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Managing System Losses to Improve Energy Efficiency within the Electricity Company of Ghana (ECG) Limited

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Abstract

The inability to achieve the target of universal access to electricity is influenced by several factors including funding limitations, the use of obsolete equipment, power theft, and system losses confronting the electricity distribution services of the Electricity Company of Ghana Limited (ECG). The study assessed the components of system losses within the ECG by determining and computing the percentage of system losses within ECG, examining the causes of both commercial and technical losses in ECG, and determining ways to improve energy efficiency by reducing system losses in the most cost-efficient manner. The study adopted deductive reasoning and a quantitative approach to guide data collection and analysis of the research output. A sample of 345 technical and non-technical staff of ECG in the Greater Accra Metropolis was selected from a population of 2500. Purposive, simple random, and cluster sampling techniques were used in identifying and accessing respondents for the study. Descriptive statistics were applied to measure central tendency and degrees of dispersion and the Relative Importance Index (RII) to predict criterion and predictor variables. The impact of low voltage network losses can adversely contribute to technical losses (20%) and reduce energy efficiency in power or electricity distribution companies. Non-technical losses are mainly caused by illegal connections, meter problems, and billing problems. Each of the non-technical losses contributes a maximum of 10% to system losses. Contributors to system losses at ECG are ranked first for power theft and least for lack of incentives. System losses at ECG include metering inaccuracies, bad workmanship, unmetered supply, and lengthy distribution lines, each recording a mean value of above 3.5. Measures to improve monitoring of the networks and systems at ECG and discourage power theft should include an extensive quantification, patrolling, and inspection of the entire network to assess the extent of the network and conditions relevant for the placement of systematically planned maintenance programmes.

Keywords

Network Management, System Losses, Electricity, Cost Efficiency, Energy Management

1. Introduction

Power generation in Ghana has gone through several phases, including diesel-fuelled generators, stand-alone electricity supply systems generally owned by industrial mines and factories, the hydro phase following the construction of the Akosombo dam, and currently the thermal complementary phase powered by gas and/or light crude oil [1]. In 1989, Ghana developed the National Electrification Scheme (NES) as part of its commitment to provide universal access to electrical power by 2020 [2]. It was estimated by the [3] at the inception of NES that only 15.0% to 20.0% of the country's population had access to electricity. Electricity access for the 2016 electricity access review by the [3] was estimated at 66.7% in 2009, 80.5% in 2015, and 82.5% in 2016. Again, the 2017 Energy Statistics by the Energy Commission of Ghana (2017) estimated that the total amount of electricity generated in 2016 was 13,022 GWh against a total of 6978 GWh of electricity in 2007. This reflected an 86.61% increase in electricity production. The increase in electricity generation resulted in the expansion of the national grid to cover many rural communities and as a result, helped farmers to preserve their agricultural produce and also supported the efforts of some entrepreneurs to expand and set up Small and Medium-scale Enterprises (SMEs). However, the successes in the expansion of electricity access were undermined by challenges associated with system losses. For instance, in 2007, a total of 6441 GWh (including commercial losses) of electricity was consumed with a loss component of 557 GWh representing 7.98% in distribution and other technical losses. The trend is similar for 2016 which indicated that out of a total of 11,418 GWh (including commercial losses) of electricity consumed, a loss equivalent to 1604 GWh representing 12.32% was recorded for distribution and other technical losses [4]. The development dealt a major blow to Ghana's effort of improving efficiency in energy supply and consumption due to the major loss of equivalence.

Ghana's National Electrification Scheme (NES) which is aimed at providing universal access to electricity by 2020 [2] has become wishful thinking due to the slow pace of progress. The inability of NES to achieve the target of universal access to electricity is argued to be influenced by factors such as funding limitations, the use of obsolete equipment, and power theft confronting the distribution of electricity by the Electricity Company of Ghana Limited (ECG). ECG is the only public utility company distributing electricity within the southern sector of the country whilst the northern sector is being handled by the Northern Distribution Company Limited (NEDCo) [5]. ECG is mainly responsible for the provision of safe, quality, and reliable electricity supply across all sectors that require the use of electricity, to support the socio-economic development of Ghana [6]. However, the existing high level of inefficiency in electricity unearths a major concern for the company to live up to its mandate of delivering cheap and quality access to electricity.

In many scholarly discourses, several reasons have been given for the shortfall in service delivery in the operations of ECG [5]. For example, identifies the unavailability of some specific relevant repair kits and inadequate logistics to attend to specialized faults in the operations of ECG. [7] also points to the cumbersome internal processes that increase the response time for attending to customer complaints. In addition, the persistent electricity rationing system (load shedding), slows down industrial activities and job schedules, income losses as well as causes interruptions in the social life of people which sometimes culminate into a perennial drag on Ghana's development agenda [1]. These challenges make it challenging for the ECG to meet the regulatory standards set for them by the regulator, that is, the Public Utility Regulatory Commission (PURC) and the Energy Commission (EC). The argument is that significant parts of these challenges can be attributed to the high level of system losses within the company [8]. Some empirical evidence suggests that the ECG has an annual system loss of 23.0%; a relatively high value compared to the World Bank standard of 6.0% for utility companies [5] [8].

In the electricity supply system, system losses refer to the amounts of electricity injected into the transmission and distribution grids but not paid for by users. The difference between energy input (purchases), and the energy collected (sales), therefore, constitutes losses. These system losses are categorized into technical and non-technical (commercial). Technical losses occur as a result of power dissipation in electricity system components such as transmission and distribution lines, transformers, and measurement systems [9]. Commercial losses, on the other hand, are caused by external actions consisting primarily of electricity theft, non-payment for consumption, and errors in accounting and record-keeping [9] [10] [11]. The Institute of Statistical, Social and Economic Research (ISSER) appraises that the economic cost of these losses ranges between $320 and $920 million annually. The 2010 Wholesale Power Reliability Report adduced that unreliable and inadequate electricity supply cost Ghana between 2% - 6% of her gross domestic product (GDP). [12] also approximates the cost of the losses to 1% of GDP.

ECG manages its technical losses through the enforcement of approved/accepted standards of network construction, use of timely reinforcement and improvement schemes, and the monitoring of the mode of operations among others (ECG, 2018). But, the commercial losses are addressed through an improvement in the accuracy of meter reading, data capturing and validation, accuracy and timeliness of billing the process and delivery among others [6]. [13] asserts that majority of the electricity distribution companies that have achieved substantial loss reduction have worked through the implementation of system loss study programmes. The ECG in its quest to implement loss reduction programs has in the past engaged the services of consultants to assist in determining the level of distribution losses in its network [6]. In recent times, ECG's in-house team has been assessing distribution losses in various networks. It is, however, worth noting that due to the various network interventions and investments implemented over several periods in ECG's system, there is the likelihood of recording a significant reduction in estimated system losses for specific networks and operational areas. Arguably, there are significant debates relating to the possible link between the quality of operational and managerial practices and system losses in power companies such as ECG.

In 2014, an Institute of Statistical, Social and Economic Research (ISSER) report asseverated that Ghana lost an average monthly output of about US$ 55.8 million through the energy crisis. A crises stage significantly undermined efforts at improving energy efficiency in many organizations in Ghana [14] [15]. By implication, the country lost an estimated amount of US $680 million, accounting for 2.0% of GDP [16]. This situation has persisted although installed generation capacity has more than doubled over the period increasing from 1730 MW in 2006 to 3795 MW in 2016 [5]. The highest electricity demand only increased by 50.0% during this same time, increasing from 1393 MW in 2006 to 2087 MW in 2016 [5]. The electricity supply challenges can be attributed to several factors, including a high level of losses in the distribution system which is mainly due to the obsolete nature of distribution equipment [7] [17], non-payment of bills by customers [18], and the high rate of illegal connections by customers [19]. These make it difficult for the ECG to collect the revenue required to ensure quality service delivery and energy efficiency in the electricity supply.

Several studies have been conducted in different countries to assess system losses in electricity companies. [10]'s study on *Commercial Loss Reduction Techniques in Distribution Sector* in India identified that theft detection drive, unauthorized connection load extension, and theft by tempering meter were the main causes of commercial loss. [13] worked on a residential demand response model and impact on voltage profile and losses of an electric distribution network to identify that DR Congo can boost system voltage due to further demand restriction through demand-side management techniques such as volt/var control (VVC). [20] also assessed ways to reduce technical and non-technical losses in the power sector. However, these studies failed to capture experiences in Ghana. A few similar studies relating to Ghana took place years ago thus making it relevant for exploitation of system losses within the Ghanaian contest. A typical example is a difference in results witnessed between the findings made by hired consultants and the ECG's in-house team that assessed distribution losses in various networks [6].

There is, thus, a paucity of the current extant literature on system losses in the power supply networks of the country. This has created a lingering uncertainty on how to effectively remedy or reduce these system losses. This study, therefore, attempts to determine the number of system losses incurred by the ECG and explore measures to reduce losses and improve energy management within ECG.

This study, therefore, seeks to assess the components of the system losses within the ECG and to explore measures to improve energy management through a reduction in system losses by.

- Determining and computing the percentage of system losses within ECG.
- Examining the causes of both commercial and technical losses in ECG and.
- Determining ways to improve energy management and reduce system losses in the most cost-efficient manner.

2. Methods

This study adopted deductive reasoning to guide the attainment of the strategic goals of the research by drawing patterns through observations to confirm a reality [21] [22]. The study employed a quantitative research strategy to guide data collection and analysis of the research output. Quantitative research focuses on the deduction, confirmation, theories/hypotheses, explanation, prediction, standardized data collection and statistical analysis [23] [24]. The use of the quantitative approach was useful in helping in the collection of data which allowed for the application of inferential analysis and identification of correlations for the data set [25]. Hence this study gathered data that examined ways to reduce system losses from a sample of technical and non-technical staff at ECG.

[26] defines a study population as a well-defined collection of individuals or objects with similar characteristics relevant to the study. The individuals who constituted the population for this study are the technical and non-technical staff of the Electricity Company of Ghana. This population was, therefore, made up of the ECG staff strength of 2500 workers.

A sample for the study was needful due to the large population size of the study [22]. The choice of the sample size was dependent on factors including the purpose of the study, the size of the population, the risk of selecting a bad sample and the allowable sampling error. Using the Yamane sample size formulae, 345 technical and non-technical staff of ECG in the Greater Accra Metropolis were selected from a population of 2500 for the study [27]. Yamane's formulae for determining sample size were adopted to ensure a fair representation of the respondents to minimize sampling bias and systematic errors.

$$n = \frac{N}{1 + N(e)^2}$$

where n = sample size; N = sample frame and e = error of acceptance, which is (0.05).

$$n = \frac{2500}{1 + 25000(0.05)^2}$$

$$n = 344.83$$

$$n = 345 \quad \text{(sample size)}$$

Purposive, simple random and cluster sampling techniques were used in identifying and accessing respondents for the study. The cluster sampling approach was used to categorize the entire population into homogenous groups to enhance the feasibility of the samples [28]. Then, the simple random approach was used to select the respondents from each cluster of the population. Additionally, the purposive approach was useful in the selection of the heads of each section including the Area Manager, Area Engineer, and Area Human Resource Officer due to their expert knowledge and the critical positions they hold in their places of work. According to [29], purposive sampling enables the researcher to use his or her judgment in selecting appropriate cases that best fit the research objective of securing valid data from the respondents.

Data collection plays a very vital role in statistical analysis. A researcher needs several data gathering tools or instruments for research work. The tools may differ in complexity, interpretation, design, and administration. Surveys, observations, questionnaires, experiments, and personal interviews are some sources of primary data. The primary source of data for this study was a field survey using close-ended questionnaires. The secondary source of information is discussed as information gathered from the review of the literature. The secondary source of information supports the findings from the analysis of the primary data. Websites, books, government publications, journal articles and internal records are some sources of secondary data [29].

Close-ended types of questions were used in the design of the questionnaire for data collection. The questionnaire was designed concerning extant literature and the research objectives of the research. The questionnaire design consisted of four main sections: Section one covered the demographic data of the respondent, whereas sections B, C and D dealt with the three core objectives of the study. To ensure consistency of measurements, the ordinal scale of measurement was used for this research work. The five-point Likert scale was used in the development of the questionnaire. Respondents were asked to score on a five-point Likert scale of 1 to 5 for causes of both commercial and technical losses in ECG (where 1: strongly disagree to 5: strongly agree), and ways of reducing system losses in the most cost-efficient manner (1: Not important to 5: very important).

The analysis of data required several closely related operations such as the establishment of categories, the application of these categories to raw data through coding, tabulation and then drawing a statistical inference [30] [31] [32]. Descriptive statistics that describe the relationship between variables in a sample population were applied to the data analysis to reduce, summarize and describe quantitative data obtained from empirical evidence [32] [33]. Regarding descriptive statistics, this study applied the measures of central tendency and degrees of dispersion (standard deviation) [34].

Also, the Relative Importance Index (RII) was assessed to aid in examining the potential of a particular variable to predict a criterion variable both by itself and in combination with other predictor variables, [23]. The Relative Importance Index (RII) was calculated by [35] using the formula.

$$\text{RII} = \frac{\varepsilon W}{A * N}$$

where [W—weighting is given to each statement by the respondents ranging from 1 to 5; A—higher response integer (5); N—total number of respondents].

The Cronbach's Alpha Coefficient was used to assess the reliability of the instruments [31] [36]. The coefficients were based on the premise that excellent reliability coefficients are around 0.9 - 0.8 for good reliability coefficients, 0.7 for satisfactory reliability, 0.6 for weak reliability, 0.5 for poor reliability coefficients, and less than 0.5 reliability coefficients as unacceptable [22].

The reliability of the questionnaire was tested through a pilot study that involved 5 respondents of the targeted population. The comments and observations made in the pilot study are summarized in **Table 1**.

The key principles of research ethics were adhered to [22] [37]. The ethical issues considered for the study included assurance of confidentiality of the research participants, assurance of a high level of honesty, objectivity, and integrity in the data collection process, and analysis and reporting of the result.

3. Results and Discussions

In all, 345 staff of the Electricity Company of Ghana Limited in various technical

Table 1. Pilot test.

S/N	Respondent	Comments	Response
1.	R1	Some variables were repeated and some were misplaced	A thorough check throughout the questionnaire was done to remove all inconsistencies and repetitions.
2.	R2	Spelling mistakes were identified throughout the questionnaire.	All grammatical and technical errors were identified and corrected with the help of third parties.
3.	R3	The phrasing of the sentences must follow a particular tense: finite or present continuous.	The tenses were changed to a progressive tense.
4.	R4	Some variables presented did not fit properly given the scope of the study.	All inconsistencies were corrected.
5.	R5	There must be a preamble to the study to aid respondents to have a fair overview of the aim of the study.	A preamble was provided

Source: Field work (2020).

and commercial positions was accessed but 211 representing 61.6% responded favourably with feedback for the questionnaire. This response rate was considered appropriate for further analysis since [38] argued that the results of a survey could be considered insufficient when the analysis is based on a 30% - 40% response rate. The reliability of the scale was checked using Cronbach's alpha coefficient test whereas the Relative Importance Index (RII) was adopted for analyzing the objectives of the study [39] [40].

Biodata of Respondents

Areas of expertise of respondents were categorized under 44.1% technical staff, 36.0% and 19.9% for a mix of technical and commercial staff. The category of experts considered for the study is directly or indirectly involved in electricity generation and distribution within ECG. Years of experience if respondents fell for 15.2% with less than 5 years experience, 31.7% with 5 - 10 years experience and lastly, 53.1% who have worked in ECG for over 10 years The results indicated that the majority of respondents have worked extensively to gain more years of experience. The extensive years of experience are useful for the study because it is argued that work experience is important for achieving quality service delivery.

Again, 63.5% (134) of respondents had a postgraduate degree (MSc./MPhil) whilst 36.5% had a bachelor's degree. The use of respondents with high academic qualifications for the research is consistent with Hallinan and Hegarty (2016) who asserted that academic qualification could help to gain more knowledge for professional development and organizational development.

System Losses

In ascertaining the weight of losses due to technical losses at ECG, the majority of respondents 61.1% (129) agreed that losses due to 33 kV networks and power frequency transformers were between 11% - 20%, with a minority (1.9%) stating that technical losses accounted for 41% - 50% (**Table 2**).

The findings of this study are consistent with Fardoun *et al.* (2012) who indicated that losses on the grid account for 20%, with 15% for technical losses and the remaining registering as non-technical losses. Generally, losses attributed to all types of transformers used by ECG were 11% - 20% for the majority (54.5%) of respondents. But only 3.3% stated that 31% - 40% of the losses are due to transformers (**Table 3**).

System losses recorded for low voltage network losses were 11% - 20% for 67.8%, whereas 13.3% of respondents indicated 21% - 30% for losses attributed to low voltage network losses (**Table 4**).

Percentage of the Non-Technical Losses

To ascertain the percentage of system losses within ECG, respondents had to indicate the scores for three non-technical causes of system losses.

The study found that over 50% of respondents were of the view that these non-technical losses hovered between 1% and 10% each of the total shares of non-technical losses for ECG (**Table 5**).

Table 2. Percentage of 33 kV networks and the power transformers losses.

PERCENTAGE OF 33 kV NETWORKS AND THE POWER TRANSFORMERS LOSSES	FREQUENCY	PERCENT
1% - 10%	40	18.9
11% - 20%	129	61.14
21% - 30%	30	14.21
31% - 40%	8	3.9
41% - 50%	4	1.9

Source: Field survey, (2020).

Table 3. The distribution of transformers losses.

THE DISTRIBUTION OF TRANSFORMERS LOSSES	FREQUENCY	PERCENT
1% - 10%	34	16.1
11% - 20%	115	54.5
21% - 30%	55	26.1
31% - 40%	7	3.3

Source: Field survey, (2020).

Table 4. Percentage of low voltage network losses.

PERCENTAGE OF LOW VOLTAGE NETWORK LOSSES	FREQUENCY	PERCENT
1% - 10%	40	18.9
11% - 20%	143	67.8
21% - 30%	28	13.3

Source: Field survey, (2020).

Table 5. Percentage of non-technical losses.

CAUSE	PERCENTAGE LOSSES
Illegal Connections	1% - 10%
Meter Problems	1% - 10%
Billing Problems	1% - 10%

Source: Field survey, 2020.

Causes of Commercial and Technical Losses in ECG

On the causes of commercial and technical losses in ECG, respondents were tasked to indicate their scores on a 5-point Likert scale ranging from 1 for Strongly disagree, 2 for Disagree, 3 Neutral, 4-Agree and 5 for Strongly agree. A reliability test was also determined to support the analysis of the findings of the study. As confirmed by [41] reliability deals with the extent to which a measuring instrument will produce the same results on repeated trials. To determine the reliability of the Likert scale used in this study, the Cronbach's Alpha Coefficient was used to test the consistency of the items on the scale. The mean, standard deviation, RII, and standard mean error were also calculated for each variable. The Cronbach Alpha test score for 10 items was 0.835. This figure is reliable for the statistical analysis since an examination of the causes of both commercial and technical losses showed that the major cause of these losses was theft (mean = 4.41, S.D = 1.033). This was followed by metering inaccuracies (mean = 4.33, S.D = 1.125) and with the least factors going for lack of incentives (mean = 3.72, S.D. = 1.301) and lengthy distribution lines (mean = 3.85, S.D. = 1.162) (**Table 6**).

All the variables had mean values greater than the hypothesized significance means of 3.0 showing that all ten identified variables contributed significantly to the causes of commercial and technical losses in ECG.

The result of the study on "power theft" is consistent with [42] who agreed that customers temper the meter through mechanical jerks, placement of powerful magnets to impair readings or disturbing the disc rotation with foreign matters and stopping the meters by remote control. These actions are all jeered towards attempts by consumers to steal electricity or use electricity without paying for it or cheat by under-reading the meter and getting under-billed. As confirmed by this study, some consumers get their premises connected to the network but failed to register an account with the electricity provider [43]. Arguments to defend some of the illegal connections are the result of delays and

Table 6. RII of causes of both commercial and technical losses.

Causes	Mean	SE	SD	RII	Ranking
Power theft	4.41	0.163	1.033	0.908	*1st*
Metering inaccuracies	4.33	0.179	1.125	0.882	*2nd*
Bad workmanship	4.17	0.157	0.952	0.876	*3rd*
Inadequate size of conductors of distribution lines	4.13	0.174	1.071	0.862	*4th*
Unmetered supply	4.09	0.179	1.112	0.846	*5th*
Installation of distribution transformers away from load centres	4.02	0.172	1.055	0.833	*6th*
Low power factor of the primary and secondary distribution system	3.98	0.184	1.157	0.785	*7th*
Feeder phase current and load balancing	3.94	0.152	1.073	0.777	*8th*
Lengthy distribution lines	3.85	0.143	1.164	0.765	*9th*
Lack of incentives	3.72	0.161	1.301	0.755	*10th*

Source: Field data, (2020).

frustrations, suffered by prospective customers when they seek to extend the electricity supply to their premises [43]. Metering inaccuracies, Bad workmanship and inadequate size of conductors of distribution lines also contribute significantly to the critical causes of both commercial and technical losses. The use of old technology meters usually built with minor errors is known to slow down with time resulting in under-recording [44]. Some arguments have centred on the fact that distribution losses are usually compounded by poor workmanship associated with joints. As a measure to reduce such losses and ensure firm relations, proper joining techniques must be used. This assertion supports the fact that to prevent sparking and heating of contacts, connections to the transformer bushing stem, drop out fuse, isolator, and LT switch, among others, should be inspected and maintained regularly [45].

Cost-Efficient Measures to Address System Losses in ECG

In addressing systems losses, respondents were assessed from a 5-point Likert scale categorized as 1 for Not important, 2 for Less important, 3-Moderately important, 4-Important and 5 representing Very important. To determine the reliability of the Likert scale used in this study, the Cronbach's alpha coefficient was tested for consistency resulting in 0.874 for 9 items. The Cronbach's Alpha Coefficient of 0.874 shows the reliability of the study results. This indicates that the scale is reliable.

The results related to ways to reduce system losses showed that the main cost-efficient measure was the use of power theft checking drives to reduce power (mean = 3.92, S.D. = 0.788). Other efficient ways to reduce systems losses included a renovation improvement programme for feeders (mean = 3.92, S.D. = 1.123 and changing out old conductors or cables (mean = 3.88, S.D. = 1.120). The worst performing variable for managing system losses was the practice of servicing agricultural customers with high-voltage delivery systems (HVDS, mean = 3.58, S.D = 1.162) (**Table 7**).

The findings show that all the variables provide some important strategies for reducing system losses in the most cost-efficient manner, especially where mean values of over 3.5 were recorded for all the variables that assessed how to reduce system losses.

The results of the study indicated that the use of power theft checking drives to reduce power theft, use of feeder renovation/improvement programmes, and replacements of old conductors or cables are significant and major ways to reduce system losses in the most cost-efficient manner in ECG. The strategies identified in this study are consistent with extant literature [43] that argued that theft of electric power is a major challenge undermining the efficiency of all-electric utilities. It is, therefore, necessary to make strict rules regarding power theft. Although, the impact of power theft is not limited to loss of revenue it is also important to note that theft affects power quality and also could result in low voltage and voltage dips. It is important to note the installation of Medium Voltage Distribution (MVD) networks in theft-prone areas in areas where each user is connected directly to the supply transformer's low voltage terminal. On

Table 7. RII on ways of reducing system losses in the most cost-efficient manner.

Measures	Mean	SE	SD	RII	Ranking
Using power theft checking drives to reduce power theft	3.98	0.123	0.788	0.898	1st
Renovation/improvement programme for feeders	3.92	0.165	1.123	0.893	2nd
Changing out old conductors or cables	3.88	0.143	1.120	0.883	3rd
Auditing and accounting for energy	3.85	0.133	0.958	0.795	4th
Evaluation of billing of embedded generations	3.81	0.139	1.004	0.785	5th
Distribution transformer metering	3.79	0.141	1.016	0.778	6th
Creating a distribution line map/data	3.65	0.162	1.170	0.775	7th
Installation of feeder metering	3.64	0.143	1.032	0.767	8th
Agricultural customers will be served by a high-voltage delivery system (HVDS).	3.58	0.161	1.162	0.752	9th

Source: Field survey (2020).

the issue of minimizing unmetered electrical energy, it is recommended that the powered distribution agencies must replace obsolete or slow meters. To ensure that the meters are fully sealed and tamper-proof, we must use properly sealed meter boxes. The output of the study shows that efforts to reduce non-technical losses would also increase the company's financial balance and also improve the load curve by putting consumption under tariff control [46].

4. Conclusions

The study assessed and computed the percentage of system losses within ECG, determined the causes of both commercial and technical losses, and identified measures being used to reduce system losses in the most cost-efficient manner at ECG. A 5-point likert scale was used to assess perceptions of respondents on how to manage system losses to improve energy efficiency at ECG, limited. A mean score of above 3 showed better performance of the variable.

The study concludes that system losses are critical challenges confronting many electricity companies including ECG. System losses impacting ECG for example, are categorized into both technical and non-technical losses. Key on the major sources of technical losses at ECG is associated with the use of a 33 kV network and power frequency transformers. The impact of low voltage network losses also can adversely contribute to technical losses and reduce energy efficiency in power or electricity companies. Non-technical losses are mainly caused by illegal connections, meter problems, and billing problems.

Contributors to system losses at ECG are ranked first for power theft and least for lack of incentives adversely impacting performance in the sector. However, it is important to acknowledge the contributions of factors such as metering inaccuracies, bad workmanship, unmetered supply, and lengthy distribution lines to system losses at ECG since each of the variables recorded a mean value of above 3.5 for a 5-point likert scale.

In addressing system losses, it is important to consider measures such as the use of power theft checking drives, renovation and improvement programmes for feeders, and the changing out of old conductors. Significantly all these variables including the least performing variables such as the installation of feeder metering would contribute to reducing system losses with mean scores.

The study recommends an extensive quantification, patrolling, and inspection of the entire network to assess the state of the network and conditions relevant for the placement of systematically planned maintenance programmes. This action would also improve monitoring of the networks and systems of ECG and thereby discourage power theft. For future research purposes, it is recommended that a simulation method or ab theoretical analysis is employed to assess the system losses at ECG, Limited.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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