Advance Guess of Electricity Price by AI using FIS-ANN Hybrid Modal

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ABSTRACT: DEREGULATION HAS MAJOR IMPACT ON ELECTRICAL POWER SCENARIO IN CURRENT ERA. PRICE GUESSING IS NECESSARY TO DEVELOP BIDDING STRATEGIES TO MAXIMIZE THEIR BENEFITS AND UTILITIES, ESPECIALLY FOR SPOT MARKETS AND SHORT-TERM CONTRACTS. THE CURRENT ELECTRICITY MARKET DEREGULATION IS EFFECTIVELY LOOK AFTER BY PRICE ESTIMATION TOOL. POWER SYSTEM RISK ASSESSMENT AND OTHER DECISION MAKING TOGETHER WITH PLANNING AND OPERATION, ARE WELL EXECUTED BY PRICE ESTIMATION. IN THIS WORK, FUZZY INFERENCE SYSTEM (FIS) AND ANN IS COMBINED TO GUESS, SHORT PERIOD-HOURLY ELECTRICITY PRICE. THE ELECTRICITY DATA FROM THE INDIAN ENERGY EXCHANGE WEB SITE, HOURLY PAST LOAD AND HOURLY PAST PRICE DATA, IS UTILIZED TO DEVELOP THE SYSTEM. ADVANCE GUESS OF ELECTRICITY PRICE ACCURACY EVALUATED BY THE CALCULATION OF MEAN ABSOLUTE PERCENTAGE ERROR (MAPE). THE RESULT INDICATES THAT AI ESPECIALLY IN A COMBINATION OF FIS-ANN MODEL, PREDICTED PRICE ACCURACY IS CONSIDERABLY NEAR TO ACTUAL PRICE.

Keywords: Electricity Price Forecasting, Fuzzy Inference System (FIS), Artificial Neural Network (ANN), Mean Absolute Percentage Error (MAPE), Price of Electricity (PoE)

1. INTRODUCTION

From every activity of electricity market, electricity price has been given first choice by launching restructuring in the electric power scenario. Across universe, due to deregulation, most of the electricity market, future demand and PoE, electricity producer and electricity traders for making bidding strategies, as well as system operators for smooth take up of the market, PoE and future demand become important for market players. Based on its requirement, price guessing can be classified into short- period (few days), middle period (few months) and longer-period (few years)

Various models have been used in Power systems for achieving guessing accuracy. They are: regression, statistical and state space methods. Artificial Intelligence (AI)based methods have been searched based on expert systems, artificial neural networks, fuzzy systems, evolutionary programming and various combinations of all above.

Fuzzy logic is very convenient and easily understandable. Mathematical concepts of if-then of it, is very simple. It is automotive learning without reaching complication. NN have the well-known advantages of dealing successfully with any nonlinear function and clear problems of any type of date which has no relationship or not solved it out quickly for any input-output, because NN are run by data.

Neural networks are a effective, efficient and flexible user-friendly tool for guessing, provided that enough data for training, necessary selection of the input–output samples, appropriate number of hidden units and sufficient computational resources available. NN have the well-known benefit of dealing successfully with numerous nonlinear functions and rectify difficulties of any type of date which has no relationship or not solved it out quickly for any input-output, because NN are run by data.

2. Electricity Price Prediction

Market-clearing price (MCP) is the basic pricing idea and PoE is the peak factor for all market participants in the power market. MCP is the only price of whole system where there is no congestion of transmission. Zonal market clearing price (ZMCP) or locational marginal price (LMP) can be employed for the solution of congestion.

Basic reason for electricity price variation is that the supply and demand should be synchronised on a second-by-second basis. Other reasons follow:

Up and down in fuel price
Fluctuating Load
Changes in electricity production
Uncertain Generation (outages)
Congestion in transmission
Look out variation in market player
Adjustment in Market

3. Performance Evaluation of Price Prediction

Determine the accuracy of the proposed approaches in guessing electricity prices, forecasting error is considered as the most important parameter. This accuracy is calculated in function of actual market prices that prevailed. Criterion of mean absolute percentage error - MAPE, is the standard parameter for evaluation of the predicting accuracy.

The MAPE criterion is given by:

$$\mathrm{MAPE} = \frac{100}{N}\sum_{h=1}^{N}\frac{|\hat{p}_h - p_h|}{\bar{p}}$$

And

$$\bar{p} = \frac{1}{N}\sum_{h=1}^{N} p_h$$

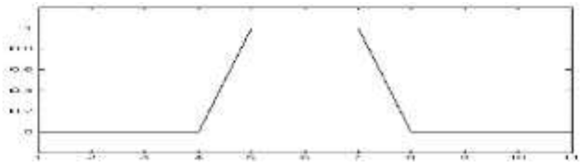
Where,
$\hat{p}h$ and ph are respectively the predicted and actual electricity prices at hour h,
$\bar{p}$ is the average price of the predicting interval and
N is the number of predicted hours.

PoE can at particular hours go up to tens or even higher times of its usual value. It goes down to zero or even to negative at other interval of times. Therefore, average price taken in formula to avoid the problem caused by prices near to zero.

4. Fuzzy Logic: -

Fuzzy Sets

It is a generalization of ordinary set, which allows the degree of membership for each element to range over the unit interval [0, 1]. Therefore, MF of a fuzzy set maps each element of the universe of discourse to its range space, which, in most cases, is assumed to be the unit interval.



$$\pi(x;\alpha,\beta,\gamma) = \begin{cases} 0, & x < \alpha \\ \frac{x-\alpha}{\beta-\alpha}, & \alpha \le x < \beta \\ 1, & \beta \le x \le \gamma \\ \frac{\delta-x}{\delta-\gamma}, & \gamma < x \le \delta \\ 0, & x > \delta \end{cases}$$

Fig 1: Trapezoidal Function

Logical Operations

The min operation by using the function min (A, B) indicate the statement A AND B, whereas the max operation by using the function max (A, B) indicate the statement A OR B. The operation NOT A becomes equivalent to the operation 1-A. The input values can be real numbers between 0 and 1.

Fuzzy Logic GUI tools for FIS:

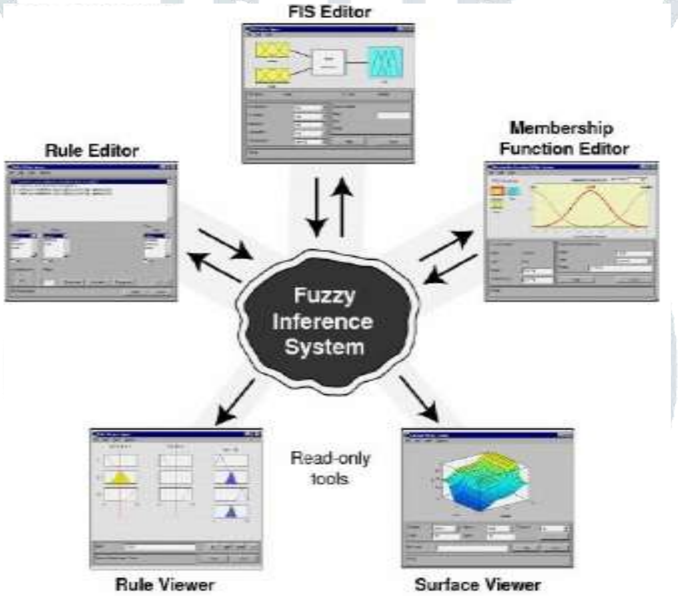


Fig 2.: Fuzzy Logic GUI toolbox

Fuzzy Inference System (FIS)

It's a nonlinear way to express input to output space. And rules are connection between above express space.

Suppose x is the input linguistic variable with a membership function A, and y is the output linguistic variable with a membership function B. Then, structure of the rule is, IF x is A THEN y is B.

In the above rule, the portion after the IF and before the THEN ('x is A') is called the premise or antecedent of the rule. And the portion after the THEN ('y is B') is called the conclusion or consequent of the rule.

Defuzzification

Inverse of the fuzzification step is called Defuzzification. Defuzzification step revert the intuition values into (0,1) values. It deals the activity to get final output as variable values So, it includes sketch a one or many output value(s) from conclusive fuzzy set passed on inference stage.

Table 1: Rules for Trapezoidal MF FIS Price Forecasting

Previous Load (pre load)	Previous Price (pre price)	Forecasted Price (Predicted price)
low	lower	Lower
low	moderate	Lower
low	higher	Lower
medium	lower	Lower

medium	moderate	Moderate
medium	higher	Moderate
high	lower	Lower
High	Moderate	Moderate
high	higher	Higher

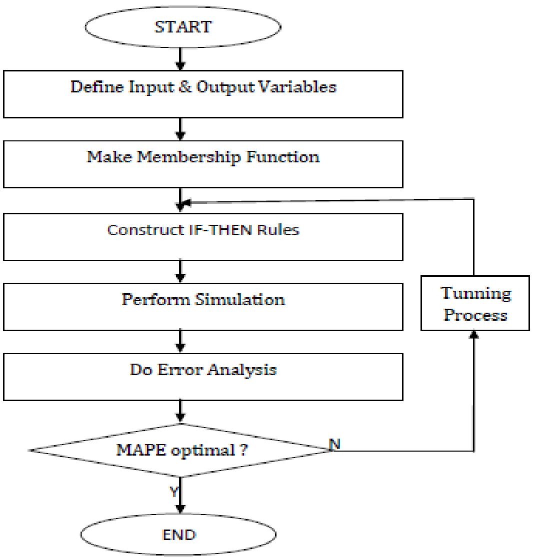


Fig 3: Flowchart of FIS model

5. Artificial Neural Networks (ANN)/ (NN)

In ANN layers of neurons used such as:

• **Input layer**: The number of inputs equals number of neurons to the NN. It's a passive node, i.e., without taking part in signal modification only transmit signal to next layer.

• **Hidden layer**: Random layers with random neurons. The nodes become active by actively participating in signal modification.

• **Output layer**: Output values and number of neurons are equals in NN o/p layer. Here nodes are active ones.

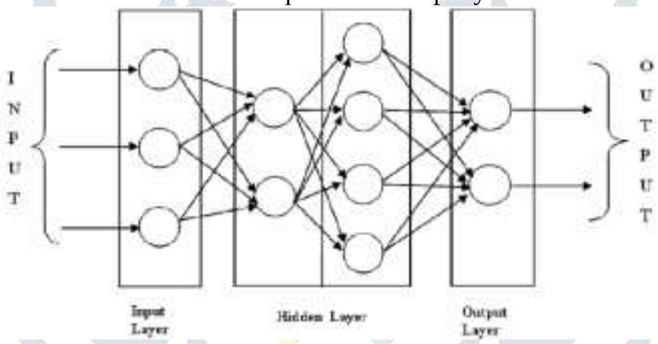


Fig.4: Structure of ANN

Neuron Structure:

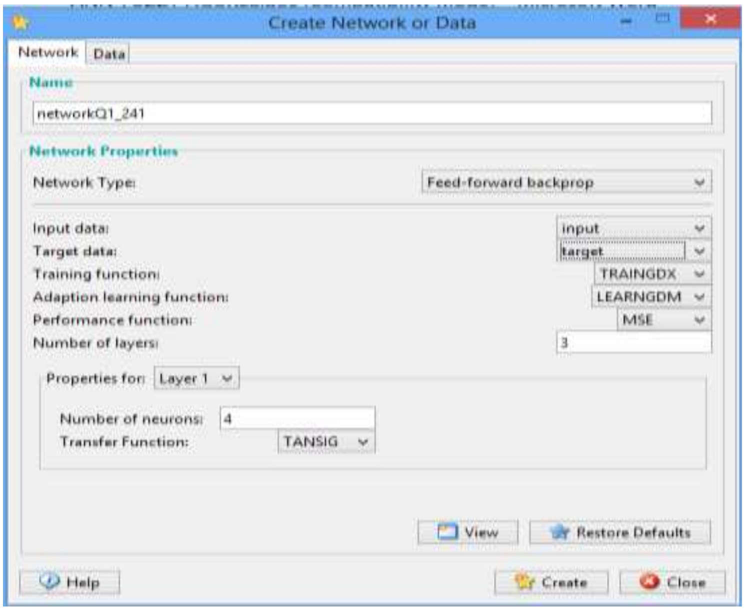
Three main parts of biological neuron are:

Cell body. Most important part of neuron having nucleus. Information processing activity performed by it.

Axon. It having only one axon keeping nerve signals away from neuron. It is heavily branched, to reach so many neurons as possible. Connection of axon to lot many neurons are called synapses.

Dendrites. These are nerve endings. From various neurons incoming signals carry up to cell body.

GUI diagram of neural network creation & training



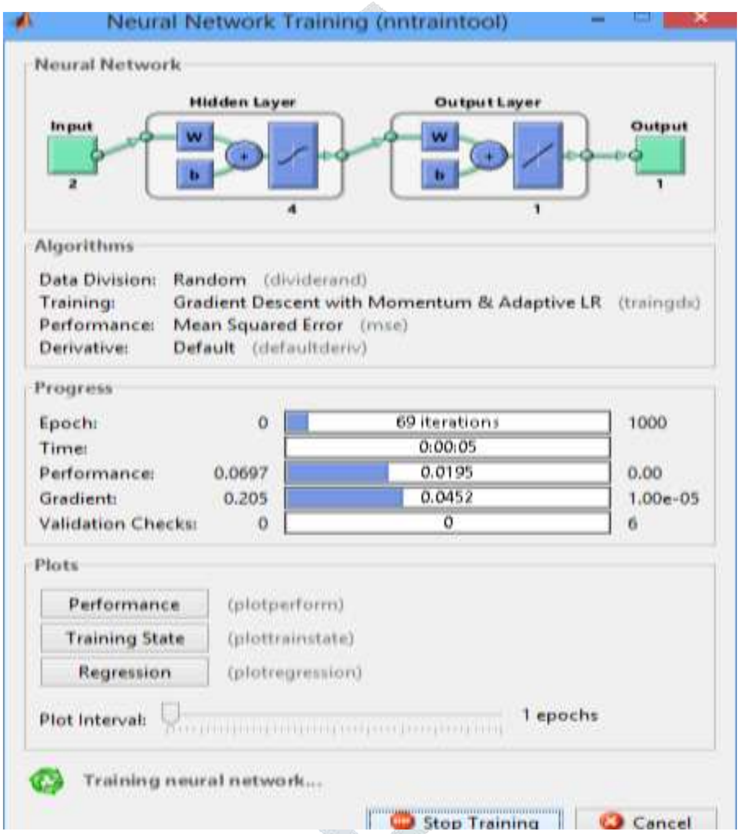


Fig 5: GUI diagram of NN creation & training

6. RESULTS

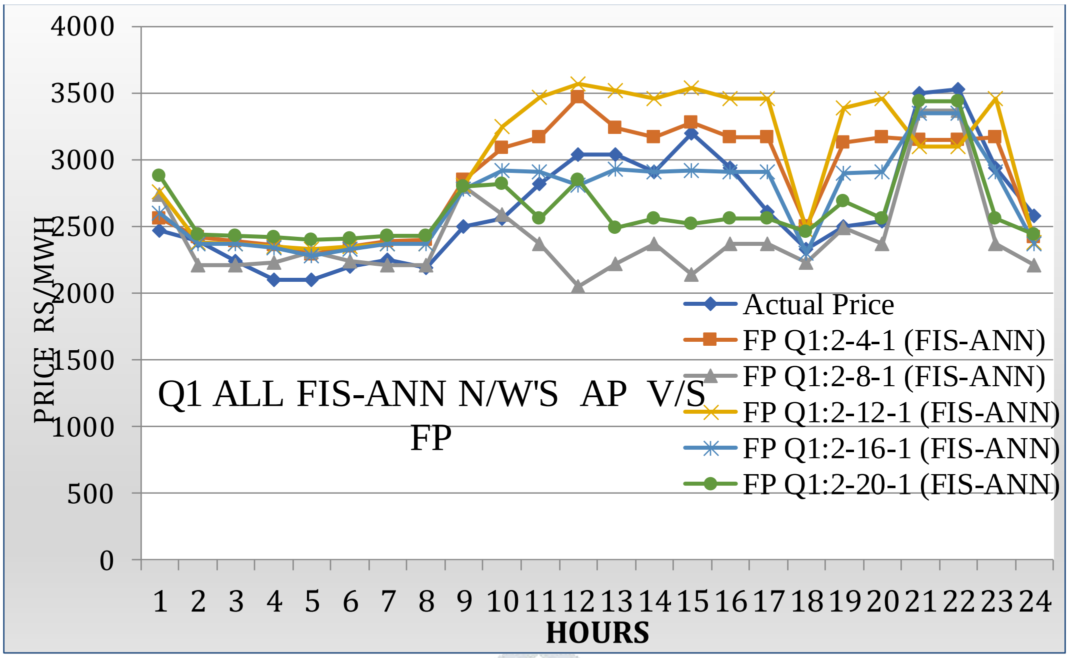


Fig 6.: Q1: All Trap. MF- FIS &NN N/W's, Actual Price V/S Forecasted price

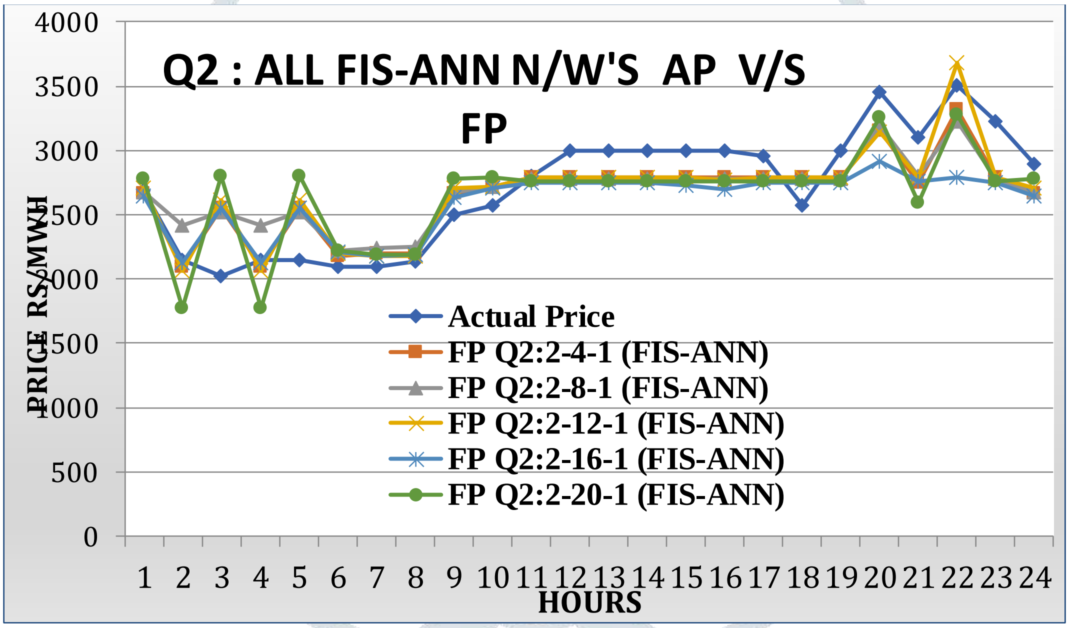


Fig 7.: Q2: All Trap. MF- FIS &NN N/W's, Actual Price V/S Forecasted price

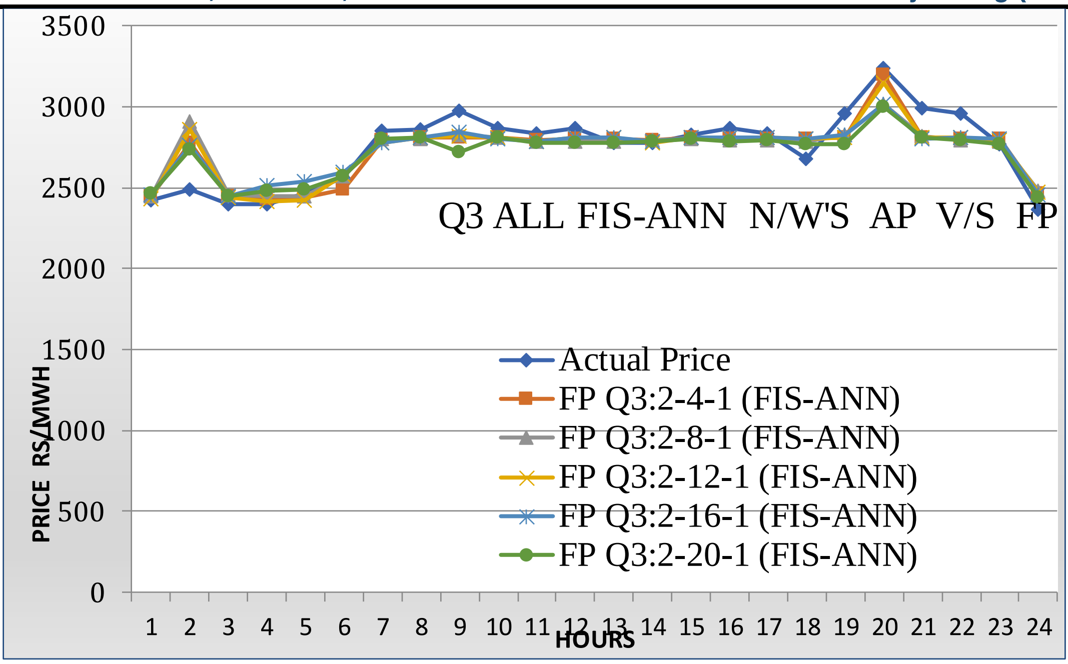


Fig 8: Q3: All Trap. MF- FIS &NN N/W's, Actual Price V/S Forecasted price

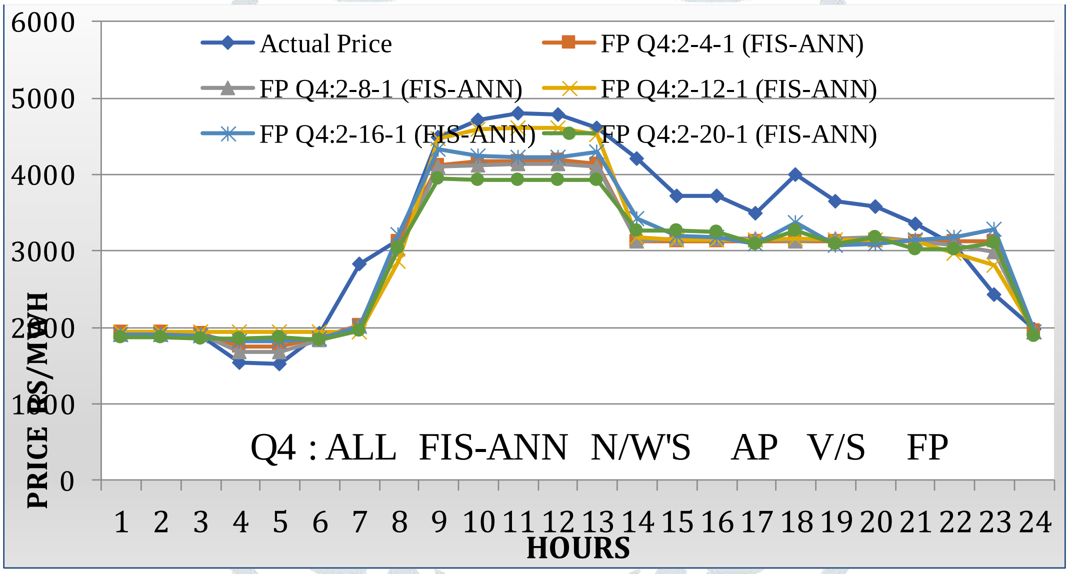


Fig 9.: Q4: All Trap. MF- FIS &NN N/W's, Actual Price V/S Forecasted price

Table 2- Values of MAPE for different quarter's of combined FIS-ANN Network's

Quarter & (Sample Size)	N/W -1	N/W -2	N/W-3	N/W-4	N/W-5
	2--4--1	2--8—1	2--12--1	2--16--1	2--20--1
Quarter 1 (2510)	8.8357	9.5597	11.1159	6.2519	9.2710
Quarter 2 (2694)	5.0130	6.0582	6.2579	3.0658	2.2442
Quarter 3 (2998)	1.2573	2.6878	2.0602	1.5412	1.2984
Quarter 4 (3310)	0.8959	0.6685	0.6095	0.2519	0.2721

7. Conclusion:

Selection of input data and effective processing is the vital factor in this process. High volatility of PoE in short interval of time, making it difficult to predict its future value. A hybrid FIS-ANN proposed model, significant results in the forecasting performance has been observed. The past electricity price and electricity demand data, selected as input factor for the electricity price guessing.
1 Mamdani Trap.MF FIS is used to combine with ANN model, and combined FIS-ANN model is evaluated for the performance of electricity price forecasting accuracy. From the result table it is clear that, when we move from Q1 to Q2 ; Q2 to Q3 and Q3 to Q4, where sample sizes are increases, accordingly MAPE value in all quarter's different network topologies improves respectively. So, larger sample size having significant effect on accurate forecasting.
2 From different quarter's graphs, it is clear that actual PoE is not far with the predicted PoE. Mostly, in office hours its value has little more difference between actual and predicted price. In off- peak as well as night times its value is good, which justify that load demand is the most significant effective factor in electricity price guessing.

8. Scope of Future Research

Future scope of work may be carried out as,
1 Load pattern is prime factor, which changes seasonally, and its not constant. Therefore, considering past years seasonal data, of load and price, for the more numbers of years, and guessing electricity price seasonally would be more effective to actual price.
2 Selecting the input variables of model in forecasting are very key issue, so it is proposed to incorporate other PoE affecting factors and find out effective and efficient method to obtain a benchmark result for better predicting accuracy.
3 Better effectiveness of PoE accuracy could be determine with other AI model comparison with hybrid FIS-ANN model.
4 With the help of ANFIS, Genetic algorithm or combination methods along with better studies and investigations in short interval PoE guessing, could be more result oriented guessing achieved by considering artificial intelligence features.

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