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Evaluation Of Omotosho Gas Power Station Based on Best Industrial Practice

[1]Thomas Olabode Ale, [1]Olubunmi Emmanuel Akinboboye, [2]Tolulope David Makanju, [1]Matthew Olayinka Oyeleye

[1] Dept. of Electrical and Electronics Engineering, The Federal University of Technology Akure, Nigeria
[2] Dept of Electrical and Information Engineering, Achievers University Owo, Nigeria

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ABSTRACT

This study is solemnly concerned with the performance evaluation of the Omotosho gas Power plant over a period of four years. The station is made up of 8 units of 42MW Gas Turbine (GT) each. Data of necessary parameters such as average actual load, the install capacity of the station, hours of operation, energy generated, peak load, amount of gas consumed, the Net calorific value of gas, generator efficiency and available turbine unit was obtained and computed to measure the performance of the station between year 2014 to 2017. The results indicated that the average availability of the station varies from 45.02% to 89.18% which is against the recommended industrial practice of 95%. Also, the reliability of the station varies from 57.95% to 86.62% which is against the recommended 99.9% for best industrial practice. Likewise, the capacitor factor of the station varies from 16.29% to 49.98%, only the CF of 2016 which is 49.98% conform to the best industrial practice of 40-80% for the TP plant. Furthermore, the thermal efficiency of the station varies from 26.66% to 30.03% and the total efficiency varies from 26.66% to 29.43% which is against the recommended standard of 49% for thermal efficiency and 80% for overall efficiency. The findings revealed that the station performance is below the recommended standard, also this study gives an indices to evaluate gas power station in accordance with industrial practice. The findings of this research can be used to evaluate the performance of any gas station. This study, therefore, suggests that maintenance crew should maintain Omotosho power plant unit in accordance with the manufacturer's specifications in order to increase the reliability of the station.

Corresponding Author:

Thomas Olabode Ale

The Federal University of Technology Akure,
Nigeria.
Email: toale@futa.edu.ng

1. INTRODUCTION

It is necessary to known that electrical energy is a source for Nigeria's socioeconomic growth [1, 2]. The generation, transmission, distribution, and use of this energy are all parts of the power system. The conventional methods of generating electricity involve the use of electrical machines which employ prime movers like gasoline, diesel, steam, gas, or hydraulic turbines [3]. Almost 21% of electricity produced in the world comes from natural gas [4]. The high occurrence of natural gas in Nigeria makes gas power plant to have a high chance in Nigeria, being one of the highest producers of crude oil in the world and the largest producer in Africa [5-7]. The gas turbine plant which is the most common generating plant in Nigeria that is interconnected to the grid network has been faced with a lot of challenges such as inability to supply the expected energy output [8], this may be due to insufficient of gas supply and downtime of the power plant which has caused a lot of variation in supply of power to the consumer. A power plant is said to perform as expected if failure is not experienced during operation. However, according to best industrial practice for Thermal Power Plant, the reliability, availability, capacitor factor and thermal efficiency are 99.9%, 95%, 40-80% and 49% respectively [9]. This implies that any thermal or gas station that will perform based on best industrial practice should meet the above specification. The Combine cycle Gas turbine (CCGT) routes its exhaust gas across a heat exchanger that produces steam at varying pressure levels. CCGT performance is primarily concerned with assessing the plant's power efficiency. Heat inputs are the energy that must be purchased at high temperatures, and net energy production is the return on the energy that was purchased, therefore a plant's efficiency has a clear economic impact. GT produces low performance and worse efficiency when the turbine's input temperature is lower. Low out is created due to the GT's lesser efficiency. There are several factors that can affect the efficiency of GT which includes age, fuel type, capacity factor, and heat sink system [10]. The lower the capacity factor the lesser the efficiency. [11] developed a model to evaluate the reliability of a CCGT, the results of the model help to determine the most important components that help in selecting convenient strategies to increase the performance of CCGT power plants. [12] used historical data to evaluate the reliability, capacity factor and availability of a power generating plant. The findings show plant unavailability, the grid constraints, and gas restriction prevents power station from running at the rated capacity. However, it was suggested that in order to improve the station reliability there is a need for better maintenance, examination of the distribution and transmission networks and adequate gas supply. [13] reported that maintainability evaluation of steam and gas turbines components in a thermal power station is essential for high reliability of equipment which depends on prompt maintenance of equipment. However, there is decrease in reliability whenever the time between the first maintenance and sub-time of system maintenance becomes farther the reliability dropped from unity. [14] stated that the average thermal efficiency and average total efficiency of the omotosho power plant between the years 2008 and 2012 is 28.38% and 29.12% respectively, the low efficiency due to system failure and instability in technology.

[15] investigates the realiability and availiabilty of thermal gas power plant using realibility indices such as mean time to failure (MTTF), meantime to repair (MTTR), failure rate, mean time between failure (MTBF) and failure rate. The results of the finding indicated that the average availiability of the station varies from 0.9701 to 0.9767 while the reliability indices for varies from 0.9840 to 0.9880. [16] evaluates the reliability study of Sunkoshi Hydro Power Station, Nepal with an installed capacity of 10.05 Megawatts (MW). The operational data for 4 years was collected and analyzed using Markov model. The state probabilitty of the turbine is 0.001932. Several Studies has been carried out on the gas turbine performance in Nigeria, but not in comparisim to best industrial practice. Therefore, a thermal plant with poor maintainability tends to be less reliable. Also, since evaluation tends to help in short- and long-term planning and decision making in term of station performance and due to unreliable electricity supply in Nigeria, it is therefore necessary to examines the performance

of one of the largest Gas thermal Plant in Southern Part of Nigeria in accordance with recommended best industrial practice. This study examines the performance of Omotosho Gas thermal station in Southern Part of Nigeria in accordance with recommended best industrial practice.

2. RESEARCH METHOD

Data of necessary parameters such as average actual load, the install capacity of the station, hours of operation, energy generated, peak load, amount of gas consumed, Net calorific value of gas, generator efficiency and available turbine unit was computed to measure the performance of the station over the years of studied against the best industrial practice of gas thermal station.
The average load was computed using equation (1)

$$L_A = \frac{E_T}{\mathrm{H}_N} \quad (1)$$

where the E_T and HN are the total energy generated and Numbers of hours of operation respectively. The load factors was computed using equation 2.

$$L_F = \frac{L_A}{L_p} \quad (2)$$

Where L_A and Lp are average load and peak load respectively.
Also, the capacity factor is computed using equation (3)

$$\mathrm{C_F} = \frac{L_A}{I_C} \quad (3)$$

Ic is the net installed capacity.

Likewise, the availability factor was computed using Equation (4)

$$\mathrm{A}_F = \frac{\mathrm{Hn}}{HT} \times 100 \quad (4)$$

The overall efficiency was computed using equation (5)

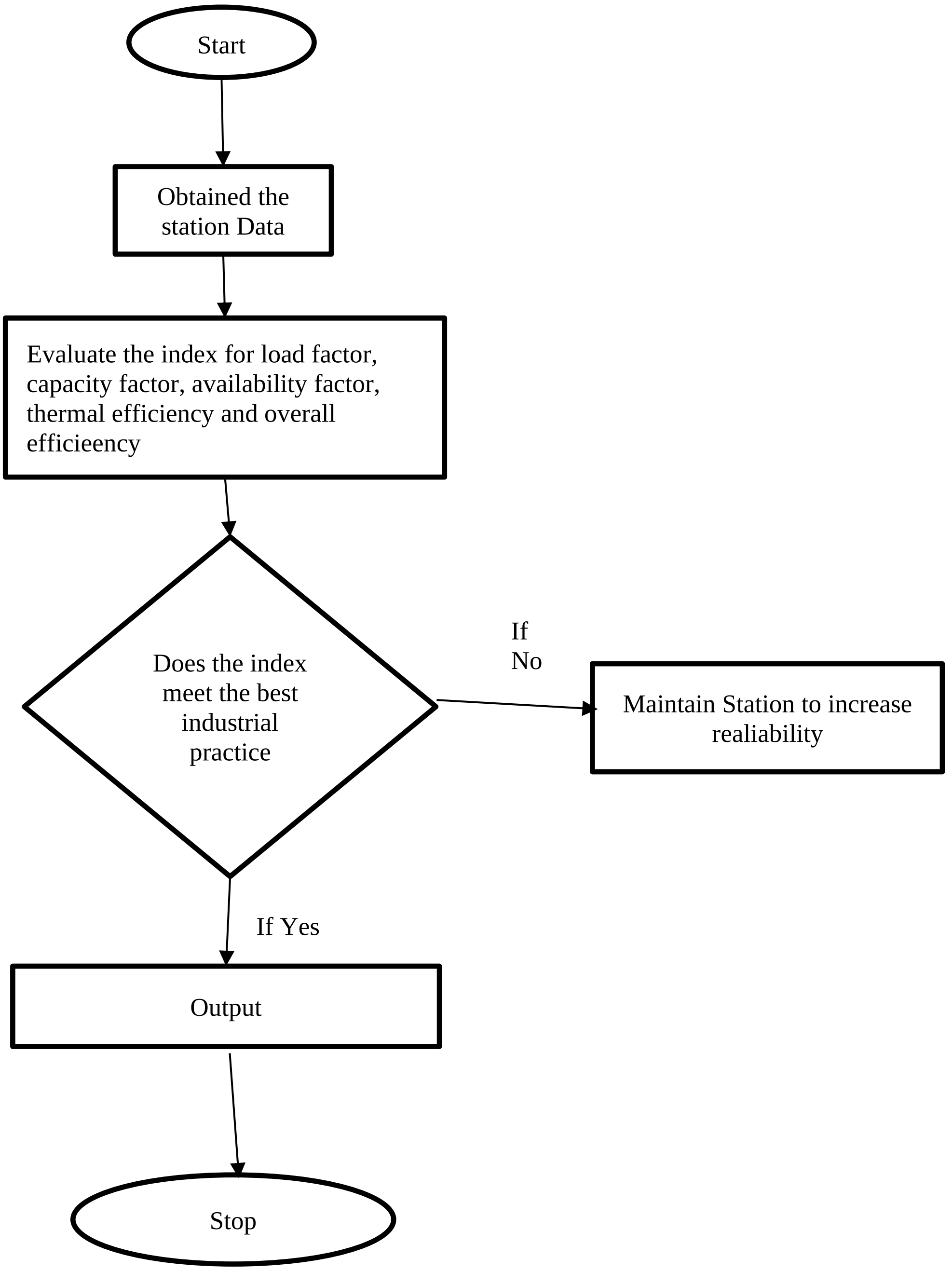
$$\eta_o = \frac{(Eg\ (MWH) \times 1000 \times 3600)kJ}{\left(\frac{Gas\ consumed \times 10^6}{35.3147}\right)m^3 \times net\ CV\left(\frac{kJ}{M^3}\right)} \times 100 \quad (5)$$

The thermal Efficiency is computed in equation 6

$$\eta_o = \frac{Overall\ Efficiency}{0.98} \quad (6)$$

Also, the percentage contribution to the unit is computed using equation 7.

$$PC = \frac{\text{total energy generated by each units}}{\text{total energy generated in the station}} \quad (7)$$



3. RESULTS AND DISCUSSIONS

Availability Factor

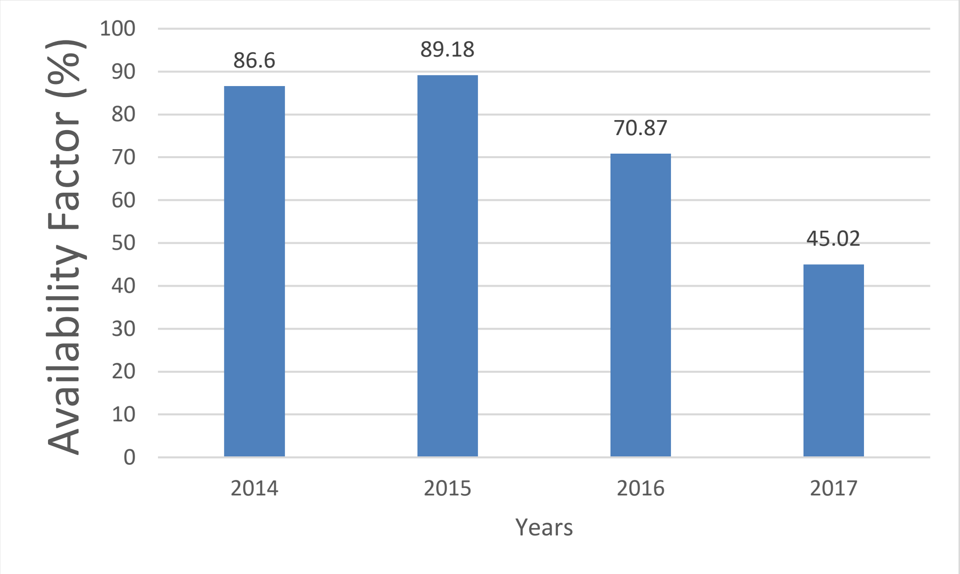


Figure 1: Availability Factor of the Station

In Figure 1, the availability of the power plant varies from 45.02% to 86.6% between the years of studies, this implies that the TPP does not meet best industry practice of 95% as recommended by international standard. The deviation of the availability factor of the TP Plant form the international standard may be due to shortage of gas supply and equipment malfunctioning of the plant. This implies that the power station is not performing upto expectation.

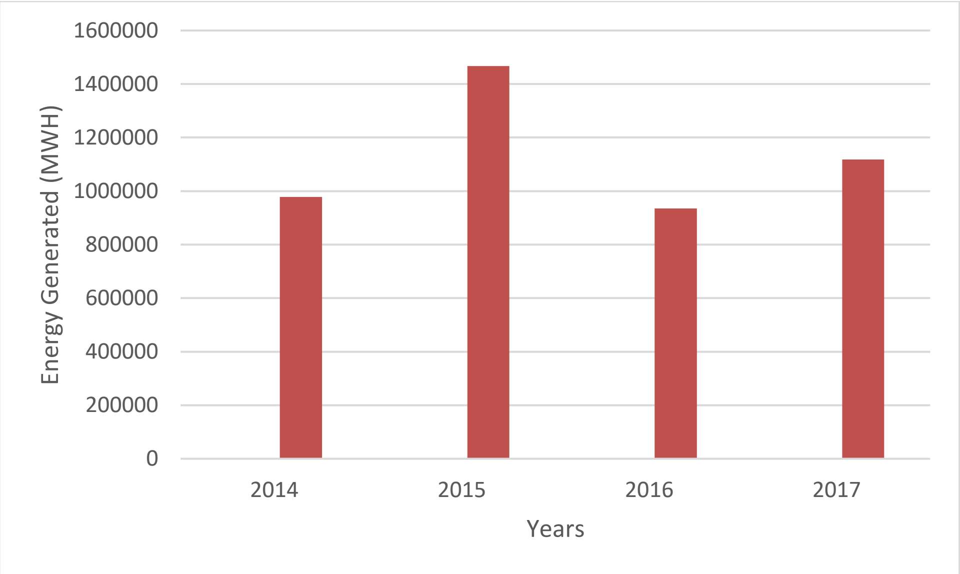


Figure 2: Energy Generated

The results presented in Figure 2, shows the total energy generated throughout 2014 was **978,644.8MWH**, six (6) units ran in the year under review, GT6 ran most with total hours of **7586hrs** out of 8760hou**s** and was able to generate **258,257MWH** which is **26.39%** of the total energy generated. The least ran unit was GT3 with 2,969hrs was able to generate up to **103865MWH** which is 10.61% of the total energy. GT8 has the lowest output with **74296MWH.** This implies that the station is not supply the deisgned capacity of energy expected due to the downtime experience for some of the units in the station. In order to ensure that the station supply the designed capacity of the power the maintenance should ensure that there is no or little downtime.

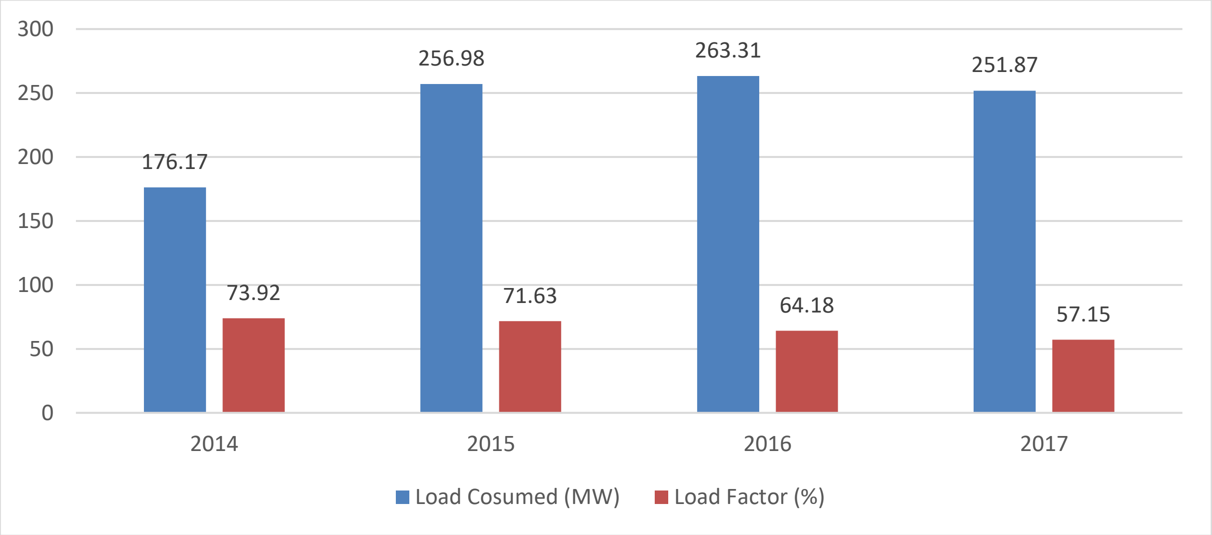


Figure 3: Load Consumed and Load Factor

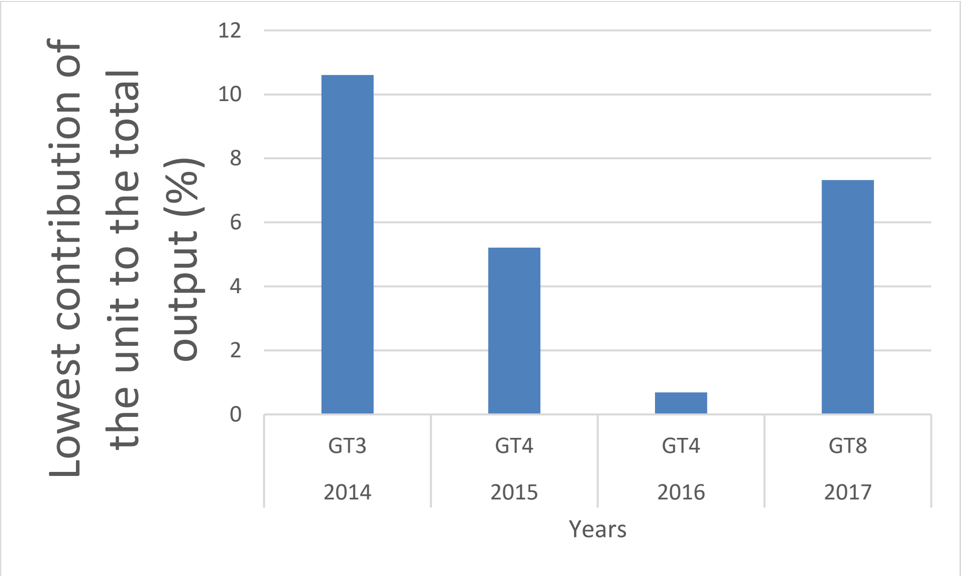


Figure 4: Lowest contribution of the Unit per Year

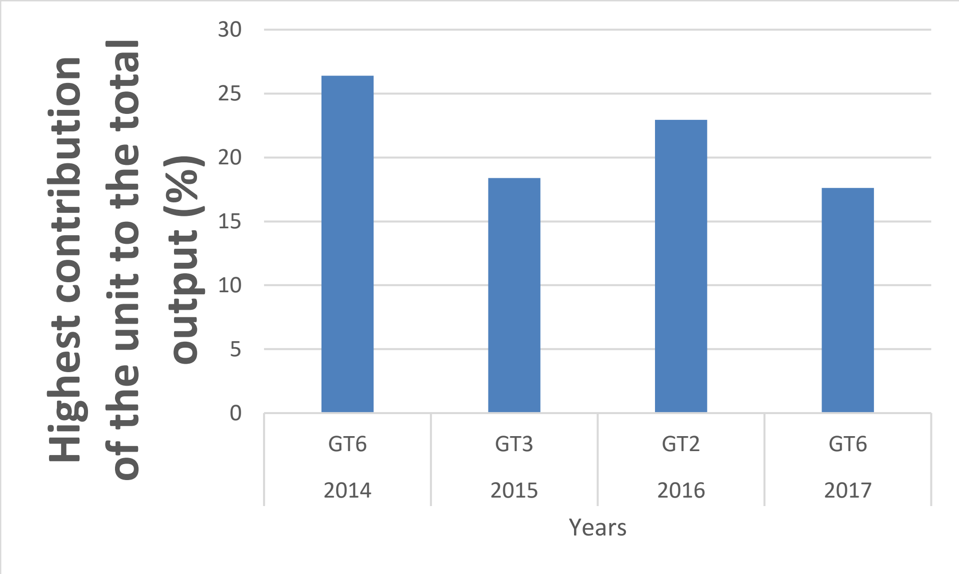


Figure 5: Highest contribution of the Unit per Year

Figure 3, shows that the station performance slightly above average in year 2014 having an average reliability of **176.17MW** which is **57.95%** of the station capability of **304MW** which is as a result of changing of change in technical staff and improper handing over of documents which is needed for operation.

The station performance in 2015 was more encouraging having an average reliability of **256.98MW** which is **84.53%** of the station capability of **304MW**.This achievement was attributed to first-class leadership and workers enthusiasm to work.

The station performance in 2016 was great having an average reliability of **263.31MW** which is **86.62%** of the station capability of **304MW**.This was achieved as a result of training the technical staff, employment of more staff and proper monitoring of the plants.

The station performance in 2017 decreases having average load of **251.87MW** which is **82.85%** of the station capability and this was as a result of malfunctioning of GT8 and instability of national grid.

Also, Figure 4 , shows the GT3, GT4, GT4 and GT8 are the turbine that contributed low to the station. Likewise, Figure 5, shows the GT that has high contribution to the yearly station performance. The results indicated that GT6, made the highest contributin for year 2014 and 2017, while GT2 and GT3 made the highest contribution for year 2016 and 2015 repectively.

Capacity Factor

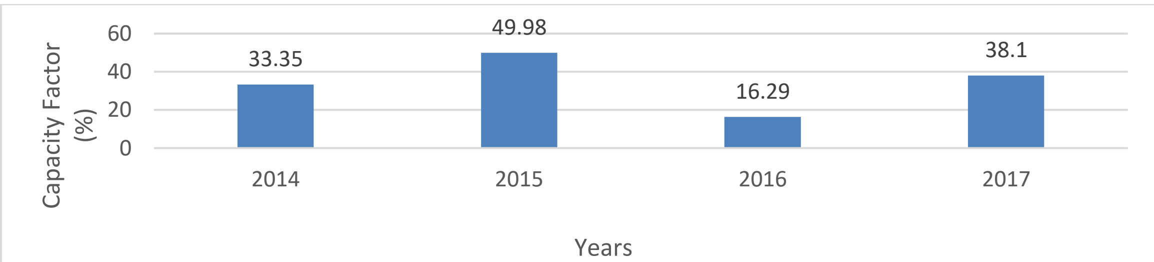


Figure 6: Capacity Factor

Figure 6, the capacitor factor of the station varies from 16.29% to 49.98% under the year of study. The capacitor factor for year 2014 (33.35%), 2016(16.29%) and 2017(38.1%) were not in conformity with the best industrial practice of 40-80% for TP plant. However, in year 2016 the station capacity factor 49.98% is within the best industrial best practice.

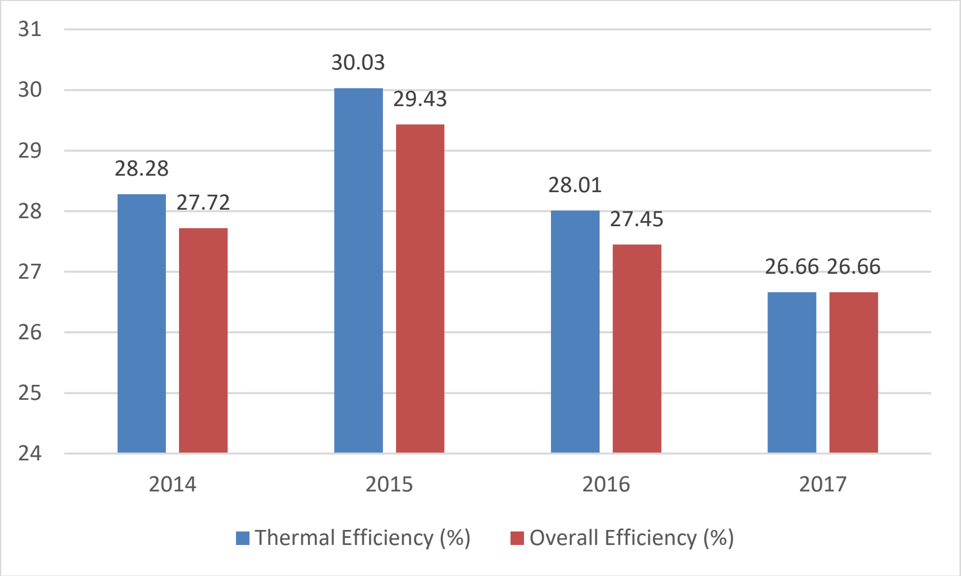


Figure 7: Thermal Efficiency and Overall Efficiency

The thermal efficiency of the station varies from 26.66% to 30.03% which is against the recommended standard of 49% for best industrial practice for TP plant. Also the total efficiency of the TP plant under the year of study varies from 26.66% to 29.43%. This implies that the efficiency of the station is low compared to standard recommendation of 80% for TP Plant. This suggests that the TP plant for the year under study is below the expected out.

4. CONCLUSION

Generation of electricity is most sensitive section in power system which must be critically scrutinize for availability, sustainability, reliability and efficiency of the system in the country which have a great effect on the economic growth, as a result of this, a concise performance test has to be considered on Omotosho Gas Power plant. The findings of the study shows that the station performance in term of availability, reliability, capacitor factor and efficiency is low compared to recommended industrial practices. sAlso, this study gives an indcies to evaluate gas power station in accordance to industrial practice. The findings of this research can be used to evaluate the performance of any gas station.

This study therefore suggests that Plant equipment should be overhauled as at when due, failed plant equipment should be rehabilitated and restored to operation as timely as possible, maintenance crew should maintain the plant unit in accordance to the manufacturer's specifications in order to increase the reliability of the station.

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