Scientific Journal of Impact Factor(SJIF): 3.134

e-ISSN(O): 2348-4470
p-ISSN(P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 2,Issue 4, April -2015

Application of Artificial Neural Network for Short Term Load Forecasting

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Abstract — *In this paper Artificial Neural Network (ANN) is use to study the Short Term Load Forecasting. The Feed forward Network is use for Day Ahead Hourly Load Forecast. One Fast training algorithm Levenberg-Marquardt (LM) is use for getting data accurate Result. The Model is train using Historical data of ISO New England. Only one month 30 Day November month load data is use. For Very accurate and less error weather data and Holiday is consider. The sensitivity of the parameters is also researched. In parameters the weather data, Holiday and change the number of Neurons all case is consider. For Network Performance MAE and MAPE is find.*

Keywords- *ANN, Feed Forward Network, Short Term Load Forecasting, Mean Absolute Percentage Error (MAPE).*

I. INTRODUCTION

Short Term Load Forecasting is important for the Unit Commitment, To Reduce Spinning Reserve Capacity and Schedule Maintenance plan. Accurate Load Forecasts are essential in both energy planning and operation [1]. Short Term Load Forecasting has been useful in safe and Economical Planning operation of an Electrical Power System. It has been also used in start-up and shut-down schedules of generating units, overhaul planning and Load Management [2]. With accurate Short Term Load Forecasting that result in Economic Cost Savings and increase system security [3].

The Short Term Load Forecast is not only depends on the Historical Load but it also depends on weather parameters. For accurate Forecast these parameters also consider. Past few years Number of Short Terms Load Forecasting Technique was Developed Like Linear Regression, Artificial Neural Network, Expert System, Fuzzy Inference and Tree Bagged [3][4][5]. ANN as the Human Brain to train known information. It is also can use weather parameter easily. ANN is able can use perform nonlinear modelling and adaptation. It does not need assumption of any functional relationship between load and weather variables in advance [2].

In this paper ANN is use for the Short Term Load Forecasting. ISO New England 30 Day November month Load data is use for the training and testing of Neural Network. The weather Data is correlated with Load data so Weather data is also take as a different parameters. MATLAB R2014b is use for the modelling and Simulation of the Neural Network.

This paper is organized in V Section. Section II described about Artificial Neural Network. Section III detail about Data Analysis and Data Input. Section IV is Simulation and Result. Section V is Conclusion.

II. ARTIFICIAL NEURAL NETWORK

An ANN or Neural Network is a computational model inspired by a biological Nervous System [6]. Similar to human beings they learn from experience.

An ANN Characterized by

- Its pattern of Connection Between the Neurons (called its Architecture).
- Its methods of determining the weights on the connections (called its training or Learning algorithm).
- Its activation function.

$$S = \sum_{K=1}^{N} X_K W_K + b$$

Where X_k are inputs
W_k are weights
b is bias

In Fig. 1 only one node of the Feed Forward Neural Network is shown. Mostly log-sigmoid activation function is use mathematically,

$$f = \frac{1}{1+e^{-X}}$$

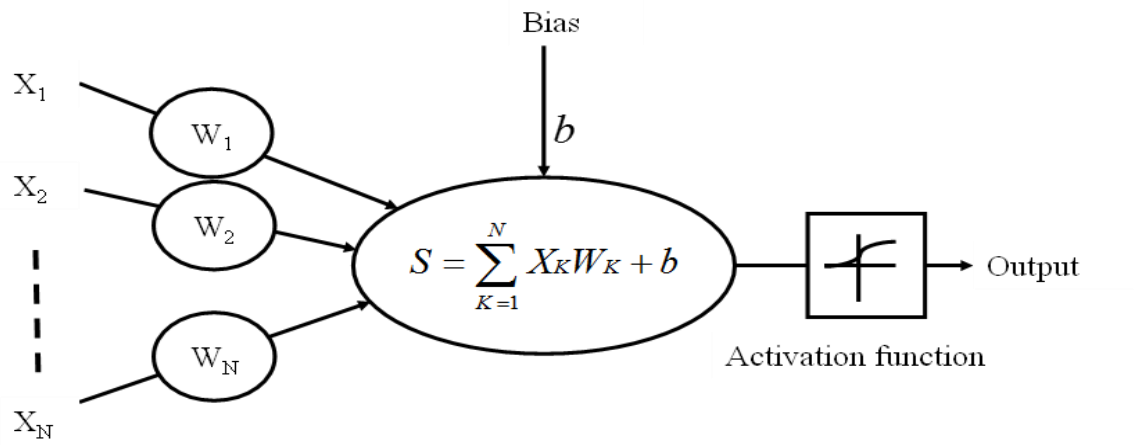

Fig. 1 Artificial Neuron

The output of each neurons acts as input for the transfer function act each node. Starting from a random initial point, the learning algorithm determines the weights. In this paper supervised learning is use for minimized error. Fig. 2 is the block diagram of the supervised learning.

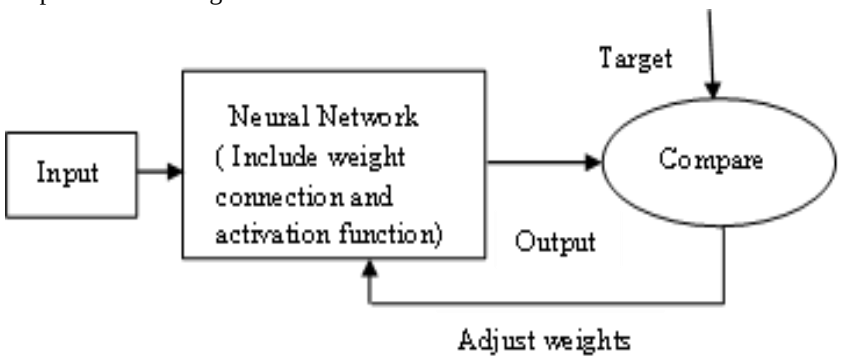

Fig.2 Supervised learning

In this paper the algorithm use for the Train to Feed Forward Network is Levenberg-Marquardt (LM) algorithm is use.

III. DATA ANALYSIS AND DATA INPUT

ISO New England one month 01-November to 30- November Historical Load data is use for Short Term Load Forecasting. Weather data is also affect on the Demand Load so Weather data is use for Forecasting Load Data. In this paper many affecting factor on Short Term Load Forecasting are consider for more accurate result.

Input used in this paper,

- *Load Data* : Total Load is more related with previous week and previous 24 hour. To Forecasting day these Data are helpful for accurate Forecast Load. Fig. 3 is plot of System load of November month.
- *Temperature* : Temperature is Different in early morning, afternoon and evening so Loads like AC, Fan and Heater are depends on Temperature.
- *Day of the Week* : Day of the Week is also consider. It is working day or off day.
- *Holiday* : Holiday is also consider because in working day may be its public holiday then it is off day.

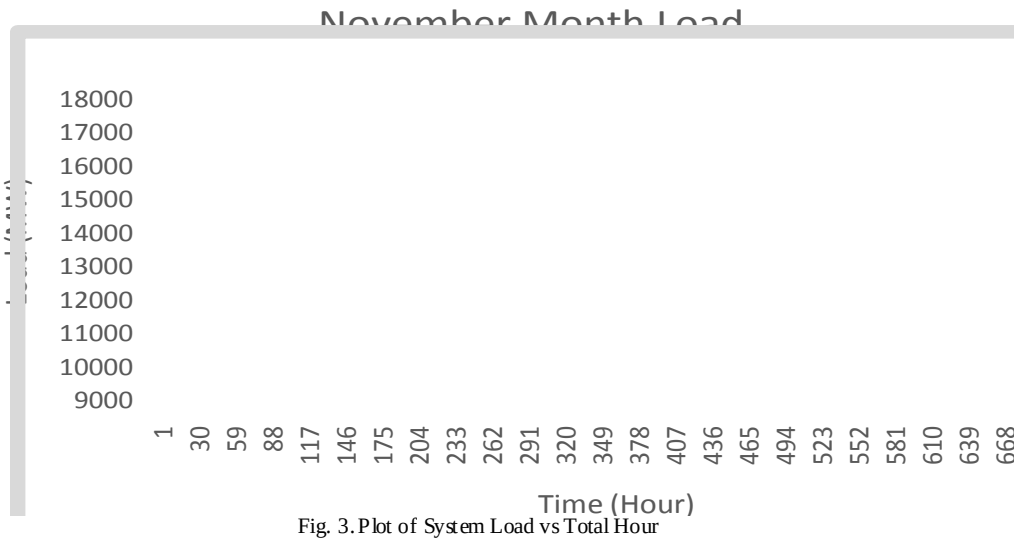

Fig. 3. Plot of System Load vs Total Hour

For greater accuracy and less error in this paper these all factors are consider as an input parameters of Neural Network. 8 numbers of Input Node is taken and 3 layer Feed Forward Neural Network is use for create Model and find error in Mean Absolute Error (MAE) and Mean Absolute Percentage Error (MAPE).

$$\mathrm{MAE} = y_t - \hat{y}_t$$

$$\mathrm{MAPE} = \frac{1}{n}\sum_{t=1}^{N}\frac{\left|y_t - \hat{y}_t\right|}{y_t} * 100$$

Where N is Number of Data

y_t is Actual Load

$\hat{y}_t$ is Forecasted Load

IV. SIMULATION AND RESULT

The following section describe about Simulation and Result. MATLAB R2014b software is use in this paper. For simulation purpose all data is converted is matrix form. Total 720 x 1 Hourly Data is use for one Node. LM algorithm is use to train model. Because this algorithm is Fast and give more accurate Result then other. Only last Day 30th 24 hour 24 x 1 Data of one Node is use as a Target and rest of Data use for Train Network. Same things apply for other input node. Totally 8 number of input Node in Input Layer and in Hidden Layer Node change 10 and 20. Only one output node is use for output. Log-sigmoid activation function use in hidden layer.

In this paper Simulation is done for both case with weather data and without weather data. Also change numbers of hidden node for both case to check effect of changing hidden node on Result. Result find in terms of MW at output Node, It is Forecast Load. Accuracy of the Model Find with Errors Mean Absolute Error (MAE) which is in same unit of input and Mean Absolute Percentage Error (MAPE) Which is in Percentage. Simulation Result shown in below Tables and Graphs.

In this paper Four case are use given below

1. *Without Weather Data with 20 Hidden Neurons.*

In this case weather data are not consider. So In 1st and 2nd case only 6 input Neurons is use in Input Layer. And 20 Hidden Neurons in Hidden Layer. Result in this case Total MAPE of 24 hour is 1.61 and Forecasted Load is shown in Fig. 4. The Minimum MAPE is at 12th hour and value is 0.027.

2. *Without Weather Data with 10 Hidden Neurons.*

With case 2 without considering weather data with 20 Hidden Neuron. A Total MAPE of 24 hour is 1.14 that is batter then case 1. Minimum MAPE is 0.04 at 15th hour that is not good compare to case 1 But overall MAPE is much batter. Forecasted Load in case 2 is shown in Fig. 5.

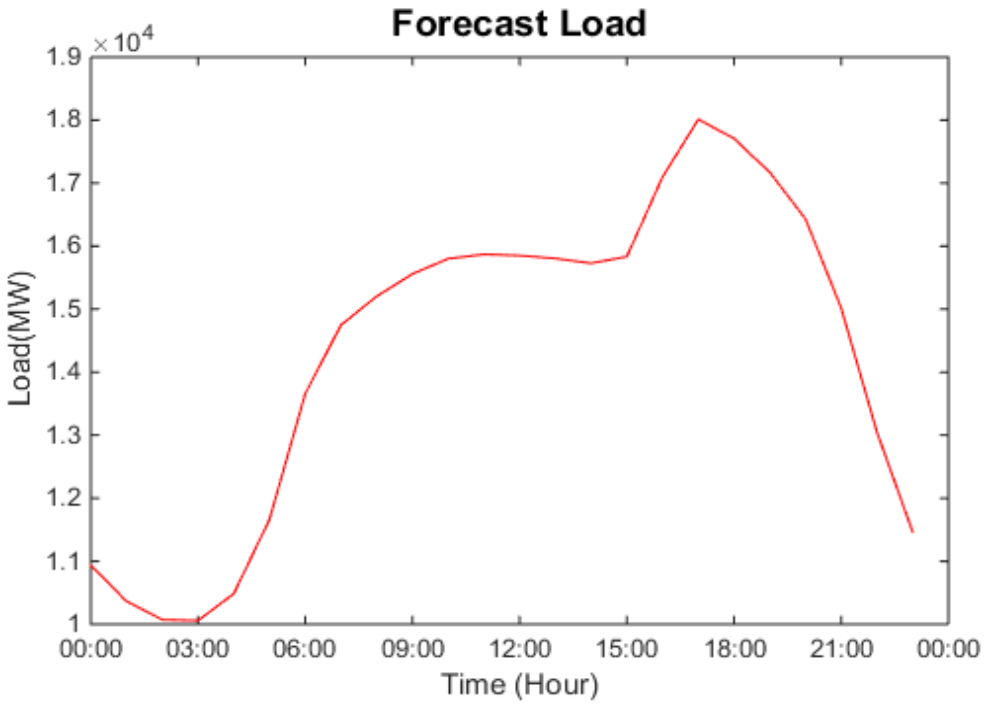

Fig. 4. Hourly Forecast Load for Case 1.

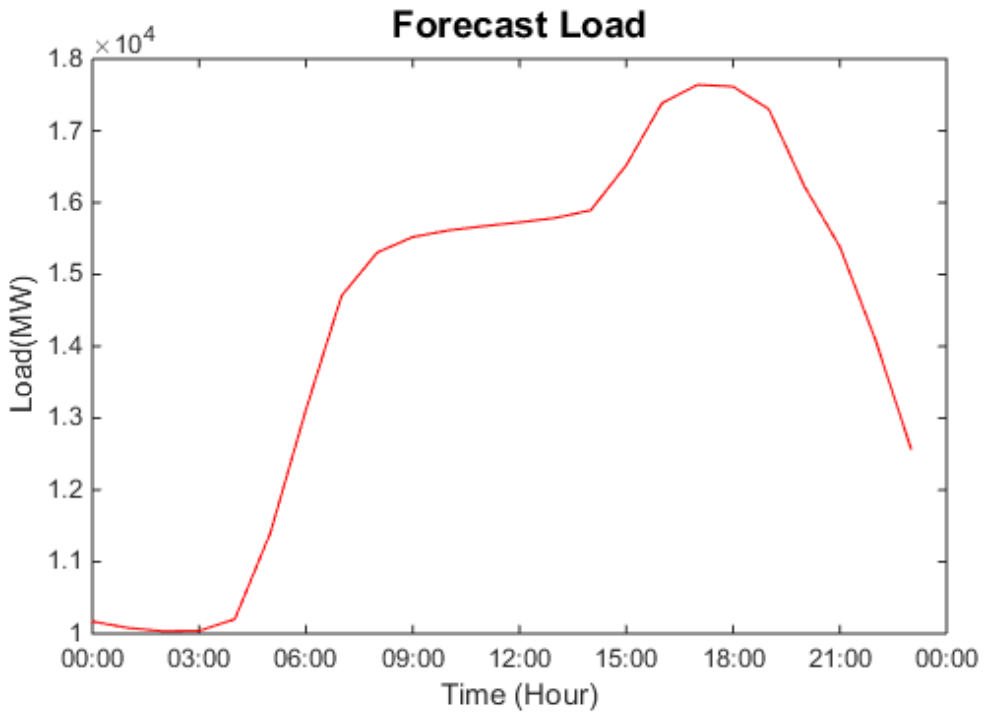

Fig. 5. Hourly Forecast Load for Case 2.

3. *With Weather Data with 20 Hidden Neurons.*

In Next both Weather data consider. As a weather data Dew Point and Dry Bulb are consider so two input Neuron add so in case 3rd and 4th 8 Input Neurons is use in Input Layer instead of 6.

In case 3 20 Neurons is use in Hidden Layer. A Total MAPE of 24 hour is 1.37 that is batter then case 1 but not good compare to case 2 and at 19th hour Minimum MAPE that is 0.15. Fig. 6 is Graph of Forecasted Load for case 3.

4. With Weather Data with 10 Hidden Neurons.

In this case 10 Hidden Neuron is taken in Hidden Layer and Both Weather data is Consider. Network of the Case 4 is shown in Fig. 7, for other case same Network is use only Input Neurons and Hidden Neurons change. In case 2 model is same only different is Input is 6. And in case 3 input is same hidden Neurons is 20 instead of 10 But in case 1 both different input is 6 and Hidden Neurons is 20 only that change in Fig. 7.

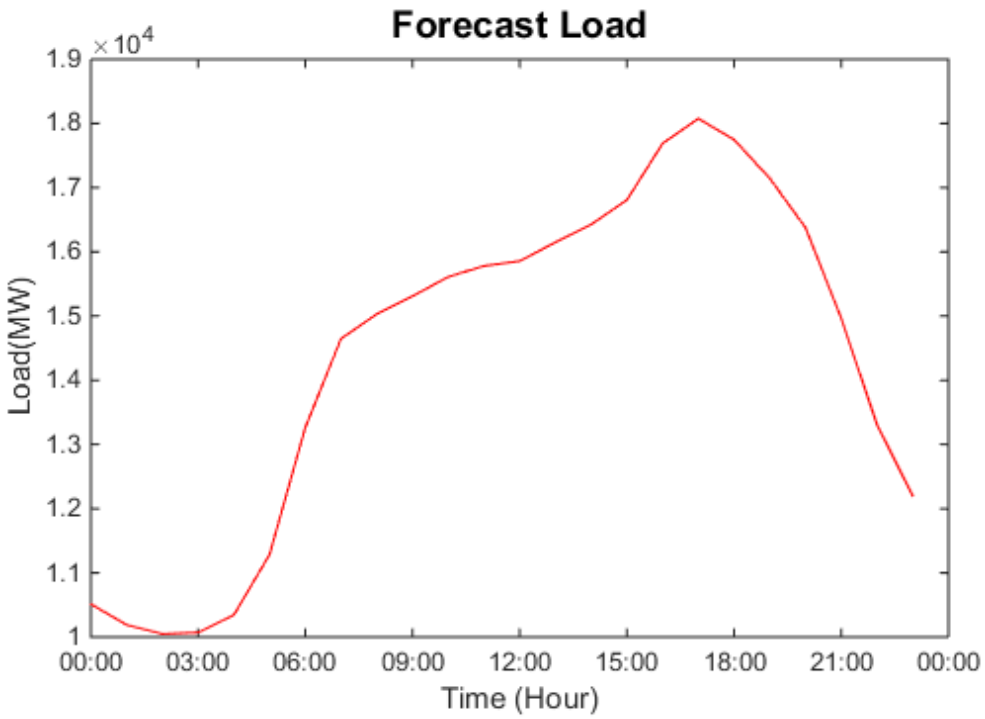

Fig. 6. Hourly Forecast Load for Case 3.

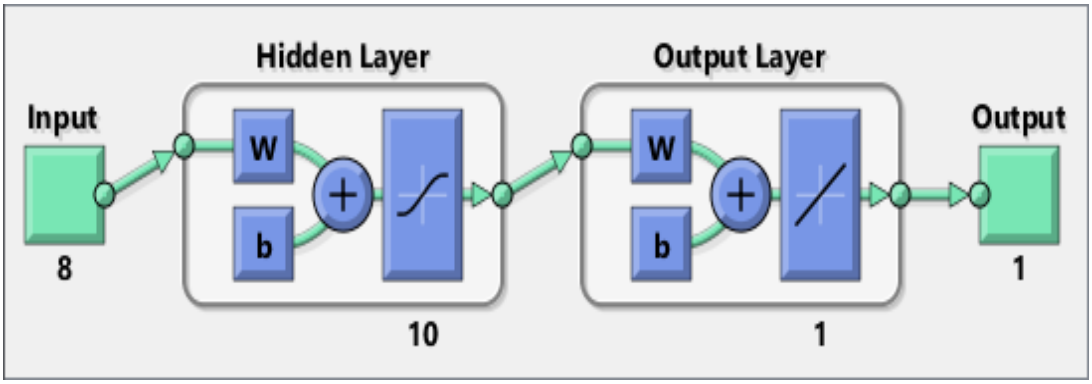

Fig. 7. Model of Neural Network.

In this case Result 1.04 is Total MAPE of 24 hour which is best in all four case. Minimum MAPE is getting at 16th hour with value 0.025 which is also best in Minimum MAPE of individual Hourly MAPE. In Fig. 8 Forecasted Load for case 4 is shown which is most Accurate and Least Error. Overall error and individual error of case 4 is least so Model of case 4 is best compare to other cases. And in Table 1 all 24 hour MAPE is given of case 4.

Regression value or R-value of Target is 1 and R-value case 4 is 0.99775 R-value is also call correlation coefficient. In Fig. 9 Regression Plot of case 4 is shown. R-value of other case are 0.99379, 0.99737, 0.9953 respectively case 1, case 2 and case 3. So R-value of case 4 is so much closer to Target so Result of case 4 is much closer to Actual Value. In Fig. 10. Comparison of Actual Load and Forecast Load of Best result of Case 4 is show. In Fig. 11 All case Forecast Load compare with Actual Load. And in Table II All case hourly MAPE is given.

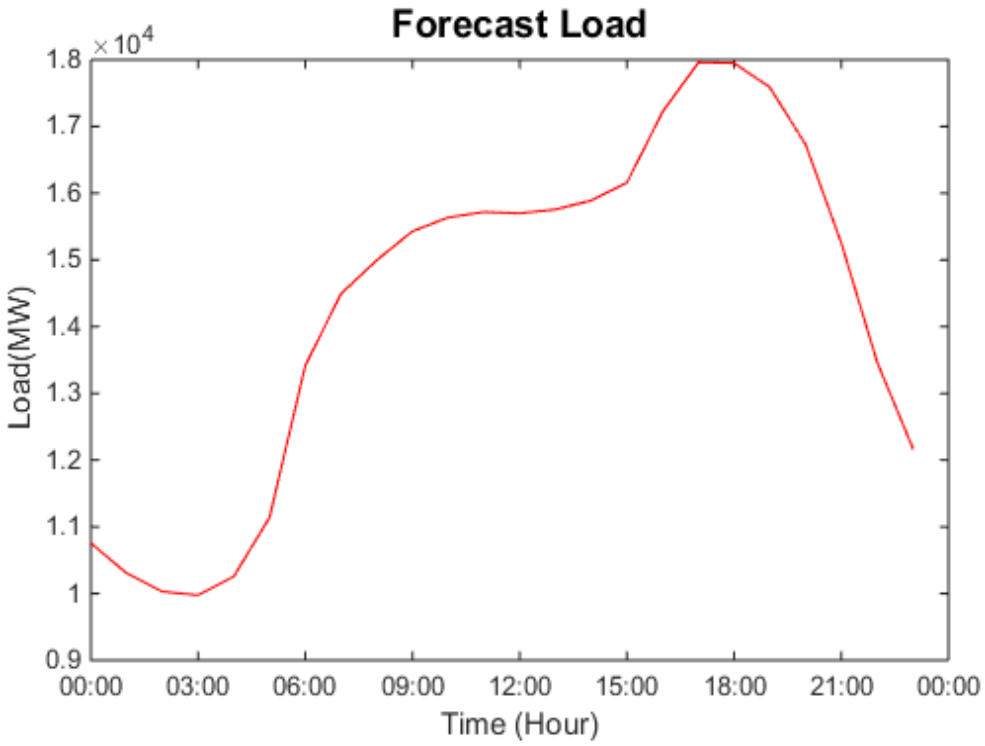

Fig. 8. Hourly Forecast Load for Case 4.

TABLE I

24 HOUR MAPE OF CASE 4.

Hour	MAPE
1	1.951
2	1.927
3	1.311
4	0.884
5	0.132
6	1.961
7	0.256
8	1.762
9	0.984
10	0.238
11	0.701
12	0.927
13	1.392
14	1.029
15	0.038
16	0.025
17	0.164
18	0.138
19	1.298
20	2.061
21	1.429
22	0.357

23	2.605
24	1.471

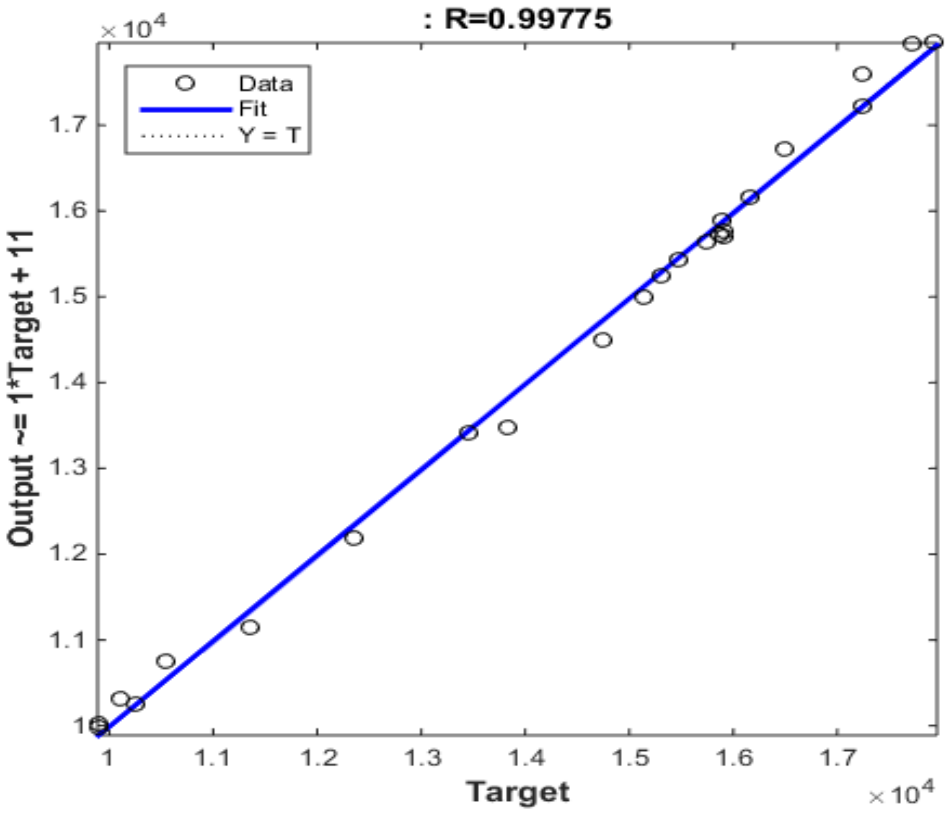

Fig. 9. Regression Plot of Case 4.

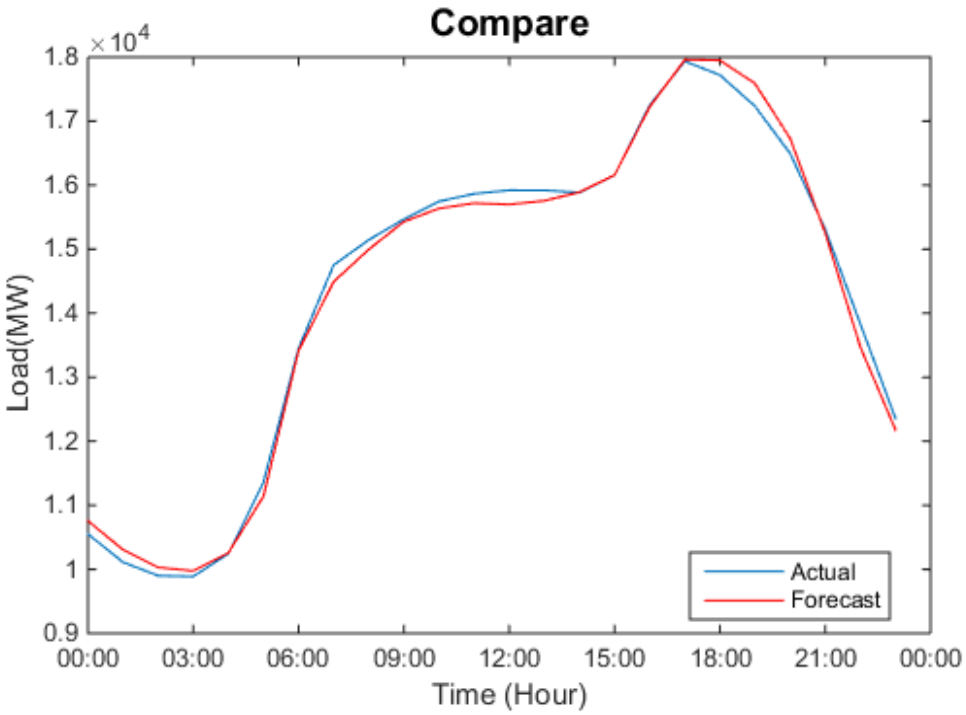

Fig. 10. Comparison of Actual and Forecast Load of Case 4.

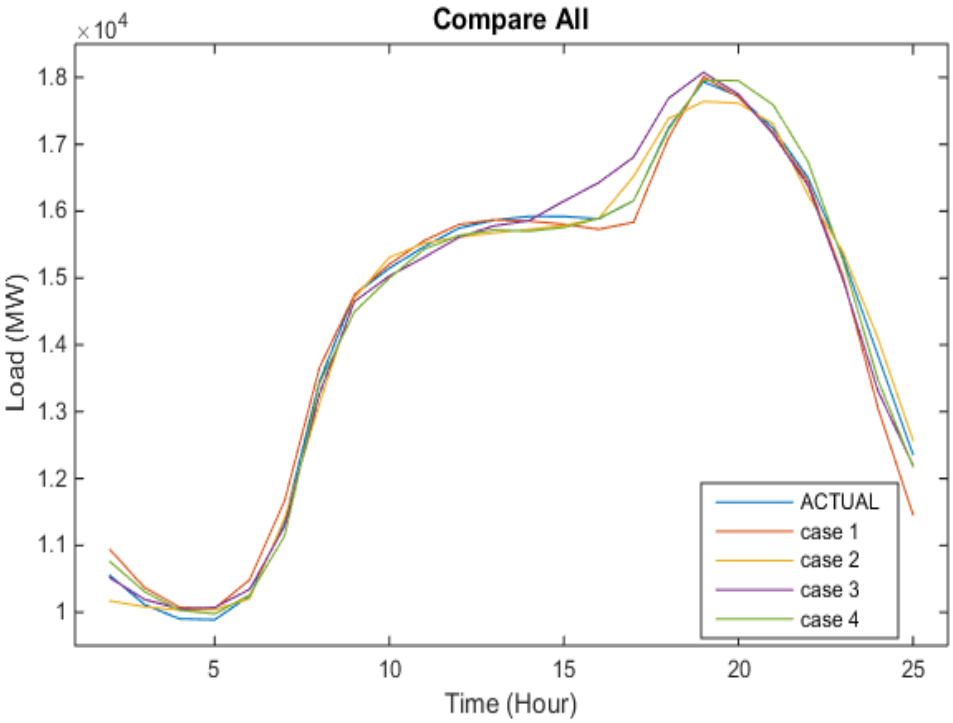

Fig. 11. Comparison of Actual and Forecast Load of All Case.

TABLE III

24 HOUR MAPE OF ALL CASE .

Hour	Case 1	Case 2	Case 3	Case 4
1	3.639	3.617	0.355	1.952
2	2.517	0.309	0.782	1.927
3	1.733	1.347	1.496	1.311
4	1.729	1.528	1.843	0.885
5	2.343	0.431	0.96	0.132
6	2.648	0.343	0.692	1.961
7	1.529	2.48	1.407	0.257
8	0.034	0.344	0.716	1.762
9	0.388	1.055	0.766	0.985
10	0.586	0.345	1.027	0.239
11	0.345	0.851	0.87	0.702
12	0.028	1.215	0.538	0.928
13	0.435	1.227	0.404	1.392
14	0.724	0.841	1.438	1.029
15	0.985	0.049	3.413	0.039
16	1.984	2.267	4.043	0.025
17	0.873	0.782	2.552	0.165
18	0.435	1.64	0.787	0.139
19	0.073	0.598	0.156	1.298
20	0.354	0.409	0.507	2.061
21	0.391	1.595	0.732	1.429
22	1.911	0.502	2.245	0.358
23	5.687	1.86	3.802	2.605
24	7.276	1.709	1.32	1.472

V. CONCLUSION

Individually Two case is relate to other two case for study of each parameter. Case 4 is compare with case 2 for study of how much affect Weather Data of Short Term Load Foresting. Case 4 and case 2 MAPE are respectively 1.04 and 1.14. And other two case 3 and case 1 MAPE is 1.37 and 1.61 respectively. Weather data is consider in case 4 and case 3 so MAPE of those are less compare no consider case 2 and case 1. With both case Result is much better with consider Weather Data. So if weather Data use then getting accurate Forecast Result. So weather is important parameter for accurate Short Term Load Forecast.

Next parameter is change in number of Hidden Neurons. For this pair of cases are case 4 – case 3 and case 2 – case 1. MAPE of 1st pair case 4 and case 3 are 1.04 and 1.37. So with lesser number of Neurons Error is less. Consider 2nd pair in this also result is batter with case 2. So with using lesser number of Hidden Neurons getting less error and accurate result.

In both case relationship of weather data with load data is Nonlinear but Neural Network is very useful for nonlinear function and it is self-learning Technique. So With Neural Network Getting Best Short Term Load Forecasting.

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