Distribution Networks Load Forecasting Using Improved Clustering Method with Particular Software

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Abstract:

This article presents an optimized algorithm for long- term electric load forecast in distribution or transmission network by using appropriate pattern curves.

This method is related to the load growth pattern and annual information of planned year on different scenarios of load growth based on non-uniform areas, where high density areas are located in smaller zones, and low-density areas in larger zones. By using appropriate software the most favorable pattern curve for each cell is fitted. These curves are used to forecast the future annual loads. Forecasting of specific cases also has been considered.

The resulted data have been applied to comprehension design of a sample city at the end.

Keywords: Distribution Networks, Load Forecasting, Clustering Method, Regression, Billing

1. Introduction

The electric load forecast is the first step in distribution network planning the load forecasts on appropriate confidence levels will influence the reliability of planning. this factor not only will effect on network framework but also will be effective role to define its concepts, such as locating the posts close to the load density center, defying the sizes and types of conductors, Circular or radial patterns for network load density and other parts of network.

Using of non-reliable data, the results will be terrible by causing load increasing and voltage dropping. In each case it will damage network system and customers. In general reliable forecasts for optimized network planning will prevent load increasing and damages on transmission lines. The precious

Posts locating and defining their accessories (sizes of transformers, connecting, and disconnecting switches, etc….), as well as its network arrangement needs aforesaid reliable forecasts.

2.Load forecasting in distribution network.

Generally load forecast is based on area load growth. The long-term load forecast method was the objective of this article. In this study small-area method has been applied by subdividing the planning area into small portions or cells which they were considered as basis to forecast their future loads. The total area load is the sum of cells loads. Selection of the cells could be done by two methods, (1) uniform, and (2) non-uniform areas.

2.1. Uniform area method

In this method each area is subdivided into is-dimensional square-form cells. Each cell coverage could be varied between 40 to several hundreds ocres. The cell size or coverage area selection will effects forecast reliability.

Fore each cell the forecast load has been estimated based on historical or billing load data. This estimation could be done by different.

2.2. Non-Uniform area method

This method has been used in this study. The study region is subdivided into several selected areas with different forms, and sizes, where each cell had its own load density. These values will be reliable for analysis feeders for certain confidence level of estimation. In this method the highly populated regions were subdivided into small areas, but low populated zones subdivided into large areas. This type of configuration does not need high capacity computer memory. The present and future forecasted loads are presented in figure 1.

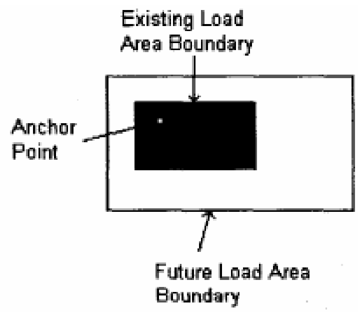


Figure 1-Rectangle form load evaluation

The final load for each area the forecast value can be estimated by using a special pattern, and or reference load value. Non-Uniform area subdivision can be done by two methods.

I. Subdivision base on feeder's coverage

In this method the study area is subdivided based on feeders where distribution post or feeders are located, and considered as the estimation cells with irregular patterns. Each feeder may transfer loads to the neighbor feeders in the past. This will cause errors in estimation.

II.Subdibvision based on billing records

In this method each area is subdivided base on recording of consumed electricity by each recording staff. Recording is being done on two months interval, and after two months each electric meter is recorded. Number of recording is the basis of area Coverage which reflects density of consumptions. High density population has smaller size, while low density consumers present larger sizes. This type of area subdivision reflects more appropriate load density centers, which are more favorable to evaluate network loads in Iran. These data can be collected by consumer billings.

3. Improved clustering method

In this method load forecasting is being done based on historical consumption? By fitting appropriate curve through recorded points the future load could be estimated. This method has economic basis with limit imported data, including measured loads of feeders and consumer billing, which are well available. Generally this data have short reliability, but using optimized clustering increase reliability. Using Temporal series and appropriate pattern are curves are considered as the optimized clustering method.

3.1. Subdividing each area based on types of consumption

Each area is divided into certain part certain part according to the electric consumers such as residential , industrial, agricultural, official, commercial and

3.2. Load estimation based on horizon year for each part

The horizon year is the end of study time interval, when the load growth will reach the saturated state. This load is estimated by using electric consumption planned data for developing projects, consisting of industrial, agricultural, comprehensive and detailed urban planning. Their reliability is time functional, where longer time consideration shows shorter confidence as indicated in figure 2.

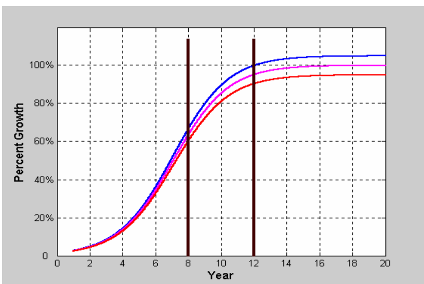


Figure 2. Relation between confidence level, and loud forecast horizon

3.3. Generally curving the consumption and growth role for each part

To construct consumption curve, the models temporal series are used. The temporal series are disconnected time functions which have values for equal time periods. The growth curve indicates "S" shape which is more reliable in load growth modeling for each area. For each area, in the early. Stage the load grows slowly, but it will increase later and will stop on the horizon year. Different states of growths and "S"- shaped curves are indicated on figure 3.

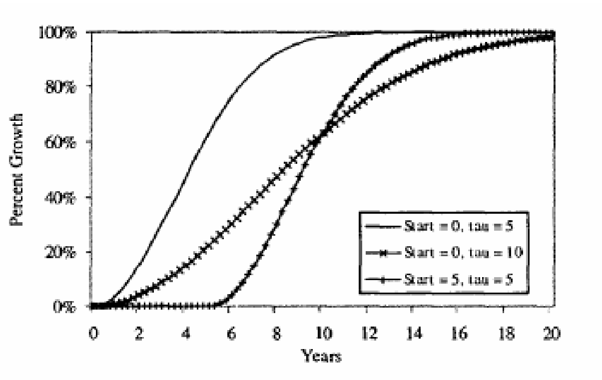


Figure 3. S-shaped curve for load growth

In this article several relations for different S-shaped curves are presented to fit the most appropriate curve as following:

1. Gomperts relation $L(t) = ae^{-e^{b-ct}}$

2. Logistic curve $L(t) = \dfrac{a}{1+be^{-ct}}$

3. Richard model $L(t) = \dfrac{a}{(1+e^{b-ct})^{\frac{1}{d}}}$

4. MMF model $L(t) = \dfrac{ab+ct^{b}}{b+t^{d}}$

5. Veibal model $L(t) = a - be^{-ct^{b}}$

In the above relations the, b, c, and d constants are defined based on load- records, and estimated value for horizon year.

Fitting of curve for each part must be repeated for each cell which is time, and cost consumer. To avoid this problem limited curves whit similar growth trend are used [6] .these defined curves are named cluster curves.

3.4. Special cases in Distribution Network forecast

I. Vacant Area Inference. (V.A.I)

During the load forecast for urban area, we can fine same new areas which were not existed in the past, and will appear in the earlier or during the growth stages. In these cases the fitted curves are not useful because the beyond values are zero. In this case the V.A.I method is applicable. In this method the barren load areas combined with areas with similar culture and consumption pattern to obtain data for consideration. In this case for barren area to stages of evaluation are used.

a. Estimation of average growth rate for future
b. This average value compares with former estimate and their difference presents the rate of growth in barren area. This concept is indicated in figure 4.

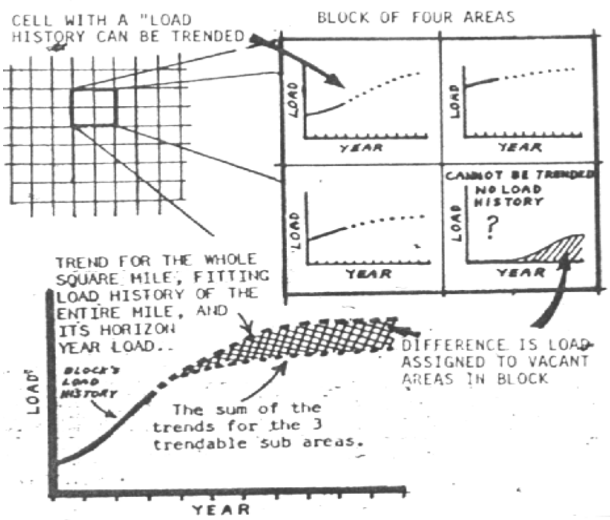


Figure 4.configuration of load growth curve for barren cell

II.area without data

to forecast the electric loads in urban areas , some parts may not existed , and no- billings are available for , which is scare case . Forecast values for these conditions will have some error but could be generalized and applied in combination with area.

III.Regression of areas with load transfer coupling

If the non uniform areas which are considered for load forecast ,are covered by a single feeder ,the will show load transfer coupling to equalize the load or reloading the posts by transferring load from a feeder to another . In this case filling the curves will face by large errors, and complex conditions as indicated in figure 5.

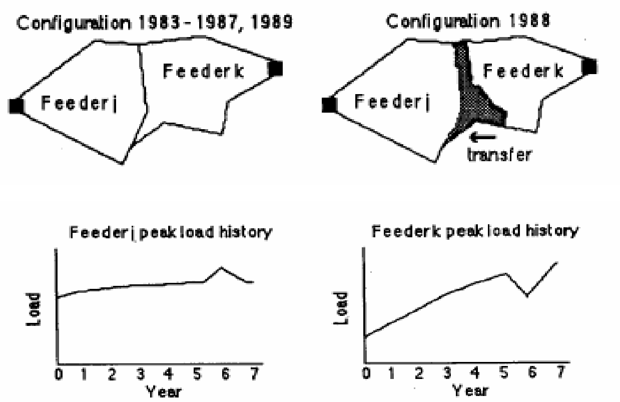


Figure 5. Load transfer coupling and its effect on real historic load records

In this case synchronous regression for two feeders and considered which may had load transferring between. Number5 and transferring directions are not needed to define. The concept of synchronous analysis in two cells for other cells is applicable, but the time of calculation by squared numbers of synchrous cells will be increased.

4. Using the applied method in a sample network

The applied method for the Sabzevar city, and its results are presented as case study for this methodology.

The Sabzevar city is subdivided into 14 recording consumed electricity zones where billings for 4 years are available.

8 further zones are proposed in developing plan as future electric consumer. Entering to present network

4. 1. Consumption records

One of the studied part in Sabzevar is Shahrak e Tow hid which belongs to zone no. a with consumed records for 1998-2001 period. The new suggested zone (zone no. A-6) has not earlier records, and will joint to network by study year. These two zones have been studying together. If the study year is considered as first year , and total consumed energy referred as 100% to normalize the recorded data , the estimated values are equal to what has been reported in table 1.

Table 1. Recorded data and normalized for two zones

Real year	1998	1999	2000	2001	2019
No. year	1	2	3	4	22
Zone no .9(MWH)	328	517.5	638. 6	2240	14980
Zone no. A-6(MWH)	0	0	0	0	6920
Sum of two zones(MWH)	328	517/5	638/ 6	2240	21900
Normalized values	1.5%	2.4%	3%	10.2%	100%

Area coverag for zone no. 9 is (476 Hec) and Area coverag for zone no. A-6 is (293 Hec)

4.2. V.A.I method for Energy fore cast for zone No.9 and Zane no. A-6 and its software.

In this case first, it is forecast Energy for sum of two zones. In figure 6 show 4 models is fitting from above zones consumption, veibal model with Regression R=0.9998567 is best model.

Because this carve is normalized, we can use this curve to zone no.9

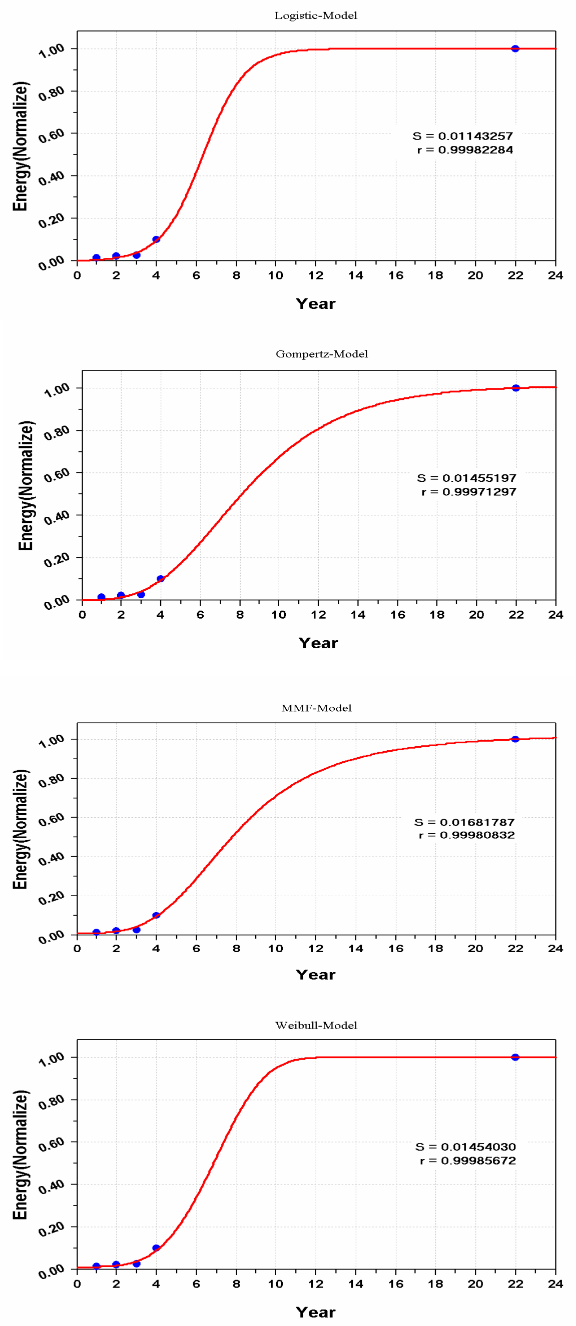
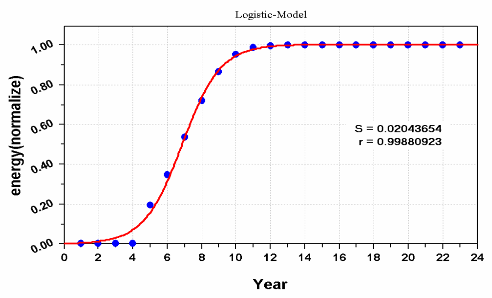


Figure 6. Fitted carves for zone no. 9

The zone no. A-6 has not any recorded data, but the load growth in this zone will be started on 2001, which its curve has been defined as difference between these two zones.

As indicated in figure 7. the MMF model presents more reliable regression to forecast future fig6 and fig7 energy consumption of the A-6 and 9 zones presented in table 2 .



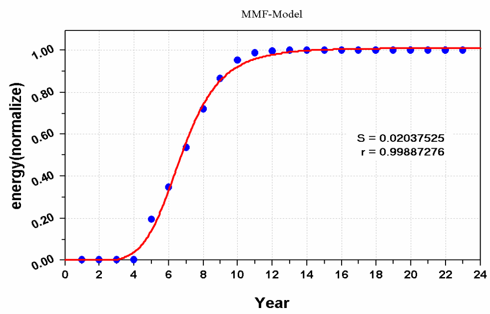


Figure 7. Fitted carves for zone no.A-6

Table 2. Forecasted energy consumption for future in zone no. A-6 and 9 according to best fitted curve

Real year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Normalized values	0.022	0.035	0.045	0.1	0.14	0.34	0.56	0.75	0.85	0.93	0.96	0.98	0.99	0.994	1
Zone no .9(MWH)	328	517.5	638.6	2240	2903	5189	8007	10805	12980	14255	14793	14949	14955	14960	14980
Zone no. A-6(MWH)	0	0	0	0	968	2353	3875	5190	5882	6436	6782	6851	6878	6895	6920

5. Conclusion

Generally to forecast electric load and consumed energy is faced with un-certainty as error. to estimate more reliable values with higher confidence level could be done by considering non- uniform areas which are more applicable to recorded network distribution data in Iran .

our case study indicates that using above mentioned method is appropriate approach to forecast energy consumption and network load by applying cluster curves for each cell to increase its reliability . The estimated figure is more reliable, and indicates better fitness by real consumption.

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