Short Term Load Forecasting Using Fuzzy Logic

Eng. Zuhra Miftah Musbah
dd2050er@gmail.com

Prof. Abdalla Idris Fadel.
Abdalla.fadel@academy.edu.ly

Abstract:

load forecasting is one of the important concerns of power system ,and it is essential for managing supply and demand of electricity .the short term load forecast (STLF) is important to predict the near future loads, since there are various factors that influence the behavior of the consumer loads . The most important factors that may be considered and effects load forecasting are load, temperature, and humidity, changes with time .in this research the Method of fuzzy logic (FL) will applied for forecasting the short-term load, for Libyan western electric power system.

Historical hourly load data available that are collected during the year 2013 by General Electric Company of Libya (GECOL), which will be used for the testing of the fuzzy logic forecasting models. Also the weather hourly data for year 2013 are used. Then forecasting load results were estimated and compared to actual load using year 2015 load and weather data.

Keywords— Load forecasting; short term load forecasting; Fuzzy logic; Fuzzy inference system.

1- Introduction

The prediction plays a key role in the formulation of economic, reliable, and secures operating strategies for the power system. Demand load forecasting is an important aspect in the development of any model for electricity planning, especially in today's reforming power system structure. The form of demand depends on the kind of planning and accuracy that is required. .[1]

Electrical energy cannot be stored, it has to be generated whenever there is a requirement for that. It is, therefore, imperative for the electrical power utilities that the load on their systems ought to be calculable. This estimation of load prior to be usually called load prognostication, which is necessary for power system planning. Power system enlargement designing starts with a forecast of anticipated future load necessities, in different sectors of the industry (generation, transmission, and distribution) with increasing demand on planning management and operations of the network. Load forecasting can be divided into three categories Short-term, medium, and Long term. .[1]

2. fuzzy logic algorithm

Fuzzy-logic is used for modeling and controlling of complex systems. The methodology of the fuzzy model of the system and control rules are obtained from input-output data with the need for a priori information. In this paper the fuzzy logic inference for short term forecast of Libyan western electric network is developed and studied, using historical data of the year 2013 load variations.

The fuzzy logic inference model and Adaptive Neural -Fuzzy Inference System developed for short term load forecast, considering the load, time, temperature, and humidity data are studied and discussed.

A research working plan is considered in this research for fuzzy logic inference models for short term load forecast, using the historical data such as the daily hours load data and weather data for the four seasons of the year to compare between actual and forecasted load.

I. Collecting load, temperature, and humidity variations with time data for 2013 from General Electrical Company of Libya (GECOL) General Electrical Company of Libya. And from weather underground data (WUGD) Weather under Ground Data.

II. Divided the case study for two section:-

Section a: - the fuzzy logic inference is used, where the historical data are obtained, these data are used in the process of the fuzzification of different parameters such as time humidity and temperature. After the russification is done, based on the different parameter of load forecasting rules are prepared, those rules are the heart of the fuzzy system, the rules are prepared to forecast the load of the desired hour.

Section b :- In this section, the Neural -Fuzzy Inference System (NFIS) is used, since it is the first and most important task for designing a system for one day ahead load .

Forecasting is the identification of input parameters. The MATLAB software of Adaptive Neural-fuzzy inference system is used for Adaptive Neural- Fuzzy Inference System (ANFIS). training and testing. The input and target data, the training and testing process is arranged as required for the modeling and development of proposed Adaptive Neural- Fuzzy Inference System (ANFIS) predictor.

III. Results and conclusions will be summarized and recommendation will be given.

3 - Short Term Load Forecasting Model with Fuzzy Logic Inference Systems: -

In this section, used the fuzzy logic toolbox in MATLAB is used to insert the historical data in membership function divided into four inputs and one output

4. Fuzzification

Fuzzification is the process of converting crisp numerical values into the degrees of membership related to the corresponding fuzzy sets. One of the main characteristics of fuzzy model is the development of the rules.

Rules development which relates the fuzzy input and the required output are presented. Fig.1 shows the whole structure of fuzzy logic system included input, reasoning rules and also the proposed output. The inference rules relate the input to the output and every rule represents a fuzzy relation.

Fuzzification is used in order to express the fuzziness of data, in this study an arrangement is made of fuzzy subsets for different inputs and outputs in complete universe of discourse as membership functions. A triangular membership function is used for the inputs as well as the output.

The four inputs taken for Short-Term Load Forecasting (STLF) are (Time, last day load, humidity and Temperature),as shown in figure (1).

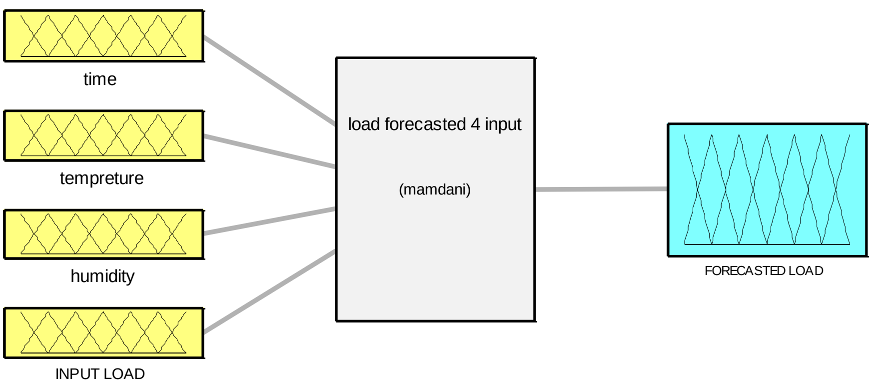

Figure 1: fuzzy logic structures.

Fig, (1.a) Shows that time has been divided into seven triangular membership functions which are as follows:

- Mid Night(MID-NG)
- DAWN
- Morning(MORN)
- NOON
- Evening (EVE)
- Dusk
- Night (NIG)

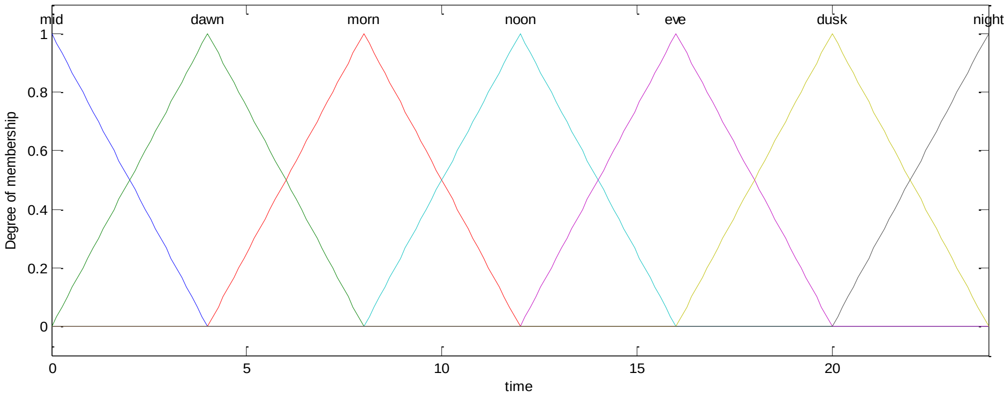

Figure (1.a) time triangular membership function

Figs. (1.b, c,d and e) Shows (temperature, humidity, input load and output forecasted load) and divided into seven triangular membership functions respectively which are as follows:

- Very Very Low (VVL)
- Very Low(VL)
- Low(L)
- Normal (N)
- High(H)
- Very High(VH)
- Very Very High(VVH)

The rules development which relates the fuzzy input and the required output are presented, as Fuzzy Rule Base.

This part is the heart of the fuzzy system. The heuristic knowledge of the forecasted is stored in terms of "IF-THEN" rules. It sends information to fuzzy inference system, which evaluates the gained information to get the load forecasted output. Some of the rules are as follows:

if (time is dawn) and (Temperature is VVL) and (Humidity is VVL) and (Input load is VVL) then (forecasted load is VVL) (1

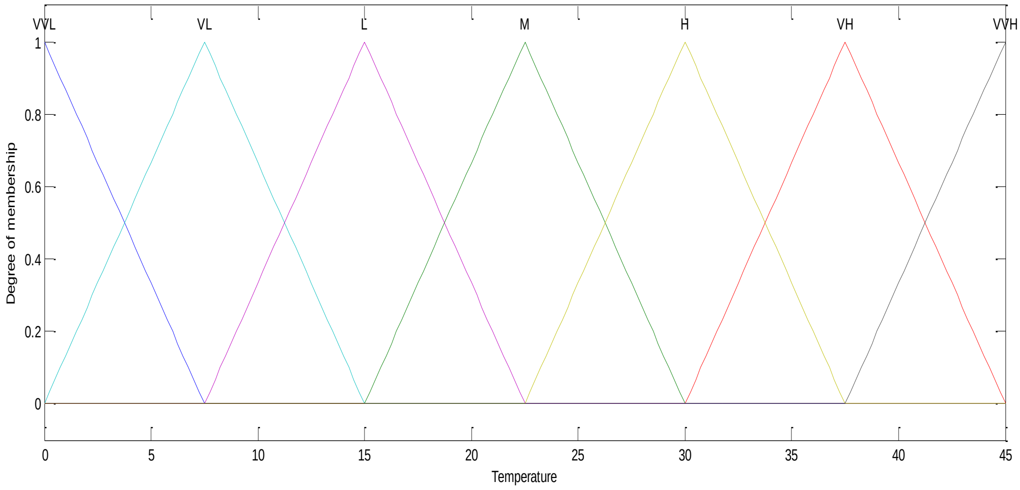

Figure (1.b): Temperature triangular membership function

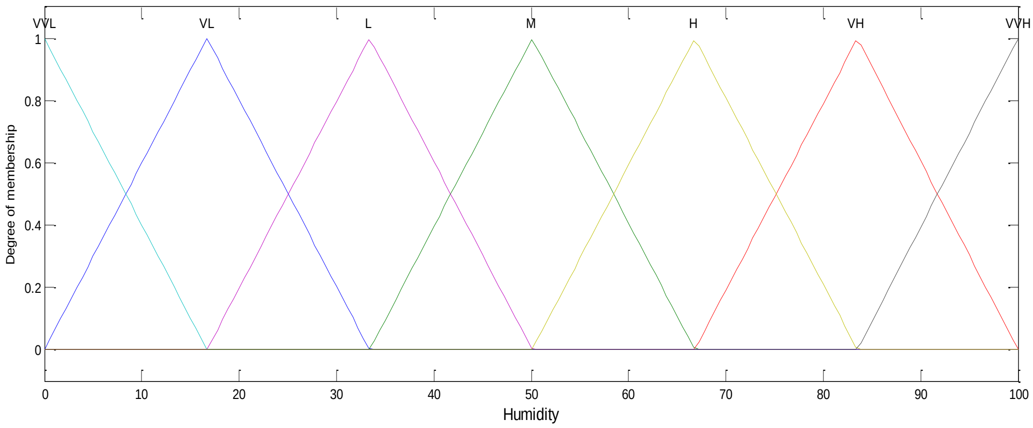

Figure (1.c): Humidity triangular membership function

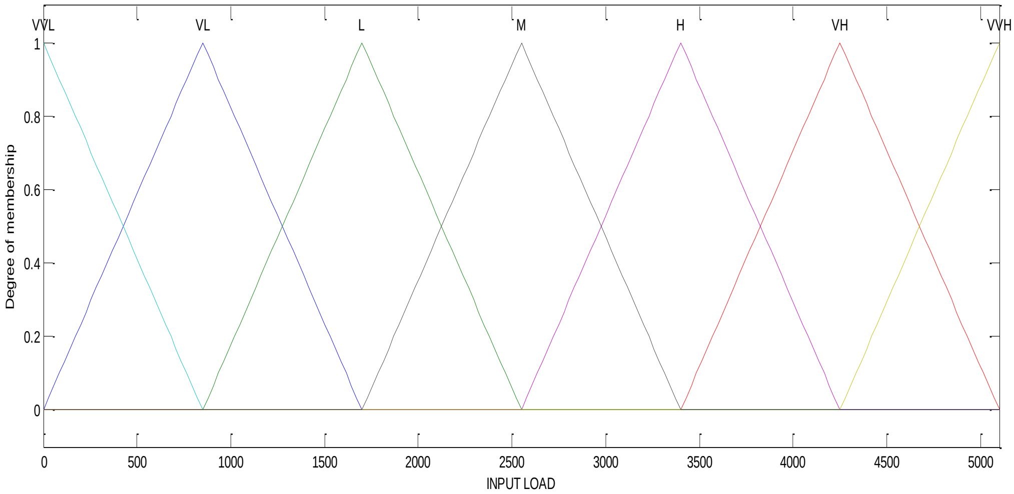

Figure (1.d): Input triangular load membership function

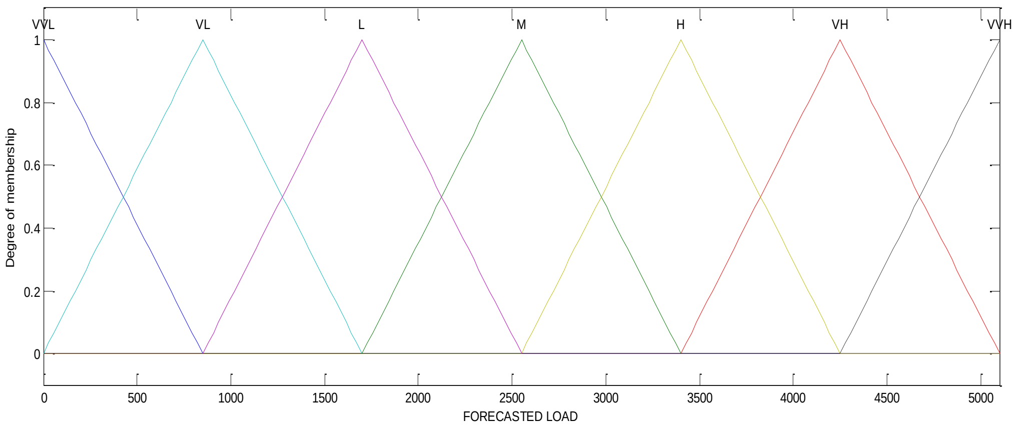

Figure (1.e): forecasted triangular load membership function

If (time is dawn) and (Temperature is VVL) and (Humidity is VVL) and (Input load is VL) then (forecasted load is VL) (1)

If (time is dawn) and (Temperature is VVL) and (Humidity is VVL) and (Input load is L) then (forecasted load is L) (1)

If (time is dawn) and (Temperature is VVL) and (Humidity is VVL) and (Input load is M) then (forecasted load is M) (1)

If (time is dawn) and (Temperature is VH) and (Humidity is VL) and (Input load is H) then (forecasted load is H) (1)

If (time is dawn) and (Temperature is H) and (Humidity is L) and (input load is L) then (forecasted load is L) (1) …………..

Similarly, fuzzy rules are prepared based on the data obtained from (GECOL) and from weather underground data (WUGD) site.

5- Case I: The Seasonally Fuzzy Logic Case Studies and Results

Different case studies to show the performance of the fuzzy logic program have been presented for chosen days of the year considering sessions of (winter, spring, summer and fall).

a- Considering short term load forecasted for a winter day the results is shown in Fig.2.

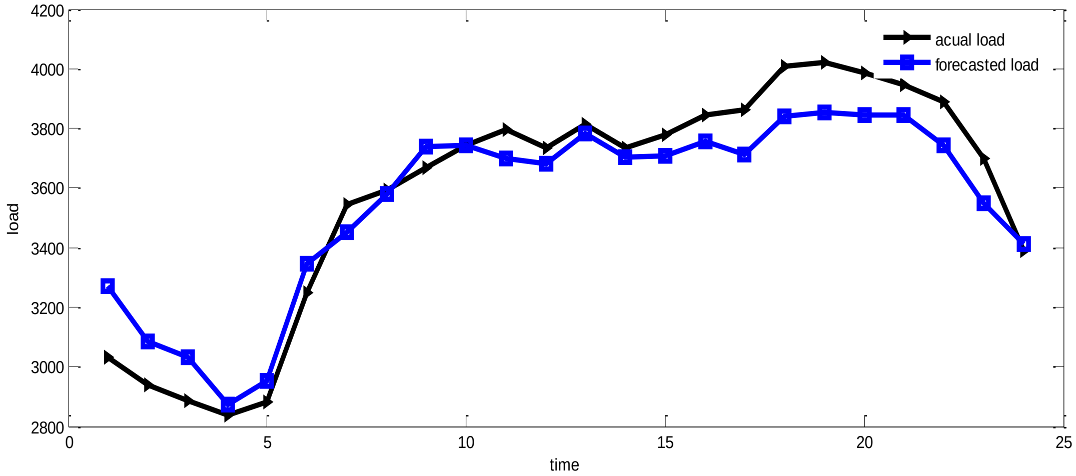

Figure 2 load curve in winter day.

As a discussion for this case the results shown in figure (2) show that the load curve plotted which is the comparison between the actual load and the fuzzy forecasted load.

The results obtained from the fuzzy logic are compared with actual load and it is found that the error is between 0.016% and 7.9 % error, In general From the curve ,it is observed that fuzzy forecasted load curve is very close to the actual load curve presents a very good results for forecast.

b- Seasonally Fuzzy Logic Case Study for Spring Season:-

In this case the data for a day in spring season is chosen for the day 15th April 2013. The results shown in Figure (3)

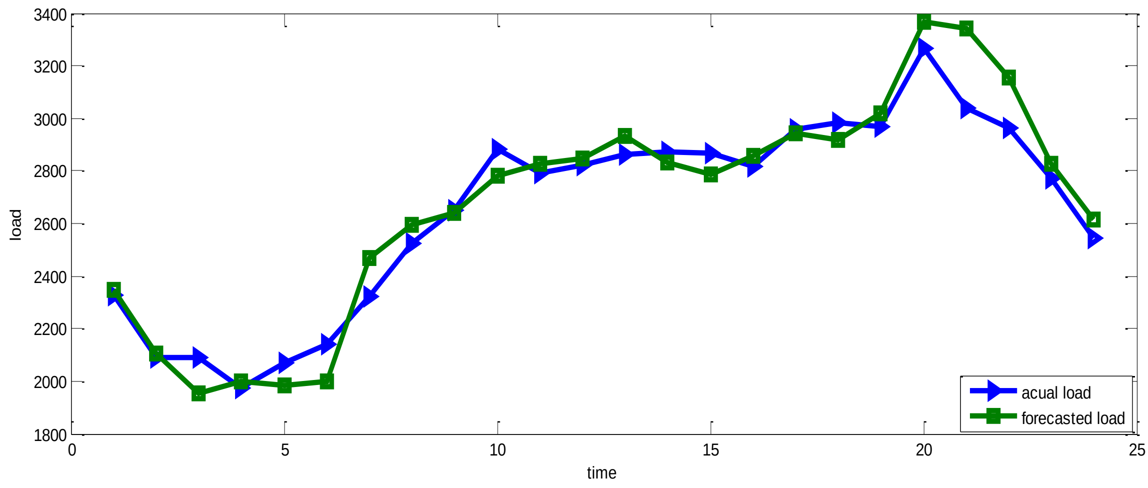

Figure (3) : load curve in spring day

As a discussion for this case

It shows that the load curve plotted, is the comparison between the actual load and the fuzzy forecasted load.

The results obtained from the fuzzy logic are compared with actual load and it is found the error is between 0.17% and 9.89 % .In general from the curve, it is observed that fuzzy forecasted load curve is very close to the actual load curve presents a very good results for forecast.

c- Seasonally Fuzzy Logic Case Study for Summer Season:-

In this case the data for a day in summer season is chosen for the day 15thJuly 2013. The results shown in Fig. 4.

As a discussion for this case from the results the error is between 0.04% and 7.5 %, In general from the curve. it is observed that fuzzy forecasted load curve is very close to the actual load curve presents good results for forecast

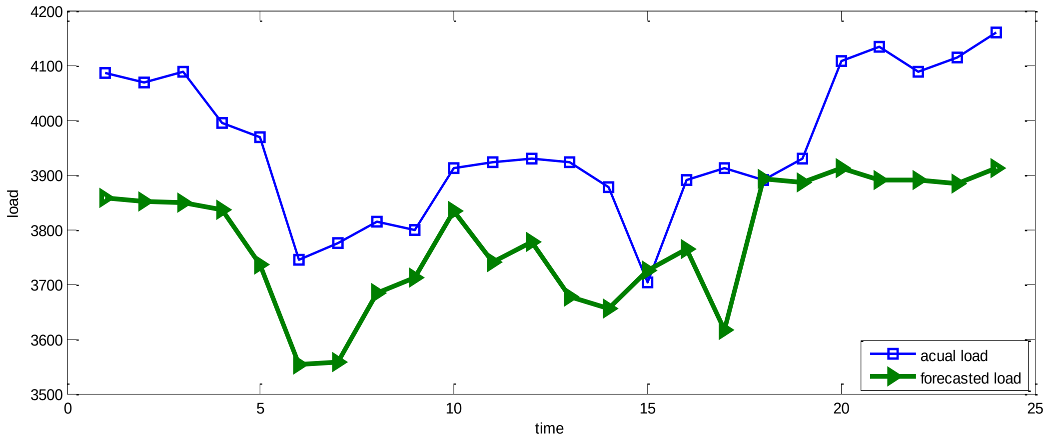

Figure (4) load curve in summer day

d- Seasonally Fuzzy Logic Inference Case Study for Autumn Season:-

In this case the data for a day in autumn season is chosen for the day 15^{th}November 2013. the results shown in figure (5).

As a discussion for this case the results shows that the sadden change in load compare to day before on the model due to unpredicted reason, the error is increase to 25.5% because this sadden changes, when the temperature change.

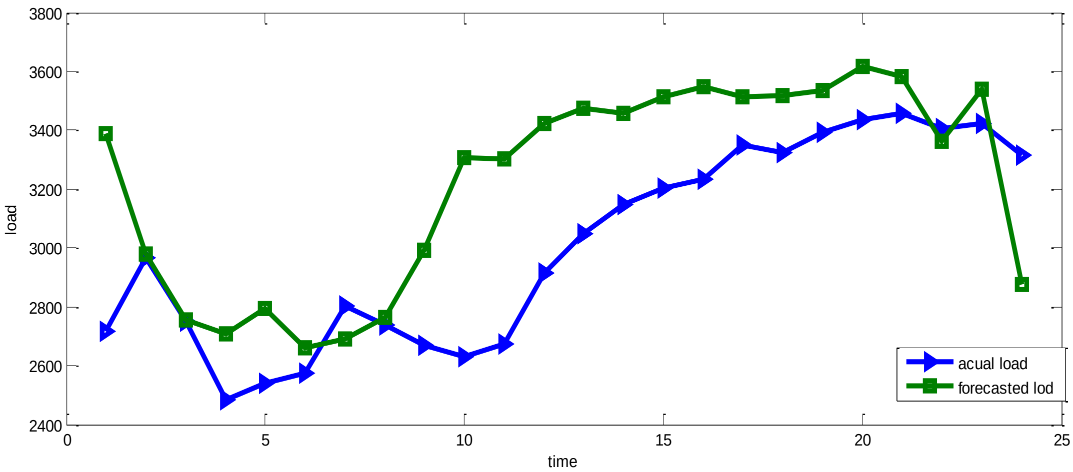

Figure (5) load curve in autumn day

6- Case II: Study Applying The Fuzzy Model With Different Inputs:-

In this case different inputs are applied with fuzzy model to compare the model accuracy and performance to see how each type of input data effects.

a- **Considering Three Inputs (Time, Humidity and Input Load):**

To check for the model performance under this condition, to the effect on the performance of the network, and shows the negative effect of temperature.

As shown in figure (6) the fuzzy logic structure (time, humidity and input load) and results will be shown in figure (7).

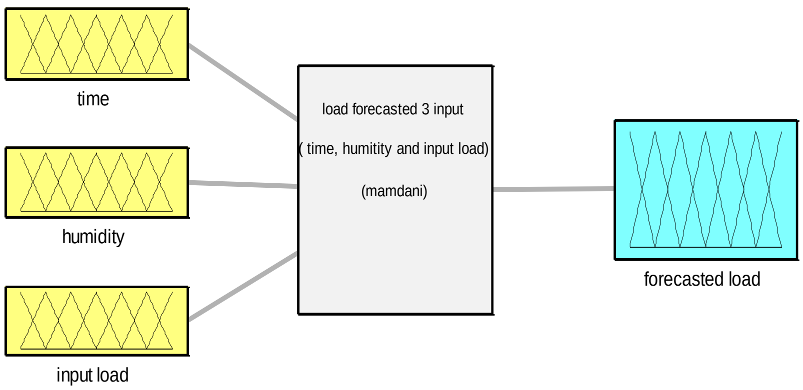

Figure (6) the fuzzy logic structure (time, humidity and input load)

Inputs (time, humidity and input load) and (time, temperature and input load) are considered

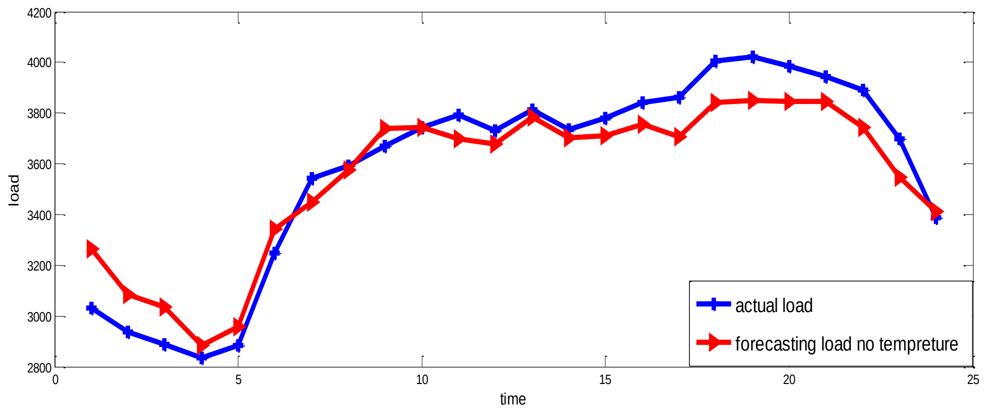

Figure (7): load curve in day of year 2013 no temperature

b- Considering Three Input (Time, Temperature and Input Load)

To check for the model performance under this condition.

As shown in figure (8) the fuzzy logic structure (time, temperature and input load) and results will be shown in figure (9).

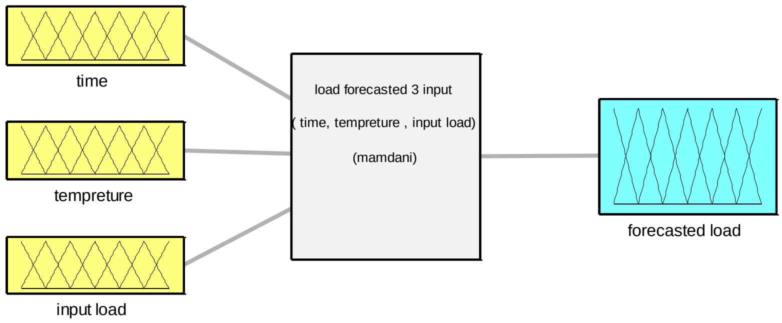

Figure (8) the fuzzy logic structure (time, temperature and input load)

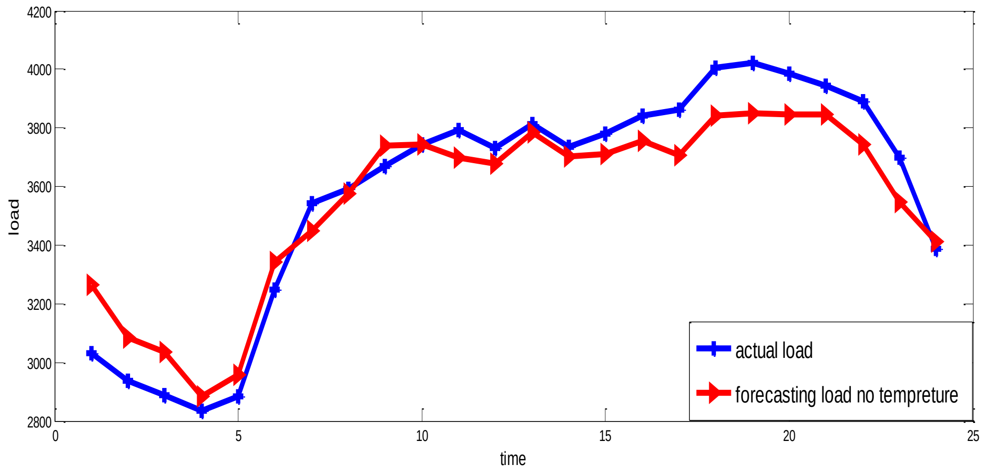

Figure (7):load curve in day of year 2013 no temperature

c- Considering Three Input (Time, Temperature and Input Load)

To check for the model performance under this condition.

As shown in figure (8) the fuzzy logic structure (time, temperature and input load) and results will be shown in figure (9).

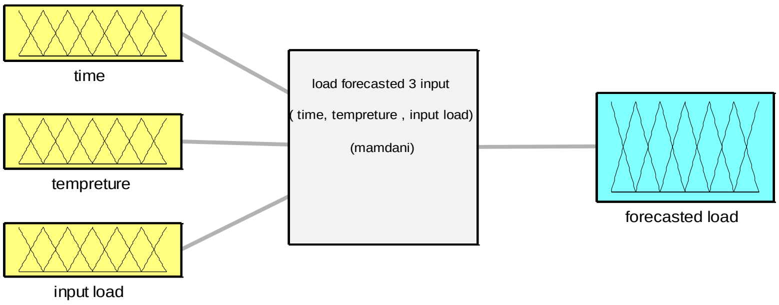

Figure (8) the fuzzy logic structure (time, temperature and input load)

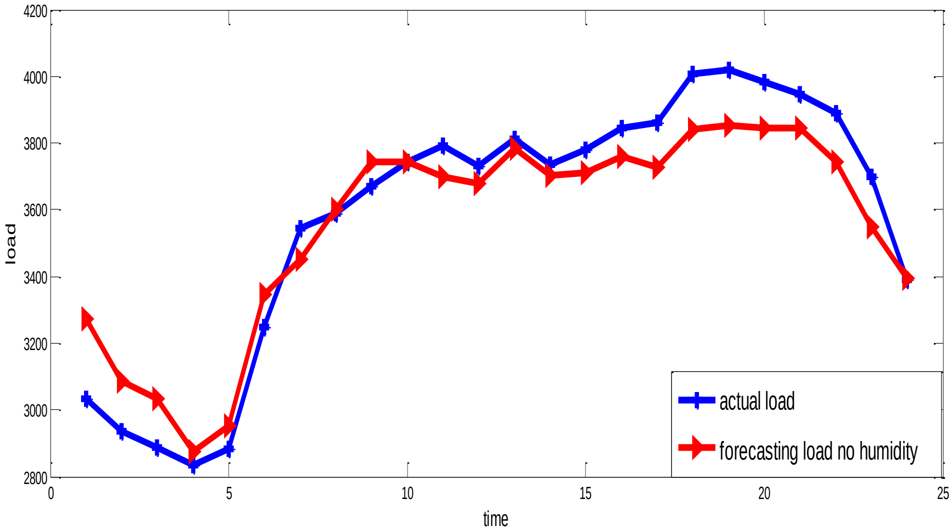

Figure (9) load curve in day of year 2013 no humidity

Comparing the results of case I and case II for different inputs where: case I the inputs (time, humidity, temperature and input load) and case II with inputs (time, humidity and input load) and (time, temperature and input load) are considered. Gave the best forecasting results compared to all other cases, as shown in table (5).

Table 1: Comparing the results of case I and case II for different inputs .

Case	%Error (min)	%Error (max)
I	0.016	7.9
II part 1	0.032	8.4
II part 2	0.037	8.9

Conclusions

This research presented a short term load forecasting (STLF) methodology using fuzzy logic, which takes into account the effect of humidity as well as temperature and time on load.

The results obtained from the simulation show that the proposed forecasting methodology, which proposes the use of weather variables. Temperature and humidity, gives a good load forecasting results with considerable accuracy. That means the proposed methodology which using more weather variables, will certainly be better than using only temperature as the weather variable affecting the load.

The study shows that the fuzzy logic model is able to forecast the short term load demand efficiently for different days of season's conditions.

Reference:

[1] Badran, H. El-Zayyat and G. Halasa, "Short-Term and Medium-Term Load Forecasting for Jordan's Power System", ISSN 1546-9239,2008.

[2] Underground weather forecast from net "temperature and humidity percent data for year 2013 and 2015 for Libya".

[3] Year 2013, and 2015 load data for GECOL.