Journal of Basic and Applied Engineering Research
Print ISSN: 2350-0077; Online ISSN: 2350-0255; Volume 1, Number 11; October-December 2014 pp. 21-24

http://www.krishisanskriti.org/jbaer.html

A Systematic Multi-parameter Time-Series Regression Based Load Forecasting Model for Assam

Rashmi Rekha Borgohain[1] and Barnali Goswami[2]

[1]Department of Electrical Engineering, Assam Engineering College, Guwahati, India
[2]Department of Electrical Engineering, Assam Engineering College, Guwahati, India
E-mail: [1]rashee.225@gmail.com, [2]goswamibarnali@yahoo.co.in

Abstract: *Load Forecasting is a crucial and mandatory task in power system planning and decision making. It seems to have become imperative for the electric industry in deregulated environment in recent times. A suitable time series based Auto-Regressive (AR) model has been proposed in the paper wherein the temperature effect has been included for the purpose of meticulous forecasting.This paper gives a general algorithm to forecast short- term load for Assam using the regression based time series method.The algorithm focuses not only on the predicted values of load but also on the errors incorporated in the forecast and the estimated values of the forecast with the inclusion of temperature effect has been found to have given minimum error.*

Keywords: *forecasting; deregulated environment; Auto-regressive; time series;*

1. INTRODUCTION

Theelectric power utilities confront a lot of economic and technical problems in operation, planning, and control of a power system so as to serve the purpose of supplying quality and reliable electric energy to the consumer in a secure and economic manner .For optimal planning and operation of power system [1], modern optimization techniques are applied with the anticipation of reducing the costs and in order to achieve this objective, the knowledge of future power system load is the foremost requirement. Load forecasting [1] is a term used to define the process of predicting the future load demand and is considered as a primary component for energy management system .It substantially helps the electric utility to take decisions on buying and generating electric power, load switching and infrastructure development. In the recent years since the last decade with the deregulation of electricity markets the importance of forecast accuracy of load has become more evident. In absence of an optimal load forecast, the utilities shall have to face the risk of over- or under-purchasing in the day-ahead market. As electricity demand is closely influenced by the climatic parameters, there is definitely an impact on demand patterns. The hourly load demand depends on these vital role parameters and therefore in this paper the effect of temperature on load demand has been included.

Load forecasting can be classified into three types: Long-term load forecasting (LTLF)[2] considers peak loads and consumed energy, on a yearly basis, for many years ahead .As for example, it plays paramount role in the planning of new electricity utilities and if the load is predicted inaccurately it has to incur important financial cost .It is needed for expansion, equipment purchases etc. Medium term load forecasting (MTLF) covers a period of one month up to a few years ahead. It is used for the purpose of scheduling fuel supplies and unit maintenance. Short term load forecasting (STLF) has a pressing role for electric power system planning. It is used to supply necessary information for the system management of daily operations and unit commitment. It is quite necessary for power system planners and demand controllers in ensuring that there would be sufficient generation to meet the required demand. Load serving entities use forecasts for purpose of system security, to schedule generator maintenance and to plan the most cost-effective dispatch. It leads to prevent equipment failures and black outs. Short Term Load Forecasting (STLF) [2][3] refers to forecasts of electricity demand (or load), on an hourly basis, from one to several days or 168 hours ahead. Here in this paper, load has been forecasted for a period of one week for both cases i.e. without considering temperature effects and with the inclusion of temperature effects.

2. SHORT-TERM LOAD FORECASTING

The significance of load forecasting has drawn alarming interests of many researchers across the world, and till date a lot number of load forecasting approaches have been developed.

A. Short-term Load Forecasting Methods

A diverse number of statistical [1] and artificial intelligence techniques have been developed for short-term load forecasting. Some of them which finds use in this paper are as follows-

1) Time Series- Time series forecasting methods[2], [4] have been used for decades in fields such as economics, digital signal processing, as well as electric load forecasting. Time series method is a basic method to process random sequence, and is widely applied in STLF for power system. In this method, power load data is viewed as a fluctuant data sequence with time point, considering the causal relationship between power load and temperature. Auto regressive[3], [4] model (AR model), moving average model (MA model) and auto regressive & moving average model (ARMA model) are three main models [3]. ARMA (autoregressive moving average), ARIMA (autoregressive integrated moving average), ARMAX (autoregressive moving average with exogenous variables), and ARIMAX (autoregressive integrated moving average with exogenous variables) are the most often used classical time series methods. ARMA models are usually used for stationary processes while ARIMA is an extension of ARMA to non-stationary processes. ARMA and ARIMA use the time and load as the only input parameters. Since load generally depends on the weather and time of the day, ARIMAX is the most natural tool for load forecasting among the classical time series models. . Considering the calculating velocity in STLF, AR(2) model has been selected in this work.

B) Temperature Influence on Load

The weather has an immense influence on electricity consumption. Weather and temperature are important drivers for electricity consumption. More than 40% of end-use energy consumption is related to the heating and cooling needs in the residential and commercial sectors. In this section, focus will be given on the effect of temperature although any other variable can be analyzed in the same way. The power load during the year followed the same the daily and weekly periods of electric load, which represents the daily and weekly cycles of human activities and behavior patterns, with some cyclical and random changes. The significance of space cooling on the electric load is very obvious during the summertime. On the other hand, during the wintertime the reverse relationship between temperature and electric demand exists because of the need for space heating.

3. TIME-SERIES MODEL

Time series[5],[6] can be defined as a sequential set of data measured over time, such as the hourly, daily or weekly peak load. The basic idea of forecasting is to first build a pattern matching available data as accurate as possible, then obtains the forecasted value with respect to time using established model. Till now, there are many forecasting methodswhich have been utilized and are classified into two basic types: **qualitative** and **quantitative** methods.Qualitative forecasting methods generally use the opinions of experts to know the future load subjectively. Such methods find use when historical data are not available or scarce.

A)Formation of AR (2) Model

For AR (2) process [6] without temperature,

$$Y_k=U_1Y_{k-1}+U_2Y_{k-2}++a_k, \quad (1)$$

For Ar(2) process including temperature,

$$Y_k=U_1Y_{k-1}+U_2Y_{k-2}+U_3T_{k-1}+U_4T_{k-2}+a_k, \quad (2)$$

k=3, 4,…….N

Where, Y_k= k^{th} observation.

U_1, U_2, U_3, U_4 are model(AR) parameter..

a_k=error term.

The model parameters U_1, U_2.U_3, U_4 are calculated by method of least square[6],[7],

For a set of linear equation, AU=B

Where, A=k*n matrix

U^T =[U, U_2,…..U_n], the unknown vector.

$B^{T=}$[b_1,b_2,…….b_n], the measurement vector

The estimated value of 'U' is given by,

$U=(A^TA)^{-1}* A^T *B$

Thus, the load of the required day can be predicted after calculating the model parameters.

B) Errors incorporated in forecasting

A certain degree of uncertainty is involved in all forecasting situations for which the errors become unavoidable.The forecast error for a particular forecast $\hat{X}_t$ with respect to actual value X_t is:

$$e_t = X_t - \hat{X}_t$$

To avoid the offset of positive with negative errors, we need to use the **absolute deviations**.

$$| e_t | = | X_t - \hat{X}_t | \quad (3)$$

Hence, we can define a measure known as the mean absolute deviation (MAD) as follows:

$$MAD = \frac{\sum_{t=1}^{n} |e_t|}{n} = \frac{\sum_{t=1}^{n} \left| X_t - \hat{X}_t \right|}{n} \quad (4)$$

Again, Mean Absolute Percentage Error (MAPE) [7] is defined as:

$$MAPE=MAD*100\% \quad (5)$$

Another method is to use the mean squared error (MSE) defined as follows:

$$MSE = \frac{\sum_{t=1}^{n} e_t^2}{n} = \frac{\sum_{t=1}^{n} (X_t - \hat{X}_t)^2}{n} \quad (6)$$

Where, n is the number of predicted values.

The *RMSE* [7]is the square root of the *MSE* and is a measure of the forecasting accuracy.

4. PROPOSED ALGORITHM

A)Algorithm for the regression based time series model

In order to demonstrate the algorithm, load data & data regarding factors influencing load has been collected for a period of 359 days (from January 01, 2012 to December 24, 2012). One of the main factors which effect the load consumption of domestic consumers is temperature. The relationship between load and this factor is linear. The algorithm for the proposed model [5] can be represented in the flow chart as follows-

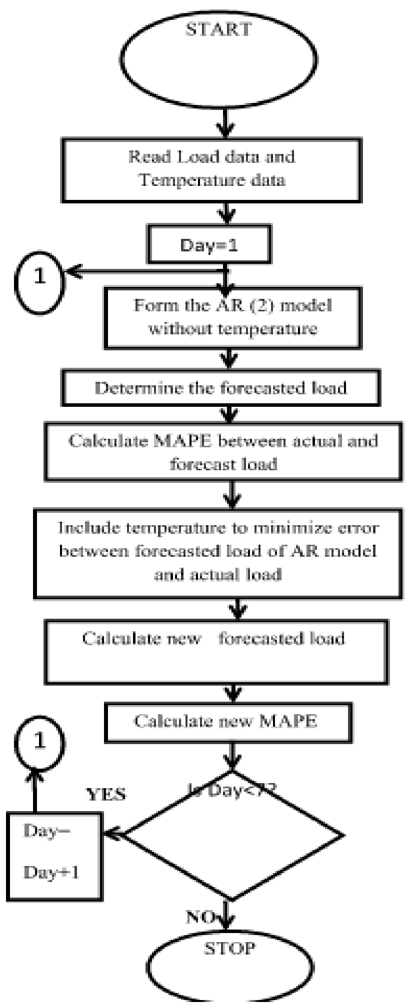

Fig. 1: Flow chart forregression based time series model

5. RESULTS AND DISCUSSION

A) Data Set Details

The data used are fifty one weeks and two days i.e. 359 days hourly load demand measured in Megawatt (MW) from January 01, 2012 to December 24, 2012. They are gathered from State Load Dispatch Centre (SLDC), Assam, India .Also .the temperature data in Celsius for the same period as load data are available from the Regional Meteorological Centre (RMC) located at the Lokpriya Gopinath Bordoloi International Airport, Borjhar, Assam .The method is applied for short term load forecasting [8] using the real time data of State Load Dispatch Centre (SLDC) for the 359 days' time span in order to forecast the last week i.e.52nd week of the year 2012 and it is implemented in *MATLAB* and graphs are plotted with number of samples representing hourly duration for the whole day in the x axis and corresponding actual load and forecast load on y axis. Here,series 1 indicates predicted load and series 2 indicates actual load.

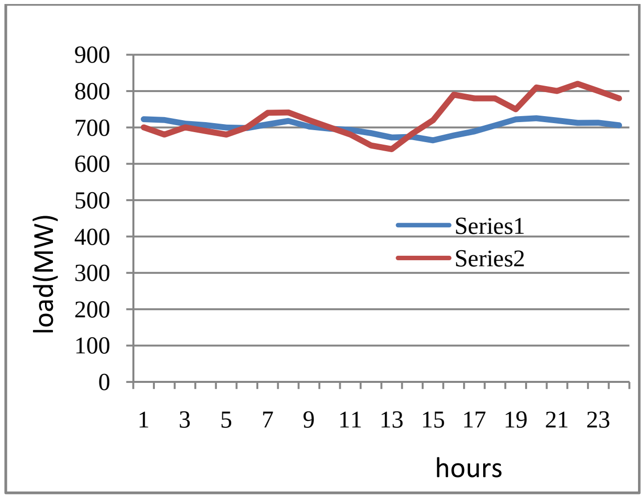

Fig. 2: Comparison of Actual/predicted load

The curve between the predicted and actual load considering temperature for the last day of 2012 i.e. 31st December, 2012is shown in fig.2. The red line indicates actual load and the blue line indicates predicted load demand. From the Fig.2, it is observed that the forecast load is very close to actual load and the calculated % error [9] was found to be negligible and within limits.. The load is predicted[10] for a week but results here in this paper are shown for only the last day of the week considered. The actual demand and predicted demand for 24 hours on 31st December, 2012 are as follows:

Table I: Hourly Actual and Predicted Demand for 31st December, 2012

Actual Demand (MW)	Predicted Demand(Without temperature)(MW)	Predicted Demand(Withtemperature)(MW)
700	736.8907	721.8907
680	735.0819	720.0819
700	725.2348	710.2348
690	720.9018	705.9018
680	712.9607	697.9607
700	712.0575	697.0575

740	721.8476	706.8476
741.2	731.1098	716.1098
720	715.6618	700.6618
700	709.9324	694.9324
680	706.5421	691.5421
650	697.6981	682.6981
640	685.6432	670.6432
682	687.6017	672.6017
720	677.8159	662.8159
790	691.0655	676.0655
800	701.5211	686.5211
780	716.7639	701.7639
750	731.8449	716.8449
850	735.8389	720.8389
820	726.8605	711.8605
800	722.0343	707.0343
780	723.3885	708.3885
800	720.0855	705.0855

6. CONCLUSION

Forecasting [11],[12],[13] load demand with high accuracy is required to avoid energy wasting and prevent system failure. Precise forecasting of load is very important for electric utilities in a competitive environment created by the electric industry de-regulation. Here, the forecasted load has been obtained by using regression based time series analysis[14],[15] and the accuracy of prediction has been improvised by including the temperature factor in the AR (2) model.Its final forecasting efficiency [16] has been evaluated by computing the mean absolute percentage error (MAPE) between the actual and predicted values. Here, for the 366th day of 2012 i.e. for 31st December we were able to obtain MAPE of 4.09% without temperature and 3.55% with temperature which represents a high degree of accuracy. Thus, the forecasting results for the whole week starting from 25th December to 31st December of the year 2012 has been obtained in a similar manner with minimum MAPE. Hence, the Regression based time series model temperature has been found to have given comparatively satisfactory results.

7. ACKNOWLEDGEMENT

The authors are grateful to SLDC, Kahilipara (Guwahati) for providing the load data and also extend their gratitude to the Regional Meteorological Centre (RMC), Guwahati for providing us the temperature data. Finally, the authors are indebted to numerous people who assisted in making constructive suggestions which have improved the quality of this paper.

REFERENCES

[1] Moghram and S. Rahman, *"Analysis and evaluation of five short term load forecasting techniques,"* IEEE Trans. Power System, vol. 4, no.4, pp. 1484–1491, Nov. 1989.

[2] B.L.Bowerman, R.T.O'Connell, and A.B.Koehler, *"Forecasting, Time Series, and Regression: An Applied Approach*," 4th ed. California: Thomson Brooks/Cole, 2005.,IEEE Transactions on Power Systems

[3] A. D. Papalexopoulos and T. C. Hesterberg, "*A regression-based approach to short-term loadforecasting*," IEEE Trans. Power Syst., vol.5, no. 4, pp. 1535–1550, Nov. 1990.

[4] Mrs. J. P. Rothe, Dr. A. K. Wadhwani and Mrs. S. Wadhwani, "*Short Term Load Forecasting Using Multi Parameter Regression*", *(IJCSIS)* International Journal of Computer Science and Information Security,Vol. 6, No. 2, 2009

[5] D.C.Montgomery, L.A.Johnson, J.S.Gardiner, "*Forecasting & Time Series Analysis*," 2th ed. New York: McGraw-Hill, 1990.IEEE Transactions on Power Systems, Vol. 8, No. 1, February 1993

[6] J.H.Chow, F.F.Wu, J.A.Momoh, *"Applied Mathematics for restructured electric power systems"*, New York: Springer, 2005

[7] G.Janacek, L.Swift, *"Time series: forecasting, simulation, applications*", West Sussex: Ellis Horwood Limited, 1993.

[8] Georgr gross, Francisco D. Galiana, "*Short-term load forecasting*", Preceeding of the IEEE, vol.75,no.12, December 1987, pp.1558-1573.

[9] J.Y. Fan and J.D. McDonald, *"A Real-Time Implementation of Short-Term Load Forecasting for Distribution Power Systems*" IEEE Transactions on Power Systems, vol.9, no.2, pp.988-994, 1994.

[10] J. H. Park, Y. M. Park and K. Y. Lee, "*Composite modeling for adaptive short term load forecasting*," IEEE PES Summer Meeting, # 90 SM 378-0 PWRS, Jul. 1990.

[11] M. T. Hagan and S. M. Behr, "*The time series approach to short-term load forecasting*," IEEE Trans. Power Syst., vol. PWRS-2, no. 3, pp.785–79, Aug. 1987

[12] LefteriH.Tsoukalas, Robert E.Uhrig, "*Fuzzy and Neural Approaches in Engineering*", A wiley-Interscience publication, JohnWilley&Sons INC, 1997

[13] R.A. Aliev, R.R.Aliev, "*Soft Computing and its Application*", World scientific publication, 2001.

[14] Tsekouras, G.J.,E.N. Dialynas, N.D. Hatziargyriou and S. Kavatza, 2007,"*A non-linear multivariable regression model for midterm energy of power systems,*" Electric Power Systems Res, 77: 1560-1568.

[15] Wei, W.W.S., 2006, "*Time Series Analysis, Univariate and multivariate Methods*", Second Edition. Pearson Addison Wesley, New York, pp: 72-166.

[16] Taylor, J.W., 2008, *"An evaluation of methods for very short-term load forecasting using minute-by-minute British data*". International J. Forecasting*24*: 645-658.