International Journal of Electrical and Electronics Research ISSN 2348-6988 (online)
Vol. 4, Issue 4, pp: (87-94), Month: October - December 2016, Available at: www.researchpublish.com

An Approach for Short Term Load Forecasting Using Fuzzy Logic

[1]Gurshan Singh Hans, [2]Jagdeep kaur, [3]Er. Simerpreet Singh

[1]Student (B.tech, Eletrical Engg), Deptt. of Electrical Engineering, Guru Nanak Dev Engineering, College, Ludhiana, Punjab
[2]Student(M.tech,Electrical Engg),Deptt. Of Electrical Engineering, Bhai Gurdas Institute of Engineering and Technology Sangrur,Punjab
[3]Assistant Prof., Deptt. of Electrical Engineering, Bhai Gurdas Institute Of Engineering and Technology, Sangrur, Punjab

***Abstract*: Forecasting the electricity load demand is an important task in power utility companies because accurate load forecasting results are economic, reliable and secure power system operation and planning. Electricity demand forecasting is concerned with the prediction of a very short-term, medium-term and long-term load demand, depending on the time horizon. Short term load forecasting can help to estimate load flows and to make decisions that can prevent overloading. In this paper, a fuzzy logic approach for short term load forecasting is attempted. Time, temperature and humidity are used as the independent variables for short term load forecasting. The regression model that takes the weather parameters in winter season. The parameters of the model are estimated using static estimation algorithm and are used later to predict the load for twenty four hours ahead. The results obtained are discussed and conclusions are drawn. New fuzzy models are developed for crisp load power with fuzzy load parameters and for fuzzy load power with fuzzy load parameters. The fuzzy parameters are obtained for the model. s**
***Keywords*: Load forecasting, short term load forecasting, Fuzzy logic, Fuzzy inference system Introduction .**

I. INTRODUCTION

Load forecasting has been an integral part in the efficient planning, operation and maintence of a power system. Short term load forecasting is necessary for the control and scheduling operation of a power system and also acts inputs to the power analysis functions such as load flow and contingency analysis [1]. Owing to this importance, various methods have been reported, that includes liner regression, exponential smoothing, stochastic process, ARMA models, and data mining models [2]-[7]. Of late, artificial neural networks have been widely employed for load forecasting. However there exist large forecast errors using AAN when there are rapid fluctuations in load and temperatures [8]-[9]. In such cases, forecasting methods using fuzzy logic approach have been employed. In this paper, we propose an approach for short term load forecasting problem, using fuzzy logic approach. This approach has an advantage of dealing with the nonlinear parts of the abrupt change in the weather variables such as temperature etc.

In this method, we select similar days from the previous days to the forecast day using Euclidean norm with weather variables [10]. There may be a substantial discrepancy between the load on the forecast day and that on similar days, even though the selected days are very similar to the forecast day with regard to weather and day type. Therefore, the selected similar days cannot be averaged to obtain the load forecast. To avoid this problem, the evaluation of similarity between the load on the forecast day and that on similar days is done using fuzzy logic [12]-[14]. This approach evaluates the similarity using the information about the previous forecast day and previous similar days. The evaluated value represents a correction factor of load curve on a similar day to the shape of that on the forecast day. After calculating the correction factor of load curves on similar days, the forecast load is obtained by averaging the corrected load curves on similar days. The approach suitability is verified by applying it to a typical data set.

This paper contributes to the short term load forecasting, as it shows how the forecast can be include the effect of weather variables, temperature as well as humidity, using a new Euclidean norm for the selection of the similar days and fuzzy logic approach. The paper is organized as follows: section ll deals with the data analysis; section lll gives the overview of the proposed forecast method, discussing the selection of similar days using a new Euclidean norm and the fuzzy inference system is presented.

Variables Impacting the Load Pattern

The analysis on the monthly load and weather data helps in understanding the variables, which may affect load forecasting. The data analysis is carried out on data containing hourly values of load, temperature and humidity of 2 months. In the analysis phase, the load curves are drawn and the relationship between the load and weather variables is established [11]. Also, the week and the day of the week impact on the load is obtained.

II. CURVE FITTING TECHNIQUE

Curve fitting is defined as summarizing the trend in the data by allocating a single function across the whole range. Curve fitting is a method of making a curve or mathematical function which has the finest fit to a given data points. Extrapolation means to utilize fitted curve further than the series of the experimental records and is focused to a level of ambiguity. As it might reproduce the technique used to form the curve to the extent that it reflects the observed data. There are different types of curve fitting like polynomial curves to data points. As we increase the degree of polynomial the best fitted curve we get.

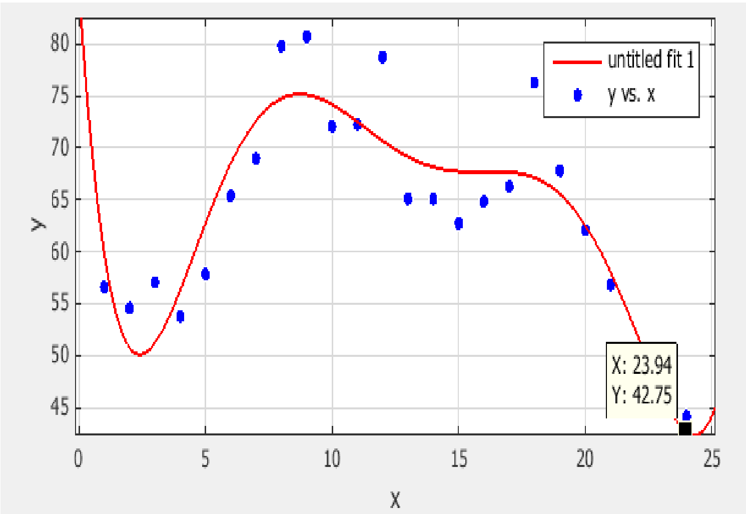


Fig.1 LOAD CURVE

The load curve for the month of August is shown in figure . The observations from the load curves are as follows:

There exists weekly seasonality but the value of load scales up and down.

1. The load curves on week days are mostly similar.
2. The load curves on the weekends are similar.
3. Days are classified based on their load into following categories:

a. Normal week days (Tuesday –Friday)

b. Monday

c. Sunday

d. Saturday

Monday is accounted to be different to weekdays so as to take care for the different in the load because of the previous day to be weekend.

III. PROBLEM FORMULATION

Short term load forecasting is necessary for the control and scheduling operations of a power system and also act as inputs to power analysis functions such as load flow and contingency analysis. STLF gives the accurate values to predict the load demand for a short period of one week.

Short term load forecasting is basically is a load predicting system with a leading time of one hour to seven days, which is necessary for adequate scheduling and operation of power systems. High forecasting accuracy as well as speed is the two most vital requirements of short term load forecasting and it is of utmost importance to analyze the load characteristics and identify the main factors affecting the load.

In this thesis, obstacle of STLF using Fuzzy is invented and resolved. Data collected from 220KV Sub Station Bhuna Haryana is analyzed and then this data is fitted in to fuzzy logic based model. Fuzzy approach has come out as supplement means to numerical methods for explaining power system difficulties.

Economic and reliable operation of an electric convenience depends upon a major degree of load forecasting precision. Appropriate load predictions with smaller proportion of error have to be prepared through the aid of fuzzy approach. A great assortment of arithmetical and artificial techniques (AI) has been build up for STLF to reduce prediction error. Electrical load requirement is subjected by various factors like economic, weather and social actions and dissimilar loads. So as to minimize the load forecasting error of the twenty four hour loads, the idea of fuzzy regression study is utilized for STLF difficulty.

Fuzzy methodology can be employed as an assist to predict the load among dissimilar lead instants. In Fuzzy, membership functions and set of laws are considered to present an easy procedure to execute experience and instinct into a computer. The model is code with help of Fuzzy Toolbox in MATLAB which executes and will give the desired results. This will be estimated load forecast for 24 hours ahead and will be compared with actual load data and will see the difference.

IV. FUZZY LOGIC

There are large varieties of mathematical methods that are used for load forecasting, the development and improvements of suitable mathematical tools will lead to the development of more accurate load forecasting techniques. The accuracy of load forecasting depends on the load forecasting techniques used as well as on the accuracy of forecasting weather parameters such as temperature, humidity etc. As per the recent trends artificial intelligence methods are the most pronounced for the STLF. From different artificial intelligence methods, fuzzy logic and artificial neural network are the most used.

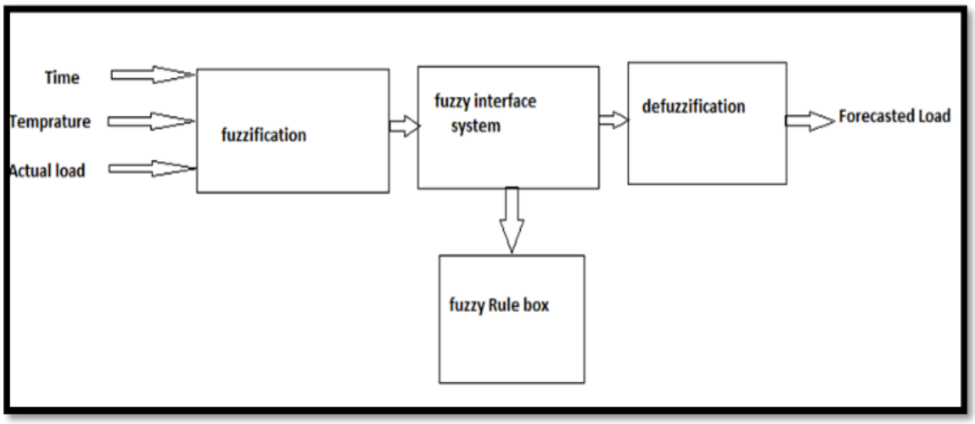


Fig.2 Block diagram of fuzzy logic methodology for short term load forecasting

Fig. shows the basic block diagram of presented work. The inputs to the fuzzy set based classifier i.e. hourly data of forecasted temperature and time are given to the fuzzy inference system through fuzzification block. The fuzzy inference block is the heart of the system as it processes the input data and gives output as the forecasted load. The inference system accomplishes the task of forecasting by the used of the fuzzy rule based prepared by the forecaster. The accuracy of the forecast depends on the experience of the forecaster, the rules prepared by the forecaster and the number of the prepared. After, the inference system gives output; the defuzzification block converts the fuzzified output to the crisp output which can be further displayed on a graph known as the load curve.

V. TEST AND RESULTS

Fuzzy logic based model is build up and presented for the STLF using the data from220 KV substation Bhuna Haryana. The key feature of the proposed method is the expansion of fuzzy approach for resolving estimating difficulties with ambiguity data for example day type, dissimilar load patterns and temperature.

The membership function and rules in the fuzzy logic formulation gives an instinctive and straight way to comprise Socratic to the load estimating. Thus the consequences obtained are demoralized to get the forecasted electrical load. Results of fuzzy logic based models are compared with the actual load demand of electricity. The prediction result are obtained and presented using data from 220kV Sub-Station Bhuna Harayana.

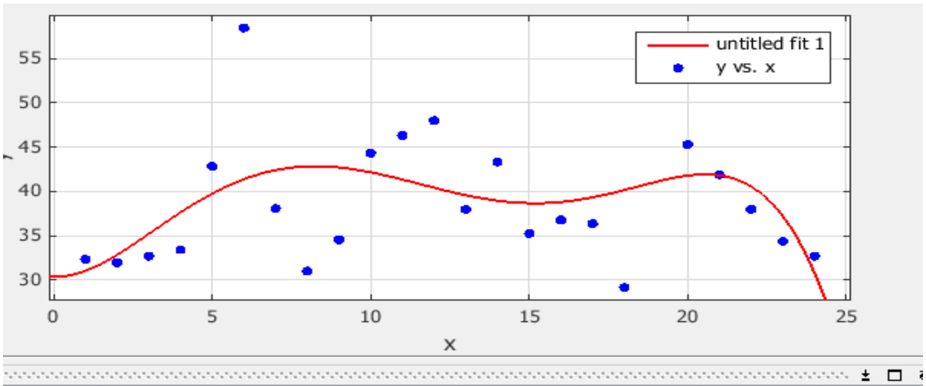
The functioning of the developed fuzzy models for Short term load forecasting is assessed using the load data. As of the figures below it is examined that the error obtained from Short term load forecasting based upon fuzzy is having much lesser than another usual method. The results of fuzzy logic model are shown in Table 5.1. This table presents the output in comparison with the actual data. The implementation of the model is assessed based upon absolute percentage error which can be determined by using formula given below

$$\% \, APE = \frac{|P_{actual} - P_{forecasted}|}{P_{actual}} \text{ x } 100$$

Where is real or actual recorded load.

is the estimated or forecasted load.

The predictable parameters during the twenty four hours are employed to estimate the load for 24 hours in advance.



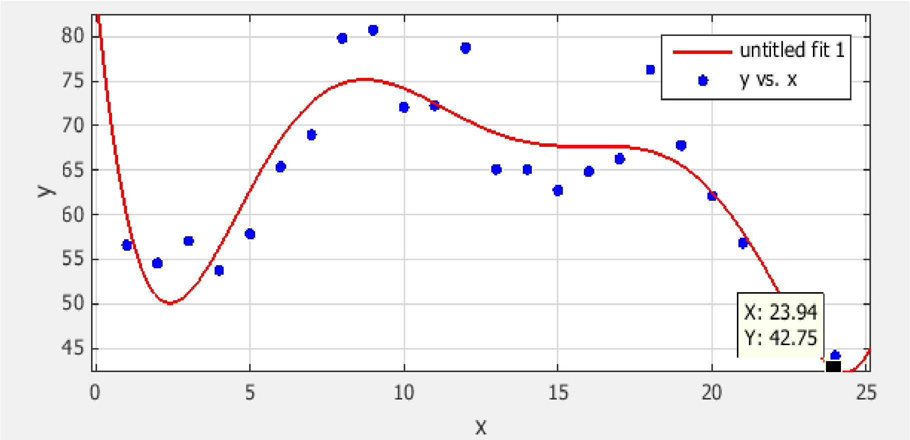
Load curve of day in the month of Feb month

Time	Temp	HuMiDity	Actual load	ForcaSted load	Fuzzy load	error	APE%
1	18	36	56.6	58.93	54.3	-4.12	-4.0636
2	18	37	54.57	51.42	54.3	5.77	-0.49478
3	17	38	57.05	52.1	54.3	8.68	-4.82033
4	17	39	53.77	56.88	54.3	-5.78	0.98568
5	16	40	57.84	63.03	49.3	-8.97	-14.7649
6	16	42	65.37	68.51	49.2	-4.80	-24.7361
7	17	43	68.94	72.46	49.2	-5.11	-28.6336
8	20	40	79.8	74.92	57.8	6.12	-27.5689
9	25	33	80.72	75.09	62	6.97	-23.1913
10	26	29	72.05	74.3	62	-3.12	-13.9486

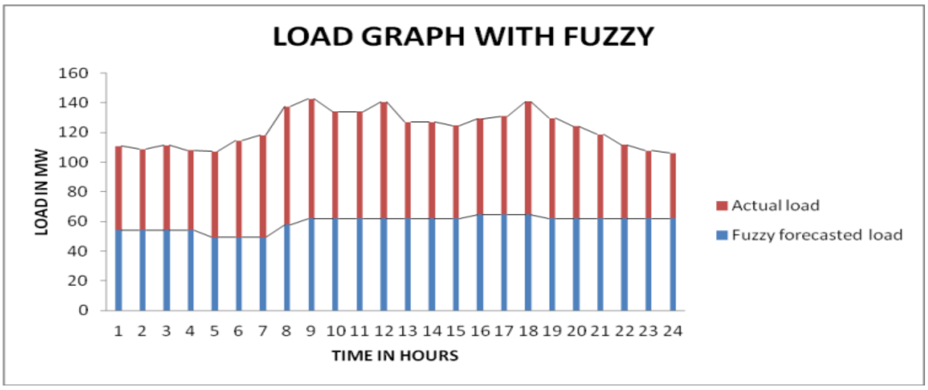
11	27	26	72.25	72.25	62	0.00	-14.1869
12	27	23	78.73	70.86	62	10.00	-21.2498
13	26	21	65.1	69.12	62	-6.18	-4.7619
14	26	20	65.1	68.17	62	-4.72	-4.7619
15	25	19	62.72	67.73	62	-7.99	-1.14796
16	24	20	64.84	67.68	64.6	-4.38	-0.37014
17	24	21	66.27	67.65	64.6	-2.08	-2.51999
18	21	24	76.25	67.06	64.6	12.05	-15.2787
19	20	24	67.8	65.92	62	2.77	-8.55457
20	20	24	62.09	62.09	62	0.00	-0.14495
21	20	24	56.81	58.95	62	-3.77	9.135716
22	19	24	49.67	53.15	62	-7.01	24.82384
23	19	23	45.64	47.02	62	-3.02	35.84575
24	19	23	44.16	42.75	62	3.19	40.39855

Comparison between actual power and fuzzy forecasted power of Feb. month

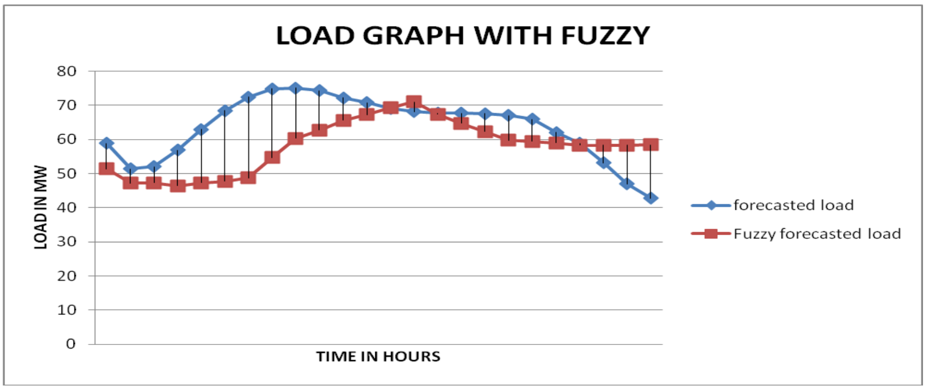
Time	Temp.	Actual load	F. load	Fuzzy load	APE %
1	9	46.72	49.17	46.3	-0.89
2	11	49.32	46.28	44.8	-9.16
3	9	49.57	48.01	42.7	-13.85
4	10	51.7	51.7	42.9	-17.02
5	9	52.79	56.49	42.6	-19.30
6	12	55.47	59.83	47.8	-13.82
7	14	59.89	61.35	46.3	-22.69
8	16	67.72	61.32	50.5	-25.42
9	15	63.93	60.34	52.2	-18.34
10	16	60.26	57.94	53.9	-10.55
11	17	55.45	55.45	57.5	3.69
12	20	49.81	53.45	56.4	13.23
13	21	46.73	52.54	55.8	19.40
14	21	47.36	52.28	55.5	17.18
15	22	53.69	53.69	55.5	3.37
16	19	62.4	54.49	55.1	-11.69
17	17	59.6	55.62	55.5	-6.87
18	16	56.98	56.98	51.9	-8.91
19	16	52.45	56.86	51.5	-1.81
20	15	52.88	56.61	51.4	-2.73
21	12	55.23	55.23	51	-7.65
22	11	56.84	55.02	51	-10.27
23	10	58.42	56.54	51	-12.70
24	9	60.05	60.05	51	-15.07



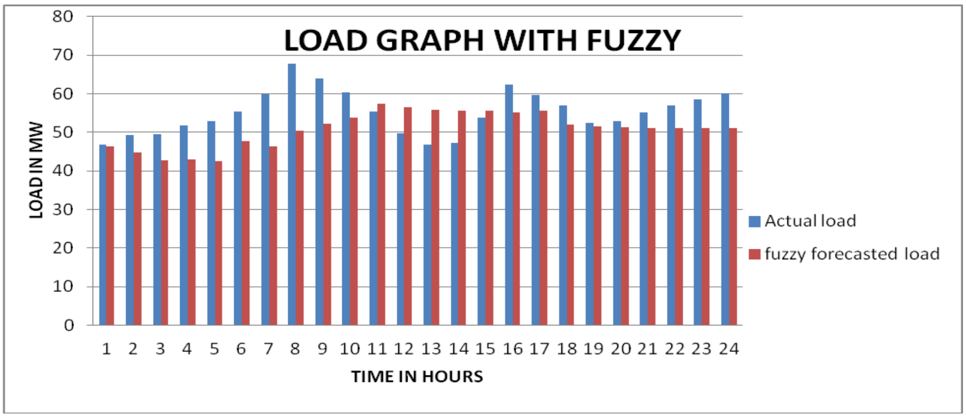
Load curve of day in the month of August month



Actual load and forecasted load curve of a day of August month



Forecasted load and fuzzy forecasted load curve of a day of February month



Actual load and forecasted load curve of day of February month

VI. CONCLUSION

In this thesis fuzzy methodology for short term load forecasting is discussed. It is concluded that using time, temperature and humidity as the inputs and by formulating rule base of fuzzy logic using available data. It is also concluded that fuzzy logic approach is very easy for the forecaster to understand as it works on simple "IF-THEN" statements. It also helps in unit commitment decisions, reduce spinning reserve capacity and schedule device maintenance. It the method, fuzzy logic is used to correct the similar day load curve of forecast day to obtain the load forecast. Fuzzy logic is used to evaluate the correction factor of the selected similar day days to forecast day using information of the previous forecast day.

In this thesis the study shows that the fuzzy approach gives the improved forecasting performance but also it has easy process to deal with forecasting. If the load comes out to be lesser than the predicted values thus the power generation will be much expensive. Conversely, if the load comes out to be more than the predicted value thus the consistency and frequency of the system are in risky situation.

For all the above cases discussed in this study load forecasting based upon the fuzzy approach is much better method and fuzzy forecasting is familiar to the actual load. Thus we conclude that fuzzy reasoning based STLF provides better as well as improved solutions.

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