Review of Price Forecasting Techniques in Deregulated Electricity Market

Manisha Waghmare¹, S.B. Warkad²
¹PG student P. R. Pote COET
²HOD Electrical Engineering Department.

Abstract: Price forecasting has become integral part of power system. In deregulated electricity market price forecasting is gaining importance between various market players in order to adjust their bids in day ahead electricity market and maximize their profit. An accurate price forecasting method is important factor for market player as it enable them to decide their bidding strategies to maximize profit. Various models have been developed they are mainly used for price forecasting time series, simulation model, stochastic model, econometric model, artificial intelligence model, game theory model. Application of various model as applied different electricity market is presented.

1. Introduction

Many integrated utilities have been replaced by separate generation transmission and distribution companies. Electricity market is becoming more competitive. In many case large industrial and commercial consumer have option to select their energy supplier. Choice extend to residential level also. These change referred as electricity deregulation. With the Introduction of deregulation of power industry, new challenges have been encountered by the participants of the electricity market due to which forecasting of wind power, electric loads and energy price have become a major issue globally mainly focusing on soft computing models. Price forecasting plays a key role in the new electricity industry. In addition to helping independent generators in setting up optimal bidding patterns and also designing physical bilateral contracts, market prices strongly affect the decision on investing a new generation facilities in the long run[2]. The applications of electricity price forecasting differ depending on the forecasting period. The fundamental applications of short-term, medium-term and long-term price forecasting can be summarized as day-ahead profit maximization, bilateral contracts planning, and investment recovery confirmation [6]. Electricity is also a commodity, and its price should also be forecasted along with time but if the same methods were used for forecasting electricity prices as other commodity prices, the forecasted price will exhibit lower accuracy without any surprise due to volatile nature of electricity price among all commodities. There are many soft computing models are used to forecast electricity prices are time series model such as stochastic model[3][5], game theory model [4], simulation models, Artificial intelligence techniques such as neural network[9] are used for application where formal analysis is difficult or impossible such as pattern recognition and non linear system and gives accurate results. This paper reviews established approaches and mainly focusing on soft computing models.

2. Factor influencing price forecasting

There are many factors affect on the price forecasting due to which prices are increases or decreases. There are many factors such as demand, seasonality that affect on prices and different factors are described below[3][4]

2.1. Price spikes - Price spikes are are electricity spot prices which are not consistent with the usual modeling via diffusion processes with normal or lognormal marginal distributions.

2.2. Price dependent volatilities. Prices are volatile in nature. All markets there is a strong correlation between price levels and levels of volatility.

2.3. Long-term non stationary - Uncertainty factors such as supply and demand or fuel costs in the long-term future, a non stationary model seems more appropriate.

2.4. Electric Power Demand - If system demand increases, spot price also increases.

2.5. Weather Conditions

Electricity demand certainly depends on environmental condition and especially daily temperature. Weather fluctuation will affect demand and hence spot price will also be affected.
2.6. Fuel Cost
Fuel cost is one of the main parts of generation cost that its variation has a major impact on electricity spot price.

2.7. Available Transmission Capacity
Electric power is generated at generating station and it transmitted through transmission system at different location. There is some physical constraint present in transmission networks that create an obstruction for market participants to buy or sell energy. This issue can affect on spot price and may increase it.

2.8. Generation Reserves
When demand increase suddenly if there is enough generation reserve capacity available as well as deliverable, consumers will be served. But if there is not sufficient generation reserve available, consumer would face with lack of received energy. To make the balance between supply and demand electricity spot price increases.

3. Price forecasting
are mainly classified into time series model and simulation model. Time series occurs in many fields and the analysis of time series has got a wide application in areas like process control, economic forecasting, marketing, population studies, biomedical science and many more areas. In time series model artificial neural network are widely used. Price forecasting techniques are

3.1. Simulation model
Simulation model establishes mathematical models and solves them for price forecasting. The simulation methods which are currently being used by the electric power industry range from the bubble-digram type contract path models to production simulation models with full electrical representation. The simulation method issues that must be addressed in any market simulation program that forecast the LMPs for the electricity market are [9]

3.2. Time series model
Time series model are classified into 3 technique
3.2.1. Parsimonious stochastic model
This model is classified into two method such as linear and non linear techniques. Autoregressive, Moving average method ,Autoregressive moving average ,Autoregressive Integrated Moving average ,Autoregressive Integrated Moving average are classified into linear model while Generalized Auto Regressive Conditional model Heteroskedasticity classified into non linear system. Autoregressive model are used to predict future values using past values. In [3] Moving Average (MA) is also one of the techniques used in the analysis of time series. It is found by taking the average of sub sequences. As the process in a time series goes on, each new observation is added to the average and the oldest observation may be dropped. Autoregressive moving average model are most useful model in statistics that can be used to understand time series data for future prediction Autoregressive moving average model are most useful model in statistics that can be used to understand time series data for future prediction. ARIMA These models have been used in different areas where there is a need for time series and, in the past have been mainly used for load forecasting due to their satisfactory accuracy and mathematical soundness. In field of statistics and econometric...
ARIMA models are widely used. Generalized Auto Regressive Conditional Heteroscedasticity (GARCH) is among the well-known time series analysis models used in the field of statistics and engineering. GARCH process can measure the implied volatility of a time series due to price spikes [9]. The GARCH model presented by provides 24-hour forecasts of the next day market clearing price based on historical data where the focus was on electricity prices with high volatility periods.

Limitation to ARMA and GARCH models do not perform well for electricity price forecasting due to insufficiency of the structure specification. One of the simplest stochastic models is autoregressive (AR) model, which treats the disturbance as ideal white noise. AR models can be extended to ARMA, which describes the correlated disturbances of assumed white noise. ARMA models can be extended to GARCH models. GARCH computes the conditional mean and variance of a time series to take into account excess kurtosis and volatility clustering, which are two important characteristics of financial. AR models and auto regressive integrated moving average — ARIMA models. This approach can be very accurate, but requires a lot of information, and the computational cost is very high.

3.2.2] ARTIFICIAL INTELLIGENCE

AI models have ability to learn complex and non-linear relationship difficult to model with conventional model. This classified into two categories

1] Artificial neural network

Artificial neural network are massively parallel adaptive network of simple non-linear computing element called neuron which are intended to abstract and model some of functionally of human nervous system in an attempt partially capture some of computational strength. Neural network possess broad range of powerful properties such as robustness, associative recall, generalization and soft constraint satisfaction. Neural network is classified into Feed-forward neural network such as single layer feed forward network, multilayered feed forward network, radial basis feed forward network. In feed forward networks, units are often arranged in layers: an input layer, one or more hidden layers and an output layer. The units in each layer may share the same inputs, but are not connected to each other. Typically, the units in the input layer serve only for transferring the input pattern to the rest of the network, without any processing. RBF networks are effective in exploiting local data characteristics, while MLP networks are good at capturing global data trends [8]. Wavelet transform is an important tool used for analyzing the frequency components of signals and it has overcome the limitations of Fourier and Short-time Fourier transform [7]. ANFIS is a class of adaptive multilayer feed forward networks, applied to nonlinear forecasting where past samples are used forecast the sample ahead. Traditional adaptive fuzzy system include ANFIS and Neuro fuzzy methods are intended to combine the advantages of ANN and fuzzy logic with the difference that ANFIS architecture has linear output function whereas neuro-fuzzy systems are essentially a subset of ANN applied to controls and classification problem [9].

The theoretical foundation behind the Extreme learning machine (ELM) architecture is explained in this section. ELM is an improved learning algorithm for the single feed-forward neural network architecture. ELM is different from the traditional neural network methodology in the sense that all the parameters of the feed-forward networks (input weights and hidden layer biases) are not required to be tuned in its case. The capability of SLFNs with randomly chosen input weights, hidden layer biases and a nonzero activation function to approximate any continuation [7]. Artificial intelligence (AI) along with the ELM-Tree Approach has been applied in price forecasting that is, the day ahead usage of the electricity and will also predict the monthly bill of the user in per the electricity usage [11]. Another techniques are support vector machine To deal with nonlinear price forecast problems which cannot be well captured by linear time series approaches, SVM is claimed to have good performance. [3] Support vector machine and least square support vector machine are applied to hot term forecasting [5]. LSSVM technique gives better result than SVM.

2] Data mining model

Data mining is a form of knowledge discovery essential for solving problems in a specific domain. Individual data sets may be gathered and studied collectively. Data mining involves fitting models to or determining patterns from observed data. The fitted models play the role of inferred knowledge. The rapid growth of interest in data mining is due to the 1) falling cost of large storage devices and increasing ease of collecting data over networks; 2) development of robust and efficient machine learning algorithms to process this data; and 3) falling cost of computational power, enabling use computationally intensive methods for data analysis [1].

3.3.3] Regression analysis

Many problems in engineering and science involve exploring the relationships between two or more variables. Regression analysis is a statistical technique that is very useful for these types of
problems. Regression has got wide applications including prediction and process control. In regression analysis, the aim is to model the dependent variable in the regression equation as a function of the independent variables. Regression analysis is broadly used for forecasting and prediction. Regression is a statistical approach to determine the relationship strength between one dependent variable usually denoted by Y and a series of other changing variables known as independent variables. Regression function is a function of the independent variables to estimate the dependent variable. In [4][3] Simple Linear Regression Models and multiple regression model, dependent variable is affected by only one independent variable then time series is simple linear regression. If there are more than one independent variable in time series then regression model is said to be multiple regression model. Multiple regression model is used to predict electricity prices in deregulated electricity market.

3.3] Game theory

Game theory model is used by market participants to decide their bidding strategies. Game theory is another approach and a carried out to address the bidding strategy problem using this approach and it has been used as a means of developing a successful bidding strategy in the newly deregulated electricity market. This approach takes the fact that market participants react to competitor strategies in order to maximum group of models, equilibrium models take the analysis of strategic market equilibrium as a key point. There are several equilibrium models available like Nash equilibrium, Cornet model, Bertrand model, and supply function equilibrium model[9]. The supply functions are non-decreasing and the market clearing price is the same for all players, this market clearing condition maximizes the (revealed) social welfare when there is no transmission congestion. This framework has been used extensively for the analysis of bidding strategies.[8]

4. Conclusion

Here concept of deregulation is defined. Price forecasting techniques are reviewed. Price forecasting are depend on time horizon and classified as short term, medium term and long term. These techniques are used by market players for their bidding strategies and maximize their profit. Factors affecting on price forecasting techniques are presented. Price forecasting are mainly classified into simulation, game theory, and time series model. Simulation model used to forecast LMP. Time series model such as stochastic model such as regressive model, moving average, ARIMA approach widely used in field of statistics and econometric analysis and Regression analysis such as linear regression, multiple linear regression are function of independent variable such as \([X]\) to estimate dependent variable \([Y]\) are used to forecast electricity prices in deregulated electricity market. Artificial neural network such as feed forward neural network, extreme learning machine, wavelet transform are used, can be concluded that there is no universal tool for price forecasting which can be used for every market and operator. For specific applications it becomes essential to select the specific tool/techniques, and following points should be kept in mind:

1) Type of forecast (i.e. long term, medium term, short term).
2) Available resources for processing, storing the historical data of the price.
3) Importance of accuracy in forecasting a fuzzy inference

5. References

http://dx.doi.org/10.10.16/j.ijforecast.2014.08.008

Journal of Power and Energy Engineering 3,19  
http://dx.doi.org/10.4236/jpee.2015.39001

[10] Roneda Mucaj Valentina Sinaj, „Price Forecasting using Artificial Neural Network”,  
International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169 Volume: 4 Issue: 4 2730

[11] Mr. Vrushab Gosalia 1, Mr. Pradip Andhare 2, Mr. Prajwal Patil 3, Mr. Arunoday Chorage 4, Mrs. Renuka Gound 5, “Electricity Price Forecasting Using ELM-Tree Approach”,  
International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 03 Issue: 01