International Journal of Scientific & Engineering Research, Volume 6, Issue 1, %ÌÉÜÜÈÙà-2015
ISSN 2229-5518

Statistical Load Modelling of Residential Load: A Case Study

V. Aundhekar
Dept. of Electrical Engineering
Govt. College of Engineering,
Aurangabad (M.S.), India.
vasudhaaundhekar@gmail.com

Dr. A. G. Thosar,
Associate Professor,
Head of Electrical Engg. Department,
Govt. College of Engineering,
Aurangabad (M.S.), India.
aprevankar@gmail.com

Samruddhi Shaha
Dept. of Electrical Engineering
Govt. College of Engineering,
Aurangabad (M.S.), India.
samruddhi.shaha@gmail.com,

Abstract— Electricity is one of the most important and basic needs of today's community, so the Demand Side Management (DSM) and load modelling is very important. To meet the demand, mission of the electric power utilities is to service the customer's needs of electric energy at optimal costs. Short and medium term load forecasting plays important role in minimizing peak demand and bring immediate benefit to utilities and customers. This paper presents statistical load modelling of residential load and impact of metrological parameters on electrical load. Regression analysis is used to predict the load by using the weather parameters specially temperature and humidity.

Index Terms— Demand side management, load forecasting, load modelling, weather parameters, multiple regression.

1 Introduction

ELECTRICITY is one of the most important and basic of today's community. India is a developing country, experienced significant increase in electricity demand .The gap between demand and supply is continuously widening and to meet this gap demand is very difficult. This gap is widening at the rate of 3% day by day. Apart from minimizing this gap, the mission of the electric power utilities is to service the customer's needs of electric energy at optimal costs. The load data is needed for defining the requirements of the network's transmission capacity, approximating the transmission losses or estimating the existing network's capability to transfer increasing loads. The effective solution to this problem is DSM strategies that lower down the peak demand and bring immediate benefit to utilities and customers. Changing electricity markets in the developing and the developed countries face several challenges, largely due to the uncertainties in the load growth, higher investments required in capacity addition, declining fuel sources and its associated environmental costs. For accurate planning of the electricity market, it is important to have load forecasts that are as accurate as possible. A dependency exists of the electricity demand levels on weather conditions, and as a result it is important to model this dependency on a load category basis. The weather parameters such as humidity, temperature, sunshine, and wind-pressure badly affects on residential as well as commercial load.

Temperature, humidity, sunshine and wind-pressure are the main factors of weather on which sub-factors like rainfall, sky cover are dependent. These weather dependent load models can be broadly classified into four categories. Regression model, time series model, Neural network model and hybrid models which combine neural network models with fuzzy logic. The forecasting model in this study is regression based. An attempt is made to model the load of residential area showing the significant influence on the consumers is identified using correlation coefficient.

Load forecasting is vitally important for the electric industry in the regulated economy. It has many applications including energy purchasing and generation, load switching, contract evaluation, and infrastructure development.

The short-term load is nonlinear, and the change of it is influenced by various factors. In a system with large geographical area, the load characteristics and weather conditions are usually diverse in different districts. Especially, when there is a significant climate change, like a cold or warm front approaching, the load pattern in a certain region may significantly differ from its neighboring region. Under such a situation, it is hard to accurately predict the overall electricity demand of the whole region by using a single forecasting model. The method of forecasting the heat sensitive portion of electrical demand and energy utilizing a summer weather load model and taking into account probability variation of weather factors. The heat sensitive portion of the load is separated from base load and historical data is used to determine the effect of weather on the system load. The method has been determined primarily for forecasting demands and energy. However, it is applicable for monthly and annual peak forecasting, but probably not applicable for short terms such as hour to hour or day to day forecast. Energy is affected by weather conditions over a period of time. A specially defined unit of cooling degree day was developed in this analysis together with a weather load model that gave good correlation to the area studied when properly applied. It was observed that the max temperature on the day of the peak and 2 or 3 days prior to the peak gave the best correlation.

International Journal of Scientific & Engineering Research, Volume 6, Issue l0%ÌÉÙÜÈÙà-2015
ISSN 2229-5518

2 Description of System Under Study

System load depends primarily upon weather characteristics of the distribution area. Residential load mainly includes home appliances, illumination load and electronic equipments which are used for comfort living. So this load is varies along with season and weather condition. Figure 1 shows single line diagram of 33 kV substation with details of feeder connected to it. 33 kV Distribution substation is situated in Center place of Aurangabad and operated by state electricity utility. There are five numbers of 11 KV distribution feeders out of which the feeder under study is 11 KV Chetana feeding 6335 consumers. (90% consumers are residential and middle class). Maharashtra State Electricity Distribution Company Limited (MSEDCL) is the utility which supplies the electricity in Aurangabad area & there are 22 numbers of 33KV Sub-stations in Corporation area. Aurangabad being historical & industry base city, is emerging as fastest developing city in India. Hence each Substation is connected in ring mains system & fed with double supply in view of reliability. 33 KV sub-station under consideration i.e. Pannalal Nagar Substation is located at central location & its feeders cover a large geographical area. There are total five 11 KV outgoing feeders from 33 kV substation, out of which one water works feeder is non sheddable. In this paper the 11 kV Chetana Nagar, feeder is considered which runs total 6335 consumers out of these 5747 are residential and remaining 588 are commercial consumers.

During winter season fans, air conditioners are not required but the heating equipments such as heater is important. Where as in summer days the air conditioner is important equipment for the consumers. Normally these models are used in developed countries or in metro cities like Delhi. This paper attempts to model a load by using statistical techniques, considering one year whether and load data. The study is held for Jawahar Colony area of Aurangabad. The weather data is provided by WATER AND LAND MANAGEMENT INSTITUTE, AURANGABAD. The parameters are temperature (Max, Min), Humidity, Wind Speed (Km/hr), Sunshine rainfall (mm) were provided by this institute from May 2009 to April 2010

3 Correlation between Electrical Load and Weather

Generally, the meteorological variables such as temperature, humidity and wind pressure, etc. are driving variables to the electricity consumption. Usually, energy demand varies because of events such as urgent maintenance of substation, contingencies and power shortage events, etc. As well as some other factors such as festivals, wedding seasons are also affecting on the residential load. The impact of weather on load characteristic is studied. The monthly electricity load data of distribution feeder with its all consumers are considered and weather data observed at the corresponding local stations have been used for the study. The weather data is obtained in the all seasons with real time values for load forecasting. The period under study is May 1, 2009 to April 30, 2010.

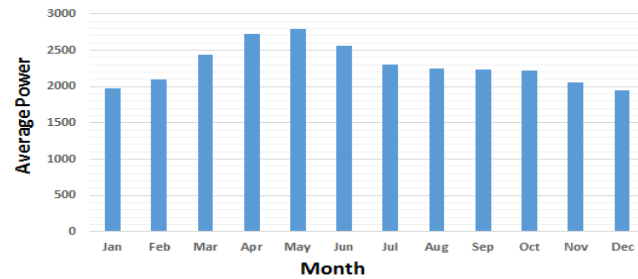

Figure 2: Average power wrt. Month

From the above graph it is observed that the power consumption is highest i.e. 2790KW in May and lowest is 1944KW for December month. There is not any typical pattern observed for whole year. Hence the load forecasting with weather parameters is non-trivial problem.

The table 1 shows the correlation coefficient between various weather parameters for every month

Table 1: Correlation coefficient between various weather parameters

Month	Temp-power	Humidity-power	Sunshine-power	Wind pressure-power	Average Power
Jan	-0.355	0.094	0.292	0.439	1977
Feb	0.757	-0.259	0.162	0.132	2097
March	0.023	0.044	0.014	-0.209	2445
April	0.425	-0.011	0.055	0.250	2730
May	0.205	0.046	0.197	0.042	2790
June	0.107	-0.078	0.244	0.347	2565
July	-0.003	-0.194	-0.153	-0.279	2302
August	0.212	-0.008	-0.007	0.213	2246
Sept	0.226	0.011	0.337	-0.177	2228
Oct	-0.035	0.662	-0.610	-0.344	2217
Nov	-0.408	0.197	-0.196	-0.042	2059
Dec	0.105	0.080	0.001	-0.084	1944

Table 1 gives correlation between power and metrological parameters. It is observed that the coefficient of temperature is positive for the month having power consumption greater than average power. Almost all metrological parameters shows 7 times positive correlation with power and 5 times negative correlation except wind pressure. In month October, November humidity is having significant influence on power consumption. It is observed

International Journal of Scientific & Engineering Research, Volume 6, Issue lÍ%ÌÉÙÜÈÙà-2015
ISSN 2229-5518

that correlation for all metrological parameters are negative in July month. For the month May the correlation between all the weather parameters are positive. The power-temperature correlation is more positive as compared to other metrological parameters, so temperature is the significant parameter. Due to all metrological parameters are positive the power for month May has maximum positive value. Temperature was consistently found to be the dominant factor compared with the other weather parameters, especially for residential load. The average of Humidity-power correlation is nearly equal in positive and negative manner. In monsoon months correlation coefficients are negatively related with power. The reason behind that is when humidity increases rain starts which reduces the demand. When weather parameters have negative coefficient then it shows that the system draws less power. So the humidity is also very important factor. Therefore, the focus is on the temperature-power and humidity-power characteristics in this paper.

Sunshine is equally correlated with power for negative and positive ways in winter. In India sunshine i**s** available averagely for 8-9 hrs except in rainy season. In winter, availability of sunshine is lesser. Hence sunshine affects on load especially in winter season as in regards of temperature i.e. due to more sunshine, temperature is more.

4 Regression Analysis

To establish mathematical relation between power and metrological parameter the regression analysis is carried out. Actual power and estimated power from regression equation is plotted with corresponding temperature, humidity for whole year. Simple regression is applied for whole year considering only temperature.

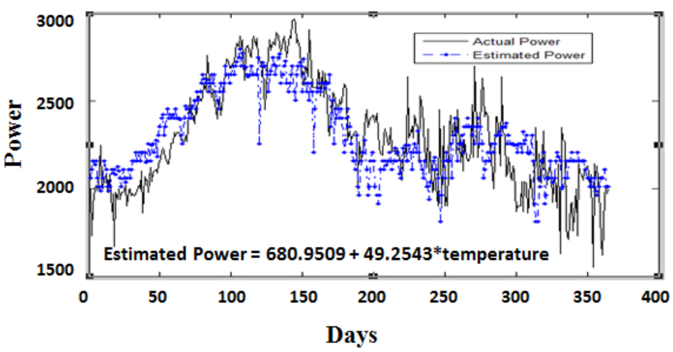

Figure3: Temperature-power curve 365 days

Above figure shows that the actual power and estimated power separately. By using simple regression the difference between actual and estimated power is calculated for minimum power which is 264 kW. The mean error is zero for simple regression. The equation which is obtained is,

$$P = 680.9509 + 49.2543 * temperature$$

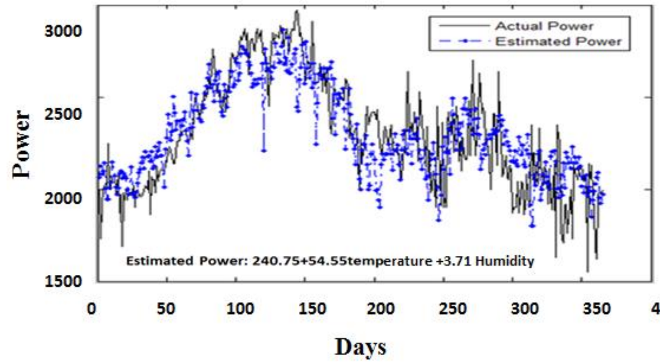

Figure4: Temperature-humidity-power curve 365 days

The humidity is also significant parameter which affects the power. In multiple regression temperature and humidity are considered and power is calculated. The difference between actual and estimated power is calculated for minimum power which is 250 kW. The mean error is zero for multiple regression. The equation which is obtained is,

$$P = 240.75 + 54.55 * temp + 3.71 * humidity$$

It is observed that considering two variable temperature and humidity the error between estimated and actual power is minimized. The error between estimated and actual power can be further minimized by adding cost on term for the uncertainties such as festivals, power outages. . It is observed that the error between estimated and actual power is prominent during the change of climatic condition.

5 Conclusion

Load forecasting is vitally important for decisions lead to the improvement of network reliability and to the reduced occurrences of equipment failures and blackouts. In the power system under consideration i.e. 11 kV Chetana Nagar feeder, 90 % of consumers are residential consumers. Hence here is comparatively more impact of weather conditions as compared to all other type of consumersSuch type of studies helps to predict load for planning. To reduce the demand-supply gap and to keep the optimal cost to give benefit to consumers. Weather parameters like temperature, humidity are related to the daily electric load demand. The comparison graph for total 365 days actual power with estimated power obtained from simple and multiple regression is calculated. The estimated power gives more accurate results when the number of weather parameters increases and multiple regression is applied. Regression analysis is beneficial for Demand Side Management (DSM). Load consumption pattern is different and varies from time to time, area to area. By using regression analysis short term load forecasting is possible. Further the study can be improved by modelling the issies like climate change and uncertainties.

International Journal of Scientific & Engineering Research Volume 6, Issue 1, January-2015
ISSN 2229-5518

REFERENCES

[1] Chen Genyong, Shi Jingtian *"Study on the Methodology of Short-Term Load Forecasting Considering the Accumulation Effect of Temperature"*

[2] S. Fan, K. Methaprayoon, and W. J. Lee, *"Short-term Multi-Region Load Forecasting Based on Weather and Load Diversity Analysis" 39th North American Power Symposium (NAPS 2007)*

[3] Area S. Fan, K. Methaprayoon and W. J. Lee, *"Multi-Area Load Forecasting for System with Large Geographical", IEEE transaction*

[4] K. Neil Stanton and Pradeep C. Gupta, *"Forecasting Annual or Seasonal Peak Demand in Electric Utility Systems"* Vol PAS-89, NO. 5/6, MAY/JUNE 1970

[5] C. E. Asbury, *"Weather Load Model For Electric Demand and Energy Forecasting"*, IEEE Transactions on Power Apparatus and Systems", vol. PAS-94, no. 4, July/August 1975

[6] Sami El-Fdrik and Roland P. Malhamd, *"Identification of Alternating Renewal Electric Load Models from Energy Measurements"*, IEEE Transactions On Automatic Control, Vol. 39, NO. 6. JUNE 1994.

[7] J. H. Park Y. M. Park, Member K. Y. Lee, "*Composite Modeling For Adaptive Short-Term Load Forecasting", IEEE transactions Power Systems 01.6, NO. 2,*

[8] H. Shakouri G., R. Nadimi,*"Investigation on the short-term variations of Electricity Demand due to the Climate Changes via a Hybrid TSK-FR Model"* 2007 IEEE