Energy Demand Forecast for The Industrialization of Nigeria Using Time-Series Analysis Model

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Abstracts. The provision of sufficient, reasonably priced, and reliable electric power is a vital prerequisite to nurture or drive this necessary desired transformation for Nigeria to make significant progress in terms of growth in its key sectors such as infrastructure, economics, and security. Additionally, the nation's electric power consumption and supply must be comprehensively planned and achieved as a matter of urgent necessity if it is to keep pace with developed countries around the world that have demonstrated phenomenal growth in economic development and transformed into industrialized nations. Epileptic power supply issues have recently gotten worse at an alarming rate. Epileptic power supply issues have recently gotten worse at an alarming rate. In particular, low power output and the national grid breakdown brought on by unrest brought on by bandit attacks on the facilities housing the transmission lines. The strength of any healthy economy is directly correlated to the expansion of the industrial sector, which is made possible by the accessibility of a reliable power supply. Today's industries in Nigeria produce their own power, largely as a result of the discontent with the available supply. Additionally, the cost of manufacturing is high due to the spike in petrol, diesel, and petroleum prices, which raises market prices for other goods and drives up inflation. If the demand and supply for electric energy can be balanced, other problems in Nigeria will be significantly less difficult to tackle. Therefore, the purpose of this study is to project the load demand for the industrial sector using a time series model. The results show that, by the year 2030 or earlier, it would be necessary to create a projected 20,000MW of electric power in order to effectively and affordably power her industry.

Keywords: - Electric Power Generation & Consumption, Electric Energy Demand Modeling, Industrialization, Time Series Model and Energy Demand Estimates.

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1. Introduction

As far as Nigeria's long-running struggle with an unstable power supply of electricity is concerned, the adage that effective planning prevents poor performance is correct. After more than 40 years of the power sector's existence, we are still having a difficult time producing a paltry 5000MW of electricity. This is partly due to the lack of effective planning for the power generation, transmission, and distribution framework; as a result, it is highly challenging to make significant progress in terms of increasing the generation capacity relative to supply.

The estimation of the amount of electricity required in Nigeria is sacred; therefore, planning is required before moving forward with the goals' associated achievement. Because attempting to implement the idea of calculating the quantity of energy required in the various power sectors may prove futile or result in higher costs [1].

Estimates of load and demand are essential for lowering system failure rates. This study is essential to determine the precise quantity of power required by Nigerians to support their industrial sector. Due to its crucial role in the industrialization and economic development of every given society, electricity is one of the most essential commodities in the nation [2][1]

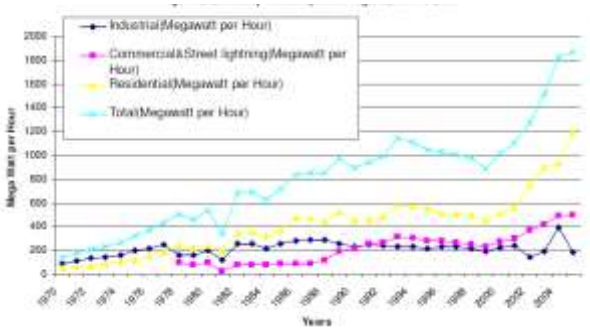
Electricity accessibility is essential for any meaningful economic and social progress. Electricity is a need, making it the most sought-after good on the market. As a result, it cannot be substituted with other types of energy [3]. The precise amount of electricity required to feed Nigeria's businesses in an effective manner is what this study aims to determine. With the objective to;

Examine the various underlying factors that influence energy demand over time in Nigeria.

Identify the various impacts of the various factors on industrial energy demand.

Predict the kilowatts (KW) of energy that Nigerians will need to supply their industries with in order to increase the annual gross domestic product (GDP) of the nation and cause the economy to grow quickly (and industrialize).

Figure 2 shows a straightforward graph with the statistics on power and consumption from 1970 to 2004. A thorough investigation has shown that since 1970, the rate of consumption of energy in the industrial sector has been decreasing [1]. This is mostly because there isn't enough of this resource to supply the industries, which drives up the cost of production because they have to source their own electricity outside of the grid.



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

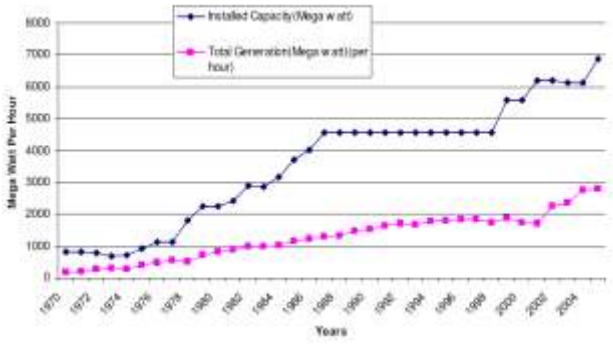


Figure 2.0: Electricity Consumption in Nigeria, 1970 to 2005
Source: National Bureau of Statistics/Energy Commission of Nigeria

2. Review of Related Literature

It is regrettable that Nigeria's energy needs have not been satisfied after six successful privatizations. Therefore, the motivation for this research paper is to offer a solution to the issue of epileptic power supply to industrial areas in Nigeria and to advance the socioeconomic development of the country by carrying out appropriate planning to identify the energy demand and supply forecast to industries in Nigeria.

2.1. Energy Demand Modeling

These researchers have conducted research on energy demand forecasting using a variety of methodologies, some of which use the input-output technique, such as [10] and [7]. 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] are further approaches used in econometric modeling of energy demand.

Additionally, pricing and income [25], and simultaneous model structure [26]. Real income or temperature; real income and prices [27]; real income, residential electricity prices, and natural gas prices [28]; real income, electricity prices, population growth [29]; population, income, price of electricity, price of oil, urbanization, weather gas, and petroleum products. However, because a sizable portion of people in Nigeria do, the independent influences of diesel and petrol prices may be very minimal.

2.2. Industrialization Development in Nigeria and the Challenges

The majority of equipment used to produce goods and other items on the market is powered by electricity, and its accessibility helps the economy grow and thrive [3][4]. Therefore, having access to effective electric energy is crucial for supporting or enhancing any country's socioeconomic development.

Many industries in Nigeria have closed down recently, and a key factor in this is a lack of electricity supply. also making it challenging for new ones to flourish [11]. Consequently, the power industry needs a comprehensive framework for development to boost its generation capacity and effectively provide the industries for output.

2.3. The Problem of Inadequate Electricity on Industrial Sector in Nigeria

It is impossible to overstate the issue of the industries' lack of access to power. This includes but is not limited to, material and equipment losses [19, 20]. [19] [20], a high rate of inflation brought on by a lack of goods

and services, Low GDP, of course, and high infrastructure costs [21, 22].

3. Methodology

After reviewing a sufficient amount of literature for this task and having numerous authors write about and explain their findings, it is expected that this problem has been resolved. But with the development of technology, effective computing tools, and a better industrial revolution in automation, the amount of research in this field is now limitless. Time series will therefore be the methodology and strategy for this endeavor.

Time series analysis is the study technique used to forecast Nigeria's industrial energy consumption. It is essential knowledge or understanding that we must have in order to proceed with the analysis and bring the model to a logical conclusion.

3.1. Time-Series Analysis

The time series model is a statistical technique that aids in predicting the likely course of events in the near future. It is used to anticipate future trends or occurrences. It is impossible to overstate the importance of time series in energy forecasting since without them, it is impossible to predict future events [1].

The three main types of load demand patterns in Nigeria are the daily load demand, the weekly load demand, and the annual load demand. Peak and off-peak hours are used to categorize the daily load demand [28].

The free-hand approach, moving average, least squares method, and semi-average method can all be used to plot trend lines. The least squares method will be applied to the data analysis in this research investigation.

3.2. The Least Square Method

To fit a trend line to a time series, it is used. The least squares method has proven to be the most effective over time at fitting a trend line to a time series, therefore it has evolved into the ideal tool for creating the graph for our model.

The linear trend equation is given as; $Yt=a+bt$ …..… (3.3)

Where; Yt = the forecasted trend values via time t,

a = the trend line values when t = 0,

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

t = the time limit.

The estimations of the trend equation's factors are "a" and "b," and they are discovered by solving the basic equations listed below;

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

And

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

Where; t = number of years under consideration

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

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

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

4. Data Source and Presentation

Data on Nigeria's electrical energy usage from 2000 to 2017 is taken from the Central Bank of Nigeria's Statistical Bulletin and the National Bureau of Statistics. These numbers serve as the foundation for Nigeria's energy demand forecasting and estimation.

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).

The rates of Nigeria's energy consumption from 2000 to 2017 are shown in Table 1.0 above. It has five vertical divisions, with the first one designating the number of years to be considered. The figures for industrial, commercial, and residential energy use, as well as the total, are shown in the second, third, fourth, and fifth vertical sections. We will enter these values in place of the raw data in our linear trend equation from equation (3) and perform the statistical calculations in a table. look at table 2.0

Keep in mind that we are focusing on forecasting industrial energy demand.

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

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

When t = 0 = gradient of the trend line.

5. Results and Discussion

The table below presents the study of the prediction for industrial energy demand.

5.1 Industrial Demand

TABLE II
TABLE OF VALUES FOR INDUSTRIAL DEMAND

Year	T	Industrial Demand (MW) y	Ty	t^2
2000	-6	1011.60	-6069.60	36
2001	-5	1987.20	-9936.00	25
2002	-4	1830.00	-7320.00	16
2003	-3	1659.80	-4979.40	9
2004	-2	1605.00	-3210.00	4
2005	-1	1615.50	-1615.50	1
2006	0	1575.00	0.00	0
2007	1	1530.50	1530.50	1
2008	2	1502.50	3005.00	4
2009	3	1585.00	4755.00	9
2010	4	1589.40	6357.60	16
2011	5	1615.50	8077.50	25
2012	6	1648.00	9888.00	36
Total	0	20755.00	483.10	182

The gradient of the trend line b=n ty− t yn t2−(t)2=2.65,
a= yn−b tn=1596.53
Trend equation, $Y= a+bt$ = 1596.53 + 2.65t

The trend values and actual Industrial demand are shown in Table 3.0 below.

TABLE III
TABLE OF VALUES FOR ACTUAL INDUSTRIAL DEMAND

Year	Industrial Demand y (MW)	Trend value Y (MW)
2000	1011.60	1580.63
2001	1987.20	1583.28
2002	1830.00	1585.93
2003	1659.80	1588.58
2004	1605.00	1591.23
2005	1615.50	1593.88
2006	1575.00	1596.53
2007	1530.50	1599.18
2008	1502.50	1601.83
2009	1585.00	1604.48
2010	1589.40	1607.13
2011	1615.50	1609.78
2012	1648.00	1612.43
Total	20755.00	20754.89

Note: The following key points.

1). Calculating the Accuracy of Industrial Forecast
The Mean Absolute Deviation $MAD = Actual - Forecast$
N=8.46∗10−3MW

2). Predicted Industrial Demand

Using the trend line value of 2.65MW, table 4.0 shows the estimate of future industrial energy demand.

TABLE IV

FUTURE INDUSTRIAL LOAD DEMAND FORECAST

Year	Industrial Demand Forecast (MW)
2018	1628.33
2019	1630.98
2020	1633.63
2021	1636.28
2022	1638.93
2023	1641.58
2024	1644.23
2025	1646.88
2026	1649.53
2027	1652.18
2028	1654.83
2029	1657.48
2030	1660.13

5.2. Total Predicted Demand

The combination of residential, commercial, and industrial energy demands is referred to as total energy demand.

The table is displayed 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

6. System Implementation

The graphs below illustrate the simulated outcomes of our analysis using the estimated values from the tables.

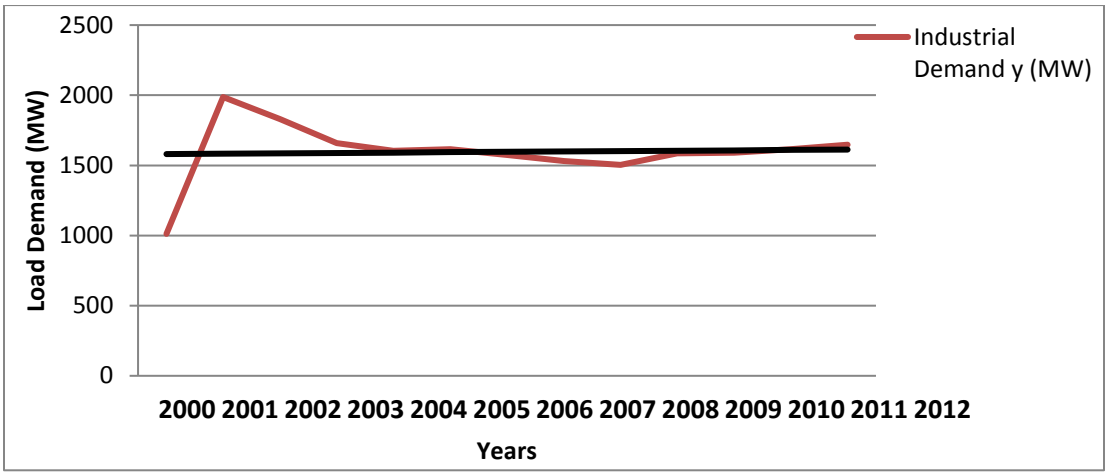


Figure 3.0: Graph of Nigeria Actual Industrial demand and trend values from 2000 – 2012

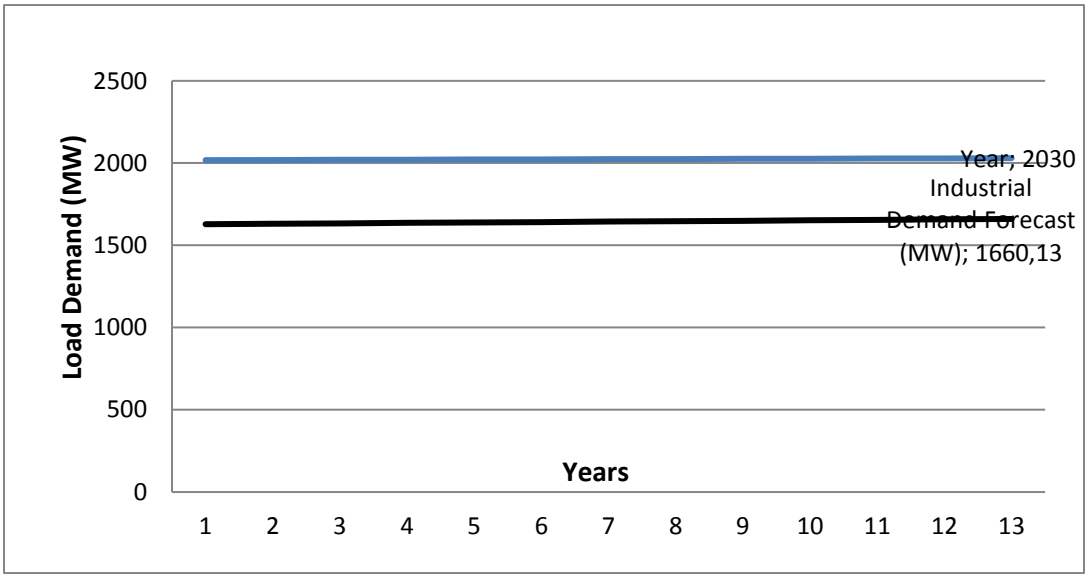


Figure 4.0: Predicted Nigeria Industrial load demand from 2018-2030

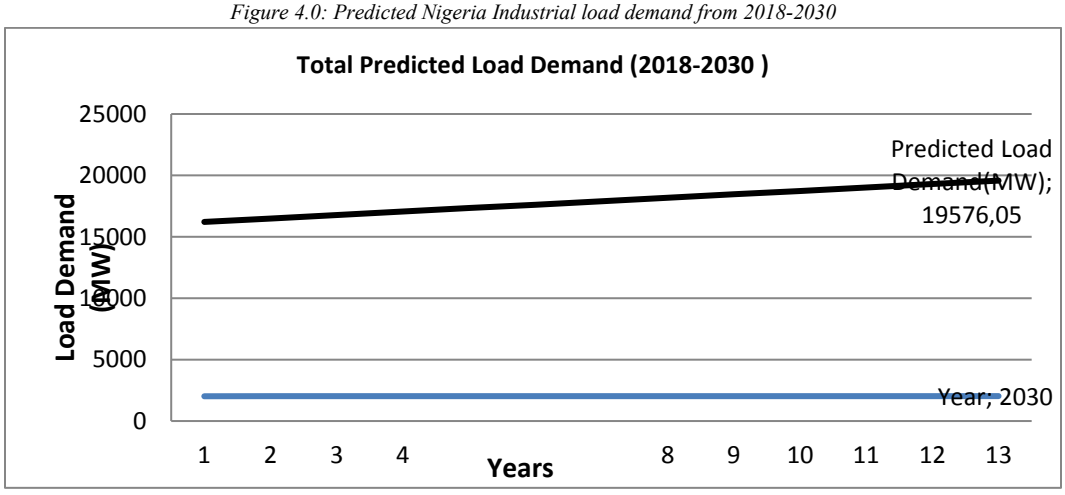


Figure 5.0: Nigeria Predicted Total load from 2018-2030

7. Conclusion

After looking into the Nigerian power industry's performance over the years, it is evident that the industrial sector of the economy has completely collapsed due to a lack of functional power generation, transmission, and distribution systems. In order to meet the projected energy demand of roughly 20,000 MW on or before 2030, more generation facilities should be built, transmission networks upgraded, and distribution facilities renovated. In light of the aforementioned, it is possible to provide efficient, dependable, and affordable electric power to her industrial sectors. This is the only method to industrialize the country and raise the Gross Domestic Product (GDP) of her economy.

Data availability statement

Valuable data and pieces of information were obtained from, The Nigerian National Bureau of Statistics and can be made available on request/approval from the agency.

Conflicts of interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this article.

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