American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-12, Issue-2, pp-43-56
www.ajer.org
Research Paper Open Access

Reliability Improvement for 11KV Distribution Network of Rumuodomaya using Predictive Method

O. O. Agha[1], D. C. Idoniboyeobu[2], S. L. Braide[3]
[1] *Corresponding Author: Department of Electrical Engineering, Rivers State University, Port Harcourt, P.M.B.5080, Rivers State, Nigeria.*
[2,3] *Department of Electrical Engineering, Rivers State University, Port Harcourt, P. M. B.5080, Rivers State, Nigeria*

ABSTRACT:*This research used predictive reliability indices to improve the performance of 11 kV distribution feeders at Rumuodomaya grid in Port Harcourt, Rivers State, Nigeria. The research used reliability indices between 2019 to 2021 of the case study to simulate system reliability indices. The simulation is carried out using the Electrical Transient Analyzer Program Software (ETAP Version 12.6). From the reliability indices result for 2019 to 2021, it was reveal that Bus 8 and Bus 21 have the highest failure rate of 0.4541 (f/years) especially in 2019, therefore, the system should be reconfigured to decrease the number of crowded distribution networks. Furthermore, the System Average Interruption Duration Index (SAIDI) value for bus 28 shows 0.0853 system hours/customer, while the Customer Average Interruption Time Index (CAIDI) value for bus 31 shows 0.0885 hours/client system. Bus 30 produced the highest CAIDI average load value of 13.825 h/fault, while Bus 14 shows the highest average load value out of 327.2 Kw. The result also shows that the Expected Power Not Delivered (EENS) for Bus 29 is the highest value of 170.9585 (IEAR), while Bus 9 gave the highest IEAR in 48.60 minutes. The overall result from the graph indicated that between 2019 and 2021, Bus 28 has the highest number of customer failures in 2019 at 35.15 minutes. From the results, the Rumuodomaya network requires expansion in the distribution infrastructure to reduce poor supply from the energy source, load shedding times, downtime due to poor line conditions, and other planned or unplanned outages.*

KEYWORDS: *Predictive Reliability indices, Distribution system, SAIDI, CAIDI, IEAR*

Date of Submission: 20-01-2023 Date of acceptance: 03-02-2023

I. INTRODUCTION

Stable and quality electricity supply contributes greatly to the economic growth and development of a country. The inexorable migration of people from rural to urban areas lead to unprecedented increases in energy consumption, which prompted the installationof the distribution grids. An essential component of the total energy supply system is the distribution system. This is because the utility's distribution grid acts as the last connection between its grid and its customers. Distribution substations monitor and adjust circuits within the system. However, over 80% of all customer issues have been determined to be caused by malfunctioning power distribution systems. The efficacy of power distribution system is assessed in terms of efficiency, continuity or dependability of service, service quality in terms of voltage profile and stability, and system performance. [1][2][13].

In Nigeria, expansions of power generation and transmission infrastructure are carefully planned, but expansions of distribution systems are often unplanned, resulting in high technical and commercial losses and poor power quality. Hence power outages have become a common thing in the country. Also, in low-voltage networks and medium-voltage networks, power failure can occur multiple times per day. Factors that contribute to power failure include poor planning, lack of system topology information or current status information of distribution components, lack of effective operational planning tools and innovative methods for discovering, isolating, and restoring services. All of these lead to increased system losses, poor power quality and reliability, increased peak demand, and poor sales performance. Also, lack of maintenance of equipment used in the distribution systems contributes to degradation or failure of power over time [2 – 6]. According to Due to this issue, distribution managers must ensure reliability of distribution system in the country.

According to a popular definition, reliability is the likelihood that a product will fulfil its intended purpose for the specified amount of time without experiencing any unanticipated failures., but in terms of power distribution system, reliability refers to the ability to deliver uninterrupted service to customers [3][4][5]. The performance efficiency at the customers' load points is connected to the reliability evaluation of a distribution system. Thus, distribution system reliability indices can be presented in many ways to reflect the reliability of individual customers, feeders, and system-oriented indices related to substations [5][6][7]. The Power Holding Company of Nigeria (PHCN) may investigate the potential causes of the inadequate electric power infrastructure and suggest solutions to enhance system performance, enabling consumers to get high-quality services that are readily available, but Port Harcourt Electricity Distribution Company (PHEDC) is the electricity company for Rivers State [8][9].

This study focus on the reliability improvement of the the Rumuodomaya grid, located in Port Harcourt, Rivers State in Nigeria. The grid has 11/33 kV substation that supplies the mains voltage in municipal distribution networks of 33 kV or 11 kV. For customer consumption, the voltage is reduced by distribution transformers to 415V three-phase or 220V single-phase. This process is common for Nigeria's power system [3]. However, the unreliable distribution systems in the region continue and power supply failure is a daily occurrence that has cause problems in equipment, production, revenue, and reputation of businesses that depend on electricity. Hence this research analyses the performance of the existing network and proffers solutions to improve the distribution system in the region. The method used is Predictive Reliability Assessment. ETAP was used for the simulation to get the reliability indices for 2019 to 2021 for the Rumuodomaya grid. The proposed approach is applicable to Nigeria's current 11kV and 33kV distribution networks.

II. LITERATURE REVIEW

2.1 Overview of electricity industry in Nigeria

In Nigeria, the electricity industry has grown from a series of relatively small stand-alone power stations in the early 1950s to an integrated system now known as the Power Holding Company of Nigeria (PHCN), which later was divided into sub-sectors and disband [10] [11]. The sub-sectors are made up of 18 companies which include: 11 Distribution Companies (DISCOs), 6 Generation Companies (GENCOs) and 1 Transmission Company of Nigeria (TCN). These companies are entrusted to execute the functions related to the generation, transmission, distribution, trading and wholesale supply as well as the resale of electricity in the country [9] [12].

The electricity generated are transmitted through transmission lines that use three phases namely alternating current (AC), single-phase AC current and high-voltage direct current system. However, transmission of electricity using high voltage (110 KVA or 330 kVA) used in Nigeria, aids in the reduction losses [12]. Substations in Nigeria reduce the voltage of transmission lines to below 33 kV and 15 kV. The voltage is then further reduced through distribution transformers to 380V three-phase or 220V single-phase voltage suitable for as many consumers as possible [12]. A substation is an enclosed yard containing switches, transformers, and other electrical equipment. When the substation voltage drops, power flows through the distribution system to industrial, commercial, and residential facilities. Distribution transformers scale down the voltage to the appropriate voltage for customers or end-users at crucial places near the distribution machine. Power distribution system efficacy is assessed in terms of efficiency, continuity or dependability of service, service quality in terms of voltage profile and stability, and power distribution system performance. Customers expect greater quality service as electrical and technological equipment becomes increasingly sensitive [1][3][6].

However, long-term statistics for Nigerian power plants are not accessible for reliability performance evaluation. Expected lifetime conditions can be teams or systems that are calculated, evaluated, planned and built [17]. To supply customers with power, most distribution systems are radial and consist of main feeders and cross-distributors. The hub-and-spoke design of electrical distribution systems is vulnerable to failure-induced outages. This research project investigates the reliability of electrical distribution systems. The frequency 'number of outages during the study period', the 'duration' of an outage lasting, and the magnitude of the outage 'how many consumers will be out of order' affect the reliability of the power grid.

2.2 Reliability of Distribution System

Reliability is the capacity of a system to carry out its intended function under operating conditions. Power distribution system reliability is the degree to which the components of the bulk electric system function in a way that permits customers to receive an amount of energy that is within the bounds of acceptable standards and in a manner that meets their needs [14] [15]. The duration of an outage, the amount of time needed to replenish supplies, its frequency, the number of customers it affects, and the severity of any negative effects on the electric supply are all measured by the power distribution system reliability. Vulnerability of the power system is a component of the reliability of the power distribution system, along with service continuity, customer satisfaction, and meeting demand.

The significance of reliability parameters is related to the of dependability characteristics, which is crucial in load analysis, as recognized by the Central Authority of Electricity (CEA) and the applicable regulatory authority. The following are the definitions of dependability parameters [16]:

i. A non-interruptible power source is required by the client (24hrs 7 days).
ii. The reliability metrics have become one of the reference parameters for evaluating the utility's performance.
iii. The National Electricity Policy of 2005 (NEP 2005) requires regular Reliability Index reports to be submitted to the CEA and the appropriate Regulatory Commission.
iv. Create a robust competition among electrical firms to compare dependability parameters.
v. With the best dependability criteria, the utility's brand image improves.

To deliver power consistently and reliably, an appropriate power distribution system must be selected. Several variables influence selection criteria, including economy, location, and practicality. Network systems should be selected based on the following characteristics [13]:

i. High reliability
ii. service continuity
iii. Low initial investment
iv. frequency and voltage variations

2.3 Levels of Service Dependability

Reliability is the chance of a system to function continuously to provide services without loss. According to [3], reliability and dependability are closely related because a reliable system is one that can be depended on. The performance of a device or system according to its function during a specific duration and operating circumstances is referred to as reliability. The various level of dependability service is divided be split into three (3) categories, among others [16]:

i. System dependability is quite high: Under normal conditions, the system has adequate capacity to deliver electricity at peak loads with excellent voltage variations, and in an emergency with grid disruptions, the system naturally requires appropriate equipment and security to prevent the existence of various types of interference in the system.
ii. Moderate system reliability: Under normal conditions, the system has the ability to deliver peak loads with good voltage swings, and even in the event of a power outage the system is able to deliver functionality. even under maximum load conditions. Therefore, a large amount of equipment was required for this system to overcome and overcome these disturbances.
iii. Low System Reliability: Under normal conditions, the system has enough capacity to deliver power during peak loads and experiences large voltage fluctuations, but when a system failure occurs, the system cannot handle the load at all. Therefore, it should be dealt with first.

2.4 Reliability Metrics

The Institute of Electrical and Electronics Engineers (IEEE) has standardized reliability metrics and reliability calculations for many electrical networks and the economic analysis assesses the likely expenses of a proposed venture, program, or policy, and allocates qualities accordingly [18].These metrics assess power system reliability by providing data on the frequency and duration of customer outages on a particular grid. Failure of one component of the power system can result in partial or total system failure. Failure rates and repair or replacement times for these components represent their availability [19]. The load point index evaluates the reliability of each load point in the system. At each load point, these metrics provide the average failure rate, average downtime, and average annual downtime. The failure rate and downtime (repair time or downtime) of each component upstream of the charging point is used to determine the load point index.

In this research, various parameters are used to determine the reliability assessment to improve distribution system of Rumudomaya substation. The IEEE Standard 1366 defined parameters for power reliability indices, reliability assessment and economic indices. Among others, these parameters are System Average Interruption Frequency Index (SAIFI), System Average Interruption Duration Index (SAIDI), Customer Average Interruption Frequency Index (CAIFI), Customer Average Interruption Duration Index (CAIDI), Average Service Availability Index (ASAI) and Average Service Unavailability Index (ASUI), as Energy Not Supplied Index (ENS), Momentary Average Interruption Frequency Index (MAIFI), Energy Not Supplied (ENS), and Interrupted energy assessment rate (IEAR) index [3] [20]:

i. SAIFI is the average frequency of sustained outages per customer within a predefined range, expressed as the total number of customer outages divided by the total number of customers served.
ii. CAIFI is a measure of the average frequency of client interruptions due to sustained interruptions. A customer is counted once regardless of the number of interruptions.
iii. SAIDI commonly known as Client Down Minutes or Client Hours, intended to provide information on the average client down time
iv. CAIDI is the average time required to serve to recover the average customer for each sustained outage, and total customer downtime is the total number of customer outages
v. ASAI is a metric that represents the proportion of time (expressed as a percentage) that customer received service during a year or defined reporting period
vi. ASUI is the index which has the complementary value compared to ASAI.
vii. ENS is measure of total energy not supplied by the system.
viii. AENS is an index representing the average energy not delivered by the system
ix. MAIFI is the total number of momentary customer interruptions divided by the total number of customers served. A measure of reliability that takes into account temporary failures.
x. ENS, for economic analysis, is the Energy Not Supplied is cost for customer sector type and geographical location.
xi. IEAR calculates the cost per unit of undelivered energy for a given load point and provides a quantitative reliability value.

III. MATERIALS AND METHOD

3.1 Description of the Distribution system in Rumuodomaya grid

The feeder stations covered by this study are fed from the Rumuodomaya grid at the 11/33 kV substation Port Harcourt. A 132 kV transmission line runs through the substation. As a result, the mains voltage in municipal distribution networks is 33 kV or 11 kV, where 11 kV direct feed to customers and 33 kV power lines for connecting substations. The 11 kV feeders are fed by a 33 kV transformer (input) connected to a two-bus 'standby and main' system. Then, this voltage is reduced to 415 or 220 volts at consumer level.The load in this system receives a voltage of 415V and the load type is a global load. The power distribution system is radial and parallel single bus bar systems are called bus bar schemes or bus bar designs. A single bus bar design uses a single three-phase phase to connect many inputs and output circuits. Not recommended for major substations due to lack of operational flexibility. If a bus or LS fails, the entire bus must be powered down. Nevertheless, it is affordable, easy to operate and needs basic protection.

In this research study, Figure 1 shows the single-track Rumuodomaya network at Port Harcourt and Table 1 shows the distribution parameter forRumuodomaya network, Table 2 gives some assumptions made for the distribution system while Table 3 shows, for 2021, the relationships between charging points, average load, outage rate, outage duration, number of customers served, total customer outages, and total customer outage duration.

3.2 Materials

Due to the nature of the research, substations inspection and technical data collection was conducted at the Rumuodomaya station in order to investigate both end-user and utility distribution issues at substations. Some of the materials used in this study are described below:

i. Distribution data were elicited from the Port Harcourt Electricity Distribution Company (PHEDC). The 2019-2021 reliability index is used as the base year for the case studies The data include number of consumers per substation, number of consumers per feeder, numbers of feeders (33kV, 11kV), numbers of power failure, duration of each failure.
ii. The physical investigations show Rumuodomaya station has radial distribution system. The 33 kV line use conductor size is 50 mm^2 or 95 mm^2 andACSR conductors are used for inputs and outputs of the feeders.
iii. For simulation of the radial distribution system, ETAP v12.6 software was used.

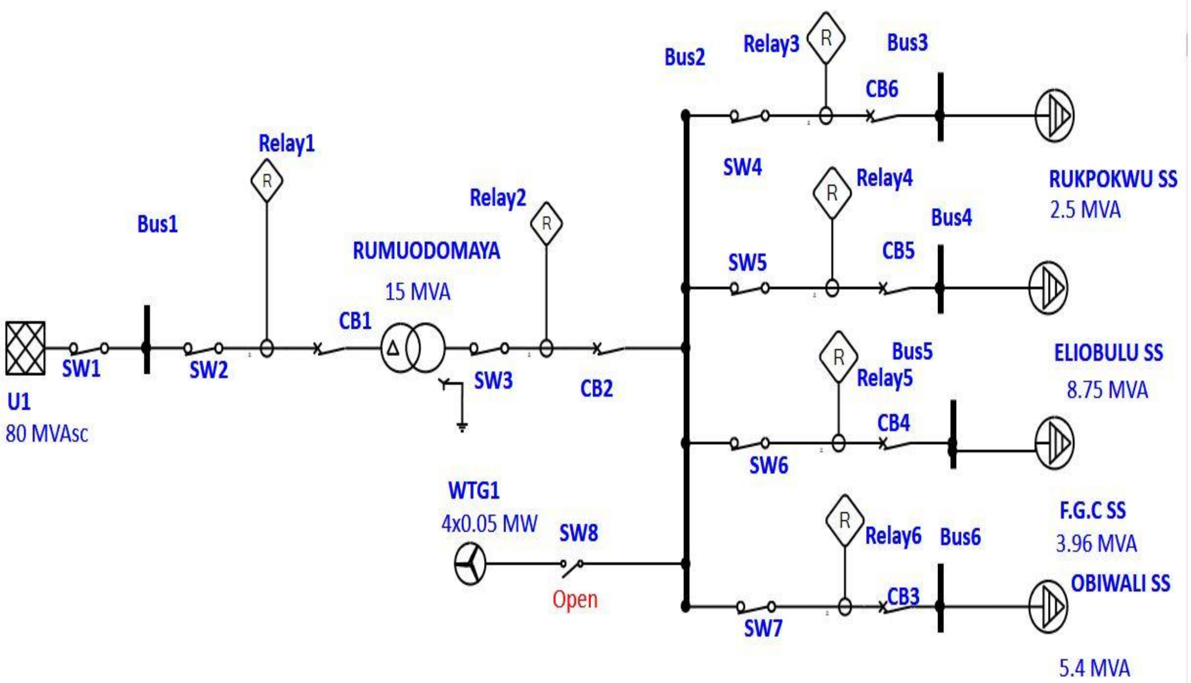

Figure 1: Single Line Network Diagram of Rumuodomaya, Port Harcourt

Table 1: Port-Harcourt Distribution Parameter for Rumuodomaya Network (33kV Feeder)

33kV Feeder line	Line Load (MW)	Length (KM)	Size (mm^3)
1	13.2	5.1	150 mm^2
2	12.1	6.2	150 mm^2
3	18.5	7.3	150 mm^2
4	15.7	10.6	150 mm^2
5	11.3	9.7	150 mm^2

Source: Port Harcourt Electricity Distribution Company (PHEDC)

Table 2: Parameters and assumptions for simulation

Parameter/system	Assumptions
Distribution line	Ground laying
Length of line	1 kilometere for each branch
Line model	Lumped parameter (Pi)
Load type	Constant power
Nominal frequency	50 Hz
System type	3-phase AC
Rated voltage	12 kV
Nominal voltage	11 kV
Voltage limits	Upper limit – 1.055 per unit; Lower limit – 0.95 per unit
Active power	1.45 W = 65% of 1.45W = 0.943MW
Reactive power	1.55 MVar = 35% of 1.55 MVar = 0.543 MVar
Nominal Voltage	11 kV
Power factor	0.85

Source: Port Harcourt Electricity Distribution Company (PHEDC)

Table 3: Relationship between load point, failure and customer served for the year 2021

Load Point	Average Load (kW)	Failure Rate (λ_i)	Outage Duration (γ_i)	No. of Customers served (N_i)	Total No. of Customer Interruptions (No)	Total No. of Customer Interruptions Duration
1	182.5	0.3312	0.78	15	4.968	11.70
2	175.8	0.3401	0.72	12	4.081	8.64
3	177.5	0.2021	0.76	15	3.032	11.40
4	183.6	0.3311	0.85	12	3.973	10.20
5	215.7	0.3312	0.70	15	4.968	10.50
6	210.8	0.3401	0.72	15	5.102	10.80
7	170.5	0.3401	0.65	17	5.782	11.05
8	165.7	0.2021	0.70	14	2.829	9.80
9	186.6	0.1985	0.80	13	2.581	10.40
10	170.3	0.3311	0.75	10	3.311	7.50
11	180.8	0.3231	0.85	13	4.200	11.05
12	212.5	0.3401	0.72	14	4.761	10.08
13	210.7	0.3351	0.70	10	3.351	7.00
14	250.6	0.2021	0.72	11	2.223	7.92
15	165.8	0.2105	0.85	10	2.105	8.50
16	278.7	0.3311	0.70	12	3.973	8.40
17	185.8	0.3312	0.81	10	3.312	8.10
18	183.6	0.2021	0.77	11	2.223	8.47
19	175.7	0.2105	0.65	12	2.526	7.80
20	190.2	0.3311	0.70	12	3.973	8.40
21	180.6	0.3311	0.78	10	3.311	7.80
22	174.7	0.3312	0.80	12	3.974	9.60
23	174.8	0.3401	0.85	11	3.741	9.35
24	182.2	0.3341	1.81	12	4.009	21.72
25	185.3	0.3311	1.80	11	3.642	19.80
26	180.1	0.3312	1.60	10	3.312	16.00
27	170.2	0.3311	1.58	11	3.642	17.38
28	182.2	0.3231	2.42	10	3.231	24.20
29	180.4	0.3311	1.65	11	3.642	18.15
30	174.9	0.3231	1.75	12	3.877	21.00
31	180.5	0.3401	1.64	11	3.741	18.04
32	180.8	0.3311	1.60	13	4.304	17.6
33	179.5	0.3312	2.52	10	3.312	25.2
				395		

3.3 Method

The Predictive Reliability Assessment Method (PRAM) is based on probability theory. It shows system indices and system failure events depending on the chance of such event and the frequency at which it occurs. PRAM follows a top-down approach that predicts how reliable the system can be and map out improvement [3]. For the reliability assessment, year 2019 to 2021 were considered.

Equation (1) to (3) give the system failure indices and power outage duration. Equation (4) to (15) gives the power reliability indices, reliability assessment and economic reliability indices [3]

$$Failure\ Rate, \lambda = \frac{Frequency\ \ of\ faliures}{period\ \ of\ operation\ \ (hr)} = \frac{F}{T} \quad (1)$$

$$Load\ Point\ Repair\ Rate,\ \mu = \frac{T_0}{(\sum T_0/\sum F)}\ (repair/yr) \quad (2)$$

$$Annual\ Outage\ \ Duration,\ \ \mu\lambda = \sum \frac{T_0}{T}(hr/yr) \quad (3)$$

$$SAIFI = \frac{Total\ number\ \ of\ customer\ \ interruptions}{Total\ number\ \ of\ customers\ \ serve\ d} = \frac{\sum_i \lambda_i N_i}{\sum_i N_i} \quad (4)$$

$$CAIFI = \frac{Total\ number\ of\ customer\ interruptions}{Total\ number\ of\ customers\ affected} = \frac{\Sigma(No)}{\Sigma(Ni)} \quad (5)$$

$$SAIDI = \frac{Sum\ of\ customer\ interruptions\ durations}{Total\ number\ of\ customers\ served} = \frac{\sum_i U_i N_i}{\sum_i N_i} \quad (6)$$

$$CAIDI = \frac{Total\ number\ of\ customer\ interruptions}{Total\ number\ of\ customers\ served} = \frac{\sum_i U_i N_i}{\sum_i \lambda_i N_i} = \frac{SAIDI}{SAIFI} \quad (7)$$

$$ASAI = \frac{Customer\ hours\ of\ avaliable\ service}{Customers\ hours\ demanded} = \frac{\sum_{i_{Ni}} \times 8760 - \sum_i UiNi}{\sum_{i_{Ni}} \times 8760} \quad (8)$$

$$ASUI = 1 - ASAI = \frac{Customer\ hours\ of\ unavaliuavle\ service}{Customers\ hours\ demanded} = \frac{\sum_i U_i N_i}{\sum_i N_i \times 8760} \quad (9)$$

$$Average\ Load, L_a = L_p \times L_f = \frac{total\ energydemanded\ in\ period\ of\ interest}{periodof\ interest} = \frac{E_d}{t} \quad (10)$$

$$ENS = \sum_i L_{a(i)} U_i \quad (11)$$

$$AENS = \frac{Total\ energy\ not\ supplied}{Total\ number\ of\ customers\ served} = \frac{\sum_i L_{a(i)} U_i}{\sum_i N_i} \quad (12)$$

$$EENSi = \sum_{i=1}^{Ne} L_i + r_{ij} \times \lambda_{ij} = Xp\mu\rho \quad (13)$$

$$ECOSTi = \sum_{i=1}^{Ne} SCDF_{ij} + r_{ij} \times \lambda_{ij} \quad (14)$$

$$IEARi = \frac{ECOST_i}{EENS_i} \quad (15)$$

Where:

λ = : failure rate; *r* = outage duration; *F* = Frequency of failures; *T* = Period of operation; μ = average annual outage time; T_0 = Outage time; L_p = peak load demand ; L_f = load factor; U_i= average annual outage time at load point *i*; L_i= total connected load (kVA) interrupted by ith interruption; E_d= total energy demanded in the period of interest *t*; *IDi* = number of interrupting device operations; I_{ij}= connected load restored duringjth restoration step; erations; N_i = number of customers experiencing momentary interruptions; N_T = total number of customers served; ECOSTi is Expected customer outage cost at load point *i*; EENSi is Expected Energy Not Supplied at load point *i; C_i* is the energy demand of customer type *I*; *Xp*= average load of load point,*p; μp* = annual outage duration at load point *p;*

IV. RESULTS

In this section, the simulation results for power reliability indices for the Rumuodomaya distribution system are presented. Figures 2 and 3 show the failure rate and outage duration for 2019 - 2021. Figure 4 to Figure 6 show the variation of SAIFI, SAIDI and CAIDI power system reliability indices in 2019, 2020 and 2021 respectively. Figures 7 and 8 give the economic indices (EENS and ECOST). Figure 9 – Figure 12 gives other power reliability indices that affect the system.

According to the 2019-2021 failure rate, 2019 has the highest failure rate, with Bus 8 and Bus 21 having a failure rate value of 0 4541 (f/years). To reduce the number of overloaded distribution networks, system reconfiguration should be considered. Expected Energy Not Supplied Index (EENS) rates for 2019-2021 show that 2019 had the highest EENS Index (Expected Energy Non-Delivered) and Bus 27 had the highest EENS Index at 11.732. This means that the Rumuodomaya network needs to invest more in developing its power distribution infrastructure so that faulty components can be replaced as soon as possible. Bus 31 has the highest CAIDI value of 7.4167 and Bus 33 has the highest SAIDI value of 0.0638. Bus 14 has the lowest SAIFI of 0.0056. in 2021, Figure 10 indicate bus 25 has the highest IEAR of 2.1303, followed by bus 17 with 2.1098, and bus 9 has an IEAR span of less than 1.2199. The results show the total number of customer outages from 2019 to 2021. Most customer failures rate occurred in his 2019, with Bus 28 having the highest score of 35.18 minutes. This means that the values are insufficient power delivery from the power supply, load dump time, line down time due to poor line conditions, and other unplanned interruptions.

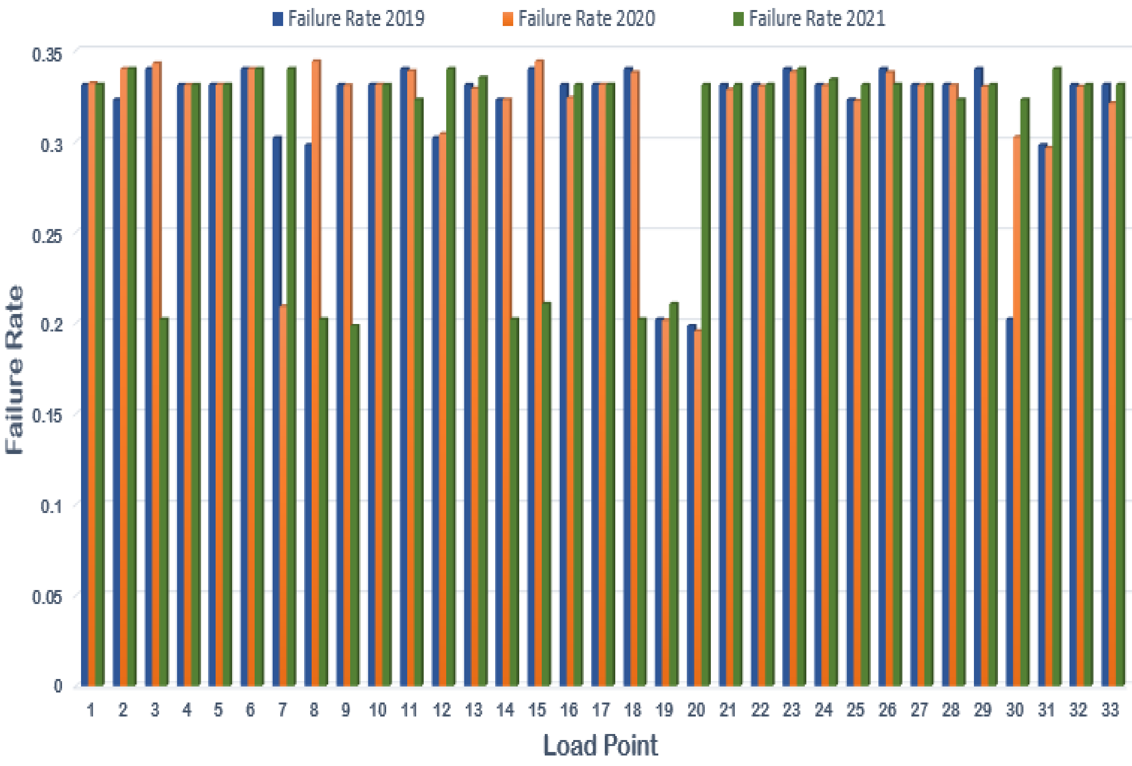

Figure 2: Failure rate for 2019 to 2021 respectively.

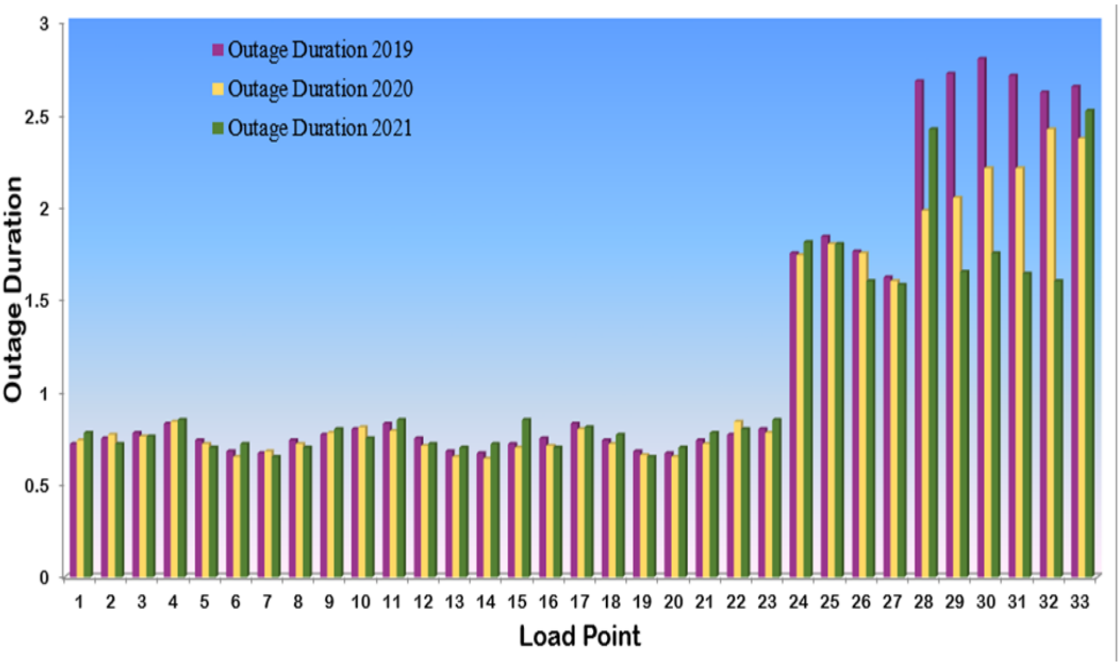

Figure 3: Power system reliability indicators of Outage duration in 2019 to 2021.

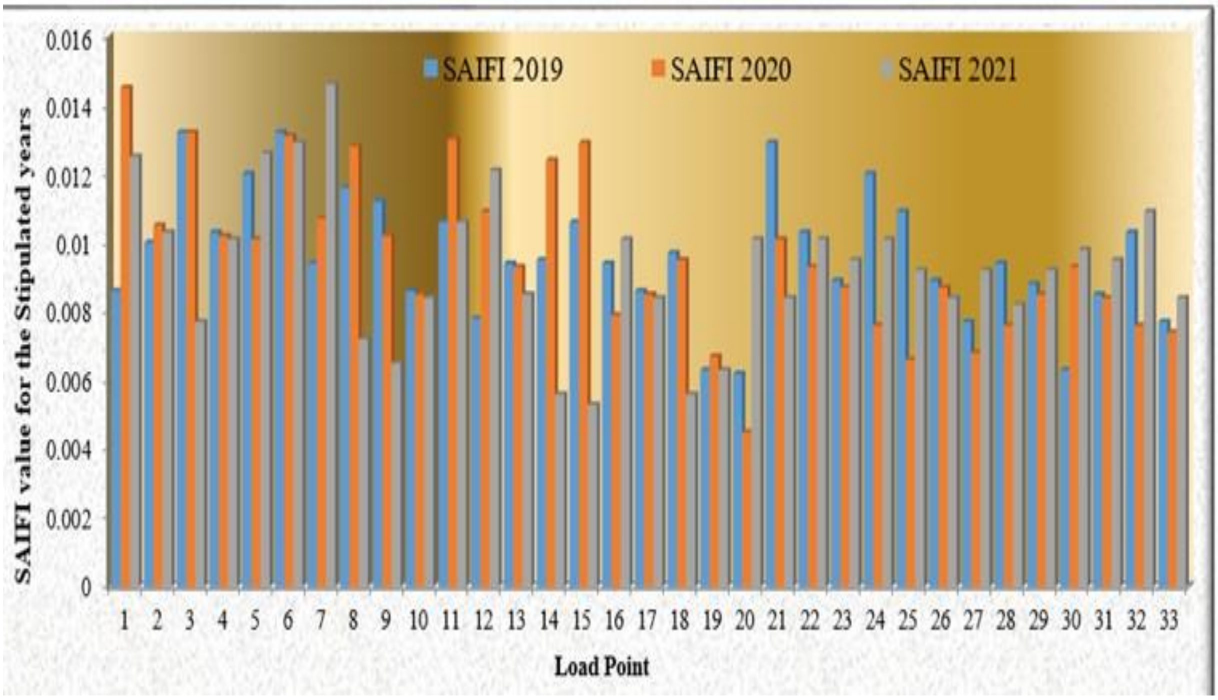

Figure 4: Power system reliability indicators of SAIFI in 2019 to 2021

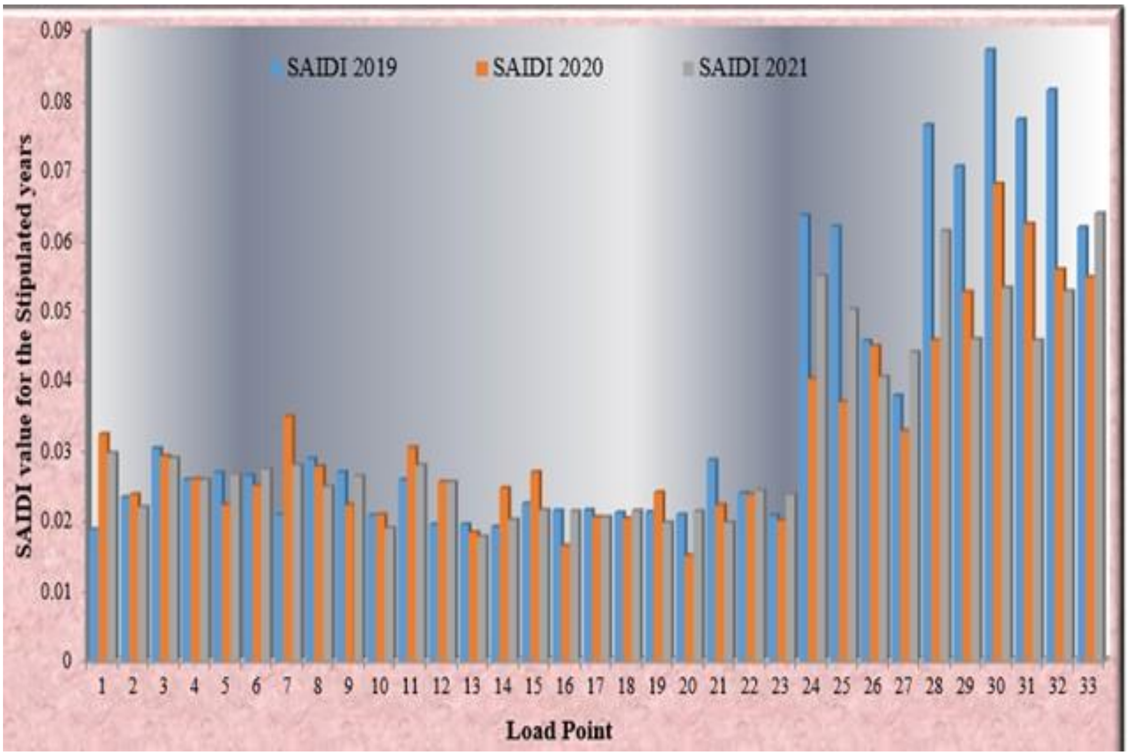

Figure 5: Power system reliability indicators of SAIDI for 2019 to 2021

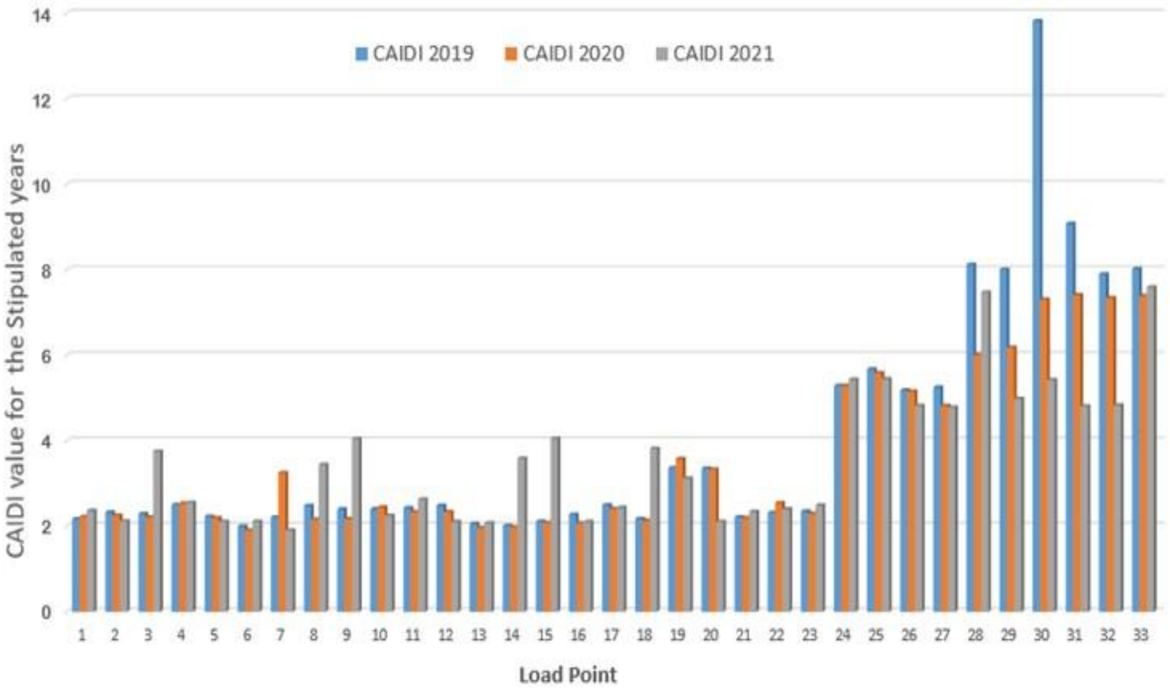

Figure 6: Power system reliability indicators of CAIDI for 2019 - 2021

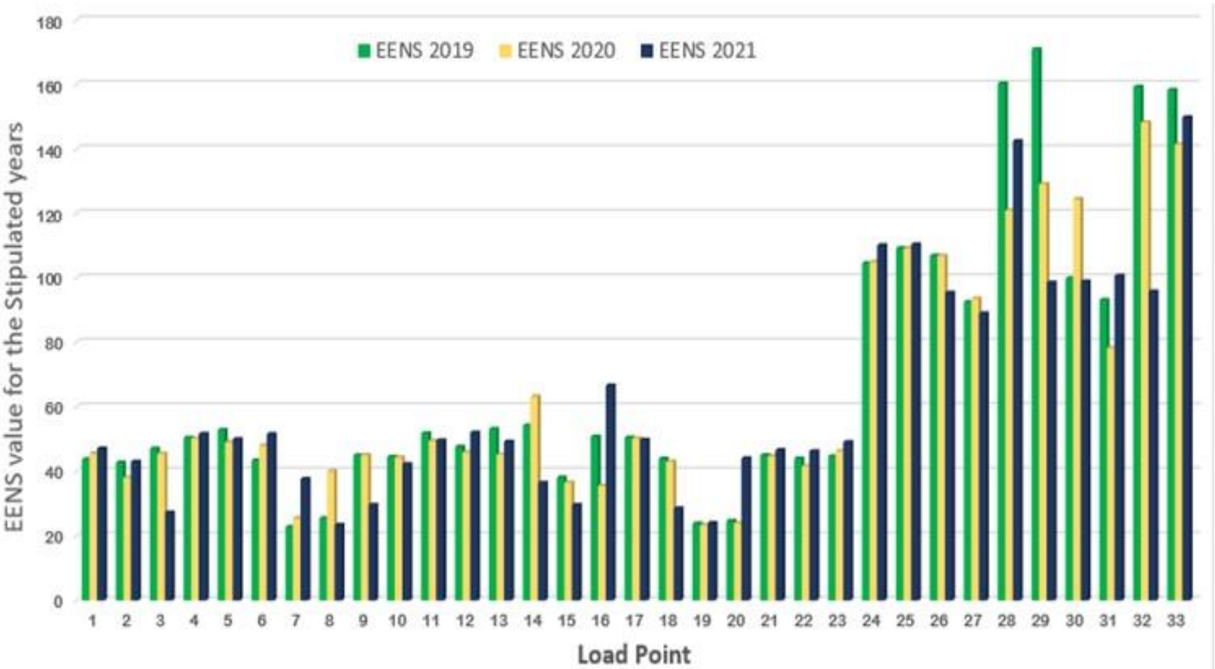

Figure 7: Power system reliability indicators of EENS in 2019 to 2021

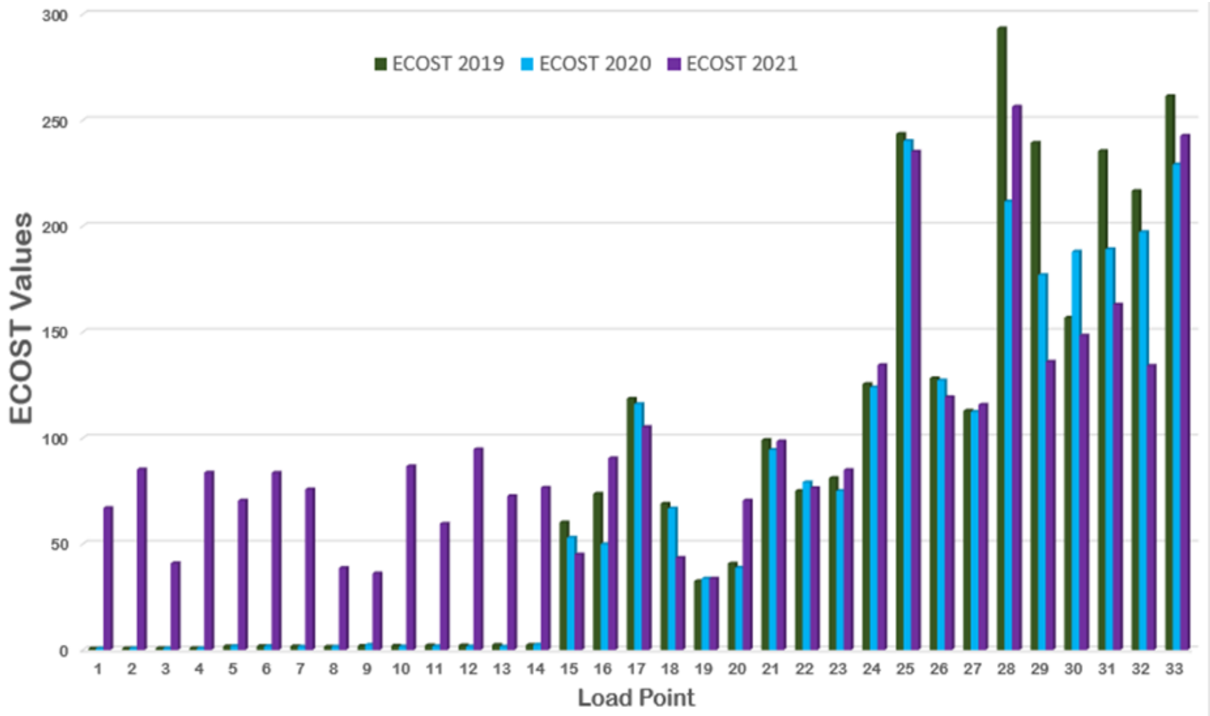

Figure 8: Power system reliability indicators of ECOST in 2019 to 2021

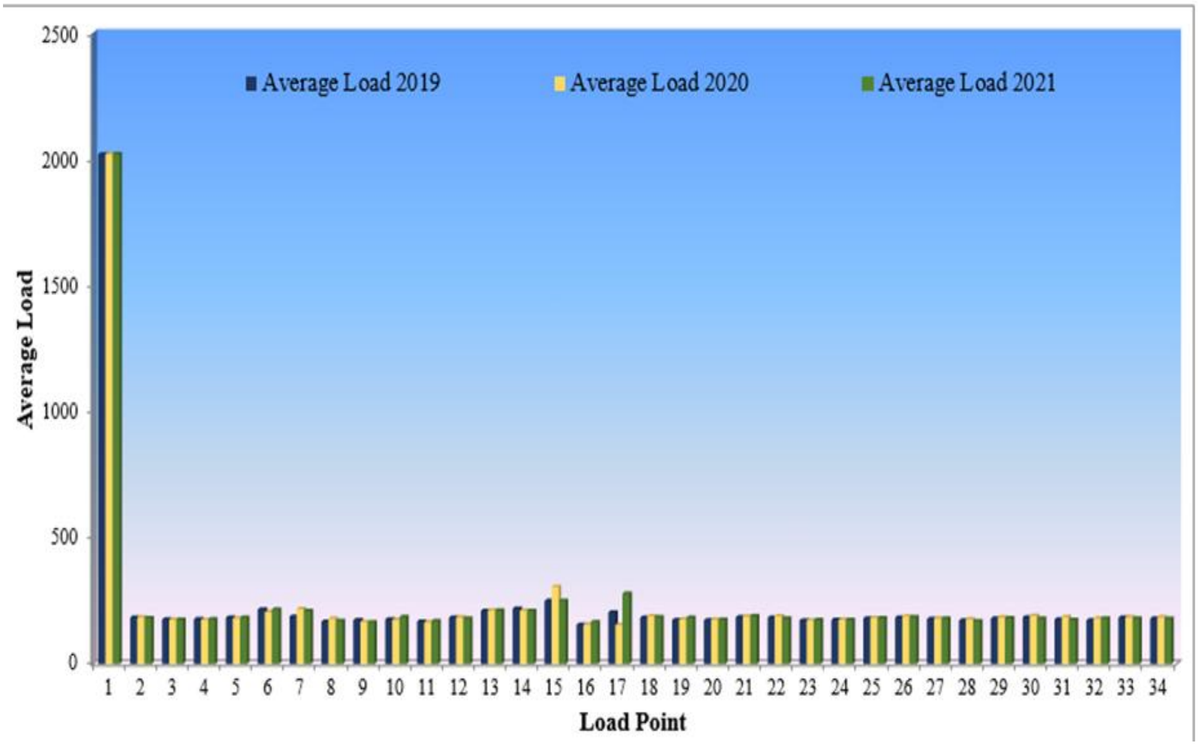

Figure 9: Average load for 2019 to 2021

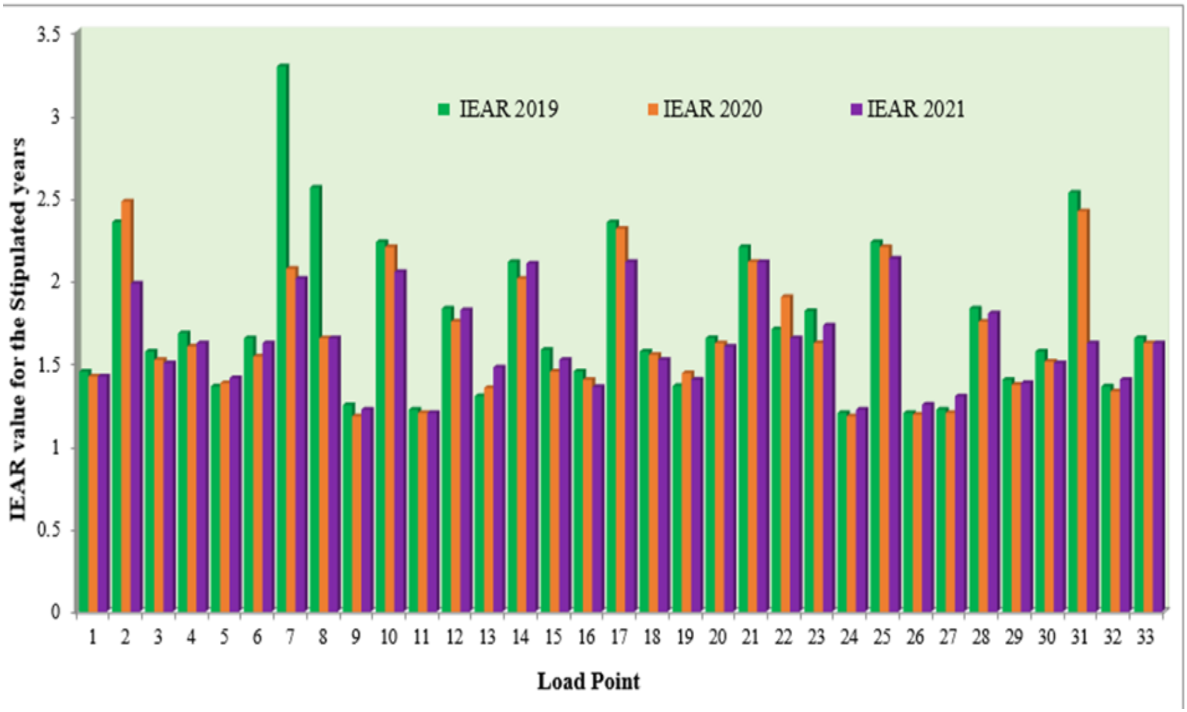

Figure 10: IEAR-reported power system reliability indices for 2019 to 2021.

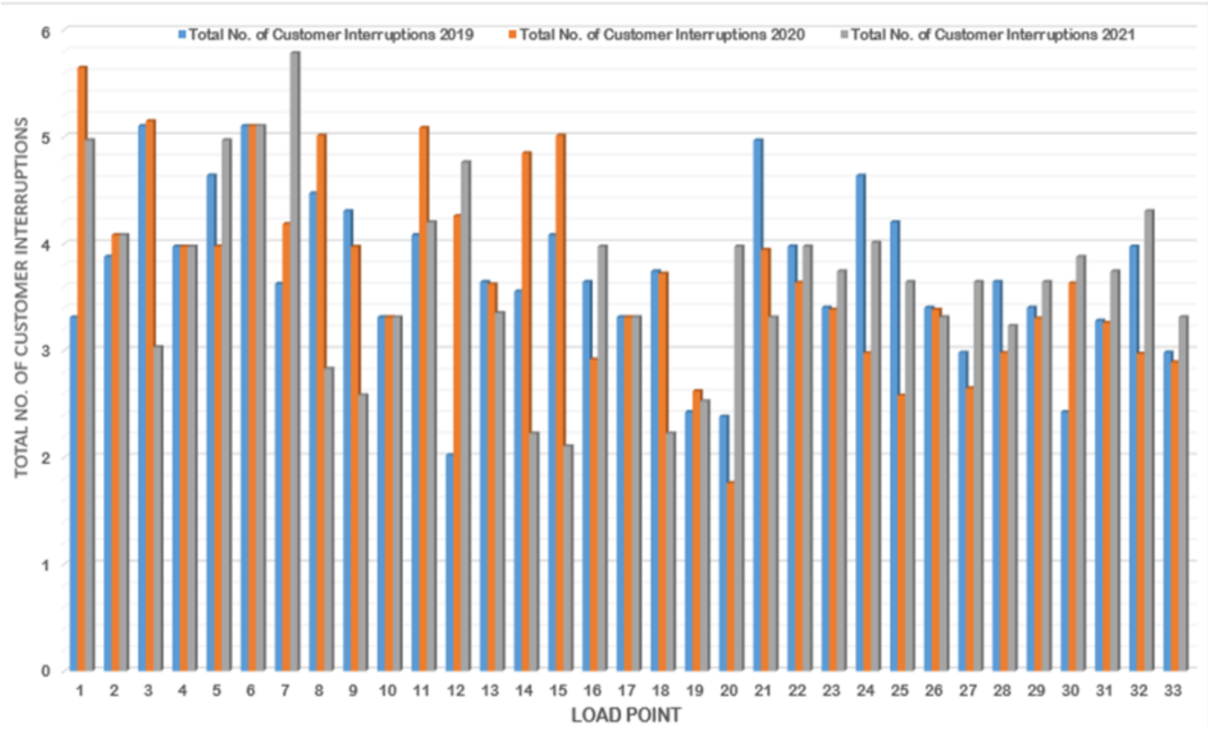

Figure 11: Power system reliability indices (total No. of customer Interruptions) for 2019 to 2021

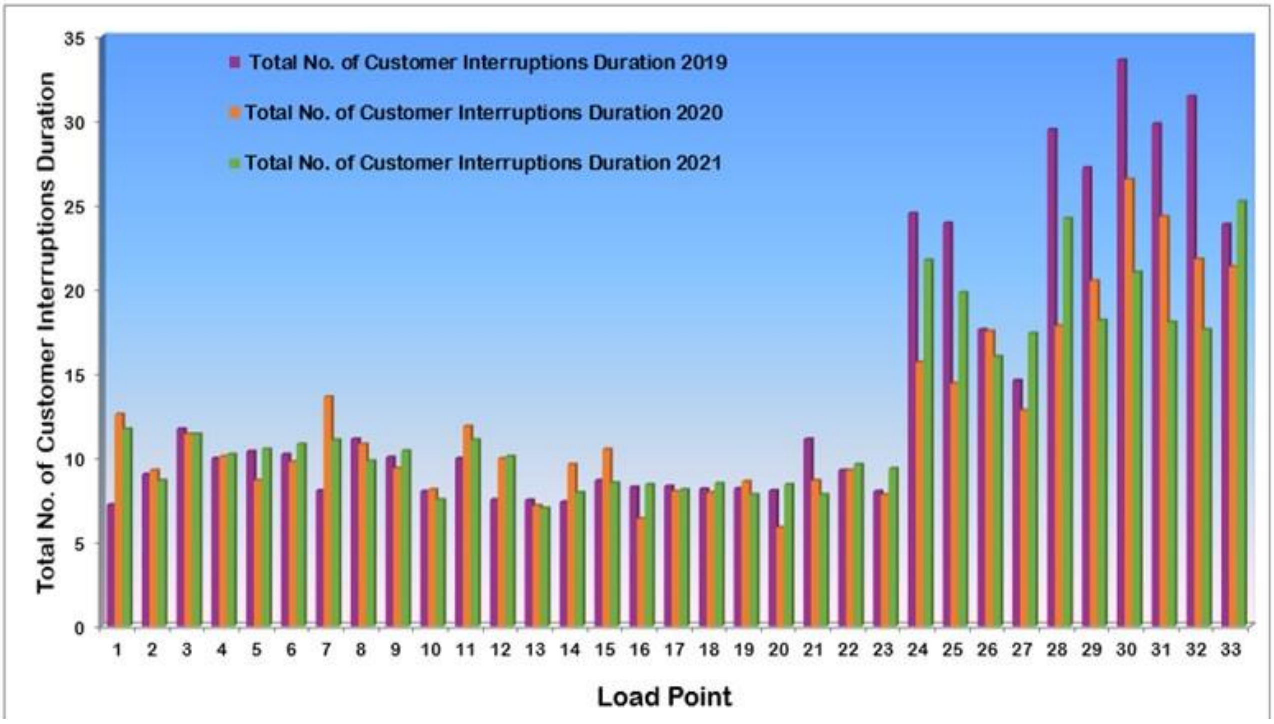

Figure 12: Power system reliability indices (total No. of customer Interruptions duration) for 2019 to 2021

V. CONCLUSION

This study thoroughly explores how predictive reliability indicators can be used to improve the performance of the Rumuodomaya 11 kV distribution feeder, as well as how analytical techniques that are simulated and evaluated for research purposes can be used to improve performance evaluated positively. As a base year, the case study uses reliability indicators from 2019 to 2021. Using the reliability evaluation module, the following reliability indices were calculated and reported as load point indices. The distribution failure rate, mean time to failure, annual failure time, and system metrics are: Average Outage Frequency Index Average System Interruption Duration Index (SAIDI), Customer Average Interruption Duration Index (CAIDI) and Expected Energy Unsupplied Index (EENS), Customer Expected Outage Index (ECOST) and Interruption Power Rating Rate (IEAR) are all calculated. The software application Electrical Transient Analyzer Program (ETAP version 12.6) is used for the simulation. For recommendations, the company should maintain accurate records of failures, causes and durations to assist in the production of accurate investigative documentation, care should be taken to minimize power outages to improve substation reliability and regular and proper inspection of utility lines such as poles, substation reliability is also improved.

REFERENCES

[1]. Behailu., A. (2014). Designing of an Improved Distribution Substation to Mitigate the Power Reliability at Bishoftu City, Master's Thesis, Federal Democratic Republic of Ethiopia, Ministry of Defence University, College of Engineering Office of Postgraduate Programs and Research.
[2]. Atwa, Y., El-Saadany, E., Guise, A.: Supply Adequacy Assessment of Distribution System Including Wind-Based DG During Different Modes of Operation. IEEE Transactions on Power System., vol 25, no. 1, pp. 78–86 (2010).
[3]. Ezeala, A. N., Idoniboyeobu, D. C., Braide, S. L.: Analysis of 11kv, Obi-Wali, Rumuigbo Distribution Network for Improved Performance using Predictive Reliability Assessment Method. American Journal of Engineering Research (AJER), vol. 9, no. 12, pp. 132 – 145 (2020)
[4]. Lakervi, E., Holmes, E. J.: Reliability. Electricity Distribution Network Design (2003).
[5]. American Society of Quality: What Is Reliability? Quality & Reliability Defined | ASQ. Asq.org [online] Available at: https://asq.org/quality-resources/reliability [Accessed 01 December 2022].
[6]. Obaro, B. A.: Reliability Evaluation of Distribution Systems - Using Failure Modes, Effect & Analysis, Master's Thesis, University of Port Harcourt, (2010).
[7]. Syrri, A. L.A., Mancarella, P.: Reliability and risk assessment of post contingency demand response in smart distribution networks. Sustainable Energy, Grids and Networks, (2016)
[8]. Issicaba, D., Lopes, J. A., Augusto da Rosa, M.: Adequacy and Security Evaluation of Distribution Systems with Distributed Generation, IEEE Transactions on Power System, vol. 27, no. 3, pp. 1681–1689 (2012).
[9]. Obuah, E. C., Alalibo, T. J.: Effect of Black Soot on the Performance of Photovoltaic Systems in Port Harcourt. Iconic Research and Engineering Journals, vol. 2, no. 6, pp. 63 – 68 (2018)
[10]. Aduloju, A.: Electrical Power Systems, Evidence Nigeria Ventures, Ilorin, Nigeria, (2003).

[11]. Emodi, N., Yusuf, S.: Improving Electricity Access in Nigeria: Obstacles and the way forward. International Journal of Energy Economics and Policy, vol.5, no.1, pp. 335-351 (2015).
[12]. Oseni, M.: An Analysis of the Power Sector Performance in Nigeria. Renewable and Sustainable Energy Reviews, vol. 15, no. 9, pp. 4765- 4774 (2011).
[13]. Venu, B., Bhargava, C., Sumanth, K.: Reliability Assessment of Radial Distribution System by Using Analytical Methods. International Journal of Engineering Studies, vol. 4, no. 4, pp. 85-196, (2014).
[14]. Popoola, M., Ponnleand, A.: Power Quality in Electric Networks: Monitoring and Standards. The second world engineering conference, vol. 8, no. 3: pp. 137-14 (2011).
[15]. Daniel, T.: Industrial power quality problems, Electricity Distribution, Part 1: Contributions. CIRED. 16th International Conference and Exhibition on (IEE Conf. Publ No. 482), vol. 2, no. 5 (2015).
[16]. Adegboye, B. A., Dawal, E.: Outage Analysis and System Integrity of an 11kV Distribution System. Advanced Material Research, vol. 3, no. 67, pp. 151-158, (2012).
[17]. Ezeolisah, C.: TCN Transmission News. In-House Journal of Transmission Company of Nigeria, vol. 4, no. 7, pp. 1-76, (2015).
[18]. Johnson, D. O.: Reliability Evaluation of 11/0.415kv Substations; A Case Study of Substations in Ede Town. International Journal of Engineering Research & Technology (IJERT), Vol. 4 no.9, pp. 127-135, (2015).
[19]. Lantharthong, T., Phanthuna, N.: Techniques for Reliability Evaluation in Distribution System Planning. World Academy of Science, Engineering and Technology, vol. 65, no. 12, pp. 431-434, (2012).
[20]. Okorie, P. U., Abdu, A. I.: Reliability Evaluation of Power Distribution Network System in Kano Metropolis of Nigeria. International Journal of Electrical and Electronic Science, vol. 2, no. 1, pp. 1-5, (2015).