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DEMAND FORECASTING OF INDUSTRIAL ELECTRICAL ENERGY CONSUMPTION FOR TAMILNADU STATE

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ABSTRACT

Energy consumption forecasting is vitally important for the deregulated electricity industry in India, particularly in Tamilnadu state. A large variety of mathematical methods have been developed for energy forecasting. In this study, historical data set including population (POP), Gross state domestic Product (GSDP), Yearly peak demand (YPD), and Per Capita income (PCI) were considered from the year 2005 to 2011.Firstly, the multiple linear regression model (MLRM)has been developed. The regression model outputs were optimized using Neural network method.

Keywords: *Forecasting, Energy consumption, ANN (Artificial Neural Network), Long term forecasting and MLRM (Multiple Linear Regression Model).*

1.Introduction

Developing energy-forecasting models is known as one of the most important steps in long-term planning. In order to achieve sustainable energy supply towards economic development and social welfare, it is required to apply precise forecasting model. The present study has a focus on the future energy prediction of a state in India, facing electricity demand deficit problems every year due to increased demand for its energy use. In order to predict the long-term energy forecasting, first the multiple linear regression models were developed to forecast total energy consumption. Then regression coefficients were optimized using optimization technique. The input variables affecting the electricity consumption were analyzed by correlation coefficient analysis. The variables considered for the forecasting are population (POP), Gross state domestic product (GSDP), Yearly Peak Demand (YPD), and Per Capita Income (PCI) [1]. The electricity demand of Iran was estimated based on economic indicators using particle swarm Optimization (PSO) algorithm [2]. PSO and GA demand estimation models were formed to estimate the future Oil demand values [3]. An integrated genetic algorithm and artificial neural network and a forward feeding back-propagation (BP) method improved by GA were obtained for the fore casting of energy consumption [4&5]. A genetic algorithm energy demand (GAEDM) model based on past data of economic indicators was proposed.

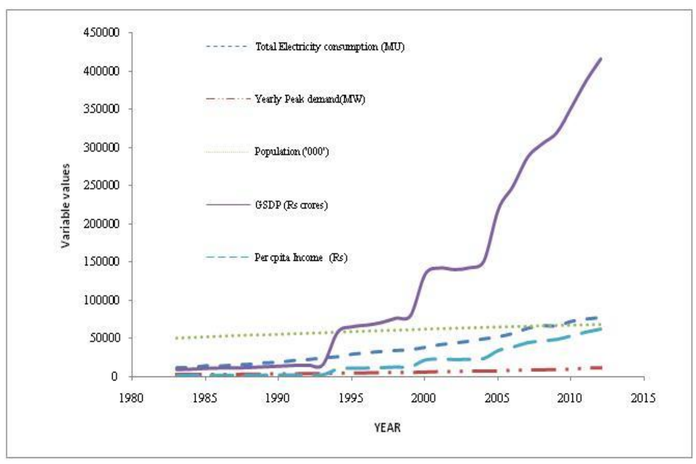

Fig. 1 The historical data of the variables from 30 years 1983 to 2012 for Tamilnadu state

2. Methodology

2.1. Regression techniques

Regression models are quite common in load forecasting and used to model the relationship between the load and external factors. Regression methods are relatively easy to implement. A further advantage is that the relationship between input and output variables is easy to understand. The proposed methodology is multiple linear regression analysis is used for modeling the energy consumption in Tamilnadu in this part of the

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study. The model taking the various socio-economic and demographic variables in to consideration.

$$P_{redicted} = w_0+w_1x_1+w_2x_2+w_3x_3+w_4x_4$$

Where x_1,x_2.x_3 and x_4 are Yearly Peak demand, Population, Gross State Domestic Product, and Per Capita Income respectively.w_0,w_1,w_2,w_3 and w_4 are the regression coefficient. The multiple linear regression equation thus formed is to be optimized using Neural network method.

Initially MLRM is formed based on the socio-economic indicators. The regression coefficients were estimated by statistical analysis using least square method. The data from 1983 to 2012 was used in the regression model. The linear regression equation obtained is 60176+2.025*PD+1.334POP +0.2493GSDP-1.241PCI

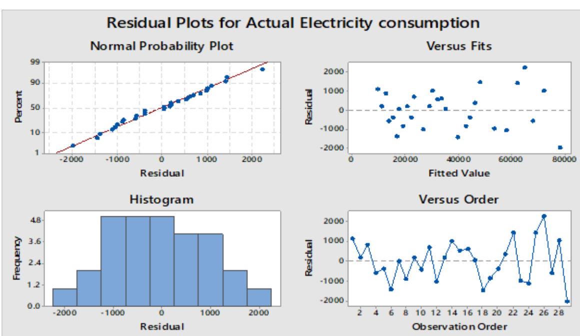

Fig.2 Regression Analysis: Actual Electricity versus Peak demand, population, GSDP at constant prices, Per capita Income

Table 1 Analysis of Variance

Source	DF	ADJ SS	ADJ MS	F-Value	p-Value
Regression	4	11228033823	2807008456	2377.86	0.000
Peak demand met (MW	1	6115581	6115581	5.18	0.032
population	1	25352663	25352663	21.48	0.000
GSDP at constant prices	1	7525869	7525869	6.38	0.019
Per capita Income at constant prices	1	4333830	4333830	3.67	0.067
Error	24	28331457	1180477		
Total	28	11256365279			

Table 2 Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1086.50	99.75%	99.71%	99.47%

Table 3 Coefficients

Term	Co-ef.	SE. Co-ef	T-Value	P-Value	VIF
Constant	-60176	13209	-4.56	0.000	
Peak demand met (MW)	2.025	0.890	2.28	0.032	144.35
Population	1.334	0.288	4.63	0.000	56.94
GSDP at constant prices	0.2493	0.0988	2.52	0.019	3321.86
Per capita Income at Constant prices	-1.241	0.648	-1.92	0.067	3180.74

Regression Equation

Actual Electricity consumption = -60176 + 2.025 Peak demand met (MW) + 1.334 population + 0.2493 GSDP at constant prices-1.241 per capita Income at constant prices

2.2. Artificial Neural Network

The Neural network is implemented with Mat lab 2014. Here we describe the method discussed by Liuetal (1996), by using fully connected feed-forward type neural networks. The network outputs are linear function of the weights that connect input and hidden units to output units, therefore the linear equations can be solved for these output weights, In each iteration through the training data (epoch), the output weight optimization training method uses feed forward back-propagation to improve hidden unit weights, then solves linear equations for the output weights using the conjugate. The aim of this technique is to minimize the MAPE.

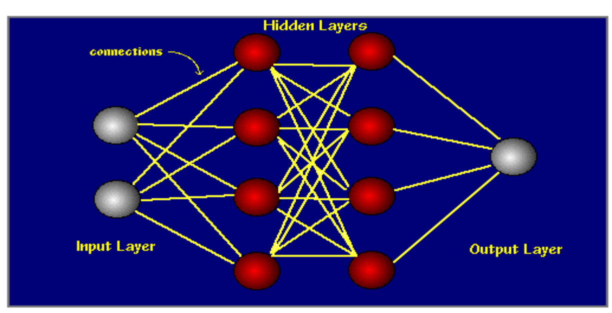

Fig. 3 Graphical Representation of Artificial Neural network

Neural networks are typically organized in layers. Layers are made up of a number of interconnected 'nodes' which have an 'activation function'. Patterns are presented to the network through the 'input layer', which communicates to one or more 'hidden layers' where the actual processing is done via a system of weighted 'connections'. The hidden layers then link to an 'output layer' where the answer is output as shown in below.

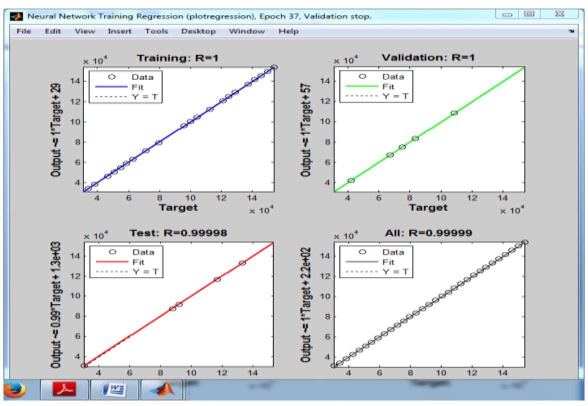

Fig.3 Regression plot-neural network

The above Graphical plot represents the value of R approximately equal to one which represents the best fit of the data.

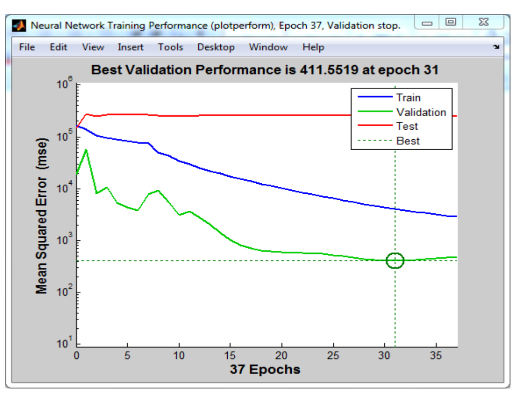

Fig.4 Performance plot-neural network

The MAPE was used to estimate the error between the actual and predicted value of Electrical Energy consumption. The MAPE error is calculated using the following formula

$$MAPE = \frac{\dfrac{\sum |Actual - Forecast|}{Actual} \times 100}{n}$$

3. Result

Table 4 Relative error between actual and predicted value using the model

Year	Actual data(mu)	MLRM	MAPE error(%)	ANN	MAPE error(%)
2010	72887	72075	1.1140	72250	0.8739
2011	76071	76512	0.5797	76630	0.7348
2012	77819	81170	4.3061	81150	4.2804
2013	83661	86049	2.8543	85880	2.6523
2014	87790	91150	3.8273	90850	3.4855
Average			2.53628		2.4053

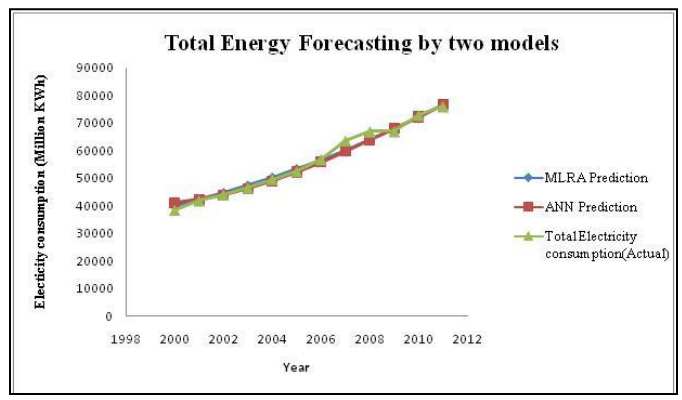

Fig.5 Total energy forecasting by MLRA and ANN Model

4. Conclusion

Hybrid techniques were proposed to predict the total energy consumption for the data collected for Tamilnadu state in India. The MAPE error obtained for the models MLRM and ANN were 2.53 and 2.40 The MAPE error for ANN model has higher accuracy than MLRM. The obtained result can be used to estimate the future energy consumption.

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