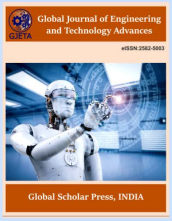
Global Journal of Engineering and Technology Advances
eISSN: 2582-5003
Cross Ref DOI: 10.30574/gjeta
Journal homepage: https://gjeta.com/



(RESEARCH ARTICLE)

Check for updates

Evaluation of a Nigerian power plant for sustainable delivery

Ayodele Salami Lawal [1], Buliaminu Kareem [2,*] and Olumide Omojugba [2]

[1] *Department of Mechanical Engineering, Ekiti State University, Ado-Ekiti, Nigeria.*
[2] *Department of Industrial and Production Engineering, Federal University of Technology, Akure, Nigeria,*

Global Journal of Engineering and Technology Advances, 2023, 15(03), 076–085

Publication history: Received on 24 April 2023; revised on 04 June 2023; accepted on 07 June 2023

Article DOI: https://doi.org/10.30574/gjeta.2023.15.3.0105

Abstract

The overwhelming objective of the electricity power policy strategy is to ensure that Nigerian has an electricity supply market that can meet the needs of its citizens. This paper evaluates challenges, prospects and performance of Olorunsogo Power Plant in Nigeria. Questionnaire was administered and oral interviews conducted among experts and staffers of the power plant. Responses on the challenges and prospects were analysed using descriptive statistics while performance was analysed using established thermal efficiency, overall efficiency and reliability models. Results generally showed that major challenge (60%) lied on the shortage of gases, and the power plant had highest sustainability prospects (60%). Performance results revealed that the average overall efficiency, thermal and reliability in the five-year span were 29.0%, 29.6% and 85.6% respectively. The outcomes were below the international best practices of 60%, 75% and 98%, respectively. Hence, continuing improvement in plant performance becomes necessary.

Keywords: Challenges; Prospects; Electricity; Supply; Performance Improvement

1 Introduction

Olorunsogo Power Plant is one of the leading electricity production plant in Nigeria. Olorunsogo Power Plant comprises of a gas power plant with 4 Gas Turbines units with an installed capacity of 500MW and 2 steam turbines. Heat recovery steam Generator (HRSG) was incorporated into the plant system to heat up water to generate steam to run additional 2 steam turbines with capacity 250MW together. This made Olorunsogo Power Generation unique and the leading power generation of the 10 power plant with installation capacity of 750MW.

The most common challenge in the transmission of power is the losses that occur during transmission and distribution [2, 3, 6, 17]. As more power is being distributed, more energy is being lost as a result of the grid resistance. Access to reliable and stable supply of electricity is a major challenge for both the urban and rural dwellers in Nigeria [20]. The challenge, however, is more significant in the rural areas where only about 10% of the population have access to electricity [8, 12, 21, 22]. An analysis of Nigeria's electricity supply prospects found that the electricity demand in Nigeria far outstrips the supply [16, 20]. The shortage in electricity supply hinders the country's development and not only restricts socio-economic activities to basic human needs; it adversely affects quality of life [7, 9,15, 20].

The National Electricity Power Authority was responsible for the administration of power production and distribution in Nigeria [5, 9, 11]. Subsequent Power Holding Company of Nigeria (PHCN) was introduced as a symbol of privatization of the sector [1, 3, 11, 14]. The deregulation of PHCN was to consist eighteen new companies, including 6 generators (GENCOs), 11 distributors (DISCOs), one transmission company (TRANSCOs) and semi-autonomous business units [2, 5, 11]. The liabilities of PHCN had been pooled together and to be managed by Nigerian Electricity Liability Management Company (NELMCO) [5, 11, 15].

*Corresponding author: Buliaminu Kareem, Email: bkareem@Futa.edu.ng

The specific objectives are to: identified the prospects of power generating plant; examine the challenges of the plant; and evaluate its performance. The research questions considered are: What are the challenges of the plant? What are the prospects of Olorunsogo power plant? Is the plant performance satisfactory? Answers to these questions are provided from the methodology adopted for addressing the stated objectives.

2 Material and methods

The primary sources of data were from questionnaire and face-to-face interview of the respondents. The secondary source of data gathering was from literature. Primary and secondary sources were chosen to enhance data collection.

2.1 Research population

The population of Olorunsogo Power Plant in Ogun State comprises three (3) formidable categories of workers in selected category which are 75 management staff, 100 senior staff, and 125 junior staff. The reason for the choice of the Olorunsogo Power Plant is because of availability of data required form the study.

2.2 Sampling and Sample Size

The total population is 300, however, 50% of the population with 150 respondents both male and female are randomly selected as sampling population. This is due to study time frame and busy schedule of top officers of the organization. Effort was made to ensure that those have adequate knowledge about the place and the information required was contacted.

2.3 Design of Questionnaire/Interviews

The purpose of using questionnaire and oral interview methods was to enable the collection of detailed and factual data related to organisation's challenges, prospects and performance.

2.4 Performance Evaluation

Performance and outage costs analyses were carried out on each plant unit. Several trips were made to the plant during which empirical data were collected from plant records from 2013 to 2017 prepared by the Efficiency Department of the utility [18]. Information on the following parameters was used in this work.

- Gross energy generated (GW h).
- Energy used in the plant (GW h).
- Energy sent out (GW h).
- Installed capacity (GW)
- Running hours (h).

Power plant performance measure depends on several indices and the three (3) most important are [1, 2, 10, 18];

- Thermal (and overall) efficiency.
- Reliability indices.
- Capacity of plant.

The plant performance indices used in this work are given as follow:

2.4.1 Plant Capacity (PC)/Overall Efficiency

This refers to both the total amount of power (GW) and energy (GWh) the plant is capable of producing, where the energy plant capacity (EPC) equals the power plant capacity (PPC) multiplied by the expected running hours (ERH).

$$EPC = PPC \times ERH \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

In 2016, Olorunsogo power plant/station generated only 164,454.10MWH of energy, down from the 918,691.97MWH it generated in 2013. This contributed to the worsening energy situation in Nigeria. As a result, a large number of consumers have resorted to self-generation of power in order to ensure an adequate and stable power supply [13]. Consequently, it was reported [21] that about 2.2 billion U.S. dollars was spent on fuelling generators with negative effect on the environment [7, 8, 19].

2.4.2 Thermal Efficiency

Gupta [6] defines thermal efficiency (TE) of a steam power plant as the ratio of the heat equivalent of mechanical energy (HE) transmitted to the turbine shaft to the heat of combustion (HC). It is generally as low as 30% [1].

That is TE = (HE/HC) x 100 %.....(2)

Volume of gas utilized for combustion is in m^3, or in standard cubic feet (MSCF). The net caloric value (CV) of the gas supplied by the Nigeria Gas Company (NGC) is usually between 34000 - 36000 kJ/m^3

2.4.3 Reliability

Reliability (R) is defined as the probability of a dangerous condition not occurring [4]. According to [10], a power plant should be able to supply electrical power at a minimum cost to the consumer. The suitable model to use in calculating the reliability (R) of the Olorunsogo plant is based on the ratio of difference between the

Expected Running Time (ERT) and the Down Time (DT) and the Expected Running Time (ERT):

R= (ERT-DT)/ERT .....(3)

The stated models (Eqns 1-3) were used for calculating the respective parameters from the operations data (2013-2017) obtained from the power plant (Table 1)

Table 1 Olorunsogo thermal power plant Operation Data

Year	**Installed capacity (MW)**	**Energy generated (MW)/MWH**	**Fuel gas consumed (SCF)**	**Net calorific value of gas (KJ/m³)**	**Expected running time (Hours)**	**Downtime (Hours)**
2013	690	(104.87) 918691.97	11092187076	34598.00	52560	7428.56
2014	690	(100.46) 879990.19	11166232994	34795.56	52560	7484.65
2015	690	(132.67) 1162150.98	13254651488	34827.46	52560	7075.72
2016	690	(18.77) 164454.1	2113300439	34871.28	52560	8521.66
2017	690	(6.61) 57912.02	837688314.8	34748.56	52560	3046.5

Source: Olorunsogo Thermal Power Station, [18].

In Table 1, figures in bracket are equivalent power generation in MW from MWH.

The data were then used to calculate the thermal and overall efficiencies for each year, 2013 for example, by using equation (2) is:

Overall efficiency

= 0.3051 x 100%

.'.Overall efficiency = 30.51%

Thermal efficiency, using equation (2) is worked out as= 31.13%

This is done similarly, for years 2014-2017.

The reliability status was calculated for each year, 2013 for example, by using equation (3).

Thus, for Year 2013

$$\text{Reliability, } R = 0.8587 \times 100\%$$

$$. \quad = \quad 85.87\%$$

This is similarly done for years 2014-2017

The calculated values of the reliability, thermal and overall efficiencies are summarized in Table 10.

3 Results and discussion

3.1 Presentation and Analysis of Personal Data of Respondents

The Table 2 shows 120 respondents with the percentage of 80% are males while 30 respondents with the percentage of 20% are females. This shows that majority of the respondents are males which indicates that both gender/sex have a fair representation in this research to express their views. As this research is not based on any particular gender but it has been generalized to give a more specific depiction on the prospect, challenges and performance of Olorunsogo as power generation company in Nigeria**.**

Table 2 Gender Distribution

Sex	**No of respondents**	**Percentage (%)**
Male	120	80
Female	30	20
Total	150	100

Table 3 shows the age distribution of our respondents as 28 respondents with 19% are within the age bracket of 18-35 years, 71 respondents with 47% are within the age of 36- 45 years. It also shows that 42 of the respondents with 28% are within the age range of 46-55 and 9 respondents, 6% are within the age range of 56- 65. The table also shows that workers within the age bracket of 36-45 are the largest in number which then means that most of the respondents are youth, matured and responsible. It can also be said that the majority of the workforce in Olorunsogo Power Plant are in their youthful age.

Table 3 Age Distribution of Respondents

Age	**No of respondents**	**Percentage (%)**
18-35	28	19
36-45	71	47
46-55	42	28
56-65	9	6
Total	150	100

From Table 4, Ninety Eight (98) of the respondent representing 65% of the respondent were married, 42 of the respondent representing 28% were single, while 10 respondents of 7% are separated/divorced. This means most of the workers in Olorunsogo Power Generation Plant are married and therefore likely to be responsible worker.

Table 4 Marital Status Distribution of the Respondents

Marital Status	No of respondents	Percentage (%)
Married	98	65
Single	42	28
Others	10	7
Total	150	100

This Table 5 shows that 13 respondents with 9% possess WASCE/SSCE certificates, 18respondents with 12% acquired OND/NCE certificates and 80 of them with 53% possessed HND/Bachelor Degree certificates respectively. PGD/Master's degree holders are11 with 20% while 19 of the respondents with 13% possessed other certificates. Here the majority of the workers of Olorunsogo Power Generation Plant are educated and likely to be competent and qualified for the job they perform. It was established that some of them are attaining higher studies, which can go a long way strengthen the plant.

Table 5 Educational Qualification of Respondents

Age	No of respondents	Percentage (%)
WAEC/SSCE	13	9
OND/NCE	18	12
HND/ Bachelor Degree	80	53
PGD/Masters	20	13
Others	19	13
Total	**150**	**100**

3.2 Data on Departmental Distribution of the Respondents

Table 6 shows that 53 of the respondent representing 35% of the respondent work in Mechanical Department, 30 of the respondent representing 20% work in the Electrical Department, 30 of the respondents representing 20 work in the Operation Department, also 20 respondents of 13% works in Instrumentation and control Department and 17 respondents of 11% works in the Job planning Department. This means all departments were covered in order to determine the prospect, challenges and performance of Olorunsogo Power Plant as power generation company in Nigeria.

Table 6 Departmental Distribution of the Respondents

Department	No of respondents	Percentage (%)
Mechanical	53	35
Electrical	30	20
Operation	30	20
Instrumentation & Control	20	13
Job Planning	17	11
Total	150	100

3.3 The Challenges of Olorunsogo Power Generating Plant

From Table 7 which is the Challenges of Olorunsogo as power generating plant, this was used to answer research question 2 that what the challenges of Olorunso Power plant in Nigeria?, this challenges ranges from policy somersault,

as 70 of the respondent representing 47% of the respondent confirm this, also we have challenges such as shortage of gas which hinder the thermal plant, this was strongly agreed to and supported by 90 of the respondent representing 60% of the respondent, when there is low gas, the productivity tends to low. Furthermore, from Table7, we have lack of exploration to tap sources of energy from the available resources which pose as one of the challenges of Olorunsogo Power generating plant, this was fully agreed to by 56 of the respondent representing 37% of the respondent. Table 3.6 confirms challenges of Olorunsogo power generating plant in the area of lack of Government proper funding; this was agreed to by 95 of the respondent representing 63% of the respondent. When there is no fund, productivity are low, this will then bring about poor electricity to the populace. The table also confirms challenges of outdated equipment or lack of modern equipment, this was ascertain and agreed to by 70 of the respondent representing 47% of the respondent. We also have challenges such as the following;

- Inadequate generation availability
- Inadequate and delayed maintenance of facilities
- Insufficient funding of power stations
- Obsolete equipment, tools, safety facilities and operational vehicles
- Inadequate and obsolete communication equipment
- Lack of exploration to tap all sources of energy from the available resources, and
- Low staff morale (Sambo, 2008).

Transmission Challenges are:

- It is funded solely by the Federal government whose resource allocation cannot adequately meet all the requirements;
- It is yet to cover many parts of the country
- Its current maximum electricity wheeling capacity is 4,000 MW which is awfully below the required national needs;
- Some sections of the grid are outdated with inadequate redundancies as opposed to the required mesh arrangement;
- The Federal government lack the required fund to regularly expands, updates, modernize and maintain the network;
- There is regular vandalization of the lines, associated with low level of surveillance and security on all electrical infrastructures;
- The technologies used generally deliver very poor voltage stability and profiles;
- There is a high prevalence of inadequate working tools and vehicles for operating and maintaining the network;
- There is a serious lack of required modern technologies for communication and monitoring;
- The transformers deployed are overloaded in most service areas;
- In adequate of spare-parts for urgent maintenance; and Poor technical staff recruitment, capacity building and training programme.

Other major challenges of Olorunsogo power plant are as follows: Generation Challenges (Gas supply difficulties, Evacuation capacity, Credibility of off-taker not proven); Transmission Challenges (Evacuation capacity, High transmission losses and overloaded transformers; Infrastructure limitations); and Distribution Challenges (Commercially viable tariff still lacking, High level of customer resistance to tariff hikes, Very few strong and financially viable distribution companies).

Table 7 The Challenges of Olorunsogo Power Generating Plant

S/N	VARIABLES	SA (%)	A (%)	U (%)	D (%)	SD (%)	REMARKS
6	Policy somersault are challenges that confronts the Olorunsogo Power Plant is Nigeria?	70 (47)	40 (27)	20 (13)	8 (5)	12 (8)	Strongly Agreed (SA)
7	Can shortage of gas hinders thermal plant of Olorunsogo Power Plant in Nigeria?	90 (60)	40 (27)	16 (11)	3 (2)	1 (1)	Strongly Agreed (SA)
8	Does lack of exploration to tap all sources of energy from the available resources can hinder the OlorunsogoPower Plant in Nigeria?	30 (20)	56 (37)	40 (26)	13 (9)	11 (7)	Agreed (A)
9	The Lack of Government proper funding can hinder the performance of Olorunsogo Power plant in Nigeria?	40(26)	95 (63)	10 (7)	2 (1)	3 (2)	Agreed (A)
10	The lack of required modern technologies for communication and monitoring in Olorunsogo Power Plant can hinder the growth of the plant?	59 (39)	70 (47)	10 (7)	5 (3)	6 (4)	Agreed (A)

SA, Strongly Agreed; A, Agreed; U, Undetermined; D, Disagreed; SD, Strongly Disagreed; (%), Percent Response

3.4 The Prospects of the Power plant

The responses to the questions on prospect of the plant are shown in Table 8. This was affirmed by 90 of the respondent representing 60% of the respondent that Olorunsogo Power Plant generation is 750MW which comprises four Gas turbines. Also from the table it was shown that some sections of the Olorunsogo Power Plant grid are outdated with inadequate redundancies as opposed to the required mesh arrangement, this was agreed to and supported by 70 of the respondent representing 47% of the respondents. The table also ascertains that the water quality affect the steam quality of the plant by agreeing of 56 of the respondent representing 37% of the respondent but was disagreed to by 13 of the respondent representing 9% of the respondent.

Table 8 The Prospects of Olorunsogo Power Plant

S/N	VARIABLES	SA (%)	A (%)	U (%)	D (%)	SD (%)	REMARKS
11	Olorunsogo Power Plant generation is 750MW which comprises of four Gas turbine	90 (60)	40 (27)	16 (11)	3 (2)	1 (1)	Strongly Agreed (SA)
12	Some sections of the Olorunsogo Power Plant grid are outdated with inadequate redundancies as opposed to the required mesh arrangement?	59 (39	70 (47)	10 (7)	5 (3)	6 (4)	Agreed (A)
13	Does the water quality affect the steam quality	30 (20)	56 (37)	40 (26)	13 (9)	11 (7)	Agreed (A)
14	Does distribution/transmission interface issues serves as one of the challenges of Olorunsogo Power Plant?	70 (47)	40 (27)	20 (13)	8 (5)	12 (8)	Strongly Agreed (SA)
15	Does gas pressure technically improve to meet up with gas turbine requirement?	19 (13)	72 (48)	30 (20)	20 (13)	9 (6)	Agreed (A) `
16	Does the downtime affect other power plant in Nigeria	70 (47)	40 (27)	20 (13)	8 (5)	12 (8)	Strongly Agreed(SA)

From Tables 9 and 10, the average overall efficiency, thermal efficiency and reliability (2013 - 2017) were 29.0%, 29.6%, and 85.6% respectively. it was a combined cycle power plant consisting of four gas turbines (GTs), four heat recovery system generators (HRSGs) and tow steam turbines (STs). This implies that the exhaust gas which is supposed to be a waste is channeled through the heat recovery steam generators to produce steam for steam turbine, thus increasing the overall power generation (Table 9).

Table 9 The Performance of Olorunsogo Power plant

S/N	Variables	SA	A	U	D	SD	Remarks
17	The advantage of heat recovery steam generator (HRSG) are over a conventional boiler?	70 (47)	20 (13)	19 (13)	40 (27)	1 (1)	Strongly Agree (SA)
18	Does Olorunsogo as power generating plant in its full capacity of 750MW can be evaluated to the National grid?	50 (33)	70 (47)	10 (7)	14 (9)	6 (4)	Agreed (A)
19	Do you agree that the performance of Olorunsogo Power Plant has increased over the year as expected?	70 (47)	40 (27)	20 (13)	8 (5)	12 (8)	Strongly Agree (SA)
20	Does the reliability performance, maintainability performance and maintenance supportability of the plant are of high ranking?	30 (20)	56 (37)	40 (26)	13 (9)	11 (7)	Agreed (A)
21	Man power training and development couple with increment of incentive can motivate the worker for greater productivity	19 (13)	72 (48)	30 (20)	20 (13)	9 (6)	Agreed (A)

Table 10 Olorunsogo power plant: Energy, efficiency and reliability profile

Year	Installed Capacity (MW)	Energy Generated (MW) & M W H	Fuel gas consumed (SCF)	Net Calorific Gad (KJ/m3)	Expected running Time (Hours)	Down Time (Hours)	Overall efficiency %	Thermal efficiency %	Reliability %
2013	6 9 0	(104.87) 918691.97	11092187076	34508.00	52560	7428.56	3 0.51	31.13	85.87
2014	6 9 0	(100.46) 879990.19	11166232994	34795.56	52560	7484.65	2 8.79	29.38	85.76
2015	6 9 0	(132.67) 1162150.98	13254651488	34827.46	52560	7075.72	3 2.01	32.66	86.54
2016	6 9 0	(18.77) 164454.1	2113300439	34871.28	52560	8521.66	2 8.37	28.95	83.79
2017	6 9 0	(6.61) 57912.02	837688314.8	34748.56	2 1600	3046.5	2 5.29	25.81	85.90
Total Average							2 9.0	2 9.6	8 5.6
International Best Practices							60	75	98

It could also be seen from Table 10 that there is a variation in both the thermal and overall efficiencies of the plant. The maximum overall efficiency of 32.01% occurred in the year 2015 as against the expected value of 40 - 45%.This implies that only 32.01% of the energy in fuel gas was converted to electrical energy and 67.99% was lost mainly as heat. This

agrees with Nag [10] that the rate of heat loss is inversely proportional to efficiency. In other words, it shows that the higher the heat loss, the lesser the efficiency. The minimum overall efficiency of 25.29% was recorded in 2017.

4 Conclusion

Energy is used inefficiently in most sectors, therefore the researcher has provides detailed analysis of the prospect of Olorunsogo as Power Generation Company inNigeriawith the aim of identifying and proposing energy efficiency measures in resolving the current and future challenges of the Nigerian energy sector. Olorunsogo power plant is one of the 22 thermal power plants operating in Nigeria. In 2016, it generated only 164,454.10MWH of energy in contrast to the high 918,691.97MWH generated in 2013. The values of reliabilities, thermal and overall efficiencies obtained over five-year study show that the plants performance has not been quite satisfactory. For instance, the average overall efficiency, thermal and reliability in the five-year span were 29.0%, 29.6% and 85.6% respectively. Compare these with the international best practices of 60% and above for overall efficiency, 75% and above for thermal efficiency and 98% and above for reliability.

From this study the following recommendations can be drawn:

- Thermal power plants such as Olorunsogo could be made to function much more efficiently if their operations are periodically evaluated or assessed. Such an assessment would generate useful data to serve as input for enhancing its future performance.
- The pipeline should be periodically inspected and routine maintenance intensified to avert sudden disruption of gas supply to the plant.
- The automated systems/components of the plant should be run in that mode as much as possible. Manual operation should not be encouraged.
- The source of gas to the plant is too far, leading to occasional low gas pressure. Thus, a booster gas station should be devised through the cooperation of both the Nigeria Gas Company and the operator/owner of the power plant.
- Training and re-training of technical staff should be emphasised in the face of fast technological changes all over the world.
- The authorities of the Olorunsogo power generating company should do well to improve on their record-keeping as there is always room for improvement.
- Olorusogo Power Generating Plant would be helpful to the populace if fed directly to industrial area in their location instead of congesting the National grid.

Compliance with ethical standards

Acknowledgments

We hereby acknowledge the management of the Olorunsogo power plant for releasing the information used in this study.

Disclosure of conflict of interest

There is no conflict of interest among the authors

Statement of informed consent

The management of Olorunsogo power plant consented to the release of information and data used in this study by giving adequate response to the questionnaire administered. Also, informed consent of all Authors of this paper was sought.

References

[1] Adegboyega G. A. and Odeyemi, K (2011), Performance Analysis of Thermal power Station: Case Study of Egbin Power Station, Nigeria. International Journal of Electrical and Electronic Engineering,

[2] Adeoye O. S. and Bamisaye, A. P. (2016), Perfrmance Evaluation and Analysis of Omotoso Power Plant in Nigeria. Innovative Energy & Research,Vol. 5, Issue 1.

[3] Anjali T. H. and Kalivarathan, G. (2015), Analysis of efficiency at a Thermal power plant. International Research Journal of Engineering and Technology,Vol. 2, Issue 5.

[4] Cooper W. F. (1989), Electricity Safety Engineering, Butterworths, London.

[5] FRN (2012), Investment Opportunities in the Nigerian Power Sector, Federal Republic of Nigeria.

[6] Gupta, J. B. (2004), A Course in Power System, Sanjeev Kumar Kataria Publishers, Delhi, India.

[7] Inglesi R. (2013), Aggregate Electricity Demand in South Africa: Conditional Forecasts to 2030, University of Pretoria, South Africa.

[8] Latham & Watkins (2011), Nigerian Power Sector Reforms: Opportunities and challenges for Investment, Client Alert No. 1144, Feb. 11.

[9] Manafa N.; Electricity Development in Nigeria, Rasheen Publisher, Lagos, 1995, pp.37-51.

[10] Nag P. K. (2011), Power Plant Engineering, Tata McGraw-Hill Pub. Co., New Delhi.

[11] NCC (2015), Grid System Operations, Annual Technical Report, National Control Centre, Osogbo, Nigeria.

[12] Nnaji B. (2011); Power sector outlook in Nigeria: Challenges, Constraints and Opportunities Vol.4, No. 2.

[13] Okoro O. I. and MaduemeT.C: "Solar Energy Investments in a Developing Economy", Renewable Energy, vol. 29, 2004, pp. 1599-1610.

[14] Okoye C. U. and Ali, N. A. (2010), Towards Efficient Electricity Generation. A Case Study of Nigeria's Electricity Facilities, Journal of Engineering Science, Vol. 2, No. 1, Pan African Book, Ghana.

[15] Okoye C. U. (2017), Analysis of Power Plant Capabilities in Nigeria's Electric Grid System for Energy Security, Paper presented at 12th University of Lagos Annual Research Conference and Fair, University of Lagos, Nigeria.

[16] Olayande J. S. and Rogo, A. T. (2008), Electricity Demand and Supply Projections for Nigeria, paper presented at the National Workshop on the participation of state governments in the power sector: matching supply with demand, Sheraton and Towers, Abuja, Nigeria.

[17] Oluseyi O. P. (2009): Conventional Energy Sources in Nigeria: A Statistical Approach. University of Nigeria, Nsukka, Polytechnic of Namibia, Windhoek, Namibia

[18] OPP (2021): Information from Olorunsogo Thermal Power Station, Nigeria, 2021

[19] Qader M. R. (2009), Electricity Consumption and G.H.C. Emissions in GCCC countries, Energies Vol. 2.

[20] Sambo A. S. (2008). Matching Electricity Supply with Demand in Nigeria. International Association for Energy Economics, Fourth Quarter 2008.

[21] The Punch (2014), Continued Deterioration in Electricity Supply, February 13, 2014

[22] Victor and Ismail, 2013; On the Issues, Challenges and Prospects of Electrical Power Sector in Nigeria.