IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 7.047 ⋇ Vol. 10, Issue 2, February 2022

DOI: 10.17148/IJIREEICE.2022.10210

LOAD FORECASTING

Vishal V. Mehtre[1], Hritik Vilas Patil[2]

Assistant Professor, Department of Electrical Engineering, Bharati Vidyapeeth (Deemed to be University)

College of Engineering, Pune- 411043, Maharashtra, India[1]

Student of Department of Electrical Engineering, Bharati Vidyapeeth (Deemed to be University)

College of Engineering, Pune- 4011043, Maharashtra, India[2]

Abstract: Electricity businesses use load forecasting to predict how much power or energy they'll need to keep supply and demand balanced at all times. It is required for the proper operation of the electrical industry. Load forecasting uses previous data from the electrical system to predict future electric load. For the planning and operation of the utility, precise models for forecasting the electric power load are required. Load forecasting can also be used to support an electric utility's future system operations, such as load switching, demand-side management, and identifying and forecasting energy consumption patterns. It can be classed as short-term (a few hours), medium-term (a few weeks to a year), or long-term (a year or more) (over a year). An econometric technique is utilised for medium-and long-term forecasting. For short-term forecasting, techniques such as regression models, time series, neural networks, statistical learning algorithms, and fuzzy logic are utilised.

keywords: Load forecasting, regression models, time series, neural networks, ARIMA model, statistical learning algorithms and fuzzy logic.

INTRODUCTION TO LOAD FORECASTING

It is impossible to store electrical energy. When there is a demand for it, it must be produced. As a result, it is critical for electric power companies to predict the demand on their systems ahead of time. Load forecasting is the term for estimating load ahead of time. It is required for the planning of power systems. The first step in power system expansion planning is to forecast future load requirements. Unbundling the power system is becoming increasingly popular. As a result, the various sectors of the business (generation, transmission, and distribution) are constantly confronted with rising demands on network design, administration, and operations. A suitable model for electric power demand forecasting is required for the operation and planning of a power utility company. Load forecasting assists a utility in making decisions about generating and purchasing electricity, load switching, voltage control, network reconfiguration, and infrastructure development. The practise of projecting future electric load using historical load and weather data as well as present and predicted weather data is known as electric load forecasting. Several models have been developed in recent decades to more correctly anticipate electric load. With the deregulation of the power industry, the participants in the energy market have faced a slew of new obstacles. Wind power, electric loads, and energy price forecasting have all become key issues in power systems. Various methodologies are used to anticipate wind power, energy price, and electricity demand based on market needs. Due to the severe volatility of power prices, the market risk associated with trading is significant. Price projections are employed by market players in their operation planning activities due to the uncertain nature of future prices in competitive electricity markets. Furthermore, ensuring the safe operation of the power system in the future necessitates research into its behaviour under a number of contingency scenarios. Demand prediction is a critical component of any model for electricity planning, particularly in today's changing power system structure. The nature of the demand is determined by the level of planning and precision necessary. The goal of this study is to give a quick overview of major power system forecasting difficulties and solutions.

LOAD FORECASTING CLASSIFICATIONS

The different ways of classification and prediction of electrical load forecasting based on the input information and future horizons are Very Short-Term Load Forecasting (VSTLF), Short-Term Load Forecasting (STLF), Medium Term Load Forecasting (MTLF) and Long-Term Load Forecasting (LTLF).

1. Short term load forecasting:

This form of predicting usually has a period of one hour to one week. It can assist us in estimating load flow and making decisions that prevent overloading. Short-term forecasting is utilised to give required information for daily operations and unit commitment in the system.

DOI: 10.17148/IJIREEICE.2022.10210

2. Medium term load forecasting:

This forecasting method has its period ranging from one week to one year. The forecasts for different time horizons are important for different operations within a utility company. Medium term forecasting is used for the purpose of scheduling fuel supplies and unit management.

3. Long term load forecasting:

This forecasting method has its period which is longer than a year. It is used to supply electric utility company management with précised prediction of future needs for expansion, equipment purchases or staff hiring.

LOAD FORECASTING METHODOLOGIES

Load forecasting methods can be classified in terms of their mathematical degree of analysis. There are two elementary types, **quantitative and qualitative methods**. The qualitative forecasting methods are mostly used for an accurate forecast by planners. Under this category, the load forecasting techniques may be classified into three foremost groups are **Traditional technique**, **Modified-Traditional Technique**, and **Soft-Computing Technique**.

Traditional Forecasting: Traditional Forecasting is one of the imperative topics to determine future load demands for the development of the infrastructure, development trends and development catalogue of the country etc. In the initial period, these estimates were done using traditional/conventional mathematical techniques. With the invention of progressive tools, these techniques have been improved for adopting several fields of forecasting studies. The classification of this technique are **Regression Method**, **Multiple Regression Method**, and **Exponential Smoothing Method.**

a. Regression method is one of the widely used statistical techniques and it is easy to use. The regression methods are used to model the connection between load consumption and other influences like weather conditions, day types and customer classes. This system assumes that the load can be separated between standard load trends and a load trend linearly reliant on some factors.

b. Multiple Regression methods are the most widespread method and are used to forecast the load under a number of influences like meteorological effects, per capita growth, electricity prices, economic growth etc. The technique used in multiple regression analysis is the least-square estimation. A least-squares approach is used to classify and enumerate the different types of loads on power lines and substations.

c. Exponential smoothing used for load forecasting is one of the alternative approaches. In this technique, first, the load model built on historical data, then to utilize this model to predict the upcoming load

2. Modified Traditional Techniques: The traditional forecasting techniques are improved so that the auto-update in constraints of forecasting model depending on varying environmental conditions. Some of the improved forms of traditional techniques are **adaptive load forecasting, time series** and **support vector machine-based techniques.**

a. Adaptive Load Forecasting: The changing load situations which automatically corrects the Adaptive Demand Forecasting model parameters. The state vector is projected by means of current prediction error and the current weather data acquisition programs. The state vector is resolute by total past data set analysis. This approach has distinctive features: The handling cyclic patterns use autocorrelation optimization & in insertion to update model parameters, the order, and structure of the time series will adapt to new circumstances.

b. Time series methods are built on the hypothesis based on the data internal structure, such as autocorrelation, trend, or seasonal variation. Time series have been used in the areas of economics, digital signal processing, and electric load forecasting. In specific, **ARMA** (autoregressive moving average), **ARIMA** (autoregressive integrated moving average), **ARMAX** (autoregressive moving average with exogenous variables), and **ARIMAX** (autoregressive integrated moving average with exogenous variables) are the most frequently used standard time series methods.

c. Support Vector Machine (SVM) technique is a prevailing machine learning method based on statistical learning theory (SLT), used for classification and regression analysis by analysis of data and recognizes patterns. In mid-term load forecasting, the temperature and other climate evidence are not much used and the introduction of time-series forecasting may advance the results.

DOI: 10.17148/IJIREEICE.2022.10210

3. Soft-Computing Techniques: Soft-computing technique has transpired to impact efficiently. It has been used extensively over the last few years. Soft-computing is a transpired approach which corresponds to the exceptional capability of the human mind to learn and reason in an environment of unpredictable and inaccuracy. It is developing as a tool to aid computer-based intelligent systems replicating the capability of the human mind to utilize modes of reasoning that are inexact rather than precise. Soft computing forms an assortment of order which includes **fuzzy logic (FL)**, **neural networks (NNs)**, **evolutionary algorithms (EAs)** etc.

a. Fuzzy logic is a simplification of the Boolean logic used for digital circuit design. An input under Boolean logic takes on a truth value of “0” or “1”, and an input has a relationship with

a definite qualitative range. For example, a transformer load may be “low”, “medium” and “high”. Fuzzy logic enables one to logically conclude outputs from fuzzy inputs. In this intellect, fuzzy logic is one of the techniques for mapping inputs to outputs. After the logical processing of fuzzy inputs, a “defuzzification” process can be used to yield such exact outputs.

b. **Neural Network (NN) or Artificial Neural Networks (ANN)** have an extensive application because of their capability to learn. There are several sorts of neural networks: multilayer perceptron network, self-organizing network, etc. There are multiple hidden layers in the network. In each hidden layer, there are many neurons. The forecasting and its benefit to traditional methods by ANN based on back-progression are proved. Recurrent NN uses the intrinsic non-linear dynamic nature of Neural Network (NN) to signify the load as the output of some dynamic system, affected by weather, time and environmental variables.

FACTORS CONSIDERED FOR LOAD FORECASTING

Load forecasting is done using a variety of elements that influence the load, such as social, economic, environmental, and temporal. As a result, no single approach of estimating load can be applied to all types of utilities. Because there are distinct classes of consumers and different load consumption patterns, the projection is also based on electrical loads. When there is an extra stress on the system owing to socio-economic variables such as a large event, sports tournaments, or religious festivals, the utilisation pattern may change. Furthermore, the ever-present component that determines the volatility in load curves at the consumer's end will be different on weekdays than on weekends. Regardless of whether it is a section of the weekdays or the weekend, a different pattern is observed during holidays; this is also an important component to consider when furcating the load in order to gain more dependable and precise data in order to forecast future demands. Weather is another significant metric that describes the state of meteorological components such as temperature, humidity, wind, and rainfall, as well as how they change over time in a given place. Climate is defined as the average weather conditions over a specific time period in a specific location. Among all the other meteorological elements, temperature and humidity have a significant impact on energy use. The inclusion of temperature and humidity limitations can improve the accuracy of anticipated load values because they have a large impact on energy generation and transmission. A utility is continually on the lookout for different types of customers and, as a result, different load consumption patterns. An industrial consumer, for example, consumes more energy in the morning, but a residential consumer consumes more energy in the evening. The important factors that should be taken into consideration for of electricity load forecasting can be classified as follows:

- Meteorological Factors: Weather, climate, Temperature, humidity, solar radiation etc.
- Temporal or Calendar factors: Hours of day, days of week, and timings of year etc.
- Economy Factors: Industrial development GDP, etc.
- Random Factors: Sports Activities, Festival etc.
- Customer Factors: Type of consumption, Size of building, Electric appliances, Number of employees etc.

FACTORS AFFECTING LOAD FORECASTING

A. Meteorological Factors:

Minimum and peak temperatures, humidity, rain and snowfall, wind speed, cloud covering is responsible for affecting load forecasting. Some of them are interrelated e.g., temperature is correlated to cloud cover, rain and humidity level. G. Zheng et. al. [5] proposed a model which correlates meteorological factors with load utilizing grey model. Some of the important factors are:

• <u>Climate</u>: It is defined as the average weather over a definite period in a particular area. It may be different for different demographic areas e.g., at high and low latitude, near and far from sea etc. Climate also depends on time:

© IJIREEICE This work is licensed under a Creative Commons Attribution 4.0 International License

DOI: 10.17148/IJIREEICE.2022.10210

seasonality, annually and on decades. This area is attracting researchers as the climate change also effect the load consumption. This factor is important for long term forecasting.

• Weather factors: It is defined as the atmosphere that may exist in a single place for a brief length of time. Weather prediction is difficult due to its fluctuating nature, even over short periods of time. The most commonly used sorts of factors for load forecasting are weather conditions. For short-term load forecasting, the weather component must be taken into account. It has an impact on home and agricultural customers' electricity usage. Variations in weather have an impact on the customer's need for comfort and, as a result, on the use of heaters, geysers, and cooling appliances. To reduce operational costs, load forecasting algorithms must take into account weather and other factors when predicting future load. The weather factors include the following:

o Temperature o Wind speed o Cloud cover o Humidity

B. Temporal and Calendar Factors:

Calendar effects are defined as the influence of calendar variation of the same month or quarter between different years. In a daily load pattern, it can be easily observed that the higher load consumption periods are at definite timings. In different seasons load consumptions are different between summer and winter (due to different start and end timings of day and nights, increased timings of day or nights), weekends compare to weekdays, timings of year leading to festival such as Diwali, New Year etc. Generally, calendar factors are classified as:

• Working days: There are significant variations in usage of electricity working days and holidays. The load pattern is different for different days. For example, Tuesday to Thursday load consumption is similar but on Mondays and Fridays has sudden variation due to adjacent weekend holidays.

• Moving holiday effects: Moving holidays such as Holi, Diwali, Dussehra, Eid, Raksha Bandhan in India may occur in different weeks or months and might affect the load forecast as on these holidays industrial activities will be minimum.

Time factor: Depending on human and economic activity, the electric load changes throughout time. During the day, there are more loads, and at night, there are less. Season of the year, weekend or weekdays, or hours of the day are all possible time factors. Holidays are difficult to predict since their occurrence is not tied to a specific month of the year. The daily load pattern depicts the everyday activities of a human life style, such as working hours, leisure time, and rest time. There are some distinct patterns of load changes throughout time. Weekend and holiday loads are lower than weekday loads due to lower activity and work in industries and offices. The load variation with time reflects the arrangement of people's daily life: working time, leisure time and sleeping time. There are some rules of load variation with time. The weekend or holiday load is lower than the week day, due to decrease of working load in industry and offices. The cyclic time dependency leads to analysing the load; on hour of day basis, day of week basis and time of year basis explained below:

• Hour indicator: This indicates that usage of electricity is varying time to time in a day. Figure 1 shows a load pattern for a typical day which explains how load is varied with time. Maximum load consumptions are around 10:00 am and 6 pm.

• Day indicator: This indicates that the usage of electricity varies in a week. From Fig. 2 it is observed that load consumption in week days is quite high in comparison to weekends.

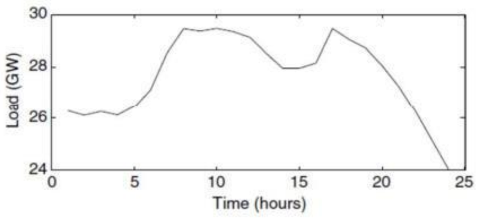

Fig.1 Load variations during a day

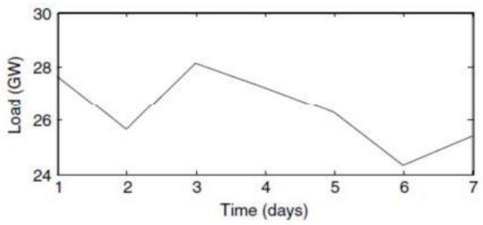

Fig. 2 Load variations during a week

 This work is licensed under a Creative Commons Attribution 4.0 International License

DOI: 10.17148/IJIREEICE.2022.10210

C. Economy Factors:

The process or system by which products or services are created, sold, or purchased in an area or country is referred to as the economy. It also has a significant influence on load forecasts. Economic considerations such as industrial development, power cost, and so on influence the load pattern. Economic considerations have a big impact on long-term load forecasting, but it's also vital for short-term forecasting. For example, the daily load curves of developed and developing countries differ in that developed countries' maximum consumption occurs between 11:00 a.m. and 4:00 a.m., whereas impoverished countries' maximum consumption occurs between 6:00 p.m. and 9:00 p.m. As a result, the economic status and industrial development of a country are also essential factors in load forecasting. The cost of electricity and the consumer's financial situation have an impact on load usage. That is, if power is expensive, domestic customers will use less of it. Electricity rates are lower at night in various parts of the country than during the day. As a result, domestic customers try to use appliances more at night to save money, and time-of-use pricing can encourage consumers to change their load. In long-term forecasting, economic issues take precedence over weather ones. In terms of functional and impact relationships, Jia et al. explained the effect of several parameters on long- and medium-term load forecasting [3]. The major is selected as follows:

- Economic trends: (Recession or Expansion)
- GDP (Gross Domestic Product): It indicates the size of economic activity and economic conditions. Economic growth and its impact on living standard is the primary impetus to stimulate the power demand.
- GNP (Gross National Product): It indicates a measure of size of nation’s economy. Also, it has been used as an indicator of economic trend.
- Population of households: Household are taken into consideration because existence of households means existence of appliances like vacuum cleaner and washing machines etc.
- Petroleum price: Petroleum oil price play a significant role as variation in petroleum price will vary the cost of electricity generation and hence price of electricity, which finally influence on vary the cost of electricity generation and hence price of electricity, which finally influence on load curve.
- Population growth: High growth rate of population will increase the power consumption. Therefore, there must be a positive correlation between population growth and power consumption.
- Number of hot days: The temperature is an effective factor of load consumption. In the summer people uses air conditioners and coolers, which may cause a raise in power consumption. As the temperature increases the load increases. Hence number of hot days is also an important factor.
- Number of cool days: For the cold days load consumption increases as the usage of heating appliances increases. The number of cool days is an also important factor for load forecasting.
- Industry development: Industrial development in a particular area will also increase the power consumption.
- Electricity price: This is also an important factor that affects the load. The amount of useless electricity consumption increases when the electricity becomes cheaper. Load curve.

Lingli et al. [4] studied load forecasting from the perspective of regional economic environment, build a complete set of indicators of regional economic environment, and assess the economic situation.

D. Random Factors:

Numerous consumers make up the electrical system. Large industrial loads, such as steel mills, and agricultural loads can cause load consumption to fluctuate or spike. Random variables are the causes of these rapid changes and spikes. Special events, such as religious or cultural festivals, are also taken into account when forecasting load. Despite this, random factors such as TV shows, industrial shutdowns, sporting events, and the wedding season rush have an impact on long-term load predictions.

E. Customer Factors:

Electric utility businesses serve a variety of consumers, including residential, commercial, and agricultural. For different customer classes, the load shape may be varied. The number, kind, and size of the customer's electrical equipment are the most important consumer determinants for power usage. While electrical equipment and installations differ from one client to the next. Customers can be classified into groups based on their characteristics. The load curve for residential consumers differs from that of commercial and industrial clients.

F. Other Factors:

In different geographical area the load curve could be different i.e., load consumption of rural areas will be different from urban. The load shape may be also depending on the class of consumers.
Varying factors may have different effects on the load, and the same factors may have different effects on different loads. Other model components generate greater effects, while the effect of others generates less, and some factors may even

DOI: 10.17148/IJIREEICE.2022.10210

have a negative impact on the model. The model structure will obviously grow quite complex if they are chosen as dependent variables. In fact, some factors have relatively minor effects on load. When these elements are removed, not only does the model become simpler and easier to use, but those factors that have a substantial impact on the load are also identified. The elimination approach is used to assess the importance of related or contributory elements to the load. Only examine those components that are significant to electrical load growth when the model is constructed, based on the relevance of removing the less influential factors. To simplify the prediction model and enhance prediction accuracy, the input variables are optimised using the elimination approach.[3]

ADVANTAGES AND DISADVANTAGES

Advantages:

1) It enables the utility company to plan well since they have an understanding of the future consumption or load demand.
2) Useful to determine the required resources such as fuels required to operate the generating plants as well as other resources that are required to ensure uninterrupted and yet economical generation and distribution of the power to the consumers. This is important for all short-, medium-, and long-term planning.
3) Planning the future in terms of the size, location and type of the future generating plant are the factors which are determined by the help of load forecasting.
4) Provides maximum utilization of power generating plants. The forecasting avoids under generation or over generation. [1]

Disadvantages:

1) It is not possible to forecast the future with accuracy. The qualitative nature of forecasting, a business can come up with different scenarios depending upon the interpretation of the data.
2) Organizations should never rely 100 percent on any forecasting method. However, an organization can effectively use forecasting with other tools of analysis to give the organization the best possible information about the future.
3) Making a decision based on a bad forecast can result in financial ruin for the organization, so the decisions of an organization should never base solely on a forecast. [1]

CONCLUSION

In this paper I have reviewed some statistical and artificial intelligence techniques that are used for electric load forecasting. Have also discussed basics and factors that affect the accuracy of the forecasts. Different techniques applied to load forecasting. It can be inferred that demand forecasting techniques based on soft computing methods are gaining major advantages for their effectual use. There is also a clear move towards hybrid methods, which combine two or more of these techniques. The research has been shifting and replacing old approaches with newer and more efficient ones.
The load forecasting is predictions of future demand based on various factors. These factors play an important role in developing the model for load forecasting. The various factors which affect the forecasting include historical information of load pattern, weather, air temperature, wind speed, calendar seasonal information, economical events and geographically information.
For short-term forecasting, the electric load is highly correlated with meteorological factors such as: temperature, humidity, and wind speed, rain and snowfall, cloud cover. The change in holidays, week days, weekends, the day before and after holidays also affects the load forecast.
For medium term load forecasting, the main affecting factors are meteorological and casual. The effect of economic factors is not of much importance due to the short time horizon for the economics effects to be felt.
For long-term forecasting, the electric load is correlated with econometric factors and meteorological factors such as climate. Amount of previous load, social and economic growth also effects the load forecast directly where as there is an inverse relation between electricity price and consumption.

REFERENCES

[1] Introduction to Load Forecasting: Tahreem Anwar, Bhaskar Sharma, Koushik Chakraborty and Himanshu Sirohia, Jayoti Vidyapeeth Women's University, Jaipur.
[2] Short-Term Load Forecasting of 400kV Grid Substation Using R-Tool and Study of Influence of Ambient Temperature on the Forecasted Load: Lekshmi. M, Associate Professor, E&EE Dept.: & Adithya Subramanya K. N, MTech Electrical Power System student, E&EE Dept.:Acharya Institute of Technology, Bengaluru, Karnataka

DOI: 10.17148/IJIREEICE.2022.10210

[3] Effects of Various Factors on Electric Load Forecasting: An Overview Shahida Khatoon, Ibraheem, Arunesh Kr. Singh, Priti; Department of Electrical Engineering, Jamia Miilia Islamia , New Delhi, India

[4] S. Lingli, D. Changhong, X. Qiushi, and Z. Chu, "Load forecasting considering the regional economic environment," Proceedings of International Conference on Automatic Control and Artificial Intelligence (ACAI 2012), IEEE, pp.1310-1314, March 2012.

[5] G. Zheng, S Chen, and S. Fan, "A Power Load Forecasting Method Based on Matching Coefficient of Meteorological Factors and Similar Load Modification," Proceedings of 4th International Conference on Intelligent Human-Machine Systems and Cybernetics (IHMSC), vol.1, pp. 216-219, Aug. 2012.