Evaluation of Performance of Electrical Power Supply in South-East Nigeria

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Abstract

This paper is on appraisal performance of electricity power supply in South-East Nigeria. The Semantic Differential Technique was adopted in constructing the questionnaire for this research which ranges from +5 Very Large Extent Agreement to -5 Very Large Extent Disagreement. A sample of 120 respondents was used in the five South-Eastern states. The Pearson correlation coefficient was employed to establish the reliability of instrument that yielded an index coefficient of 0.906, which proved the instrument reliable. The study hypothesis was tested using Regression Analysis statistical technique, while charts with percentage were used in the demographical data. The study revealed that there is a significant improvement in the performance of electrical power supply in Nigeria since the p-value (0.000) is < 0.05 (level of significance). The result further reviewed that there is a strong and positive improvement in the performance of electrical power supply since the slope (0.782) is positive and the coefficient of determination is 0.793. Implementation of this research work will enhance ameliorate power losses, and ensure efficient and effective economic dispatch of electric power. The study however recommends that future researchers should study a similar work by examining other geo-political zone and employing different statistical technique to compare result.

Keywords*:* *Evaluation, Performance, Electrical Power Supply, Effective Utilization, Power generation*.

I. INTRODUCTION

Nigeria has an abundant supply of energy sources. It is endowed with thermal, hydro, solar, and oil resources, and yet it is described as an energy-poor country because the sector is relatively under-developed. The statistics available show that only about one third of Nigeria or approximately 40 per cent of the population has access to electricity. The distribution of electricity shows great disparities between rural and urban, and between residential and industrial areas in the urban centers (Ali-Akpajia and Pyke, 2003). The very poor quality of power supply in recent years has been a major constraint on the performance of most industries in the economy. In this regard, adequate supply and distribution of electricity constitute a central development issue which cannot be over-emphasized. Apart from serving as the pillar of wealth creation in Nigeria, it is also the nucleus of operations and subsequently the engine of growth for all sectors of the economy (Ayodele, 2001). In recognition of the consoled bating linkage between the energy sector and the other sectors of the economy, electricity development and utilization therefore have pervasive impacts one range of socio-economic activities and consequently on the economic progressiveness and wellbeing of citizens of the country. It is in the light of this facts that Okonkwo (2002) stated that there is a correlation between electricity supply, industrialization, and business growth in Nigeria.

The efficient and effective utilization of its resources to produce goods and services goes a long way to demonstrate the management’s ability to accomplish organizational goals (Jones, 2003). However, the inability of an organization to judiciously manage its resources effectively means it has failed as an entity and cannot meet the challenge of providing goods and services to its consumers.

In recent years, electricity supply has become very significant owing to the indispensable role played by electricity in every facet of our economic and daily lives. Absence of electricity for long periods causes discomfort and hampers productivity. It is also a known fact that electricity consumption has become a parameter by which the standard of living as well as the level of industrialization of nations is measured (Mahammed, 2005). The Federal Government of Nigeria in 1998 mandated the Power Holding Company of Nigeria (PHCN) to generate, transmit and distribution power to Nigerians. The question now, is there any significant improvement in the performance of electrical power supply in Nigeria? If not, what are the problems militating against its inability to successfully implementation of this mandate and how can these problems be addressed? This is the task this study hopes to investigate. To achieve this objective, the paper has therefore been organized with necessary technique to achieve this objective.

II. REVIEW OF RELATED LITERATURE

Okoye and Igboanugo (2015) researched on Performance appraisal of gas based electric power generation system using transfer function modeling.

Gas flaring for years has been a major environmental problem in many parts of the world. One way of solving the problem of gas flaring is to effectively utilize the abundant supply of gas for power generation.

To effectively utilize gas for power generation requires highly efficient gas turbines and power facilities. Traditional methods of assessing the efficiency of power generation turbines do not take into consideration the stochastic nature of gas input and power output. In a power generation system, as in any typical production system, there is generally marked variability in both input (gas) and output (power) of the process. This makes the determination of the relationship between input and output quite complex. This work utilized Box-Jenkins transfer function modeling technique, an integral part of statistical principle of time series analysis to model the efficiency of a gas power plant. This improved way of determining the efficiency of gas power generation facilities involves taking input–output data from a gas power generation process over a 10-year period and developing transfer function models of the process for the ten years, which are used as performance indicators. Based on the performance indicators obtained from the models, the results show that the efficiency of the gas power generation facility was best in the years 2007–2011 with a coefficient of performance of 0.002343345.

Similarly, with a coefficient of performance of 0.002073617, plant performance/efficiency was worst in the years 2002–2006. Using the traditional method of calculating efficiency the values of 0.2613 and 0.2516 were obtained for years 2002–2006 and 2007–2011 respectively. The result is remarkable because given the state of the facilities, it correctly predicted the period of expected high system performance i.e. 2002–2006 periods, but the traditional efficiency measurement method failed to do so. Ordinarily, using efficiency values obtained through the traditional method as the metric, the system managers would assume that the period 2002–2006 was better than in the period 2007–2011 whereas the reverse is the case. The result of this study is expected to open new ways to improving maintenance effectiveness and efficiency of gas power generation facilities.

Liu et al (2010) used (Data Envelopment Analysis) DEA to evaluate the power-generation efficiency of major thermal power plants in Taiwan during 2004–2006. They conducted a stability test to verify the stability of the DEA model. According to the results, all power plants they studied achieved acceptable overall operational efficiencies during 2004–2006, and the combined cycle power plants were the most efficient among all plants.

Sozen et al (2010) used DEA to conduct efficiency analyses of the eleven lignite-fired, one hard coal-fired and three natural gas-fired state-owned thermal power plants used for electricity generation in Turkey. They used two efficiency indexes: operational and environmental performance. In their calculation of the operational performance, main production indicators were used as input, and fuel cost per actual production (Y) was used as output (Model 1). On the other hand, in their calculation of the environmental performance, gases emitted to the environment were used as output (Model 2). They investigated the relationship between efficiency scores and input/output factors. Employing the obtained results, the power plants were evaluated with respect to both the cost of electricity generation and the environmental effects. Fallahi et al (2011) used an empirical analysis of the determinants of energy efficiency in 32 Power electric generation management companies over the period 2005–2009 in India.

The study used non-parametric Data Envelopment Analysis (DEA) to estimate the relative technical efficiency and productivity change of these companies. In order to verify the stability of their DEA model and the importance of each input variable, they also conducted a stability test. The results of the study indicate that average technical efficiency of companies decreased during the study period. Nearly half of the companies (El-Samanoudy, et al 2010) are below this average level of 88.7% for five years. The study equally showed that the low increase of productivity changes is more related to low efficiency rather than technology changes.

Atmaca and Basar (2012) used the multi-criteria decision making technique of Analytic Network Process (ANP), a multi-criteria evaluations of six different energy plants were performed with respect to the major criteria such as technology and sustainability, economical suitability, life quality and socio-economic impacts.

Nixon et al (2013) used Hierarchical Analytical Network Process (HANP) model for evaluating alternative technologies for generating electricity in India.

They concluded that HANP successfully provides a structured framework for recommending which technologies to pursue in India, and the adoption of such tools is critical at a time when key investments in infrastructure were being made.

Oyedepo et al (2015) worked on Assessment of performance indices of selected gas turbine power plants in Nigeria. The results of the study showed that for the period under review (2006–2010), the percentage short-falls from the target energy in the selected power plants range from 26.33% to 86.61% as against the acceptable value of 5–10%. The capacity factor of the selected power plants varies from 16.88% to 73.67% as against the inter-national value of 50–80%. The plant use factor varies from 45.89% to 97.03% and the utilization factor varies from 6.31% to 93.074% as against the international best practice of over 95%. From this result, it can be concluded that the generating units were underutilized. This is due to inadequate routine maintenance and equipment fault development. The analyses of reliability indicators revealed that the mean time between failures varies from 5.42 to 378.44 h, the mean time to repair varies from 18.3 to 153.88 h and the plant availability varies from 12.86% to 91.31% as against the Institute of Electrical and Electronics Engineers recommended standard of 99.9% Evaluation of operating figures of the selected power plants revealed that starting reliability (SR) and operating reliability vary from 71.95% to 93.9% and 5.33% to 55%, respectively. The SR of the selected power plants is low in value compared with standard value of 99.9%. The statistical analysis carried out on plant availability revealed that at 95% confidence level; there is a significant difference in availability of the selected power plants. This indicates differences in their systems installation, operation and maintenance. The performance indicator developed to evaluate the performance indices for the selected stations can also be applicable to other power stations in Nigeria and elsewhere. Measures to improve the performance indices of the plants have been suggested in this paper.

Having reviewed these past researches, it becomes imperative to examine the appraisal performance of electrical power supply in the South-East Nigeria.

III. RELIABILITY OF THE INSTRUMENT

In order to determine the reliability of the instrument, the researcher administered the instrument to 30 respondents. The data collected through trial testing were analyzed to determine the extent of internal consistency with which the items of the instrument would measure the various traits of interest. The Pearson correlation coefficient was employed to establish the reliability of instrument which yielded an index coefficient of 0.906. The researcher therefore considered the instrument suitable and adequate for the study. See below the reliability result from SPSS software.

Table 1 - Correlations

		VAR00001	VAR00002
VAR00001	Pearson Correlation	1	.906**
	Sig. (2-tailed)		.000
	N	30	30
VAR00002	Pearson Correlation	.906**	1
	Sig. (2-tailed)	.000	
	N	30	30

**. Correlation is significant at the 0.01 level (2-tailed).

A. Data Analysis Technique

This section explains the statistical tool that would be used in analyzing the data. The Semantic Differential Technique was adopted for this research.

Osgood, Suci and Tannenbaum (1957) developed the technique. It consists of pairs of antonyms-bipolar adjectives or phrase with cues spaced in between (Okpara, 1998). By using a number of bipolar adjectives and respondents requested to rate the objects, subjects and events against the bipolar adjectives, a pattern of one's attitude emerges. The rating has a degree ranging from positive to negative. The rating model containing seven points can be shown as follows:

+5 Very Large Extent Agreement
+4 Large Extent Agreement
+3 Little Extent Agreement
0 Neutral
-3 Little Extent Disagreement
-4 Large Extent Disagreement
-5 Very Large Extent Disagreement

The respondent or rater is expected to rate each behavior either from the positive standpoint or negative standpoint. At the extreme left, +5 indicates a strong agreement of effect, 0 is the point of neutrality while – 5 at the extreme right indicates strong disagreement. The sum of all the rating which might either fall in the negative or positive side will indicate how effective the leadership in question is.

B. Simple Linear Regression

This is a regression line that involves only two variables as it is applicable in this research study. A widely used procedure for obtaining the regression line of y on x is the Least Squares Method.

The linear regression line or y on x is

$$y = \alpha + \beta x + e \quad \ldots \quad (1)$$

Where y is the response or dependent variable, x is the predictor or independent variable. α is the intercept, β is the slope, while e is the error term.

Using the least squares method, the parameters are estimated as shown in equations (2) and (3);

$$\hat{\beta} = \frac{n\Sigma x_i y_i - \Sigma x_i y_i}{n\Sigma x_i^2 - (\Sigma x_i)^2} \quad \ldots \quad (2)$$

$$\hat{\alpha} = \bar{y} - \hat{\beta}\bar{x} \quad \ldots \quad (3)$$

C. Test Hypotheses

The null and alternative hypotheses may be stated as follows:

$H_0 : \hat{\beta} = 0$ (No significant improvement)

$H_1 : \hat{\beta} \neq 0$ (There is significant improvement)

Test statistic can be gotten using the t-test, z-test or the f-test. However, we shall present the F-test in the research study.

The calculation is usually set out in Analysis of Variance (ANOVA) table as shown in Table 1

Table 2 - ANOVA Table for Regression

Variance	Degree of freedom	Sum of square	Mean square
Regression	1	RSS = $\beta\Sigma xy$	$RMS = \frac{RSS}{1}$
Error	n – 2	ESS = TSS – RSS	$EMS = \frac{ESS}{n-2}$
Total	n – 1	TSS = Σy^2	

The test statistic is given by

$$F_{cal} = \frac{RMS}{EMS} \quad \ldots \quad (4)$$

The F_{cal} is now compared with the F-value obtained from the F-table or F-tabulated with 1 and (n – 2) degree of freedom.

D. The Decision Rule

The decision rule is to reject H_0 if p-value is less than 0.05, otherwise, we accept H_0.

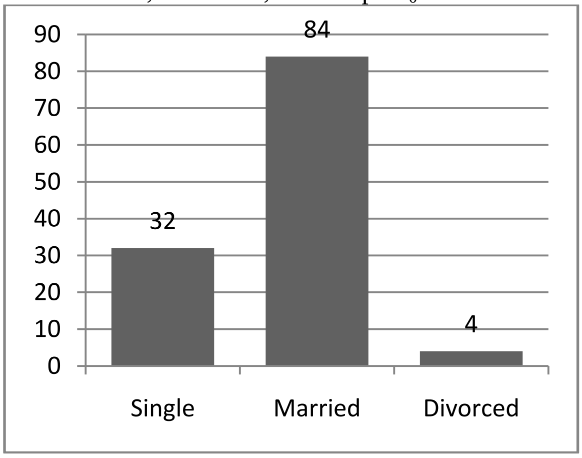

Fig. 1: Simple Bar Chart of Data Respondents on Marital Status

From figure 1 of marital status, it shows that the married respondents have highest frequency of 84 out of 120 while the divorced respondents have the least frequency of 4. The single respondents have a frequency of 32 out of 120 respondents.

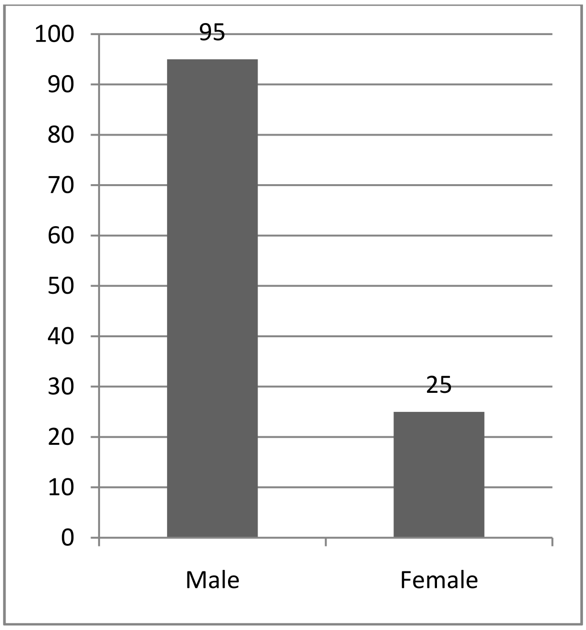

Fig. 2: Simple Bar Chart of on Sex Composition of Respondents

In figure 2, it shows that the male respondents have the modal frequency of 95 out of 120 while the female respondents have the lower frequency of 25 of them.

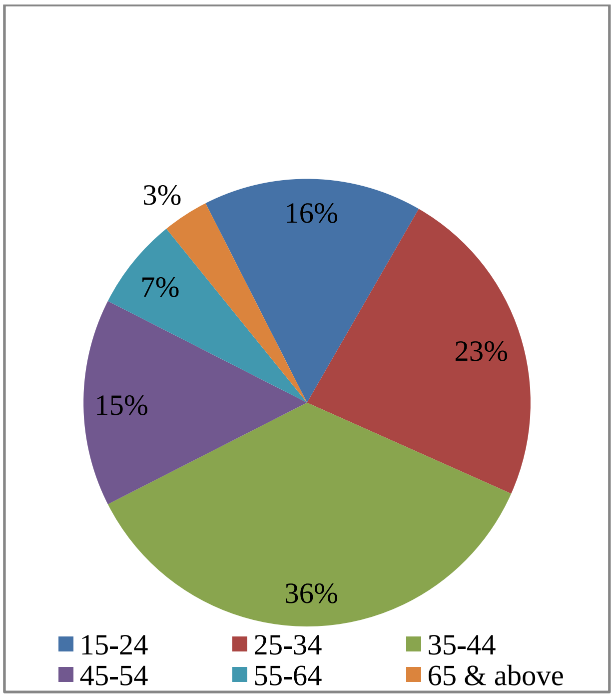

Fig. 3: Pie Chart of Data on the Ages of Respondents

From figure 3, it shows that the age groups of respondents are 15-24, 25-34, 35-44, 45-54, 55-64, and 65 & above, and they subtend angles at the centre of the circle with percentage to 16%, 23%, 36%, 15%, 7% and 3% respectively. Thus, this shows that the age class of 35-44 years has the highest frequency of 43.

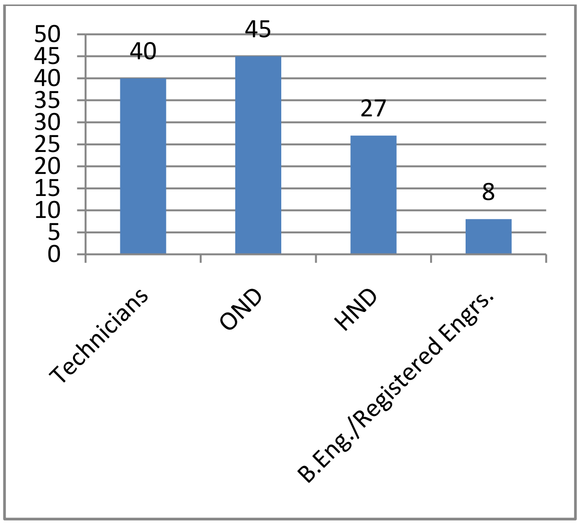

Fig. 4: Bar Chart of Data on the Highest Educational Qualification of Respondents Based on figure 4, it shows that 40 respondents have SSCE, 45 of them are OND/NCE holders, 27 of them are HND/B.Sc. holder while 8 of them are M.Sc. & others. This shows respondents with OND/NCE recorded the modal frequency of 45.

E. Test of Hypothesis

To achieve the objective, the null and alternative hypotheses are;

H_0: There is no significant improvement in the performance of electrical power supply in Nigeria.

H_1: There is significant improvement in the performance of electrical power supply in Nigeria

The SPSS output is displayed below;

F. Regression

Table 3 - Descriptive Statistics

	Mean	Std. Deviation	N
VAR00001	4.0125	1.37728	120
VAR00002	3.9438	1.56896	120

Table 4 - Correlations

		VAR00001	VAR00002
Pearson Correlation	VAR00001	1.000	.890
	VAR00002	.890	1.000
Sig. (1-tailed)	VAR00001	.	.000
	VAR00002	.000	.
N	VAR00001	120	120
	VAR00002	120	120

Table 5 - Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
1	VAR00002[a]	.	Enter

a. All requested variables entered.
b. Dependent variable: VAR00001

Table 6 - Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
				R Square Change	F Change	df1	df2	Sig. F Change
.890[a]	.793	.791	.62960	.793	451.466	1	118	.000

a. Predictors: (Constant), VAR00002

Table 7 - ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	178.957	1	178.957	451.466	.000[a]
	Residual	46.774	118	.396		
	Total	225.731	119			

a. Predictors: (constant), VAR00002
b. Dependent Variable: VAR00001

Table 8 - Coefficients

Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.

		B	Std. Error	Beta		
1	(Constant)	.930	.156		5.960	.000
	VAR00002	.782	.037	.890	21.248	.000
a. Dependent Variable: VAR00001						

Since the p-value is 0.000<0.05 (See SPSS output above) is less than the level of significance (0.05), we reject the null hypothesis and accept the alternative hypothesis. This implies that there is significant improvement in the performance of electrical power supply in Nigeria. The result further reviewed that there is a strong and positive improvement in the performance of electrical power supply since the slope (0.782) is positive and the coefficient of determination is 0.793.

REFERENCES

[1] Atmaca E, Basar HB. Evaluation of power plants in Turkey using analytic network process (ANP). Energy 2012; 44(1):555–63.

[2] Behjat V, Hamrahi M. Dynamic modeling and performance evaluation of axial flux PMSG based wind turbine system with MPPT control. Ain Shams Eng J 2014;5(4):1157–66.

[3] Berg S. Water utility benchmarking: measurement methodology and performance incentives. Int Water Assoc 2010.

[4] Box GEP, Jenkins GM, Reinsel GC. Time series analysis forecasting and control. USA: McGraw-Hill Inc.; 1994.

[5] Cerci Y. Performance evaluation of a single-flash geothermal power plant in Denizli, Turkey. Energy 2003; 28(1):27–35.

[6] Dunham J, Came PM. Improvements to the Ainley–Mathieson method of turbine performance prediction. J Eng Gas Turbines Power 1970;92(3):252–6.

[7] El-Samanoudy M, Ghorab AAE, Youssef ShZ. Effect of some design parameters on the performance of a Giromill vertical axis wind turbine. Ain Shams Eng J 2010;1(1):85–95.

[8] Fallahi A, Ebrahimi R, Ghaderi SF. Measuring efficiency and productivity change in power electric generation management companies by using data envelopment analysis: a case study. Energy 2011;36(11):6398–405.

[9] Fink DG, Beaty HW. Standard handbook for electrical engineers. 11th ed. New York: McGraw Hill; 1978.

[10] Howell J, Buckius R. Fundamentals of engineering thermodynamics. New York: McGraw-Hill; 1992. Holman Jack P. Thermodynamics. New York: McGraw-Hill; 1980.

[11] Igboanugo AC, Nwobi-Okoye CC. Transfer function modeling as a tool for solving manufacturing system dysfunction. In: Proceedings of NIIE 2011 conference; August 4–6, 2011. p. 22–32.

[12] Jha DK, Shrestha R. Measuring efficiency of hydropower plants in Nepal using data envelopment analysis. IEEE Trans Power Syst 2006; 21(4):1502–11.

[13] Jha DK, Yorino N, Zoka Y. A modified DEA model for benchmarking of hydropower plants. Power Tech, 2007 IEEE Lausanne; 1–5 July 1–5, 2007. p. 1374–9.

[14] Jones E.A (2003) contemporary Management, McGraw — Hill Press, New York

[15] Kacker SC, Okapuu U. A mean line prediction method for axial flow turbine efficiency. J Eng Gas Turbines Power 1982; 104(1):111–9.

[16] Kelejian HH, Oates WE. Introduction to econometrics: principles and applications. New York, USA: Harper and Row; 1989.

[17] Lai P. Transfer function modeling relationship between time series variables* Concepts and techniques in modern geography (**CATMOG**), No. 22. London School of Economics; 1979.

[18] Liu CH, Lin SJ, Lewis C. Evaluation of thermal power plant operational performance in Taiwan by data envelopment analysis. Energy Policy 2010;38(2):1049–58.

[19] Moustapha SH, Kacker SC, Tremblay B. An improved incidence losses prediction method for turbine airfoils. J Turbomach 1990; 112(2):267–76.

[20] Nixon JD, Dey PK, Ghosh SK, Davies PA. Evaluation of options for energy recovery from municipal solid waste in India using the hierarchical analytical network process. Energy 2013; 59(15):215–23.

[21] Nwobi-Okoye CC, Igboanugo AC. Performance evaluation of hydropower generation system using transfer function modeling. Int J Electr Power Energy Syst, Elsevier 2012;43(1):245–54.

[22] Okoye, C. C. N., and Igboanugo, A. C. (2015). Performance appraisal of gas based electric power generation system using transfer function modeling. Ain Shams Engineering Journal (2015) 6, 541–551.

[23] Okpara, G.C. (1998). Methods of Data Analysis for Researchers (A Statistical and Econometric Approach) Ebonyi: Willy Rose and Appleseed Publishing Company.

[24] Osgood, C.E., Suci, G.J. & Tannenbaum, P.H. (1957).The measurement of meaning. Urbana: University of Illinois Press.

[25] Oyedepo, S.O., Fagbenle, R.O. & Adefila, S.S. (2015). Assessment of performance in dices of select gas turbine power plants in Nigeria. Energy Science and Engineering 2015; 3(3); 239-256.