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# Development of Distribution Feeder Reliability Profile: A Case Study of Egbu Feeders in Imo State Nigeria

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***ABSTRACT:*** *The evaluation of a system reliability model has proven importance just as the load flow model in system planning, expansion and security level determination. Power system reliability parameters and indices evaluation is important in determining system behavior. The techniques employed for system reliability evaluation are predictive, deterministic or probabilistic. This paper evaluates the Egbu 33kV feeder using the probabilistic approach and state transition from the Markovian model. From the feeder's analysis, it was observed that the feeders experience low reliability quotient due to the high failure rates. The feeder reliabilities are 12.75%, 45.4%, 11.53%, 37.94%, 52.74% and 18.82% for Umuahia, Owerri main, Owerri Airport, Oguta, Orlu, and Okigwe respectively.*

***Keywords*** *-reliability profile feeder, reliability parameter, Markovian model, transition matrix*

## I. INTRODUCTION

The provision of reliable, uninterruptible and secured power supply for all customers has been the major problem of power system designers and operators. This has led most of the power driven nations to device means of measuring the system reliability through the use of some customer based metrics [1]. Distribution system delivers power from bulk power system to the system load (customers). For this, it is a normal practice for utility companies to measure the coefficient of power availability to the customer at a particular security and quality. The economic and social effects of loss of electric service have significant impacts on both the utility supplying electric energy and the customers. The power system is vulnerable to system abnormalities such as control failures, protection or communication system failures, and disturbances, such as lightning, and human operational errors. Therefore, maintenance is a very important issue for power systems design and operation. The function of an electric power system is to satisfy the system load requirement with a reasonable assurance of continuity and quality. The ability of the system to provide an adequate supply of electrical energy is usually designated by the term of reliability, but if all generation and transmission supply condition is met, the system reliability will simply be distribution system bound [1]. The concept of power system reliability is extremely broad and covers all aspects of the ability of the system to satisfy the customer requirements. There is a reasonable subdivision of the concerndesignated as "system reliability", which is shown in figure 1.

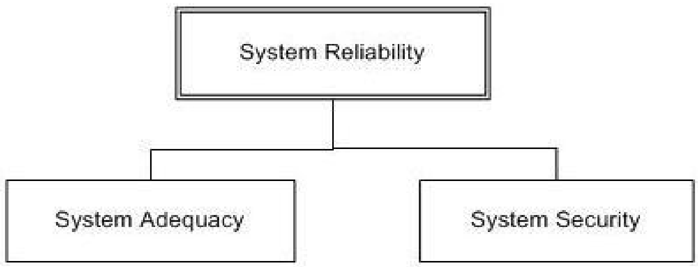



Fig.1:Sub-division of system reliability

According to reliability of power system describes the security of that system and avoidance of outage to the customers [2], while defines reliability as the ability of a system/component to perform its desired function [3]. Similarly, [4] defines reliability as simply the ability of the power network to deliver uninterrupted power to its customer at a prescribed level of quality and security. From the above definitions, it can be inferred that power system reliability is a measure of power availability to the customer at an acceptable security limit and avoidance of outage. The distribution system reliability can therefore, be defined as the probability of supply to the customer if all supply conditions is met by the generation and transmission system.

Distribution system reliability assessment is complex because of its direct connection to the system load, sparsity of components, large number of components, and radial design of network. As a result for a customer with 90 minutes of interruption per year, 70-80 minutes of interruption is as a result problems from the distribution end of the network [5].

Prior to the 1960's, the reliability of proposed power systems was often estimated by extrapolating the experience obtained from existing systems and using rule-of-thumb methods to forecast the reliability of new systems [6]. This approach is referred to as deterministic technique. During this period, considerable work was done in the field of power system reliability and some excellent papers were published. The most significant publications were two company papers by a group of Westinghouse Electric Corporation, and Public Service and Gas Company authors [7], [8]. These papers introduced the concept of a fluctuation environment to describe the failure rate of transmission system components. The techniques presented were approximations which provided results within a few percent of those obtained using more theoretical techniques, such as Markov processes [5]. Indeed, randomly occurring or probabilistic events in the system are easy to recognize: forced outages of distribution system components, failure of overhead lines, and uncertainty in customer demand. Probabilistic methods can provide more meaningful information to be used in design and resource in planning and allocation. There are two main approaches for probabilistic evaluation of power systems reliability; Analytical methods and Monte Carlo simulation [2]-[5].

Analytical techniques represent the system by mathematical models and use direct analytical solutions to evaluate a priori reliability indices from the model [9]. Monte Carlo simulation estimates posterior reliability indices by simulating the actual random behavior of the system [2]. Whichever approach is used, the predicted indices are as good as the derived models, the relevance of each technique and the quality of the data.

The Nigeria Electricity Regulatory Commission (NERC) is an independent regulatory body which is saddled with the regulation of electric power industry in Nigeria. NERC which is analogous to North American Electricity Reliability Council was formed in 2005 for:

- Electricity Tariffs
- Transparent power Policies regarding subsidies
- Promotion of power policies that are efficient and environmentally friendly
- Enforcing of standards in the creation and use of electricity in Nigeria.

The primary duties of NERC as regards Power Holding Company of Nigeria (PHCN) unbundling and privatizations are:

- Protect interest of customer, which was divided into
  - Regulation of Tariffs
  - Creation of safe and friendly work environment
  - Improvement of reliability of the electricity supply
- Licensing of operators.

Since NERC has to guide the duty of the utility in providing power to the customer, the reliability computation of the distribution system supply will help in penalizing defaulters based on the degree of default below a threshold point.

## II. EXPONENTIAL DISTRIBUTION

Probability distribution functions are mathematical equations allowing a large amount of information, characteristics and behavior of a system to be described by a small number of parameters. Probability distribution density is the likelihood that a random variable, t, will be a particular value. Probability density function $f(t)$ value lies between 0 and 1, the limits inclusive. The integral over all possible outcomes must be unity.

$$f(t) \in [0,1] \qquad 1$$

$$\int_{-\infty}^{\infty} f(t)dt = 1 \qquad 2$$

*Cumulative distribution function $F(t)$ is the integral of the probability density function, and reflects the probability that $f(t)$ will be equal to or less than t.*

$$F(t) = \int_{-\infty}^{\infty} f(t)dt \quad 3$$

*Probability distribution density function is the probability that the component has already failed.*

*Hazard rate, $\lambda(t)$, is the probability of a component failing if it has not already failed. It is also called hazard function if it is constant.*

$$\lambda(t) = \frac{f(t)}{1 - F(t)} \quad 4$$

*Expected value (μ) is the average of the entire data collected for analysis.*

$$expected\ value\,(\mu) = \int_{-\infty}^{\infty} tf(t)dt \quad 5$$

*Variance is the measure of how the function varies from the mean.*

$$variance = \int_{-\infty}^{\infty} [f(t) - \mu]^2\ dt \quad 6$$

*Standard deviation ($\sigma$) is the normalization of the variance to a smaller value for critical analysis.*

$$\sigma = \sqrt{variance} \quad 7$$

$$\%\,\sigma = 100 * \frac{\sigma}{\mu} \quad 8$$

*Reference [2] defines reliability as the probability of a device or system performing its function adequately, for the period of time under an intended operating conditions. This definition not only gives the probability of failure, but also its magnitude, duration and frequency.*

*The probability of a component/system failure can be described by a function of time as*

$$P(T \le t) = F(t); \quad t \ge 0 \qquad 10$$

$where\ T\ is\ a\ random\ variable\ representing$

$the\ failure\ time$

$F(t) is\ the\ probabilty\ that\ component\ will$

$fail\ by\ time\ t$

*The probability that the component/system will not fail in performing its intended function at a time t is defined as the reliability of the component/system.*

$$R(t) = 1 - F(t) \quad 11$$

$F(t)\ is\ failure\ distribution\ function$

*also called unreliability function*

$R(t)$ *is reliabilty distribution function*

*If the time to failure random variable has a density function* $f(t)$

$$R(t) = 1 - \int_0^t f(t)\,dt \quad 13$$

$$R(t) = \int_t^\infty f(t)\,dt \quad 14$$

The exponential distribution is used to express components failure rate because of the assumption of a constant failure rate at the components useful life period.

But for an exponential distribution function

$$f(t) = \lambda e^{-\lambda t} \quad 15$$

$$R(t) = e^{-\lambda t} \quad 16$$

If $Q(t)$ is defined as unreliability distribution function

$$Q(t) + R(t) = 1 \quad 17$$

$$\therefore \quad Q(t) = \int_0^t f(t)dt \quad 18$$

*Expected life or mean* $E(t)$

$$E(t) = \int_0^\infty e^{-\lambda t}\,dt = \frac{1}{\lambda} \quad 19$$

If after failure, the component is not repaired but wholly replaced, $E(t)$ is referred to as mean time to failure (MTTF).

$$MTTF = \bar{m} = \frac{1}{\lambda} \quad 20$$

If after failure, the component is repaired and put back in service, $E(t)$ is referred to as mean time between failures (MTBF)

$$MTBF = \bar{T} = \bar{m} + \bar{r} \quad 21$$

*where* $\bar{r}$ *is mean time to repair*

Mean time to repair (MTTR) is the reciprocal of the average repair rate.

$$MTTR = \bar{r} = \frac{1}{\mu} \quad 22$$

*where* $\mu$ *is the average repair rate*

## III. SYSTEM MODELLING

The system is modelled using Markov probabilistic technique based on system states and transition between these states. It makes two basic assumptions regarding system behavior [8]:

i. System is memory – less – (i.e. probability of event is solely a function of the existing state of the system and not what has occurred prior to the system entering the present state).

ii. The system is stationary – (i.e. transition probabilities between states are transient and do not vary with time).

Markov models can either be discrete or continuous. Discrete models have state transitions that occur at specific time steps while continuous models have constant state transition. Discrete Markov chain characterizes a system as a set of states and transition between these states that occur at a discrete time interval. Whereas the Markov process is described by a set of states and transition between these states. It processes state transition rates for this purpose. Markov processes are easily applied to distribution system reliability model which describes the failure rates - ʎi, repair rates - µi and switching rates of the system components as shown in Fig. 2 below.

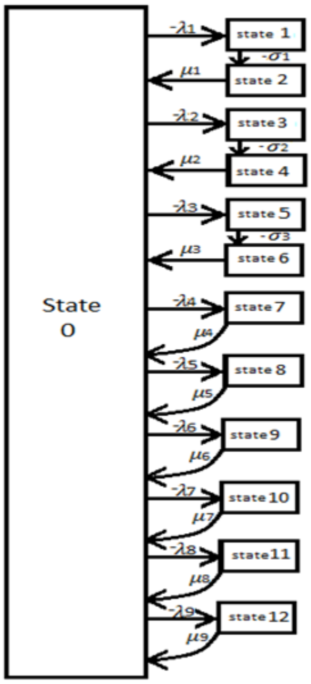



Fig. 2: System transition state

$$P'_0 = -\lambda_1 P_0 + \mu_1 P_2 - \lambda_2 P_0 + \mu_2 P_4 - \lambda_3 P_0 + \mu_3 P_6 - \lambda_4 P_0 + \mu_4 P_7 - \lambda_5 P_0 + \mu_5 P_8 - \lambda_6 P_0 + \mu_6 P_9 - \lambda_7 P_0 + \mu_7 P_{10} - \lambda_8 P_0 + \mu_8 P_{11} - \lambda_9 P_0 + \mu_9 P_{12} \quad 23$$

$$P'_1 = \lambda_1 P_0 - \sigma_1 P_1 \quad 24$$

$$P'_2 = \sigma_1 P_1 - \mu_1 P_2 \quad 25$$

$$P'_3 = \lambda_2 P_0 - \sigma_2 P_3 \quad 26$$

$$P'_4 = \sigma_2 P_3 - \mu_2 P_4 \quad 27$$

$$P'_5 = \lambda_3 P_0 - \sigma_3 P_5 \quad 28$$

$$P'_6 = \sigma_3 P_5 - \mu_3 P_6 \quad 29$$

$$P'_7 = \lambda_4 P_0 - \mu_4 P_7 \quad 30$$

$$P'_8 = \lambda_5 P_0 - \mu_5 P_8 \quad 31$$

$$P'_9 = \lambda_6 P_0 - \mu_6 P_9 \quad 32$$

$$P'_{10} = \lambda_7 P_0 - \mu_7 P_{10} \quad 33$$

$$P'_{11} = \lambda_8 P_0 - \mu_8 P_{11} \quad 34$$

$$P'_{12} = \lambda_9 P_0 - \mu_9 P_{12} \quad 35$$

$where\ P_0 = probability\ of$

*being in normal operating state;*

$P_1 = probability\ of$
*being out due to faulty transformer*

$P_2 =$ probability of partial
restoration due to transformer fault

$P_3 = probability\ of\ being\ out\ due$
*to faulty circuit breaker*

$P_4 = probability\ of\ partial$
*restoration due to circuit breaker fault*

$P_5 = probability\ of\ being\ out\ due$
*to faulty busbar*

$P_6 = probability\ of\ partial$
*restoration due to busbar fault*

$P_7 = probability\ of\ being\ out\ due$
*to faulty cable*

$P_8 = probability\ of\ being\ out\ due$
*to faulty pole*

$P_9 = probability\ of\ being\ out$
*due to faulty overhead lines*

$P_{10} = probability\ of\ being\ out\ due$
*to faulty insulator*

$P_{11} = probability\ of\ being\ out$
*due to faulty bushing*

$P_{12} = probability\ of\ being\ out$
*due to disconnector*

Putting the above equations in a markovian matrix;

$$\Pi = \begin{bmatrix} -\lambda & 0 & & & \mu_1 & 0 & \mu_2 & 0 & \mu_3 & \mu_4 & \mu_5 & \mu_6 & \mu_7 & \mu_8 & \mu_9 \\ \lambda_1 & -\sigma_1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \sigma_1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \lambda_2 & -\sigma_2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \sigma_2 & -\mu_2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \lambda_3 & 0 & 0 & 0 & 0 & -\sigma_3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \sigma_3 & -\mu_3 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\mu_4 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\mu_5 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\mu_6 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\mu_7 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\mu_8 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\mu_9 \end{bmatrix} \begin{bmatrix} P_0 \\ P_1 \\ P_2 \\ P_3 \\ P_4 \\ P_5 \\ P_6 \\ P_7 \\ P_8 \\ P_9 \\ P_{10} \\ P_{11} \\ P_{12} \end{bmatrix} \quad 36$$

Where;
$\lambda$ = the sum of all the components failure rates
$\lambda_i$ = the failure rates of power transformer, circuit breaker, busbar, cable, pole, surge arrester, insulator, bushing and disconnector respectively.
$\mu$ = the components repair rate.
$\mu_i$ = the repair rates of power transformer, circuit breaker, busbar, cable, pole, surge arrester, insulator, bushing and disconnector respectively.
$\sigma$ = the systems switching rate.
$\sigma_i$ = the switching rate of power transformer, circuit breaker, busbar and states represents a state of partial restoration.

## IV COMPONENT MODELING

A distribution system consist of various components such as Transformers, Circuit Breakers, Overhead lines, Underground, Cables, Fuse cut-outs and Sectionalizing switches with different unique characteristics. Components model are critical to distribution system reliability. A component model should be simple, but must capture all the features critical to the component [8].

## V COMPONENT RELIABILITY PARAMETER

Simple reliability models are based on component failure rate and repair rates of the system components.

- Permanent Short Circuit Failure Rate($\lambda_p$): Describes the number of times per year a component expected to experience a permanent short circuit.
- Temporary Short Circuit Failure Rate($\lambda_T$): Describes the number of times per year a component is expected to experience a temporary short circuit.
- Open Circuit Failure Rate($\lambda_{oc}$): Describes the number of times a component will interrupt the flow of current without causing fault current to flow.
- Schedule Maintenance Frequency($\lambda_m$): The frequency of schedule maintenance for a component
- Mean Time to Repair($MTTR$): Expected time it will take to repair a fault. A single MTTR is typically used for each component, but may be different for different failure modes.
- Mean Time to Switch($MTTS$): The mean time it will take a sectionalizing switch to operate after a fault occurs on the system.
- Probability of Operation Failure($POF$): Conditional statement that a component will not operate when called to operate.
- Mean Time to Maintain($MTTM$): The average time taken to perform schedule maintenance on a component.

## VI INTERRUPTION CAUSES

Customer's interruptions are caused by a wide range of phenomena which include equipment failure, tree, animals, severe weather and human error [10]. The interruption causes are at the distribution system primarily and understanding these phenomena will allow for practical perspective to reliability studies analysis [11]. Of all these phenomena, the most frequent and severe is equipment failure.

### A EQUIPMENT FAILURES

All distribution system equipment has a probability of failure associated to it [12]. When first installed, a piece of equipment can fail due to poor manufacturing, damage during shipping or installation [13]. Healthy equipment may fail as a result of high current or voltage, animals, severe weather etc., equipment will also fail for reasons such as chronological age, thermal aging, state of chemical decomposition, state of contamination and state of mechanical wear [14].

### B SEVERE WEATHER

Hash weather conditions are extreme situations which can be grouped under contingency [5][10]. They include: Tornadoes, Hurricanes, Earthquakes, and Heat Storm etc. The weather condition contingency that will be considered for the purpose of this paper is lightning Storm.

### C HUMAN FACTOR

These are reliability concern based on human. It is divided into three groups which would not be considered by this paper.

- Schedule Interruption
- Human Switching errors and
- Vehicular accidents

## VII TRANSITION MATRIX GENERATION AND EVALUATION OF FEEDER RELIABILITY INDEX:

The procedure for the evaluation of feeder reliability quotient; indices and availability are evaluated as shown below:

- Evaluate average feeder failure rate.
- Evaluate feeder mean down time
- Evaluate components failure; repair rate and switching rate.
- Evaluate feeder availability and distribution system reliability index.

System Average Interruption Frequency Index (SAIFI): measure of how many sustained interruptions an average customer will experience over the course of a specified time.

$$SAIFI = \frac{\sum customer\ sustained\ interrption}{Total\ number\ of\ customers\ served} \quad 37$$

System Average Interruption Duration Index (SAIDI): measure of how many interruptions an average customer will experience over the course of a specified time.

$$SAIDI = \frac{\sum customer\ outage\ duration}{Total\ number\ of\ customers\ served} \quad 38$$

CAIDI: measure of how long an average interruption lasts. It is a measure of utility response time.

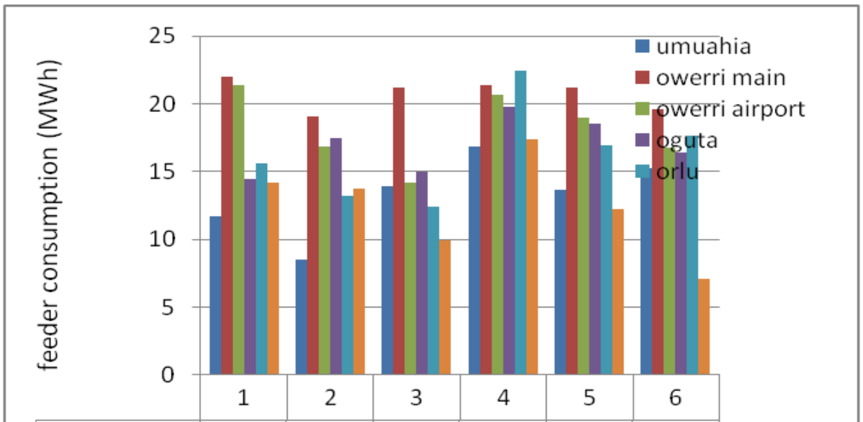
$$CAIDI = \frac{\sum customer\ interruption\ duration}{Total\ number\ of\ customers\ served} \quad 39$$

Average System Availability Index (ASAI): measure of customer weighted availability.

$$ASAI = \frac{Total\ customer\ served\ hour}{Total\ customer\ served\ time\ required} \quad 40$$

## VIII RESULTS AND DISCUSSION

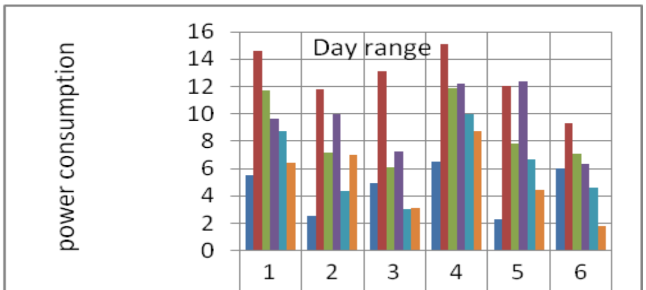
Figures 3 and 4 below show the monthly and daily feeder consumptions respectively.




| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| umuahia | 11.7 | 8.5 | 13.9 | 16.8 | 13.64 | 15.25 |
| owerri main | 22 | 19.1 | 21.2 | 21.4 | 21.2 | 19.625 |
| owerri airport | 21.4 | 16.8 | 14.2 | 20.7 | 19 | 16.75 |
| oguta | 14.47 | 17.5 | 15 | 19.8 | 18.5 | 16.375 |
| orlu | 15.6 | 13.2 | 12.4 | 22.4 | 16.9 | 17.625 |
| okigwe | 14.2 | 13.7 | 9.9 | 17.4 | 12.2 | 7.125 |

Day range

Fig.3. Monthly feeder consumption




| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| umuahia | 5.52 | 2.588 | 4.918 | 6.524 | 2.326 | 6.025 |
| owerri main | 14.57 | 11.79 | 13.14 | 15.08 | 12.06 | 9.32 |
| owerri airport | 11.68 | 7.202 | 6.104 | 11.86 | 7.814 | 7.125 |
| oguta | 9.638 | 10 | 7.29 | 12.18 | 12.36 | 6.36 |
| orlu | 8.722 | 4.368 | 3.03 | 9.998 | 6.718 | 4.62 |
| okigwe | 6.402 | 6.97 | 3.104 | 8.782 | 4.48 | 1.775 |

Fig.4. Daily feeder consumption

From the monthly and daily bar chart, it can be observed that Owerri main is the most industrialized feeder and the daily consumptions of the feeder are relatively high.

Table 1below shows the actual, modified failure rates and reliability of the feeders. The actual failure rates of the system gives an approximately zero reliability but with the failure rate modification, some reasonable reliability quotient was obtained.

Table1: Feeder failure rates and reliability.

| Feeder | Original failure rate | Modified failure rate | Reliability (%) |
|---|---|---|---|
| Umuahia | 41.203 | 0.41203 | 12.74 |
| Owerri main | 15.972 | 0.15972 | 45.4 |
| Owerri airport | 43.117 | 0.43117 | 11.53 |
| Oguta | 19.381 | 0.19381 | 37.94 |
| Orlu | 12.795 | 0.12795 | 52.74 |
| Okigwe | 33.406 | 0.33406 | 18.82 |

Table 2 shows the feeder reliability indices against the other. The worst performing feeder can be observed to be Owerri airport and the factor necessitating the ill performance can be corrected.

Table2: Feeder down time and reliability index

| Feeders | Total down time | ASAI | SAIDI | SAIFI | CAIDI |
|---|---|---|---|---|---|
| Umuahia | 1406.69 | 0.3781 | 0.0354 | 0.005275 | 0.1760 |
| Owerri main | 152.40 | 0.041 | 0.0038 | 0.001975 | 0.0190 |
| Owerri airport | 359.49 | 0.0966 | 0.0090 | 0.054 | 0.0450 |
| Oguta | 454.78 | 0.1222 | 0.0114 | 0.002425 | 0.0570 |
| Orlu | 314.44 | 0.0845 | 0.0079 | 0.00135 | 0.0398 |
| Okigwe | 969.30 | 0.2606 | 0.0242 | 0.04175 | 0.1212 |

Table 3 shows the energy not served and cost of energy not served incurred by the utility.

Table 3: Total Energy Not Served(ENS) and Cost

| Feeder | Total ENS (MWh) | Average ENS (MWh) | Cost of ENS (N million) |
|---|---|---|---|
| | | | |
| Umuahia | 393.9 | 78.78 | 1.010 |
| Owerri main | 167.25 | 33.45 | 0.429 |
| Owerri airport | 161.89 | 32.38 | 0.415 |
| Oguta | 122.37 | 24.46 | 0.313 |
| Orlu | 350.41 | 70.08 | 0.898 |
| Okigwe | 583.62 | 116.72 | 1.496 |

$P_0 = 0.8684;\ P_1 = 0.0419;$
$P_2 = 0.03673;\ P_3 = 0.00125;$
$P_4 = 0.00334;$
$P_5 = 0.000119;\ P_6 = 0.000297;$
$P_7 = 0.000397;\ P_8 = 0.0465;$
$P_9 = 0.000397;\ P_{10} = 0.000238;$
$P_{11} = 0.000238;\ P_{12} = 0.000238$

## IX CONCLUSION

From the analysis performed on the systems parameter, it can be observed that the feeders exhibit high average failure rates, high repair rates and low switching rates. The nature of the system parameter undoubtedly makes the system have the following:

i. Low Reliability quotient

ii. Average availability quotient
iii. High SAIFI
iv. High SAIDI
v. High CAIDI and
vi. Low ASAI

With these observable problems of the feeders, a customer would rather resort to the back-up supply rather than the utility supply. From the analysis performed, the factors causing the system low reliability and reliability quotients are:

a. Feeders component high failure rates due to
   i. Maintenance problem
   ii. System components overloading
   iii. Operators operation
b. Feeders high repair rates due to
   i. Low utility response to fault clearance
   ii. Manual operation of system
c. High energy not served during fault because of the feeder is not segmented.

## X RECOMMENDATION

The feeder as analyzed above shows the reliability quotient and feeder indices. For optimal performance of the system the following recommendation should be considered.

- Increase the ratings of components employed in the feeder. Most of the feeder failure is due to component overloading.
- Adopt preventive maintenance schedule. The schedule for maintenance can be allocated using the consumption bar chart presented in figure 1.
- Dividing system into segment so as to reduce energy not served. Utility incur high cost of energy not served (CENS) when faults occur. If the feeder circuit is increased and divided by fuses, the amount of energy not served will reduce and hence cost of energy not served
- Creation of Performance Based Rating (PBR) Regulatory. The regulation has to place a stipulation on the reliability quotient and reliability indices of utility to help improve service to customer.

Adopting Customer Cost of Reliability technique. Making the customers has their reliability contracts.

## XI ACKNOWLEDGEMENT

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