Electric Load Forecasting in Smart Grid Environment and Classification of Methods

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ABSTRACT: A Review and Categorization of Electric Load Forecasting Techniques is Presented Smart Grid Environment and its impacts on grid loads, existing forecasting principals, Parametric methods and artificial intelligence based methods are discussed.

Keywords – Load forecasting, power quality, smart grid, neural networks, genetic algorithms, wavelet networks and fuzzy logics.

I. INTRODUCTION

Load forecasting is a central and integral process in planning and operating of electric utilities. It involves the accurate prediction of both the magnitudes and geographical locations of electric load over the different periodic usually hours of the planning horizon. The basic quantity of interest in load forecasting is typically the hourly total system load.

There are three types of load forecasts, short – term, medium term and long term, Long term forecasts are made for the period up to ten years or up to several decades and they help companies to plan their investments, plan and develop generation, transmission and distribution systems. It is made to, forecast electrical energy consumption and maximum loads in a grid so that companies could make economical based decisions of installing or replacing electrical equipment in a grid to make it capable of generate, transmit and distribute. Forecasted energy and provide and acceptable level of power quality and reliability of power supply. Smart technologies are being developing very actively, they allow increasing power quality and power supply reliability, reduce energy flows in a grid. There are several types of smart technologies, smart and efficient end use devices, distributed energy sources, advanced communication system and smart home systems. All these new technologies will effect on future energy consumption and maximum power. Some of smart technologies improve energy efficiency and increase savings, reduce peak load and load demand.

Most of existing forecasting principles use statistical forecasting of load growth and changes of load types for decision. We can only create different scenarios of their future implementation and evaluate how it could effect on energy consumption and future loads. We can use load models to calculate future electricity consumption and peak loads.

II. SMART GRID ENVIRONMENT AND IT'S IMPACTS ON GRID LOADS

Nowadays smart grid technologies are actively under research and they are planned to be actively used in the near future. There is a variety of technologies based on smart grid, smart end-use devices, distributed energy resources, highly advanced control and communication systems. All these technologies will influence on the future electricity load demand. Some of them improve energy efficiency; increase permanent energy savings, permanent demand reduction and temporary peak load reductions but some new electricity loads will appear in the future and they will increase electrical energy consumption.

There are four main types of smart grid technologies.

a) Smart distributed energy resources.
b) Advanced whole-building control systems.
c) Integrated communications architecture.

These technologies allow to create a highly energy – efficient and automated system, to optimize its operation based on utility's and consumer's requirements and constraints and other variables.

III. DESCRIPTIOJN OF EXISTING LOAD FORECASTING PRINCIPLES

Long term forecasting of electrical loads is the first step in planning and development of generation, transmission and distribution system. Based on the results of such forecasts, companies co-ordinate their resources to meet the forecasted demand. Long term load forests are made for a period up to several decades. They are very important in planning and help to make an economical based decision of buying and installing new equipment and facilities to meet the consumers future electric demand and to provide an acceptable level of power quality and reliability.

Methods used for long-term forecasting can be classified into two categories: Parametric methods and artificial intelligence based methods. Parametric load forecasting methods are based on statistical techniques and historical data of loads and factors affecting on loads. The parametric methods are described below: Trend analysis, end use modeling and economic modeling. The artificial intelligence methods are

classified into neural networks, genetic algorithms, wavelet networks and fuzzy logics methods.

IV. PARAMETRIC METHODS

As it was already said, parametric methods take into account historical data of loads, factors affecting on load demand and with the use of statistic make a long term forecast.

4.1 Trend analysis

Trend analysis focuses on information about changes in electricity demand in past and based on this information predict changes in electricity demand by extending past rates of electricity demand in to the future.

4.2 End use models

The end-use approach makes load forecasts based on the statistical information about customers along with dynamics of charge of loads. These models use extensive information on end users, for instance, customer size, size of houses and so on. End use models divide customers for several sections (Residential, commercial, and industrial) and they are based on the principle that electricity demand is derived from customer's demand for light, heating, cooling etc.

4.3 Econometric models:

The econometric approach estimates the relationship between energy consumption and factors influencing consumption by the least square method or time series methods. To forecast electricity demand it uses economic theory and statistical techniques.

In the econometric models the dependent variable, in our case it is a demand for electricity, is expressed as a function of various parameters such as population income per capita or value added or output, price of power, prices or alternative fuels, proxies for penetration of appliances/equipment etc.

Thus we have a formula for electricity demand.

ED = f (Y, Pi, Pj, POP, T).

Where,

ED is electricity demand,

Y is output or income.

Pi is own price

Pj is price related to fuels.

POP population and T is technology

The advantage of using econometric models in load forecasting is that a researched cannot only forecast an electricity demand, but also explain its behavior in the future, why is it increasing or not and what factors and how effect on it. A disadvantage of using econometric models in load forecasting is that during the forecasting period the changes in electricity remain the same as in the past in order to get an accurate forecast.

V. ARTIFICAL INTELLIGENCE METHODS

Nowadays artificial intelligence methods became very popular and these are also used in load forecasting. Some kinds of them are described in this section.

5.1 Artificial neural networks:

Methods based on artificial neural networks can solve various power system problems, such as design, planning, control protection, security analysis, fault diagnosis and load forecasting. Artificial neural networks are very popular in load forecasting because of their ability in mapping complex non-linear relationships.

In most cases ANN'S are used in short-term load forecasting, but they are also used in long term forecasting.

To design a neural network it is needed to choose its architecture, method of training and also type, size and number of used neural.

The output of ANN is

$$Yi = \sum_{i=1}^{n} WiXi$$

Where Xi - is input

Wi – weight of network

Yi – one of the outputs.

i = 1, 2 ……n

Types of ANN'S that can be used for long-term forecasting are recurrent neural network (for peak load forecasting) and feed forward back probation (to forecast annual peak load).

5.2 Wavelet Networks:

Wavelet theory received wide attention in electrical load forecasting. It has an improved forecasting accuracy comparing tradition load forecasting methods.

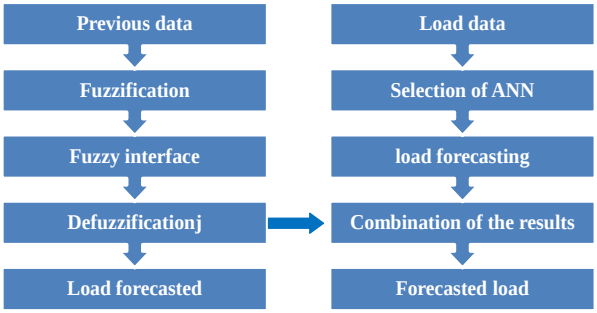
This theory provides powerful and flexible tool to decompose load data in to different frequency components, component and its characteristics

5.3 Genetic Algorithms:

Genetic algorithm (GA) is a numerical optimization technique. It is a very popular optimization tool and helps to solve problems in engineering, finance, economics science etc.

5.4 Fuzzy logic model:

Fuzzy control system is a decision mechanism represented by a set of fuzzy rules. The fuzzy logic model provides and algorithm to convert strategy based on expert knowledge into an automatic strategy.



A skilled human operator can be replaced with a fuzzy rule based system. Fuzzy logic models can be combined with neural network to train ANN. This combined system provides better load forecasting result. It combines advantages of both methods and generalization capability of artificial neural network and the ability of fuzzy logic model to use forecaster's knowledge and experience. This method gives quite accurate load forecasts.

Fig. 1. Schematic structure of ANN and fuzzy logic methods

VI. CONCLUSION

Thus, there are a lot of various long-term load forecasting methods existing. They are based on statistics, historical data, data on customers, expert knowledge and experience, artificial intelligence methods etc.

They all have advantages and disadvantages and for better forecasting result a combination of several methods can be used. In our case we need to forecast load behavior when new types of load coil appear and new technologies will be implemented. We can model behavior of different types of loads, different scenarios of existing equipment and technologies future usage load. We can also use trend analysis forest future usage

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