A Research on Electric Load Forecasting Factors Effecting and Methods Involved

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Abstract Why load forecasting? And what are the methods are there up to now and methods yet to come in future to do electrical load forecasting. This paper presented a detailed study on electrical load forecasting with traditional; Knowledge based expert systems, artificial intelligent techniques and Hybrid techniques (EMD and ANN) with a brief explanation about the conventional and non-conventional methods of electrical load forecasting. And a very clear individual comparison of both conventional and non-conventional methods.

Keywords: EMD, ANN, Hybrid, conventional method, EEMD.

I. INTRODUCTION

Electrical energy can't be stored using any batteries or any other storage devices. So, it has to be generated based on need or demand for it. So, it is very important to estimate the load required in future based on population growth because based on population growth the load utilization may vary and also climate makes crucial role in estimating the future power demand. So, to satisfy all these conditions some methods are required with some nomenclature with technicality included in it.That technical name is called Load forecasting. [1]

Estimation of Both energy and demand requirement is an important task for an effective system planning. When the future load is estimated then perfect planning is made to meet the future demand of load. [2]

1.1 IMPORTANCE OF ELECTRICAL LOAD FORECASTING

For planning power system with proper planning of transmission and distribution facilities for proper power system operation for proper

Financing For proper man power development for proper grid formation for proper electrical sales [1- 5]

II. FACTORS EFFECTING THE ELECTRICAL LOAD FORECASTING

Factors effecting the electric load forecasting are mainly classified as four types

2.1 Meteorological factors:

The meteorological factor depends up on rain, snow fall, wind speed, minimum and maximum temperatures, cloud covering are the factors that affecting load. Fore casting temperature and humanity are some factors that effecting load. Fore casting temperature and humidity are included in meteorological factor. [3]

2.2 Temporal and Calendar factors:

The calendar factor is defined as calendar variation of same month are quarter between different years. It can be easily identified in daily load pattern that the higher load consumption periods at definite time.

2.2.1 Working Days:

There are [3] important differences in usage of electricity in working days and in holidays. The load pattern may change according to working days and holidays

2.2.2 Moving holiday effects:

Moving holidays such as pongal, Diwali, holy, Dussehra. So in India different festival may occur in different weeks or months and might this affect the load forecast as on these days industrial loading will be less [2][1]

2.2.3 Time factor:

Depending up on the human activity and economic activity the time of electrical load varies. [3]

2.3 Economy factors:

Economic factor is defined as the factors based on region or country which bought, sold or produced. It is the main factor that influencing the electrical load forecasting [3].

2.4 Random factors:

The electrical power source consists of more number of consumers like large scale industry and agriculture load is also main reason for sudden variation in load consumption.

2.5 Customer factor:

There are different type of Customers like residential and commercial customers and agricultural relations Factors provided by electricity utilities companies. [3]

2.6 Other factors:

In different parts of our country the load variation curve is different that is load consumption of rural area will be different from urban area. The load shape is depending up on the type of consumers.

III. CLASSIFICATION

Electrical load forecasting is splitted into two types Demand and Energy. Demand forecasting is calculated through past basis of fast growth rate of demanded energy forecasting is calculating the future fuel requirement. And Demand forecasting is classified in to three types [4][5] [16].

1. SHORT TERM
2. INTERMEDIATE OR MEDIUM TERM
3. LONG TERM

How the classification takes place will get or know with the following table

S.NO	Classification	Based on time factor	Other factors effecting
1	SHORT TERM	This is a forecasting operation being conducted from one hour to several days	For short-term forecasting, the electric load is highly correlated with meteorological temporal and calendar factors
2	MEDIUM	The energy consumption from several days to a number of months	The main affecting factors are meteorological and Temporal.
3	LONG	The energy consumption from few months to few years	Econometric factors and meteorological factors such as climate.

Table 1 Classification table

IV. CLASSIFICATION LOAD FORECASTING TECHNIQUES

Studies related to forecast the demand including the following techniques

1. Statistical Techniques
2. Knowledge based expert system
3. Artificial intelligent Technique
4. Hybrid Techniques

4.1 Statistical Technique

Most valuable thing for the planners and new techniques building research scholars needs basic or conventional methods to know about the methodology of load forecasting. Those methods are called statistical or traditional techniques.

Which includes the following methods Regression Method Most closely used statistical technique is called Regression technique and it is often simple for the implementation.

4.2 Multiple regression method

From [10-11] numerous relapse examination for stack determining utilizes the source of weighted minimum squares estimation. This examination of factual connection between add up to load and climate conditions and additionally the day sort impacts can be ascertained.[10] The relapse coefficients are figured by a similarly or exponentially weighted slightest squares estimation utilizing the characterized measure of chronicled information.

t Sample Time, Yt Measured system load, Vt Vector of acceptable variable such as time, temperature, humidity etc., αt Transposable vector of regression coefficients, $\mathcal{E}t$ an error at time t. [11]

4.3 Exponential smoothing

From one of the ancient methods used for load forecasting is exponential smoothing models uses by Rahman the load at time is molded using a suitable function and is expressed in the form

$$y(t) = \beta(t)T + f(t) + \mathcal{E}(t) \text{------------[2]}$$

F (t) suitable vector function of the process β (t) coefficient vector ε (t) colorless noise and T transpose operator [12]

4.4 Iterative reweighted least square

From [13] mentioned a stepwise data as the iteratively reweighted least-square to find the model order and parameters. The technique utilizes an administrator that controls one variable at any given moment. [4] The weighting capacity, the tuning constants and the weighted aggregate of the squared residuals frame a multiple-way choice variable in recognizing an ideal model and the ensuing parameter gauges [12].

$$Y = X\beta + \varepsilon(3) \text{-----------[3]}$$

Where Y is an n x1 vector of observations, X is an n x p matrix of noted coefficients (based on previous load data), β may be a p x one vector of the unknown parameters and ε is an n x one vector of random errors

V. ABRIEFCOMPARISIONON TRADITIONAL TECHNIQUES

Traditional techniques includes the four techniques which are done with the fore more years data.in that regression technique uses the statistical technique which is often simple to implement and another method called multiple regression method they uses the weighted least square estimation method for getting statistical relationship between the total load and whether conditions and exponential smoothing used the technique of the previous knowledge to forecast the longer term load demand and therefore the final ancient technique is iterative reweighted least sq.

technique of iteratively reweighted statistical method to spot the model of series and parameter. This is the comparative study about the rational techniques.

VI. KNOWLEDGE BASED EXPERT SYSTEM

All traditional methods will dependent on previous year data and the calculation is very complex because number years got increase the calculation part becomes more complex. To avoid this complexity, we need some knowledge based methods. Knowledge based systems include the following methods [16] [1].

1. Empirical Mode Decomposition (EMD)
2. Esemble Empirical Mode Decomposition (EEMD)

Because of many scholar's extensive research, they proposed a different level of forecasting methods which are knowledge based methods. Before going to knowledge based techniques we have to know about a term called IMF (Intrinsic Mode Function) because based on this method only they done load forecasting using the knowledge based methods.

6.1 IMF (Intrinsic Mode Function)

From [16] a practical way to decompose the data so that the components all satisfy the conditions imposed on them an intrinsic mode function (IMF) is a function that satisfies two conditions: (1) The number of null crossings should be equal or differ at most by one From the whole data set and (2) At any point, the mean value of the envelope defined by the local maxima and the envelope defined by the local minima is zero. By the above mentioned rules they decompose the data in to different categories. And using that data they complete the load forecasting calculations.

6.2 EMD

It is the method to decompose the statistic signals into many alternative sorts of statistic parts. Already I have stated why we are going to knowledge asked systems. Because of complexity. In this method they get the data from the previous years and if they find any difficulty they deposes the data using IMF function. [10][1][16]

$$s(t) = \sum_{i=1}^{n} c_i + R_n \text{-----------} [4]$$

R_n is the residue of data s (t); C_i is the itch IMF obtained from s (t).

Drawback:

From [16] typically EMD cannot decompose the initial knowledge sequence properly. as a result of IMF shifted out from the initial signal, it's not a mono element. there's some individualism with totally different completely different} scales exist with some IMF or similar scale with different IMF.Mode mix is completed through physical which means and weakens the regularity.

To rectify this downside a brand new methodology is given that is termed EEMD

6.3 EEMD

From [16] this method is invented in 2005 as an improvement to EMD

Rules followed in EEMD model are

1. Add a colorless noise to the mentioned data
2. Decompose the data with added colorless noise in to IMFs
3. Using the different colorless noise series do step 1 and Step2.
4. To get the final decomposition need to get the following IMF.

$$\overline{C_j(\bar{t})} = 1 \sum C(t) \text{-----------} [5]$$

$N_n = 1$

$\overline{C_j(\bar{t})}$ EEMD original data is decomposed by IMF in which N is the colorless noise Component added number. [16]

From [16] the drawbacks which are mentioned in the EMD is modified in this EEMD. Small amplitude colorless noise is used to remove the mod mixing of uniform distribution statistical characteristics. Because of different measures and scale signal. The signal will be continuous.

Drawback: Through [2] it rectifying the drawback posed by the EMD it poses the drawback in calculation. It is knowledge based approach however, manual calculation is required.

6.4 ARTIFICIALNEURAL NETWORKS:

From [2] [12]. Electrical load prediction is well matched through ANN for 2 reasons. First, it's been demonstrated that ANN area unit ready to approximate numerically any continuous operate to be desired accuracy. during this case the ANN is seen as variable, nonlinear and statistic ways

Secondly, ANNs area unit date-driven ways, within the sensors that it's not mandatory for the investigator to use important modals so forecast their parameters. ANNs area unit ready to mechanically map the connection between input and output; they learn this relationship and store this learning into their parameters the primary manner is by repeatedly prediction one hourly load at a time. The second manner is by employing a system with twenty-four NNs in parallel, one for every hour of the day [16].

S.NO	SIMILAR DAY(SD)	DAY	PEAK LOAD(MW)
1	20th	Monday	3100
2	21th	Tuesday	2800
3	22nd	Wednesday	2500
4	23rd	Thursday	2300
5	24th	Friday	2200
6	25th	Saturday	1900
7	26th	Sunday	2200

Table 2 Similar day approach in July 2017[1]

6.5 Expert Systems

From [2] Expert systems are the new techniques which are come out as an output of Artificial Intelligence(AI) from the last two decades. In this system a computerized program is used which has an ability to act as an expert. So, it is called as an expert system. This method uses IF –THEN [2] production rules. 'Knowledge Engineer' this knowledge from load forecast expert which is called acquisition module component of expert system.

6.6 FUZZY LOGIC

From [1-4] the method which uses the zero's and one's that is in digital signaling method is called Boolean logic. With an example, a transformer operating at high and low signals in this fuzzy logic allows to get the result from the inputs digitally. It uses the mapping between the inputs and outputs which is called curve fitting. There are some advantages for fuzzy logic. They are: it does not need any numerical models for mapping when this method is used time saving is more.

6.7 HYBRID SYSTEMS

From [1] which is combination of two techniques EEMD and ANN. Because of the advantages with the Esemble Empirical Mode Decomposition as the drawback mentioned in EMD has rectified using EEMD technique. And ANN has the advantage to do similar approach and decomposition of complex data using the intrinsic mode function. [1-3] so, mixing this two the output will be more accurate.

To build hybrid technique we need to know the following details.

How the week days Effect the Load forecasting

S.NO	SIMILAR DAYS(SD)	Days	Peak Loads(MW)
1	5th	MONDAY	2350
2	6th	Tuesday	2200
3	8th	Wednesday	2180
4	9th	Thursday	2050
5	10th	Friday	2000
6	11th	Saturday	1800

Table 3 Load distribution of one week in the month of April 2017[1]

From these two tables it is clear that compared to working days holidays will consume less energy.

6.8 EMD-LSTM Neural Networks with aBoost Algorithm

6.8.1 Boost algorithm:

The algorithm which used for the similar day approach from the previous data. This algorithm mainly used for the dimensionality limitation in clustering. So, this Boost uses the similar day selection [16].

$$\omega l2(T) = \sum J-1\ Tt2 ----------- [6]$$

S.NO	Factors	Relative imports for Load Forecasting
1	Wind Speed	0.04
2	Precipitation	0.09
3	Day Type	0.095
4	Humidity	0.21
5	Day_a head peak	0.245
6	Temperature	0.31

Table 4 Factors Effecting Value

From the above table it is clear that temperature is the major climatic factor which effects the electrical load forecasting. Compared to other factors so this temperature changes will lead to increase the energy consumption that is shown with the following table.

S.NO	DAYSCOUNT	Temperature	Load(MW)
1	1	30	2000
2	50	30	2000
3	100	30-35	2250
4	150	30-37	2700
5	200	37-45	3000
6	250	42-47	3200
7	300	.30	2000
8	350	35	2250

Table 5 temperature Effected data in the year 2016[1]

Now from [13] all these data a hybrid model is presented in to do load electrical load forecasting using the hybrid method. Which uses the similar dayapproach and IMF method with Xgboost algorithm for the data decomposition? [1]

Procedure for the SD-EMD-LSTM model is shown below in Figure 1.

1.   For selecting the similar days this algorithm calculates the Similar day's cluster.

2.   The decomposition takes the input data and it decomposes the data with the intrinsic mode algorithm.

3.   Separate forecast for the IMF and residual for the each single LSTM model.

VII. COMPARISION OF KNOWLEDGE INTELLIGENT AND HYBRID SYSTEMS& RESULTS

In this comparative study poses about the IMF which is the major function in knowledge based systems which are helpful for decomposition of the complex data.

EMD decomposes the data using time series signals into different forms of series time components by following some of the functions to decrease the complexity. This technique poses some drawbacks which are rectified in EEMD technique they are EMD having mode mixing of uniform distribution statistical characteristics .

But it is having drawback in calculating and getting accurate value .Then to rectify this drawback in calculating and getting accurate value. To rectify this drawback a method called ANN method is introduced to use the Which uses the models and to calculate their parameters. And another method called Expert system uses artificial intelligence which uses IF-THEN [2] approach. Fuzzy Logic technique which uses Boolean logic which uses 0's and 1's for high and low signals uses graphical method. Then another technique is introduced which is called hybrid method which is a combination pf EMD and ANNwith Xgboost algorithm and similar day approach. This is the comparison on conventional methods.

VIII. CONCLUSION

In this work a brief explanation is given about the conventional and non-conventional methods with separate comparison for both conventional and non- conventional methods. And some of the data is mentioned how the temperature affects the electrical load forecasting with tabulation and mentioned about factors criteria.

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