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ANALYTICAL APPROACH IN RELIABILITY ASSESSMENT IN SOME PARTS OF 33/11KV POWER DISTRIBUTION SYSTEM USING FAULTS OUTAGE DATA OF PHED POWER OPERATOR IN PORT HARCOURT RIVERS STATE NIGERIA

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ABSTRACT

Reliable and steady supply of electrical energy to consumers at distribution voltage level in every network is of fundamental importance to both service providers their customerss. For the customerr equipment to function properly the quality of supply must be assured, therefore there must be a method of performing a reliability assessment the network in question. This paper presents an analytical approach in reliability assessment of some parts of the 33/11kV Port Harcourt Electricity Distribution (PHED) network. The assessment was carried out using some of the 2017 power outage data from the PHED operator.

KEYWORDS: *Lightning Faults, Power Outages Due to Various Faults, Load Shading, PHED Power System Facilities Breakdown Due to Faults, Protection of Power System Facilities, etc.*

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INTRODUCTION

Reliability Improvement implies the restoration of system reliability to a first-class rating. The three major objectives of Reliability Improvement were to reduce outages and supply downed times, the number and duration of customers supply interruptions in each outage, and restoration time. Overhead primary electric power lines were inspected, and those that needed restoration improved. During the restoration activity, lightning arresters and grounded shield wires were employed in many locations to provide safety from lightning strokes and other types of faulted conditions. Introducing Circuit loopings or ring mains units (R.M.U'S) helps in improving the reliability of electric power supply, with this approach, feeders are provided with alternative supply routes to reduce outages and maintain continuity of supply in the event of occurence of fault. Also, automatic and remote circuit switching like auto-reclosers are necessary to isolate power line faults during a restoration of supply.

Systems Integration

Systems Integration is helping the power industry to achieve new levels of performance, with innovative ideas and better practices. The use of expert industry tested engineers help to improve the system reliability. Systems Integration is comprised of advanced degree electrical engineers with varied and complementary backgrounds. With over 35 years

experience combined with their education, they are able to offer practical solutions for today's system challenges. Their objective is clearly defined: To provide technical expertise for the most cost-effective application of power system equipment.

Theory to Application

Analytical studies are performed to evaluate equipment interactions and develop specifications for electrical distribution power systems. An analysis has to be done prior to a new installation or upgrade to avoid problems leading to costly shutdowns and repairs. Custom made software and measurement equipment should be available for monitoring, analyzing, and troubleshooting of existing system. There can be an ongoing technical support to provide thorough training programs, publications, and on-site consultations.

One Stop Solution

Whether the objective is to design, upgrade or troubleshooting an electrical power distribution system. Systems Integration must possess the experience, expertise and technology to assist with distribution power quality, reliability, environmental or distribution automation concerns. They can provide the complete analysis of services that include on-site investigations, quantifiable reliability improvements, root cause analysis, customer software, measurement equipment and studies. Systems Integration pioneered by custom harmonic and voltage flicker measurement equipment, in response to industry needs. Technical workshops and publications are needed to provide on-going training, focused on practical, cost-effective solutions

Deterministic Method of Data Collection

Using the deterministic approach in data collection, the main interest is to maintain adequate supply to the customers under most likely outage conditions while accepting responsibility for equipment non-performance under low probability outages involving distribution facilities such as protective gears and equipment gears.

Probabilistic Approach

Direct Analytical

Monte Carlo Simulation

Hybrid

Reliability Indices

System Problem Indices:

These indices are calculated without remedial actions and thus represent an upper bound on unreliability.

Demonstration Sample System

The analytical method employed in this paper is derived from what is known as Commercial Reorientation of the electricity Sector toolkit (CREST). This is software employed in monitoring the implementation of the Reliability Index.

The sample system used for this evaluation involves the *33/11kV power distribution feeders from which faults outage data are obtained.* The facility has a primary feeder line operating from 33kV and a secondary feeder line operating from an 11kV network that functions as an alternative supply route in the case of problems on the primary feeder line.

33/11kV power distribution system faults outage data are obtained from the PHED data bank.

Port Harcourt Electric Distribution Company Diobu District

Measurements of System Reliability Index 1

MONTH: June, 2017

DATE: 4Th June, 2017

Table 1: 33KV System Reliability Index: Supply Hrs/Total Hrs

S/N	Feeders Name	Outage Time (Hr)	Reason for Outage	Reliability Index (%)
1	Airport	192	12% Line fault,88% Load Shedding	73.33
2	Refinery Line 1	200	10% Line fault,90% Load Shedding	72.22
3	RSPUB 1	298	11% Line fault,89% Load Shedding	58.61
4	U.S.T 33kv	73	13% Line fault,87% Load Shedding	89.86
5	Turbine Line	52	100% Line fault,0% Load Shedding	92.78

For monitoring the implementation of the CREST (Commercial Reorientation of the electricity Sector toolkit). The Reliability Index for 33KV feeders in Diobu district for the month of June is $\frac{386.80}{5} = 77.36$. The percentage reliability for 33kv system in Diobu district in the month of June is 77.36%

Table 2: 11KV System Reliability Index: Supply Hrs/Total Hrs

S/N	Feeders Name	Outage Time (Hr)	Reason for Outage	Reliability Index (%)
1	U.S.T 11kv feeder	73	22% Line fault,78% Load Shedding	89.86
2	Ojoto Street Area	250	15% Line fault,85% Load Shedding	65.28
3	Wokoma Street	540	08% Line fault,92% Load Shedding	25.00
4	Federal Govt College	533	09% Line fault,91% Load Shedding	25.97
5	Oyigbo Area	554	N/A (No Radio Communication)	23.06
6	Zenith Bank	540	N/A (No Radio Communication)	25.00
7	Eligbolo Area	470	06% Lines Faults, 94% Load Shedding	34.72
8	F.G.College	474	0% Lines Faults, 100% Load Shedding	34.17
9	Choba Area	512	16% Lines Faults, 84% Load Shedding	28.89
10	Rumuola Area	191	50% Lines Faults, 50% Load Shedding	73.47
11	Bori Camp Military	122	20% Lines Faults, 80% Load Shedding	83.06
12	New GRA/Amadi Flat Junction	453	5% Lines Faults, 95% Load Shedding	37.08
13	D-Line Area	177	16% Lines Faults, 84% Load Shedding	75.42
14	Abonnema Wharf	412	10% Lines Faults, 900% Load Shedding	42.78
15	Aluu Area	490	12% Lines Faults, 880% Load Shedding	31.94
16	Rumuomoi Area	450	3% Lines Faults, 97% Load Shedding	37.50
17	Okporo Area	380	15% Lines Faults, 85% Load Shedding	47.22
18	Mile one Diobu Area	10	06% Lines Faults, 90% Load Shedding	68.06
19	Old Diobu Area	204	07% Lines Faults, 93% Load Shedding	71.67

Therefore the Reliability Index for 11KV feeders in Diobu district in the month of June is $\frac{920.15}{17} = 54.26$. The percentage reliability for 11kv system in Diobu district in June is 54.26%. The overall Reliability for the month is 65.81%

MONTH: July, 2017

DATE: 2ND July, 2017

Table 3: 33KV System Reliability Index: Supply Hrs/Total Hrs

S/N	Feeders Name	Outage Time (Hr)	Reason for Outage	Reliability Index (%)
1	Airport	189	12% Line fault,88% Load Shedding	73.08
2	Refinery Line 1	210	10% Line fault,90% Load Shedding	70.08
3	RSPUB 1 Injection Station	140	11% Line fault,89% Load Shedding	80.06
4	U.S.T 33kv Feeder	89	13% Line fault,87% Load Shedding	87.32
5	Turbine Line Area	40	100% Line fault,0% Load Shedding	94.30

For monitoring the implementation of the CREST (Commercial Reorientation of the electricity Sector toolkit). The Reliability Index for 33KV feeders in Diobu district in July is $\frac{404.84}{5} = 80.97$. The percentage reliability for 33kv system in Diobu district in July is 80.97%

Table 4: 11KV System Reliability Index: Supply Hrs/Total Hrs

S/N	Feeders Name	Outage Time (Hr)	Reason for Outage	Reliability Index (%)
1	U.S.T 11kv feeder	109	22% Line fault,78% Load Shedding	84.24
2	Ojoto Street	230	15% Line fault,85% Load Shedding	31.62
3	Wokoma Street	480	08% Line fault,92% Load Shedding	34.47
4	Federal Govt College	460	09% Line fault,91% Load Shedding	31.48
5	Oyigbo Street	481	N/A (No Radio Communication)	31.62
6	Zenith Bank	480	N/A (No Radio Communication)	55.13
7	Eligbolo Street	315	06% Lines Faults, 94% Load Shedding	56.98
8	F.G.C Street	302	0% Lines Faults, 100% Load Shedding	28.92
9	Choba	499	16% Lines Faults, 84% Load Shedding	28.89
10	Rumuola	200	50% Lines Faults, 50% Load Shedding	71.51
11	Bori Camp	102	20% Lines Faults, 80% Load Shedding	85.47
12	New GRA/Amadi Junction	431	5% Lines Faults, 95% Load Shedding	38.60
13	D-Line	261	16% Lines Faults, 84% Load Shedding	62.82
14	Abonnema Wharf	400	10% Lines Faults, 900% Load Shedding	43.02
15	Aluu	450	12% Lines Faults, 880% Load Shedding	35.90
16	Rumuomoi	401	3% Lines Faults, 97% Load Shedding	42.88
17	Okporo	331	15% Lines Faults, 85% Load Shedding	52.85
18	Mile one	320	06% Lines Faults, 90% Load Shedding	54.42
19	Old Diobu	300	07% Lines Faults, 93% Load Shedding	57.26

Therefore the Reliability Index for 11KV feeders in Diobu district in July is $\frac{965.86}{17} = 56.82$. The percentage reliability for 11kv system in Diobu district in July is 56.82%.**The overall Reliability for the month is 56.82%**

Measurements of System Relaibility Index II

MONTH: August, 2017

DATE: 2ND August, 2017

Table 5: 33KV System Reliability index: Supply Hrs/Total Hrs

S/N	Feeders Name	Outage Time (Hr)	Reason for Outage	Reliability Index (%)
1	Airport	75	6% Line fault, 0% Station Guarantee 94% Load Shedding	89.67
2	Refinery Line 1	82	2.9% Line fault, 8.6% Station Guarantee 88.5% Load Shedding	88.71
3	RSPUB 1	121	9.5% Line fault, 19% Station Guarantee 71.5% Load Shedding	83.33
4	U.S.T 33kv	13	30.8% Line fault, 0% Station Guarantee 69.2% Load Shedding	98.21
5	Turbine Line	6	0% Line fault, 40% Station Guarantee 60% Load Shedding	99.17

For monitoring the implementation of the CREST (Commercial Reorientation of the electricity Sector toolkit) The Reliability Index for 33KV feeders in Diobu district in August is $\frac{459.09}{5} = 91.82$. The percentage reliability for 33kv system in Diobu district in August is 91.82%

Table 6: 11KV System Reliability Index: Supply Hrs/Total Hrs

S/N	Feeders Name	Outage Time (Hr)	Reason for Outage	Reliability Index (%)
1	U.S.T 11kv feeder	16	27% Line fault, 0% Station Guarantee 73% Load Shedding	97.80
2	Ojoto	106	27.5% Line fault, 15.7% Station Guarantee 56.8% Load Shedding	85.40
3	Wokoma	347	16% Line fault, 04% Station Guarantee 80% Load Shedding	52.20
4	Federal	348	22% Line fault, 05% Station Guarantee 73% Load Shedding	52.07
5	Oyigbo	516	09% Line fault, 3% Station Guarantee 88% Load Shedding	28.93
6	Zenith	612	22% Line fault, 09% Station Guarantee 69% Load Shedding	15.70
7	Eligbolo	377	05% Line fault, 07.5% Station Guarantee 87.5% Load Shedding	48.07
8	F.G.C	414	13% Line fault, 04% Station Guarantee 83% Load Shedding	42.98
9	Choba	466	07% Line fault, 06% Station Guarantee 87% Load Shedding	35.81

Table 6: Contd.,				
10	Rumuola	192	18.5% Line fault, 04% Station Guarantee 77.5% Load Shedding	73.55
11	Bori Camp	230	11.5% Line fault, 02% Station Guarantee 86.5% Load Shedding	68.32
12	New GRA/Amadi Junction	285	20% Line fault, 06% Station Guarantee 74% Load Shedding	60.74
13	D-Line Axis	196	23% Line fault, 08% Station Guarantee 69% Load Shedding	73.00
14	Abonnema Wharf	233	03.5% Line fault, 10.5% Station Guarantee 86% Load Shedding	67.91
15	Aluu	353	15% Line fault, 10% Station Guarantee 75% Load Shedding	51.38
16	Rumuomoi	116	09% Line fault, 06% Station Guarantee 85% Load Shedding	84.02
17	Okporo	300	05% Line fault, 11% Station Guarantee 84% Load Shedding	58.68
18	Mile one	230	10% Line fault, 10% Station Guarantee 80% Load Shedding	68.32
19	Old Diobu	141	07% Line fault, 14.8% Station Guarantee 79% Load Shedding	80.58

Therefore the Reliability Index for 11KV feeders in Diobu district in August is $\frac{1145.46}{17} = 67.38$.

The percentage reliability for 11kv system in Diobu district in September is 67.38%.

Measurements of System Reliability Index III

MONTH: September, 2017

DATE: 3RD September, 2017

Table 7: 33KV System Reliability Index: Supply Hrs/Total Hrs

S/N	Feeders Name	Outage time (Hr)	Reason for Outage	Reliability Index (%)
1	Airport	216	10.34% Line fault, 01.16% Station Guarantee 88.50% Load Shedding	70.00
2	Refinery Line 1	165	02.00% Line fault, 0% Station Guarantee 98.00% Load Shedding	77.08
3	RSPUB 1	Breaker By-passed	Breaker By-passed	Breaker By-passed
4	U.S.T 33kv	19	52.94% Line fault, 0% Station Guarantee 47.05% Load Shedding	97.36

Table 7: Contd.,				
5	Turbine Line	48	35.30% Line fault, 0% Station Guarantee 64.70% Load Shedding	93.33

For monitoring the implementation of the CREST (Commercial Reorientation of the electricity Sector toolkit). The Reliability Index for 33KV feeders in Diobu district in September is $\frac{337.77}{4} = 84.44$. The percentage reliability for 33kv system in Diobu district in September is 84.44%

Table 8: 11KV System Reliability Index: Supply Hrs/Total Hrs

S/N	Feeders Name	Outage Time (Hr)	Reason for Outage	Reliability Index (%)
1	U.S.T 11kv feeder	42	15% Line fault, 0% Station Guarantee 85% Load Shedding	94.03
2	Ojoto	92	17.39% Line fault, 10.87% Station Guarantee 71.74% Load Shedding	86.93
3	Wokoma	336	16% Line fault, 04% Station Guarantee 80% Load Shedding	52.27
4	Federal	331	08.23% Line fault, 09.42% Station Guarantee 82.35% Load Shedding	52.98
5	Oyigbo	461	08.23% Line fault, 01.33% Station Guarantee 90.67% Load Shedding	35.97
6	Zenith	420	19.75% Line fault, 03.71% Station Guarantee 76.54% Load Shedding	41.67
7	Eligbolo	469	12.33% Line fault, 02.74% Station Guarantee 84.93% Load Shedding	34.86
8	F.G.C	533	18.39% Line fault, 03.45% Station Guarantee 78.16% Load Shedding	25.97
9	Choba	536	15.63% Line fault, 07.29% Station Guarantee 77.08% Load Shedding	25.55
10	Rumuola	269	03.77% Line fault, 01.89% Station Guarantee 94.34% Load Shedding	62.64
11	Bori Camp	251	14.28% Line fault, 05.37% Station Guarantee 80.35% Load Shedding	64.35
12	New GRA/Amadi Junction	253	09.80% Line fault, 01.97% Station Guarantee 88.23% Load Shedding	64.06
13	D-Line	313	17.95% Line fault, 01.28% Station Guarantee 80.77% Load Shedding	55.54
14	Abonnema Wharf	272	21.43% Line fault, 03.57% Station Guarantee 75.00% Load Shedding	61.36

Table 8: Contd.,				
15	Aluu	225	04.61% Line fault, 07.70% Station Guarantee 87.69% Load Shedding	68.04
16	Rumuomoi	299	13.11% Line fault, 08.20% Station Guarantee 78.69% Load Shedding	58.47
17	Okporo	196	08.06% Line fault, 06.46% Station Guarantee 85.48% Load Shedding	72.78
18	Mile one	243	01.69% Line fault, 03.40% Station Guarantee 94.91% Load Shedding	66.67
19	Old Diobu	141	01.86% Line fault, 12.96% Station Guarantee 85.18% Load Shedding	80.42

Therefore the Reliability Index for 11KV feeders in Diobu district in September is $\frac{1104.83}{17} = 64.99$.

The percentage reliability for 11kv system in Diobu district in September is 64.99%

DISCUSSIONS

1. From the tables 1, 2, and 3, the percentage reliability for 11kv system in Diobu district in the month of August is 67.38%. **The overall Reliability for the month is 79.60%.**

It can be observed that the individual Reliability Index for the 11kv feeders is generally fair, but that of Choba Area, Oyigbo and Zenith Bank appear lowest. Efforts need to be made in improving on the outage time of these feeders on both Load shedding and station guaranteed supply which could be controlled by proper time secheduling. The Managers in charge of Protection and Control (P & C) and Operations and Maintenance (O & M) might have to work on the coordination of Station Guaranteed supply, in particular feeders that are grouped into common time and day arrangement, thereby reducing the frequency of the application of station guaranteed supply (**this is so called because these network areas must receive supply under all conditions**), which will help in improving on the Reliability Indices.

2. Also from tables 4 to 8 the percentage reliability for 11kv system in Diobu district in September is 64.99% on the other hand; the overall Reliability for the month is 74.73%

It can be noted that the individual Reliability Index of the 11kv feeders is generally fair, but that of Choba Area, F.G.C (Federal Government College) and Eligbolo which are tied to an Airport 33kV feeder line appear to be the lowest. Efforts must be made to improve (i.e.reduce) at the outage time of these feeders with a special interest in Airport feeder which controls to a reasonable extent the reliability Indexes of these feeders lines. This will improve the general reliability indices of the District.

CONCLUSIONS

Outage due to faults of various origins must be minimized in other to meet consumer's power supply needs. Lightning activities when it become a source of either outage or power disruption must be provided with adequate protection in an absolute sense. Although it is essentially impossible to eliminate lightning faults. Lightning can overcome

any barrier man can conceive. A hazard mitigation approach to lightning safety may be a prudent course of action. Power authorities should develop a lightning safety policy and integrate it into their overall safety plan. Appropriate training policies should be arranged for all employees designed to develop a realistic awareness of personal on lightning safety. Futher, training should be given to indoors employees using telephones and other indoor electrical facilities can be a source of shocks. Employees working outdoors must understand the nature of the lightning hazard as well as appropriate safety measures. Lightning stroke and other outages may be forecasted for but none the less it has its own agenda and may cause damage despite application of best technology, including those described above. Any comprehensive approach for protection of electric power apparatus should be site-specific to attain maximum efficiencies. In order to mitigate the hazard, ordered attention to details of grounding, bonding, shielding, air terminals, surge arrestor devices, maintenance, and employment of risk management principles should be provided for.

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