Electricity Distribution Loss in Selected Consumer Service Centre Area of Ceylon Electricity Board

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ABSTRACT

Electricity generated at power stations is distributed through large, complex transmission networks. Some of the components used in the transmission systems are substations, transformers and electricity transmission cables. Through the transmission system, electricity is distributed to the end users. However, the units generated at the power stations are more than the units of electricity distributed to the end users. This difference is called as the electricity distribution loss. The electricity distribution loss causes for reduction of financial performance of the electricity provider and also dissatisfaction of the consumers. The objectives of this research are to estimate the average units of electricity distribution loss per period, identify the possible causes for the electricity distribution loss and analyze the intensity of these causes for distribution loss. The study was based on secondary data, which were collected by electricity provider during 12 months of 128 transformers in a selected consumer service center area in Sri Lanka. Results revealed that there are three factors highly affected for the electricity distribution loss. They are illegal consumption, damaged and defective meters and number of breakdowns. Electricity provider needs to pay attention on all the causes which affected the distribution loss. Then remedial actions can be taken to the prioritized causes, since it is extremely difficult to eliminate all the causes simultaneously. The study showed that the damaged and defective meters highly affected the electricity distribution loss and illegal consumption was the least affected factor for such loss. Hence it was recommended to use a systematic way to monitor consumer meters, maintain and replaced damaged consumer meters with modified sealed meters.

KEYWORDS: Distribution Loss, Non-Technical Loss, Technical Loss

INTRODUCTION

Growing populations and industrializing countries create huge needs for electrical energy. Electricity is not always used in the same place where it is produced. Long distance transmission lines and distribution systems are necessary to operationalize the electrical energy. But transmitting electricity over distance and via networks involves electricity distribution loss. Electricity distribution loss refers to the amounts of electricity injected into the transmission and distribution grids that are not paid for by electricity users (Pedro, 2009). The two types of electricity distribution losses are technical losses and non-technical losses. Technical losses are defined as the losses that are caused by the physical quality of the distribution system. Non-technical losses occur due to power theft, non-payment of customers or errors of record keeping. Power theft can be any form of illegal activities such as illegal connections, meter tampering or false reading.

To ensure the financial viability of the electricity providing company, the electricity provider could be able to collect the billed amount while reducing the technical loss. This paper will discuss the causes for electricity distribution loss, and intensity of the causes.

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Research Problem

An electric power distribution system is the final stage in the delivery of electrical energy to consumers; it carries electricity from the transmission system to individual consumers. But it causes significant percentage of technical and non-technical losses during the period of transmitting and distribution of electricity. Technical losses are unavoidable but can be minimized using power system planning and modeling. Non-technical losses are avoidable financial losses and need to pay more attention on reducing it. Hence the research was carried out to find what percentage of electricity was lost at the distribution and the causes for such losses.

Research Objectives

The primary objective of this study is to identify the intensity of the causes of electricity distribution loss. The other objectives are to estimate the electricity distribution loss percentage per period, possible causes for the electricity distribution loss and to identify possible solutions for reducing loss.

LITERATURE REVIEW

Distribution Loss

Distribution losses are referred to the difference between the amount of energy delivered to the distribution system and the amount of energy that customers is billed or customer is to be paid. (Navani, Sharma, & Sapra, 2013; Ghosh, 2012; Agrawal & Bhuria, 2013; Parmar, 2013; Singh et al, 2009).

The two broad categories of losses in power systems are technical losses (TL) and non-technical losses (NTL) (Jiménez, Serebrisky, & Mercado, 2014; Pedro, 2009). Singh et al (2009) mentioned that the electricity theft is the main reason for NTL, that causes more losses and cannot be predicted or calculated beforehand.

Technical loss can be divided into two categories; fixed losses and variable losses (Jiménez, Serebrisky, & Mercado 2014). Fixed technical losses are caused by physical inefficiencies such as hysteresis, eddy currents losses in the iron core of transformers, and the corona effect in transmission lines. Variable technical losses occur when the power current flows through lines, cables, and transformers of the network.

"Each component of an electrical network (an overhead line, underground cable or a transformer, etc.) offers resistance to flow of current and thus consumes some energy while performing its expected duty. The cumulative energy consumed by all such components is termed as technical loss." (Khobragade & Meshram, 2014)

"The NTL are caused by actions external to the power system or loads and condition that the technical losses computation failed to take into account. NTL are more difficult to measure since these losses are often unaccounted for the system operators and thus have no recorded information" (Navani, Sharma, and Sapra, 2013)

Navani, Sharma, and Sapra, (2013) have suggested non-technical strategies which can minimize or mitigate the NTL. Upgrading of electricity meters, using smart card technology for minimizing the theft of energy, using integrated billing system and prepaid energy meters are some of them. Providing technical training to the operating personnel for enhancing employees' loyalty to eliminate pilferage in the distribution system, and also statistical monitoring of energy consumption per sector, per class and geographical setup and statistical evaluation of meter readings are some of the institutional level strategies to minimize the NTL.

Electricity Theft

Electricity theft constitutes a major chunk of the NTL. Major forms of electricity theft include bypassing (illegal tapping of electricity from the feeder), tampering the energy meter, (Jiménez, Serebrisky, and Mercado, 2014) and physical methods to evade payment (Smith, 2004 Cited in Depuru, 2012).

Smith (2004) suggests three methods to reduce the power theft, as technical/ engineering, managerial, and system change. According to Barasubramanya (2014), revenue losses caused by electricity theft affect the quality of supply, the electrical load on the generating station, and the tariff imposed on usage by genuine customers.

"Any illegal consumption of electrical energy, which is not correctly metered, billed and revenue collected causes commercial losses to the utilities", (Khobragade and Meshram, 2014). "Almost all the commercial losses occur at the distribution stage and that is where action has to be taken to control that" (Ghosh, 2012).

Distribution Loss Reduction in Selected Consumer Service Center Area

According to the annual report and accounts of Ceylon Electricity Board (CEB) 2010, The CEB's system losses and distribution level losses are 21% and 17% of gross generation respectively in 2002. It has been gradually brought down to 13.5% and 9.78% respectively by the end of 2010.

Table 1: Provincial Level Losses for the Year 2010

Province	Energy input (GWh)/year	Estimated Loss% from the input
Consumer service area 1	1,022.5	10.1

METHODOLOGY

The study was commenced with a review of literature on electricity distribution loss. It identified the possible causes for the electricity distribution loss. Based on the empirical literature survey, the following research model was developed.

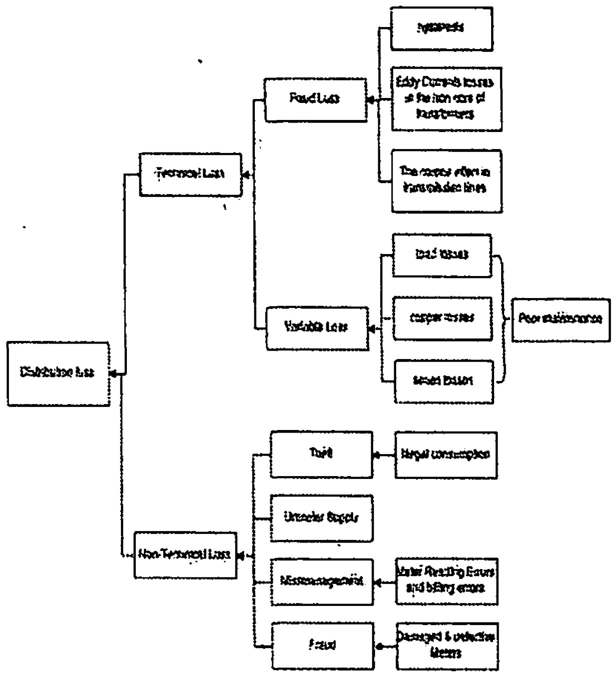

Figure 1: Research Model

Electricity generated data at transformers in a selected consumer service area and billed amount at the same area during September 2013 to August 2014, were considered for the analysis. The number of replaced meters in a month, number of maintenance per month, illegally consumed units per month, number of meter reading and billing errors per month, transformer meter readings and consumer meter readings were also collected from secondary data sources.

Since four factors affect the NTL of electricity distribution, regression analysis was used to model the relationship between four explanatory variables and a response variable by fitting a linear equation for the observed data.

DATA ANALYSIS

Electricity Consumer Diffusion

Generally electricity consumers are categorized based on the type of connection that they are served. Those three types are one phase supply, two phase supply and bulk supply. In the selected consumer service area, consumer diffusion is presented in Figure 2.

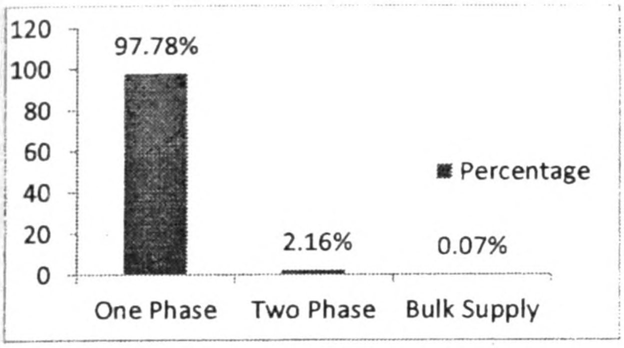

Figure 2: Diffusion of Consumers in Consumer Service Area 1

The majority of the consumers are single phase suppliers (97.8%), and bulk supply consumers are very less, and about 0.07% of the whole consumer group.

Electricity Distribution Loss Percentage

Average electricity distribution loss was calculated using the following formula.

$$\text{Average Distribution Loss Percentage} = \frac{\textit{Distribution Loss in month}}{\textit{Sum of Distribution Loss in year}} * 100$$

Figure 3 shows the monthly distribution loss as a percentage of total generation in consumer service center area reporting from September/2013 to August/2014. The highest loss 12.71% is reported in October/2013 and April/2014.

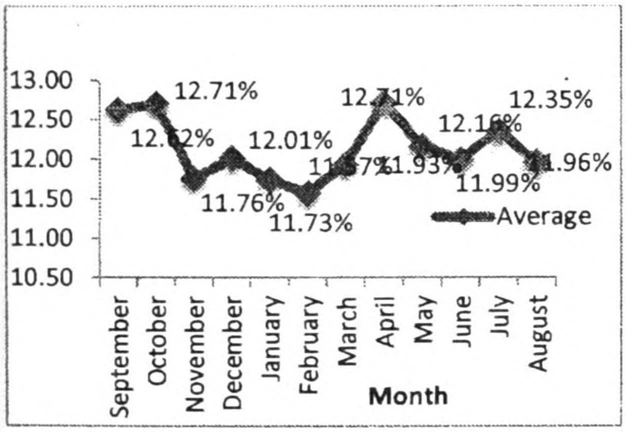

Figure 3: Electricity Distribution Loss Percentage

Normality Test

To perform parametric test for data analysis, the data should be tested for normality. Therefore following hypothesis was tested.

H_0: Data follow normal distribution
H_1: Data do not follow normal distribution

Table 2: Shapiro-Wilk Test

	Shapiro-Wilk		
	Statistic	df	Sig.
Average Loss Percentage	0.982	128	0.084
Illegal Consumption	0.966	128	0.053
Number of Damaged and Broken Meters	0.973	128	0.052
Number of Breakdowns	0.981	128	0.066
Number of Billing Errors	0.918	128	0.000

Except the number of billing errors, the significance values of average loss percentage (dependent variable), illegal consumption, number of damaged and broken meters, and number of breakdowns are greater than 0.05. Therefore, H_0 is accepted. This concluded that, except number of billing errors, other factors normally distributed at 5% significance level.

Linear Regression Model

Table 3: Multiple Linear Regressions

Summary of the Findings		
Variables entered to fit the regression line	Illegal Consumption, Number of damaged and broken Meters, Number of Breakdowns,	
R^2 Value	0.560	
ANOVA Table Significant Value	0.042	
Model : Coefficients Table- Significant Value		
Constant	11.345	0.000
Illegal Consumption	0.001	0.042
Number of damaged and broken Meters	0.049	0.043
Number of Breakdowns	0.027	0.000

Table 3 represents the variables in the regression line against the distribution loss percentage. Since the coefficients were significant, following equation was derived.

Distribution loss percentage (Y) = 11.345 (Constant) + 0.001 (Illegal consumption) + 0.049 (Number of damaged and broken meters) + 0.027 (Number of breakdowns)

It describes that if illegal consumption is increased by 1 unit, while all other variables are constant then distribution loss percentage will be increased in 0.001 units. If the number of damaged and broken meters is increased by 1, while all other variables are constant then distribution loss percentage will be increased in 0.049. If the number of breakdowns is increased by 1, while all other variables are constant then distribution loss percentage will be increased in 0.027.

Other factors which affect the technical loss are represented by the constant.

DISCUSSION AND CONCLUSION

It is necessary to minimize the frequencies of occurrences of the factors which affect the distribution loss. Therefore, minimize the revenue loss occurred due to the illegal consumption, number of damaged and defective meters, and number of breakdowns, are compulsory.

There are various factors which affect distribution losses that need to be eliminated. Numbers of damaged and broken meters are highly affected for the distribution loss with compare to illegal consumption and number of breakdowns. Also it is necessary to take actions to reduce the number of breakdowns and eliminate the illegal consumption.

Some solutions may be that the meter readers can observe unnecessary hooking, damages of meters once a month since they physically visit every household once a month, identify the areas which have high percentage of distribution loss, strength the distribution system, launch a systematic way to maintain the meters, replace all the broken and damaged meters with sealed meters, minimize the poor quality sealing meter, charge a high price from consumers for damaging meters due to human errors. Theft of electricity should be publicized as a social and economic crime and people should be informed of the provisions in electricity laws for this. Electricity providers can implement preventive and regular maintenance and better management of distribution transformers as another solution.

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