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Forecasting of Electrical Energy Demand in Nigeria using Modified Form of Exponential Model

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ABSTRACT: *This paper presents long term electric power load forecasting for twenty years (20 years) projection, in Nigeria power system using modified form of exponential regression model. The model is implemented in Matlab platform with a plot in residential load demand, commercial load demand and industrial load demand in (MW). To analysis and predict the energy (power) demand (MW) requirement for a projection period of (2013 - 2032), data are collected between 2000 - 2012, from the Central Bank of Nigeria (CBN), and National Bureau of Statistics (NBS). The results obtained shows that energy generated from the respective generating station including Egbin Thermal Power Station, Sapele Thermal Power Station etc. are grossly inadequate and this mismatch is a major problem in power system planning and operation. The result also shows that there is deviation between predicted energy demand (MW) and available power (or capacity allocated). The predicted energy demand into the projected future of 20years is 395,870.2MW. The work also extended the prediction form into: least-square, exponential regression to modified form of exponential regression. Evidently, the comparism plot for least-square, exponential and modified exponential model shows similar predicting pattern: particularly least-square exhibit linear behaviour, while exponential and modified exponential shows non-linear behaviour but the new modified exponential model developed gives more accurate result with percentage error of 1.37% compared to existing model with 1.67%.*

Keywords – *Energy Demand; Load Forecasting; Regression Analysis;*

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I. INTRODUCTION

The power generating stations of Nigeria power system are strategically located across the geopolitical-zone in Nigeria with different generating capacity. Increase rural to urban migration has led to an excessive demand of electricity due to the fast growing rate of industries, economic development and increasing population of the residence which has resulted to epileptic power supply, power failure, fluctuation and total power outage, therefore causing loss of energy utilization by the consumers and utility companies [1].

Peak load forecasting is essential in electrical power system operation, unit commitment and energy scheduling [2]. Energy demand forecasting initiates proper planning and developing of future generation, transmission and distribution facilities. One of the tasks of electric utility is to accurately predict energy demand requirements at all times, basically for a long term planning. Based on the outcomes of such forecasts utilities coordinates their resources to meet the forecasted energy demand, thereby engaging a least-cost energy management plan and follow-up which are subject to numerous uncertainty, that is, in planning for future capacity resources, we need an information and operation of the existing generation resources, in order to predicts future capacities [3]. Power system serves one main function that is, to supply energy to the respective customers, which are residential, commercial and industrial consumers with electrical energy at economical, safe and reliable condition. Another responsibility of power utilities is to recognize the needs of their customers (Demand) and the supply the necessary energies [4]. Evidently, limitations of energy resources in additions to environmental factors, requires electric energy to be used, more efficient power plant and transmission lines to be constructed. Sustainable supply of electric power is essential and energy generation, transmission and distribution foster all forms of economic development in the country. The Nigerian power system is not generating enough electric power; this inadequacy has resulted into frequent load shedding; reduction in quality of power; extra ordinary line losses and eventually failure and collapse of power system [5]. Therefore there is need to overcome this challenges of poor supply of power to the end users at all times.

The electricity utilities, regulatory agencies and Nigeria at large, would benefits great, owing to the fact that development of electricity infrastructure is undoubtedly a capital intensive project that needs a serious attention. Hence, Energy demand forecast shall be taken as the first priority for future expansion planning program. Therefore to keep Nigeria abreast with other developing countries which have exhibited in every standard a substantial growth in economic development this means that, the existing gap between the electric power generation and energy demand requirement must be bridged.

II. RELATED WORKS

Many researchers have investigated possible outcomes of typical forecast on energy consumption of different geographical locations [6-7]. Research works on load forecasting with Nigeria and its environs in focus are becoming topical issues [8-10]. Many physical factors such as weather, national economic, public holidays, etc. affect the electrical energy consumption. Both traditional method like regression analysis are very useful in forecasting [11-12] however researcher are making much progress in the use of AI techniques/tools for load forecasting, monitoring, estimation. The AI techniques could be classified further into: ANN with backpropagation learning has been proposed in [13-15]; ANN using SVM including Support Vector Regressors (SVR) have also been proposed in [16]. Genetic Algorithm (GA) based neural network as proposed in [17] and fuzzy logic [18], and expert systems [19].

Moulika [20] focuses on the significance of unsupervised learning and its application in the short term load forecasting. Self-organizing feature map network was proposed to illustrate the use of unsupervised learning in load forecasting. The performance of the neural network was satisfactory as the MAPE (Mean Absolute Percentage Error) was used to evaluate it performance.

Adepoju [8] presented a study of short-term load forecasting as applied to the Nigeria Electric power system using Artificial Neural Networks (ANNs). The neural network was trained on input data depicting real life case study of the power industry in Nigeria as well as the associated target values. The ANN was evaluated using absolute mean and a high degree of accuracy was achieved.

This work presents modified exponential regression analysis for forecasting the quantity of Energy (Power) needed to be generated (data) that can be used by generating station, considering the epileptic condition of the power supply and possibly plan for future increments. This will reduce cost of energy consumption, thereby reversing the ideas of load shedding and therefore reduce power outages to minimum. The study strongly need to investigate the deviation of the capacity allocated to that of the capacity utilization on the view to analyze the rate of load consumption pattern with respect to capacity allocation by the Central Controlling Body: National Control Centre of Nigeria.

III. METHODOLOGY

The methodology employed in this research study is modified exponential regression analysis for forecasting. The modified exponential regression analysis is an inexpensive method in terms of cost of data processing. The materials required for the analysis of electricity (demand) prediction, were the load-capacity (allocation) and capacity-utilization data of previous years obtained from Central Bank of Nigeria (CBN), National Bureau of Statistics (NBS) and Power Holding Company of Nigeria (PHCN). Energy consumption data are collected for resident, commercial and industrial:

Table 3.1: 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	7910.05	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

Source: Central Bank of Nigeria Statistical Bulletin and National Bureau of Statistics (NBS).

This method employs the modified exponential technique used in developing a curve that describes the relationship between two or more variables. The variables considered were capacity allocation (A), capacity utilization (U), and difference between the two capacities as errors (E) etc. The technique is a non-linear model which can give a good result between the exponential relationships of the variables considered in the study.

3.1. Modified form of Exponential Regression Analysis

The expression for the modified form of exponential regression is given below:

$$Y = A\ell^{Bx} \tag{3.1}$$

Therefore the modified form of exponential demand equation may be re-expressed as:

$$Y = P_{D_i} = \ell^{a+b}(x_i - x_0) \tag{3.2}$$

Where X_i becomes; $X_i = x_i - x_0$ (3.3)

Now, taking natural log of equation (3.2):

We obtain as: $In\, P_{Di} = In(\ell^{a+bX_i})$ (3.4)

$$In\, P_{Di} = a + bX_i \tag{3.5}$$

$$Y_i = In\, P_{D_i} \tag{3.6}$$

Where:

For considering the historical data for energy demands for consecutive year are

(3.7)

The utilization load demand is represented as expected demand while allocated load is represented as available power (MW).

$$Y_1 = In\, P_{D_1}$$

$$Y_2 = In\, P_{D_2} \tag{3.8}$$

$$\vdots$$

$$Y_n = In\, P_{D_n}$$

In order to predict the demand correctly, the sum of square of error should be minimum.

$$Summation\ (S) = \sum_{i=1}^{n} [Yi - (a + b \times i)]^2 \tag{3.9}$$

For S to be minimum value, the conditions are:

$$\frac{\partial s}{\partial a} = 0\ and\ \frac{\partial s}{\partial b} = 0 \tag{3.10}$$

Differentiating equation (3.9) with respect to 'a' we have:

$$O = \frac{\partial s}{\partial a} = \sum_{i=1}^{n} 2\left[Yi - \left(a + bX_i\right)\right]\left(-1\right) = 0 \qquad (3.11)$$

Similarly, differentiating equation (3.9) with respect to 'b' we have:

$$\frac{\partial s}{\partial b} = \sum_{i=1}^{n} 2\left[Yi - \left(a + b \times i\right)\left(-1\right)X_i\right] = 0 \qquad (3.12)$$

Where:

$\ell = 2.718$

a : intercept

b : Slope or gradients

x_i : Projected look ahead period

$X_{i_{New}}$: Difference between projected year and base year (MW)

x_0 : Base year (reference year) = 2006

B : base (MW) = $1 \times 10^3 = 1000MW$

Where:

$$a = \frac{1}{n}\sum_{i=1}^{n} Y_i = \frac{1}{13}\sum_{i=1}^{13} Y_i \qquad \text{where } n = 13$$

$$= \frac{1}{13} \times 26.333456$$

$$a = 2.02565$$

and

$$b = \frac{\sum_{i=1}^{n} Y_i x_i}{\sum_{i=1}^{n} x_i^2} = \frac{\sum_{i=1}^{13} Y_i x_i}{\sum_{i=1}^{13} x_i^2}$$

$b = 4.40883055/182$

$$b = 0.02422$$

3.1.1. Modified Form of Exponential Regression Calculation and Analysis for Load Demand for the Year 2013, when our base year is equal 2006

Case 1: Residential

$$Y_i = PD_i = \ell^{a+b(X_i)}$$

$$Y_i = PD_i = \ell^{a+b(x_i - x_0)}$$

Where $X_i = (x_i - x_0)$

But x_i = predicted energy demand = 2013.

x_0 = based - year = 2006

Note: $\ell = 2.718$

We can find our peak load demand from

$PD_i = 1000$

But $PD = 1000\ell^{a+b(x_i - x_0)}$

That is when x_0 = 2006 (datum case) or base year

x_i = 2013 (prediction case)

3.1.2. Modified Form of Exponential Regression Calculation and Analysis for Load Demand for the Year 2013, when our base year is equal 2006

Case 2: Commercial

recall

$$Y_i = PD_i = \ell^{a+b(X_i)}$$

$Y_i = PD_i = \ell^{a+b(x_i - x_0)}$

Where $X_i = (x_i - x_0)$

And also x_i = predicted energy demand.

x_0 = based - year = 2006 and

$\ell = 2.718$

Using the relation

$$a = \frac{1}{n}\sum_{i=1}^{n} Y_i = \frac{1}{13}\sum_{i=1}^{13} Y_i$$

$$= \frac{1}{13} \times 16.4793142$$

$$a = 1.267639$$

$$b = \sum_{i=1}^{n} Y_i x_i \quad = \frac{6.6718312}{182}$$

$$= 0.036658$$

3.1.3. Modified Form of Exponential Regression Calculation and Analysis for Load Demand for the Year 2013, when our base year is equal 2006

Case 3: Industrial

recall

$Y_i = PD_i = \ell^{a+b(x_i)}$

$Y_i = PD_i = \ell^{a+b(x_i - x_0)}$

Where $x_i = (x_i - x_0)$

And also x_i = predicted energy demand.

x_0 = based - year = 2006

Note: $\ell = 2.718$

From the relation

$$a = \frac{1}{n}\sum_{i=1}^{n} Y_i = \frac{1}{13}\sum_{i=1}^{13} Y_i$$

$$= \frac{1}{13} \times 5.954935$$

$$a = 0.458071$$

$$b = \sum_{i=1}^{n} Y_i x_i = \frac{1.01287}{182}$$

$$b = 5.56521978 \times 10^{-3}$$

$$b = 0.005565$$

The Modified Form of Exponential Regression was used to calculate and analyse for Load Demand for the range of years (2000-2012) with the base year taken as 2006. Each load demand pattern (Residential, Commercial & Industrial) was computed as shown in Table 3.2, 3.3 & 3.4 of the Appendix.

The Total **Residential Energy Demand Summation** = 288316.2MW

The Total **Commercial Energy Demand Summation** = 132897MW

The Total **Industrial Energy Demand Summation** = 34657MW

Table 3.5 shows the calculated values for the predicted years (2013-2032); and therefore total **Overall Energy Demand**:

228316.2MW (Residential) + 132897MW (Commercial) + 34657MW (Industrial) = 455870.2MW

3.2. Analysis of Allocation (Available Demand)

Analysis of Allocation (available demand) in MW with respect to energy demand prediction (forecast):

Case 1: Residential demand

Capacity Allocation @ 2000 = 4608.40MW (or available)

Load forecast (prediction) @ 2000;

$$Y_{i,2000} = P_{D_{2000}} = \ell^{a+b(x_i)}$$

$$Y_{i,2000} = P_{D_{2000}} = 2.718^{2.02565+0.130249(x_i)}$$

$$Y_{i,2000} = P_{D_{2000}} = 2.718^{2.02565+0.0130249(x_i - x_0)}$$

Where $X_i = x_i - x_0$

$a = 2.02565, \; b = -0.0130249$

x_0 = base year = 2006

Y_i = predicted year = 2000

@ 2000 (Prediction)

$$Y_{i,2000} = 1000 \times P_{D_{i2000}} = 2.718^{2.02565+0.0130249}$$

$$Y_{i,2000} = 1000 \times P_{D_{i2000}} = 2.718^{2.02565+0.0130249(2000-2006)}$$

$$Y_i = P_{D_i} = 1000 \times 2.718^{2.02565+0.0130249(-6)}$$

or

$$Y_{i,2000} = P_{D_i} = 1000 \times 2.718^{(2.02565+0.0781494)}$$

$$Y_{i,2000} = P_{D_i} = 1000 \times 2.718^{1.9475006}$$

or

$$Y_{i,2000} = P_{D_{i,2000}} = 1000 \times 7.009726431$$

$$Y_{i,2000} = P_{D_{i,2000}} = 7.009.723MW$$

Total summation of predicted load in the case of residential load (2000 – 2012); that is,

Predicted residential energy demand = (7009.723+7101.6150 + 7194.708 + 7289.02 + 7384.571 + 7481.37 + 7579.44+7678.80 + 7779.46+7881.44 +7984.76+ 8089.43+ 8195.47)

$$\sum_{predicted} = 98{,}649.807MW$$

Similarly, the actual allocated Residential load for the period (2000 – 2012) becomes:

Actual = (4608.40+7714.80 + 7668.50 + 7668.50 + 7725.30 + 7760.00 + 7650.00 + 7860.30 + 7910.05 + 8075.00 + 8205.20 + 8285.60 + 8350.00)

$$\sum_{Actual} = 99.481.65MW$$

$$M_{AD} = \frac{\sum(Actual - Forecast)}{N}$$

$$= \frac{99481.65 - 98649.807}{13}$$

$$= \frac{831.843}{13}$$

$$= 63.9879MW$$

This analysis was also carried out for the Commercial and Industrial load for the same given period.

Total summation of predicted load in the case of Commercial load (2000 – 2012), that is, Predicted Commercial energy demand = 2608.273809 + 2746.036366 + 3551.990568 + 3390.872288 + 3443.749528 + 3497.451339 + 3551.990568 + 3607.380282 + 3663.633742 +3720.764419 +3778.785991 + 3837.71235 + 3897.557592 = 45,298.19884MW

$$\sum_{predicted} = 45{,}296.19884\,MW$$

Similarly, the actual allocated Commercial load for the period (2000 – 2012) becomes:

Actual = 2346.00 + 2439.00 + 3297.60 + 3583.00 + 3830.30 + 3851.00 + 3900.80 + 3915.00 + 3852.00 + 3865.50 + 3925.80 + 4004.70 + 4025.40 = 46, 836.1MW

$$\sum_{Actual} = 46{,}836.1\,MW$$

$$MAD = \frac{\sum(Actual - Forecast)}{N}$$

$$= \frac{46{,}836.1 - 45{,}29619884}{13}$$

$$= \frac{1539.9}{13}$$

$$= 118.45\,MW$$

Total summation of predicted load in the case of Industrial load (2000 – 2012), that is,

Predicted industrial energy demand = 1529.128596 + 1537.591103 + 1546.10044 + 1582.77518 + 1589.944005 + 1600.342399 + 1609.199074 + 1618.104703 + 1627.058416 + 1636.064105 + 1645.118416 + 1654.222836 + 1663.377641 = 20,839.02692MW

$$\sum_{predicted} = 20{,}839.02692\,MW$$

Similarly, the actual allocated Industrial load for the period (2000 – 2012) becomes:

Actual = 1011.60 + 1987.20 + 1830.00 + 1659.80 + 1605.00 + 1615.50 + 1575.00 + 1530.501502.50 + 1585.00 + 1589.40 +1615.50 + 1648.00 = 20755.00MW

$$\sum_{Actual} = 20{,}755\,MW$$

$$MAD = \frac{\sum(Actual - \Pr edicted)}{N}$$

$$= \frac{20{,}755 - 20{,}839.02692}{13}$$

$$= \frac{-84.02}{13}$$

$$= 6.463\,MW$$

Standard deviation was used to analyse the error of prediction and computation of error gap made. It was compared with the actual values as shown in Table 3.6 of the Appendix.

IV. RESULTS AND DISCUSSIONS

The result obtained showed that the (utilization capacity) expected demand (MW) does not give positive reflection of the available power (MW) when conducted in Matlab for residential, commercial and industrial plot (MW). This mean that there is a deviation between installed capacity and that of (utilization capacity) expected demand of the consumer at the receiving end which need to be match in order to avoid overload and system collapse.

The modified exponential model was compared with linear model as well as exponential regression model. The work showed that linear model, exponential regression model and modified exponential model plot exhibit similar relationship in residential, commercial and industrial plot.

Evidently, the comparison plot for linear model, exponential and modified regression model shows different behaviour, the least square model display linear graph while the exponential and modified model graphs exhibit non-linear behaviour which is recommend because of nonlinear relations between the available power (MW) and that of expected demand.

Table 4.1: Forecasted Values for the Future Commercial, Residential & Industrial Load Demand

Year	Commercial Demand Forecasted (MW)	Residential Demand Forecasted (MW)	Industrial Demand Forecasted (MW)	Total Predicted Load Demand (MW)
2013	4424.78	8773.13	1615.08	14812.99
2014	4542.21	8933.23	1617.73	15093.17
2015	4659.64	9093.33	1620.38	15373.35
2016	4777.07	9253.43	1623.03	15653.53
2017	4894.50	9413.53	1625.68	15933.71
2018	5011.93	9573.63	1628.33	16213.89
2019	5129.36	9733.73	1630.98	16494.07
2020	5246.79	9893.83	1633.63	16774.25
2021	5364.22	10053.93	1636.28	17054.43
2022	5481.65	10214.03	1638.93	17334.61
2023	5599.08	10374.13	1641.58	17614.79
2024	5716.51	10534.23	1644.23	17894.97
2025	5833.94	10694.33	1646.88	18175.15
2026	5951.37	10854.43	1649.53	18455.33
2027	6068.80	11014.53	1652.18	18735.51
2028	6186.23	11174.63	1654.83	19015.69
2029	6303.66	11334.73	1657.48	19295.87
2030	6421.09	11494.83	1660.13	19576.05
2031	6538.52	11654.93	1662.78	19856.23
2032	6655.95	11815.03	1665.43	20136.41

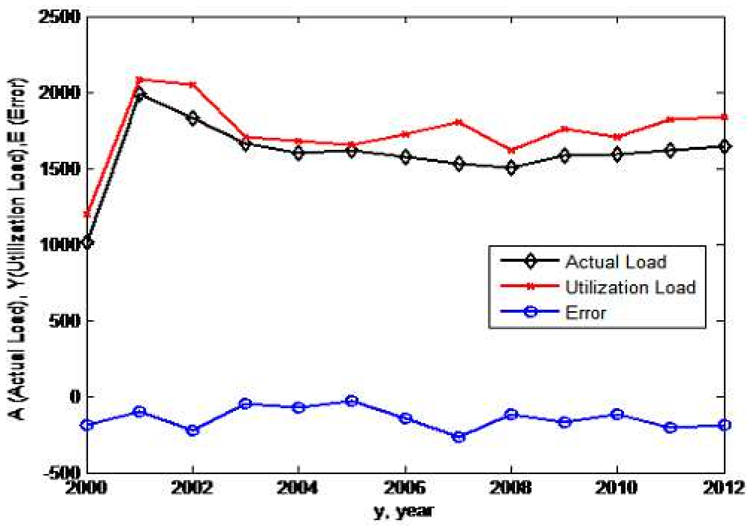

Figure 4.1: Actual Load, Utilization and Error

The Figure 4.1 shows the different between load allocation and utilization load known as error in mega-watts. Meaning that there are mismatches between load allocations and energy utilization.

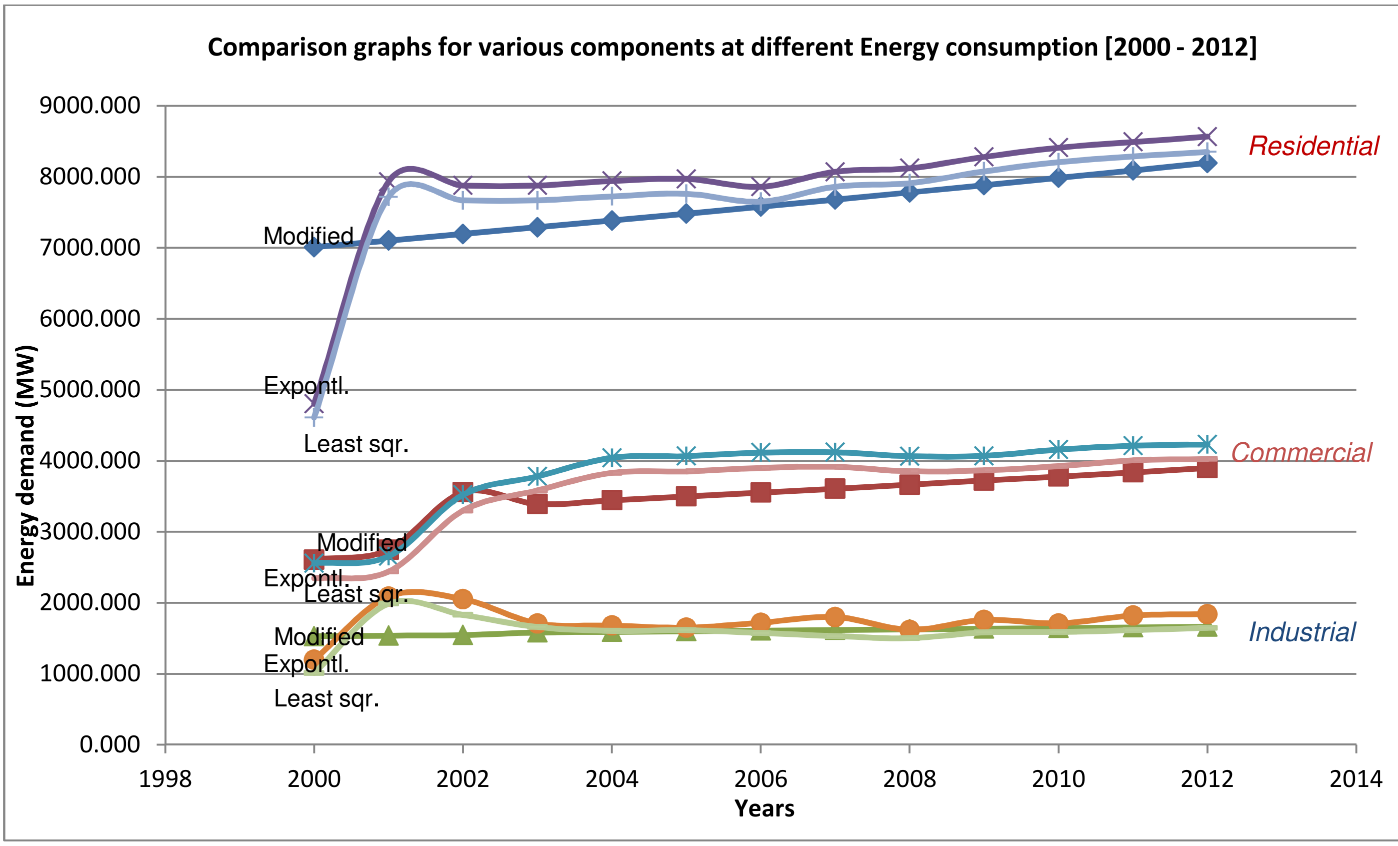

Fig. 4.2: Comparison Graphs for Various Components at Different Energy Consumption [2000 - 2012]

Figure 4.2 show the comparison error of different components which indicates that the curve of the data trend was non-linear in nature, therefore non-linear model is better.
From the graph above; it shows that energy demand from the residential consumer is very high, the commercial consumer load demand is moderate and that of Industrial demand is very low, because they all depend on their own power supply.

V. CONCLUSION

The outcome of this study was a successful one, it enabled us appreciate the growth trend of the number of years under study with predicted energy demand into the projected future of 20 years at about 395,870.20MW. These projections can be used in determining the amount of investments on generation, transmission and distribution for effective system planning in Nigeria.

The result obtained shows the areas of inadequacies resulting to mismatches, which may negatively impact overloads on transmission and distribution network. It shows that there is mismatch between installed capacity (MW) and available capacity (MW) in the case of residential load, commercial load and industrial load demand; therefore the result suggested that there is need to bridge the gap by building more generating stations or do an upgrade to the existing capacity in order to enhance high reliability and efficiency in power system operation in Nigeria.

This work also identified the relationship of least-square model, exponential regression and modified exponential regression analysis which is plotted in Matlab environment. Since the deviation between the installed and available capacity (MW) are non-linear, the exponential regression and modified exponential regression analysis are therefore recommended, because of the non-linear behaviour of the capacity and load demand requirement.

APPENDIX

APPENDIX 1: ANALYSIS TABLES

Table 3.2: The Modified Exponential Regression Analysis for Residential

S/N	Year x_i	Residential energy demand (MW) PDi	$PD_i' = PD_i/1000$	$Y_i = In(PD_i')$	X_i	Y_iX_i	X_i^2
1.	2000	4608.40	4.6084	1.527880725	6	9.16728435	36
2.	2001	7714.80	7.7148	2.043140562	5	10.21570281	25
3.	2002	7668.50	7.6685	2.037121029	4	8.148484116	16
4.	2003	7668.50	7.6685	2.037121029	3	6.111363087	9
5.	2004	7725.30	7.7753	2.044500657	2	4.089001314	4
6.	2005	7760.00	7.76	2.048982334	1	2.048982334	1
7.	2006	7650.00	7.65	2.034705648	0	0	0
8.	2007	7860.30	7.8603	2.061824774	1	2.061824774	1
9.	2008	791005	7.9100	2.068134103	2	4.136268206	4
10.	2009	8075.00	8.075	2.088772869	3	6.266318607	9
11.	2010	8205.20	8.2052	2.1047681	4	8.4190724	16
12.	2011	8285.60	8.285	2.114519068	5	10.57259534	25
13.	2012	8350.00	8.350	2.122269539	6	12.73356923	36
		$\sum P_{Di} =$ 99481.65		$\sum Y_i =$ 26.32743244	$\sum X_i = 0$	$\sum Y_i X_i =$ 4.40883055	$\sum X_i^2 =$ 182

Table 3.3: The Modified Exponential Regression Analysis for Commercial

S/N	Year (x_i)	Commercial energy demand (mw) PD_i	$PD_i = PD_i/1000$	$Y_i = In(PD_i)$	X_i	Y_iX_i	X_i^2
1.	2000	2346.00	2.346	0.8527117	6	5.1162702	36
2.	2001	2439.00	2.439	0.8915881	5	4.4579405	25
3.	2002	3297.60	3.2976	1.1931949	4	4.7727796	16
4.	2003	3583.00	3.583	1.2762004	3	3.8286012	9
5.	2004	3830.30	3.8303	1.3429431	2	2.6858862	4
6.	2005	3851.00	3.851	1.3483328	1	1.3483328	1
7.	2006	3900.80	3.9008	1.3611816	0	0	0
8.	2007	3915.00	3.915	1.3648153	1	1.3648153	1
9.	2008	3852.50	3.852	1.3485924	2	2.6971848	4
10.	2009	3865.50	3.8655	1.3520910	3	4.056273	9
11.	2010	392580	3.9258	1.3675701	4	5.4702804	16
12.	2011	4004.70	4.0047	1.3874686	5	6.937343	25
13.	2012	4025.40	4.0254	1.3926242	6	8.3557452	36
		$\sum PD_i =$ 99481.68		$\sum Y_i =$ 16.4793142	$\sum X_i = 0$	$\sum Y_i X_i =$ 6.6718312	$\sum X_i^2 =$ 182

Table 3.4: The Modified Exponential Regression Analysis for Industrial

S/N	Year (x_i)	Industrial energy demand (mw) P_{Di}	$P_{DI} = P_{Di}/1000$	$Y_i = In(P_{Di})$	X_i	Y_iX_i	X_i^2
1.	2000	1011.60	1.0116	0.011533	6	0.069198	36
2.	2001	1987.20	1.9872	0.686726	5	3.43363	25
3.	2002	1830.00	1.83	0.604315	4	2.41726	16
4.	2003	1659.80	1.6598	0.506697	3	1.52009	9
5.	2004	1605.00	1.1.605	0.473123	2	0.946246	4
6.	2005	1615.50	1.6155	0.479644	1	0.479644	1
7.	2006	1575.00	1.575	0.454255	0	0	0
8.	2007	1530.50	1.5305	0.425594	1	0.425594	1
9.	2008	1502.50	1.5025	0.407130	2	0.81426	4
10.	2009	1585.00	1.585	0.463356	3	1.390068	9
11.	2010	1589.40	1.5894	0.463356	4	1.853424	16
12.	2011	1651.50	1.6155	0.479644	5	2.39822	25
13.	2012	1648.00	1.648	0.499562	6	2.997372	36
		$\sum P_{Di} =$ 20755		$\sum Y_i =$ 5.954935	$\sum X_i = 0$	$\sum Y_i X_i =$ 1.01287	$\sum X_i^2 =$ 182

Table 3.5: Modified Exponential for Residential, Commercial and Industrial

Predicated Year	` Residential	Commercial	Industrial
2013	8981.7	4509	1643
2014	9201.9	4762	1655
2015	9427.5	4940	1662
2016	9658.6	5123	1661
2017	9894.0	5315	1680
2018	10138.0	5514	1691
2019	10386.5	5720	1699
2020	10641.2	5933	1709
2021	10902.0	6155	1718
2022	11169.3	6385	1728
2023	11443.0	6623	1737
2024	11723.7	6870	1747
2025	12011.1	7127	1757
2026	12305.5	7393	1767
2027	12607.2	7669	1776
2028	12916.3	7955	1786
2029	13233.0	8252	1796
2030	13555.7	8560	1802
2031	13889.7	8880	1816
2032	14230.3	9212	1827
	228316.2	132897	34657

Table 3.6: Energy consumption (MW) Residential, Commercial and Industrial

ENERGY CONSUMPTION (MW)									
Year	Residential			Commercial			Industrial		
	Available power (MW), Y	PREDICTION (Y_t)	Error/ Gap (Y Y_t)	Available power (MW)	Prediction (Y_t)	Error/ Gap (Y Y_t)	Available power (MW) Y	Prediction (Y_t)	Error/ Gap (Y Y_t)
2000	4608.40	7009.723	-2401.323	2346.00	2608.273809	262.273809	1011.60	1529.128596	517.528596
2001	7714.80	7101.6150	613.185	2439.00	2746.036366	307.036366	1987.20	1537.591103	449.608897
2002	7668.50	7194.708	473.792	3297.60	3557.990568	260.390568	1830.00	1546.100444	283.899556
2003	7668.50	7289.02	379.48	3583.00	3390.872288	192.127712	1659.80	1582.77518	77.02482
2004	7725.30	7384.571	340.729	3830.30	3443.749528	386.550472	1605.00	1589.944005	15.055995
2005	7760.00	7481.37	278.63	3851.00	3497.451339	353.548661	1615.50	1600.342399	15.157601
2006	7650.00	7579.44	70.56	3900.80	3551.990568	348.809432	1575.00	1609.199074	34.199074
2007	7860.30	7678.80	181.5	3915.00	3607.380282	307.619718	1530.50	1618.104703	87.604703
2008	7910.08	7779.46	130.62	3852.00	3663.633742	188.366258	1502.50	1627.058416	124.558416
2009	8075.00	7881.44	193.56	3865.50	3720.764419	144.735581	1585.00	1636.064105	51.064105
2010	8205.20	7984.76	220.44	3925.80	3778.78599	147.01401	1589.40	1645.118416	55.718416
2011	8285.60	8089.43	196.17	4004.70	3837.71235	166.98765	1615.50	1654.222836	38.722836
2012	8350.00	8195.47	154.53	4025.40	3897.557592	127.842408	1648.00	1663.377641	15.377641

Source: Central Bank of Nigeria Statistical Bulletin and National Bureau of Statistic (NBS)

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