



Research Article

## Short-Term Electrical Energy Demand Forecasting Using Fuzzy Logic Technique

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### ARTICLE INFO:

#### Keywords:

Fuzzy logic,  
Load forecasting,  
Model adequacy,  
Power System,

#### ABSTRACT

Minimization of electrical energy wastage and provision of its regular supply make electrical load forecasting an important aspect of the power infrastructure. An accurate load forecasting is crucial for the reduction of the cost of electrical energy generation and spinning reserve capacity. Therefore, in this study, fuzzy logic (FL) technique was employed for the projection of electrical energy demand on short-term basis. The FL model was trained using the six months hourly load and temperature data respectively obtained from 132/33 kV Ikeja West Transmission Station, Ayobo and Nigerian Meteorological Agency, Oshodi, Lagos State, Nigeria. Triangular and trapezoidal membership functions (MFs) were used in the training of the model with Mamdani fuzzy inference system. The time, load and temperature inputs were fuzzified into six, four and three MFs respectively while the fuzzification process used 25 fuzzy rule bases. The centroid method of defuzzification was used to change the results into readable values. The adequacy of the FL model was determined using five metrics including mean square error (MSE), mean absolute error (MAE), mean absolute percentage error (MAPE), chi square ( $\chi^2$ ) and F- test. The obtained results revealed that the FL model developed excelled in all the five tests of adequacy considered with MSE, MAE, MAPE,  $\chi^2$  and F-test values of 4.17, 6.74, 11.51%, 7.93 and 1.27 respectively and hence, performed satisfactorily. This work established that the fuzzy logic approach is appropriate for electrical load projection on short-term basis.

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## INTRODUCTION

Availability and regular supply of electricity are major propelling forces for economic growth and development of any country (IEA, 2019). Access to energy is important in actualization of the sustainable development goals (SDGs) by the year 2030 (Rahman *et al.*, 2018; Ruseh. and Shashi, 2022). Electricity supply in a developing economy such as Nigeria has been outrageous due to many challenges affecting the sector, which range from lack of regular supply of gas to the power plants to lack of regular maintenance and obsolete equipment. This has resulted in irregular supply of electricity making it difficult for the utility companies to meet the increasing demand of the customers. This inconsistency in electricity supply has consequently led to daily load shedding, thereby making productivity to drop and further resulting into slow economic growth and development.

Several efforts have been put forward in many developing countries across the globe including Nigeria to address the lingering power supply problems. One of such efforts is to have an accurate electricity demand forecasting model which is crucial for planning present and future energy usage. Generally, forecasting is knowing what may occur to a system in the near period (Mir *et al.*, 2020; Hammad *et al.*, 2020). Extending this to power system domain, electrical energy demand or load forecasting is defined as a method of estimating futuristic energy needs using past load records (Chheepa and Manglani, 2017; Islas *et al.*, 2021). It is a procedure used by power utility companies to envisage the energy required to keep the power supply and load demand at a stable condition regularly. Electricity demand forecasting provides input to future planning of resources (Faysal *et al.*, 2019; Girraj *et al.*, 2017). The cost of electricity and load forecasting are mutually related. Therefore, any error in forecasting the load will cause a spike in the cost of electricity since it depends greatly on the load demand.

Three categories of load forecasting exist in power system; namely short-term load forecasting (STLF) for one hour to one-week, medium-term load forecasting (MTLF) for one month to one year and long-term load forecasting (LTLF) for one year to 20 years. The focus of this study was, however, on short-term load forecasting. STLF is a very vital tool in the management of operation of the power infrastructure (Kavanagh, 2017; Miguel *et al.*, 2019). The reduction in the risk associated with the failure of substation and transmission equipment is achieved through the application of outcomes from conducting STLF (Upadhaya *et al.*, 2019).

Forecasting methods are divided into three major classifications which are statistical, artificial intelligence (AI) or machine learning and hybrid models (Husain *et al.*, 2017; Ibrahim *et al.*, 2021). Application of modern algorithms involving the use AI techniques such as FL in the development of electrical load forecasting models on short-term basis has been reported to provides minimal operational cost, optimal resources utilisation, efficient management of power and effective planning procedure (Chien *et al.*, 2022; Lv *et al.*, 2019).

Fuzzy logic is employed to complex system whose mathematical formulation is not clear or well defined. It is a method that represents information in a clear language understood my human (Islas *et al.*, 2021; Oladimeji *et al.*, 2021). This method digs out the correlation existing between the load and those factors that influences the energy demand. The STLF and LTLF can be achieved using this method as it has the capability to sort out any relationship between parameters used. Weather condition does not stop this method from performing an accurate prediction since analog and digital converters are not needed. One advantage of FL systems is that they can work with imprecise terms such as cold, warm, hot, or near boiling that humans commonly use.

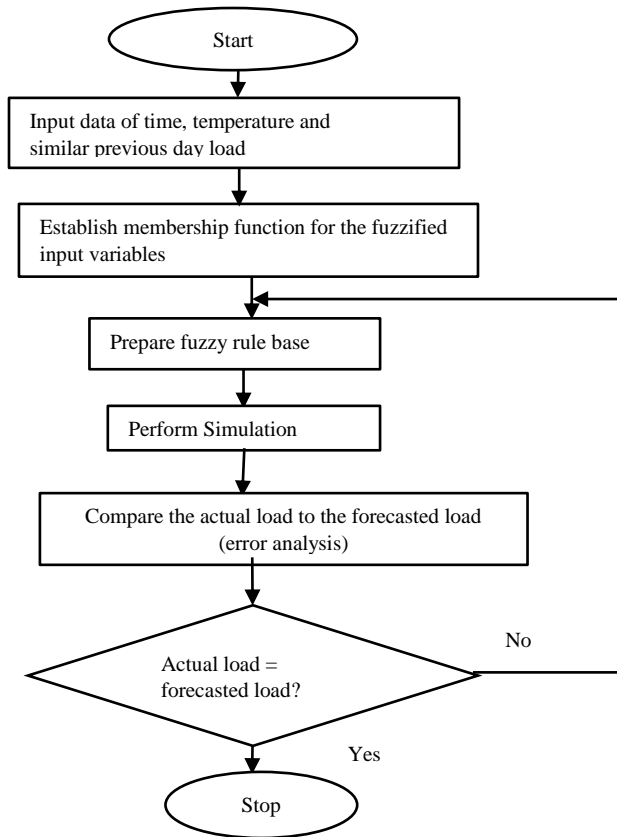
On this account, many researchers have conducted investigations to develop a model that will enhance the accuracy of the forecast using FL approach. *Islas et al. (2021) presented a FL model for hourly electrical power demand prediction considering temperature, humidity, time of the day, weekday, weekend or holiday, average previous load, load demand for previous day and previous week. Oladimeji et al. (2021) evaluate the performance of different membership functions (MFs) in FL technique for STLF of one day load ahead. Using time, temperature, and past load data as inputs, the developed fuzzy logic model was used to project 24 hours load demand. Manish and Sikander (2018) worked on STLF using fuzzy logic tool approach where the load increase during the normal days was found to be insignificant but was appreciable over the weekends or holidays. Analysis of the above highlighted literature points to the fact that more research attempts are still greatly required in the area of application of FL technique for STLF of electrical energy demand using practical load information. More so, the performance of the technique needs to be critically examined to determine its suitability for*

*a given forecasting application. Therefore, in this study, fuzzy logic model was employed to predict electrical energy demand on short-term basis considering the load data from 132/33 kV Ikeja West Transmission Station, Ayobo, Lagos State, South Western, Nigeria as a case study.*

## **MATERIALS AND METHODS**

### **Fuzzy Logic Technique**

The fuzzy logic approach consists of six basic stages which are input, fuzzification, controller, rule base, defuzzification and output stages. In the input stage, parameters for inputs are chosen and fuzzified or classified into membership functions (MFs). The MF is the curve that maps the input interval between 0 and 1 membership values. In this study, the triangular and trapezoidal MFs were employed. The controller receives the combination of the fuzzification process and the fuzzy rules. The controller is the fuzzy inference system where the implementation of the non-linear mapping of the input and output interval is carried out. The fuzzy controller processes the inputs with respect to the fuzzy rules to obtain the desired output. The flowchart showing the process of the fuzzy logic approach for this study is presented in Figure 1.



**Figure 1:** Flowchart of the fuzzy logic model

### Fuzzification of Input Data

Fuzzification is the process of arranging the fuzzy sets into membership functions. The Mamdani type of fuzzy inference system was used in this study. The time input was fuzzified into six fuzzy sets which include midnight (MN) ranging from 1 to 4 am, morning (M) from 2 to 10 am, noon (N) from 4 am to 12 pm, afternoon (AN) from 10 am to 18 pm, evening (E) from 12 to 20 pm and night (NT) from 16 pm to 24 am. The load input was fuzzified into four fuzzy sets as low load (LL) ranging from 31 to 34 MW, average load (AL) from 32 to 40 MW, high load (HL) from 34 to 42 MW and very high load (VHL) from 40 to 46 MW. The temperature input was fuzzified into three fuzzy sets as very low temperature (VLT) ranging from 26 to 28°C, low temperature (LT) from 27 to 31°C and high temperature (HT) from 30 to 33°C.

### Fuzzy Rule Base

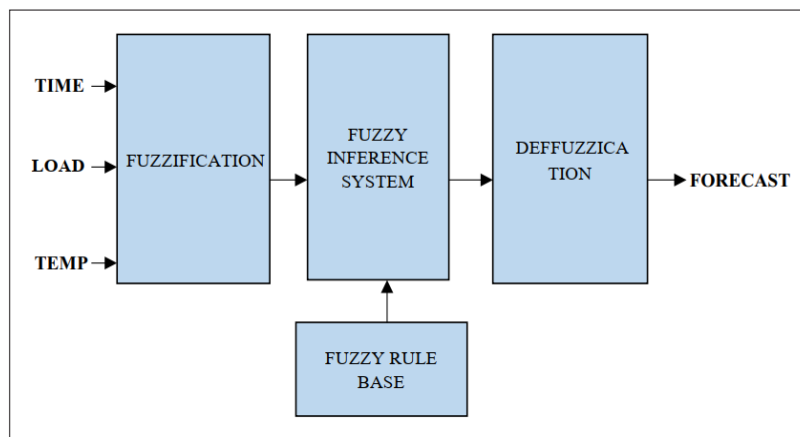
The rule base determines the fuzzy output accuracy. In this study, some of the 25 rule bases employed for the fuzzification process are presented as follows:

- i. IF (Time is MN) AND (Hourly Load is LL) AND (Same hour load for preceding day is LL) AND (Past week maximum load is LL) AND (Temperature is VLT) THEN (Forecasted load is low)
- ii. IF (Time is MN) AND (Hourly Load is LL) AND (Same hour load for preceding day is LL) AND (Past week maximum load is LL) AND (Temperature is LT) THEN (Forecasted load is low)
- iii. IF (Time is M) AND (Hourly Load is LL) AND (Same hour load for preceding day is LL) AND (Past week maximum load is LL) AND (Temperature is LT) THEN (Forecasted load is low)

- iv. IF (Time is M) AND (Hourly Load is AL) AND (Same hour load for preceding day is AL) AND (Past week maximum load is AL) AND (Temperature is LT) THEN (Forecasted load is average)
- v. IF (Time is M) AND (Hourly Load is HL) AND (Same hour load for preceding day is HL) AND (Past week maximum load is HL) AND (Temperature is LT) THEN (Forecasted load is high)

### Defuzzification

Defuzzification was performed to change the outputs from the fuzzification stage to readable values or distinct numbers and presented as the forecasted outputs. The centroid method of defuzzification was used to obtain the forecasted outputs for 24 hours by presenting the values of various inputs of the time, hourly load, past day same hourly load, past week maximum hourly load, and temperature. Figure 2 is a block diagram of a simple FL process deployed for this study.



**Figure 2:** Fuzzy Logic Process

### Data Collection and Analysis

Temperature data of Lagos State were obtained from Nigerian Meteorological Agency (NiMet) at Oshodi, Lagos State while the load data were collected from 132/33kV Ikeja West Transmission Station at Ipaja – Ayobo Road, Lagos State, Nigeria. The hourly temperature and hourly load data were collected for six months (April 3 to September 30, 2022) from NiMet and Ikeja West Transmission Station respectively for the study. Data collected from 3rd to 9th April 2022 were used for the training of the model while data from April 10 to September 30, 2022 were utilised for the testing and validation. The temperature and load data obtained were prepared in processed using MATLAB R2018a software.

The FL application using the MATLAB software is divided into three steps: The first step starts by opening the MATLAB software, prepared the

fuzzy editor, add the input variables, define each input, the output and title of the design and save the work on the workspace. The second step involves defining MF for each input and output. The type of MF was chosen (for this study trapmf was chosen for the first and last MF while trimf was used for the other MFs) and the number of MF (according to the number of fuzzy set) is also stated. The range and parameters of each MF is indicated according to range of fuzzification of the input and output. At the final step the 25 fuzzy rules were defined and each input value were inserted in the input box and the output viewed as the forecasted load. Finally, the predicted results for each day of the week is viewed on the MATLAB live editor and saved.

### Testing of Model Adequacy

In testing the adequacy of the developed fuzzy logic model, five indices were used. These

include the mean absolute error (MAE), mean absolute percentage error (MAPE), mean square error (MSE), chi square ( $\chi^2$ ) test and F-test. These metrics were chosen so as to check how close the forecasted loads are to the actual loads. The lower the value of the metrics the closer the predicted load to the actual load.

$$MAE = \frac{\sum_{i=1}^n |Y_i - X_i|}{n} \quad (1)$$

Where  $Y_i$  is the forecast value,  $X_i$  is the actual value and  $n$  is the total number of variables. MAPE evaluates in percentage the correctness of the forecast and the lower the value of MAPE and the higher the accuracy of the prediction. MAPE is mathematically expressed by equation (2):

$$MAPE = \frac{1}{n} \sum_{i=1}^n \left| \frac{\text{actual}(i) - \text{forecast}(i)}{\text{actual}(i)} \right| \quad (2)$$

MSE is the average of the square of variation between actual and forecast values. A lower value of MSE gives an indication of closeness between actual and forecast values. It given mathematically by equation (3):

$$MSE = \frac{1}{n} \sum_{i=1}^n (X_i - Y_i)^2. \quad (3)$$

$\chi^2$  is a hypotheses test that is used to determine if there is a relationship between two definite variables and it is by expressed by equation (4):

$$\chi^2 = \sum \frac{(\text{Observed} - \text{Expected})^2}{\text{Expected}} \quad (4)$$

F-test is an index use to test the null hypothesis that the variation of two populations is equal. It is expressed by equation (5):

$$F = \frac{\text{Larger estimate of variance}}{\text{Smaller estimate of variance}} \quad (5)$$

## RESULTS AND DISCUSSION

### Collected Data

Some samples of the load and temperature data collected for this study are presented in Tables 1

MAE is the mean of the absolute values of each forecast errors at all point in the test set and the lower the MAE score the better the prediction. MAE is expressed mathematically by equation (1):

to 7. The tables contain information on hour of the day, hourly load, past day same hourly load, past week maximum load and temperature.

**Table 1:** The actual hourly energy demand and temperature data for Sunday 03/04/2022

Hour of the Day	Hourly Load (MW)	Past Day Same Hourly Load (MW)	Past Week Max Load (MW)	Tempt. (°C)
1.00	30.10	28.80	46.60	28.00
2.00	32.10	32.70	46.60	28.06
3.00	39.60	40.20	46.60	28.00
4.00	41.20	40.20	46.60	28.67
5.00	33.50	34.30	46.60	28.56
6.00	34.50	32.20	46.60	28.73
7.00	35.70	33.10	46.60	29.12
8.00	36.40	39.10	46.60	29.34
9.00	41.50	39.60	46.60	29.12
10.00	39.80	41.20	46.60	29.96
11.00	39.80	43.50	46.60	29.68
12.00	33.70	36.50	46.60	30.02
13.00	36.40	35.70	46.60	30.24
14.00	44.10	40.40	46.60	30.63
15.00	38.10	43.80	46.60	30.24
16.00	37.10	38.50	46.60	31.25
17.00	39.10	41.90	46.60	30.80
18.00	37.70	42.10	46.60	31.86
19.00	39.60	38.70	46.60	31.36
20.00	38.90	41.40	46.60	31.98
21.00	40.80	41.50	46.60	32.48
22.00	39.70	39.80	46.60	33.15
23.00	37.90	43.90	46.60	33.60
24.00	38.60	36.40	46.60	34.33

**Table 2:** The actual hourly energy demand and temperature data for Monday 04/04/2022

Hour of the Day	Hourly Load (MW)	Past Day Same Hourly Load (MW)	Past Week Max Load (MW)	Tempt. (°C)
1.00	33.70	30.10	46.60	28.00
2.00	37.30	32.10	46.60	28.00
3.00	40.60	39.60	46.60	28.00
4.00	39.00	41.20	46.60	28.56
5.00	36.20	33.50	46.60	28.56
6.00	31.80	34.50	46.60	28.56
7.00	38.00	35.70	46.60	29.12
8.00	38.70	36.40	46.60	29.12
9.00	41.20	41.50	46.60	29.12
10.00	39.60	39.80	46.60	29.68
11.00	41.30	39.80	46.60	29.68
12.00	38.80	33.70	46.60	29.68

13.00	39.40	36.40	46.60	30.24
14.00	38.00	44.10	46.60	30.24
15.00	41.00	38.10	46.60	30.24
16.00	35.90	37.10	46.60	30.80
17.00	41.30	39.10	46.60	30.80
18.00	36.50	37.70	46.60	31.36
19.00	37.00	39.60	46.60	31.36
20.00	40.00	38.90	46.60	31.92
21.00	37.90	40.80	46.60	32.48
22.00	40.70	39.70	46.60	33.04
23.00	35.20	37.90	46.60	33.60
24.00	40.10	38.60	46.60	34.16

**Table 3:** The actual hourly energy demand and temperature data for Tuesday 05/04/2022

Hour of the Day	Hourly Load (MW)	Past Day Same Hourly Load (MW)	Past Week Max Load (MW)	Tempt. (°C)
1.00	28.20	33.70	46.60	28.06
2.00	30.00	37.30	46.60	28.00
3.00	37.00	40.60	46.60	28.11
4.00	38.60	39.00	46.60	28.56
5.00	32.00	36.20	46.60	28.73
6.00	35.70	31.80	46.60	28.56
7.00	36.40	38.00	46.60	29.34
8.00	39.80	38.70	46.60	29.12
9.00	38.50	41.20	46.60	29.40
10.00	41.90	39.60	46.60	29.68
11.00	42.10	41.30	46.60	30.02
12.00	37.80	38.80	46.60	29.68
13.00	37.80	39.40	46.60	30.63
14.00	40.80	38.00	46.60	30.24
15.00	38.90	41.00	46.60	30.69
16.00	32.50	35.90	46.60	30.80
17.00	43.10	41.30	46.60	31.30
18.00	38.90	36.50	46.60	31.36
19.00	42.40	37.00	46.60	31.42
20.00	43.60	40.00	46.60	31.92
21.00	41.40	37.90	46.60	32.59
22.00	40.70	40.70	46.60	33.04
23.00	40.90	35.20	46.60	33.77
24.00	39.50	40.10	46.60	34.16



**Table 4:** The actual hourly energy demand and temperature data for Wednesday 06/04/2022

Hour of the Day	Hourly Load (MW)	Past Day Same Hourly Load (MW)	Past Week Max Load (MW)	Tempt. (°C)
1.00	30.00	28.20	46.60	28.01
2.00	33.00	30.00	46.60	28.56
3.00	35.10	37.00	46.60	29.13
4.00	43.00	38.60	46.60	29.68
5.00	37.90	32.00	46.60	30.26
6.00	30.60	35.70	46.60	30.80
7.00	37.60	36.40	46.60	31.38
8.00	38.10	39.80	46.60	31.92
9.00	38.40	38.50	46.60	32.51
10.00	39.70	41.90	46.60	33.04
11.00	39.00	42.10	46.60	33.63
12.00	32.30	37.80	46.60	34.16
13.00	32.10	37.80	46.60	34.76
14.00	39.80	40.80	46.60	35.28
15.00	43.10	38.90	46.60	35.88
16.00	38.50	32.50	46.60	36.40
17.00	39.80	43.10	46.60	37.01
18.00	40.50	38.90	46.60	37.52
19.00	42.20	42.40	46.60	38.09
20.00	41.70	43.60	46.60	38.65
21.00	41.80	41.40	46.60	39.20
22.00	45.50	40.70	46.60	39.78
23.00	40.40	40.90	46.60	40.32
24.00	39.90	39.50	46.60	40.90

**Table 5:** The actual hourly energy demand and temperature data for Thursday 07/04/2022

Hour of the Day	Hourly Load (MW)	Past Day Same Hourly Load (MW)	Past Week Max Load (MW)	Tempt. (°C)
1.00	30.90	30.00	46.60	28.00
2.00	33.50	33.00	46.60	28.06
3.00	35.20	35.10	46.60	28.00
4.00	42.90	43.00	46.60	28.62
5.00	36.80	37.90	46.60	28.56
6.00	32.10	30.60	46.60	28.63
7.00	35.20	37.60	46.60	29.12
8.00	39.80	38.10	46.60	29.19
9.00	39.40	38.40	46.60	29.12
10.00	38.90	39.70	46.60	29.76
11.00	40.20	39.00	46.60	29.68
12.00	33.20	32.30	46.60	29.76
13.00	34.40	32.10	46.60	30.24

14.00	39.20	39.80	46.60	30.33
15.00	42.60	43.10	46.60	30.24
16.00	38.70	38.50	46.60	30.90
17.00	38.50	39.80	46.60	30.80
18.00	43.90	40.50	46.60	30.90
19.00	41.40	42.20	46.60	31.36
20.00	40.20	41.70	46.60	31.47
21.00	41.20	41.80	46.60	31.92
22.00	45.80	45.50	46.60	32.03
23.00	40.40	40.40	46.60	32.48
24.00	40.60	39.90	46.60	33.21

Table 6: The actual hourly energy demand and temperature data for Friday 08/04/2022

Hour of the Day	Hourly Load (MW)	Past Day Same Hourly Load (MW)	Past Week Max Load (MW)	Tempt. (°C)
1.00	30.80	30.90	46.60	28.00
2.00	34.60	33.50	46.60	28.06
3.00	34.30	35.20	46.60	28.06
4.00	42.50	42.90	46.60	28.63
5.00	36.80	36.80	46.60	28.63
6.00	33.60	32.10	46.60	28.64
7.00	34.10	35.20	46.60	29.20
8.00	41.30	39.80	46.60	29.21
9.00	40.40	39.40	46.60	29.22
10.00	39.10	38.90	46.60	29.78
11.00	39.80	40.20	46.60	29.79
12.00	33.10	33.20	46.60	29.79
13.00	34.70	34.40	46.60	30.36
14.00	39.20	39.20	46.60	30.36
15.00	42.50	42.60	46.60	30.37
16.00	38.70	38.70	46.60	30.93
17.00	38.90	38.50	46.60	30.94
18.00	43.00	43.90	46.60	31.51
19.00	41.20	41.40	46.60	31.51
20.00	41.60	40.20	46.60	32.08
21.00	42.60	41.20	46.60	32.08
22.00	44.90	45.80	46.60	32.65
23.00	40.50	40.40	46.60	32.65
24.00	41.90	40.60	46.60	33.22

**Table 7:** The actual hourly energy demand and temperature data for Saturday 09/04/2022

Hour of the Day	Hourly Load (MW)	Past Day Same Hourly Load (MW)	Past Week Max Load (MW)	Temp. (°C)
1.00	29.60	30.80	46.60	28.28
2.00	33.40	34.60	46.60	28.34
3.00	35.10	34.30	46.60	28.39
4.00	42.20	42.50	46.60	29.01
5.00	37.60	36.80	46.60	29.06
6.00	33.30	33.60	46.60	28.85
7.00	33.00	34.10	46.60	29.41
8.00	40.00	41.30	46.60	29.42
9.00	40.00	40.40	46.60	29.42
10.00	39.50	39.10	46.60	29.99
11.00	39.90	39.80	46.60	29.99
12.00	33.70	33.10	46.60	30.00
13.00	33.70	34.70	46.60	30.56
14.00	38.00	39.20	46.60	30.57
15.00	42.40	42.50	46.60	30.58
16.00	37.70	38.70	46.60	31.14
17.00	39.40	38.90	46.60	31.15
18.00	43.50	43.00	46.60	31.15
19.00	43.50	41.20	46.60	31.72
20.00	40.80	41.60	46.60	31.72
21.00	42.40	42.60	46.60	31.73
22.00	45.10	44.90	46.60	32.30
23.00	40.20	40.50	46.60	32.86
24.00	40.40	41.90	46.60	32.87

### The Developed Fuzzy Logic Model

The different graphical user interfaces (GUIs) of the developed fuzzy logic model for STLF in the study are presented in Figure 3 to 8. Figure 3 presents the GUI of MFs for the time input fuzzification into midnight, morning, noon, afternoon, evening and night while GUI of MFs for load input fuzzification into low, average, high and very high loads is shown Figure 4.

Figure 5 depicts the GUI of MFs for temperature input fuzzification into very low, low and high temperatures. Figure 6 is the GUI for the forecasted output MF. The GUI in Figure 7 shows samples of the 25 rule bases on the fuzzy set in the fuzzification process. The GUI in Figure 8 gives the values of the output obtained after the forecast.

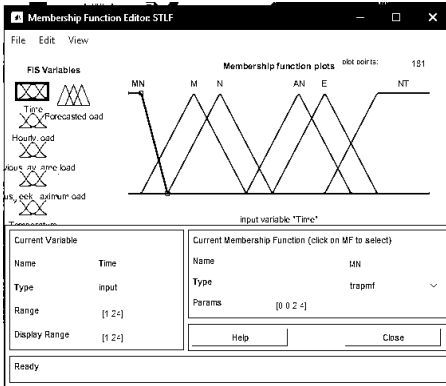


Figure 3: GUI of MFs for input time

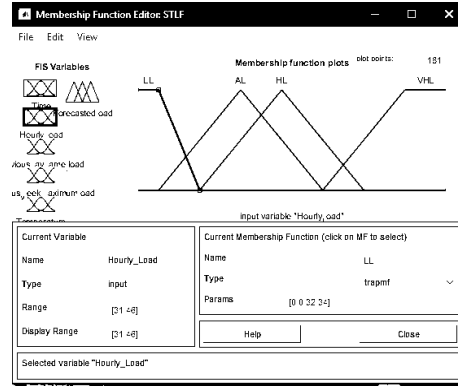


Figure 4: GUI of MFs for input hourly load

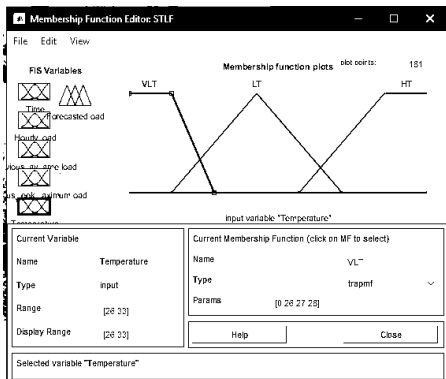


Figure 5: GUI of MFs for input temperature

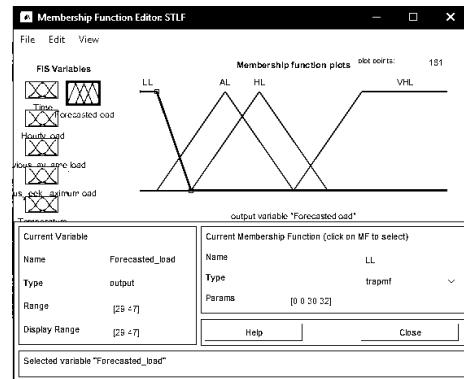


Figure 6: GUI of MFs for output forecasted load

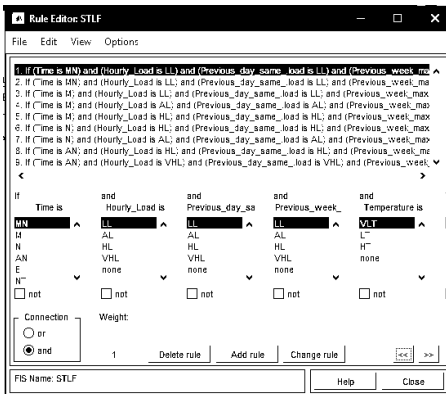


Figure 7: GUI of developed rule base

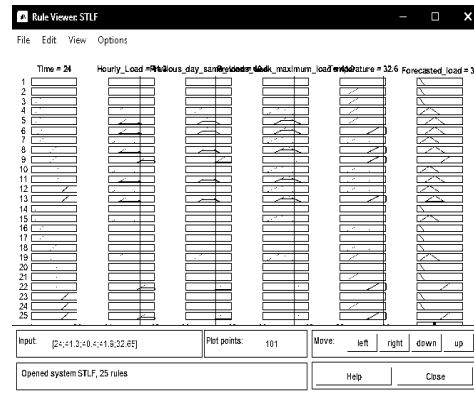
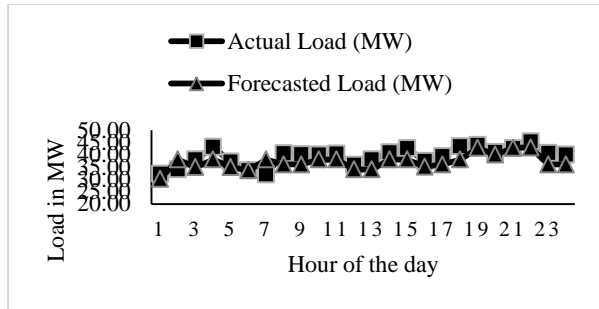


Figure 8: GUI of forecasted output

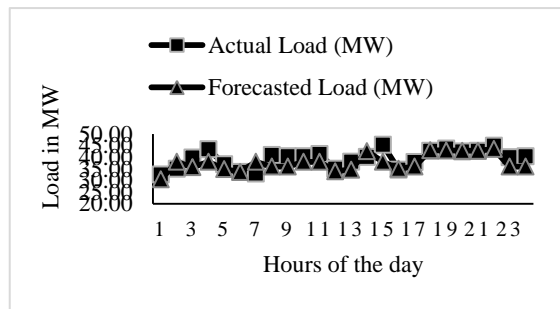
### Results of Load Demand from the Developed Fuzzy Logic Model

The fuzzy logic model developed was used to project load for 24 hours period for different days

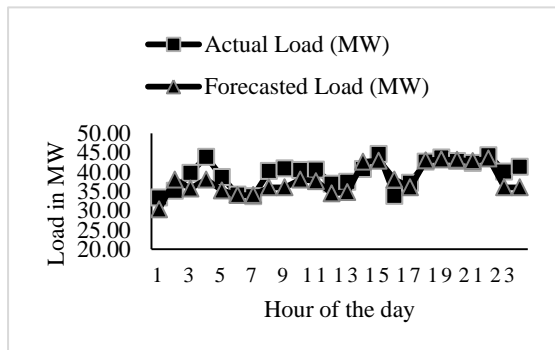
in the month of April 2022 and the results obtained where the forecasted loads were compared with the actual load are presented in Figures 9 to 16.



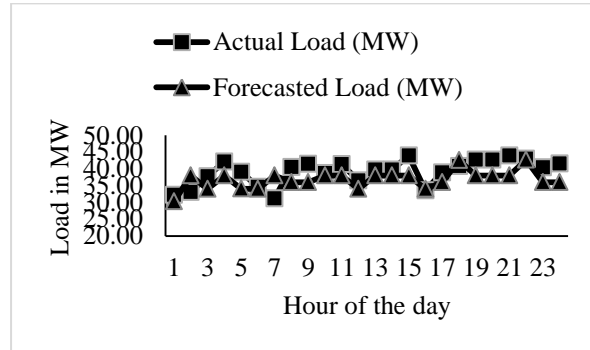
**Figure 9:** Fuzzy logic actual and forecasted hourly load for Sunday 10/04/2022



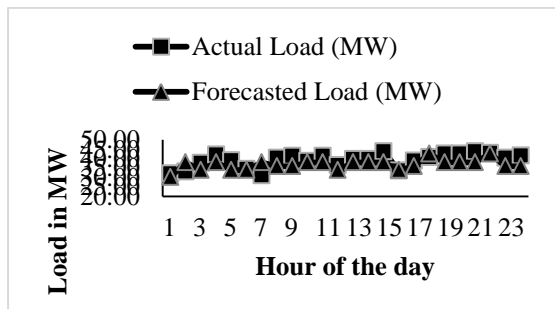
**Figure 10:** Fuzzy logic actual and forecasted hourly load for Monday 11/04/2022



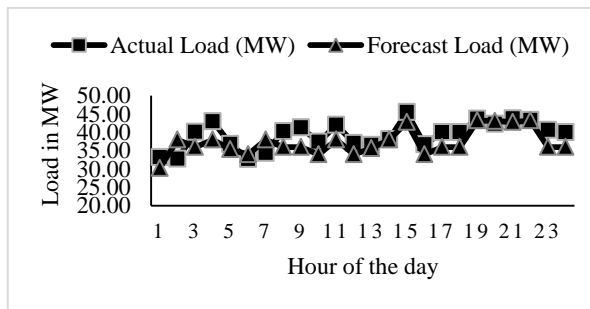
**Figure 11:** Fuzzy logic actual and forecasted hourly load for Tuesday 12/04/2022



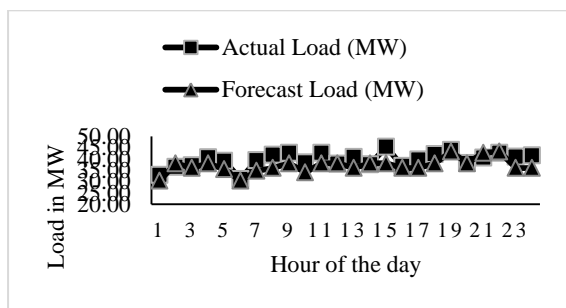
**Figure 12:** Fuzzy logic actual and forecasted hourly load for Wednesday 13/04/2022



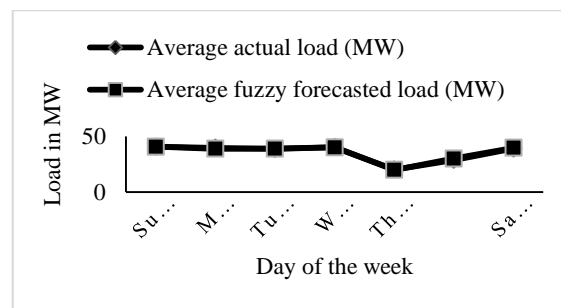
**Figure 13:** Fuzzy logic actual and forecasted hourly load for Thursday 14/04/2022



**Figure 14:** Fuzzy logic actual and forecasted hourly load for Friday 15/04/2022



**Figure 15:** Fuzzy logic actual and forecasted hourly load for Saturday 16/04/2022



**Figure 16:** Fuzzy logic actual and forecasted hourly load for 17th to 23rd April 2022

The results in Figures 9 to 16 showed that the load values forecasted by the fuzzy logic model developed typically followed the same trend as the actual load values and the plots of the forecasted and actual load profiles for the days considered almost overlap, with minor deviation observed. This indicated that the developed model is suitable and useful for projecting load demand on short-term basis, achieving the intended goal of the study. The results in Figures 8 to 15 further revealed that increase in load demand is dependent on the time of the day. An increase in load demand was observed from Figures 9 to 15 at those times of the day where energy consumption activities tend to increase. These times include 4 – 5 am, 9 am – 12 noon, 2 – 3 pm and 7 – 10 pm. The results showed that when the weather is hot there is a significant increase on the electricity demand. The increase on electricity demand is caused by the rise in temperature. When it rains, the energy consumption drops as the temperature decreases. The average computed MSE, MAE, MAPE,  $\chi^2$  and F-test for the model were 4.17, 6.74, 11.51%, 7.93 and 1.27 respectively. These values signify that the FL model was adequate in terms of accuracy and suitable for short-term load demand forecasting.

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## CONCLUSION

Accurate load forecasting is a very important part of the power system regarding generation, transmission and distribution of electricity as well as planning and procurement of equipment. An inaccurate load projection can cause a great loss to the power utility companies in that under or over estimation can lead to under-utilization or wastage of resources. Therefore, this study developed a fuzzy logic model for projecting load demand on short-term basis. The results obtained showed that the fuzzy logic model was adequate and appropriate for STLF. Comparison of the forecasted loads from the fuzzy logic model with actual loads indicated a minimal error between the two load values, confirming the suitability of the developed model for STLF. This study established that a fuzzy logic technique when properly applied can be used to develop a potent short-term forecasting tool for planning and management purposes in power systems for efficient operation. The hybrid model based on neuro-fuzzy inference system such as adaptive neuro-fuzzy inference system (ANFIS) can be considered and future studies can incorporate information about the customer class and population for a clearer insight on the forecast.

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