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# Nigerian Commercial Energy Demand Estimate Using Time-Series Model (A Panacea to Foster Rapid Growth and Development)

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**ABSTRACT:** *Economic growth and development of any nation is unarguably reliant on the supply of adequate, affordable and reliable electric power. Nigeria is yet to attained a meaning level of development in both infrastructure and economy. For the nation to achieved the desired growth in terms of development and grow her commercial sector thereby improving the GDP of the nation, the electric power demand needs and supply of the country must be holistically meet. The devastating effect of lack of sufficient power to commercial centers has been on the increase over the years. The negative impact has been estimated in various forms, such as failure to thrive and total collapse of commercial centers as well as loss of revenue which has negative impact on return on investment. Most of these commercial centers usually rely more on (off-grid) supply rather than connecting to the national grid. This alternative source of energy and technology has a direct negative impact on the cost of the daily functionality in terms of production and services of those centers especially with the ever increasing cost of fuel and diesel. With the increase in population, energy demand is on the increase over the years. The aim of this research paper is to forecast the actual electric energy demand for commercial centers of the power sector using time-series model. Its outcome reveals that Nigerians needs approximately about 20,000MW of power to efficiently supply here commercial sector for optimum productivity and maximum results on or before 2030.*

**KEYWORDS***:* electric power generation & consumption, energy demand modeling, commercialization in Nigeria, time-series analysis and electric energy demand estimate

## INTRODUCTION

One of the core mandate of the Power Holding Company of Nigeria was to coordinate the generation, transmission and distribution of electric power energy [1]. The estimation of energy demand in Nigeria must be carried out during the power system design process. This is to ensure that future expansion framework is feasible. Also to ensure that system failure rate is drastically reduced. The electric power energy estimate adopted is the time series analysis.

The study is important in order to estimate the exact quantity of power needed by Nigerians to overcome the perennial challenge of inadequate supply thereby plan for future network expansion, increase supply, avoid transmission and distribution system collapse and reduce power outages to minimum with special emphasis on the commercial areas of the power sector. Energy is essential for all human activities and, indeed is critical to social and economic development [2] [1].

The major aim of this research study is to appropriately analysis the amount of electric power energy is needed in Nigeria need to efficiently, affordably supply the commercial centers; and also understand the various factors that determine commercial energy demand. With the following objectives;

•Is to investigate the dynamics of electric energy demand over the years in Nigeria

• Is to identify the various effects of these factors on commercial energy demand

• Also to Forecast the kilo-watt (KW) of energy Nigeria needed to supply to its industries with utmost reliability that will in turn boost the annual gross-domestic product (GDP) of the comm1ercial centers in the country thereby making the economy grow at a very fast pace.

The signing of the power sector reform bill in 2004 was to allow private participation in the energy sector. By this reform act, it is expected that greater achievement in power sector that will in turn have positive impact in the economy is expected. Figure 2 reveals the electricity consumption data from 1970 and 2004.

It is also observed from the table below, that the amount of energy used for Commercial purposes has been on the decline since 1970 whereas that of residential consumption has been on the increase. This goes on shows the inefficient power supply that has forced many of the big commercial centers or hubs such as government owned as well as Privates Hospitals/Health Care Facilities, Higher Educational Institutions/Schools, Tourism/Recreational Centers, Government Agencies/MDAs and Markets etc. shot-down or operate below its capacity. Thus causing some of these commercial centers to generating their own power and using less power from the national grid. Consequently, most of these commercial centers out of frustration were forced to fold up as they could no longer bear the burden of high cost of generating their electric power energy used for the day to day functionality of those centers.

## REVIEW OF ELECTRIC ENERGY GENERATION AND DISTRIBUTION IN NIGERIA

Major economies of the world are relied upon electric energy. In Nigeria electricity is used for a number of purposes such as industrial, commercial and residential purposes. As at today the expansion framework in electricity supply in Nigeria has covered all the states of the federation although some villages and remotes arears areas are yet to be connected to the national grid [1]

On the other hand, in terms of distribution; TCN grid network has a total estimated wheeling capacity of about 7,500MW across over 20,000km transmission lines. Although the transmission system footprint does not cover every area of Nigeria [2].

It is sad, that after so many years of privatization, the national grid network is yet to be extended to reach many remote or interior areas largely due to various challenges being faced by the sector. Therefore, in other to proffer solution to the problem of epileptic power supply to Industrial areas in Nigeria and to increase the socio-economic development of the nation by carrying out proper planning towards determining the energy demand and supply forecast to industries in Nigeria is the motivation for this research paper.

*A. Energy Demand Modeling*

The estimate of electric power has so many methods, for instance [10] [7] uses input – output models to estimate. The econometric approach, the Non-Stationary, the Co-Integration Technique [11] [12], the Multivariate Co-Integration System (Johansen Approach) [13], and the Structural Time-Series Model (STSM) [14] [15] [16] [25] [26] [27] [28] [29].

*B Commercial Sector Development in Nigeria and the Challenges*

The major cause of economic challenges in Nigeria can be traced to lack of adequate, reliable and efficient power supply. This singular problem has a direct bearing or connection to the many problems being witnessed today ranging from lack of infrastructure, low GDP, Inflation, poverty and insecurity etc. The diversification of the Nigerian economy is sacrosanct in order to reduce the over dependence on the oil as the only source of her economic stake. This can only be achieved when the energy demand of the country's commercial and industrial sector is ascertained and as well provided.

*C. Effects of Inadequate Electricity Supply on Commercial Sector in Nigeria*:

Inadequate power supply and infrastructural development in Nigeria has greatly hindered the growth and development of Nigeria. The dilapidated infrastructure, to lack of basic social amenities has further impacted negatively on the GDP of the economy. The Nigeria power sector has been trying to survive over the years but due to some systemic challenges, such as inadequate power supply, high cost of fuel and low returns on investments. The nations have a huge tourism prospect that needs to be given adequate attention and explore, but high cost of operating these facilities which is majorly on the electric power generation using the fuel/gas turbines to generate power outside the national grid contributes to the many problems that most SMEs in the commercial sector are confronted with daily.

## METHODOLOGY

Having reviewed enough of literature in this work and many authors wrote and presented their findings, it is expected that this issue should have been laid to rest. But, because of technology advancement, efficient computation software, improved industrial revolution in automation, research in this area becomes endless. Therefore, the approach and methodology to this work will be Time series [1]. Time-series analysis has been a notable and an outstanding model for energy demand forecast in recent times. It's used when little is known about the underlying process one is trying to forecast. Also when

appropriately deployed, reveals more clearly the underlying trends especially in energy demand forecasting.

The research method used in analyzing the commercial energy demand forecast in Nigeria, is time series. In order to carry on with the analysis, they are fundamental knowledge or understanding we need in order to derive the model to a logical conclusion.

*A. What is Time-Series Analysis*

Time-series analysis may be defined as a statistical method of seeing into the future. Its deals with the statistical technique of analyzing past data and projecting them to obtain estimates of future values. In its simplest form, we can therefore define it as series of observation recorded over a period of time. The uses of time series in energy forecasting can never be over emphasized as it helps to predict or forecast the behavior of a variable in future and it helps in the analysis of past behavior of a variable [1].

Basically, the understanding load demand pattern in Nigeria can be categorized into three; the daily load demand, weekly load demand and the annual load demand. The daily load demand pattern in Nigeria is divided into off-peak and peak periods, [28]. For this paper, the least square method of the time series will be used in the analysis of our data.

*B. The Least Square Method*

The least square method is being used to fits in the trend line to a time series. It is the most widely used method of finding the trend. Since the most reliable method over the years in fitting trend line to a time series is the least square method, then it's become the best tool to generate the graph for our model. $Yt=a+bt$ …… (3.3)

$Yt$= the estimated trend value for a given time period t,

a = the trend line value when t = 0,

b = the gradient or slope of the trend line, i.e. the change in $Yt$ per unit time, t = the time limit.

The estimates of the parameters of the trend equation are _a 'and _b'

$at+b\sum t=\sum$ ..... (3.4)

And

$a\sum t+b\sum t^2=\sum ty$ ..... (3.5)

Where; t =number of years under consideration. It can also be obtained from the values of _a'and _b 'by minimizing the sum of squares of error. Formula for the parameter estimates are;

$$a=\frac{\sum y}{n}-\frac{b\sum t}{n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.6)$$

$$b\frac{n\sum ty-\sum t\sum y}{n\sum t^2-(\sum t)^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.7)$$

**Where**;

t =the time period Eg. a year
y = value of the item measured against time
a = the Y-intercept and
b = the coefficient of t indicating slope of the trend.

## IV. DATA COLLECTION AND DISCUSSION

In the process of this research, data of electrical energy consumption in Nigeria from 2000 – 2017 broken down into three categories, residential, commercial and industrial was utilized. It was sourced from The National Bureau of Statistics and the Central Bank Statistical Bulletin. This table of values forms the basis for the estimation/forecasting of energy demand in Nigeria.

TABLE I:
ENERGY CONSUMPTION DATA (MW)

| | **Energy Consumption (mw)** | | | |
|---|---|---|---|---|
| **Year** | **Industrial** | **Commercial** | **Residential** | **Total** |
| 2000 | 1011.60 | 2346.00 | 4608.40 | 8688.90 |
| 2001 | 1987.20 | 2439.00 | 7714.80 | 9034.40 |
| 2002 | 1830.00 | 3297.60 | 7668.50 | 12842.40 |
| 2003 | 1659.80 | 3583.00 | 7668.50 | 12866.60 |
| 2004 | 1605.00 | 3830.30 | 7725.30 | 13160.60 |
| 2005 | 1615.50 | 3851.00 | 7760.00 | 13226.60 |
| 2006 | 1575.00 | 3900.80 | 7650.00 | 13125.80 |
| 2007 | 1530.50 | 3915.00 | 7860.30 | 13305.80 |
| 2008 | 1502.50 | 3852.00 | 7910.08 | 13264.55 |
| 2009 | 1585.00 | 3865.50 | 8075.00 | 13525.50 |
| 2010 | 1589.40 | 3925.80 | 8205.20 | 13720.40 |
| 2011 | 1615.50 | 4004.70 | 8285.60 | 13905.80 |
| 2012 | 1648.00 | 4025.40 | 8350.00 | 14023.40 |
| 2013 | 1615.08 | 4424.78 | 8773.13 | 14812.99 |

| | | | | |
|---|---|---|---|---|
| 2014 | 1617.73 | 4542.21 | 8933.23 | 15093.17 |
| 2015 | 1620.38 | 4659.64 | 9093.33 | 15373.35 |
| 2016 | 1620.03 | 4777.07 | 9253.43 | 15650.53 |
| 2017 | 1625.68 | 4894.50 | 9413.53 | 15933.71 |

From table 1.0 above, it shows the energy consumption rates in Nigeria from year 2000-2017. It comprises of five vertical sections and the first vertical section represents the number of years in view. The second, third, fourth and fifth vertical sections represent the industrial, commercial, and residential energy consumption data as well as the total. Since the raw data has been given we will substitute these values into our linear trend equation from equation (3) and then calculate statistically in a table. See table 2.0

Remember that our emphasis here is on industrial energy demand forecast.

From equation (3), $Yt=a+bt$

Where; $a = \frac{\sum y}{n} - \frac{b\sum t}{n} and b \frac{n\sum ty - \sum t \sum y}{n\sum t^2 - (\sum t)^2}$

At t = 0 = gradient of the trend line/

## RESULTS AND DISCUSSION

The analysis of the industrial energy demand forecast is being presented using the table below.

*A. Commercial Demand*

TABLE II
VALUES FOR COMMERCIAL DEMAND

| **Year** | **T** | **Commercial Energy Demand (MW) y** | **Ty** | **$t^2$** |
|---|---|---|---|---|
| 2000 | -6 | 2346.00 | -14076.00 | 36 |
| 2001 | -5 | 2439.00 | -12195.00 | 25 |
| 2002 | -4 | 3297.60 | -13190.40 | 16 |
| 2003 | -3 | 3583.00 | -10749.00 | 9 |
| 2004 | -2 | 3830.30 | -7660.60 | 4 |
| 2005 | -1 | 3851.00 | -3851.00 | 1 |
| 2006 | 0 | 3900.80 | 0.00 | 0 |
| 2007 | 1 | 3915.00 | 3915.00 | 1 |
| 2008 | 2 | 3852.00 | 7704.00 | 4 |
| 2009 | 3 | 3865.50 | 11596.50 | 9 |
| 2010 | 4 | 3925.80 | 15703.20 | 16 |
| 2011 | 5 | 4004.70 | 20023.50 | 25 |
| 2012 | 6 | 4025.40 | 24152.40 | 36 |
| Total | 0 | 46836.10 | 21372.60 | 182 |

The calculation of the gradient of the trend line is done using the formula $b=nty- tynt2-( t)2=117.43$ The Trend line value when t = 0: is $a= yn-btn=3602.77$ Trend equation $Y=a+bt=3602.77+117.43t$

Therefore, the trend values from the above equation gives rise to the actual commercial demand and is given in the table below:

TABLE III
VALUES OF ACTUAL COMMERCIAL LOAD DEMAND

| Year | Commercial Demand y (MW) | Trend Value Y (MW) |
|---|---|---|
| 2000 | 2346.00 | 2898.19 |
| 2001 | 2439.00 | 3015.62 |
| 2002 | 3297.60 | 3133.05 |
| 2003 | 3583.00 | 3250.48 |
| 2004 | 3830.30 | 3367.91 |
| 2005 | 3851.00 | 3485.34 |
| 2006 | 3900.80 | 3602.77 |
| 2007 | 3915.00 | 3720.20 |
| 2008 | 3852.00 | 3837.63 |
| 2009 | 3865.50 | 3955.06 |
| 2010 | 3925.80 | 4972.49 |
| 2011 | 4004.70 | 4189.92 |
| 2012 | 4025.40 | 4307.35 |
| Total | 46836.10 | 46836.01 |

*Note;*

*1). Calculating the Accuracy of Commercial Forecast*

The Mean Absolute Deviation MAD= Actual−Forecast N=6.92∗10−3MW

*2). Predicted Commercial Demand*

The trend line value (117.43MW) will be used to forecast the load demand up to 2030 by adding it to the preceding load to get the load for the next year as shown below.

TABLE IV
TABLE OF COMMERCIAL LOAD DEMAND FORECASTED

| Year | Commercial Demand Forecast (MW) |
|---|---|
| 2018 | 5011.93 |
| 2019 | 5129.36 |
| 2020 | 5246.79 |
| 2021 | 5364.22 |
| 2022 | 5481.65 |
| 2023 | 5599.08 |
| 2024 | 5716.51 |
| 2025 | 5833.94 |
| 2026 | 5951.37 |
| 2027 | 6068.80 |
| 2028 | 6186.23 |
| 2029 | 6303.66 |
| 2030 | 6421.09 |

*B. Total Predicted Demand*

The summation of the various load demand forecast i.e Residential, Commercial and Industrial.

TABLE V
TOTAL PREDICTED LOAD DEMAND

| Year | Predicted Load Demand(MW) |
|---|---|
| 2018 | 16213.89 |
| 2019 | 16494.07 |
| 2020 | 16774.25 |
| 2021 | 17054.43 |
| 2022 | 17334.61 |
| 2023 | 17614.79 |
| 2024 | 17894.97 |
| 2025 | 18175.15 |
| 2026 | 18455.33 |
| 2027 | 18735.51 |
| 2028 | 19015.69 |
| 2029 | 19295.87 |
| 2030 | 19576.05 |

*VI. SYSTEM IMPLEMENTATION*

The simulated results for our analysis using the estimated values in the tables are shown in the following graphs below.

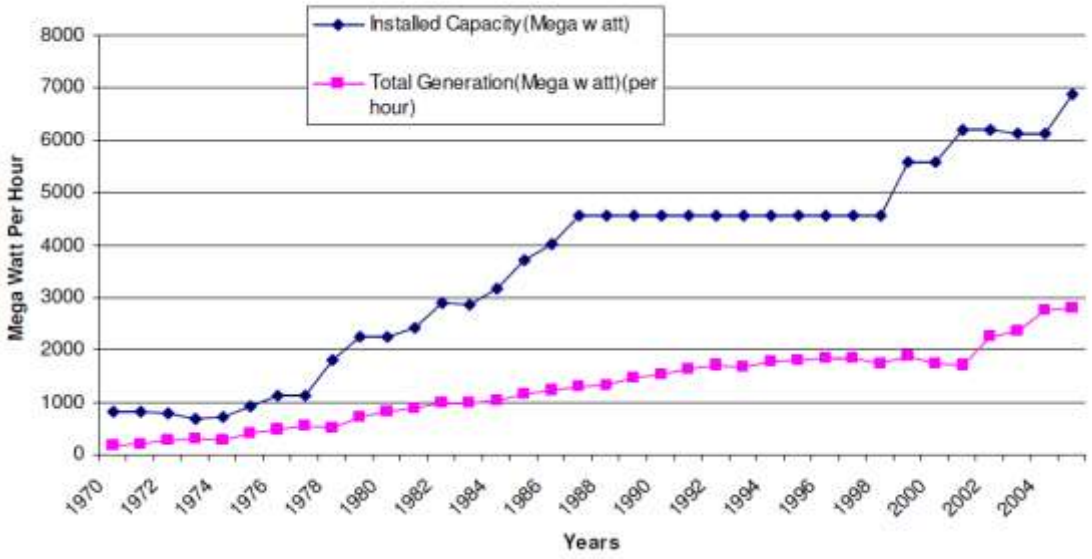


Figure 1 : Electricity Generation in Nigeria, 1970-2005
*Source: National Bureau of Statistics/Energy Commission of Nigeria*

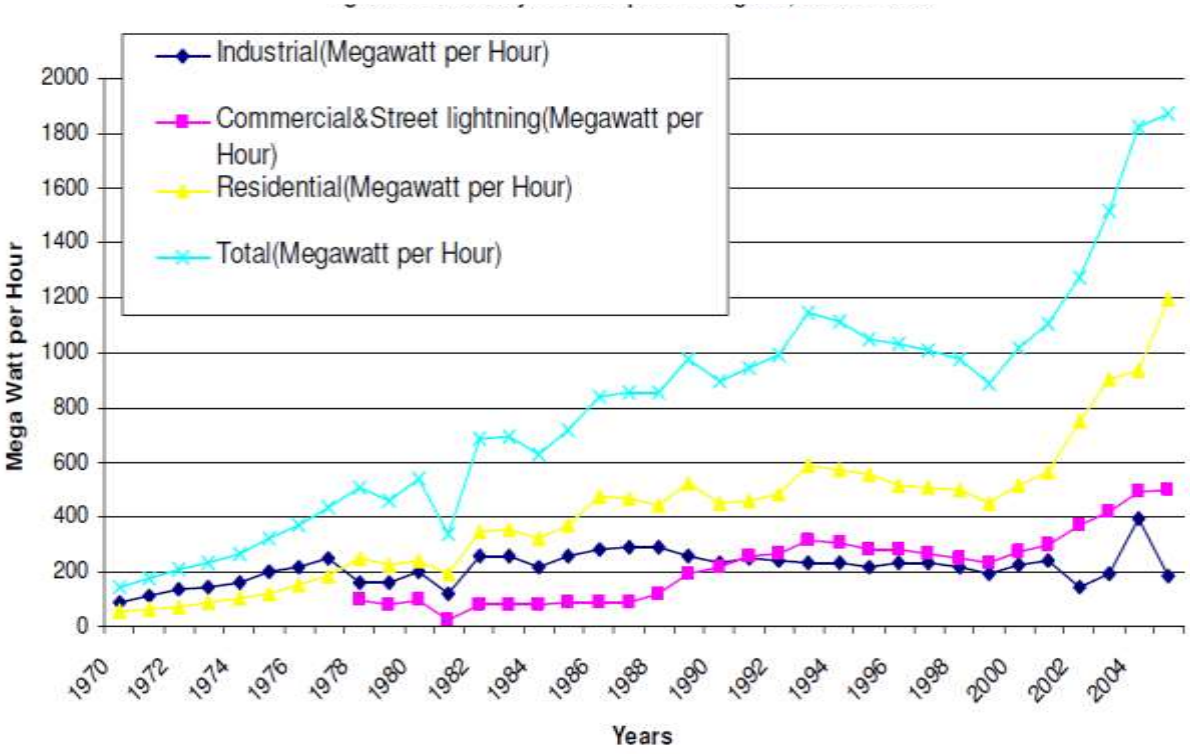


Figure 2 : Electricity Consumption in Nigeria, 1970 to 2005
*Source: National Bureau of Statistics/Energy Commission of Nigeria*

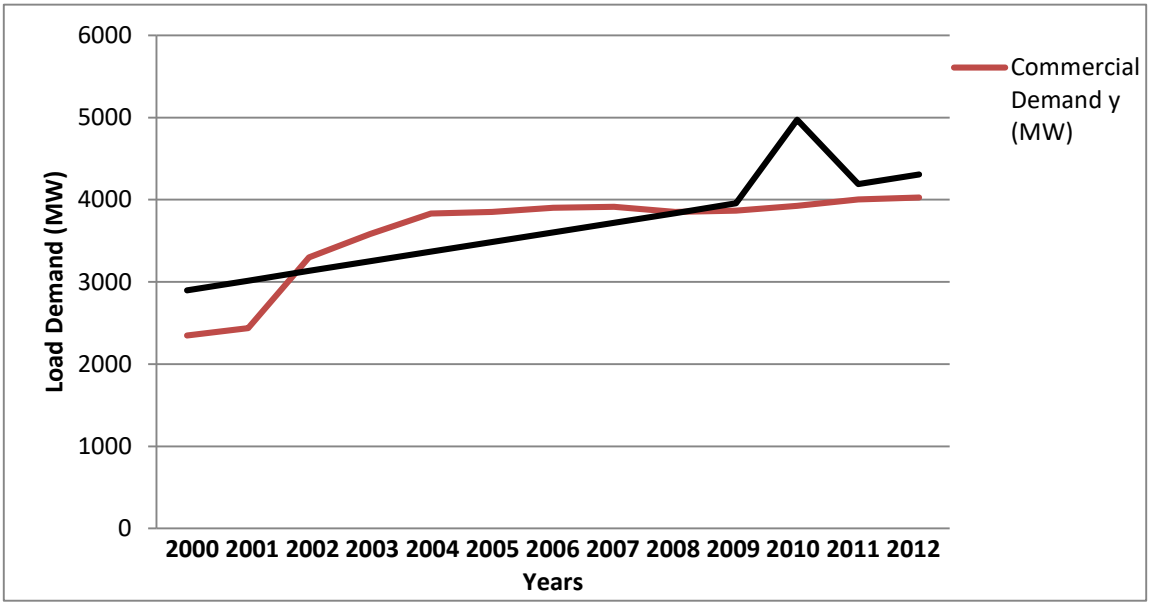


Figure 3 : *Graph of Actual Commercial load demand and trend values from 2000-2012*

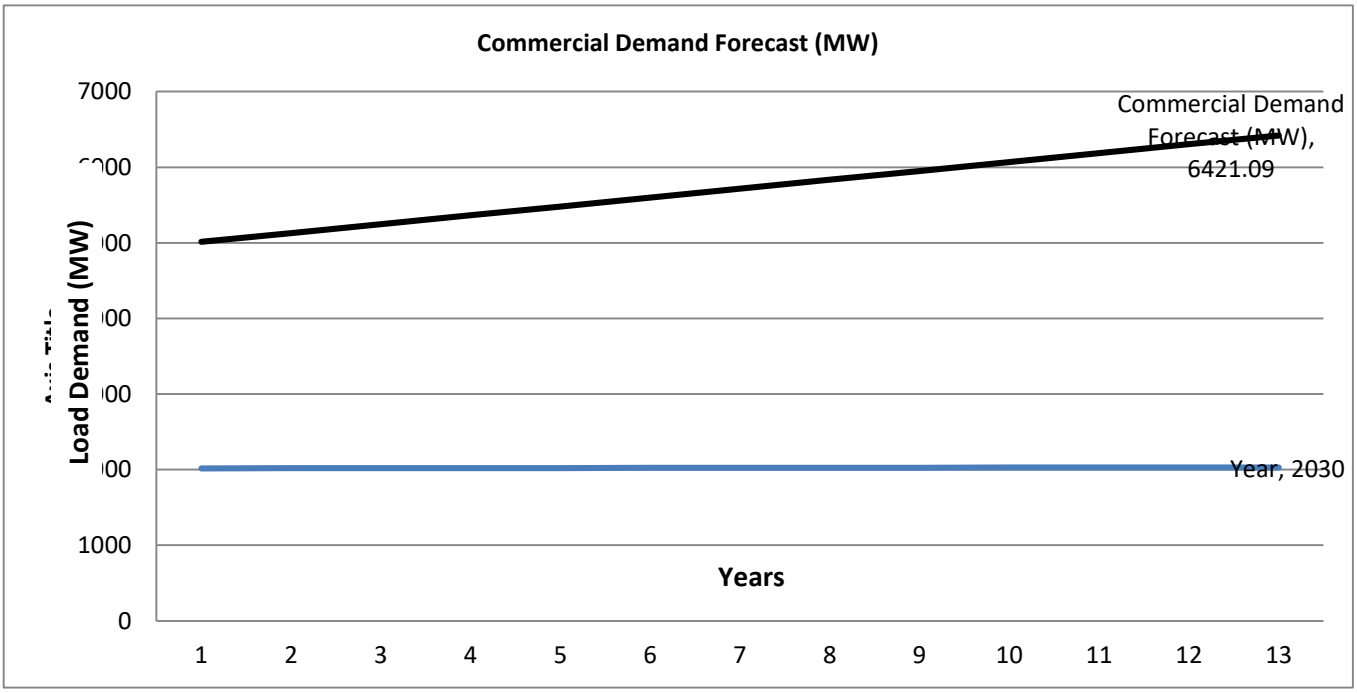


Figure 4 : *Predicted Nigeria commercial load demand from 2018-2030*

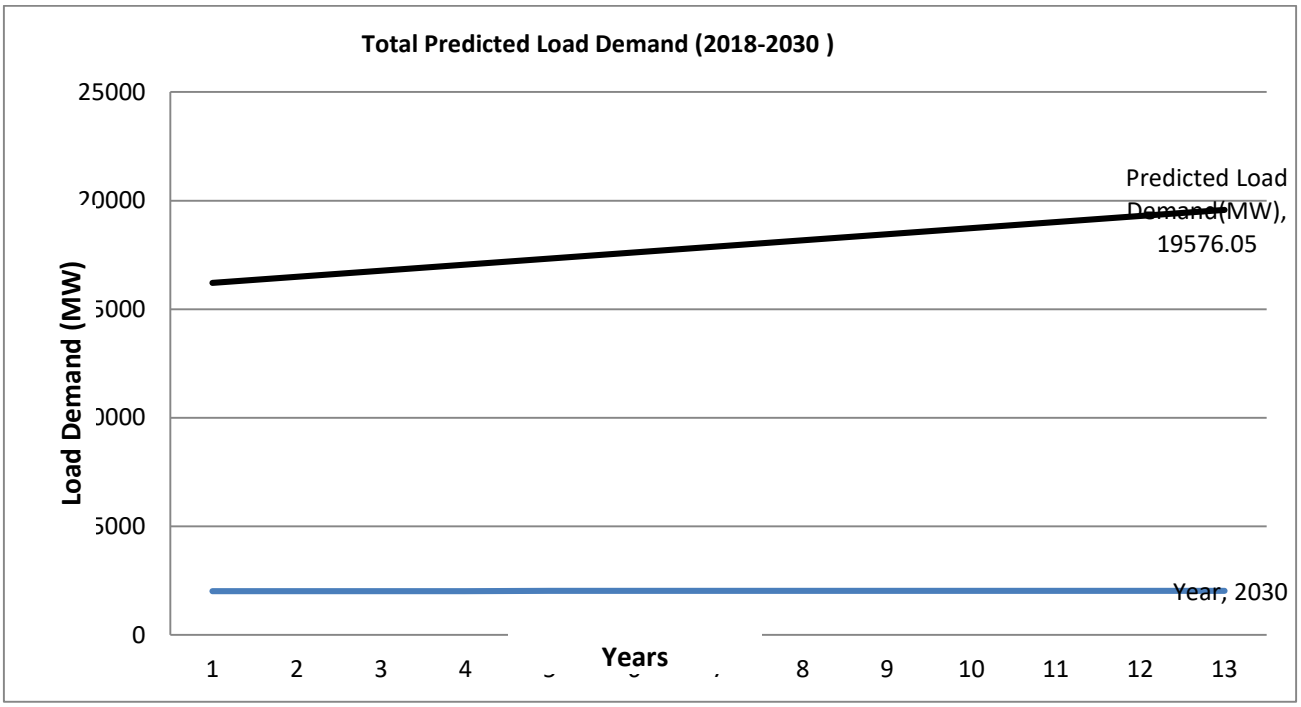


Figure 5 : *Nigeria Predicted Total load from 2018-2030*

## CONCLUSION

Having investigated the Nigeria power sector and its performance over the years, it is observed with outmost dismay that the country is still having the problem of insufficient electric power being supply in Nigeria today. Largely due to inadequate power generation, transmission and obsolete distribution network that has cause the failure to thrive or total collapse of the commercial sector of the economy. The outcome of the research has glaring shown that Nigeria need to build more power generating plants, invest in her transmission networks and rehabilitate all the existing distribution facilities in order to achieved the estimated electric energy demand of 20, 000MW. Especially, the concept of Demand Side Management must be upheld and fully implemented as enshrined in the Nigerian power sector reforms. In view of the above, efficient, reliable and affordably electric power supply to her commercial areas can be achieved for this is the only way to commercialize and grow the economy of the nation and also improve the Gross Domestic Products (GDP) of the country.

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