Various Electricity Load Forecasting Techniques with Pros and Cons

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Abstract: ***The rapid growth of stored information in the demand forecasting, associated with data analysis provoked an utmost need for generating a powerful tool which must be capable of extracting hidden and vital knowledge of load forecasting from available vast data sets. Being a promising sub domain of computer science, numerous data mining techniques suits the solution to this problem very well. This paper presents a vast, rigorous and comparable survey of tremendous data mining techniques useful in forecasting the electricity load demand of different geographic area. Based upon the rigorous survey, primary challenges involved in the current technologies and future goals are also discussed.***

Keywords: Load Forecasting, Regression, Time Series and Artificial Neural Networks.

I. INTRODUCTION

The main challenge to forecast demand is to choose an effective technique. With the growth of 3 to 7 percent in electricity energy demand per year, many factors have become dominant to the generation of electricity energy. Electricity load forecasting has always been very important for planning of customer's requirements and new operations and maintenance of distribution of electricity. Electric load refers to the consumption of electricity in the form of energy or power. Electric Energy is the curial issue in our daily life and growth. The electricity price, demand and dependence on the fossil fuels are increasing rapidly. The development of novel electricity demand forecasting for meeting the growing needs is great challenge for any country about power or energy. Since the electrical energy is very difficult to store in buffer, therefore to ensure proper delivery of electricity energy to consumers of electricity it is important to forecasts electricity demand.

The forecasted values of electricity demand are used for following:-

- Load Scheduling and Distribution Planning.
- Deciding the fuel allocation amount to generation units and their maintenance.
- Meeting the customer requirements in different seasons.

II. CLASSIFICATION OF LOAD FORECASTING

Load forecasting can be classified into two types based on the consumption of electricity; one is spatial forecasting and second is temporal forecasting. Spatial forecasting means forecasts the electricity load for the particular region on the earth, such as whole country, a state or the particular city. Temporal forecasting means forecasts the electricity load for specific supplier or collection of consumers for future related particular time like hours, days, months or years. Temporal load is classified into four categories as in [4, 3]

Table 1. Temporal Load Forecasting

Forecasting	Period	Purpose
Long Term load forecasting	5 to 20 years	• Planning and growth of the generation capacity. • Planning to building new sub stations and new lines. • Decision making whether to add new features in existing systems. • Staff hiring
Medium Term load forecasting	Few weeks to few months	• Used to meet requirements in the summer and winter season. • Used for Decisions of purchasing fuels and revising tariffs.
Short Term load forecasting	From few hours to few weeks	• Hourly electric load Prediction calculation. • Weekly and Daily Max load of electricity energy generation. • Usage: fuel allocation to generation units; short term Maintenance; generator unit commitment.
Very Short Term load forecasting	From minute to an hour	• Used in Energy Management Systems (EMS).

III. CLASSIFICATION OF LOAD FORECASTING TECHNIQUES

There are different approaches introduced for electricity demand predictions and they can group into two main categories: Models and methods. These models and methods follow a more classical approach i.e. which apply concepts stemming from time series & regression analysis models which belong to fields of artificial and computational Intelligence [5]. Another classification of electric load forecasting is: Univariate modeling and multivariate modeling. Univariate models also called time series models, in which the load is modeled as a function of its past observed values this forecasting ignores the exogenous factors such as weather and day type. Examples of these types of models are multiplicative autoregressive models, dynamic linear or non-linear models, threshold autoregressive models, Kalman filtering [3]. Multivariate models are the models in which load is modeled as a function of some exogenous factors specially weather and social variables. Examples are Box and Jenkins transfer functions, ARMAXS models, non–parametric regression, curve fitting

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procedures. Multivariate models are also called causal methods [4].

IV. OVERVIEW OF DIFFERENT METHODS

5.1 Regression based models: These models are used to make correlation between electric load and exogenous variables i.e. Max Temp, Min Temp and Days related data that are mainly used linear regression. In regression, forecast seems to mean to estimate a value whether it is future, current or past w.r.t. the given data. Problems exist in identifying the best model, which is due to the nonlinear correlation between electric loads and influencing factors [5]. It is easy to make relationship between output and input variables of model. These models easily implement and handled. Multiple regression models also exist to state the load as a function, of exogenous factors [4].

C. Fan, F. Xiao and S. Wang [12] in this paper present a technique to build up model by ensemble modeling for forecasting energy consumption of next day. The Ensemble modeling is a method of machine training in which more than 2 base models are integrates to create end result. The Ensemble Learning or Ensemble Training is done in two steps: In first step a number of base models are developed these models are either in parallel or in sequence manner and in 2nd step base models are used to make final result by using different grouping schemes. The genetic algorithms are used to determine weights associated to each of the base model used on this technique. This technique is used to forecasting electricity load demand for a building in Hong Kong. In this research work it was observed that Multiple Linear Regression takes a more time for computational work.

5.2 Time series approaches: In time series, forecasting seems to mean to estimate a future values given past values of a time series. Among the oldest methods applied in electricity demand prediction, the "Time Series Approach" sometimes used as "Univariate" or "Multivariate". The advantage of Univariate modeling is that it does not need additional time series of the exogenous factors [3]. The Time Series Approach as univariate models are used for prediction of short term electric energy demand. Univariate models are used to prediction of electricity energy demand, for this work these models used the past experimental values while ignoring the other related variables. Various methods of Univariate modeling are "Multiplicative Autoregressive Models", "Threshold Autoregressive Models", "Dynamic Linear Models" and "Methods Based on Kalman Filtering". The multivariate models are also used to prediction of electricity energy demand but for this work these types of models used the different exogenous factors like Social parameters, Temperature, etc. [4] The limitation of such methods is they are time consuming, require a lot of human intervention and may become numerically unstable [3].

Gonzalez-Romera et al. [29] this is research paper they use method of trend extraction to find the electric load of Spain. A two series of approach is used in this research work. The first series gives the trend of the electric load consumption and the second series gives the fluctuation around the trend which is given by the first series. The results from this approach are good compared to direct prediction of electric load forecasting.

The advantages and disadvantages of Time Series methods are [38]:

Advantages

- It examines chronological data sets very fairly.
- A time series operation performed in minimal cost.
- A time series method requires less historical data for operations.
- With the help of time series statistical methods we can evaluate uncertainty of short term load forecasting.

Disadvantages

- Time Series method doesn't study deeply underlying patterns.
  With time series method it is difficult to find and interpret the sources of errors.
- In time series changes and conversation with operation cannot be possible easily.
- The previous or chronological time series patterns not useful for long term demand forecasting.

5.3 Neural Networks: There are lots of methods and techniques which are very useful for demand forecasting. On the basis of demand and region these techniques and methods are designed and used for demand forecasting. There are lots of factors which are considered for designing and implementation of appropriate technique one the basis of different types of demands. AI based techniques are very important when we study and reviews the literature for demand or load forecasting. AI based techniques are based of neural networks. A Neural Network is a network of two or more neurons. Neurons are used to processing the values of input variables and used for its weight processing in neural network. These neurons are works same as human brain neurons. Neural Network is designed to form the structure in which it performs the task and solve the problems as the way like human brain performs and solve the problems. The network is implemented by simulation in software on a digital computer and by using electronic components. A neural network has the ability to storing previously observed information. Neural Network works in a distributed manner. A Neural Network works like human brain in 2 respects. First Information is stored by neurons interconnected with their weights. Second the information is made by the neural network is from training the network. Neural networks for load forecasting first used by Dillon et al. in 1975 by using single layer preceptor.

S. Badran and O. Abouelatta [1] in this paper presented a technique of ANN with regression method; historical data of electricity demand is used in this work was taken from the Jeddah in KSA. The Electricity load was predicted by using this technique and the comparisons with other techniques were carried out which shows Artificial Neural Network is to be better with results. Weights used for different input variables in Network were initialized by a random number generator. Work is done by technique is divided into two rounds: In first round preprocessing of data is done and in second round prediction of electricity energy is achieved. The Limitation in

this technique was that at beginning adjustments of weights is difficult task.

Slobadan Ilie et al [2] in 2013 in their research work presented a technique for load forecasting for short term based on ANN. This work is divided into two phases: first phase used for preprocessing of data and second phase done the task of energy demand prediction as neural network. It is verified about very strong nonlinear relationship between daily electric load and daily temperature. Three exogenous variables are used as inputs: "Electric Load of Previous Day", "Temperature" and "Type of Day". In this technique learning of Artificial Neural Network is done by using "Modified Back Propagation" algorithm. During the Training of neural network sigmoid Activation function is used in all hidden layers. All this work of neural network is performed in MATLAB environment.

Abdel-Aal [3] in their research work presented a method for load forecasting for next year of all months. The data used for this work was Six years back historical data. In this work 2 modelling techniques were used. The first one employing twelve devoted models to forecast the twelve individual months in a straight line and 2nd one is used for prediction of next month electricity energy. In this research work adductive models and different ANN techniques are used for load forecasting for next year of all months.

J. Deng [8] in his research work in the year of 2010 presents a method of modelling and forecasting of electricity consumption of china using ANN. In this method back propagation of learning algorithm is used for prediction and Multi Layer Perceptrons are used for prediction as structure of network. In this approach "Linear Activation Functions" and "Tangent Sigmoid Activation Functions" are used for ANN. The demand of Energy is modeled as the task of the "Gross Domestic Product", import-export, Population and Data (1990 to 2008) was used for prediction. The Limitation of this structure of neural network is that it gives bad results as error method and trial.

W. Mai et al [9] in his research work in the year of 2014 presents methods of electricity load prediction for office in large building based on "Radial Basis Function Neural Network" (RBFNN). The Real time data of building was used to learning and testing the model. Radial Basis Function Neural Network has been selected for this reason. The causal models and Statistical Time Series model mostly used for linear type of load forecasting. This is a disadvantage of these types of models. The different types of exogenous variables that are used in prediction of electric loads are normally Non-Linear types. The Different types of exogenous variables are considered in these types of models i.e. Input as Time, inputs as 7 days of week (Mon to Sun days for week), Hours (hour 00:00 to hour 23:59 hours for Day), and Weather Inputs i.e. "Max Temp and Min Temp", "Humidity", "Solar Radiation Intensity" and "Electric Load" of Previous days are used as exogenous variables. The other exogenous variables are covered in the load of previous days. This forecasting technique gives advantages over Multi Layer Perceptron. By using an evolutionary method this learning algorithm gives best optimal radius and best center for each unique neuron in all hidden layers.

H. K. Mohamed et al [11] in his research work in the year of 2006 presents a technique for prediction of electricity load for long term Electrical Network in Egyptian. The demand of electricity is credited to 11 different variables i.e. "Temperature", "Total Electricity Generation", "Total Electricity Consumption", "Load Factors", "Energy Losses", "Electric Energy Prices", "Gross Domestic Product", "Humidity" and "Population". This forecasting model consists of 4 different steps. The 1st step is used for collection of data and the 2nd step of this model is used to preprocessing of data to find outliers by the methods of Cluster Based Interpolate algorithm and detection of out of scope variables, the regression and histogram algorithm are useful for prediction of energy. In third step forecasting is done with different techniques of regressions in feed forward ANN. This is shows that ANN gives very good results for prediction when Mean Absolute Percentage Error is less than 4% to 5%. In this work different methods are compared and finding better algorithm to analyses result at each phase/step.

Prakash GL et al [13] in this research work presents three different models with Artificial Neural Networks that are used to predict both days ahead and hour's basis electricity load. The past historical electricity load data as well as the past historical weather forecasted data were collected and then by using clustering techniques the cleansing the data is preformed. The MATLAB environment is used in this research work for building proposed models. The performance of each and every model is then calculated by using MAPE. In this paper they represent a method of data cleansing that is based on data mining techniques.

There are three broad classes of neural networks: Different methods that are used in neural network to train the system is called learning or training algorithm, and the activation functions are used to update or modify the weights. The "Back Propagation" is the basic learning algorithm used for training purpose in neural network for load prediction. Several other variations of this algorithm are proposed and are discussed in the section Survey of Neural Network Learning Techniques.

The advantages and disadvantages of neural networks methods are [39]:

Advantages:

- It works like human thinking.
- Neural Network can handle missing and noisy data.
- Neural Network can handle large number of parameters or variables.
- Neural Network has ability provide solutions for forecasting problems with very good predictive result.
- It has feature of continuous learning.
- Neural Network can works with the non-linearity models.

Disadvantages:

- Neural networks are a "black box" and have limited ability to explicitly identify possible causal relationships.
- It is difficult to implement neural network model.
- They use more resources for computational work.
- They have the problem of over-fitting.
- They have issues which are remaining to be resolved like related to development and methodology.

5.4 Support Vector Machine (SVM): The SVM is the machines learning

algorithms and manly used for set of supervised problem. For example SVM is used as classifier in machine learning. In SVM algorithms one very useful algorithm is Support Vector Regression (SVR) algorithm. The Vapnik has developed the SVR in 1995 to solve issues related to regression. The principle of the developed SVR is based on the SVM system [16].

5.5 Hybrid approach: This approach is a combination of more than two approaches or techniques in regulates to defeat the drawback of the original technique [5]. Such approach can be called as a hybrid approach.

V. ISSUES RELATED LOAD FORECASTING

There are so many issues in load forecasting model development and the very basic and main issue is pre processing of data used in training. The main issue of data preprocessing is cleaning of data. Cleaning of data involves the outliers/noise data and missing values in data set. The Outlier/noise data problem is solved by some smoothing techniques. The missing values problem is solved by Mean, Median, Regression, and by interpolation methods.

VI. RESEARCH RESULT

From the various research works we have found the different results like Technique used, Data set, various Inputs, Outputs, Training Methods, and the applications of the proposed research work are as follows.

Table 2. Literature Review

Year	Ref No	Technique	Data Set	Inputs	Outputs	Training Method	Use
2006	11	Regression Neural Networks	collected from Egyptian electricity sector	11 parameters	Model for Long Term load forecasting is designed	i)Gradient descent for NN with 1 layer ii)Back Propagation algorithm for trainable forward cascade NN	To solve power system expansion planning problem
2007	3	Neural Networks and abductive networks	6 years historical data obtained from Puget Power utility, Seattle, USA	Load and Temperature	Predicted load	Two approaches were used:- i) Time series ii) Dedicated models	Predicted monthly demand for seventh year
2009	4	SVM	2 years historical data	Electric load data	Predicted load	SVM Clustering	Prediction of next day load
2010	8	ANN, Linear Regression	Data from National Bureau of Statistics of China(1990 to 2008)	1.GDP, 2.Population 3.Import-Export 4.Energy demand	Predicted energy demand	Back Propagation	Long Term Prediction of Electric Energy for China till 2050
2012	1	ANN, Regression	Previous Days Load Data from city of Jeddahin KSA (01/01/98 to 31/12/06)	Electric load data	Predicted load for specific time, day, month & year	Two models were considered One large 24 dimensional NN Second 24 small NN for each hour	Used for prediction up to 2020 Energy Management Systems
2013	2	Neural	Obtained for	Electric	Predicted load of	Modified back propagation	Distribution

		Networks	specific users in power electricity board	Load and Temperature Data	forecasting day	algorithm 5 neurons NN was used	Management system

2014	13	Neural Networks	State Load Dispatch Centre, Dehradun, year(2011-13)	Energy data,Meteorological data	Short Term Load Forecasting for Uttarakhand	Levenberg Marquardt algorithm	Prediction of Electricity Load Consumption
2015	14	Neural Networks	SCADA city of "Abu Dhabi Emirate's" electricity utility, and "Masdar City's" Station of Weather.	Energy data,Meteorological data	Short Term Load Forecasting for Abu Dhabi	Levenberg Marquardt algorithm	Prediction of Electricity Load Consumption
2013	41	Neural Network Ensemble (NNE)	-----	Power consumption and variables related to climate	24 hourly outputs	A strong NNE based on Regularized Negative Correlation Learning (RNCL) is projected for improving the model of learning and with this improved recognition capability and with less discrepancy.	STLF
2011	42	Multiple Classifier System (MCS)	Sep 2008 - Aug 2010, And Validation Training data from Aug 2K9 to Aug 2K10	Energy consumption and weather based parameters	24 hourly outputs	The classifier or algorithm can be trained with different parameters.	STLF
2012	43	SVR	Training phase: Feb. 2009 - June 2009; Validation phase: July	Power consumption and climate variables	STLF	SVR using leastsquares	Peak Load
2011	44	SVM and MLP	1 year	Energy consumption	24 hourly outputs	Multi Layer Preceptor with 01 hidden layer (within 10 neurons). Using the SVR based techniques.	STLF
2011	45	MLR+MA+ANN+Fuzzy	Slovenian power system (1 year)	Temperature, cloud cover, precipitation, speed of wind, electric load	24 hourly outputs	In this research work they used the weather sensitive ANN, non weather sensitive moving average and multiple linear regression approach for forecasting electric load. They have used a fuzzy based grouping to minimize the forecasting errors and to increase the robustness.	STLF

2011	46	Modified general regression NN	------	Date information	Forty Eight Output values (1/2 hour)	In this research work they use 2 different methodologies for STLF. In the first methodology they produced local loads and in the second methodology they forecast the global loads and the contribution factors to compute the local loads. They use the modified regression neural network for forecasting. In this research paper we also found the procedure to automatically reduce the number of inputs for ANN.	STLF
2011	47	ANLR+SVM +QP	Two typical Chinese power grids (Beijing and Jiangxi) June 8, 2005 to September 6, 2005	Day type, Temperature, humidity and load	96 Outputs (1/4 hour)	In this research paper they use the hybrid forecasting method. This hybrid forecasting method consists of two stages. The first stage gives the daily load consumption predicted by use time series technique. While the second stage gives the deviation which is used by time series method and the other relative factors which are considering for forecasting the load by first stage, for this analysis, an Adaptive Local Nonparametric Regression (ANLR), Quadratic Programming (QP) and Support Vector Machine (SVM) is used.	STLF
2002	48	ANN	England and Wales (November 1998 to 30 June 2000)	Electric load, cloud, temperature, speed of wind	STLF	In this research work they use ensemble neural network technique for prediction of 1 to 10 days ahead electric load consumption. In this weather ensemble NN multiple scenarios are used for weather variable.	Daily maximum load forecasting
2009	49	ANN	Taiwan Power Company's	Heat Index (HI) and Electric load	24 Outputs (hourly)	In this research work they proposed methodology for forecasting the load for short-term for different multi regions. By focusing the Heat Index parameter they improved the accuracy of load forecasting in Taiwan Power Company's System	STLF

2010	50	ANN	19 Dec -25 Dec 2006 Wuhan city of the province of Hubei (China)	Solar power, speed of wind, direction of wind, solar irradiation and circumstance temperatur, day type	24 Outputs (hourly)	Neural Network is integrated for forecasting.	STLF
2009	51	ARMA+ MLP	City (Jiang-Men) 2005; Validation phase: December 2005	------	24 hourly consumption values	In this research paper they used the ARMA model to forecasting the linear elements of the time series. And the errors in this time series can be seen as non linear elements and the MLP has used for finding this non linear errors.	STLF
1991	52	MLP	Nov. 1988 -Jan. 1989 Region (Tacoma -US)	Hourly Power consumption and weather based parameters	24 hourly consumption values, with peak load	Two MLP are used in this research work one is for peak load forecasting and second is for total load forecasting. For first MLP one input layer has 3 neurons, one hidden layer has 5 neurons and output layer has 2 neurons. For second MLP one input layer has 3 neurons, one hidden layer has 5 neurons and one output neuron on output layer.	STLF
1998	53	MLP	------	Power consumption, climate variables and social variables	24 hourly consumption values	In this work MLP is used which has 15 input variables and one output neuron which is used for repeatedly for forecasting electric load.	STLF
1999	54	MLP	2 years	Power consumption, climate variables and social variables	------	In this research work the two same neural networks are used, the training data is randomly divided into two sets for input purpose to two identical ANNs. For output simple averaging of each of the ANN is used for output.	STLF

1992	55	MLP	Country (Korea)	24 hourly consumption values	24 hourly consumption values	In this SLFT there are 2 different types of ANN based methods/techniques are represented. First technique is based on a static approach, and second one is based on dynamic approach. First technique forecasts electric load simultaneously for whole day 24 hours. Second technique gives result 24 hours electric load in sequentially. First technique uses 48 input values, 2 hidden layers and output layer has 24 neurons for 24 output values. Second technique uses 8 input values and 01 hidden layer and output layer with one output neuron.	STLF
1996	56	MLP	Country (United Arab Emirates)	24 hourly consumption values	24 hourly consumption values	A three layered network was used for all models	STLF
2013	57	MLP	Micro grid (small city) 3 years	24 hourly consumption values	24 hourly consumption values	Input layer: 29 neurons (Periodic variables are supplied to the neural network in the form of Continues input values; with the development of this network model it is found that this transformation appreciably improves the output result of the neural network.)	STLF

Table 3. Advantages and Disadvantages of different Methods

Methods	Advantages	Disadvantages
MLP	1). Accomplishment of MLP in a power utility in USA confirmed that it has very good results and its performance also good with reliability [58]	1). Lack of information of used dataset. It takes too long time for the process of forecasting [58]
	2). The proposed forecasting technique can minimize the size of the training data set, and the technique improves accuracy of the forecasting electricity load for hourly and for the peak-load hour of the day and minimize the errors for forecasting for STLF [54]	2). The time taken for the process of load forecasting is very long [54]
	3). The method 2 with dynamic approach gives better results comparable with the method 1 with static approach. The method 2 with dynamic approach uses less neurons and fast training, It gives better results for peak hours.[55]	3). It has no knowledge about the data set and amount of used data for training and validation.[55]
	4). Suitable for short time series.[56]	4). High error figures. [56]
	5). The conclusion of the study explains that how the neural network gives the accurate results for hourly forecasting of loads of energy. [59]	5). The conclusion of the study explains that how neural network has compound arrangement of neurons with two hidden layers are complex with weights. It is not necessary that gives good with very small dataset for validation. [59]

ARMA+MLP	The combined ARMA and MLP model has good results over the single ARMA or MLP[51]	Complicated definition of the model equations [51]
ANN	1). The results shows improved load forecasting with minimal errors. It gives good forecasting values for Taipower's system with ANN parameters.[49]	1). The results shows that with HI gives good results only with high temperature not with low temperature[49]
	2). Use of the ANN shows that techniques used for electric load forecasting with weather related parameters[50]	2). It was found in the research that some other factors like industrial related parameters and commercial related parameters can be considered for more perfect results. And Research can be done on Industrial and commercial region.[50]
	3). It was found in the research that ANN gives best results for load forecasting with temperature data set at the time of training the ANN and gives accurate future demand prediction for electricity load [52]	3). It was found that on specific occasional day when consumers having specific electricity usage demands on specific day than having big errors between given result and required demand of electricity. [52]
SVR	The designed method is useful for utilities in load forecasting for end users entity at any granularity level[43]	Some drawbacks of SVR are Small dataset. The developed model validity from January to May has not done[43]
Expert System	Expert systems are very useful for establishing the different load calculations for different shapes. Knowledge and experience from these expert systems can be used for prediction of energy demand[60]	It is difficult to add new rules of knowledge in these expert systems. This characteristic feature of expert system is the disadvantage of these type of knowledge based expert systems[60]

VII. CONCLUSIONS

This study introduced different methods available for demand forecasting. We defined some forecasting terms and also discussed some important issues for analyzing and electricity load forecasting. One more application of short term load forecasting is wireless sensor network. By the use of STLF the redundant data transmission is minimized by short term day a head prediction model of each sensor. In this paper we have given an overview of load forecasting and methods employed for load forecasting. Artificial Neural Networks technique is relatively newer. ANN has so many opportunities to predict and reduce the error between actual demand and forecasting demand.

REFERENCES

1. SlobadanIlie, Aleksander Selakov, SrdanVukmirovie, Aleksandar Erdeljan, Filip Kulie.: Short term load forecsting in large scale electrical utility using artificial neural network. Journal of Scientific & Industrial research. Vol. 72,739-745 (2013).
2. R.E. Abdel-Aal.: Univariate modeling and forecasting of monthly energy demand time series using abductive and neural networks. Computers & Industrial Engineering, vol. 54, pp. 903-917 (2007) .
3. Amit Jain, B. Satish.: Clustering based Short term Load Forecasting using Support Vector Machines. roceedings of 2009 IEEE Bucharest Power Tech, vol. 3, 212 (2009).
4. Heiko Hahn, Silja Meyer-Nieberg, Stefan Pickl.: Electric load forecasting methods: Tools for decision making. European Journal of Operational Research, vol. 199, pp. 902-907 (2009).
5. Tao Hong, David A. Dickey.: Electric load forecasting: fundamentals and best practices (2009).
6. JiaweiHan, MichelineKamber.: Data Mining: Concepts and Techniques. Morgan Kaufmann publications, 2nd ed. (2006).
7. Jian Deng.: Modeling and Prediction of China's Electricity Consumption using Artificial Neural Network. IEEE Circuits and Systems Society, ICNC(2010).
8. WeijeMai, C.Y. Chung, Ting Wu.: Electric Load Forecasting for Large Office Building Based on Radial Basis Function Neural Network. IEEE (2014).
9. S. Saravanan, S.Kannan, C. Thangaraj.: India's Electricity Demand Forecast Using Regression Analysis and Artificial Neural Networks based on Principal Components. ICTACT Journal on Soft Computing, pp. 365-370 (2012).
10. H. K. Mohamed , S. M. El-Debeiky, H. M. Mahmoud and K. M. El Destawy.: Data mining for electrical load forecasting in egyptian electrical network. Proc. Int. Conf. Comput. Eng. Syst. IEEE, pp. 460-465 (2006).
11. C. Fan, F. Xiao and S. Wang.: Development of prediction models for next-day building energy consumption and peak power demand using data mining techniques. Appl. Energy, Elsevier, vol. 127, pp. 1-10 (2014).
12. Prakash GL, K. Sambasivarao, Priyanka Kirsali and Vibhuti Singh.: Short Term Load Forecasting for Uttarakhand using Neural Network and Time Series models. IEEE (2014).
13. Luiz Friedrich and Afshin Afshari.: Short-term forecasting of the Abu Dhabi electricity load using multiple weather variables. Energy Procedia, Elsevier (2015).
14. Fausett L.: Fundamentals of Neural Networks Architectures, Algorithms and Applications. Dorling Kindersley (2008).
15. Jeyaseeli S.S., Kathirvalavakumar T.: Adaptive modified backpropagation algorithm based on differential errors. International Journal of Computer Science, Engineering and Applications, vol. 5, pp. 21-33 (2011).
16. Arunesh Kumar Singh, Ibraheem, S. Khatoon, Md. Muazzam and D. K. Chaturvedi.: Load Forecasting Techniques and Methodologies: A Review. 2nd International Conference on Power, Control and Embedded Systems, IEEE, pp. 631-640 (2012).
17. Jiangxia Zhong, Xinghuo Yu, Miguel Combariza, and Jinjian Wang.: An Intelligent Relational Pattern Matching System for Electricity Demand Prediction. IEEE, pp. 3510-3516 (2014).
18. Yu, Z.J., Haghighat, F. & Fung ,B.C.: Advancesand challenges in building engineering and data mining applications for energy-efficient communities. Sustainable Cities and Society, Elsevier (2016).
19. Navjot Kaur and Amrit Kaur.: Predictive modelling approach to data mining for forecasting electricity consumption. 6th International Conference - Cloud System and Big Data Engineering, IEEE (2016).
20. Jian Deng.: Modeling and prediction of China's electricity

consumption using Artificial Neural Network. 6th International Conference on Natural Computation (2010).
21. L.I. Belic, I.Belic, B. Erjavec and Janez.: Neural network modelling of coldcathode gauge parameters. Material In Tehnologij, pp. 401-405 (2002).
22. Czernichow T, Germond A, Dorizzi B and Caire P.: Improving recurrent network load forecasting. International Conference ICNN'95, Perth, Western Australia, IEEE, vol. 2, pp. 899–904 (1995).
23. Mandal J, Sinha A and Parthasarathy G.: Application of recurrent neural network for short term load forecasting in electric power system. International Conference ICNN'95, IEEE, vol. 5., pp. 2694–98 (1995).
24. Sforna M and Proverbio F.: A neural network operator oriented short-term and online load forecasting environment. Electric Power Syst. Res., pp.139–49 (1995).
25. Kiartzis S, Bakirtzis A and Petridis V.: Short-term load forecasting using neural networks. Electric Power Syst. Res., pp. 1–6 (1995).
26. Kiartzis S, Kehagias A, Bakirtzis A and Petridis V.: Short-term load forecasting using a Bayesian combination method. Electric Power Energy System, pp. 171–177 (1997).
27. Kumar U and Jain VK.: Time series models (Grey-Markov. Grey Model with rolling mechanism and singular spectrum analysis) to forecast energy consumption in India. Energy, pp.1709–1716 (2010).
28. Gonzalez-Romera E, Jaramillo-Maron MA and Carmona-Fernandez D.: Monthly electric energy demand forecasting based on trend extraction. IEEE Transactions on Power Systems, pp. 1946–53 (2006).
29. Himanshu AA and Lester CH.: Electricity demand for Sri Lanka: a time series analysis. Energy, pp. 724–39 (2008).
30. Jannuzzi G and Schipper L.: The structure of electricity demand in the Brazilian household sector. Energy Policy, vol.19, Issue 9, pp.879–91 (1991).
31. Harris JL, Lon-Mu L.: Dynamic structural analysis and forecasting of residential electricity consumption. Forecasting, vol. 9, pp.437–55 (1993).
32. Furtado AT and Suslick SB.: Forecasting of petroleum consumption in Brazil using the intensity of energy technique. Energy Policy, vol. 21(9), pp. 958–68 (1993).
33. Harry CM.: Trends in Dutch energy intensities for the period 1969–1988. Energy, vol. 23(10), pp.815–22 (1998).
34. Egelioglu F, Mohamad AA and Guven H.: Economic variables and electricity consumption in Northern Cyprus. Energy, vol. 26(4), pp. 355–62 (2001).
35. Yumurtaci Z and Asmaz E.: Electric energy demand of Turkey for the year 2050. Energy Sources, vol. 26(12), pp. 1157–64 (2004).
36. Tunc M, Camdali U and Parmaksizoglu C.: Comparison of Turkey's electrical energy consumption and production with some European countries and optimization of future electrical power supply investments in Turkey. Energy Policy, vol. 34(1), pp. 50–92 (2006).
37. Charles River Associates.: A Guide to Electricity Forecasting Methodology. Washington D.C.: Edison Electric Institute (1986).
38. Jack V. Tu.: Advantages and Disadvantages of Using Artificial Neural Networks versus Logistic Regression for Predicting Medical Outcomes. J Clin Epidemiol, Elsevier, vol. 49, no. 2, pp. 1225-1231 (1996).
39. Hastie T, Tibshirani R, Friedman J.: The elements of statistical learning: data mining, inference, and prediction. 2nd ed. New York: Springer Series in Statistics (2009).
40. A. Chaouachi, R. M. Kamel, R. Andoulsi, and K. Nagasaka.: Multiobjetive Intelligent Energy Management for a Microgrid. IEEE Transactions on Industrial Electronics, vol. 60, no. 4, pp. 1688-1699 (2013).
41. P. P. K. Chan, W.-C. Chen, W. W. Y. Ng, and D. S. Yeung.: Multiple classifier system for short term load forecast of Microgrid. International Conference on Machine Learning and Cybernetics (ICMLC), July 2011, vol. 3, pp. 1268-1273 (2011).