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Comparative Analysis of Electricity Consumption among Residential, Commercial and Industrial Sectors of the Nigeria's Economy

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Abstract
Electricity outage is one of the main challenges confronting the residential, commercial and industrial sectors of the Nigeria's economy. All attempts at addressing this problem have not yielded the desired results. This study compares electricity consumption in these three sectors using time series data that covered 35 years period, ranging from 1970 to 2004. Analysis of variance technique was used in testing the hypothesis postulated from the objective of the study. The results suggest that electricity consumption differed significantly among the three sectors, with the exception of the industrial versus commercial sectors, at 0.01 level (Fcal=19.805, α-sign = .000). The residential sector has the highest mean electricity consumption (396.405 mw per hour). It is followed in descending order by industrial sector (9223.9429 mw per hour) and commercial sector (175.33629 mw per hour). A comparison of the mean electricity consumption in each of the three sectors with daily electricity demand of (5000mw per hour) shows that the three sectors are grossly under supplied with electricity. This reveals the root cause of power outages. The outcome of this study will be useful in enhancing policies towards eliminating electricity shortages in Nigeria.
Keywords: Electricity, Residential, Commercial, Industrial, Consumption.

1. Introduction

Electricity shortages constitute one of the main challenges facing the Nigerian nation. The situation is as a result of inability of the electricity supply to meet the consumers demand in the industrial, commercial and residential sectors of the nation's economy. Electricity supply in the country has been erratic and epileptic, thus resulting in frequent power outages that have impaired economic growth and development. The residential, commercial and industrial electricity consumption accounted respectively for 51.3, 26.7 and 22 percent of total electricity consumption. These sectors have experienced serous decline in electricity consumption in the past two decades.
This situation has been attributed to the inability of electricity supply to meet the estimated nation's daily demand of 5000 mega watts (mw) per hour. The nation's daily generating capacity has declined from 5000mw per hour to 1600mw per hour. This is worsened by the phenomenal growth in population and economic activities, lack of maintenance of the existing power stations as well as failure of the government to improve on the nation's generating capacity in order to meet the growing demand in the various sectors of the economy.
The impacts of this problem on the nation's economy were enormous. Industrial and commercial establishments operate below their production capacity. Some have resorted to the use of diesel generators as alternative source of power. This resulted in increased cost of production and high cost of goods and services in the country (Adenikinja 2003). Some others have relocated to neighbouring countries where there is steady supply of electricity. All the efforts aimed at addressing the power problem have been marred by corruption.
The aim of this study is to compare electricity consumption among the industrial, commercial and residential sectors of the Nigerian economy. This is with a view to determining the pattern and extent of differentials in electricity consumption among the three sectors. It is hoped that the outcome of this study is capable of enhancing current measures aimed at elimination of load shedding and power outages in the country.

2. Literature Review

Studies have been carried out on electricity consumption around the globe. Ubani (2009) determined the electricity consumption pattern in south-south geopolitical region of Nigeria. The results showed that there were significant differences in electricity consumption pattern amongst the six states that constitute the geopolitical region. River state had the highest mean consumption rate, followed in descending order by Delta, Edo, Akwa Ibom, Bayelsa and Cross River states. He recommended for strategic and systematic distribution of electricity to ensure adequate supply in south-south geopolitical region
Arimah (1993) discovered that that there was spatial variation in electricity consumption in Nigeria. This, he attributed to variation in socio-physical variables among various regions. These variables are the price of electricity, urbanization, income, population, number of residential houses, land area, commercial activities, industrial activities and distance of each state to Kanji Dam. Adenikinja (2003) discovered that the cost of

electricity failures on the Nigerian manufacturing sector was quite high. Firms incurred huge costs on the provision of expensive back-up to minimize the expected outage costs. The average costs of this back-up were on the average of 3 times the cost of public supplied electricity. This had negative impact on costs competitiveness of the manufacturing sector. The study supported the efforts to privatize and liberalize the electricity sector. This, he hoped would mitigate the burden of poor power supply as well as introduce the needed competition into the electricity market in the country.

Donatos and Mergos (1991) examined the determinants of residential consumption in Greece over the period 1961 – 86. The result showed that: first, the residential demand for electricity was price inelastic but income elastic. Second, there was high substitutability between electricity and liquefied natural gas. Third, during the examined period, the number of consumers played a very important role in the expansion of electricity consumption in Greece. Fourth, there was no regional variation in residential electricity demand. Similarly, Tserkezos (1992) studied household electricity consumption in Greece. The results showed that personal disposable income, prevailing temperature and price of electricity used by the household played an important role in the demand for electricity.

Tiwani (2000) determined the short run residential demand for electricity using household survey data for Bombay (Mumbai), India. The results showed that the price and income elasticities of residential electricity demand were -0.70 and -0.34 respectively. Holtedahl and Joutz (2004) showed that residential demand for electricity in Taiwan was a function of household disposable income, population growth, the price of electricity and the degree of urbanization. In the long-run, the income was inelastic and the own-price effect was negative and also inelastic. The short-run income and price effects were small and less than the long run effect. Halvorsen and Larsen (2001) used discrete and continuous modeling approaches to estimate residential electricity consumption in Norway. The results showed that the estimated long-run electricity was only slightly more price elastic than the short-run. The long-run elasticity did not differ significantly between the two approaches. This was because, since there was no alternative source of energy for the electrical appliances, there were no substitution effects.

Garbacz (1983) used a three variable equation model (demand, price appliance stock index and current national household data) to develop partial and total electricity estimates for the USA. The results showed that the partial elasticities were 0.102 for income and 0.193 for price, while total elasticity was 0.410 for income. Zachariadies and Pashourtidou (2007) carried out an empirical analysis of electricity consumption in Cyprus. The results showed that long-term elasticities of electricity use were above unity for income and of the order of -0.3 to -0.4 for prices. The short-term consumption was inelastic, mostly affected by weather fluctuations. There was exogeneity of electricity prices and bidirectional causality between residential electricity consumption and private income. The commercial sector was less elastic and reverted faster to equilibrium than the residential sector. Badri (1992) estimated total elasticities of electricity demand for three sectors (residential, commercial and industrial) in USA. The estimates showed that own-price elasticity was above unity for commercial demand but less than unity for the residential and industrial demands.

Jamil and Ahmad (2010) analyzed the relationship between electricity consumption, its price and real GDP at the aggregate and sectoral level in Pakistan. The results showed that there was the presence of unidirectional casualty from real economic activity to electricity consumption. Specifically, industrial and agricultural sectors tend to increase electricity consumption, whereas in residential sector, growth in private expenditure was the cause of rising electricity consumption. The study recommended that electricity production and management needed to be better integrated with overall planning exercises. They opined that this was essential to avoid electricity shortfalls and load shedding.

Al-Ghandoor et al (2008) found that industrial production outputs and capacity utilization were the two most important variables that affected demand for electricity in the industrial sector of Jordan. The study predicted that electricity consumption and associated GHG emission for industrial sector will be 63 percent in the year 2019. Wang et al (2010) showed that activity effect and shift effect which were caused by the change in the electricity's share of industrial energy use. These are the major factors responsible for the rise in China's industrial electricity consumption between 1998 and 2007. In addition, it was found that street change contributed to the increase in electricity consumption. In contrast, technological effect was responsible for a decrease in electricity consumption during the study period. Furthermore, the results showed that the main contributors to increased electricity consumption among industrial subsectors were manufacturing of raw chemical materials and products, non-metal mineral products, smelting of ferrous and non-ferrous metals, and production and supply of electric power and heat power.

Wiesmann et al (2011) discovered that household and dwelling characteristics had significant influence on residential electricity consumption in Portugal. The results also showed that the direct effect of income on electricity consumption was low and became smaller when more relevant variables were included in the analysis. Future demand of electricity would be significantly influenced by trends in socio-economic factors as well as changes in the building stock. The study concluded that these trends should be taken into consideration in the

formulation of policy measures towards reducing electricity consumption.
Zachariadis (2010) revealed that electricity consumption in Cyprus might be about 2.9 percent higher in 2030 than was estimated. This might lead to welfare losses of 15 million Euros in 2020 and 45 million Euros in 2030. He opined that if the past trends continued, electricity use was expected to triple in the subsequent 20 – 25 years with the residential and commercial sectors increasing their already high share in consumption.
Meyers and Sathaye (1998) examined changes in electricity consumption of the largest developing countries between 1970 and 1986. The results showed that average annual growth in electricity consumption ranged from 4.4 percent in Argentina to 13 percent in South Korea. Combined electricity consumption for the 13 countries under study had an average growth of 10 percent per annum in the 1970s and 7.1 percent in the 1980 – 1986 period. The industrial sector continued to dominate electricity consumption but its share of total consumption declined in the face of faster growth in the residential and commercial sectors. Industrial sector consumption rose significantly in Latin America during the 1970 – 1986 period, but did not increase greatly in most of the Asian countries. Increases in residential electricity use per capita and the number of homes that have electricity had been most rapid in Asia. However, most Latin American countries still had higher use per capita than most Asian countries.
Rancharran (1990) showed that the aggregate demand for electricity was slightly income elastic, and had significant impact on economic growth in Jamaica. The electricity consumption intensity had increased over time; residential demand was fairly income elastic, commercial demand was price inelastic and the rate of adjustment was slow. These results suggested that conservation policies might have been ineffective. Narayan et el (2007) showed that long run residential demand for electricity in G7 countries was price elastic and income inelastic. The study concluded that from an environmental perspective, there was potential to use pricing policies to curtail residential electricity demand and thus minimize carbon emission in the long-run.
It is apparent from the literature that there exist national differences in the results of comparative analysis of electricity consumption among the residential, commercial and industrial sectors. This study deals with the situation in Nigeria.

3. Methodology

Data used n this study, namely electricity consumption in residential, commercial and industrial sectors, were collected from official records. These include time series data which cover a period of 35 years, ranging from 1970 to 2004 obtained from Power Holding Corporation of Nigeria. This study was limited to the year 2004 because of non-availability of data on electricity consumption beyond year 2004.
Analysis of Variance technique (ANOVA) was used in testing the research hypothesis which states that: there is no significant difference in electricity consumption among the residential, commercial and industrial sectors of the Nigeria's economy. The dependent variable (y) was electricity consumption. The independent variables were represented by residential, commercial and industrial sectors which were coded in the analysis as treatment categories 1, 2 and 3 respectively. The formulae for ANOVA are given as follows:

$$SST = \sum X^{2} - \frac{(\sum X)^2}{N} \quad \ldots\ldots\ldots\ldots (1)$$

$$SSB = \frac{(\sum X_1)^2}{N} \times \frac{(\sum X_2)^2}{N} \times \frac{(\sum X_3)^2}{N} \times \frac{(\sum X_n)^2}{N} \quad \ldots\ldots\ldots\ldots (2)$$

$$SSW = SST - SSB \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where:
SST = Total variation (Total sum of squares)
SSB = Variation between groups (sum of squares between)
SSW = Variation within groups (sum of squares within)

4.Data Presentation Analysis and Findings

Table 1 and figure 1 show the trend of electricity consumption in the residential, commercial and industrial sectors from 1970 to 2004. The analysis reveals a fluctuation in electricity consumption by the industrial sector. Between 1970 -1977, this sector had the highest consumption of electricity accounting for 53.6 percent of total electricity consumption. It then declined to 32.2 percent from 1978 to 1990, making it the second largest consumer of electricity. This fall in the consumption of electricity by the industrial sector can be attributed to a heavy dependence on private generating plants as a result of frequent power outages. The contribution of the commercial sector to national total prior to 1991 was less than 15 percent. However, due to all in electricity consumption by the industrial sector from 1992 to 2004, the commercial sector became the second largest consumer after the residential sector. This rise in consumption in commercial sector can be attributed to the

increase in activities of the informal sector in Nigeria. The residential consumers of electricity became the largest electricity consumers amongst the three sectors from 1978 to 2004. It consumed about 52 percent and 52.4 percent of total electricity between 1978 – 1990 and 1991 to 2004 respectively. This increased electricity demand by residential sector could be attributed to the rising standard of living among Nigerians who use high power consumption appliances and gadgets.

Table 1: Electricity consumption among the residential, commercial and industrial sectors from 1970-2004 (MW/H).

Year	Residential	Commercial	Industrial	Year	Residential	Commercial	Industrial
1970	53.90	49.20	91.40	1988	443.80	118.60	219.10
1971	66.20	50.30	114.90	1989	523.60	195.30	257.90
1972	72.90	52.90	138.20	1990	450.80	219.60	230.10
1973	86.60	50.40	146.10	1991	495.30	254.10	253.70
1974	103	49.10	163.20	1992	481.60	266.10	245.30
1975	118.30	49.60	200.40	1993	592.40	311.60	237.70
1976	155.20	101.90	211.60	1994	575	306.70	233.30
1977	182.70	102.30	253	1995	552.60	276.60	218.70
1978	253.20	93.50	157.70	1996	518	280	235.30
1979	221.90	77.90	60.30	1997	508.30	264.50	236
1980	243.10	94.10	199.70	1998	500	253.90	218.90
1981	193.60	21.30	121	1999	455.10	236.80	191.80
1982	344.80	79.10	262	2000	518.80	274.70	223.80
1983	358	84.30	254.40	2001	564.50	298.30	241.90
1984	326.60	81.70	217.20	2002	752.80	372.60	146.20
1985	372.60	85.60	259.80	2003	905.60	417.90	196
1986	476.60	84.70	280.50	2004	938.50	489.30	398
1987	468.60	90.20	294.10				

Source: Power Holding Corporation of Nigeria

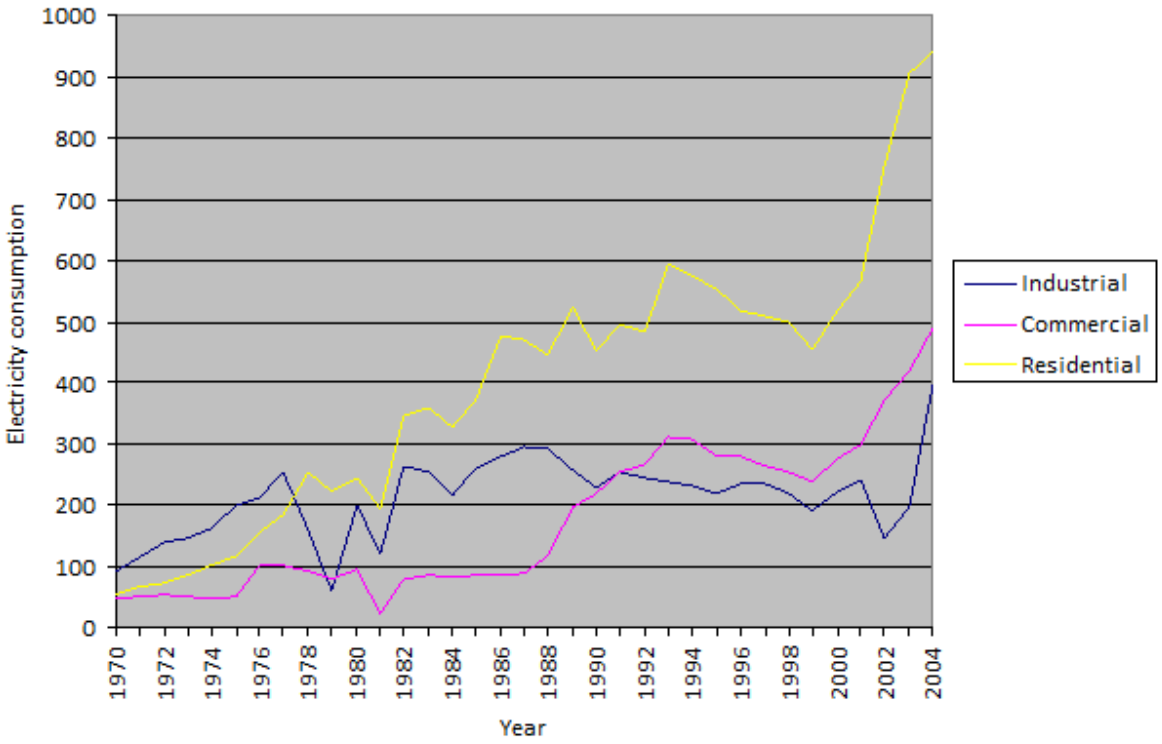

Figure 1: The trend of electricity consumption in industrial, commercial and residential sectors from 1970-2004

Table 2 shows the results of the test of hypothesis which suggest that there was a significant difference in electricity consumption among the residential, commercial and industrial sectors at less than 0.1 significant level. However, the ANOVA multiple comparisons output in table 3 shows that the mean differences in electricity consumption between the three sectors, except industrial versus commercial sector, were significant at 0.01 level.

The mean difference between industrial and commercial sectors was not significant even at 0.05 level
Table 2: Analysis of Variance Output Table.

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	944572.979	2	472286.489	19.805	.000
Within Groups	2432395.966	102	23847.019		
Total	3376968.945	104			

Source: Statistical Packages for Social Sciences analysis.

5. Discussions

The results of the test of the hypothesis suggest that there exist significant difference in electricity consumption between the three sectors except industrial versus commercial which have lower and similar consumption trend. This implies that electricity consumption is not the same in the three sectors. The mean difference in electricity consumption between residential and commercial was highest (221.04286 mega watts per hour). It was followed by residential and industrial with 172.46286 mega watts per hour. However, industrial and commercial sectors were homogenous (48.5800 mega watts per hour), that is, there was no significant difference in electricity consumption between the two sectors (see table 3)

Table 3: Analysis of Variance Multiple Comparisons Output Table

Multiple Comparisons
Dependent Variable: industrial commercial and residential sector

(I) groups	(J) groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
		Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound
Industrial	Commercial	48.58000	36.91459	.471	-41.0330	138.1930
	Residential	-172.46286(*)	36.91459	.000	-262.0759	-82.8499
Commercial	Industrial	-48.58000	36.91459	.471	-138.1930	41.0330
	Residential	-221.04286(*)	36.91459	.000	-310.6559	-131.4299
Residential	Industrial	172.46286(*)	36.91459	.000	82.8499	262.0759
	Commercial	221.04286(*)	36.91459	.000	131.4299	310.6559

* The mean difference is significant at the .01 level.

Source: Statistical Packages for Social Sciences analysis.

Table 4 shows the subsets of the ANOVA analysis. The results indicate that residential sector has the highest mean consumption of electricity during the study period (396.4057 mega watts per hour per day). It was followed in descending order by industrial sector (223.9429 mega watts per hour per day) and commercial sector (9175.3629 mega watts per hour per day)[See figure 2]. A comparison of the mean electricity consumption in the three sectors with the nation's daily demand of 500 mega watts per hour shows that residential, commercial and industrial sectors were grossly under supplied with electricity. This tends to be responsible for load shedding and power outages that have bedeviled the nation in the past decade.

Table 4: Subset of ANOVA analysis.

	N	Subset for alpha = .05	
Roups	1	2	1
Commercial	35	175.3629	
Industrial	35	223.9429	
Residential	35		396.4057

. Source: Statistical Packages for Social Sciences analysis, 2011

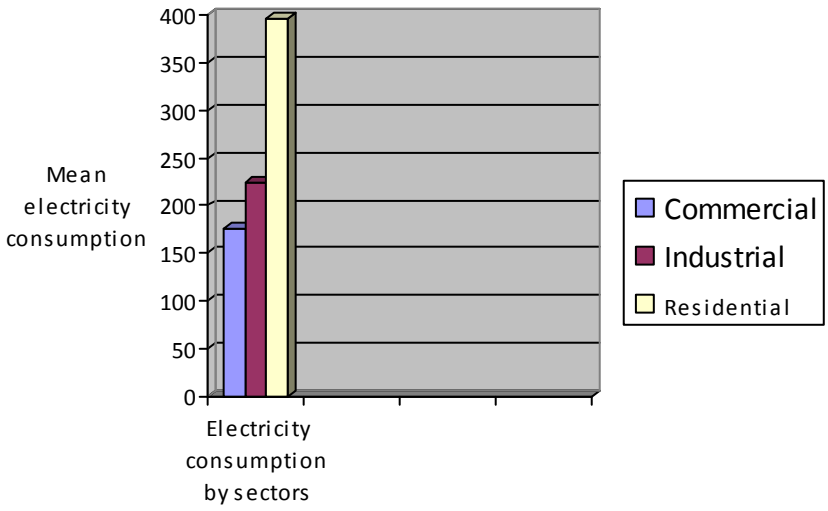

Figure 2: Mean electricity consumption among commercial, industrial and residential sectors

6. Recommendations

The government should ensure that the demand for electricity is met in the residential, commercial and industrial sectors of the economy. There is the need to improve the nation's electricity generating capacity to meet the daily demand. To achieve this target, the Federal Government should as a matter of urgency lay more emphasis on the expansion of the generating capacity of the existing power stations as well as the construction of new ones. Also, there should be development of alternative sources of power such as biogas, wind and solar radiation which are abundant in the country. Finally, the Federal Government should encourage the participation of the private sector in generation and distribution of electricity by removing all impediments inimical to their participation. These efforts will in the long-run result in the generation of electricity that will meet the demands in the residential, commercial and industrial sectors of the Nigeria's economy.

7. Conclusion

This study compared electricity consumption among the residential, commercial and industrial sectors of Nigeria's economy. The results of the hypothesis suggest that there exist significant differences in electricity consumption among the three aforementioned sectors with exception of industrial versus commercial sectors. The residential sector has the highest mean consumption of electricity. It is followed in descending order by industrial and commercial sectors. A comparison of mean electricity consumption in each of the three sectors with daily demand shows that the three sectors are grossly under supplied with electricity. There is the need for adequate supply of electricity to meet the consumers' demand in the residential, commercial and industrial sectors of Nigeria.

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