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Secondary Distribution System Losses Estimation using Statistical Technique

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Abstract: *The accurate and estimate evaluation of electrical energy loosening powers systems has important technical, economic, and regulatory repercussions. For Example, electrical energy losses are increasing one of the most important measures of system performance, especially in connection with public private sector participation (PPP) in the distribution segment of the industry. A focus area of energy management research is the reduction of both technical and non-technical losses occurring in the electrical distribution network. Reducing these losses ensure that the cost of electricity will be reduced and efficiency of distribution network will be improved. Presently, the T&D losses are calculated on primary distribution system whereas secondary distribution system serves larger area and consumers and utilities are facing problems in calculating the losses in secondary distribution system. For this purpose, the thesis aims at estimating the power losses in the power distribution utilities secondary distribution network. We apply a statistical technique for estimating the technical as well as total losses of secondary distribution system based on the data of Okhla Industrial Area Phase-1, BSES Rajdhani power Ltd.*

Keywords: Distribution Network, Primary Distribution System, Statistical Technique

I. INTRODUCTION

India's power sector is characterized by inadequate and inefficient power supply. Since the country's independence, consumers are confronted with frequent power cuts, and fluctuating voltages and frequencies. In addition, system losses are high throughout India's T&D networks. In addition to these enormous direct losses, the indirect losses in terms of lost productivity and trade, sagging economic activity, rapidly shrinking of domestic and foreign investment in the sector, uneconomical and misallocated investments in captive power, and reduced income generation could be many-fold. J.W Fourie& J.E Calmeyer, A statistical method to minimize electrical energy losses in a local electricity distribution network, at IEEE AFRICON 2004 pp.667-673. A focus area of energy management research is the reduction of electrical energy losses occurring in an electricity distribution network. There losses are the technical and non-technical losses. Reducing these losses ensure that the cost of electricity to consumers will be reduced and in turn the efficiency of the distribution network will be improved. The model developed minimizes the non-technical Electrical energy losses of an electrical distribution network. This model simulates the electrical distribution network and includes different parameter that calculates the estimated technical losses of the electricity distribution network. The model is used as a bare for developing a strategy that minimizes the electrical energy losses of an electrical distribution network.[7]. Carlos A. Dortolina, Senior Member, IEEE, and Ramon Nadira, The Loss That Is Unknown Is No Loss At All: A Top-Down/Bottom-Up Approach for Estimating Distribution Losses in IEEE transactions on power system, vol. 20, No. 2, May 2005.The accurate evaluation of losses in power systems has important technical, economic, and regulatory repercussions. For example, losses are increasingly becoming one of the most important measures of system performance, especially in connection with private sector participation (PSP) in the distribution segment of the industry. This paper proposes a top-down/bottom-up approach for accurately estimating technical losses in power distribution systems when a complete set of modelling data is not available. The results of the recent application of this approach in a developing country are also presented [6]. Robert P. Broadwater, Member, Asif H. Khan, Hesham E. Shaalan, Member, The Bradley Department of Electrical Engineering, Virginia Polytechnic Institute and State University Blacksb and Robert E. Lee Member Pennsylvania Power & Light, Allentown, Pennsylvania, Time Varying Load Analysis To Reduce Distribution Losses Through Reconfiguration in IEEE

Transactions on Power Delivery, Vol. 8, No. 1, January 1993. An electrical distribution system reconfiguration Algorithm to reduce system losses is presented. The Algorithm calculates switching patterns as a function of time. Either seasonal or daily time studies may be performed. Both manual and automatic switches are used to reconfigure the system for seasonal studies, whereas only automatic switches are considered for daily studies. A load estimation algorithm provides load information for each time point to be analysed. The load estimation algorithm can incorporate any or all of the following: spot loads, circuit measurements, and customer time- varying diversified load characteristics. Voltage dependency of loads is considered at the circuit level. It is shown that switching at the system peak can reduce losses but may cause a marginal increase in system peak. Data Structures used to model loads and to store switch configurations as a function of time are described. Example Problems are provided to illustrate result [9]. Juan Carlos Olivares, Member, IEEE, Yilu Liu, Senior Member, IEEE, Jose M. Cañedo, Member, IEEE, Rafael Escarela-Pérez, Member, IEEE, Johan Driesen, Member, IEEE, and Pablo Moreno, Member, IEEE, Reducing Losses in Distribution Transformers in IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 18, NO. 3, JULY 2003. This paper examines three methods of reducing distribution transformer losses. The first method analyses the effects of using aluminium electromagnetic shields in a distribution transformer. The goal of placing electromagnetic shields in the distribution-transformer tank walls is to reduce the stray losses. A 500-kVA shell-type transformer was used in the experiments. The overall results presented indicate that stray losses can be considerably reduced when electromagnetic shielding is applied in the transformer tank. In the experiment, the tank walls were lined with aluminum foil. The possibility of reducing the dielectric losses was shown through experiments in the second method. And the third method of this work analysis the behaviour of wound-cores losses in distribution transformers, as a function of joint configuration design parameters. The joint configuration used in this paper is called step-lap joint [10]. R. Sudhir Kumar, T. Raghunatha, R.A. Deshpande, Distribution Systems Division Central Power Research Institute Bengaluru, India, Segregation of Technical and Commercial Losses in an 11 kV Feeder in 2013 IEEE GCC Conference and exhibition, November 17-20, Doha, Qatar. This paper describes the segregation of losses into technical and commercial and uses both empirical and simulation techniques. Conclusion shows that in case of feeders which are small and has fewer components the empirical formulas could well be used to segregate the losses [11].

II. METHODOLOGY

2.1 Introduction

There are various types of losses in secondary distribution system. Figure 1 below gives the schematic diagram of all such type of losses.

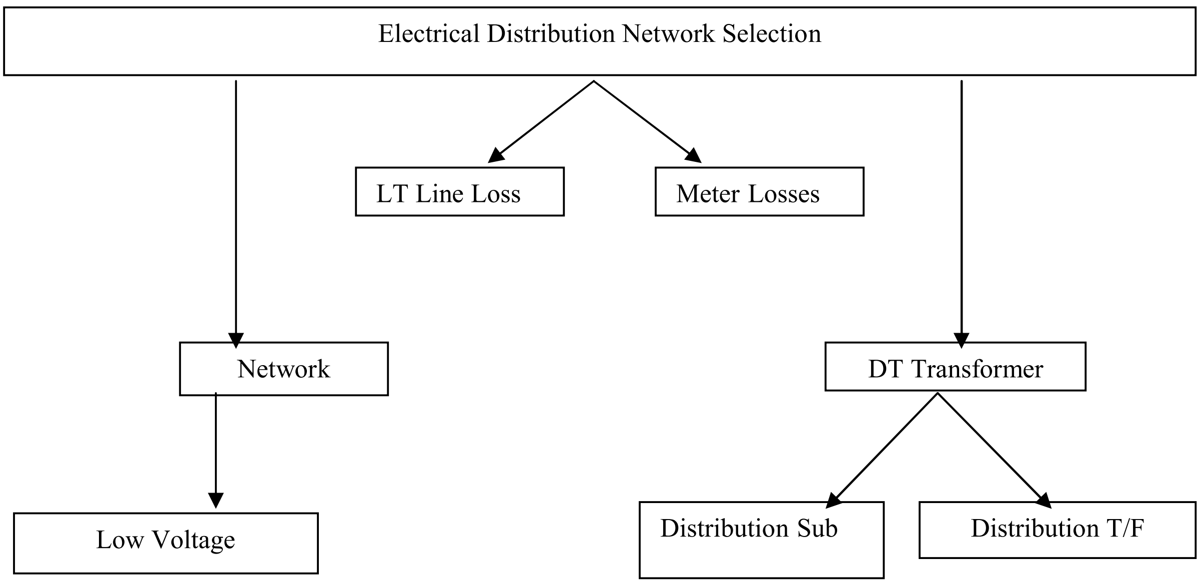

Figure: Different Types of Secondary Distribution Losses

The schematic diagram is used to develop a strategy to minimize the electrical energy losses in an electrical secondary distribution network. We estimate the technical losses in secondary distribution network using load factor and load loss approach. After estimating the losses these can be compared to measured values of the secondary distribution system. Based on these measured and estimated loss values, we identify the problematic area using the statistical methods like calculation of p values of the paired t test, does an f test and calculation of the confidence interval and standard deviation of the distribution network.

2.2 Statistical Evaluation Techniques [8]

Most commonly used statistical techniques for comparing interrelated (before and after observation) data on the same subjects are Paired t-test. A paired t-test is used to compare two population means where you have two samples in which observations in one sample can be paired with observations in the other sample. Examples of where this might occur are:

- Before-and-after observations on the same subjects (e.g. students' diagnostic test results before and after a particular module or course).
- A comparison of two different methods of measurement or two different treatments where the measurement/treatments are applied to the same subjects (e.g. blood pressure measurement using a stethoscope and a dynamos).

This approach consists of four steps:

- Formulate the hypotheses,
- Prepare an analysis plan,
- Analyse the sample data obtained, and
- Interpret results

Formulate the Hypotheses: Every hypothesis test requires the analyst to state a null hypothesis and an alternative hypothesis. The hypotheses are stated in such a way that they are mutually exclusive. That is, if one is true, the other must be false; and vice versa.

The hypotheses concern a new variable d, which is based on the difference between paired values from two data sets

$d = x_1 - x_2$

Where x_1 is the value of variable x in the first data set and x_2 is the value of the variable from the second data set that is paired with x_1.

The table below shows three sets of null and alternative hypotheses. Each makes a statement about how the true difference in population values μ_d is related to some hypothesized value D. (In the table, the symbol ≠ means "not equal to ".)

The first set of hypotheses (Set 1) is an example of a two-tailed test, since an extreme value on either side of the sampling distribution would cause a researcher to reject the null hypothesis. The other two sets of hypotheses (Sets 2 and 3) are one-tailed tests, since an extreme value on only one side of the sampling distribution would cause a researcher to reject the null hypothesis.

Prepare an analysis plan: The analysis plan describes how to use sample data to accept or reject the null hypothesis. It should specify the following elements.

- Significance level. Often, researchers choose significance levels equal to 0.01, 0.05, or 0.10; but any value between 0 and 1 can be used.
- Test method. Use the matched-pairs t-test to determine whether the difference between sample means for paired data is significantly different from the hypothesized difference between population means.
- Analyse the sample data obtained: Using sample data, find the standard deviation, standard error, degrees of freedom, test statistic, and the P-value associated with the test statistic.
- Standard deviation. Compute the standard deviation (s_d) of the differences computed from n matched pairs.
  $s_d = \text{sqrt} [(\Sigma(d_i - d)^2 / (n - 1)]$
- where d_i is the difference for pair i, d is the sample mean of the differences, and n is the number of paired values.
- Standard error. Compute the standard error (SE) of the sampling distribution of d.

- SE = s_d * sqrt{ (1/n) * [(N - n) / (N - 1)] }

where s_d is the standard deviation of the sample difference, N is the number of matched pairs in the population, and n is the number of matched pairs in the sample. When the population size is much larger (at least 20 times larger) than the sample size, the standard error can be approximated by:

SE = s_d / sqrt(n)

- Degrees of freedom. The degree of freedom (DF) is: DF = n - 1.
- Test statistic. The test statistic is a t-score (t) defined by the following equation.

$$t = [(x_1 - x_2) - D] / SE = (d - D) / SE$$

Where x_1 is the mean of sample 1, x_2 is the mean of sample 2, d is the mean difference between paired values in the sample, D is the hypothesized difference between population means, and SE is the standard error.

- P-value. The P-value is the probability of observing a sample statistic as extreme as the test statistic. Since the test statistic is a t-score, use the t Distribution Calculator to assess the probability associated with the t-score, having the degrees of freedom computed above. (See the sample problem at the end of this lesson for guidance on how this is done.)

Interpret Results: If the sample findings are unlikely, given the null hypothesis, the researcher rejects the null hypothesis. Typically, this involves comparing the P-value to the significance level, and rejecting the null hypothesis when the P-value is less than the significance level.

Confidence interval for the true mean difference: It would be useful to calculate a confidence interval for the mean difference to tell us within what limits the true difference is likely to lie. A 95% confidence interval for the true mean difference is:

$$d \pm t * \frac{sd}{\sqrt{n}} \text{or equivalently } d \pm (t * \times SE(\bar{d}))$$

III. RESULTS

Results obtained by the statistical approach are shown in Table No. 5.7 and 5.8. In the statistical evidence group the OKH145 and the OKH178 are identified as problem areas, but these problem areas could be a result of problems lower down in the network. The OKH109, OKH067, OKH131 and OKH104 have no problem.

In the measuring data groups the data integrity of the OKH101, OKH064, OKH100 and OKH115 has been verified. These are identified as problem areas. Rest are no problem area. By combining the statistical and measured data tests the results were prioritized as follows:

1. OKH109 - No problem area.
2. OKH101 - Problem area as huge Commercial Losses in Secondary Distribution System due to illegal connection taken by consumers of unauthorised colony.
3. OKH145 - Potential problem area on lower level.
4. OKH067- No problem area.
5. OKH104 - No problem area.
6. OKH131 - No problem area.
7. OKH064 - Problem area as huge Commercial Losses in Secondary Distribution System due to illegal connection taken by consumers of unauthorised colony.
8. OKH178 - Potential problem area on lower level.
9. OKH100-Problem area as huge Commercial Losses in Secondary Distribution System due to illegal connection taken by consumers of unauthorised colony.
10. OKH115 - Problem area as huge Commercial Losses in Secondary Distribution System due to illegal connection taken by consumers of unauthorised colony.

IV. CONCLUSION

In India, the T&D loss% of the secondary distribution system is very high due to high technical losses in secondary distribution systems and commercial losses. In view of this, the power utilities are facing power shortage, huge amount of losses in millions of crores, poor and unreliable power etc. The reasons for the technical losses in urban industrial areas include the lack of inadequate T&D capacity, improper load distribution etc. Presently, the T&D losses are calculated on primary distribution system whereas secondary distribution system serves larger area and consumers and utilities are facing problems in calculating the losses in secondary distribution system. For this purpose, the thesis works at estimating the power losses in the power distribution utilities secondary distribution network. Firstly, we have to identify and found different power losses like technical and non-technical losses. This is the today's need of our developing country is more important where total T&D loss % loss are very high. The power distribution utilities based on various techniques will be able to estimate the losses where the data for computing the technical and non-technical losses are generally not available.

The statistical technique is used in this dissertation to estimate the technical losses in the power distribution system. This approach not only helps in identification of technical and non-technical losses but also help to reduce these losses and improve the overall health of the power distribution utilities. The case study of OKHLA PH-1 of ALAKNANDA division of BSES Rajdhani power limited, a power distribution utility of Delhi was considered. Firstly, we calculated the technical losses for distribution transformers, using load factor and loss load factor approaches and LT feeder of secondary distribution system. For this load profile distribution transformers and was taken.

We implemented the statistical technique for estimating the total and technical losses of the OKHLA PH-1 Area of BSES power distribution utility and based on this technique problematic areas of secondary distribution system are identified. This technique will help in reducing the T&D losses in the secondary distribution system of power distribution utility.

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