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An Overview of Different Types of Load Forecasting Methods and the Factors Affecting the Load Forecasting

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Abstract: ***load forecasting is vitally important for the electric industry in the deregulated economy. Load forecasting is about estimating future consumptions based on various data and information available and as per consumer behavior. Load forecasting mean forecasting average load in kw or total load in kwh for blocks of hourly, daily, weekly, monthly or yearly. There are different tools and techniques for load forecasting. One of the primary tasks of an electric utility is to accurately predict load demand requirements at all times, especially for short term. It has many applications including energy purchasing and generation, load switching, contract evaluation, and infrastructure development. Hence knowing the load behavior in advance is very important in planning, analysis and operation of power systems to maintain an uninterrupted, reliable, secure and economic energy providing.***

Keywords: electric load forecasting, short time load forecasting (stlf), long term load forecasting (ltlf) , medium term load forecasting (mtlf)

I. INTRODUCTION

Load forecasting is extremely important in electric energy generation, transmission, distribution and markets. Load forecast has been a central and an integral process in the planning and operation of electric utilities. The Purpose of load forecasting is proper planning and operation of a power utility requires an adequate model for electric power load forecasting [1]. Load forecasting plays a key role in helping an electric utility to make important decisions on power market, load switching, voltage control, network reconfiguration, and infrastructure development. Here we have discussed three type of load forecasting which are:-

Long-term electric load forecasting used to supply electric utility company management with prediction of future needs for expansion, equipment purchases or staff hiring. This is longer than a year.

Medium-term forecasting, used for the purpose of scheduling fuel supplies and unit maintenance. This is usually from a week to a year. Short-term forecasting, it is used to supply necessary information for the system management of day-to-day operations and unit commitment [1][5].

II. LOAD FORECASTING MODEL DEVELOPMENT

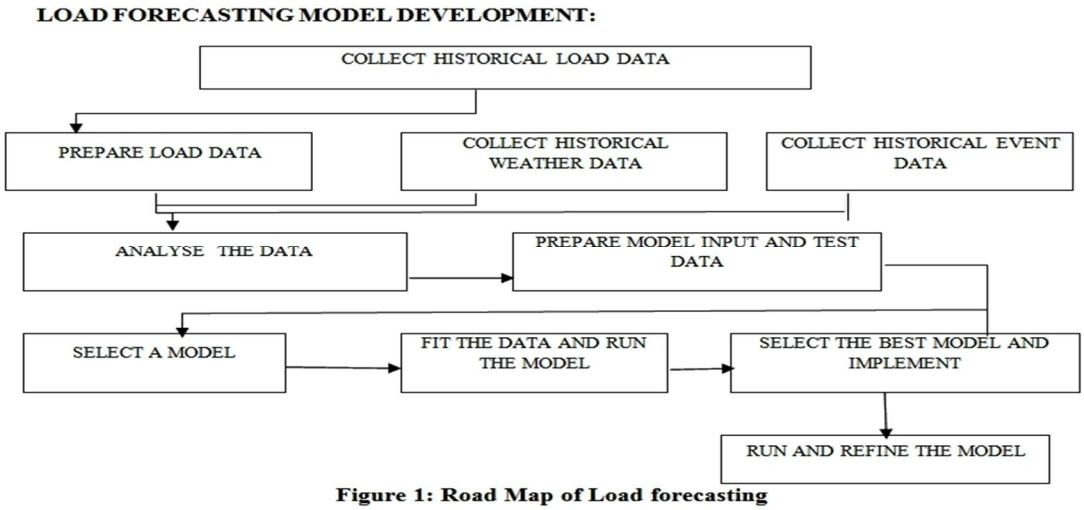

Figure 1: Road Map of Load forecasting

A. Short Term Load Forecasting

Short-Term Load Forecasting is basically a load predicting system with a leading time of one hour to seven days, which is necessary for adequate scheduling and operation of power systems. It has been an essential component of Energy Management Systems (EMS). For proper and profitable management in electrical utilities, short-term load forecasting has lot of importance. Short term load forecasting methods are:

1) *Similar Day Look up Approach:* Similar day approach is based on searching historical data of days of one, two or three years having the similar characteristics to the day of forecast. The characteristics include similar weather conditions, similar day of the week or date [7].
2) *Regression based Approach:* Linear regression is a technique which examines the dependent variable to specified independent. The independent variables are firstly considered because changes occur in them unfortunately. In energy forecasting, the dependent variable is usually demand of the electricity because it depends on production which on the other hand depends on the independent variables [8] [9] .
3) *Time Series Analysis:* Time series forecasting is based on the idea that reliable predictions can be achieved by modeling patterns in a time series plot, and then extrapolating those patterns to the future. Using historical data as input, time series analysis fits a model according to seasonality and trend. Time series models can be accurate in some situations, but are especially complex and require large amounts of historical data [12].
4) *Artificial Neural Networks:* ANN is a soft technique used in various optimization processes. This method is able to perform non-linear modelling and adaptation. It does not require assumption of any functional relationship between load and weather variables in advance. We can adapt the ANN by exposing it to new data. The ANN is also currently being investigated as a tool in other power system problems such as security assessment, harmonic load identification, alarm processing, fault diagnosis, and topological observability [13].
5) *Expert Systems:* An expert system is a computer program, which has the ability to act as an expert. This means this computer program can reason, explain, and have its knowledge base expanded as new information becomes available to it. The load forecast model is built using the knowledge about the load forecast domain from an expert in the field [14][15].
6) *Fuzzy Logic:* Fuzzy logic based on the usual Boolean logic which is used for digital circuit design. In Boolean logic, the input may be the truth value in the form of "0" and "1". In case of fuzzy logic, the input is related to the comparison based on qualities.
7) *Support Vector Machines:* Support Vector Machines (SVM) is the most powerful and very recent techniques for the solution of classification and regression problems. In support vector machines, linear functions are used to create linear decision boundaries in the new space. In the case of neural network, the problem is in the choosing of architecture and in the case of support vector machine, problems occurs in choosing a suitable kernel [16][17].

B. Medium and Long-Term Load Forecasting

The end-use modeling, econometric modeling, and their combinations are the most often used methods for medium- and long-term load forecasting. Descriptions of appliances used by customers, the sizes of the houses, the age of equipment, technology changes, customer behavior, and population dynamics are usually included in the statistical and simulation models based on the so-called end-use approach. In addition, economic factors such as per capita incomes, employment levels, and electricity prices are included in econometric models. These models are often used in combination with the end-use approach. Long-term forecasts include the forecasts on the population changes, economic development, industrial construction, and technology development. Medium and long-term load forecasting methods are:

1) *Trend Analysis:* Trend analysis (trending) extends past growth rates of electricity demand into the future, using techniques that range from hand-drawn straight lines to complex computer-produced curves. These extensions constitute the forecast. Trend analysis focuses on past changes or movements in electricity demand and uses them to predict future changes in electricity demand. Usually, there is not much explanation of why demand acts as it does, in the past or in the future. Trending is frequently modified by informed judgment, wherein utility forecasters modify their forecasts based on their knowledge of future developments which might make future electricity demand behave differently than it has in the past [15].
2) *End Use Analysis:* The basic idea of end-use analysis is that the demand for electricity depends on what it is used for (the end-use). For instance, by studying historical data to find out how much electricity is used for individual electrical appliances in homes, then multiplying that number by the projected number of appliances in each home and multiplying again by the

projected number of homes, an estimate of how much electricity will be needed to run all household appliances in a geographical area during any particular year in the future can be determined. Using similar techniques for electricity used in business and industry, and then adding up the totals for residential, commercial, and industrial sectors, a total forecast of electricity demand can be derived. The advantages of end-use analysis is that it identifies exactly where electricity goes, how much is used for each purpose, and the potential for additional conservation for each end-use [18].

3) *Econometric Analysis:* Econometrics uses economics, mathematics, and statistics to forecast electricity demand. Econometrics is a combination of trend analysis and end-use analysis, but it does not make the trend-analyst's assumption that future electricity demand can be projected based on past demand. Moreover, unlike many end-use models, econometrics can allow for variations in the relationship between electricity input and end-use. Econometric models work best when forecasting at national, regional, or state levels. For smaller geographical areas, meeting the model can be a problem [15].
4) *Neural Network Technique:* It is similar as to the neural network technique used for the short term load forecasting except in this technique with train the network with the large data and forecast the load for the whole or for long term [13].
5) *Multiple Linear Regressions:* Regression is the one of most widely used statistical techniques. Since, the load is totally dependent on the temperature, humidity, wind speed and day type parameters hence regression is used to obtain the relationship between load and these parameters [10][11].Firstly, using the past data the values of regression parameters a, b, c is calculated and using these parameters and the load is forecasted for long term.

C. Factors Affecting Short Term Load Forecasting

1) *Time Factor:* Time is the most important factor in short term load forecasting because its impact on consumer load is highest. From observing load curve of several different grid stations it is found that the load curve has "time of the day" property, also it has "day of week", "week of month" and "month of season" property[19].
2) *Economic Factor:* Since electricity nowadays became people's daily life necessity so it has turned to be a commodity. Thus economy of the state has also an impact on the usage of electricity. Economic factor has more importance in long term forecasting, but it also can impact the load curve for short term load forecasting. Economic factors such as price of electricity, management of load and degree of industrialization have a significant impact on system average load and system maximum demand [19].
3) *Weather Factor:* Weather is the most important independent variable for load forecasting. The effect of weather is most prominent for domestic and agricultural consumers, but it can also alter the load profile of industrial consumers. Load forecasting models use weather forecast and other factors to predict the future load, thus to minimize the operational cost.. Unpredicted sea breeze, after moon thunderstorms, back door fronts is some of the environmental factors that can decrease the temperature and thus causing overestimated load forecast. Thus we are producing more power than required[19].The weather factor includes:

Temperature: Temperature can also alter the conductivity of the transmission lines. Thus temperature can affect the overall carrying capability of the transmission lines. High temperature can increase not only the resistance of the transmission lines, but also it can alter the reactance of line, due to temperature induced expansion of the length of transmission line[19].

4) *Humidity:* Humidity is a term used for the amount of water vapors in air. Humidity has no effect on real temperature but it can intensify the severity of hot climate. So it is concluded from the above observation that for the prediction of daily load of domestic consumers we must consider apparent temperature instead of real temperature. But if we are dealing with an area having all types of consumers from industrial to agricultural and domestic "temperature humidity index" can be employed as the affecting factor for load forecasting [19].

It is the measure of the motion of air with respect to the surface of the earth covering a unit distance in unit time.

a) *Effect of Wind Speed on Load Consumption:* At low humidity rates the speed of wind lowers the apparent temperature and increases the rate of evaporation of perspiration from the human body therefore it gives the cooling effect. Thus during a windy day of summer the consumption of electricity will be lower because lesser cooling appliances will be used
b) *Wind Chill Index:* Wind chill factor is the felt air temperature on exposed skin due to wind. Wind chill temperature is always less than the air temperature and is undefined at temperature above 10 degree Celsius. Therefore in winter season load consumption on a windy day will be high ,thus wind speed can also affect the load consumption [19].
5) *Random or Occasional Spikes:* The power system consists of different types of consumers for example domestic, agricultural, industrial etc. The overall load of domestic consumers shows good statistical rules and is periodic in nature, but on the other

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hand industrial and agricultural loads are highly inductive and start up and shut down of such type of load induce huge spikes to the load curve. These spikes are called the random disturbance because start up and shut down of these huge loads is quite random in nature and there is no way to predict the occurrence of these spikes. CNG station load also lies in this category. If we add these spikes in the training data of ANN model then the average error of the model becomes very high. Special events such as religious or cultural celebrations also are another source of random disturbance. Diwali, Eid day, Christmas and other religious events [19].

D. Factors Affecting Medium and Long Term Forecasting

The end-use modeling, econometric modeling, and their combinations are the most often used methods for medium and long term load forecasting. Some of the most influencing factors that affects the Medium and Long term load forecasting can enlisted as below:

1) Descriptions of appliances used by customers.
2) The sizes of the houses.
3) The age of equipment.
4) Technology changes.
5) Customer behavior.
6) Population dynamics are usually included in the statistical and simulation models based on the so-called end-use approach.
7) Economic factors such as per capita incomes.
8) Employment levels, and
9) Electricity prices are included in econometric models.

III. LOAD FORECASTING IS CRITICAL IN INDIAN SCENARIO

India being a developing country load forecasting is one of the most concerned tasks in the power market. Apart from the conventional factor that affects the load forecasting, there are some more factor that play an important role in the load forecasting in India. Some of those can be enlisted as Energy Deficit Market, Significant Growth, Continuous shift of growth pattern as GDP of India in 2014 was 7.2% , and in 2015 it increased to 7.6% [3], Technical and Commercial Losses as there was a recession in 2008 in India due to slow down in US economy[4], Distribution Infrastructure, Metering Infrastructure, Nascent Market Mechanism Regulatory Policies, Renewable / Distributed Generation [2][4][5].

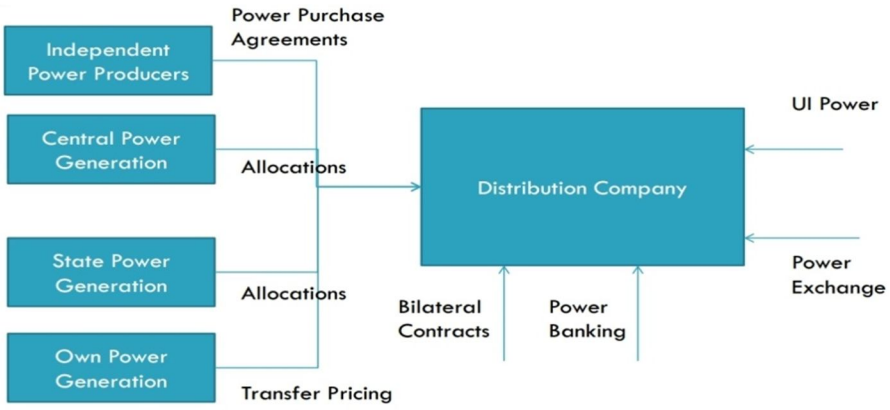

Figure 5: Sources of Power for Distribution Company [5]

IV. CONCLUSION

In this paper a discussion on several statistical and artificial intelligence techniques, Indian Scenario for load forecasting that have been developed for short, medium and long term electric load forecasting. Also a discussion on the factors that affect the accuracy of the forecasts such as weather data, time factors, customer classes, as well as economic and end use factors is done. Instead of using the single weather forecast, weather ensemble predictions can be used as multiple inputs for load forecasts. These inputs generate multiple load forecasts. A comparative analysis of the practical load forecasted result can be done among some methods .After that the best method may be recommended to several power utilities.

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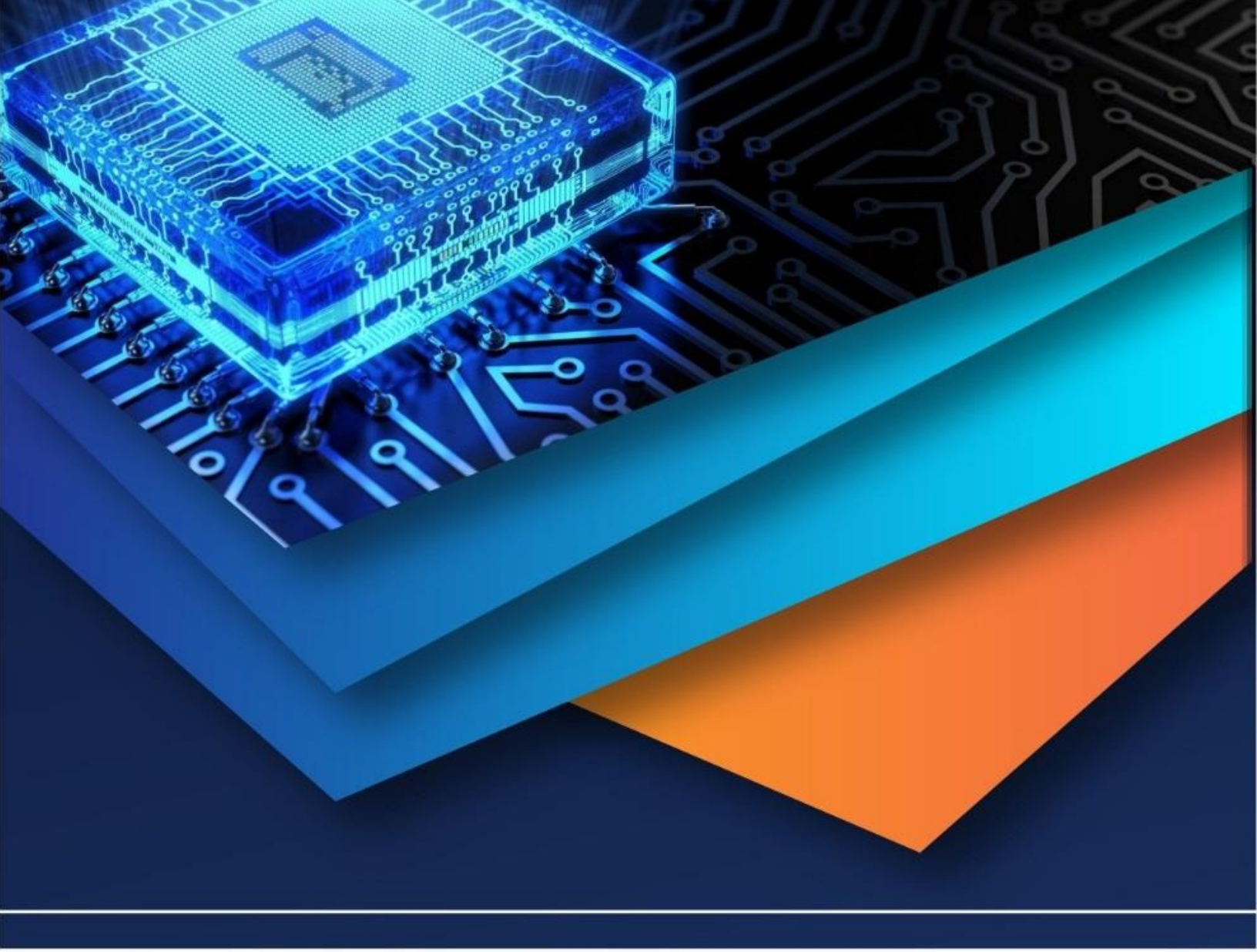

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