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Study of Load Forecasting Techniques using Fuzzy Logic

Ashwini Tale[1], Arvind Singh Gusain[1], Jyotirmoy Baguli[1], Rubina Sheikh[1], Dr. Altaf Badar[2]

Student, Dept. of EE, Anjuman College of Engineering and Technology, Sadar, Nagpur, Maharashtra, India[1]

Assistant Professor, Dept. of EE, Anjuman College of Engineering and Technology, Sadar, Nagpur, Maharashtra, India[2]

ABSTRACT: In today's world, load forecasting is an important part of planning in power system for developing countries, to utilise power more efficiently. In developing countries like India, Ethiopia, Ghana, large amount of power is wasted due to inaccurate generation, transmission, and distribution. It is due to lack of accuracy in forecasting the daily load. Forecasting of electricity demand is a fundamental process for planning periodical operations and future load growth in the electricity sector. Thus, accurate load forecasting plays a vital role in reducing the generation cost and optimising the spinning reserve capacity. Various authors have conducted research on the analysis of load forecasting and methods to improve the accuracy and efficiency in prediction. This paper presents a review of research and development in load forecasting methods for improving the forecasted error using fuzzy logic. The accuracy of the prediction model constructed using fuzzy logic is better than the forecasting models based on classical prediction methods.

KEYWORDS: Power system, Load Forecasting, Fuzzy Logic, Fuzzy Rules, Neural Network, Takagi-Sugeno, APE.

I.INTRODUCTION

The prime duty of any utility is to transmit reliable power to its customers. Customer load demand in electric distribution systems is subject to vary because of human activities follow daily, weekly, and monthly cycles. The load demand is generally high during the daytime and in the late afternoon, when industrial loads are high, lights are on, and lower in the late evening and early morning for the most of the population is asleep. The prediction of future active loads at various load buses in power system is known as load forecasting [1]. Load forecasting techniques can be classified into different types according to forecasting period as -

1) Short-term Forecasting – hourly, daily or weekly forecasting,
2) Mid-term Forecasting – extends from a month to one year, and
3) Long-term Forecasting – ranging from one year to ten years.

Accurate load forecasting can promote economical and reasonable arrangements for all kinds of renewable power generation. A number of methods and techniques have been implemented for accurate prediction of short-term load such as Artificial Neural Networks (ANN), Fuzzy Logic, Regression Methods, and time series model etc. Neural Networks are having the properties of slow convergence time as well as poor ability to process a large number of variables at a time. However, on another side, Fuzzy logic provides a platform to represent and process data in linguistic terms that makes the systems easily readable, understandable [2].

In the last decade, deterministic approach such as fuzzy forecasting has been widely studied for forecasting data, which are of the dynamic and non-linear type. The Fuzzy logic approach is a generalization of a Boolean logic. A fuzzy set is fully defined by its membership functions.

The main concept of fuzzy logic is based on fuzzy sets, linguistic variables, possibility distribution, and fuzzy IF-THEN rule base. IF-THEN rule base is used to convert the fuzzy input to fuzzy output. The process to convert the actual numerical value (crisp) to its membership value (fuzzy) through membership functions is called as fuzzification process [3]. These membership values are later used in fuzzy rule inference process.

As the fuzzy inference process is achieved, the results will be in membership units. There may be situations when the output of a fuzzy process needs to be a single scalar quantity as opposed to a fuzzy set. Therefore, a

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defuzzification process is used to get the actual crisp output from the fuzzy value for final decision-making. Several methods of defuzzification have been proposed and used. The centroid method is one of the most popular defuzzification techniques.

II. LOAD FORECASTING TECHNIQUES

A. FUZZY LOGIC

Patel Parth Manoj & Ashish Provinchandar Shah [4] attempts fuzzy logic approach for short-term load forecasting using Mamdani implication. The Fuzzy rule base is prepared based on time, temperature, and similar previous day load. Matlab Simulink software is used for analysis. For load forecasting, load data from area load dispatch center is considered. The paper concludes that by using Fuzzy logic approach it is simple for the forecaster to understand, as it works on the simple "If Then" statements. Rectangular membership functions are used for the inputs as well as for output variable. It also helps in unit commitment decisions and schedule device maintenance.

The forecasts prepared by Jagbir Kam et al. [5] focuses on minimizing the error between the actual value and forecasted value. The model is developed by using different membership functions namely triangular function and trapezoidal function. The data has been taken from PSTCL, 220 KV Sub Station V.P.O. Pakhowal, Punjab. It is found that fuzzy logic is a better method and fuzzy forecasting is very much closer to the actual value.

Fuzzy logic is a very robust artificial intelligent technique for forecasting load on a long-term basis as described in [6]. To forecast long-term load, the paper presents a general algorithm. The algorithm is demonstrated with the help of data collected from residential sectors. It is concluded that the algorithm is capable of forecasting load with very high accuracy even when forecasting is done on a larger magnitude. The results obtained by the proposed fuzzy technique proved to be superior to conventional techniques in forecasting long-term load accurately.

The proposed methodology in [7] decreases the forecasted error and the processing time. The process involves Gaussian membership function, if-then rules, and fuzzy logic operation. Fuzzy based on short-term load forecasting (STLF) method is applied to a real case study and result shows that the STLF of the fuzzy implication has more accuracy & better outcomes. In addition, the present Fuzzy STLF model helps the economic condition by reducing the error in load prediction.

A new method in fuzzy rules by genetic algorithms, which is based on Takagi-Sugeno Fuzzy Logic System for the electric load forecasting, is given in [8]. The method can effectively improve the forecast accuracy and speed. Based on the combination of genetic algorithms and fuzzy logic technology, they produce fuzzy rules automatically by genetic algorithms then establish the fuzzy model of the system, based on Takagi-Sugeno Fuzzy Logic System model of electric load. It overcomes the intrinsic defects of an artificial neural network of slow learning speed. Its network structure is difficult to determine yet it produces local minimum points. Hence it results in an improved accuracy and speed through the imitation computation.

A methodology on short-term load forecasting includes operational mechanism under the changed regime of power sector in India proposed in [9]. It also shows the effect of load, the temperature on generation, transmission, and distribution. The load forecasting has been done by using triangular membership function. The load curve is drawn by using linear regression method. From various calculations, it is concluded that error is less than 4%.

S.E.Papadakis, J.B.Theocharis, A.G.Bakirtzis [10] has suggested building fuzzy models for short-term load forecasting (STLF). The model building process is divided into three parts: (a) identification, based on a fuzzy C-regression method, (b) selection of the proper model inputs which is achieved using a genetic algorithm and (c) fine tuning by means of a hybrid genetic or least squares algorithm. The suggested model is compared with the ANN model in terms of prediction accuracy, robustness, and model complexity. The simulation results demonstrated that the model exhibits very good forecast capabilities.

An electric load forecasting using fuzzy logic considering similar day approach is proposed by Mahmuda Akter Monne et al. [11]. The data has been taken from the power system of Bangladesh (Dhaka division). To achieve the better

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accuracy, Least Square based Multiple Regression Analysis Model (LSMRA) and a fuzzy logic application had been used. The method achieves approximately 1.18% error in updating each load on a similar day.

Hasan H Çevik & Mehmet Çunkas [12] discusses a work on short-term load forecasting for the holidays. The purpose of the paper is to present different models using the Fuzzy logic method without weather information. The data between the year 2009 & 2011 are used to design the forecasting models. In the study, two different fuzzy logic models (model 1 & model 2) are developed and tested for each holiday types using Matlab Fuzzy Logic Toolbox. In the paper, each Fuzzy model had three inputs and one output. While historical data from past years, consumption data from last week & the type of holiday are selected as input. The results showed that model 2 could have better forecasting accuracy than Model 1 in terms of Mean absolute percentage error (MAPE) values.

V.Y.Hsu and K.L Ho [13] presents short-term load forecasting using fuzzy set theory. The load data has been taken from Taiwan Power Company. In order to improve the accuracy of forecast an hourly load, load updated every one hour or few hours have been considered. A minimum-maximum algorithm and an equal area algorithm have taken into consideration to reach the desired change in peak load and trough load. It is observed that the mean square error (MSE) is reduced from 2.38% to 1.20%.

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Per Capital gross domestic product (GDP) and Population are taken as input variables and the predicted electricity consumption is taken as an output variable in [14]. To predict the annual electricity requirement in India, Fuzzy Decision Tree is applied. Past 30 years of historical data has been used for training and 4 years of data is used for testing the Fuzzy Decision Tree. The results state that proposed Decision Tree model has given high performance and less error rate than the Artificial Neural Network model.

The Fuzzy Logic technique is used for the prediction of the load [15]. Analysis and examination are done based on previous data, taken from Hayatabad 132 kV grid station, Peshawar, Pakistan. Triangular membership functions are used for input and output variables. Simulation is done in MATLAB software. It is observed that the error is very small i.e. less than 3% using this method. It has better accuracy than any other conventional methods.

Zuhaing Ismil and Rosnalini Mansor [16] give a new concept in forecasting cycle based on fuzzy logic. The load data has been taken from Tenaga National Berhad (TNB) Malaysia for training and testing purpose. The analysis is done on triangular membership functions. Four defuzzification methods Center of Area (COA), Center of gravity (COG), Middle of maxima (MOM) and Last of maxima (LOM) are chosen. The result shows that fuzzy model with Center of Area (COA) defuzzification method gave a better performance compared to other defuzzification methods.

Short-term load forecasting experiment is conducted to estimate load demand of Adama Science and Technology University, Ethiopia [17]. The input parameters are day's minimum temperature, day's maximum temperature, season, day capacity, rain, and daylight intensity (Cloudy). To analyse the result Mamdani model in the Fuzzy logic methods is used. The error of load forecasting is reduced by using fuzzy method along with the Artificial Neural Network. The error range is reduced nearly 3%. The data have been analysed in MATLAB Software.

A methodology using fuzzy logic for short-term load forecasting is proposed in [18]. For designing of the fuzzy rule base, the methodology proposed by Wang & Kosko is used here. The results are obtained using triangular membership function. The Forecasted load is compared with the actual load and average percentage error is calculated (APE). In the paper, defuzzification is done using Centroid of area (COA). In future, increasing the number of membership functions and by using the trapezoidal, Gaussian bell membership function the APE can be reduced.

Shahram Javadi [19] suggests the general methodology to use fuzzy logic for spatial load forecasting. To aggregate the information for load forecasting the proposed scheme provides Land usage-based spatial load forecasting technique and Geographic Information Systems (GIS) technology. A new spatial load forecasting method can be used in non-uniform areas and it gives superior output compared to other distribution load forecasting accuracy. The method requires substantially less manpower, time, operation costs etc.The results provide a satisfactory of the loads in line with the expectations in the Ghaen City area. The algorithm accurately constrained the load growth within the forecast area.

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A time series model in which, to calculate the forecasting value in the de-fuzzification process weighted fuzzy method is used. This method reduces the difficulties of encounter non-linear data and large fluctuations. To estimate the models desired result the empirical data of load from Chongqing China is used in [20]. A weighted defuzzification method is used to improve the fuzzy approach. The key issue of weighted fuzzy time series (WFTS) is based on the cyclic time series values of previous experience and adapting weights between output values of the fuzzy rule. The experimental result shows that the proposed WFTS model performs better than other methods of load forecasting.

W. T. Ghareeb [21] introduces Genetic Algorithm to optimized Radial Basis Function network (GA-RBF) with a fuzzy corrector for the problem of short-term load forecasting. Mamdani is a type of inference system, which has been used in designing the fuzzy corrector. A real data set of the Egyptian electrical network is also used in this study. The result shows that forecasting accuracy obtained from the GA-RBF system with fuzzy corrector is highest compared to the neuro-fuzzy system.

The short-term load forecasting can also be illustrated by using Time-variant slide fuzzy time series method [22]. Data of National Electric Power Company situated in Jordan has been taken for forecasting. The result shows that the maximum mean absolute percentage error (MAPE) in proposed method is less than 1%, which produces more accurate training results as compared to the fuzzy inference model. The numerical results obtained in this study shows, that the proposed model is a valid and promising alternative for the improvement of the forecasting precision.

Saleh Ahmadi et al. [23] implies the analysis of fuzzy logic framework for the sake of short-term load forecasting (STLF) issue. The STLF method is examined on a real distribution power networks. It shows that the load forecasting using fuzzy implementation is faster and more accurate than the conventional forecasting methods that deal with rigid data and a long processing time. In addition, the present fuzzy STLF model helps the utility economically by reducing the error in load predictions. The data used here have been taken from the Sanandaj Distribution of Company. In this work, Sanandaj power network in Kurdistan of Iran is considered as the case study.

The method is used based on Takagi-Sugeno Fuzzy Logic System and establishing the fuzzy model for load forecasting [24]. Takagi-Sugeno Fuzzy logic systems are based on local linear function and the global non-linear is implemented by blending the subsystems models. They have concluded that it overcomes the intrinsic defects of artificial neural network that its learning speed is slow, its network structure is difficult to determine rationally, and it produces local minimum points. They found the global optimum fitting effect so the accuracy is improved. Through the imitation computation, it is proved that the accuracy and speed are improved. It is a new and effective method of electric load forecasting.

The paper [25] includes the detail analysis of previous year's load data records of an Engineering College in India using the concept of fuzzy methods. The fuzzy rule base are prepared based on Day's minimum temperature, Day's maximum temperature, season, day capacity, rain, and daylight intensity (Cloudy). The analysis has been done on Mamdani type membership functions. The error has been reduced to a considerable level in the range of 2-3%. The above analysis with fuzzy can be merged with some other methods to get accurate result.

B. NEURAL NETWORKS WITH FUZZY LOGIC

Neural Network combined with Fuzzy Logic is used for determining long-term forecasting [26]. The relationship between the humidity, temperature, & load is identified with a case study for a particular region in Oman. The paper uses Triangular membership functions for forecasting. The data is taken for three years & the results are obtained for the fourth year. It has been observed that the variation of predicted load from actual load has an average percentage error of 7.8%.

C.P.Ronald Reagan and S.R.Sari [27] consider a collaborative fuzzy neural technique to estimate the long-term forecasting. In this proposed technique, the historical data sets of Tamil Nadu are considered from the year 1983 to 2012 for energy forecasting. The error obtained for this model is compared with the other existing methodologies. After applying the fuzzy-neural approach to predict the annual energy consumption in Tamil Nadu, improves the efficiency of the prediction than other existing methods.

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The development of a hybrid neural network to model a fuzzy expert system for time series forecasting of electric load is presented in [28]. For training the fuzzified neural network a hybrid-learning algorithm consisting of unsurprised and surprised learning phases are used. To improve the accuracy two types of fuzzy expert system model, abbreviated as FES1 and FES2 has been used. In order to adjust the weights and membership function, back propagation and linear Kalman filter algorithm has been considered. It is observed that the fuzzy expert system gives faster convergence and accurate prediction of load.

An adaptive neuro-fuzzy interference system (ANFIS) for the non-linear system has been proposed by M.Mordjaoni,B.Boudjema et al. [29]. It is discussed in detail how using ANFIS is successfully applied to weekly load forecasting with respect to different day types. The input - output data is of France of the years 2009 obtained from the RPE website. The focus of the paper is to reduce negative aspects of existing STLFM and to reduce complexity structure of neural networks. The forecasting performance obtained reveal the effectiveness of proposed method & shows that it is possible to build a high accuracy model with less historical data using neural networks in combination with Fuzzy logic in real time system.

The difficulty in developing fuzzy rules and membership function give rise to Adaptive Neuro Fuzzy Inference System (ANFIS). ANFIS integrate both neural networks and fuzzy logic in a single framework. The paper published by Saurabh Ghose and Amit Goswami [30] focuses on short-term load forecasting of Chhattisgarh Grid using ANFIS. ANFIS is based on Takagi-Sugeno Fuzzy Inference System. The data is obtained from State Load Dispatch Centre of Chhattisgarh State Power Transmission Company Limited (CSPTCL). The forecasts data obtained from ANFIS method is compared with the real load of the same day along with the prediction error. The prediction error is low and hence gives high accuracy.

A solution to short-term load forecasting using ANFIS is an integrated approach of wavelet, neuro fuzzy for forecasting [31]. In the second section, they discussed above conversation & artificial intelligence based method for STLF. In this approach, prediction of load depends upon the weighted combination of three components. In third section wavelet analysis is performed. It is smooth and has properties like vanishing moments or size of the support. While neuro fuzzy system discussed in section four is performed using MATLAB. In neuro Fuzzy Wavelet approach 4 wavelet coefficients are used also, lower the value of wavelet coefficient higher the prediction accuracy. Hence, the method gives quite encouraging results.

Seema Pal & Dr.A. K. Sharma [32] presents ANFIS method for short-term load forecasting. Data analysis is done using a matrix with row represents a number of hours and column represents a FIS model and temperature. The design of ANFIS is done by constructing an inference system of five layers. Each layer contains several nodes called as node function. They use Gaussian membership function for each input. Output data of one node acts as input to another node in the present layer. The results obtain with considerable accuracy and mean absolute percentage error of 5.705.

A new model, which divides the electric load into two parts: 1) the load scaled curve and 2) the day maximal load and the minimal load is proposed in [33]. The load scaled curve is forecasted using five artificial neuron networks. The 24 hourly forecast loads of the future day are predicted by combining the results of the artificial neuron networks and the fuzzy logic method. The benefit of the proposed hybrid method is to utilize the advantages of both i.e. the generalization capability of artificial neuron network and the ability of fuzzy logic for handling uncertain problems. The test result shows that the proposed forecasting method could provide a considerable improvement in the short-term load forecasting accuracy.

A. R. Koushki, M.Nosrati Maralloo et al. [34] proposes a neuro-fuzzy model for the application of short-term load forecasting. This model is identified through Locally Linear Model Tree (LoLiMoT) learning algorithm. The model is compared to a multilayer perception, Generalized Regression Networks (GRNN), Kohonen Classification, and Intervention Analysis. It is concluded that the performance of the LoLiMoT model on short-term load forecasts is much better than that of the other classical methods. The superior performance displayed by the model seems to be justified by its very flexible and interpretable structure.

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A methodology for short-term load forecasting is based on Grid method and Time series fuzzy neural network, which has been proposed by Hong Li [35]. Steel plant load is selected as the high-energy consumption load to carry out load forecasting which has a relationship with its own production plans in the period of 12 days. The results obtained effectively solve the problem of decreased forecasting accuracy due to some factors caused by high-energy consumption enterprises.

Jia Zheng-yuan and Tian Li [36] suggest short-term power load forecasting model based on fuzzy Radial Basis Function Neural Network (RBFNN). The data has been taken from Power Grid of East China. Based on one month load analysis is done, it indicates that prediction accuracy of fuzzy RBF neural network is better than other neural network methods. The model built in the paper is based on the strengths of both fuzzy logic and RBFNN. RBFNN method becomes a great contribution to the scheduling of generators.

A method based on polynomial neural networks and fuzzy logics, optimized by a technique known as Particle Swarm Optimization (PSO) is introduced in [37]. The paper consists in generating a final structure that is compact, flexible, and capable of producing good results when applied to resolving system identification problems and time series forecasting. Based on the quality of the results, a great number of tests are carried out with different sets of data and compared with traditional methods. It is concluded that the proposed method is very viable.

C. OTHER METHODS

SARIMA Model

Néstor González Cabrera, G.Gutiérrez-Alcaraz and Esteban Gil [38] propose a paper in 2013. It is compared with two different methodologies for short-term load forecasting, a classic statistical model called as Seasonal Auto Regressive Integrated Moving Average (SARIMA model) and a model based on artificial intelligence Fuzzy Inductive Reasoning model (FIR). In the SARIMA model, the future value of a variable is assumed a linear function of several past observations and random errors. The FIR methodology has four basic functions they are fuzzification, qualitative modelling, qualitative simulation, and de-fuzzification. The results are compared to both models and they have concluded that the FIR and all of the Neuronal Network approaches shows less error and require less computation time than SARIMA models.

Least Error Technique

The long-term load forecasting with least error technique is prepared by Er.Daljeet Kaur, Er.Dagra Er Sonia Grover [39]. In the paper, data has been taken from substation of Amritsar city for last 18 years (from 1997 to 2014). In order to obtain the least error, fuzzy logic methodology along with various mathematical equations has been used. Moreover, to analyze the future load, extrapolation techniques has been taken into account. It is found that maximum percentage error occurred in parabola equation and minimum percentage error occurred in S-curve equation. It is also observed that S-curve method is best suited for conducting accurate load forecasting using fuzzy logic.

Soft Computing Technique

D. K. Chaturvedi, Sinha Anand Premdayal et al. [40] proposes a Short-term load forecasting using soft computing technique. The paper represents different methods of soft computing technique. The aim of the paper is to find a solution to short-term load forecasting using GNN with wavelet for accurate load forecasting results. The soft computing technique forecasts each component separately. It is observed that the modified GNN performs better than the traditional GNN. The improvement in the results shows that accuracy of forecasting increases in the combined model and can give correct output for short-term load forecasting.

Regression Analysis

Two load forecasting model based on fuzzy theory is presented by 'Yan Yan' and 'Aimin Yang' [41] they are fuzzy clustering model and improved fuzzy regression analysis model. In order to improve the prediction effect of subarea, load forecasting fuzzy clustering model is taken into consideration. To build multi-level and multi-factor decision-

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making analysis structure, the improved fuzzy analytical hierarchy process has been used. The paper shows the overall stepwise calculation for regression analysis for both the methods.

GRF Methodology

Nikhil kumar B S and Kale Pallavi V [42] gives a revised radial basis function (RBF) network combined along with the genetic algorithm. To include the sudden changes in load values fuzzy inference system is used in combination with the modified RBF network. RBF is a three-layer neural network. The input layer is made up of a signal source node, the second tier is hidden layer, and the third tier is the output layer. The proposed method is compared with feed forward neural network. The prediction error for the proposed GRF methodology is less as compare to feed forward neural network. Hence, it is concluded that the forecasting accuracy and convergence speed better than feed forward neural networks.

Euclidean Norm

In the paper E. Srinivar & Amit Jain, Member IEEE [43] represents a methodology for short-term load forecasting using Fuzzy logic approach. The approach has the ability to deal with non-linear part of the forecasted load curves and abrupt change in weather. Euclidean norm with weight factors is used to determine the similarity between the forecast day and the searched previous days. Fuzzy logic is used to find the correction factor for the selected similar days to the forecast day using the information of the previous forecast day & the previous similar days.

Phase Space Reconstruction Model

An interval type 2 fuzzy logic model for the time series of one hour of power load forecasting on Phase Space Reconstruction Model [44]. The type 2 fuzzy logic model has taken into consideration to improve the prediction accuracy. To obtain the accurate results, back propagation algorithm of a fuzzy model with interval type 2 fuzzy law model has been used. The result shows that by comparing with traditional type fuzzy logic, the processing ability of type-2 fuzzy logic has more uncertainty and the robust control.

Tabu Search

Hiroyuki Mori, et al. [45] suggests a Tabu search method for constructing a fuzzy inference model for short-term load forecasting. Tabu search is a method used to optimize the fuzzy membership functions. The paper uses maximum, minimum, and average temperature, minimum humidity, weather conditions, day types, elapsed days and years as input variables and the daily maximum loads in summer for calculation. The simulation results have shown that information on the maximum and minimum temperature is more important and indicate that input variables explain the extent of the model non-linearity through the width of the fuzzy membership functions.

Chaos Theory

Based on chaos theory a new short-term load-forecasting model is proposed in [46]. This method makes use of chaos time series analysis to capture characteristics of complicated non-linear dynamical systems. The chaos system is a definite system; it is extremely sensitive to the initial value of the system. The paper shows that forecasting by chaos theory, compare time series of load demand to actual history data, presenting the feasibility of forecasting method. Moreover, the results indicated that it would be a bright merit to use chaos theory predicting power load demand and controlling power safe supply of power station.

Kalman filter

A load prediction methodology for the short-term load forecasting to estimate hourly load is used in [47]. The prediction is carried out using a linear fuzzy model of previous year loads and weather. The Kalman filtering technique with a fuzzy rule-based inference is employed to estimate the fuzzy model coefficients. The method produces both crisp and spread values of the forecast load. The result shows that the prediction has 0.7% mean absolute percent error

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and 0.84% absolute percent error. Moreover, the predicted spread value is useful for determining the amount of extreme the load may reach each hour.

Combined Regression-Fuzzy Method

R.-H. Liang and C.-C.Cheng presents a combined regression-fuzzy approach for short-term load forecasting [48].The regression methods are first used to obtain preliminary forecast peak load and valley load. Then correction values of forecast error from a fuzzy inference machine are added to the preliminary forecast peak load and valley load from the regression method to obtain the final forecast peak load and valley load. The proposed approach can obtain better results than those from traditional multi-linear regression (MLR) method. The effectiveness of short-term load forecasting has been investigated on the Taiwan power system with different load types. It is found that the approach is very effective in obtaining proper peak load and 24 hourly load forecasting.

III.CONCLUSION

Load Forecasting plays a crucial role in all aspects of planning, operation, and control of an electric power system. In this paper, different methods of load forecasting are studied. Accurate load forecasting is very important for electric utilities in a competitive environment created by the electric industry deregulation. Load forecasting helps in the planning of the future load. The load forecasting can be done by using various methods. It is observed that fuzzy logic approach is simple 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.

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