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Long Term Load Forecasting Using Artificial Neural Network

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ABSTRACT:*Power supply is becoming more complex as a result of increasing population, expansion and improper planning of government and individuals. Monthly electric energy consumption data from January 2008 to February 2013 were obtained from Works and Services Department of Federal University of Agriculture, Abeokuta, Ogun State (FUNAAB). Artificial Neural Network on Matlab version R2012a was trained to forecast electric load consumption of FUNAAB from 2013 to 2027. Regression plots of the Neural Network were performed. The forecasted result indicated that by 2027 the consumption load of FUNAAB would be 1.94 x 10^5kwh (10104.1 kVA and 8083.3 kW).The regression plots displayed the network outputs with respect to targets for training, validation and test sets. The data fell along a 45 degree line, where the network outputs were equal to the targets, with a significant correlation coefficient R = 0.69. Load forecasting could be done for a state or a country to develop her electricity in infrastructure.*

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I. INTRODUCTION

Electrical loads are changing everyday as result of modern civilization and advances in technology. Residential, commercial and industrial loads are never constant resulting in the under loading or over loading of power systems[1]. The same applies to the Federal University of Agriculture, Abeokuta. As a result, there is need to forecast the future load demands in Federal University of Agriculture, Abeokuta, Ogun State. This will help to determine and estimate the amount of load required and prepare for the generation capacity that would meet the load demand. Load forecasting is a method of estimating the electric load required by a certain geographical area using previous records of load usage in that geographical area and other important factors such as population, weather forecasts etc.[2].It is carried out using future electric load demand values by mainly extrapolating past load consumption and considering other factors which affect the amount of electrical load used in any place at any point in time [3].

Load forecasting helps an electric utility to make crucial and necessary decisions including decisions on purchasing and generating electric power, load switching, and infrastructural development[4]. Load forecasts are extremely important for energy suppliers, financial institutions, and other participants in electric energy generation, transmission and distribution. Some factors that affect electric load forecasting include: time factor, weather condition, socio-economic (working days or festivities) and cultural conditions, historical load data and type of area [5][6]. All these factors determine the amount of load that would be required by a particular area at any point in time.

II. METHODS OF LOAD FORECASTING

Electric load forecasting is challenging because of the different characteristics of the electric loads associated with them. There are various methods used to forecast electric load. They are broadly divided into 2 main groups. They are: statistical methods – which involve a lot of mathematical analysis and expert systems (which is the use of computer for load forecasting).
The methods mostly used are discussed below:

(a) Simple Statistical Method

Statistical models usually require a mathematical model that represents load as functions of different factors such as time, weather, and customer class. The important categories of such models are additive and multiplicative models [4].

(b)**Expert Systems**

Expert systems incorporate rules and procedures used by human experts in the field of interest into software that is then able to automatically make forecasts without human assistance. This means this program can reason, explain and have its knowledge base expanded as new information becomes available to it. The load-forecast model can be built using the knowledge about the load forecast domain from an expert in the field [2].

Artificial Neutral Network (ANN).

It is a simplified model of the central nervous system and is form of artificial intelligence. Neural network is an attempt at creating machines that work similar way to the human brain by building these machines using components that behaves like biological neurons. Neural networks are interconnected neural computing elements that have ability to respond to input stimuli and to learn, to adapt to the environment.

This project developed a very simple model for predicting the electric load from 2013 to2027 in Federal University of Agriculture, Abeokuta, Ogun State using Artificial Neural Network.

The table below indicates the monthly electric energy consumption of Federal University Agriculture, Abeokuta, Ogun State from January 2008 to February 2013.

Table 1: 2008 Table of the monthly electric energy consumption from Power Holding Company of Nigeria (PHCN) by Federal University of Agriculture, Abeokuta, Ogun State

Months	Unit consumed (kWhr) in 2008	Unit consumed (kWhr) in 2009	Unit consumed (kWhr) in 2010	Unit consumed (kWhr) in 2011	Unit consumed(kWhr) in 2012	Unit consumed (kWhr) in 2013
January	93591	107291	178150	63630	141730	274990
February	90391	90391	216630	106120	111790	155790
March	102020	95975	168020	102660	161490	215390
April	83605	106714	133450	159640	156350	7179.67
May	115354	92760	141100	242980	102420	
June	105734	58256	138360	24030	124870	
July	89743	76918	190950	72010	131580	
August	82066	76020	178950	104610	138340	
September	70060	104139	178840	63360	130850	
October	136478	91898	102020	94550	139650	
November	176806	106230	85230	100100	205020	
December	125901	178150	86300	163340	182120	
Mean	105979.1	93873.8	149833.33	108085.83	14385.85	
Average consumption per day	3532.64	3129.13	4994.44	3602.86	4795.03	
Total unit consumed	**1,271,749**	**1,184,742**	**1,798,000**	**1,297,030**	**1,726,210**	**430780**

III. FORECASTING RESULTS

(a) Load forecasting

This project predicted the total load consumption in a given year from 2013 – 2027 using a long-term forecasting procedure built on the Artificial Neural network model using MATLAB. The equation representing the model showed in equation 1

$$y_{t+1} = f\left(y_t, y_{t-1}, \ldots.\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where t represents the present year and y represents the mean power in kWhr.

To ensure efficiency of the network, the data were normalized so that the input to the network was within the range of 0 to 1 as given by the equations 2 and 3

$$y_{norm} = \frac{y - y_{\min}}{y_{\max -} y_{\min}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The data after simulation or forecasting was restored with the equation 3 below:

$$y = y_{norm} X\left(y_{\max} - y_{\min}\right) + y_{\min} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

The network was trained for 1000 epochs (runs).

Network Performance

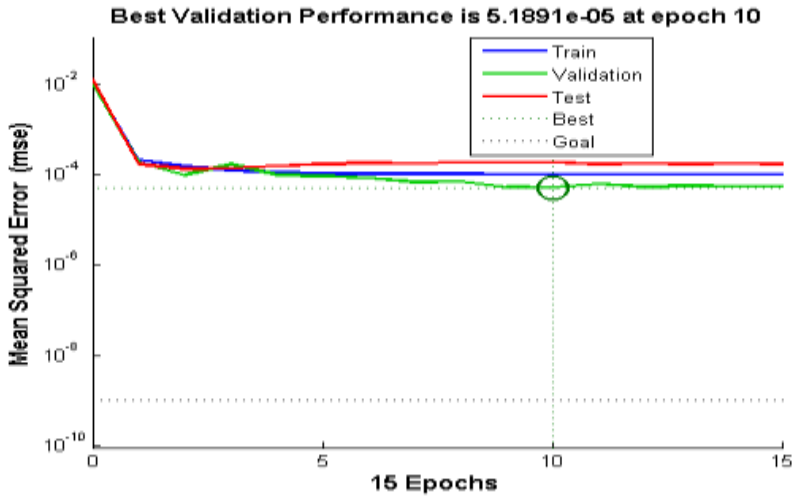

Figure 1: Network Performance

The graph in the figure 1 showed the performance of the network during the training process (set by the number of epochs used). During the training process, the data was divided into three, train data, test data and validation data. For this model, the trained data was 70% of the total data and others were 15% each. These sets of data were used to adjust the parameters of the network for the best performance during the process. Training stopped when a set validation criteria was met, i.e. where all data sets were at their lowest, which in this case occurred at the 10^{th} epoch. The graph in figure 2 showed the forecasted result from 2013 to 2027, there was a gradual rise in power consumption based on existing power consumption pattern, it was expected that by 2027 the load consumption of FUNAAB will rise to1.94 x 10^5 kwh. Also table 2 indicated the monthly loads consumption forecasted for FUNAAB from 2013 to 2027 in kwh.

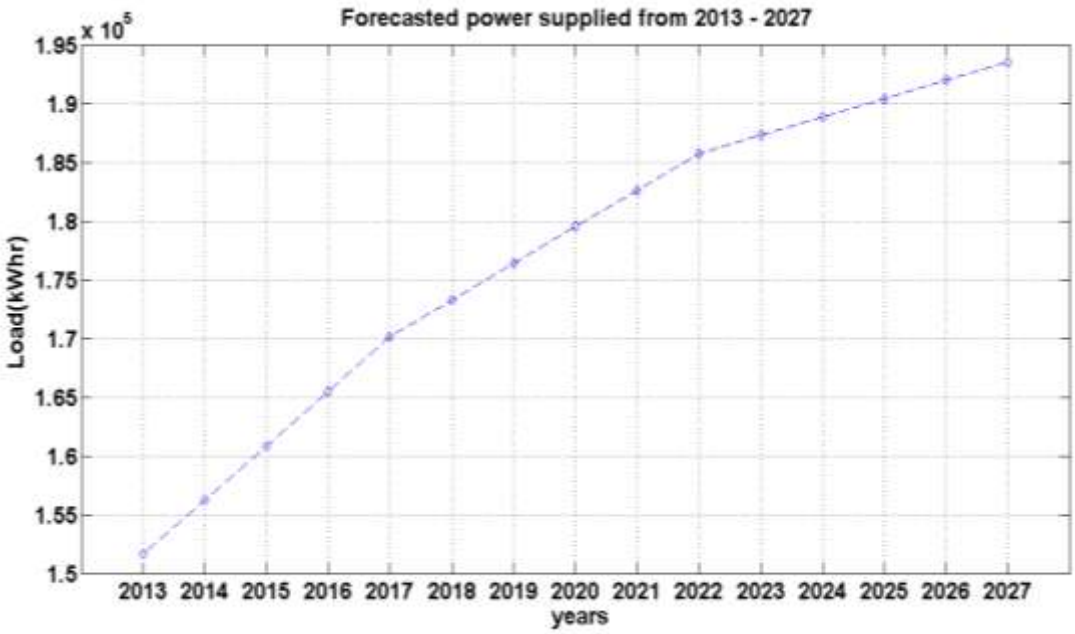

Fig 2: Forecasted load consumption from 2013 to 2027.

Table 2: Complete loads forecast result from 2013 to 2027 in KWhr

	2013	2014	2015	2016	2017	2018	2019
JAN	102943.6	116263.8	175061.9	87689.05	147773.1	111544.5	126681.8
FEB	100530.3	100530.3	160070.4	114956.5	121452.2	109106.4	109106.4
MAR	110594.5	104915.4	165500.4	111250.6	159861.1	120055.4	113637.8
APR	96212.75	115616.7	142923.1	158420.8	156052.2	105120.4	125931.8
MAY	125626.2	102291.6	147441.8	17186.76	111003.4	136633.6	110871.8
JUN	114530.9	85960.41	145949.7	76014.88	135917.4	124665.6	97598.14
JUL	100072.8	92820.91	184346.2	90732.16	141602.0	108660.7	102338.8
AUG	95365.6	92416.93	175794.2	113308.1	145938.5	104396.9	102027.7
SEP	89973.97	112803.4	110594.5	87598.95	141056.6	100234.7	122640.5
OCT	144855.0	101634.3	110594.5	103718.6	146664.4	149390.2	110203.9
NOV	173810.9	115078.3	97156.5	108687.0	181684.3	170966.9	125304.9
DEC	136889.2	175061.9	97807.29	161376.3	178567.3	145100.2	172160.7

	2020	2021	2022	2023	2024	2025	2026	2027
JAN	172160.7	98688.88	150916.2	121164.7	137601.7	169390.3	107345.7	152652.1
FEB	158749.0	125162.9	132462.0	118331.7	118331.7	157754.9	136197.0	142238.4
MAR	163233.0	120821.1	158588.9	130958.6	123619.5	161286.7	131788.5	157637.1
APR	148393.7	157514.2	155849.9	113860.2	136917.7	151249.2	156862.1	155713.7
MAY	150739.9	74004.69	120532.3	144948.2	120378.7	152551.1	91547.29	131477.1
JUN	149957.0	92414.66	144514.6	135720.7	106345.1	152108.2	102026.0	149214.6
JUL	180345.9	100775.2	147706.1	117820.0	110920.1	177044.0	109347.2	150880.4
AUG	172856.4	123232.7	149951.1	113079.2	110602.4	170054.5	134304.9	152104.9
SEP	120055.4	98630.4	147418.8	108817.8	133701.8	130958.6	107291.2	150727.7
OCT	120055.4	112357.0	150330.1	151793.1	119601.0	130958.6	122116.8	152318.1
NOV	105949.1	117850.2	178200.9	168255.0	136331.6	114767.7	128499.8	175108.7
DEC	106534.5	159770.3	175445.2	149516.8	169390.3	115416.6	158519.7	172525.2

IV. CONCLUSION

Electric load required by the Federal University of Agriculture, Abeokuta, Ogun State was forecasted from 2013 to 2027 from the PHCN data that were available to the Federal University of Agriculture, Abeokuta, Ogun State using artificial neural network. The results obtained indicated the effectiveness of the developed method. The network was subjected to 50 training sessions with 1000 number of training cycles. After each experiment the network was tested for its ability to correctly classify the test data.

The results showed that ANN model with the developed structure can perform good prediction with least error and finally this neural network could be an important tool for long term load forecast.

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