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A REVIEW: INTRODUCTION AND UNDERSTANDING OF LOAD FORECASTING

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Abstract- Load forecasting is a process of predicting future load demand. It is very important function in electrical power system. This paper deals with the review and understanding about the load forecasting, in which you will get to know about Importance of forecasting, Benefits of good forecasting, needs and purpose of load forecasting, different class of load forecasting, factors which affect the accuracy of load forecasting, merits and demerits of load forecasting. Among this the strong focus in done on short term load forecasting. Because the short term load forecasting become an emerging field in research for reliable and efficient operation of power system in past few years. In power system the forecasting is used for Load Forecasting, Electricity Price Forecasting, Solar Power Forecasting, and Wind Power Forecasting, all of this become favored topics for research work in recent era. Also, the load forecasting is important for day to day operating of power system.

Keywords- **Forecasting, Load Forecasting, STLF (Short Term Load Forecasting), MTLF (Mid Term Load Forecasting), LTLF (Long Term Load Forecasting), Factor affecting Load Forecasting.**

I. INTRODUCTION

Load forecasting is a technique used by electric utilities or by energy management system (grid operator) to predict the electricity needed to balance the generation and load demand. Load forecasting is a process of predicting future load demand. For reliable operation of electric grid, the load or demand is estimated in advance. This predicted load or demand is commonly known as load forecasting. Load forecasting is important for power system planner and grid operator for ensuring that there should have enough generation of electricity to deal with the increasing demand in future [3]. Load forecasting is also necessary for other participant in the electric energy generations, transmission system and distribution system. Load forecasting is use for capacity expansion, better grid operation, better budget planning, scheduling maintenance, and fuel management.

Forecasting is carried out in various fields, for e.g. in finance to predict goods (stock) exchange courses or indices of stock markets, in business to schedule staff, manage inventory and forecast demand, in medicine to monitor the spread of diseases, and in meteorology for forecasting weather. Equally, forecasting plays crucial role in the control of electric utilities and electric power purchase (exchange) in inter connected power system [1].

Load forecasting is broadly classified into four types; (a) Very Short Term Load Forecasting, (b) Short-Term Load Forecasting, (c) Mid-Term Load Forecasting, and (d) Long-term Load Forecasting. For the purpose of predicting future load demand several forecasting models has been developed in past few decades. Depending on data available used for input, time frame, time resolution (minutely to annually), the scale (for one building or for a particular region etc.) the suitable forecasts model/method is chosen for achieving the accurate result. The forecasted result and the actual result is compared and it is measure in term of percentage error. The different types of percentage error in load forecasting are; (a) Mean Percentage Error, (b) Mean Absolute Percentage Error, (c) Root Mean Square Error, (d) Co-efficient of variance of Root Mean Square Error [1]. This paper has five section, the first section carries introduction of load forecasting, the second section is based on classification of load forecasting, the third section represent the

basic steps for load forecasting and classification of load forecasting techniques, the fourth section include the advantages and disadvantages of load forecasting, and the fifth section will illustrate the overview of this paper.

Why Forecasting is Important:

1) Integration of Renewable Energy Resources
2) Restructuring of Power System
3) Energy Deficit Market
4) Significant Growth
5) Distribution Infrastructure
6) Technical and Commercial Losses
7) Regulatory Policies
8) Nascent Market Mechanism

Benefits of Good Forecast:

1) Efficient power procurement/bidding
2) Resources planning
3) Selling of excess power
4) Optimum supply schedule
5) Network planning
6) Good DSM (Demand Side Management) strategies
7) Optimum renewable placement and sizing plan

Need (purpose) of Load Forecasting:

1) For proper planning of capacity expansion.
2) For proper planning of Transmission and Distribution Facilities.
3) For proper power system operation.
4) For proper financing.
5) For proper manpower development.
6) For proper electric grid formation.

II. CLASSIFICATION OF LOAD FORECASTING:

As mention in the introduction the load forecasting is classified into:

- Very Short Term Load Forecasting (VSTLF),
- Short Term Load Forecasting (STLF),
- Mid Term Load Forecasting (MTLF), and
- Long term Load Forecasting (LTLF).

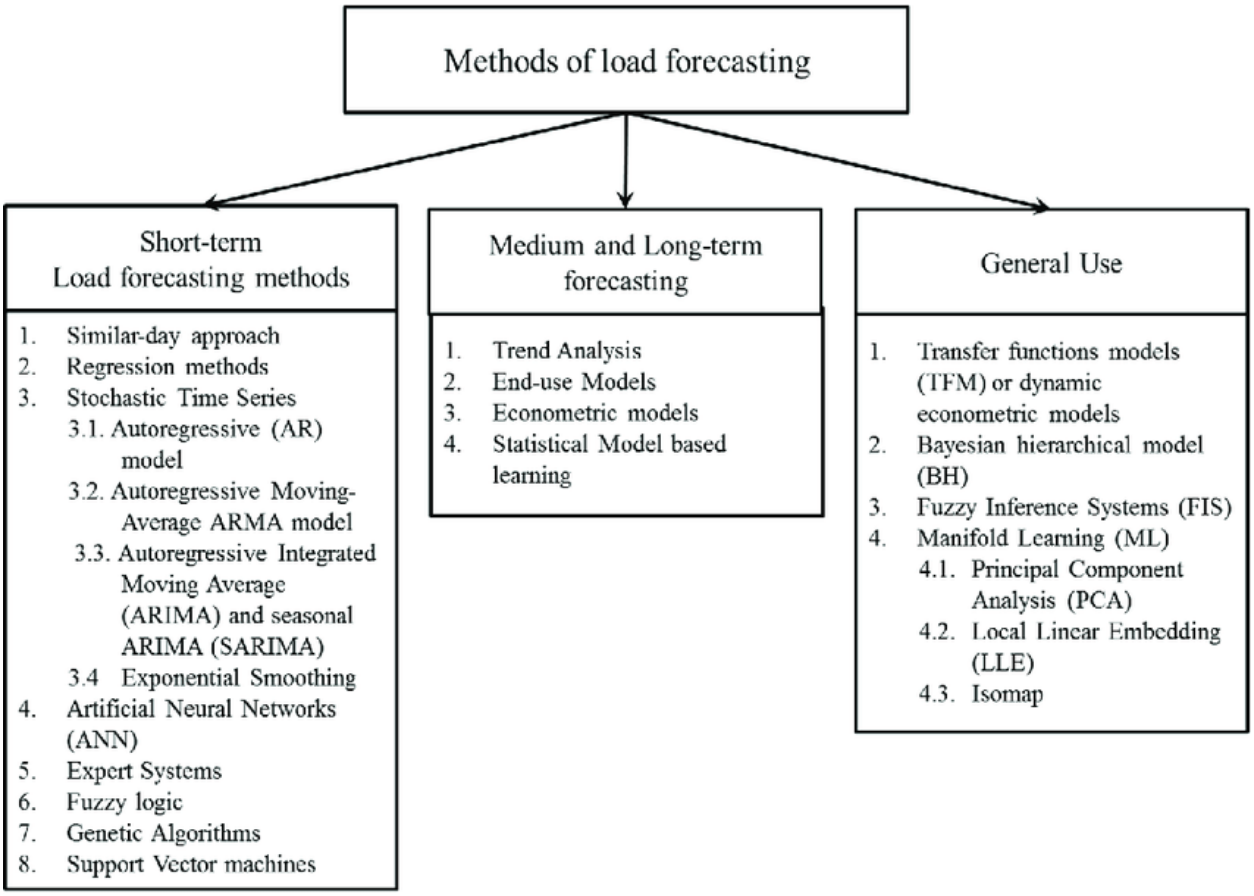

Figure (1): Different methods use for load forecasting

Very Short Term Load Forecasting (VSTLF):

The period of Very Short Term Load Forecasting (VSTLF) is from one minutes to one day (up to one day). VSTLF is helpful for electric utilities and grid operator for making important decision on real-time scheduling of electricity generation, real time operation, demand response, security assessment, sensitivity analysis and load frequency control. Very short term load forecasting is much familiar to the short term load forecasting because they both take weather forecasts as an input for prediction. The commonly used method for VSTLF is regression models, Time Series Analysis, Support Vector Machine (SVM) and Artificial Neural Network (ANN). Among this Time Series Analysis and Support Vector Machine is widely used for very short term load prediction. Different researchers have tried various techniques to forecast the load of the next few minutes to hours [11]. Various method/techniques is compared and accuracy is measure to find best suitable technique of very short term load forecasting.

Short Term Load Forecasting (STLF):

Short Term Load Forecasting plays an essential role in operation of power system. STLF has span from one day to one week (seven days or several days) ahead and give hourly based forecasts result. The STLF is important for decision making in overload condition, used for the unit commitment, spinning reverse planning, for the daily operation of system it gives information to the EMSs (Energy Management Systems) [6]. STLF is also have an application in balancing the generation and demand. Another application of STLF is in optimizing the operational state of a power system in terms of reactive power management, generating unit scheduling and load flow.

Similar Day Look up Approach, Regression based Approach, Time Series Analysis (including Autoregressive Moving Average and Autoregressive Integrated Moving Average), Artificial Neural Networks, Expert Systems, Fuzzy Logic, Support Vector Machines, this are the some commonly used methods for Short Term Load

Forecasting [5]. For achieving better accuracy, the hybridization of above method can be carried out. Corentin Kuster [1] has referred 113 case studies and 41 academic paper in which he analyzes that about 43.59 percentage of short term prediction has been carried out in different research paper. Artificial Neural Network (ANN) is widely used method for short term load prediction by researchers. The use of ANN in midterm and long term prediction is less. Some of hybridization techniques using artificial neural network is successfully applied in short term load forecasting [9]. Such techniques are: ANN with Back Propagation (BP) Algorithm, ANN with Fuzzy Logic, ANN with Genetic Algorithm (GA), and ANN with Particle Swarm Optimization (PSO) [9]. Different algorithm is hybridized and that algorithm are implemented for forecasting by several researchers to achieve better accuracy.

The improvement and development of the appropriate mathematical tools will lead to the development of more accurate load forecasting techniques [7].

(A) Statistical Technique

- Multiple regression method
- Exponential smoothing
- Iterative reweighted least square
- Adoptive load forecasting
- Stochastic time series

(B) Artificial Intelligent (AI) Technique

(C) Knowledge Based Expert Systems

(D) Hybrid Techniques

Factor affecting short term load forecasting:

1. Time Factor

Time is the most significant factor in STLF (Short Term Load Forecasting) because its effect on consumer load is much more. By analyzing demand curve of several different sub stations it is found that the demand curve has “hours of the day” property, also it has “day of week”, “week of month” and “month of season” property. This means that load curve is periodic in nature. From examine the daily load curve of any sub-station it can be seen that load variation follows the certain rules with the “time point” of the day [2].

2. Economy Factor

Nowadays electricity is become essential part for each and every people, so electricity is gone to be a commodity. Thus economy of the state has also an effect on the consumption of electricity [2]. In short term load forecasting this factor is given less importance but it still affects the load profile.

3. Weather

Weather is the most significant factor in load forecasting. The usage for electricity by domestic or agriculture consumers is varied as per the nature of weather, so the load profile is likely to change due to effect of weather. The weather may also change the units consumed by (load curve) industrial consumers. Load forecasting using the climate (weather) forecast to optimize the operational cost.

The weather factors include:

a. Temperature
b. Humidity
c. Precipitation
d. Wind speed

(a) Temperature:

The temperature is defining as the measure of degree of hotness or coldness of a body. There is two type of correlation between temperature and load, i.e. positive correlation and negative correlation. During summer time there is high positive correlation between temperature and load, likewise there is high negative correlation between temperature and load during winter season [2]. Temperature may change the conductivity of the transmission lines. High temperature alter the resistance as well as the reactance of lines, so due to due this it can affect the power carrying capability of transmission system.

(b) Humidity:

Humidity is defining as the amount of water vapors in air. There are a two types of humidity, which are absolute humidity and relative humidity. According to the research at pen state, the high humidity can make it feel colder when the temperature is lesser than 53˚F and it can make feel warmer when the temperature is above 53˚F [2]. During the rainy and winter season the humidity is much high so human can feel colder, so the usage of cooling appliance is lesser and load curve has lower peak, but during the summer season the humidity is in low quantity, due to this the human feel hotter and the cooling appliance is used more and more and hence there is increase in electricity consumption. From the above discussion the humidity can affect the load curve.

(c) Precipitation:

The Precipitation is defining as the amount of rain, snow or hail fallen at a specific place within a specific period of time. Precipitation can affect the electricity consumption directly or indirectly.

i. Direct effect:
Heavy snow or rain can make people to stay at home and there is also a darkness in environment, so there will be more consumption of electricity. It alters the load consumption and load profile.

ii. Indirect effect
By saying in term of indirect way, it has positive and negative effect on the load consumption. Due to heavy snow or rain the temperature will decrease, so from this we can say that if the consumption will increase then there is a negative effect or if the consumption will decrease then there is positive effect. Both possibility can be occurring due to heavy rain or snow.

(d) Wind speed:

Let see how the wind speed effect the load profile, if the rate of humidity is low then the speed of wind is lower and it will increase the rate of evaporation of perspiration from the human body, as a result it gives a cooling effect. So during the windy day in the summer, it will reduce the use of cooling appliance.

Also, if we have the hybrid generation i.e. we have hydro generation plus renewable generation (solar, wind, geothermal, etc.), considering wind generation, the power generation of wind farm will be more during windy day [2]. During this condition the forecasting models has to consider the wind speed because at this stage there is more possibilities of over generation by conventional plant. For STLF the wind speed is also important factor for balancing the supply and demand.

Mid Term and Long Term Load Forecasting (MTLF and LTLF):

MTLF have a time period in one month to one year or up to three years, while the LTLF have a time period in more than one year but less than fifteen years. Mid-term load forecasting and long term load forecasting plays an important role in maintenance scheduling, fuel reverse planning, unit commitment, energy contracts, load dispatching analysis, revenue from sales, load dispatching coordination, monthly peak load studying and capacity expansion for electric utilities, Network planning, capital investment, purchase of generating units, purchase of equipment, revenue analysis, staff hiring respectively [6]. LTLF is primary step which is taken by operator for planning the future generation, transmission and distribution system in power system. The long term load forecasting is inaccurate by nature because (1) Peak demand is mostly dependent on change in temperature (2) Some of necessary data for LTLF such as economic

data, weather data are not available (3) A huge amount of investment and several years is required to build the new generation and transmission system.

Different methods used for mid-term load forecasting and long term load forecasting are: Trend Analysis, End Use Analysis, Econometric Analysis, Neural Network Technique, k-Nearest Neighbor and Multiple Linear Regression [4]. Also, the regression and multi regression are widely used method for long term load forecasting and it give a much more accurate result based on long term prediction. In detail, the long term load forecasting is broadly classified in two categories, parametric methods and artificial intelligence methods [8]. The parametric methods further include regression methods, time series prediction methods, and Traditional statistical load forecasting techniques. Also, artificial intelligence based methods further include Neural Network, Genetic Algorithm, Support Vector Machine, Fuzzy Logics, Expert System and Wavelet Networks [8]. Corentin Kuster [1] has referred 113 case studies and 41 academic paper in which he analyzes that about 61.54 percentage of long term prediction has be carried out in different research paper. Regression Model is widely used for long term prediction because of its simplicity and accuracy.

Factor affecting mid-term and long term load forecasting:

1) Population
- Number of Electricity consumers
- Number of House hold units
- Number of Electricity connections
- Number of Electric units consumed or supplied

2) Weather
- Temperature
- Global Warming Index
- Rainfall
- Humidity

3) Economy of the considered territory
- GDP
- Per Capita Income
- GNP
- Gross National Income

4) Standard of living
- Sales pertaining to luxury items including appliances
- Increase in per capita
- Exchange rate and Gold Price
- Technology development

5) Fuel & Electricity Prices
- Oil Price, Gas Price, Petroleum price
- Electricity Price
- Accessibility to amenities

6) Geographical and Regional Developments
7) Government Policies
8) Random factors

III. Basic Steps for Load Forecasting and Classification of Load Forecasting Techniques:

- *Steps for load forecasting:*

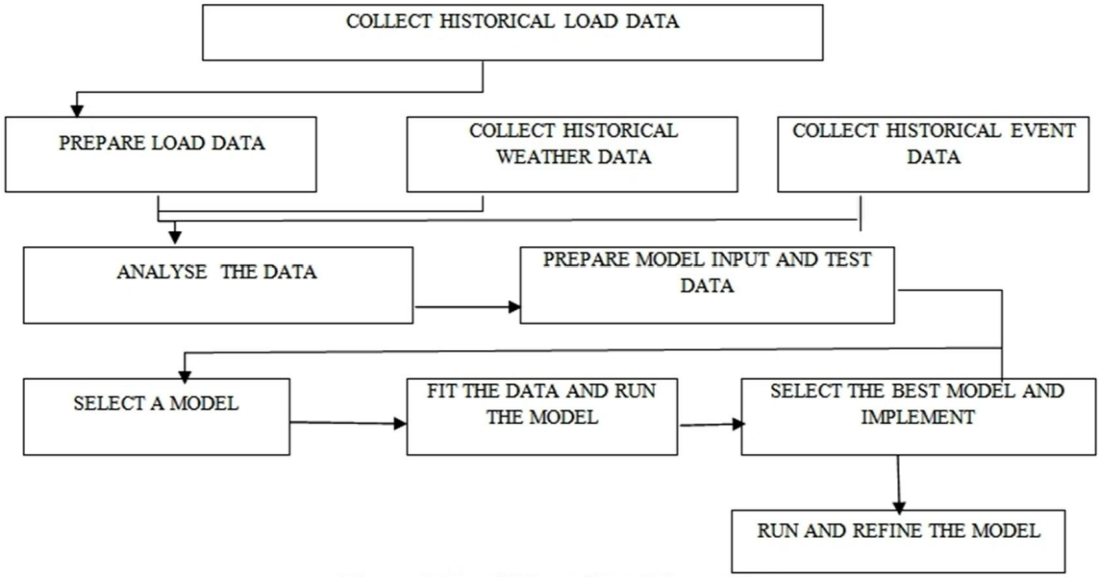

Figure (2) [5]: Road map of load forecasting

- *Classification of Load Forecasting Techniques:*

The Load Forecasting Technique can be classified into three types: Traditional Forecasting Techniques, Modified Traditional Techniques, and Soft Computing Techniques [10].

1) Traditional Forecasting Techniques further classified as:
   A. Regression Method
   B. Multiple Regression Method
   C. Exponential Smoothing
   D. Iterative Reweighted Least-Squares

2) Modified Traditional Techniques further classified as:
   A. Adaptive Demand Forecasting
   B. Stochastic Time Series
      a. Autoregressive (AR) Model
      b. Autoregressive Moving-Average (ARMA) Model
      c. Autoregressive Integrated Moving-Average (ARIMA) Model
      d. Seasonal Autoregressive Integrated Moving-Average (SARIMA) Model
   C. Support Vector Machine based Techniques

3) Soft Computing Techniques further classified as:
   A. Genetic Algorithms
   B. Fuzzy Logic
   C. Neural Network
   D. Knowledge-Based Expert Systems

IV. Advantages and Disadvantages of Load Forecasting:

Advantages:

- An electric utilities or energy management system can plan well with the help of predicted load demand or future consumption.
- Utility company can take reliable decision on expansion as well as investment of future generation and transmission system.
- Load forecasting helps to determine the required resources to operate the power plant.
- With the help of predicted load, the operator can plan future term such as type, size, and location of future generating plant. This helps in reducing the transmission and distribution losses, for e.g. if future load in some particular area is going to increase for a long time then near to this load a renewable generating plant can build and thus it will reduce the losses of transmission and distribution system.
- By understanding and predicting the demand, it helps to make decision and planning on maintenance of power system equipment. For e.g. utilities will carry out the maintenance on residential area during day time when most of the people is at their work and load demand is low.
- There will be a maximum utilization of electric generation plants and also forecasting avoids under or over generation.

Disadvantages:

- Forecasting is based on the assumed condition such as climate (weather). Dismally, the climate sometimes unpredictable due to its stochastic nature and the forecasting can be different when the actual climate varies from the expected.
  Furthermore, the weather condition in different region may be different so it will affect the load demand. Suppose the demand is predicted high, then electric utilities have to generate more electricity to meet expected high demand and actually the demand is less compare to demand expected and if the electricity is generated by the fossil fuel generator then there is a negative impact on revenue.
- Most of the electric utilities using manual methods for forecasting, which may not give the accurate result. So utilities have to use a technology which can give high accurate result and remove the problem associated with forecasting.
- Different consumer using different meters either traditional meter or smart meter, depending on the meter the usage of electricity will vary. The different forecast model must be introducing for each meter to achieve better accuracy. Otherwise, they may get inaccurate result.
- Due to change in price the consumption may change and it will difficult to get accurate data for forecasting.
- None of forecasting method is 100% accurate they always have an error.

V. CONCLUSION:

In this paper we have reviewed (discussion) on classification of load forecasting, different methods used for forecasting and classification of load forecasting techniques, factor which affect the accuracy of load forecasting, advantages and disadvantages of load forecasting. Also, some points of needs and benefits of forecasting is mention in section 1. Overall, the accurate result of predicted load will help the operator to manage real time operation, maintenance scheduling, fuel management, overload condition, unit commitment, capacity expansion, etc. Load forecasting become an important term after restructuring of power system.

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