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Low Voltage Distribution Feeder Load Estimation Based on a Practical GIS-Based Method

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***Abstract*— Carefully load estimation has an important role in power distribution networks. Planning and operation using a more realistic and accurate load estimation are more economic and efficient. In this paper, a new simple and practical method is proposed which can be used for any complex distribution network that are modelled in GIS. This method uses easily accessed energy consumption data in billing databases and an estimation/correction algorithm.**

***Keywords*— Active Demand, GIS, Load estimation, Power distribution.**

I. Introduction

By increasing of commercial, industrial, residential areas and population growth in developing countries, electricity demand has been increased, too. As a result, naturally requirement to control and estimate of the load has a significant importance.

So detecting an accurate load pattern to describe consumer requirements and forecasting of future requirements of distribution network is an important challenge. In distribution companies, load estimation is also the base of all planning and operation decisions especially in restructured networks.

This field has been researched around the world by many specialists and different methods such as logistical regression, fuzzy regression, artificial neural network (ANN) etc. were presented [1]. All these methods have their own advantages and disadvantages, but in all of them, gathering required detailed power consumption data is needed which is almost difficult. In addition, study of each circuit or feeder is different depends its supplied area.

The method introduced in this paper does online estimation by a simple algorithm for distribution networks which are entered in Geographical information system (GIS). Using this method, some other required information, such as, current of the line, voltage of buses, apparent power and feeder loading percentage will be estimated, too.

The main advantage of the proposed algorithm will be clear when one notes that "consumers' energy” is usual data of the distribution utilities by means of counter reading. In fact, consumption data in distribution companies are easy to access on the “billing databases” by the high accurate, but almost no reliable data is accessible for “consumers' active demand”.

II. Proposed Method

The proposed method in this paper is based on converting billing's data (consumer's energy) to demand of whole consumers of a feeder or a specific area. On the other hand estimating of the current at the beginning of the line is possible by calculating each consumer's demand from consumer's energy with considering a reasonable power factor. Thus, calculating of the all downstream nodes voltages is possible only by a simple measurement at the beginning of the feeder.

This measurement could be done by automatic meter read (AMR) system and the results could be collected and analyze subsequently. So each distribution company has a comprehensive attitude about its feeders.

At the first step, following initial data are required:

- Voltage of the first of the line.
- Static characteristics of feeder (length, cross section of conductors).
- Location of consumers on the feeder (GIS could very simplified this matter).
- Consumption of consumers during of the study period (estimation could be done according the previous consumption of each consumer based on similarity period of last years).

Entering these data and single line of the network besides “demand of each consumer” to a load flow program is the next step. But the demand have to be obtain for all the feeders nodes first.

Average daily consumed energy (ADCE) of each customer is obtained by dividing measured energy by its counter in the period of reading by the number of the days in this period. It can be assumed that ADCE is consumed during H_{base} hours in a day and in the other 24-H_{base} hours, consumption is zero. To find an accurate common H_{base} for all customers, one can uses an estimation/correction algorithm, so that the energy consumed in real manner (Fig.1(a)) would be equal to that of estimated manner shown in (Fig.1(b)) for all customers.

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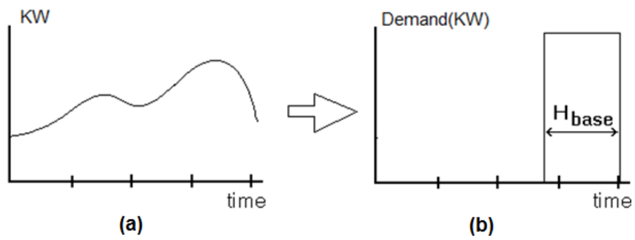

Fig. 1: Finding an optimal common H_{base} for all customers

Knowing the peak active demand of all customers, one can consider a reasonable power factor (say for example 0.8) to obtain their reactive demand. An appropriate load flow program (i.e. with forward/backward method [2]) in GIS can run having this active and reactive demands in order to find all bus voltages and section currents in the feeder.

III. SIMULATION AND RESULTS

The mentioned above method was carried out on three low voltage feeders in Isfahan (the second largest city in IRAN) and results were obtained as follow:

A. *First Study*

Fig. 2 shows the residential feeders which were considered for this study. Its tabulated customer's energy consumption data energy in billing database are shown in Fig. 3. At the first step, a typical value of H_{base}=10 was considered for the customers. With this value active and reactive demand for all customers were calculated considering power factor of 0.84 which seemed to be suitable for this residential for these residential feeders.

A forward/backward load flow written in GIS used these demands and returned the results shown in Table. 1. A predictable high error is seen in this table (about 38%). Executing estimation/correction algorithm, the optimal value for H_{base} was converged to 12.

Fig. 2: Feeder single line in GIS (First study)

	G	F	E	D	C	B	A	
	مجموع روزانه روی هر باس	روزانه(۲۴ساعت)	تعداد روز(زمستان سال ۸۸)	توان مصرفی	کد اشتراک	کد سریال	ADDRESS	1
1	45.9009	12.5246	61	764	3766829	3150	A1	2
		12.033	61	734	3766810	3100	A1	3
		9.6393	61	588	90388584	3000	A1	4
		4.311	61	263	90388576	2950	A1	5
		7.393	61	451	3766802	2900	A1	6
14	13.386	8.576	59	506	89376823	6450	B	7
		4.81	59	284	89378320	6400	B	8
72	47.2186	13.867	60	832	90043234	8500	C	9
		5.45	58	316	90073427	8450	C	10
		6.0833	60	365	3950719	8400	C	11
		0.8413	63	53	90699440	8350	C	12
		11.644	59	687	3772683	7100	C	13
		9.333	60	560	3772675	7050	C	14
34	30.1474	0.1724	58	10	3772667	7000	C	15
		13.263	57	756	3772659	6950	C	16
		5.949	59	351	86931060	6900	C	17
		10.763	59	635	86931052	6850	C	18
97	40.9307	2.3051	59	136	91505088	6750	C	19

Fig. 3: customer's energy consumption data energy in billing database (First study)

TABLE 1
ESTIMATION OF HBASE FOR THE FIRST STUDY

H_{base}	Current measured at the beginning of the feeder (A)	Current calculated at the beginning of the feeder (A)
10	90.0	124
12	90.0	90.5

B. *Second Study*

A commercial-residential feeder which was considered for this study. According to consumer's energy database, five categories were established:

A-consumption between 0 to 200KWH per 60 days
B-consumption between 201 to 400KWH per 60 days
C-consumption between 401 to 600KWH per 60 days
D-consumption between 601 to 800KWH per 60 days
E-consumption more than 800KWH per 60 days

The estimation/correction algorithm convergenced to H_{base}=8 (Table. 2). Here, the question was: "What makes of H_{base} the first and the second studies different?"

For the first feeder ADCE was 753.01 kWh and for second feeder was 493.825 753.01 kWh. H_{base} for the first feeder was 12 and for the second was 8 so. According to the linear relation between energy and consuming time it seemed to be logical that:

$$ADCE \propto H_{base}$$

To check this relationship, the third study was done.

C. *Third Study*

An industrial-commercial-residential feeder which was considered for this study. Final value for H_{base} obtained as 11.3 for ADCE of 706.669 kWh. It confirms the above

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mentioned relationship. The result of simulation and local metering shown a good converges (Table. 2) and high accuracy (about 2%).

TABLE 2
RESULTS OF THE CASE STUDIES

		The Studies		
		First	second	third
ADCE (kWh)		753.01	493.83	706.67
energy of customers in each category (kWh)	A	15.32	15.91	16
	B	38.74	52.27	32.35
	C	27.93	25	27.45
	D	10.81	5.68	18.63
	E	7.21	1.14	4.9
Total number of customers		111	88	102
Current measured at the beginning of the feeder (A)		90.0	135.1	86.9
Current calculated at the beginning of the feeder (A)		90.5	134.8	86.6

IV. CONCLUSIONS

A new simple and practical method was proposed in this paper which can be used for any complex distribution network that are modelled in GIS. The main advantage of the proposed algorithm is that it consumers' energy data instead of power data which the former is almost easy to access and the later not. Applying this method to the three practical feeder shown its simplicity and accuracy. Currently many of low voltage feeders in Isfahan city are forecasted by this method.

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