TIME-SERIES ANALYSIS OF COMMERCIAL ENERGY DEMAND FORECAST IN NIGERIA (A PANACEA TO FOSTER RAPID GROWTH AND DEVELOPMENT)

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Abstract: *The growth of a country is largely dependent on the supply of adequate, affordable and reliable electric power. For Nigeria to keep tracks with other developed countries which have exhibited a substantial growth in economic development and grow her commercial sector thereby improving the GDP of the nation, the existing gap between the electric power demand and supply of the country must be holistically bridged. The devastating effects of poor, inadequate and unsupplied power to commercial centers have been estimated in different ways by many studies. These studies evaluated various types of value of unproduced output and outage costs, such as failure to thrive and total collapse of commercial centers as well as loss of revenue which has negative impact on return in investment. It is a common knowledge in Nigeria that most cottage industries/commercial centers rely more on private (off-grid) power generation than the national grid. The diesel and petrol plants are commonly used generators and at times gas turbine plant, with the relative consequence of high cost of fuelling. 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. With the increase in population, electric load demand is on the increase over the years. This research studies a load demand forecast for commercial center of the power sector using time-series as a tool for analysis. The results show that there is need to constantly improve power generation, transmission and distribution network to deliver at least 20,000MW of power to its commercial centers in other to meets the estimated or forecasted power of 19576.05 MW on or before the year 2030.*

Keywords: *Electricity Generation & Consumption, Energy Demand Modeling, Commercialization in Nigeria, Time-Series Analysis and Energy Demand Forecast.*

I. INTRODUCTION

Power holding company of Nigeria (PHCN) was empowered to generate, coordinate and maintain the economic system of electricity distribution to all the nooks and crannies of the nation; that will have propelled the nation's technological and industrial growth [1]. It is proactive to ensure that the forecast of power demand in Nigeria must be performed during and as an integral part of the power system design process. It is not practical to add the load forecast at a later date and an attempt to do so could prove unrewarding and involves considerable and unnecessary cost even if it is physically possible. Load forecasting is needed to reduce transmission and distribution outages over the system and reduce system failure rate. The later section of this research focuses on the long term load forecasting of Nigeria electricity demand, and the method of forecasting employed is the stochastic/probabilistic extrapolation method which is based on the time series analysis of past load demand curve using straight line graph/curve ($Y = a + bt$).

This study is essential to be able to predict /forecast the quantity of power needed by Nigeria owing to the epileptic nature of the Nigerian power supply and plan future network expansion, reduce cost of energy generation, stop load shedding 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. Energy is only one of the many important inputs for production, conversion, processing, industrialization and commercialization in all sectors [2] [1]. It is generally recognized that energy, including electricity, plays a pivotal role in the economic development of a country as it enhances the productivity of the nation when inputs such as capital and labor are considered.

Access to electricity is important to human development. Electricity in practice, is an indispensable commodity for certain basic household activities, such as lighting, refrigeration and the running of household appliances, and cannot easily be replaced by other forms of energy [3]. There is difficulty in designing or evaluating policies and programs intended to address the impact of the use of energy within industrial areas/zones. It is the aim of this study is to provide an appropriate analysis of how much electric power or energy do Nigeria need to efficiently, affordable supply/feed its commercial centers; thus what factors contribute to commercial energy demand. With the objectives as follows:

To investigate the dynamics of electric energy demand over time in Nigeria

To identify the various effects of the different 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 commercial centers in the country thereby making the economy grow at a very fast pace.

In 2004, the power sector reform bill was signed into law thus enabling private companies to participate in electricity generation, transmission, and distribution. By this reform act, the nation has a new map towards achieving a meaningful progress in her power sector. Figure 2 below shows the categories of electricity consumption figures between 1970 and 2004.

It is also observed from the table below, that the proportion of electricity used for Commercial purposes has been on the decrease since 1970 while residential consumption has been on the increase. This is easily explained by the epileptic and inadequate 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 generate more of 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.

II. AN OVERVIEW OF ELECTRICITY GENERATION AND DISTRIBUTION IN NIGERIA

The Nigerian economy is heavily dependent on energy. Electricity is used for a number of purposes that include industrial, commercial and residential purposes. During the inauguration of NEPA in 1973, only five of the then 19 state capitals were connected to the national transmission grid system. But as at today, practically all state capitals are being served from the national grid, although haphazardly [1]

On the other hand, in terms of distribution; TCN grid network has a total (theoretical) wheeling capacity of 7,500MW across over 20,000km transmission lines. The transmission system footprint does not cover every area of Nigeria [2]. A new generation and transmission peak of 5,375MW was achieved on thursday 7th February 2019 at 2100hrs (TCN, 2019).

It is sad, that after six years of privatization, the electricity grid network is yet to be extended to reach many areas due to various challenges being face 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

Energy estimation has been carried using so many methods, for instance [10] [7] uses input – output models to estimate. Also, The econometric modeling approach of energy demand, the Non-Stationary and the Co-Integration Technique [11] [12], Multivariate Co-Integration System (Johansen Approach) [13], and the Structural Time-Series Model (STSM) [14][15][16].

A number of approaches has been deployed for the estimation of electricity demand over the years. It can be found in the literature ranging from aggregative analysis of the relationship between electricity demand, income and prices [25], to more detailed disaggregated analysis [26]; based on simultaneous model structure. In the most basic model, the demand for electricity, has been modeled as a function of a single variable, such as real income or temperature; real income and prices [27] real income, residential electricity price and price of natural gas [28]; real income, electricity prices, population growth, structural changes in the economy and efficiency improvement [29] population, income, price of electricity, price of oil, urbanization, weather; real income, price of electricity and diesel (used in for captive power generation to meet the shortages), and reliability of power supply from utilities real income, the real price of electricity, and the variable that captures the seasonal component of the demand for electricity.

Population is another important factor to determine electricity demand in Nigeria. Higher population level is expected to increase electricity consumption. A positive correlation between population growth and electricity demand is therefore expected. Economic theory suggests that electricity purchases will depend on the prices of substitutes: natural gas and petroleum products. However, the independent influences of diesel and gasoline prices may be rather small because a sizeable number of people in Nigeria do not have access to a power generating set to generate electricity when there is power outage. In our view, natural gas is not also appropriate in the case of Taiwan, since its consumption is concentrated on the urban rich and can be said to be comparatively small.

B Commercial Sector Development in Nigeria and the Challenges

The causes of economic challenges in Nigeria can be traced to the following major causes such as; In-effective leadership and corruption, over reliance on oil, inflation, unemployment, government policy, monetary policies, inadequate infrastructures and power supply. Also inadequate health facilities, insecurity and some way forward were identified from the study which are; the development of both private sector and small scale businesses, unity, implementation of the right monetary policy, provision of employment opportunities for the youth, Provision of adequate security, improvement on housing and home ownership for Nigerians and diversification of the economy improvement of the economy is a collective responsibility of all Nigerian so all hands should be on desk to promote the economy.

Government needs to look beyond oil and start the production of other essential commodities which will be a future idea on the growth of the economy. Government should do everything in his power to solve the problem of power generation in Nigeria. Timely implementation of the nation's budget should be ensured by all agencies in charge of the budget implementation. Government should focus on agriculture as a means of diversifying the economy and also creating employment for youths interested in agriculture. The Federal government should come up with a formidable economic policy that would arrest the continuous decline in the economy of the nation to forestall the present hardship been experienced in the country. Nigeria should lift the ban on the importation of some essential commodities. There is nothing too bad in importing what we don't have. In international trade context for instance, countries depend on each other. Using Adam Smith theory of absolute advantage and Ricardo's theory of comparative advantage, Nigeria has to concentrate in the production of goods for which she has absolute advantage. All security agencies should work together for a better and secured Nigeria Corruption should be eliminated completely; Corruption can be beaten if we work together.

C. The 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, it has been mismanaged, and many workers in the electricity sector are not equipped with the proper skills or training. Domestic production suffers in these conditions, but many foreign companies also find it difficult to conduct business in Nigeria because of frequent power failures. The problem of bad road networks has made a lot of businesses suffer in Nigeria as the roads are not dependable. This problem keeps Nigeria in a third world country status from year to year. Nwadinobi 2016[30]

III. 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 models are particularly useful when little is known about the underlying process one is trying to forecast. Also when properly applied, reveals more clearly the underlying trends especially in energy demand forecasting.

In summary, a significant number of studies suggest that energy demand responds differently depending on whether prices fall, rise or above some previous maximum.

The research method used in analyzing the industrial 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. Time - Series Analysis

Time-series analysis is a widely used statistical method used in the task of peeing into the future. Time-series analysis deals with the statistical technique of analyzing past data and projecting them to obtain estimates of future values. We therefore define time series as a 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 also helps in the analysis of past behavior of a variable and helps in comparative studies in the value of different variables at different times or places [1].

Basically, 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]. The off peak period lasts for about fifteen hours and this is the period of minimum load demand of the day. The first off-peak periods occur in the morning between 0000hrs-0500hrs during this period most of the commercial centers, club homes and other recreational places are shut down for the day. The second off-peak period occurs between 0800hrs-1800hrss, during this period the residential power consumption drops as most have all left for offices and industries, the commercial and industrial loads predominates at this period. The first peak period occurs between 0500hrs-0800hrs when people wake up in preparation for the day 's activities and as such so many home appliances are switched on.

Nigeria, weekly load demand follows a specific pattern, it is higher at week days when factories and most commercial centers are in operation and lower in weekends when most of them are shut down making the residential load to predominate. The daily and weekly load forecast fall under short-term load forecast while the annual load forecast fall under long-term load forecast.

The estimation of the trend of a time-series start with plotting the time series data on a graph. The trend line can be found by using; the free hand method, the method of moving average, the least square method and the semi-average method. 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

This method is used in fitting 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.

The linear trend equation is given as; $Yt=a+bt$ ... (3.3)
Where; 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'and they are obtained by solving the following normal equations;

$at+b\sum t=\sum$ .....(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;

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

$$b=\frac{n\sum ty-\sum t\sum y}{n\sum t^2-(\sum t)^2} \quad \text{.....(3.7)}$$

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 SOURCE AND PRESENTATION

The data used in this research covers electrical energy consumption in Nigeria from 2000 – 2017 broken down into three categories, residential, commercial and industrial. They were collected 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:
TABLE OF ENERGY CONSUMPTION (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

Source: Central Bank of Nigeria STATISTICAL BULLETIN and National Bureau of Statistics (NBS).

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; $a = \frac{\Sigma y}{n} - \frac{b\Sigma t}{n}$ and $b = \frac{n\Sigma ty - \Sigma t \Sigma y}{n\Sigma t^2 - (\Sigma t)^2}$
When t = 0 = gradient of the trend line/

V. RESULTS AND DISCUSSION

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

A. Commercial Demand

TABLE II
TABLE OF VALUES FOR COMMERCIAL DEMAND

Year	T	Commercial 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 gradient of the trend line b=nty− tynt2−(t)2=117.43 Trend line value when t = 0: a= yn−btn=3602.77 Trend equation y=a+bt=3602.77+117.43t. The trend values from the above equation gives the values actual commercial demand and is given in the table below:

TABLE III
TABLE OF VALUES FOR ACTUAL COMMERCIAL 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

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 VALUES FOR COMMERCIAL 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 total Predicted demand is gotten by summing the individual demand forecast of residential, commercial and industrial. The table is shown below;

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

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VI. SYSTEM IMPLEMENTATION

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

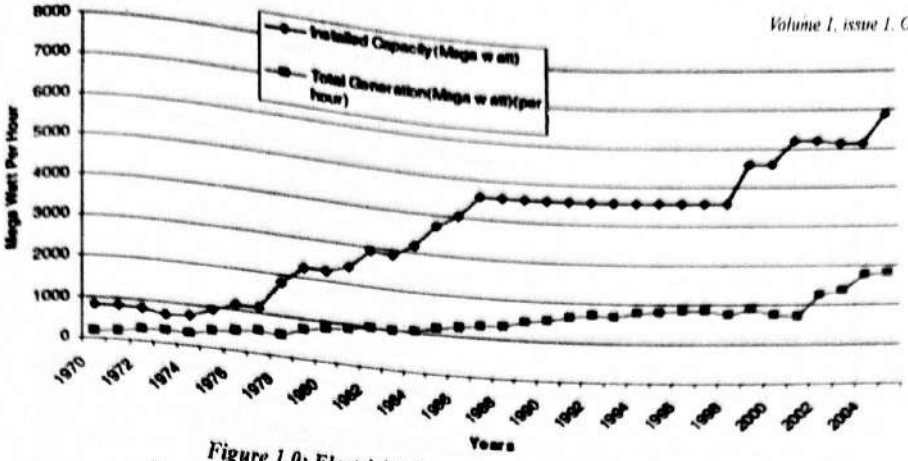

Figure 1.0: Electricity Generation in Nigeria, 1970-2005
Source: National Bureau of Statistics/Energy Commission of Nigeria

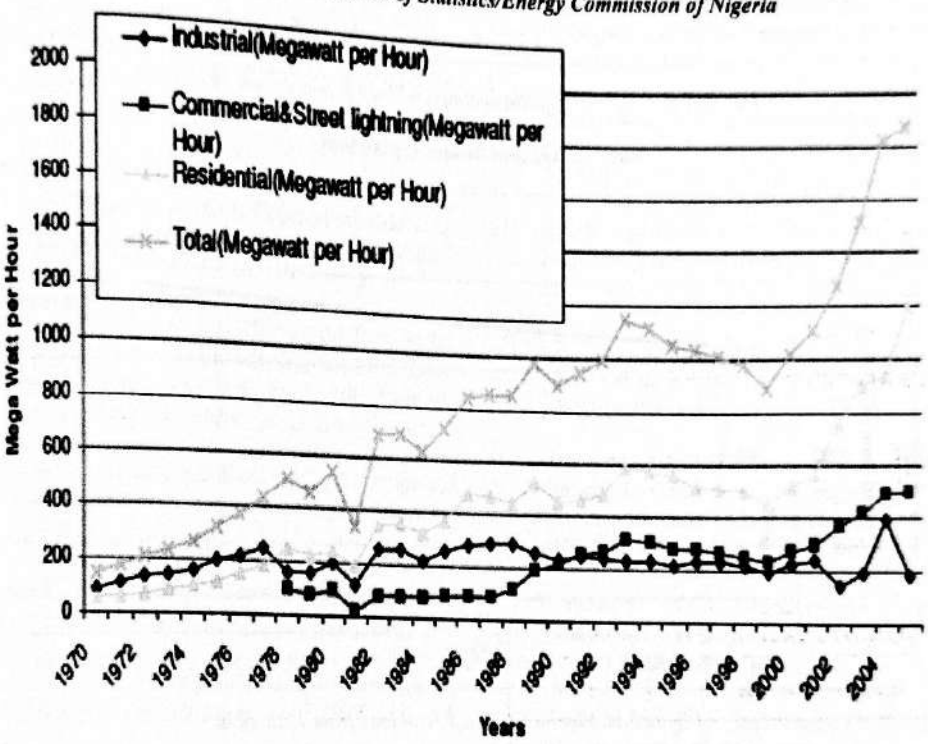

Figure 2.0: Electricity Consumption in Nigeria, 1970 to 2005
Source: National Bureau of Statistics/Energy Commission of Nigeria

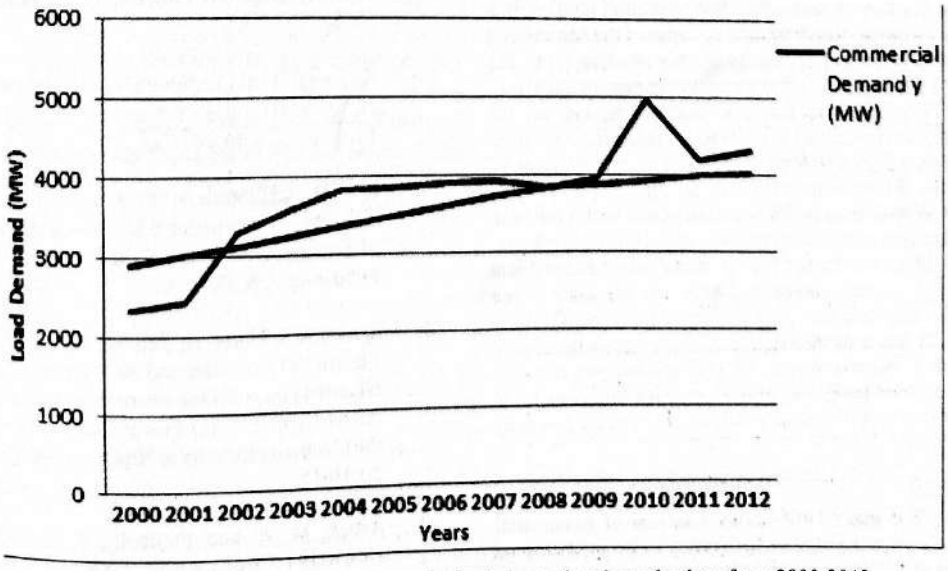

Figure 3.0: Graph of Actual Commercial load demand and trend values from 2000-2012

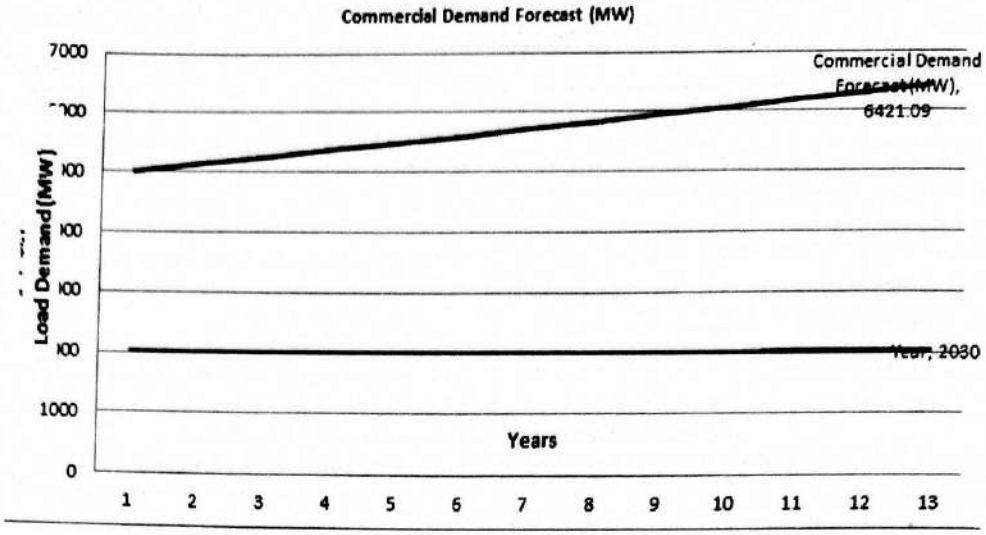

Figure 4.0: Predicted Nigeria commercial load demand from 2018-2030

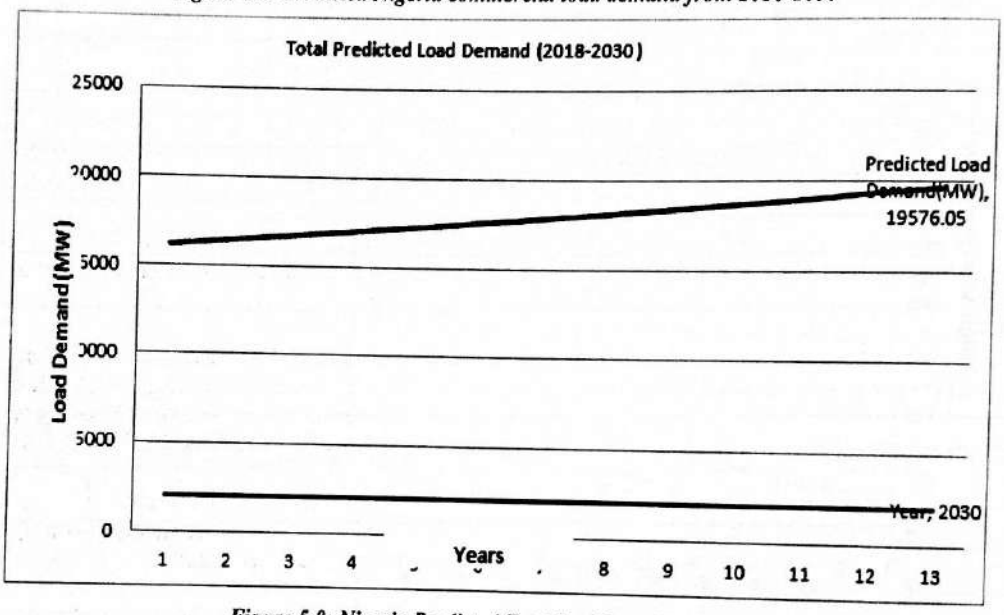

Figure 5.0: Nigeria Predicted Total load from 2018-2030

VII. CONCLUSION

Having investigated the Nigeria power sector and its performance over the years, it is observed with outmost dismay that there is inadequate power supply due to insufficient 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 results of this research work has shown that Nigeria need to build more power generation plants, invest in her transmission networks and rehabilitate all the existing distribution facilities in order to achieved the forecasted energy demand of 19,576.05MW. 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. The outcome of this project should guide the energy policy makers in Nigeria aimed at building more power plants and to increase more budgetary allocation to the power sector in order to achieve the estimated approximate 20, 000MW power by the year 2030.

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