TELKOMNIKA Indonesian Journal of Electrical Engineering
Vol. 12, No. 8, August 2014, pp. 5963 ~ 5968
DOI: 10.11591/telkomnika.v12i8.6068

Peak Load Chopping Applying Fuzzy Bayesian Technique for Regional Load Management-Performance Evaluation

Arindam Kumar Sil[1]*, N. K. Deb[1], Ashok Kumar Maitra[2]
[1]Department of Electrical Engineering, Jadavpur University, Kolkata, India
[2]Department of Electrical Engineering, Bengal Engineering and Science University, Shibpur Howrah, India
*Corresponding author, e-mail: ak_sil@yahoo.co.in

Abstract

In this paper Fuzzy Bayesian Synthetic algorithm based methodology has been evaluated for its performance using real time data for chopping off peak load demand. The paper deals with the number of conditions that are to be considered for the chopping of peak demand and there after evaluating the proposed method by using real time data from load dispatch centers for predicting a new peak demand pertaining to chopping of the peak demand on for a given day. This is achieved by judiciously scheduling load from the regional load under a new load management technique. This technique validates the timely decision making capacity of the system to reduce peak demand hence giving us a chance to reduce the peak demand and hence reduce the stress of generating excess power during the peak period. This method uses data of a previous day and then predicts for the next day. Thus by evaluating this process it was found that the new peak demand has a reduced value as compared to the actual peak demand. It is evident that this method can not only reduce peak demand by chopping of the regional loads by following the proposed algorithm but also helps in generating indirect revenue by saving energy. This method authenticates the proposed method and saves peak demand or otherwise energy by about ten to fifty megawatts on daily basis depending on the service condition of the network and solar day light hour availability over span of a day.

Keywords: *energy management, peak load, regional load, fuzzy Bayesian technique*

1. Introduction

This paper deals with the proposed process of chopping of peak demand using an artificial intelligent technique based on mathematical modeling drawn from fuzzy Bayesian technique. The technique evaluates the process on scoring of points by different regions or places under consideration for sharing of power for peak power reduction. The proposed method considers peak power demands of different states or regions in India for their power sharing and followed by a judicious method of load management by shedding of load on priority basis. The priority is set by the fuzzy basiean technique which comprehends the both present power patterns and other aspects to be kept in consideration for such load management as well as power sharing. The present technique as a methodology has been termed as DLS technique. DLS – Day Light Saving technique is what we call in our process. In this process the solar daylight hour for a given region is first evaluated. The process of finding solar day light hour is calculated by formulas which are already mentioned in our earlier research paper [1]. Then on the basis of availability of sun ray, the regions with maximum peak demand is considered first which is then compared with areas of lesser peak power demand. Since these places under consideration are separated by quite a lot positional distance calculated by their latitude and longitude therefore separation by distance is equated to time.

The Indian standard time is fixed all over the country, but due to changing solar position, the local span of a day varies, therefore as the solar position doesn't remain same so when we move from far east to far west throughout the stretch of the country it is found that the load pattern does also varies with the local sunrise to sun set timing. Hence using this time difference between places in Far East to west we have made a proposal to shift or shed loads by a priority evaluation method based on fuzzy basiean technique, such that certain loads can be reduced from the grid reducing some demand directly [2]. Thus to do this and achieve a

Received April 7, 2014; Revised May 25, 2014; Accepted June 14, 2014

considerable amount of result we proposed a technique called fuzzy basiean technique which after indentifying the loads which can be shed off the demand and which are calculated by the proposed algorithm which has a particular scoring pattern and finally evaluates out which particular load can be shed out and which should be given power. Thus after reducing the demand the equivalent amount of power so generated out of load shedding by this algorithm, and judicious load management, power can be send across from one demand area to another or otherwise can be shared among utilities with higher peak demand [3].

As we all know that the federal agencies in India have proposed an ambitious scheme “power for all by 2012”. Thus to keep in pace with the rapid industrialization and development it is evident that a new robust energy management technique has to be developed so as to cater the need of the time. In particular it is felt that a fast, time saving and accurate method would be able to help tackle the crisis situation of energy need. Therefore a new renewable energy management technique was necessary to be developed so as that it can be used for efficient energy management.

2. Calculating Solar Day Light Hour

In this context it is evident that use of sun ray becomes an important factor for saving energy, and fulfilling the shortfall. Using solar based alternate resources will be also of interest for remote areas. In general it is evident that the time for which we receive solar radiation or sunrays will decide the length of the day and thus help us to decide the exact time and areas where peak demands in morning and in the evening can be chopped off. The solar radiation on earth surface is a function of geometry of the receiving surface relative to the sun. As explained in the figure1 & 2 below it is evident that the factors which will be governing the calculation of total daylight hour which is also necessary [5]. In this context we need to understand terms like solar declination angle δ, solar time B and lastly calculation of daylight hours. Solar declination δ is the angle between the sun-earth centre-to centre line and the projection of this line on the equatorial plane. This is given by:

$$\delta = 23.45 \sin [360/365(284+n)];$$

Where n is the day of the year.

Solar Time is the time based on the apparent angular motion of the sun across the sky, with solar noon the time the sun crosses the meridian of the observer.

$$\textit{Solar time}=\textit{standard time}+4(L_{st} - L_{loc}) +E.$$

Where E is the equation of time in minutes, L_{st} is the standard meridian for local time zone, and L_{loc} is the longitude of the location in question in degrees east.

$$E= 9.87 \sin 2B-7.53\cos B-1.5\sin B$$

$$B= [360(n-81)]/364; \text{ where } n= \text{days of the year.}$$

$$1 \le n \le 365$$

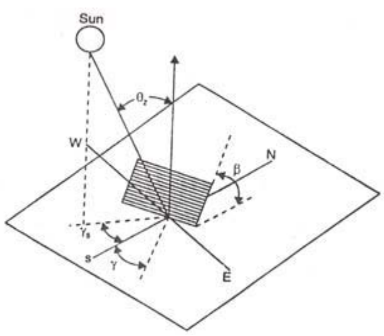

Figure 1

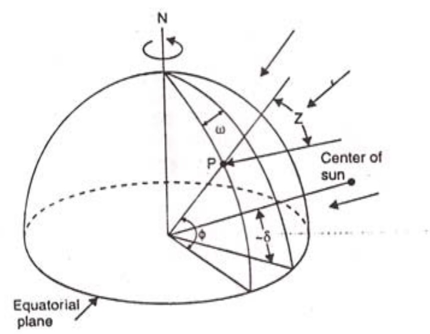

Figure 2

The hour angle ω of a point on the earth's surface is defined as the angle through which the earth would turn to bring the meridian of the point directly under the sun. Thus a conclusive formulation tells us the relationship between the different angles and hence the role of sun ray in deciding the requirement of electrical power from place to place. Thus from Figure 1 & 2 the angles and the relationship are as follows:

Φ=Latitude, δ=Declination,
β=slope, that is, the angle between the plane surface in question and the horizontal
γ=surface azimuth angle; ω=hour angle; θ= angle of incidence, the angle of incidence of beam radiation on a Surface and the normal to that surface.

The equation relating the angle of beam radiation θ and the other angles is:

$$\cos\theta = \{\sin\delta \sin\Phi \cos\beta - \sin\delta \cos\Phi \sin\beta \cos\gamma + \cos\delta \cos\Phi \cos\beta \cos\omega + \cos\delta \sin\Phi \sin\beta \cos\gamma \cos\omega + \cos\delta \sin\beta \sin\gamma \sin\omega\}.$$

For horizontal surface β =0° and the angle of incidence is the zenith angle of the sun θz.
Thus we have:

$$\cos\theta z = \cos\delta \cos\Phi \cos\omega + \sin\delta \sin\Phi.$$

The above equation can be solved for the sunset hour angle ωs, when θz = 90°.

$$\cos\omega s = -(\sin\Phi \sin\delta / \cos\Phi \cos\delta) = -\tan\Phi \tan\delta.$$

It also follows that the number of daylight hour s is given by:

$$N = 2/15 \cos^{-1}(-\tan\Phi \tan\delta)$$

Thus for any given day at a particular point on the surface of earth it is possible to calculate a number of daylight hours. This basically helps us in predicting the total length of a day at any given point on earth surface.

Thus applying these formulas we can calculate the total available solar daylight hour. Thereafter depending upon the result and the considered day in a given year we have indeed set the factor by which the loads that could be brought under DLS technique. We have found that 6 to 8 solar daylight hours are required for such DLS technique implementation for energy saving or peak load calculation.

Table 1. Day Light Hours in a whole Year in India

Month	Average sunlight (hours/day)	Month	Average sunlight (hours/day)
January	7.6	July	5.6
February	8.6	August	6.2
March	7.8	September	7.5
April	9.2	October	9.4
May	8.1	November	9.5
June	6.4	December	8.0

The latitude and longitude that are to be considered for the application of DLS technique should have at least 8 to 10 hours of day light. The region in India suitable for such applications are states along the line starting from West Bengal, Jharkhand, Madhya Pradesh, Gujarat, Rajasthan, Delhi and Punjab in the north, and southern part of Uttar Pradesh. These states as a belt of areas can be utilized for DLS technique provided there is a smooth and stable pattern of demand. If there is an abnormal demand situation where there is a sharp rise or fall of demand, than what was predicted could get deviated from the prediction then a factor of load defined as:

"load reduction factor" is supposed to be introduced such that it should be brought into action to achieve the desired result. Otherwise system doesn't work as per our assumptions.

3. Proposed Fuzzy Bayesian and Fuzzy synthetic Methodology to Reduce Peak Demand

An algorithm has been developed based on Fuzzy Bayesian decision method to predict, calculate, and determine the exact amount of peak power demand. To achieve this, data used for share of power to reduce peak demand amongst regions are considered. For this, two states of the country namely west Bengal and Punjab are considered which are the two region lying apart in the Far East and west of the country. Two states or the regions are apart by about one hour time, which is the time difference by which the sun rises locally. The power demand and generation pattern for these states are almost same or nearly same [3, 6]. Both regions also have similar power pattern during peak hours. Hence the algorithm is suitable for calculating how much and which loads can be considered for load shedding and hence takes care of all aspect corresponding to this and then determines how to chop the peak demand and reduce the power stress in these peak periods. Certain major aspects like geographical distance, available solar day light hour, peak period power pattern, tariff, human habits of energy usage, working hours and system conditions has been taken into consideration for evaluating the loads and their priority setting. This method chops off peak power demand by about 50MW to 90 MW as calculated from our previous work [11]. In this paper a further valediction of this method is done by predicting a demand pattern for the region of west Bengal which is calculated from the data available from our previous finding .This is a considerable amount of energy saved. On daily basis at two of the peak periods subjected to other circumstances. The algorithm of research method is written below for our finding and further valediction of the same.

a) The states or region under consideration are to found out on the basis of power demand and power generation pattern. These both regions should be almost identical power generation or demand pattern.
b) These states are supposed to be apart geographically by latitude and longitude which should equate to time difference of sun rise and sunset by about 45 minutes to one hour approximately
c) These regions are then taken into account on their demand pattern, load type and their ultimate usage type on any given day, month or in a year.
d) Then fuzzy Bayesian synthetic method is applied on these loads to determine which loads are to be supplied with power immediately and which can be shed of.
e) This is decided by Fuzzy Bayesian technique which evaluates point scored by loads, on the basis of percentage of load that can be chopped off.
f) This is again achieved by the condition prevailing to loads at a given time, climate, weather, duration of the day and work culture of humans at that region, aspects like geographical distance, available solar day light hour, peak period power pattern, tariff, human habits of energy usage, working hours etc are considered.
g) Thus on that basis the loads with high scoring will have high priority power supply whereas low scoring loads can be shed off.
h) Loads that are considered for this application are agricultural load, commercial load, industrial load, public lighting etc.

Therefore in our work what we suggested was already implemented using these data's obtained from Eastern region load dispatch center. But to validate the algorithm it was essential to predict a power demand of a date as per our suitability and to find out how much of actual demand could have been saved.

4. Validation of Fuzzy Synthetic Method

In order to evaluate the actual load that will be required to reduce the peak demand and also to ascertain the performance of this algorithm; it was decided to predict a particular day's power demand well in advance considering all the different types of condition and clauses that we had already discussed in our previous research work [9], [3-4]. So what we did is to consider the power demand for a particular day in a given month of a year. We decided to work on a data that was of the same day but about a month before. So that using it we can predict the following date's power demand. In order to achieve it we got data of 10th January 2011, using which we predicted the demand pattern of 10th February 2011. Then we have compared it with the actual data of the same day obtained from the load dispatch center. What we found was exactly the same as we had proved in our earlier papers. The results are shown in the Matlab programming and plot. The two times considered are morning 9:00 am and that of evening 9:00 pm. In both these places we find peak power has reduced by about 57.5MW and 74MW respectively as was earlier predicted by us.

The entire concept of load reduction is based on utilizing two main mathematical models. One Fuzzy Bayesian Technique for scoring and load identification for sharing of power between regions or states [4]. Thereafter using the Fuzzy Synthetic method to evaluate the amount of load that can be shed off to reduce peak demand [1].

This particular paper is written keeping the process of valediction of the second mathematical model. Even though both the models are considered for evaluation of load and thereafter its success.

5. Result and Conclusion

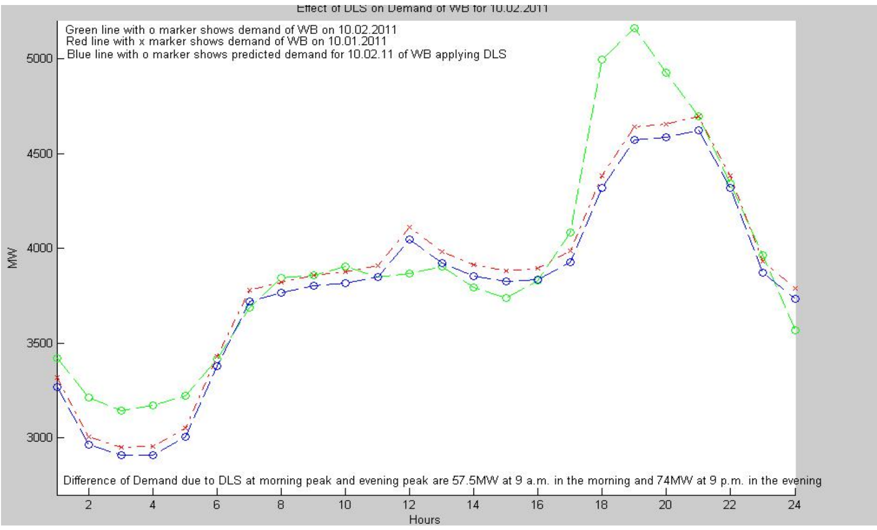

Figure 3. Change in Peak Demand after Applying DLS Technique

6. Conclusion

It is found that much of the prediction has helped in reducing the peak demand by about 50-100 MW. Such kind of mathematical model to reduced peak demand is a success only when the solar ray availability and judicious scheduling of load is done. Load identification, demand reduction by loads of less priority is utmost important in such kind of work. We also suggest identifying such methods with better performance so that it becomes a new renewable technique for peak power reduction. Other countries or regions following this method can chop off peak demand. Thus it is evident that this method is a very robust yet very effective method to reduce peak demand.

References

[1] Arindam Kumar Sil, Nirmal Kumar Deb, Ashok Kumar Maitra. Energy Saving by Chopping off Peak Demand Using Day Light. *TELKOMNIKA, Indonesian Journal of Electrical Engineering*. 2011; 9(2): 395-400, e-ISSN: 2087-278X (p-ISSN: 1693-6930)

[2] Ahuja DR, Gupta DPS, Agrawal VK. Energy Savings from Advancing the Indian Standard Time by Half an Hour. Current Science. 2007; 93(3): 101-106.
[3] Sil AK, Deb NK, Maitra AK, Sen, PS. Chopping Off Peak Demand Using DLS Technique Formulating an Intelligent Technique for Load Identification*. IEEE International Conference on Industrial Technology (ICIT).* Chile. 2010: 909-913.
[4] Sil AK, Deb NK, Maitra AK. *Chopping off Peak Load Between Similar Group States-Using DLS Technique.* International Conference on Energy and Environment (Enviro Energy 2009). Chandigarh, India. 2009.
[5] Chauhan DS, Srivastava SK. Non-Conventional Energy Resources. *New Age Publication.* 2005.
[6] Report on Eastern Region Power Sector Profile. *Ministry of Power, Government of India*. 2007.
[7] Annual Report of Central Electricity Authority. *Ministry of Power, Government of India.* 2007-2008.
[8] Annual Report. *Ministry of Power. Government of India.* 2005-06.
[9] Ross TJ. Fuzzy Logic with Engineering Applications. Second Edition.
[10] Sil AK, Deb NK, Maitra AK. An Approach for Chopping Off Peak Load Demand by DLS Technique for Regional Load. 1st International Conference ICAECT. Manipal Karnataka, India. 2010.