, there was significant probability of the use of Tiger brand with significant probability (0,26), Tigmax (0.25) and Elepaq (0.15). The implication of this result is that various types of brand of generating sets were used in the buildings sampled that could be based on their perception of the failure patterns and level of efficiency. The result of this study based on the procurement and use of different brand of generating sets is in line with past works of World Bank (2005) that various types and make of generators were used by well over 90% occupants of different buildings in Nigeria.

Table 14: One-Sample Binomial Test on the Brand of Generating Sets Used

		Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
Residential Buildings	Group 1	Elemax	78	.20	.50	.000
	Group 2	Tiger	65	.17		
	Group 3	Elepaq	58	.15		
		Σ(Other Brand)	181			
	Total		382	1.00		
Commercial Buildings	Group 1	Tiger	23	.26	.50	.000
	Group 2	Tigmax	22	.25		
	Group 3	Elepaq	13	.15		
		Σ(Other Brand)	28			
	Total		86	1.00		

COST OF THE USE OF GENERATORS

Table 15 showed economy of the use of generating sets by respondents in the study area when the price of petrol was fixed at 87 naira per litre in the country before the sudden increase in its price due to scarcity and further deregulation of the petroleum sector by the federal government which led to higher increase in its price. A large proportion of respondents, 81(66.39%) in the suburban residential buildings spent between 5,100 to 7000 naira monthly on the cost of fuelling their generators. A contrast in the economy of use was found among respondents in the core zone as 117(66.86%) and 53(30.29%) of the respondents spent up to 1000 naira and between 1,100 to 3000 naira monthly respectively, while majority of respondents, 97(70.80%) in the transition zone spent between 1,100 to 3,000 naira monthly. It was also found that the mean amount spent on the fuelling of generators were 1,450, 2,955 and 5,975 naira in the core, transition and suburban zone respectively. This also revealed that the income level of respondents influenced how they lived in the suburban zone by using generating sets of higher output ratings and more appliances than those living in other zones. Similarly, the result showed that respondents in commercial buildings in the transition zone spent significantly higher than those in other zones across the study area on the fuelling of their generators with a mean amount of 3,994 naira followed by respondents in the core and suburban zone with a mean amount of 3,152 and 1,821 naira respectively. This was traced to the level of commercial activities that respondents in the transition zone used their generating sets for relatively.

Table 15: Cost of the Use of Generators

Amount Spent (Naira)	Residential Building			Total	Commercial Building			Total
	Core Zone	Transition Zone	Suburban Zone		Core Zone	Transition Zone	Suburban Zone	
	F %	F %	F %	F %	F %	F %	F %	F %
≤ 1,000	117 66.86	31 22.63	0 0.00	148 34.10	2 5.88	1 2.78	0 0.00	3 2.23
1,100 - N3,000	53 30.29	97 70.80	6 4.92	156 35.95	25 73.53	11 30.55	16 69.56	52 55.92
N3,100 – N5,000	4 2.29	9 6.57	26 21.31	39 8.99	7 20.59	23 63.89	6 26.09	36 38.71
N5,100 – N7,000	1 0.56	0 0.00	81 66.39	82 18.89	0 0.00	0 0.00	1 4.35	1 1.07
N7,100 – N9,000	0 .00	0 0.00	9 7.38	9 2.07	0 0.00	0 0.00	0 0.00	0 0.00
> N9,100	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	1 2.78	0 0.00	1 1.07
Total F %	175 100.00	137 100.00	122 100.00	434 100.00	34 100.00	36 100.00	23 100.00	93 100.00

Past studies on the economy of using generator either at institutional or household level were significantly congruent with the findings of this study. FGN (2014) opined that the Federal Government of the country spent appropriated large sum of money in fuelling generators in its various ministries, departments and agencies. In the same vein, NOI Polls (2015) found that the use of generators subjected households to financial burden as opposed to direct supply from power distributing companies (DISCOs). This indicated that the dependence on various generating sets by building occupants seemingly caused financial stress for the users and which would be higher in the face of galloping prices of petroleum products between N145 to N250 per litre when there was scarcity and deregulation of the downstream sector of petroleum industry.

Capacity of the Generators Used in Powering Appliances

The respondents were asked to indicate capacities of their generators to power at a moment, all the electrical appliances used in their buildings when compared with the time that they used to get normal supply of electricity from IBEDC. The study revealed that in the residential buildings, 25(23.36%) of generating sets of respondents in the suburban zone had capacities to power all their appliances when compared with the full supply of voltage of electricity from IBEDC as shown in Table 16. Majority of the respondents, 107(70.40%), 61(67.03%) and 82(76.64%) in the core, transition and suburban zone respectively as 250(71.43%) in all zones could not use their generating sets to power all their appliances when compared with the supply of electrical energy of adequate voltage to their buildings. The results of the Chi-square tests carried out, (χ^2 = 332.994, p < 0.001) revealed that there was significant relationship between the capacity of generating sets and the appliances that they could power. These results further substantiated the position ascribed to the country in being a generator-economy nation because dependence of the respondents on varying capacities of the available generators had not been able to give building occupants the much needed satisfaction as an alternative power supply in the face of the current epileptic power supply. However, in the commercial buildings, the result revealed that a significant proportion, 25(96.15%), 19(90.48%) and 16(94.12%) of respondents in the core, transition and suburban zone respectively indicated that their generating sets could power the basic equipment/appliances used for their commercial activities. This implied that the power inputs of their appliances were within the output ratings of the generating sets used.

Table 16: Capacity of Generating Sets in Powering All Electrical Appliances Used

Residential Building Sampled	Response on Capability of Generating Sets to Power All Appliances		Total F	Commercial Building Sampled	Response on Capability of Generating Sets to Power All Appliances		Total F
	Yes (%)	No (%)	%		Yes (%)	No (%)	%
Core	45	107	152	Core	25	1	26
	29.60	70.40	100.00		96.15	3.85	100.00
Transition	30	61	91	Transition	19	2	21
	32.97	67.03	100.00		90.48	9.52	100.00
Suburban	25	82	107	Suburban	16	1	17
	23.36	76.64	100.00		94.12	5.86	100.00
Total	100	250	350	Total	60	4	64
	28.57	71.43	100.00		93.75	6.25	100.00

4 Conclusion And Recommendations

The study showed that inadequate supply of electricity informed the wide use of electric power generators by respondents in the study area. It also showed that variation in the socio-economic characteristics of the respondents such as level of income, educational, occupancy and employment status influenced the variation in the type, rating, brand and economy of the generating sets used. The mean rate of supply of electricity by the Ibadan Electricity Company (IBEDC) during the course of the study to residential buildings in the core, transition and suburban zone respectively were 4.37 hours, 5.31 hours and 7.63 hours daily. The reduced rate in the average hours of supply power by the Ibadan Electricity Distributing Company (IBEDC) to the residential and commercial buildings sampled in various zones of the study area informed the wide use of generating sets in buildings.

The generator audit carried out in both residential and commercial buildings across zones of the study area reflected sharp variation in the types, output ratings and brand of generating sets used by the respondents. From the results obtained, 47.79%, of respondents in the residential buildings in the suburban zone used generating sets that were of higher output ratings than those used in either core or transition zone. Similarly, 92.86% of respondents in the suburban zone used diesel engine generators. It was established that 23.36% of respondents in residential buildings in the suburban zone were capable of powering all the electrical appliances used indoor when compared with when they used to get adequate supply of electricity. Across the zones, 71.43% of respondents in the residential buildings could not use their generators to power their electrical devices simultaneously. However, in the commercial buildings across the zones, 93.75% of respondents were able to use their generators to power all their electrical appliances indoor. The myriad of poor power supply that forced building occupants to procure various types of generating sets and run generator economy should be addressed by harnessing environmentally friendly and alternative sources of energy that will enhance power security and overall sustainability of the environment.

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