IJAREEIE

e-ISSN: 2278-8875
p-ISSN: 2320-3765

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

Volume 10, Issue 7, July 2021

ISSN INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.282

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 7, July 2021 ||

| DOI:10.15662/IJAREEIE.2021.1007003 |

Reducing Losses in the Electricity Distribution System

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ABSTRACT: Technical losses are losses that occur when the energy is dissipated by the equipment and conductors in the distribution lines and are generally because of inefficient electrical machines such as transformers, pumps and industrial loads, inadequate size of conductor in the distribution lines, phase load imbalance, long distribution lines, bad workmanship, installation of transformers far from load centers, low power factor, overloaded lines**,** andinstallation of distribution systems to cope with demands to new areas without regard to electricity distribution ethics.For commercial losses, meters may be made to indicate less power than what is actually utilized which may be generally considered as energy theft while the inability of the electric energy provider to collect some of the money billed the customers represents collection losses.

KEYWORDS: Losses, Technical Losses, Commercial Losses, Collection Losses, Electricity Distribution System, Electric Energy.

I. INTRODUCTION

Losses can be viewed as the result of inefficiency in the system. Losses in this case represent part of the received energy that is not converted into its equivalent value in money or revenue[1].In any case, losses in electricity distribution system may be classified into technical, commercial and collection losses respectively. The technical losses are the losses incurred in the system due to resistance presented by the network equipment and lines to the flow of current (power) as it is being transported from one location to another within the network. On the other hand, commercial losses are the losses incurred in the system due to theft of electricity which lead to substantial amount of energy received but not billed and hence cannot be paid for. Collection losses are losses due to the inability of the electric energy provider to collect some of the money billed the customers [2].

The ability of the electric energy provider to reduce these losses in the system will generally lead to higher yield of revenue from the same quantity of energy received when the losses were very high. The Aggregate Technical, Commercial and Collection (ATC&C) losses have posed a serious challenge in electricity distribution system. The ATC&C losses represent the sum total of the losses recorded in the technical, commercial and collection activities in the distribution system put together by the company that provides the electric energy [3].

In Nigeria for example, the distribution companies purchase the product (energy) from the generating stations through the wholesale dealer known as the Nigeria Bulk Energy Trader (NBET) who procures the energy through a Power Purchase Agreement (PPA) from the generating stations. Distribution companies after the purchase, retail the energy to the numerous classes of customers under their licensed coverage area. For the company to have an understanding of the quantity of energy it has procured from the NBET, meters are usually fixed at all the energy input points or sources of energy into the company network and are read at a specified time of the month.

The concept of revenue loss in utility companies is a global phenomenon that requires proper grasp of the concept, and ability to apply methods and standards in line with international best practices in handling the colossal challenge. There is that need for revenue experts to be proactive in analyzing how to set effective standards and policies, to enable them create a working environment, where all losses are treated on merit, there is that dear need to eliminate or minimize the losses with speed and efficiency, to avert or prevent the company from crippling.

II. LOSSES IN THE ELECTRICITY DISTRIBUTION SYSTEM

A. **Technical Losses**: These losses are losses that occur due to the existence of several loose contacts in the distribution network which develop hot spots in sections such as loose jumpers and joints, loose contacts between the fuses and the feeder pillar units, loose contacts between cable lugs and the terminals, loose isolator and breaker contacts, loose

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contacts at meter terminals, loose contacts at universal line taps, etc, and the use of undersized conductors and cables, overloaded transformers, feeder pillar units especially where a fuse of 400A is placed on a bar of 200A, and other equipment in the distribution network. If a current much higher is allowed to flow along a conductor or any equipment, the equipment is said to be overloaded. This can lead to very high friction resulting from the high resistance the conducting material is presenting as the current (electron) is forcing itself through the materials of the conductor. This eventually leads to conversion of some of the electrical energy to heat energy thereby producing increase in the temperature of the conducting material [4].The power dissipated or amount of energy loss at this point can be represented as:

$$Energy\ Loss = I^2R$$

The amount of heat energy produced is equal to the amount of the electrical energy lost (I^2R). This energy loss is easily observed through voltage drop along the line as the current which is usually the power in this case, is transported over a distance along the cable or conductor or across equipment.as far as this loss is inevitable, it becomes obvious to say that no matter the size of the line material or equipment used, standard allowable limits have been set for each of them and growth beyond the standard limit is what is considered as the loss in the network. This kind of loss being a technical loss and eventually energy lost in the system, is an unbillable energy loss[4].

Power dissipation to the earth if sustained because of protection failure is a horrible means of wasting electric energy. This energywasted through the means of leakage cannot be accounted for by the distribution company at the time of settlement. In some case, vandals are in the habit of putting the network in this kind of loss crises.

$$Total\ Technical\ Losses = (HT\ Line\ Losses + LT\ Line\ Losses + Annual\ Cu\ Losses + Annual\ Iron\ Losses)$$
$$\%\ Technical\ Loss = (Total\ Losses)/(Unit\ Sent\ Out\ Annually)X100$$

It is known that technical losses occur when the energy is dissipated by the equipment and conductors in the distribution lines. The losses are greatly dependent upon the mode of operation and characteristics of the network. Technical losses are either fixed or variable. Fixed technical losses in the distribution lines account for between $1/4$ and $1/3$ of the total technical losses and are usually in the form of heat and noise and occur whenever the transformer is energized and cannot be influenced by the amount of load current flowing, but rather by the leakage current losses, open circuit losses, corona losses, and dielectric losses[5].In addition, Electrical India[6]asserted that technical losses can as well be influenced by losses due to continuous load of measuring elements and losses due to continuous load of control elements. In essence fixed losses do not vary in accordance with current flow. Fixed losses take the form of heat and noise and therefore occur because the transformer is energized. Between one-quarter and one-third of technical losses on distribution networks are usually referred to as fixed losses.

According toElectrical India[6], variable technical losses are losses that vary with the amount of electricity distributed and are, more precisely, proportional to the square of the current which consequently depicts that a 1% increase in current gives rise to an increase in losses of more than 1%. In the same vein, it is worthy to notethat variable technical losses are losses proportional to the square of the load current and therefore account to between 2/3 and ¾ of the technical losses in a distribution system and are essentially because of the line impedance, contact resistance and the joule heating losses.Practically, technical losses in distribution system irrespective of type occur because of the following conditions:

Lengthy Distribution Lines: In practice, 11 kV and 0.415 kV lines in rural areas are extended over long distances to feed loads scattered over large areas resulting in high line resistance, hence high I^2R losses in the line.

Inadequate Size of Conductors of Distribution Lines: The size of the conductors not selected on the principle of the required voltage regulation

Installation of Distribution Transformers away from Load Centers: Distribution transformers are not located at load centers hence the farthest consumers obtain very low voltage even if a good voltage level is maintained at the transformers secondary. This generally gives rise to higher line losses.

Low Power Factor of Primary and Secondary Distribution System: A low power factor contributes towards high distribution losses. For a given load, if the power factor is low, the current that flows becomes high and losses proportional to square of the current will be high too.

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BadWorkmanship: Bad Workmanship contributes significantly towards technical losses in the distribution system. Loose joints are a source of power loss.

Feeder Phase Imbalance: In this case three-phase customers have less voltage due to voltage drop among the phases.

Non-Compliance to Load Factor: If load factor within an area is not identified as power consumption of customer varies throughout the day and over seasons distribution losses will occur.

Poor Transformer Sizing and Selection: Since transformers have both load losses and no-load core losses and fixed iron loss depends on transformer core design and steel lamination molecular structure, poor sizing and selection will contribute to power losses.

Transformers on Continuous Load: If only one transformer is required during times of low demand such that the other may be switched off in order to reduce fixed losses and yet both are allowed to be on continuous load, then fixed technical losses become higher.

Other Conditions for Technical Losses: If the three phases of the low tension system have unequal load distribution thereby giving rise to high neutral currents, overloaded lines, abnormal operating conditions of electrical machines, low voltages at consumer terminals resulting to higher currents flow due to inductive loads, poor equipment quality and industrial loads, and current leakage.

B. Commercial Losses: These losses are losses incurred by the energy distribution company due to theft of electricity leading to substantial amount of energy received not billed and hence cannot be paid for. This kind of loss in the system represents the inefficiency in billing the available energy leading to some of the billable energy not billed. The billing inefficiency also known as commercial loss can be derived as:

$$Commercial\ Loss = 100 - Billing\ Efficiency$$

Where

$$Billing\ Efficiency = \frac{Energy\ Billed}{Energy\ Recieved}$$

In another way, Electrical India [6],maintained that Commercial losses are losses that can be traced to meter reading, defective meter and error in meter reading, billing of customer energy consumption, lack of administration, financial constraints, and estimating unmetered supply of energy as well as energy thefts. It is also important to note that commercial losses occur due to energy theft, billing problems, error in meter reading, unmetered power supply, and unmetered Losses for very small Load [6].

According to PHED[2], commercial loss being energy received but not billed or billable energy loss can appear in the form of the following:

Illegal Connection: In this scenario, consumers of electricity who are not in the billing system of the electric energy provider. This is especially perfected by touts and some staff of the electric energy provider who are not faithful in their duties. This is a condition of energy theft.

Tampering with Meters: If this is done with the sole objective of reducing the meter consumption especially by touts or staff of the electric energy provider.

Meter Bypass: Diversion of all or some of the load from the meter by constructing a bypass line to feed all or some of the customers' load. This kind of scenario is always made possible by touts or staff of the electric energy provider.

Under Billing of Customers: Customers are billed below their consumption. This is most of the time through connivance between the customers and the staff of the electric energy provider not probably with the intention of defrauding the company that provides the energy. Illegal reduction of the unit consumption of directly connected customers is part of under billing. This is usually done between the staff and customer.

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Placement of Consuming Customer on Minimum Charge: Some customers of this kind are placed on minimum charge sometimes through connivance between the staff and the customer out of inefficiency on the part of the staff. Laziness plays role in this kind of scenario. Customers are placed on a lower tariff. Sometimes, staff and customer connive to perfect this process.

Customer Reactivation Problem: Inability to reactivate customer whose account was closed due to fault and had been cleared and power supply restored. Inefficiency and laziness on the part of the staff can encourage this situation.

Illegal Credit Balance to Customer: Giving illegal credit balance to a consuming customer and sometimes not billing them for the energy consumed. This is always made possible through connivance between staff and customer.

Diversion of Power to Unscheduled Feeder: The idea of collecting money from customers with intent of diverting power to an unscheduled feeder is a serious challenge to the energy provider. This ushers in huge losses in the system because the billing system classifies the customers and their tariffs. It is therefore a sabotage for energy to be shipped to an unscheduled customer.

Generally, commercial losses are losses that can be traced to unmetered supplies, incorrect billing, untimely billing, wrong tariff, defective meters and energy thefts. The unmetered supplies are supplies that may not be captured when estimated amounts are used to calculate the amount of power to bill for. Secondly, some consumers may tamper with the meters to make them indicate or display less power than what is actually utilized.Energy theft may arise when consumers tamper with the metering, or collude with the energy supply or utility personnel to make illegal connections[5].

C. Collection Losses: These are losses that arise because of the inability of the electric energy provider to collect some of the money billed the customers. This can be derived as:

$$Collection\ Losses = Energy\ Billed - Energy\ Soled\ and\ Revenue\ Collected$$

Collection loss always arise because of illegal activities of some customers and some of the staff members of the energy provider that lead to the inability of the electricity providing company to collect some of the money billed the customers. It is actually a billed energy loss. It represents collection inefficiency and can be determined as:

$$Collection\ Inefficiency = 100 - Collection\ Efficiency$$

Where

$$Collection\ Efficiency = \frac{Amount\ Collected}{Amount\ Billed}$$

According to PHED[2], collection losses are usually made possible in the following ways:

Existing Account being Abandoned by Customer: Dropping of account where the staff connive with the customer to abandon the customer existing account which has high debt and open a new account for the customer with the debt on the old account unpaid.

Reduction of Customer Bill in the Billing System: Customer conniving with the staff of the energy provider to crash his bill in the billing system. In this case the staff may reduce the customer's high debt to the minimum or even to zero amount. Meanwhile the energy provider has to account for all these losses at the time of settlement for energy delivered to her.

Customers Refusal, Unwillingness or Forgetting to Pay:This is particularly when there is no strategic plan for the staff to persuade or at worst coarse where necessary the customers to clear their bills. Individuals, communities are not only the ones involved in non-payment of electricity bills, government agencies are not left out [7].In some cases, the company resort to bulk billing if individuals fail to pay for the energy utilized. Bulk billing is perceived to play in because of resistance from individuals to pay their electricity bills. Non-payment of electricity bills by some consumers lead to losses on monthly basis and it is a challenge to the electric energy provider. In certain places, residents claim to be indigene to avert payment of electricity bill. This is not applicable to the petroleum sector. Especially in Nigeria, Government wants the electric energy provider to pay for the value of energy delivered, but its agencies are not paying their electricity bills regularly and, in some cases, not at all.

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Bill Payment Problems Due to Bank Processes: Customer bill payments that get stuck due to bank processes resulting from wrong payment processes or channel. Absence of enough payment outlets to enable customers who are willing to pay their bills especially in the rural areas to pay their bills conveniently. Some staff who are not faithful in their duties and touts who collect money from customers pretending to help make payment into their accounts for them but divert such money for personal use. Illegal reconnection of customers disconnected due to non-payment and theft by touts and some staff members.

III. CONVENTIONAL METHODS OF LOSS REDUCTION

A. Technical Loss Reduction Methods

Considering that energy loss due to heat is a technical loss, it becomes very obvious when there is leakage of power supply to the ground through a resistance as an example, when vegetation is in direct contact with the current carrying line and the soil where the trees present high resistance to the flow of the current to the ground. This kind of loss can always be avoided by using covered conductors while constructing lines in such high vegetation areas [7].

Technical losses can be put under control by choosing appropriate sizes of materials and ensuring that current (power) flow through them is within their standard ratings and ensuring trees do not come in contact with the line. The moment this condition is achieved, some unbillable energy will be recovered for possible utilization and billing. It is necessary to have functional distribution code that will cover engineering interactions and relationships within the distribution system [1]. The Government must collaborate with the electric energy provider in tackling vandalism.

Technical losses in the electricity distribution system cannot be eliminated, but can be minimized by proper planning of the distribution systems to ensure that power remains within limits by making use of proper jointing techniques and keeping the number of joints to a minimum, appropriate selection of conductor size and transformer in terms of efficiency, size and location, connecting heavy consumers directly to the feeders, regular inspection of the connections, isolators, drop out fuses, low tension switches, transformers, transformer bushing-stem, and other distribution equipment, use of efficient electronic meters that are also tamper-proof, maintain the network components and replace those that are deteriorating, worn out or faulty, improving power factor by adding shunt capacitors, and proper load management and load balancing. Very importantly, it is important to locate the distribution transformers at the load center and if possible, keep the number to a minimum [5].

According to Electrical India[6],better ways of reducing technical losses in the electricity distribution system are numerous with effort on converting low voltage line to high voltage Line, connecting large commercial or industrial customers directly to the feeder,carry out preventive maintenance program of line to reduce losses due to faulty, improvement of weak areas of the network, reducing the length of low tension lines,separation of rural feeders from industrial feeders, reduction of number of transformers in the network, placement of feeders and transformerson average capacity utilization, reconductoring of the network (line), use of Arial Bundle Conductor (ABC), and installation of lower capacity transformers at each consumer premises.

B. Commercial Loss Reduction Methods

Commercial losses can be reduced or eliminated if there is effective capturing of all the illegally connected customers in the network, fixing of appropriate types and sizes of smart and tampering of proof meters and in some cases installing, and effectively monitoring, the split type prepayment meters on service poles remote from customers' buildings and monitoring to identify illegal downward migration of customer tariff, the recovering of most of the billable lost energy for billing. Collaboration with relevant law enforcement agencies to ensure that unauthorized people who climb the poles belonging to electric energy provider are apprehended and punished accordingly [2].

A technology meant to aid efficient meter reading and billing system is generally adequate for this scenario. If this technology is introduced into the billing system, it averts the prolong process of meter reading, processing and compilation. The device will put an end to the delayed and tiring process of marketers going to the field to read meters, compile figures and sent over the server for processing eliminating the need for marketers to wait to receive back the figures for ratification before the final collation and print. The device works in sync with the server which accesses meter readings for immediate collation, billing and printing. If the device is correctly used, readings will be correctly captured, customers billed appropriately and bills will be timely printed and dispatched, thereby averting customers'

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complaints of estimated and delayed billing, enabling them more time to make payments. Indeed, this is an automated billing system.
The use of prepaid meter is an essential and the surest means to enhance loss reduction in distribution system. Every customer is metered and avoidance of meter bypass must be encouraged in the system to avoid effort in futility. Every consumption is automatically paid for and generally leads to lower ATC&C losses.

The Government must collaborate with the electric energy provider in tackling energy theft. Anti-theft drive is one of the surest ways of reducing revenue loss.

According to Electrical India [6], another means of reducing commercial losses include: engage ondebts recovery programs, engage online data mapping, implementation of energy audits schemes, use power theft checking drives to mitigate power theft.

C. Collection Loss Reduction Methods

In pursuance to mitigation of poor collection the need toinstitutea culture that will generally make it impossible for customers who owe the electricity provider to have power supply must be encouraged. Another important remedy is to enforce commensurable punishment for defaulting staff and touts who engage in illegal reconnection and diversion of customers' money meant for payment of electricity bill for personal use. Different payment channels must be encouraged for ease of payment of electricity bill and also discourage slow banking process that normally hang customer's money in a bid for bank staff to meet target. Very importantly is the regular auditing of the billing system to help identify customers' debt crash, normalize the account and give appropriate punishment to the staff and customers involved in this kind of act [2].

Accurate metering systems to ensure financial viability of the electricity supply industry is mandatory. This means that modern accurate metering systems with reliable communication facilities are deployed to measure and record electrical energy generation, transmission, distribution and use [1].

Major operational plans should be adopted in relation to the building of new commercial lines to several places on the energy provider's network including many new payment points.

As a means of curbing losses, it is mandatory to follow the diagram on meter reading, bill distribution, and customer validation for customers not connected to prepaid meters. It is certain that effective cash collection begins with effective bill distribution. As a means of recovering debt, it is important for the energy provider to carry out debt discount promotion. It is believed that the energy providing company will assuage its billing problems if the debt discount promotion platform is well articulated. This exercise will obviously bring the required solutions to customers' billing issues, with a view to encouraging them to pay. Energy calculator has to be embedded to make the process transparent as it will produce accurate bills. The doubt to the billing methodology in most case which include issues relating to non-reading of meters, wrongful disconnection, and wrongful estimation, among others will be ameliorated.

Every utility company providing energy should carry media along with their modus operandi to customers because it is part of their interest to pass information across. The involvement of the media will help in rebranding and building the mindset of the customers with regards to the services rendered. This platform will encourage customers who are in the habit of not paying their bills to pay their bills or risk disconnection.

IV. CONCLUSION

For every energy provider to be able to pay for energy it received, it must be very efficient in the handling of the energy it received by ensuring that energy received is not wasted as it is being transported to the customers having in mind that all the customers who received the energy correctly pay for it to achieve the expected level of efficiency. Measures must be put in place to account for the energy as it is being transported from one point of its network to the other until the last customer receives it. To do this, meters must be installed at the voltage interface points, and at the geographical boundary interface points amongst the administrative cells.

The revenue processes must focus on the different auditing processes, understanding the auditing documents, remedial actions, replacing of meters and the correct means of data management. Tamper detection and investigation processes must be guided by proactive tamper prevention measures. Tampering detection process and investigation methods are

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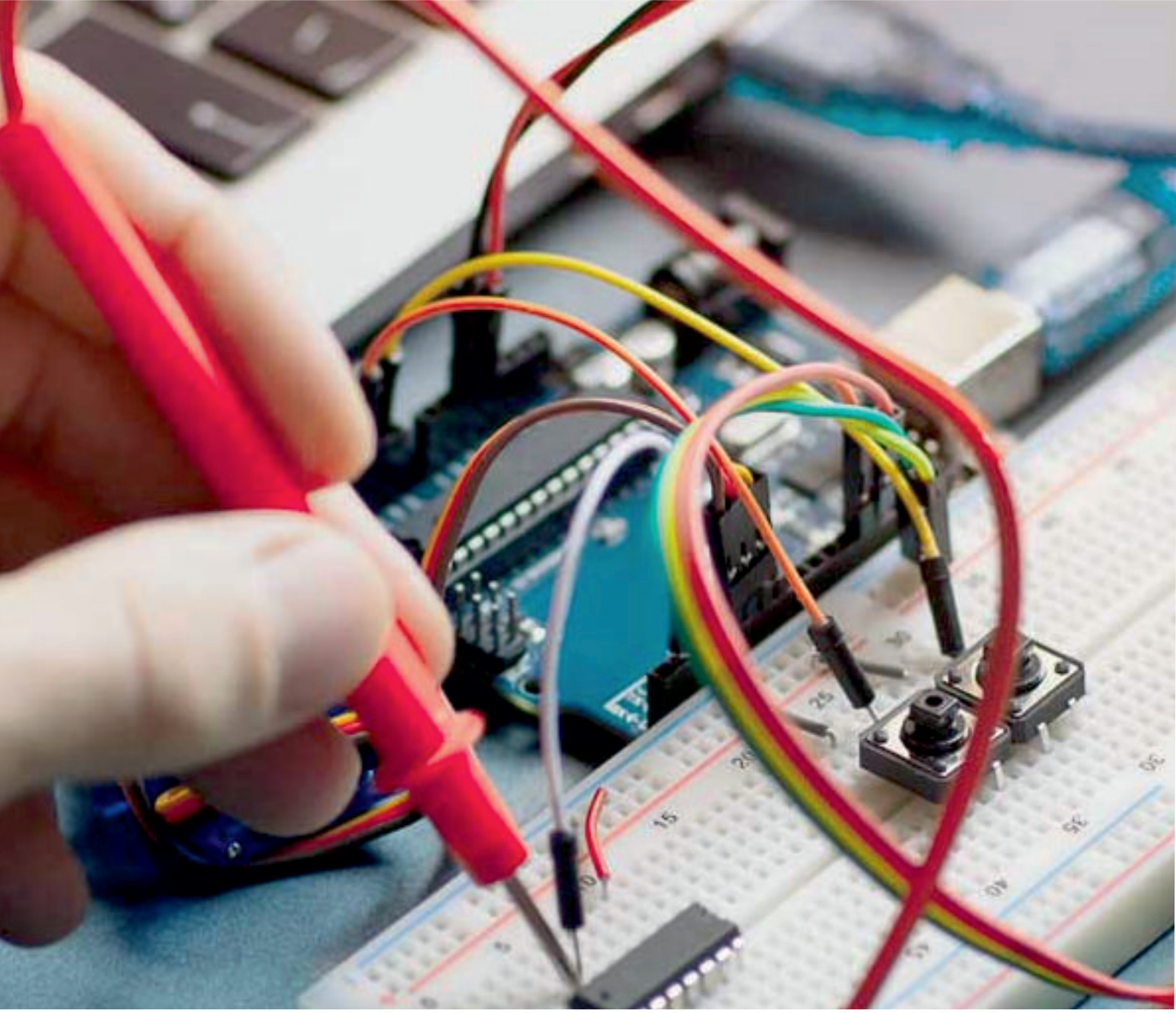
| DOI:10.15662/IJAREEIE.2021.1007003 |

essential for effective loss reduction. Standards, policies, guidelines and laws must be in place for efficient revenue loss prevention. In addition, best practices and new technology that could be used to curb or minimize losses are encouraged.

REFERENCES

[1] Manitoba, "Transmission System Operator (TSO) Training," Manitoba Hydro International, A division of Manitoba Hydro International Ltd, 2015.
[2] PHED,"Intelligent Power Special Edition Newsletter," Port Harcourt Electricity Distribution Company, 4th Edition, vol. 3, Feb. 2015.
[3] PHED,"Intelligent Power Special Edition Newsletter," Port Harcourt Electricity Distribution Company, 4th Edition, vol. 4, March 2015.
[4] PHED,"Intelligent Power Special Edition Newsletter," Port Harcourt Electricity Distribution Company, 4th Edition, vol. 1, Dec. 2014.
[5] Engineering@Electrical-Equipment.Org.,"Power Losses in Distribution Lines: How to Reduce Them," 2021.
[6] Electrical India, "Losses in Distribution and Transmission Lines," India's Oldest Magazine on Power and Electrical Products Industry, 2018.
[7] PHED,"Intelligent Power Newsletter," Port Harcourt Electricity Distribution Company, 2nd Edition, vol. 1, May 2014.



INNO SPACE
SJIF Scientific Journal Impact Factor

Impact Factor: 7.282

doi cross ref

ISSN INTERNATIONAL STANDARD SERIAL NUMBER INDIA

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International Journal of Advanced Research

in Electrical, Electronics and Instrumentation Engineering

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