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Evaluation of Aggregate Technical, Commercial and Collection Losses in 11kV Power Distribution Network

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ABSTRACT

The aim of this study is to evaluate the Aggregate Technical, Commercial and Collection (ATC&C) losses in 11kV power distribution network in order to assist the power distribution companies (Discos) to operate efficiently in the Nigerian Electricity Supply Industry (NESI). Monthly and yearly data were obtained based on recording, reading of energy meter and energy consumption (kVA, kWh) from 11kV line at Okpana sub-station in Asaba, Delta State, using Itron ACE pilot version 6.3.0 software to obtained relevant data from Okpana 11 kV feeder and EDMI EziView RAJ 4.40. The data obtained from ATC&C losses are energy delivered, energy received, energy and amount billed and amount or cash collection etc. The billing efficiency, collection efficiency and market efficiency were used to evaluate the power losses parameters from the 11kV power distribution network, resulting to determine the billing efficiency, collection efficiency, and market efficiency. It was observed that bill efficiency value is exponential distributed in nature; this was due to variation in energy delivering to customers. The revenue collection efficiency value has a correlation with ATC&C based on technical losses present in power distribution network. The energy losses resulting to loss in revenue can be reduced by deployment of silver conductor cable for power distribution network.

1. Introduction

Growing population and industrialization create huge need for electrical energy [1]. Unfortunately, electricity is not always used in large demand in the same location it has been generated. Hence, long cables and conductors are used to transmit the generated electrical power through overhead and underground system known as transmission. Transmission as good as it may sound i.e., making electrical power available to all consumers at different locations and distances far away from generating stations has its own short comings or challenges, of which losses is a major one [2].

Distribution line losses are responsible for the huge gap between energy injected or amount of energy delivered to the distribution system and amount of energy consumers are billed, this aspect is considered as the Aggregate Technical, Commercial and Collection (ATC&C) losses. It is important to know the magnitude and cause factors of line losses because the cost is recovered from consumers. The difference between the transmission and distribution energy units is referred to as transmission and distribution losses, which

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can be expressed as Transmission and Distribution (T&D) losses and loss due to non-realization of payable demand [3, 4].

Power system losses are wasteful energies due to internal or external factors that are dissipated in the system. Radial distribution system has only one source of power for group of electricity consumers. Its network leaves the substation and passes through the network area with no usual connection to any other supply [5, 6]. The efficiency of a power transformer is less than 100 percent due to the present of power losses in forms of copper losses, core losses and auxiliary losses. A large part of distribution losses appears in distribution transformers, while maximum efficiency of a transformer is achieved when copper losses are equal to iron losses [7, 8].

No matter how careful a power system is designed, losses are inevitable. Therefore, evaluation of these losses is of paramount importance. If there is a genuine baseline for computation of these losses, utilities can take steps to limit or minimize them, and this will lead to gross reduction in the cost of operations and consequently, gross reduction in the cost of electricity to consumers. Aggregate Technical and Commercial (AT&C) losses is the appropriate index used in a situation where the system is associated with losses which occur due to various reasons [9, 10]. In Nigeria, as contained in (NERC, MYTO-2.1), this concept is referred to as ATC&C losses. ATC&C losses were adopted by Nigerian Electricity Regulatory Commission (NERC) during the Nigerian Electricity Distribution Companies privatization in the year 2013 as one of the criteria for identifying the most preferred bidders. That is, the buyers with the most aggressive but feasible ATC&C loss reduction trajectory over a 5-year period were considered.

Notwithstanding, it is hoped that in this paper, various feeders in the network area and their nomenclatures will be identified, energy import and export points of the network area will be established and a methodology for evaluating losses of the network under study using the index ATC&C losses will be developed. ATC&C losses as an index to indicate losses in the power system is trendy as it provides clear picture of both energy and revenue loss conditions [11].

Since system losses represent a considerable cost for utilities and energy consumers, its evaluation and reduction have been recognized as of interest by researchers. There are many distribution network devices responsible for energy loss, these includes losses along distribution feeders, losses in transformer windings and losses associated with unbalanced loads connected to transformers. Unbalanced load is a common occurrence in three- phase distribution systems. However, it can be harmful to the operation of the network components, its reliability and safety. Thus, a distribution system unbalance phenomenon has been the focus of research in recent decades [12, 13].

According to [14], the distribution sector is a major revenue generation drives that link the Generation - Transmission -Distribution chain. Any drawback on the distribution sector will affect the power sector value chain and is threatening the entire process of power sector reforms. While the power generation sector in the country is struggling to meet rising demand, the distribution sector has been reeling under losses and has been in focus with various measures being taken by the Government of India to make the State DISCOMs/Utilities viable.

The distribution losses can be reduced by proper selection of distribution transformers, feeders, proper re-organization of distribution network, placing the shunt capacitor in appropriate places, theft control, adoption of upgraded technology etc. HVDS should be implemented at a faster rate. Training of the operating personal would result in improved system operation. The distribution companies should be ready for initial investment keeping in view of future savings in energy. To reduce the losses and to improve the system efficiency, a policy has been made [15].

The Policy initiatives for Distribution Reforms are aimed at system up-gradation, loss reduction (aggregate technical and commercial losses), theft control, consumer orientation, commercialization, decentralized distributed generation and supply for rural areas, introducing competition [16].

By 2001, T&D losses in New Delhi had reached 53%. A large part of these losses was due to theft. The Delhi Vidyut Board had run heavy losses for a long time, and only survived due to fiscal support. Delhi's government invited bids for the purchase of a 51% stake in the utility. These bids were not to be based on the utility's asset levels, but rather

electricity loss reduction targets, which would form the basis for tariff determination. The private sector company that quoted the largest reduction in electricity loss levels would win the auction. Tata Power, one of India's largest private sectors utility companies, won the auction and took a 51% stake in the company. The main ownership was retained by the Government of Delhi. Tata subsequently employed professionals at top-level management; empowered use of IT enabled services; and cracked down on electricity theft by installing meters and tracking consumption trends. As a result, Tata Power brought down transmission and distribution losses from 52 % in 2002 to 18.5 % in 2008 [17, 18].

The followings are the major problems that initiated from this research; an analysis of the ATC&C loss data obtained from the NERC, has shown that the eleven electricity distribution companies (Discos) are still finding it difficult to cut down losses. Theft and pilferage of electricity, metering issues, inefficient Billing, inadequate revenue collection by discos, low customer satisfaction, non-remunerative tariff structure & subsidies are all forms of "commercial and collection losses" that bedevilled the NESI. It is upon this backdrop that a research on the evaluation of ATC&C losses is being studied in view to improve the electricity power delivering in Nigeria.

2. Methodology

The monthly data based on meter reading and recording of energy consumption (kVA, kWh) from 11kV line at Okpana community in Asaba Delta State were obtained; using Itron ACE pilot version 6.3.0 software linked to Okpana 11 kV feeder and EDMI EziView RAJ 4.40-meter software. The data obtained from ATC&C losses data are energy delivered, energy received, energy billed, amount billed and cash collection etc. Also, 2013 to 2019 monthly data were obtained from 11kV Okpana sub-station. Using the billing efficiency, collection efficiency and market efficiency formula to evaluate the power losses from the 11kV power distribution network, resulting to determine the value of billing efficiency, collection efficiency, market efficiency etc., the corresponding data are presented (Table 1).

Table 1 Obtained Data on Energy Delivered, Energy Billed and Total Amount Billed.

Year	Energy Delivered (kWh)	Energy Billed (kWh)	Total Amount Billed (₦)	Cash Collected (₦)
2013	242,209,770	172,358,112	2,818,421,849.06	1,773,031,709.85
2014	251,913,531	206,482,134	3,209,631,447.64	1,664,919,766.26
2015	229,344,270	200,718,004	3,108,937,226.58	1,692,535,443.71
2016	248,976,300	211,148,784	3,113,709,200.63	1,688,908,603.63
2017	235,863,820	201,074,603	3,027,233,886.96	1,782,909,468.58
2018	227,602,340	191,886,125	3,009,647,027.53	1,605,520,552.13
2019	236,414,990	198,083,528	3,347,818,884.72	1,765,982,261.50

The following formula, were used to evaluate the data obtained from the field under the area of investigation.

$$Billing\ Efficiency = \frac{Billed\ Enegy}{Input\ Energy} \quad (1)$$

$$Collection\ Efficiency = \frac{Revenue\ Collection}{Billed\ \ Amount\ (current\ \ Assessment)} \quad (2)$$

Marketing efficiency is the degree of market performance. Marketing efficiency is the ratio of the market output to market input (cost of resource).

$$Marketing\ efficiency = \frac{Output}{Input} \quad (3)$$

Table 2 Results obtained for Bill Efficiency, Collection. Efficiency, and ATC for seven years (2013 to 2019)

Year	Bill Efficiency (%)	Collection Efficiency (%)	ATC (%)
2013	71.16	62.91	55.23
2014	81.97	51.87	57.48
2015	87.52	54.44	52.35
2016	84.81	54.24	54.00
2017	85.25	58.90	49.79
2018	84.31	53.35	55.03
2019	83.79	52.75	55.80

3. Results and Discussion

The data obtained from the 11kV line at Okpana community in Asaba Delta state, were analysed using Microsoft excel, the corresponding bar chart are presented in Figs. 1 - 6.

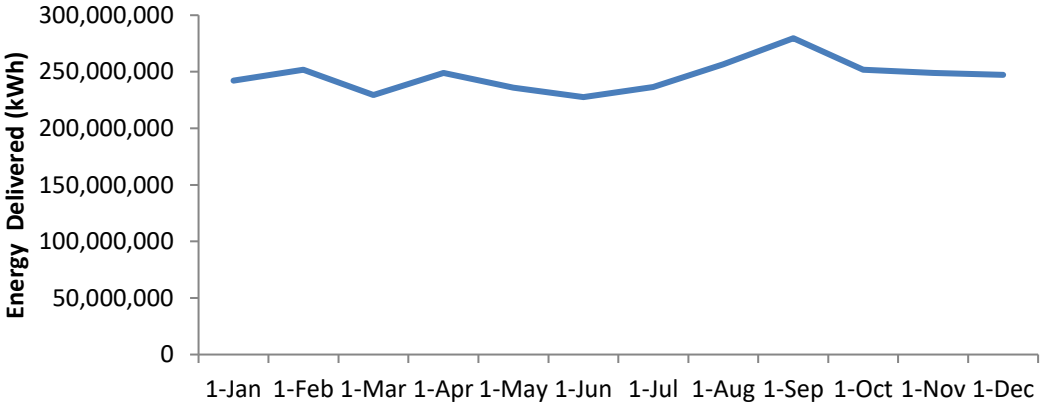

Fig. 1 Energy Profile for year 2013.

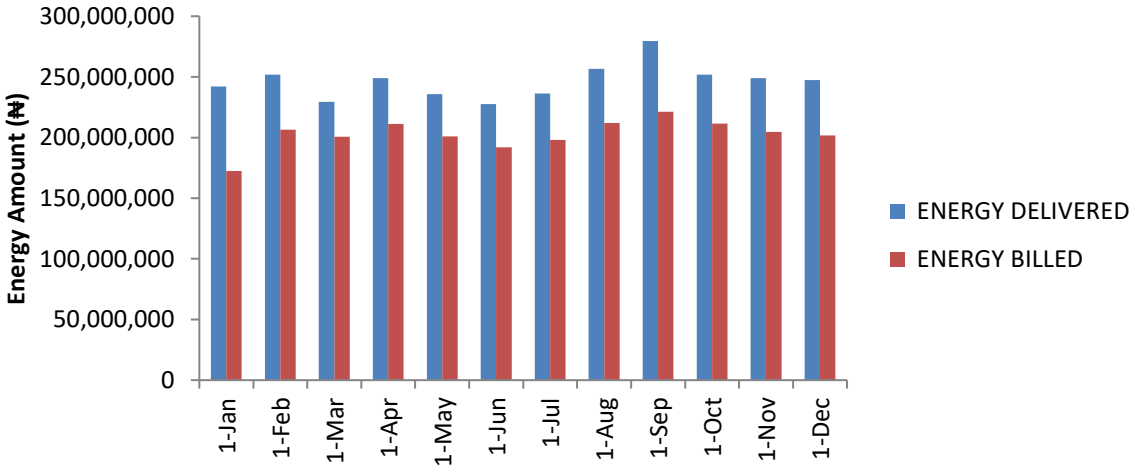

Fig. 2 Comparison between Energy Delivered and Energy Billed in 2013

In Fig. 1, the energy delivered against the year were considered. It was observed that energy delivered is not constant or linear for the year 2013. Therefore, the availability of power is not constant due to insensate supply of electricity.

It was observed from the bar chart (Fig. 2), i.e., the comparison between energy delivered and energy billed in 2013, that both delivered energy and energy billed in 2013 are not the same; therefore, losses availability in power network was established. Such could be copper, core loss etc.

A corresponding comparison of energy delivered and energy billed for various years is presented in Fig. 3. It was observed that there is decreased in Energy delivered and energy billed from 2013 to 2015 and the system witnessed a slightly increase of energy delivered and energy billed from 2016 to 2018. The differences in energy level for various years are presented in Fig. 4. The energy level differentials are due to copper losses, energy theft and core loss etc.

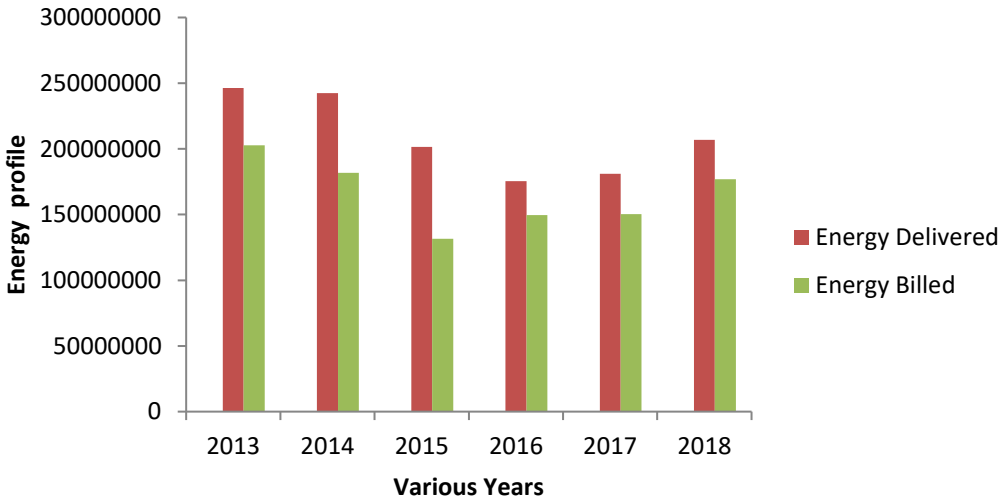

Fig. 3 Comparison of Energy Delivered and Energy billed various Years.

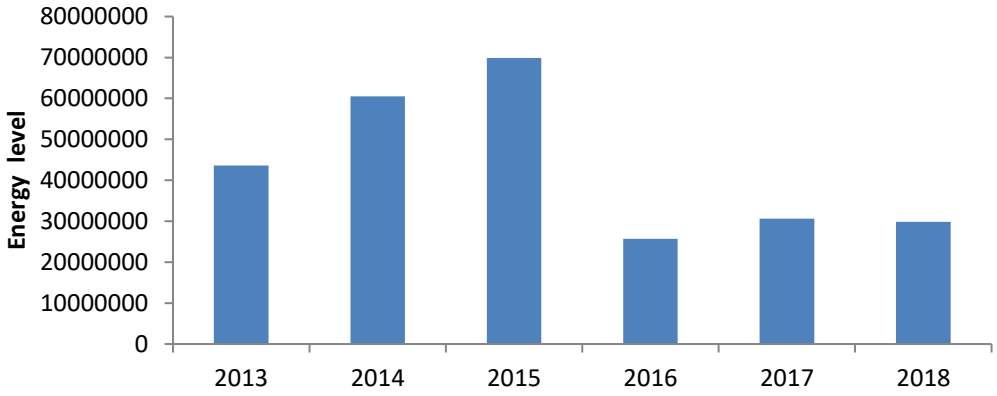

Fig. 4 Difference in energy level in various years.

The data from Table 1 as presented in Fig. 5 show the comparison between total amount billed and cash collected. In Fig. 6, the three basic output parameters were determined for difference years considered in this study. It was observed that bill efficiency is exponential distributed in nature, this was due to variation in energy delivering to customers. In addition, revenue collection efficiency has a correlation with Aggregate Technical, Commercial and Collection (ATC&C) based on technical losses present in power distribution network also result to losses of energy in terms of revenue and deployment silver conductor help to reduces loss along the power distribution cable lines.

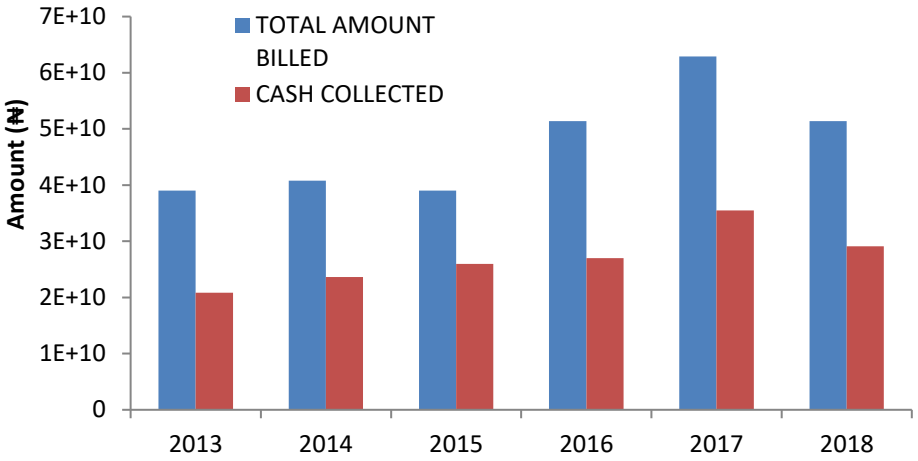

Fig. 5 Comparison between total amount billed and cash collected.

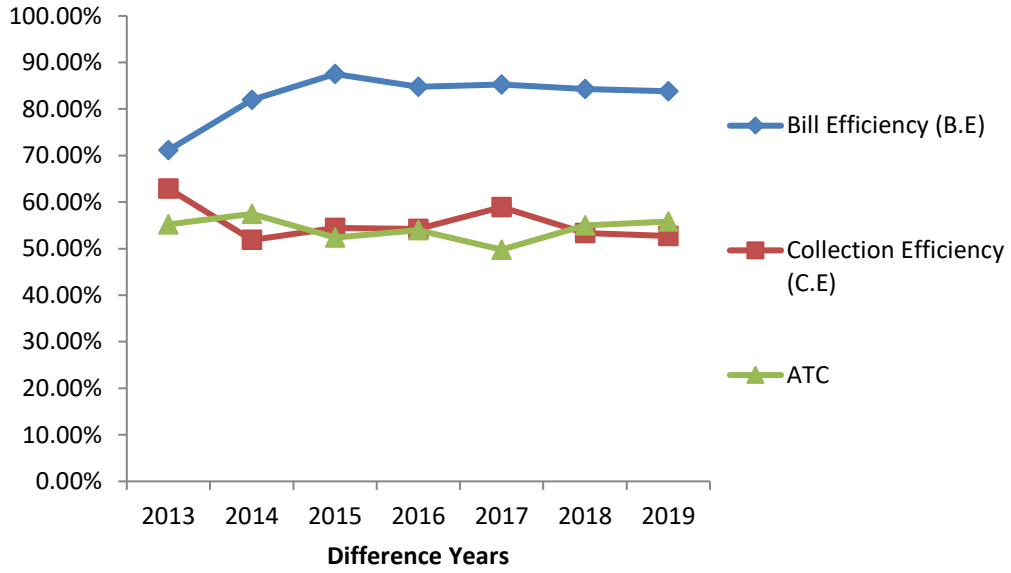

Fig. 6 Output Parameters for various Years.

4. Conclusion

Based on this study, the DISCOs can easily determine the various parameters affecting ATC&C losses in 11kV power distribution network. It was observed that bill efficiency is exponentially distributed in nature, this was due to variation in energy delivering to customers. The revenue collection efficiency has a correlation with ATC&C based on technical losses present in power distribution network. Energy losses in terms of revenue can be enhanced by deployment silver conductor to reduced loss along the power distribution cable lines. The DISCOs will generate more revenue as a result of the reduction in ATC & C losses in the power distribution network and also power loss reduction on 11kV distribution network. The eradication of energy loss will enhance the available of power electricity to consumers. In addition, consumer's tariff on energy charge will be reduced and maximum utilisation of installed capacity of transformer, switch gears and lines are enhanced.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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