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Design and Analysis of Electrical Load Forecasting using Various Methods: A Review

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Abstract:
A reliable and continuous supply of electrical energy is necessary for the functioning of today's complex society. Because of the combination of increasing consumption and obstruction of various kinds, and the extension of existing electrical transmission networks and these power systems are operated closer and closer to their limits. It is known for all that electrical energy cannot be stored efficiently, due to this factor that the electrical load could be controlled by utilities only to a very small extend. The electric load forecast is an important topic for power generation and transmission. In these paper different techniques of electrical load forecasting and their outcomes are discussed.

Keywords: Forecasting, ANN, Electricity, Extrapolation, Correlation.

I. INTRODUCTION

The electric load forecast is an important topic for power generation and transmission. Because of the long duration of this forecast, it is much more difficult to forecast off-peak load demand and so the main emphasis is on the annual peak system load. Long term electric load forecasting is essential in determining the load growth in a particular city. The peak load forecasted helps the power utilities in establishing whether upgrades of a particular network need to be performed. The capacity in terms of electrical power in that area may be exceeded thus making long term electric load forecasting a key factor in planning of a utility. The key contribution of forecasters is their knowledge of electricity consumers and understanding of the way they use electricity and other competing energy forms. This problem gains special aspect in developing cities, because of the high demand growth rate as well as the wide differences in the modes and levels of consumption in the various regions in the country.

1.1 Load Forecasting: Load forecasting is the prediction of future electrical demand. It is important since electrical power generation requires efficient management. This is because the power generated needs to be equal to that consumed. For the any city power generating companies to meet the requirements, it is necessary to predict or forecast the future Electrical load requirements. The term load forecasting refers to the projected load requirement determined using past knowledge to define future load in sufficient quantitative detail [1]. Demand electric load prediction is an important aspect in electricity planning [2] of electric utilities. It is a means of knowing how much power to schedule for the future demand, useful in drawing up a feasibility report for power plants and is also useful in determining whether the current capacity of the power stations or sub-stations of a service area will be exceeded. The latter is usually determined when the load demand is forecasted for a period longer than a year.

Load forecasting can be categorized into three important parts namely:

I. Short-term load forecasting.
II. Medium-term load forecasting.
III. Long-term load forecasting

In short-term load forecasting refers to a few minutes to a week forecast of electrical demand. Medium-term load forecasting is usually from a week to a year ahead whilst long-term load forecasting is for a longer duration which is from a year up to 20 years. The forecast period mentioned above is not a definite period, some literature mention that medium term is the period from six months to a year, and some say it is from a year to five years into the future. The period varies from utility to utility and so for the purpose of this project, a period from a week to less than a year will be referred to as medium-term electric load forecasting.

The following section discuses the three types of forecasting:

Short Term Load Forecasting: The term short implies that forecast can be done for every hour, day, and week. The forecast value is usually the total system load demand as well as the values of the system load at different times of the day. Short-term load forecasting (STLF) is essential for the economic generation dispatch of power systems. This means that power generation can be planned according to the forecasted value decreasing the risk of equipment failures such as transformer and transmission lines. The possibility of blackouts occurring is also reduced as well as losses in revenue of power utilities.

The key objectives of this forecast are as follows:

· Provide load prediction for the basic generation scheduling.
· Supply timely dispatcher information based on the load predictions.
· Assist with the assessment of the security of the system at any particular time, thereby improving the network reliability.

Short-term load forecasting helps to improve system reliability in that the system load forecast that can be generated using short-term load forecasting is essential for the offline network analysis function, and for the detection of future conditions under which the power system may be vulnerable. This helps the dispatcher to make informed decisions and take the necessary actions. These actions may compromise of bringing peaking units online load forecasting scheduling, switching operations so that the reliability of the system is no hindered.

Medium Term Load Forecasting: Medium –term load forecasting is predictions of demand for a week to a year in the future. It is necessary for the maintenance and network development work performed by power utilities. It involves the forecasting of systems load and sometimes bulk power interchange levels. Peak load demand is the main focus in this forecast but off-peak demand is also forecasted.

Long Term Load Forecasting: This type of forecast is for much longer duration into the future. The forecast period may last up to twenty years. Because of long duration of this forecast, it is much more difficult to forecast off-peak load demand and so the main emphasis is on the annual peak system load. Long-term load forecasting is essential in determining the load growth of a particular area. The peak load forecasted helps the power utilities in establishing whether upgrades of particular networks need to be performed. The capacity in terms of electrical power in that area may be exceeded thus making long term forecast, a key factor in planning operations of a utility.

1.2 Factors Affecting Electric Load

Before a load forecast model can be developed, the forecaster needs to determine the factors that affect the electric load demand in the particular areas that need to be forecasted.
The factors that need to be considered are:
· Time of the day
· Day of the week
· Time of the year (including seasons, holidays, etc)
· Weather
· Customer class
· Demographic factors (Population, housing)
· Macroeconomic factors (GDP, CPI, HSI)
Customer classing is the division of load demand into groups that utilize power in the same manner. This means that the load demand can be broken down into classes namely; residential (domestic), commercial (banks, hotels, schools, etc), Industrial (sugar milling companies, paper mills), mining (e.g. cement manufacturing plants), agricultural and transport. The customer class defines the load profile, for example the power demand for a residential class is not the same as that of an industrial class. Industries may require more power because of equipment such as heavy duty motors that they use whereas the appliances used by those of residential class do not draw as much power.
Other factors that affect electric load forecast are as follows
· Historical electric load
· Appliance sales
· Price of electricity
· Number of customers in the class
· The economic as well as demographic data.
These usually affect the medium and long-term forecasts.
The following are regarded as the most important factors.
Weather: Weather factors are as follows: Wind speed (this defines how cold people feel), temperature, humidity, cloud cover and rainfall. There is a varying of load demand from season to season influenced by the change in weather temperature; for example in Okaya the load demand in summer is not as high as in winter because of increase in temperature. In winter, people start using heating appliances in order to keep warm. Lights come on earlier for a much longer period than in summer as the sun sets at an earlier time.
There is a shift in the load peak-time as a result. It is difficult to incorporate weather factors in the long-term forecasts because it is continually changing and there are no long-term weather forecasts available. Short term forecasts take weather forecasts into great considerations because they affect the daily load profile and this is necessary for accurate forecasting. Medium-term electric load forecasting take weather into consideration and the seasonal effects are accounted for in the model. We can find that not all weather factors are important. Some are typically random during a period of time, such as wind speed and thunderstorms. Also some factors are interrelated. Among all those factors, temperature is the most important because it has direct influence on many kind of electrical consumption, such as air conditioner, heater and refrigerator. However, the leading weather influential factor for specific consumer may be different.
Electricity Pricing: In general, this is a factor that has not been greatly used in the forecasting of load. Very few models include this factor; because electricity prices vary depending on place and time and consumers can adjust their consumption behavior according to the price of the electricity.
Economical or Environmental: The economy has an effect on the electric demand patterns. The general trend has an effect on the increase or decline of electricity consumed. This includes levels of industrial growth activities, changes of farming sector, emergency of new industry, service area demographics (rural, residential), Economic trends (recession or expansion), demand side load management.
Unforeseeable Random Events: In Kenya random events are inevitable. This includes recurrent post elections violence, widespread of strikes, start or stop of large loads (steel mill, factory reviving and furnaces), sporting events and popular televisions shows and recording and also shutdown of industrial facility.

2. ELECTRICAL LOAD FORECASTING USING NEURAL NETWORK

The electric load forecasting is a problem that is difficult to deal with because of the nonlinear and random behavior of system loads as well as other factors that may influence the demand. The artificial intelligent techniques are effective to a certain extend. The main disadvantage of these techniques is their inability to incorporate and handle this random-like behavior of system loads. Moreover, because of the developments in technology, economic growth, past trends, causes the classical methods to produce incorrect predictions which may have a negative effect on the power utilities. A need that requires models to be able to adapt quickly to the changing environment and be able to learn on their own without human assistance arises. Methods with improved accuracies that can be updated without interfering with the rest of the system, and can incorporate as many input parameters as possible without failing to converge become a necessity. Various research programs have been undertaken in order to find solutions to these problems and one of the result was Artificial Intelligent techniques (NEURAL NETWORKS) AITs are unconventional ways of solving classes of problems. A number of artificial intelligent techniques have been developed over the past century and their applications are global. They are able to use human knowledge to create solutions to problems. This type of knowledge is stored in knowledge basis such as the expert systems. They are able to gain experience over time and are able to handle uncertainty in information very well like the fuzzy logic system.
Advantages
· ANN systems are fast and robust.
· Possesses a good learning ability.
· Capable of adapting to the data.

· Appropriate for non-linear modelling.
· Does not require a mathematical model of the load

3. ECONOMETRIC MODEL

This method incorporates statistics, economics and mathematical theory in order to forecast the electricity demand. The approach estimates the relationships between energy consumption and factors influencing consumption [3]. It is a combination of the end-use and trend analysis methods but it does not take on the assumption used in trending that future demand can be predicted based on past demand. Unlike the end-use model, it allows the variation of the relationships between the end-use and the amount of electrical power received by consumers. Complex mathematical equations are used to show past relationships between demand and the demand-affecting factors [9]. The equation can show whether these factors decrease or increase the demand as well as the percentage increase or decrease. The equation is then tested for its reliability and accurate representation of past data. Thereafter, projected values of the factors (price, population etc) are put into the equation and a forecast is made. In this method past electricity consumption data was used and GDP growth was established and regression method was used to obtain the electricity demand for the consecutive years.

Advantages

· Shows how and why electricity increases or decreases.
· Provides detailed information about the future levels of electricity demand.
· Provides separate forecasts for residential, commercial and industrial demand.
· Flexible and useful for analyzing load growth under different scenarios [9]

4. LITERATURE REVIEW

Swaroop R. et all in [6] Proposed load forecasting technique using artificial neural network. They showed that neural network method is better than other methods because it adopt learning directly from historical data. They used past set of data such as humidity, temperature etc. They used back propagation algorithm to train the network. It creates the matrix which can be used for the new set of inputs and average temperature and humidity taken as inputs and average load is taken as the output. In this paper they collected data for the year 2007, 2008 and 2009 and used to get the predicted output for the year 2010. They suggested that ANN model with the developed structure can perform good prediction with least error and finally this neural network could be an important tool for long term load forecasting. Rabindra Behera et all in [7] described an application of combined model of extrapolation and correlation techniques for short term load forecasting of and Indian substation. They consider past data for load, respective weather condition and growth of people as main factors. Curve fitting technique is and MTALAB tools is used for designing. The approach is very advantageous in forcing the forecaster to understand clearly the interrelationship between load growth patterns and other measurable factors. They suggested that load data can be divided into three parts. 1) constant about 90%; 2) weather dependent about 5%- 6%; 3) Unpredictable about 4% - 5%. It can be suggested that if the model can be prepared including all the three factors, accuracy of forecasting can be increased.

Hien dang-Ha et all in [8] discussed solutions for local one-day-ahead load forecasting problem, which needs to be able to model thousands of load time-series automatically without human intervention. One baseline and five models have been proposed, including avg ARIMA, orgi DSHW, mod DSHW, NARX-RF, TBATS, and Semi Par. These models were tested on 40 different load time-series, collected from US and Norway at different aggregation levels with different characteristics. The experiment results show that the Semi Par has superior performance on high-aggregation load. Their experiment also suggested that at low aggregation level, long term underlying processes and temperature information do not contribute much to the forecasting accuracy. Apparently, one can develop a better and more general model for the task by automatically combines or select among those methods proposed in this paper. However, one must acknowledge the fact that this would complicate the deployment and maintenance process, where thousands of models are involved.

Mosad Alkhathami et all in [9] presented a comparison of various loads forecasting methodologies and material presented in this paper can be used as a guide to select the most appropriate forecasting model for a specific power network. They suggested that some techniques are complex because the factors utilized as the load frequently have complex variables. This implies that the more complex the method applied, the more accurate the results obtained. This automatically shows that artificial-based techniques will produce the most accurate results as they incorporate all aspects of factors such as the social, environment and the economy. These techniques were observed to employ complex techniques, which identify both linear and non-linear relationships that can be seen between electricity consumption, as well as factors affecting consumption. Furthermore, these techniques are mostly used by experts as they usually rely on their experience and opinions in order to be accurate. In the long run, experts in this field will have to analyze these variables at length in order to have a clear understanding as to how they behave, in an effort to create advanced methods of forecasting load or electricity demand.

Alfares and Nazeeruddin [10] presented a regression- based daily peak load forecasting method for a whole year including holidays. To forecast load precisely throughout a year, different seasonal factors that affect load differently in different seasons are considered. In the winter season, average wind chill factor is added as an explanatory variable in addition to the explanatory variables used in the summer model. In transitional seasons such as spring and fall, the transformation technique is used. Finally for holidays, a holiday effect load is deducted from normal load to estimate the actual holiday load better.

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