

CALCULATION AND ANALYSIS OF CUSTOMER DISSATISFACTION INDEX FOR RELIABILITY STUDIES IN GILAN ELECTRIC DISTRIBUTION NETWORK

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ABSTRACT

Reliable electric energy is one of the most important necessities for customers and there are high correlation between customer based reliability indices and customer satisfaction. Electric power interruptions have not only economics problems but also it makes social and mental difficulties. However customers' sensitive is different against interruption. Culture and living stiles of customers have significant effects on their satisfaction from utilities. For consideration of customer view point against interruptions, it seems that Customer Dissatisfaction Index (CDI) should define and enter as a reliability index. Based on this index, reliability enhancement strategies can be planned for maximizing customer satisfaction index. In this paper for assessing customer dissatisfaction index, questionnaires are designed. As case study these questionnaires have been filled by domestic customers in Rasht, a big and costal city in north of Iran. Gathered data has entered in SPSS software and customers' reply stochastic indices have obtained and analyzed. According to results, sharp threshold values for customer satisfied regarding reliability of supply were found. Results show customers' sensitive for number and duration of outages and transient fault depends on time a day or seasons, in this paper time based Customer Dissatisfaction Index has been analyzed.

INTRODUCTION

There are high correlation between customer based reliability indices, outage management and customer satisfaction. Nowadays, sensitive loads like residential appliance, automatic industry and etc. are increased. They need high reliability but outages make big economic losses. Consequently the fold and duration of interruption have to be standard. Utilities have to supply costumers with enough stabilities and securities. But some problem like bad climate, old equipments, poor design and technical problems make fault and outage.

Also interruptions have not only economics problems but also it makes social and mental difficulties. Customers' sensitive is different against interruption and reliability based on applications, Culture and living styles of customer have affected on satisfaction of utilities. Comparing customers' experience of outages and system reliability

follows better understanding of utilities performance [1]. Asset owners and managers have to link between customers' expectation and companies' goals [2]. Now, reliability indices such as SAIFI, SAIDI, CAIDI are based on systems averages behavior. Customers experiment and necessity have no any reflection in these indices. For consideration of customer view point against interruptions, it seems that Customer Dissatisfaction Index (CDI) should define and enter as a reliability index. Reliability investment is another reason needs customer satisfaction index. Due to different indices in different location of a city or different cities, for reliability investment and system improvement, technical and social studies have to be done. CDI can show customers satisfaction or dissatisfaction threshold [1]. This index gives an opportunity to design and develops a network with sufficient quality without doing any unknown over investment [3].

Determining an international standard for this new and important index needs to have enough samples all over the world and also it should be examined from different aspects. One of important issue to calculate and use of CDI is required information.

In this paper for assessing customer dissatisfaction index, two-part questionnaires are designed. In first part questions are about age, education and settling place and Second part concern customers' exceptions and experiments of outages. As case study these questionnaires have been filled by domestic customers in Rasht, a big and costal city in north of Iran. Also Cocran method is used to sample 1400 customers. Gathered data has entered in SPSS software and customers' reply stochastic indices have obtained and analyzed. Chi-square method is used to analyze the correlation between part one and two of questionnaires.

Results show sharp threshold value for the customer satisfaction regarding reliability of supply. Consequently Customer Dissatisfaction Index formula (CDI) has obtained for this special location. CDI is defined as a probability that illustrates the relation between SAIFI, SAIDI and customers satisfaction. This formula is applied for Rasht because survey has done there. CDI depends on time because customers sensitivity and satisfaction vary in all a day and different seasons. CDI is very important for investment and networks design and improvement, in this paper; it is analyzed considering the time.

CUSTOMER SATISFACTION THRESHOLD

The first step to calculate SACDI is finding customers

expectation and experiences about outages. Therefore, a survey was done and threshold values of customers' satisfaction have been gotten.

Case study

There are different methods to find customers threshold values of satisfaction. A qualitative research about problem has done like holding conversations to managers and staff of Gilan electricity distribution company, outages analyzing to use events record software, to analyze complaints and suggestions. Then questionnaire as tool, field style as data collection method, non possibility availability as sampling method and description-analytical style and Chi square as decomposition and analysis have chosen.

As case study these questionnaires have been filled by domestic customers in Rasht, a big and coastal city in north of Iran with 267477 customers

The questionnaire has divided to two parts: personal information and main questions. Personal information follow three question including age range, education and address to find the effect of these factors on answers of main question, the second part of questionnaire has thirteen questions concern customers' exceptions and experiments of outages. The questions are user-friendly, multiple choice and easy to answer for customers. For example survey asks "if you have to have an eight hours outage in a month due to maintenance, which method is suitable for you" or "if you have to have an outage in one day, how many hours make serious problem or how many interruptions make problem for you in a day, month or summer". There were some questions about transient faults. The multiple choice answers design by special pattern which can show questionnaire goals.

Rasht city has been divided to three geographical regions from economical level of customers as poor, average and affluent. For statistical analysis SPSS software is used and error of samples has been detected with cocaran method. Fault rate in gathered data was 2.5 percent.

Questionnaire goals

The questioner result was the folds and duration of outages that customers could tolerate in studied location. Another questions that survey answer are following:

- Does customers' threshold value despond on time that outage happen or not?
- How much is customers sensitive to transient outage?
- Is there a significant relation between age and customers threshold values?
- Is there a significant relation between education and customers threshold values?
- Is there a significant relation between economic category and customers threshold values?

All answers of these questions have been used to identify customers dissatisfaction index.

Questionnaire results

The result of survey over 1400 customers shows numbers

and duration of outage that customers can tolerate. It is two fold and two hours in summer for majority.

Of course threshold values are different considering time of one day and seasons.

Duration of outage is more important than numbers for customers. Results show suitable time of programmed outages for maintenance was 5 to 9 and the worst time was 13 to 24. There is a significant point the most dissatisfaction time was announced between 13 to 18. So programmed outages for maintenance should be happened in the morning. According to answer, three and less than three transient faults have no complain but more than four transient fault make dissatisfaction.

Chi square test shows when age increase, threshold values decrease. There is no correlation between age and threshold values for transient fault. Education has no effect on numbers and duration of threshold values. There is no consideration correlation between economic category and folds and duration of outage that customers don't complain. But middle class threshold values are little more than poor and rich category. Result shows age, education and economic category have no effect on the time of programmed outage that is suitable for customers.

CALCULATION FORMULA FOR SACDI BASED ON SURVEY RESULTS

According to the survey result, customer will be satisfaction if outages repeat two times and less than it and each one take two hours and less. CDI is defined as probability of poor reliability for appreciate customer. In this case study, poor reliability is an outage longer than two hour or interruptions that happen more than two times. 5 minutes and less are not covered.

$$CDI = 1 - P_r \{suitable\} \quad (1)$$

Suitable state can define as without interruption, an interruption less than two hours or two interruptions that both are less than two hours. It is supposed that duration of interruptions are equal and there are not any correlation between them. Reliability theory said time between interruption is exponentially distributed. Consequently CDI formula is following:

$$CDI = 1 - e^{-F} - F e^{-F} P_2 - \frac{1}{2} F^2 e^{-F} P_2^2 \quad (2)$$

$$P_2 = P_r \{T < 2\} \quad (3)$$

Where P_2 is the probability of interruption that lasts less than two hours. The duration of an interruption follows a Weibull distribution [1]. Consequently P_2 can be obtained as follow:

$$P_2 = 1 - \exp\left(-\left(\frac{2}{D} \times \Gamma\left(1 + \frac{1}{\beta}\right)\right)^\beta\right) \quad (4)$$

In weibull function α is characteristic value and β is shape factor. When β is equal to one, an exponential distribution with expected duration α is obtain. α is not equal to expected value. They are related each other by gamma function of shape factor as follow:

$$D = \alpha \times \Gamma \left(1 + \frac{1}{\beta} \right) \tag{5}$$

Expression (4) is valuable all the city and it can be used for each part of city, a substation, one or more medium or low voltage feeder and even for single or some customers. But for other city or places, a new expression must be obtained based on their survey and information. The system average CDI is the average value of the CDI of the all customers [1]:

$$SACDI = \frac{1}{N} * \sum_{i=1}^N CDI_i \tag{6}$$

SACDI is the system average that shows the customer’s experiences of insufficient reliability.

Calculation of SACDI for a feeder and results

Dissatisfaction index is nonlinear function of number and duration of outages and It can be use such as SAIFI, SAIDI and etc. In this paper, CDI has been calculated for the customer supplied from a medium voltage distribution feeder that called Fajr. The length of feeder is 7.5 km and it feed 7692 customers that 7676 customer are single-phase and other are three-phase. SACDI, SAIFI and CAIDI were calculated and the results are shown in table 1.

Table1: calculated indices for sample feeder

Index	SAIFI	SAIDI	CAIDI	SACDI
Calculated	19.06	10.81	0.57	0.99

SACDI is a number between 0 and 1. The index that is closer to zero is better situation and it means customers are satisfied. Correlation between SACDI, SAIFI and CAIDI are shown in figure 1. The figure illustrate that when SAIFI and CAIDI are improved consequently SACDI is improved too. When SAIFI and CAIDI are less than two, SACDI is closer to zero. It means that customer is satisfied. Red color shows this area. When SAIFI and CAIDI are more than two, the color of graph desire to be yellow. Consequently in this case customers are not satisfied and reliability indices must be improved.

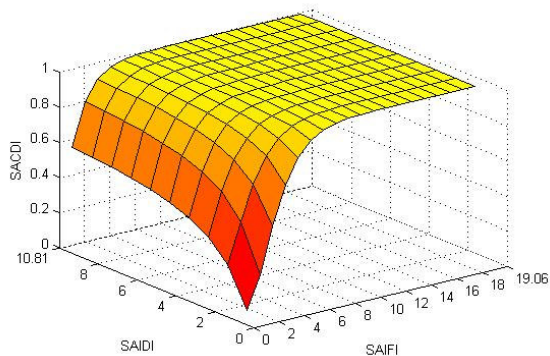


Figure1: correlation between SAIFI, CAIDI and SACDI for sample feeder

Profile which depends on SAIFI will be one sooner than the profile depends on CAIDI. It means people are more sensitive about number of interruption than duration.

The important question is that what is acceptable value for SACDI? Enough research about people and electrical networks can answer this question.

CONCLUSION

Using CDI is an opportunity to design and assess power system operation, especially for sensitive and important customers. It can prevent to over-investment Also it is convenient index for operation assessment of utilities.

The standard SACDI can shows the reliability indices which electrical networks have to have based on customers' type. The result of survey shows fold and duration of threshold values are different in variety period of a day and also in different seasons. Consequently CDI is depends on time but its average can be used in calculations, designs and assessments.

According to analysis, the customer expects are not logical in this case study and it needs more investment and networks improvement. Low threshold values show that there is not enough knowledge about electrical network operation. It should be improved by notification methods. Special customers need high reliability which it needs more investment. Consequently electricity price will increase.

Customers' threshold values, reliability indices especially SACDI always need monitoring to be effective on designing and operating. Consequently, it needs a surveyor system to be online. These days, utilities use OMS and DMS systems. They start to make infrastructure of intelligent grids. These systems have a lot of data and databases which give much information about whole system. Therefore data have to process based on special target. So utilities have to have comprehensive view to choose new technology to obtain useful information. Also systems have to be compatible with each other to prevent further over- investment.

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