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A Literature Survey of Load Forecasting Methods and Impact of Different Factors on Load Forecasting

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Abstract: ***Load forecasting is vitally important for proper functioning of electrical industry. It has many applications including energy purchasing and generation, load switching, contract evaluation, and infrastructure development. Power planning and generation of power according to the demand plays a vital role in the present scenario. A large variety of mathematical methods have been developed for load forecasting. This paper deals with the analysis of various Long Term Load Forecasting, Medium Term Load Forecasting and Short Term Load Forecasting techniques which will help to forecast the power for short period of time and these techniques include Regression Technique, Curve Fitting Technique, and Artificial Neural Network Technique and finally their results are compared in order to determine the suitable technique. Also, a comparative analysis of merits and demerits of different load forecasting technique is done.***
Keywords: ***Electric Load Forecasting, Short time load forecasting (STLF), Long Term Load Forecasting (LTLF), Medium Term Load Forecasting (MTLF***)

I. INTRODUCTION

Load forecasting is as important as the generation and transmission of the power. The basic requirement of any power system is to keep a close track on the system load at all times .This monitoring ranges from hourly basis to the span of years. For seconds the automatic generation control ensures the generation and the load demand in the desired range. For a time ranges form few minutes to hour where a large variation in the load can take place economic load dispatch functions used to allocate the load economically. For more large time the variation in the load is still large. The system needs the monitoring keeping many aspects in view. These can be the generation control function such as unit commitment, scheduling of load, hydrothermal coordination. A proper watch for non conventional source of power generation also must be done because these source are not much flexible .For example the solar power generation is not totally controlled by human intelligence since it varies with the variation in the weather [1].The availability of fuel also need the load forecasting so that there must be availability of surplus fuel for the forecasted power generation.

Types of load forecasting: Load forecasting is mainly done for three time horizon based on the time of the requirement by the utility company. Long-Term Load Forecasting (LTLF): It is mainly for system planning, typically covers a period of 10 to 20 years. Medium-Term Load Forecasting (MTLF): It is mainly for the scheduling of fuel supplies and maintenance usually covers a few weeks. Short-Term Load Forecasting (STLF): It is done for the day-to-day operation and scheduling of the power system. This is usually from an hour to a day [2][3][4][5].

Methods of Load Forecasting: In modern era many computer tools are available for load forecasting. Starting with the use of conventional methods in computer there are many soft techniques for load forecasting.

Long Term Load Forecasting Techniques and Medium Term Load Forecasting: Approach and methods for both the LTLF and MTLF are nearly same since the load variation in both periods can be approximated to each other. Some of the important methods are Trend Analysis, End Use Analysis, Econometrics, Neural Network, and Multiple Linear Regression.

Short Term Load Forecasting: Soft techniques have taken over the conventional methods due to their advantages in the use and the results. The soft techniques used for load forecasting are:

Similar Day Lookup Approach: This method is somehow similar to the conventional method. It is based on searching historical data for any day with the same characteristics, such as weather, humidity, day of the week, dates (if holiday or any special day) as that of the present considered day. The historical data can be used in linear combination or regression to make a trend analysis [6].

Regression Based Approach: Linear regression is a technique which examines the dependent variation to specify independent. The independent variables are firstly considered because changes occur in them unfortunately. In energy forecasting, the dependent

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variable is usually demand of the electricity because it depends on production which on the other hand depends on the independent variables. Independent variables are usually weather related, such as temperature, humidity or wind speed. Slope coefficients measure the sensitivity of the dependent variable that how they changes with the independent variable. The future value of the dependent variable can be estimated [7] [8] [9] [10].

Time series analysis: The sequence of data typically at successive uniform intervals is used in Time series Analysis. This method attempts to understand the pattern of the data and predicts the future events based on the past events. TSA is often used for a short period into the future [11].

Artificial Neural Network: 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 [12].

Expert System: 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. The "Knowledge Engineer" extracts this knowledge from load forecast (domain) expert which is called the acquisition module component of the expert system. This knowledge is represented as facts and rules by using the first predicate logic to represent the facts and conditions are produced as a set of rules. This representation is built in what is called the knowledge base component of the expert system [13].

Fuzzy logic: Fuzzy logic is somehow same as that of Boolean logic in which the input may be the truth value in the form of “0” and “1” whereas in case of fuzzy logic, the input is related to the comparison based on qualities. In fuzzy logic there is no need of mathematical models for mapping between inputs and outputs. It is not affected by noise (error) [14]]there is no need of precise or even noise free inputs. After the whole processing is done using the fuzzy logic, the “defuzzification” is done to get the precise outputs.

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 [15].

Factors affecting STLF:

Time factor: Time factor in case of STLF is most concerned thing for precise load forecasting because SLTF is done on hourly basis. A load demand curve is published in a report by Sri Lanka Government [16] as shown in Figure (1).Curve showing the peak demand at 18HRS. So a uniform analysis for load forecasting is not enough. Close monitoring of load in hourly basis will give good forecast. Also load at same time in summer and winter varies with a large margin. Certain changes in the load pattern occur gradually in response to seasonal variations such as the number of daylight hours and the changes in temperature. Figure (2) shows the system peak occurs with a steep increase from 18:00 to 19:00 and depreciates with a slow rate of decreasing which takes about 3 hours. (From 19:00 to 22:00) This feature is common for all three curves. General opinion on the night peak is that it is predominately governed by domestic activities and lighting. Morning peak of weekdays (recorded at 06:00) is rather symmetrical, which consists with rapid increase and a rapid decrease. However, when considering only Sundays, the curve does not show a significant peak demand, but just a slight increase, which is recorded at 06:30.

Weather Factors: Load pattern is largely depends on the Weather Factors Meteorological conditions because most utilities have large components of weather-sensitive load which affects the load demands. These loads can be space heating machines, air conditioning, and agricultural irrigation. Temperature is the most important weather variable in terms of its effects on the load [17]. Unit commitment pattern is largely affected by the deviation of the temperature variable from a normal value may cause such significant load changes .Temperature accumulation day by day i.e. past temperature also affects the temperature rise forecasted earlier. Humidity is a factor that may affect the system load in a manner similar to temperature, particularly in hot and humid areas. Thunderstorms also have a strong effect on the load due to the change in temperature that they induce. Other factors that impact on load behaviour are wind speed, precipitation, and cloud cover light intensity.

Random Disturbances: Random disturbances in load demand include the sudden turning ON of radio program of any minister to public, any program to be held in any locality etc. Also, The power system consists of different types of consumers for example domestic, agricultural, industrial etc. Power system contains mainly the inductive loads such as electrical machines lightning etc

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whose turning on and turning off causes sudden surge in the loads. These sudden 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. If we add these spikes in the training data of ANN model then the average error of the model becomes very high [18]. Special events such as religious or cultural celebrations also are another source of random disturbance. Diwali, Eid day, Christmas and other religious events.

Economic Factors: Economic factor has larger influence in Long Term load forecasting but it has also some effect on the SLTF. The economics of an environment also has a clear effect on the load consumption. Several factors, such as the service area demographics, levels of industrial activity, changes in the farming sector, the nature and level of penetration/saturation of the appliance population, developments in the regulatory climate and, more generally, economic trends

have significant impacts on the system load growth . In addition, utility-initiated programs, such as changes in rate design and demand management programs also influence the load [19].

Conclusion: Electrical demand forecasting has now become a most concerned matter in the power industries as more electrical appliances became popular; the complexity of the forecasting problem grew. Also, with the advent of time conventional methods to the soft techniques several methods are invented for optimization. Some of them are being used in the electrical industries in several aspects. Smart grid needs advanced methodologies for accurate and precise monitoring of the power system. Also Smart-grid investment and technologies have brought new challenges to the energy forecasting field, such as demand-response forecasting and renewable-generation forecasting. The centuryold energy forecasting field has found new life in the smart-grid era. Many computer techniques are available but all have some merits and demerits as studied in this paper. A good forecasted result must include various parameters and also gives less MAPE in the result.

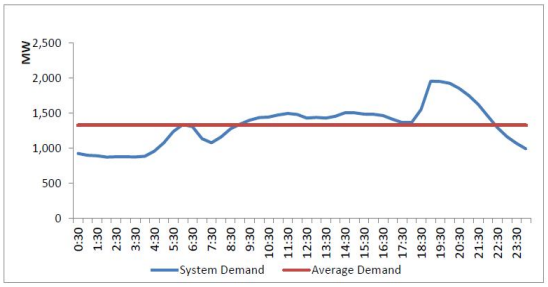

Figure 1: Typical System Load Profile

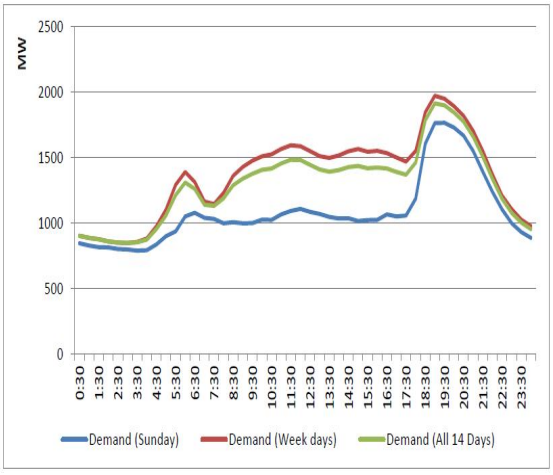

Figure 2: Special days demand Analysis curve

Table: 1

Methods	Merits	Demerits
Similar Day Approach	Easy to implement, Flexible in application	Less accuracy, Less parameters can be taken into consideration

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Multiple Linear Regression	Good accuracy, Easy to implement, update and automate	Problem in function selection, Needs explanatory variables, at least two year history required
Time Series Analysis	Simple trend Formulation, easy to use,	Prediction can be done only in a particular boundary, not much flexible
Artificial Neural Network (ANN)	Minimum statistical or domain knowledge required ;good accuracy during normal days	Heavy computation; over-parameterization; difficult to interpret, low accuracy during extreme weather condition.
Expert System	Easy , human interface so practically used	Less accuracy , largely affected by less data i.e less knowledge
Fuzzy Logic	No need of mathematical model, No need of precise noise free data.	Contains stages of calculation i.e fuzzy and defuzzification
Support Vector Machines	Simple Linear equation is used, accurate, flexible in application	Problems occurs in choosing a suitable kernel, complex to use

Future Work: As represented in this work there are many methods for load forecasting with several merits and demerits. This work can be extended by using some methods in through analysis. 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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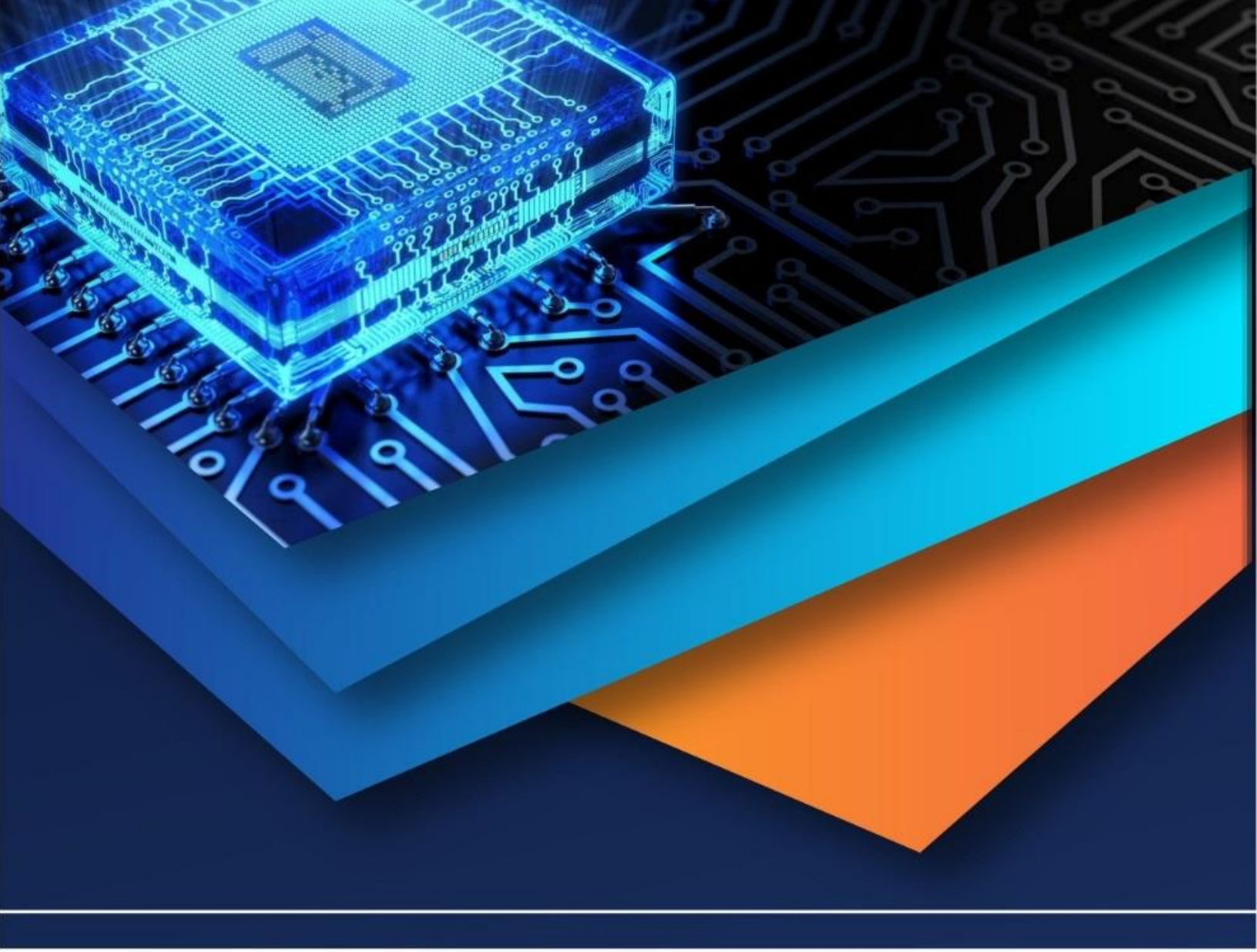

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