

ESTIMATING THE EFFECT OF **LOAD-SHEDDING** ON OUTAGE RATE IN A LOW VOLTAGE NETWORK

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ABSTRACT:

It has been observed that **Low Voltage (LV)** network in Ado-Ekiti have high outage frequencies and durations. There have been incessant power outages, voltage drop and rise during peak and off-peak periods on the LV network. These are the major electricity supply challenges being experienced in the low voltage distribution networks. An investigation to the causes of the outages became necessary to determine measures to increase supply availability on the LV network. In this work, causes of LV network faults, interruptions and outages were investigated and analyzed using quantitative statistical method. In the course of the investigation, it was discovered that the average rate of outage/fault occurrence in the LV network when considered with **load-shedding** ranges from 0.012 to 0.039 events/hour, that is from 2-7 outage event/week at an average of 5 outages per transformer per week of operation while the rate without **load-shedding** ranges from 0.0065 to 0.021 events/hour. Prominent among the categories of outages analyzed are “no supply” (46.7%) and “low voltage” (40.8%). System reliability was also measured using customer and load-oriented indices as the assessment tool.

Keywords: Low voltage, Distribution network, Power Outages.

1. INTRODUCTION

Power outages is a recurrent phenomenon in most sub-Saharan African countries and describes a state of complete absence of electricity at the consumers end (Amadi, 2015). Despite the billions of dollars invested in the Nigeria power sector, electricity supply situation in the country keeps worsening, day by day to the extent that about 95% of Nigerians cannot boast of 16 hours of electricity availability daily (The Daily Pilot, 3rd April, 2014), while many urban cities and towns across the country hardly enjoy three to four hours of uninterrupted power supply each day due to the ever-widening gap between demand and supply, especially in the urban cities.

In fact, power outages have assumed a very high embarrassing dimension in Nigeria. There are several areas of national life that power outage should never rear its ugly

head but alas in Nigeria power outage for several days is common and could happen just anywhere (Arobieke et al, 2012).

According to Gaver (2001), the level of disruption is a function of dependency of people on electricity which can be very high for a developed country and low for developing countries. In Nigeria, the available power generated is not enough to meet the demands of the users leading to constant **load-shedding** and blackout. Also, Musa et al (2015) stated that outages in the network are due to “**ageing of equipment and defects, lighting, vandalization, poor maintenance etc**”.

From the work of Amadi (2015), it was found that any power outage, even of the shortest duration in Port Harcourt City has severe economic impact. Business and social activities in the area are becoming rapidly more dependent on electricity and there is likelihood that the potential impacts of power outages on industries would abate in the nearest future.

Amadi thereafter, suggested immediate upgrade of power infrastructures beginning with distribution subsector to ensure they can efficiently distribute amount of electrical power being generated currently and in the foreseeable future.

Contrary to Amadi (2015) suggestion on the upgrade of the distribution sector did not note that outages experienced at the distribution end is a resultant effect of generation and transmission deficiencies. Therefore, all sectors in the power industry requires total overhaul.

Several researches have been carried out on how to reduce or eradicate power outage and ways of improving the power distribution system. Owing to the fact that electrical energy cannot be stored, there is always a huge loss in revenue when the available power on the transmission line could not be effectively distributed to the consumers. This phenomenon causes persistence black out in Ado-Ekiti and its environment. The outage cost is a responsible indicator for the power supply availability in a distribution system.

Reliability describes the ability of continuous service without outages or failure or interruptions. Outage is state of a component when it is not available to perform its intended function while interruption is loss of electric power supply to one or more loads (Chinwuko, 2011). Chinwuko went further by saying that the distribution companies should demand side resource that would improve the reliability, operation and economics of the local distribution system. They should focus on the distribution system that considers all available resources to meet distribution needs. Investment at distribution level should be guided by the principles of efficient reliability, least cost and resource parity.

Chinwuko did not consider the effect of unbalance loading of distribution transformers on power outages. Installation of new distribution transformers may not solve the problem of power outage.

In addition, Quoriga et al (2011) states that faults are abnormal state of the network, usually associated with short circuits or insulation breakdown between two or more points, which cause the actuation of protective (automatic and manual) systems.

Quiroga (2011) concluded that from results on year to year the number of incidence rate do not follow a specific trend whereas the failures follow an increasing trend. His observation was based on failure rate obtained by aging and atmospheric influences per kilometer of line.

As distribution systems are growing large and being stretched too far, leading to higher system losses and poor voltage regulation, the need for an efficient and effective distribution system has therefore become more urgent and important (Hemasekhar et al, 2014).

Owing to the fact that the basic function of the electric power distribution system in a power network is to receive power at one or more supply points and to deliver it to the various loads, therefore, the best distribution system is one that will, cost effectively, efficiently and safely, supply adequate and uninterrupted electric service to both present and future probable loads (Pabla, 2008).

The review of literatures above concentrated largely on the incidences of failures and interruptions/outages as being occasioned by network/equipment aging, atmospheric influence and level of dependency on electricity. But certain important factor such as the effect of load-shedding on LV network outage rates was not addressed. Investigation of the effect of the unaddressed factor, load-shedding, on supply availability and outage rate on LV network provides the basis for this research work.

2. METHODOLOGY

The objective was achieved by collection of data through both primary and secondary sources. Primary data were collected through personal observations on the field and discussions with the utility personnel. The LV outages reports between January-December 2011 indicates types of outage and frequencies of occurrence on distribution transformers. This was collected from Benin Electricity Distribution Company (BEDC), Ado-Ekiti Dispatch office (customer's complaints) for quantitative statistical analysis. From the analysis, Availability and outage rates were estimated using customer oriented indices. These estimated indices were considered with and without load-shedding effect. Physical inspection was carried out on the network and standards of practice were used to identify the weaknesses observed as main causes of the LV outage, and through the analysis of the data; the LV outage/faults were characterized.

The collected data was applied to customer and load-orientated indices to assess the severity of system outages on future reliability prediction analysis.

2.1 Collection and Analysis of LV Outage Data

The LV outage report was collected from BEDC dispatch office. These contain information on all outage events on each distribution transformer. They were recorded in a narrative form, but for the purpose of this research work, the records were restructured and translated into a tabular and quantitative database in terms of outage category, frequency and duration, as shown in Tables 1 and 2.

The outage frequencies and durations were summarized into their respective averages - MEAN (OF) and MEAN (OD) as shown in Tables 3 and 4.

$$\text{Mean} = \frac{\sum_{i=1}^n OF_i}{n} \quad (1)$$

$$\text{Mean} = \frac{\sum_{i=1}^n OD_i}{n} \quad (2)$$

Where OF_i is Outage Frequency, OD_i is Outage Duration/Downtime, and n is the total number of transformers considered.

The analysis was performed with and without the consideration of load-shedding effects on the LV outages.

These data were used to evaluate supply availability (A) and Outage rate (λ) for each substation-line system and analyzed. A and λ were evaluated as in Equations 3 and 4:

$$A = \frac{\text{Mean uptime}}{\text{Mean Uptime} + \text{Mean Downtime}} = 1 - \frac{\text{Mean(OD)}}{OP} \quad (3)$$

$$\lambda = \frac{\text{Outage frequency}}{\text{Observation period}} = \frac{\text{Mean(OF)}}{OP} \quad (4)$$

Meanwhile, load-shedding scheme on the HV side of the transformers also contribute to the outage period, this factor was put into consideration as below;

Ado Ekiti distribution network is made up of four(4) 11kV feeders, which are being rotated on every 4hours. Two (2No) feeders are always on closed position at a time during peak period between 6.00am -8.00pm while 3No feeders are closed during off-peak period between 8.00pm and 6.00am. Therefore, the possibility of any feeder being supplied is (14hrs-18hrs) per feeder per day and not being supplied is (6hrs-10hrs) per feeder per day.

To determine a factor for load-shedding on outage rate and supply availability. Range from load-shedding minimum to load-shedding maximum was considered.

Load-shedding is minimum at complete 24hours, while at maximum between (6-10)hours availability

$$A_{LS(\min)} - A_{LS(\max)} = (24hr) \rightarrow \frac{6hr \rightarrow 10hr}{24hr} = 1 - (0.25 \rightarrow 0.42) =$$

For the worse case, 0.58 is applied in Equations 5 and 6

$$A = (A_{LS(\min)} - A_{LS(\max)}) = 1 - \frac{\text{Mean(OD)}}{0.58 * OP}$$

$$\lambda = \lambda_{\min} - \lambda_{\max} = \frac{\text{Mean(OF)}}{(A_{LS(\min)} - A_{LS(\max)}) * OP} = \frac{\text{Mean(OF)}}{0.58 * OP}$$

OP = 8760hours (12-months), 0.58 was being considered for worse case. Where $A_{LS(\min)}$ is Availability at minimum load

shedding, $A_{LS(max)}$ is availability at maximum load shedding and OP is the observation period.

The values of A and λ are presented in Table 5.

2.2 System reliability assessment

The use of customer and load orientated indices was the valuable tool used in measuring the system reliability. These indices are as follows.

- System Average Interruption Duration Index, SAIFI

$$SAIFI = \frac{\sum u \cdot N}{\sum n} \quad (7)$$

- System Average Interruption Duration Index, SAIDI

$$SAIDI = \frac{\sum u \cdot v}{\sum u} \quad (8)$$

- Customer Average Interruption Frequency Index, CAIFI

$$CAIFI = \frac{\sum v}{\sum u \cdot v} \quad (9)$$

- Customer Average Interruption Duration Index, CAIDI

$$CAIDI = \frac{\sum W}{\sum V} = \frac{SAIDI}{SAIFI} \quad (10)$$

Where U is the customer population, V is the number of interruptions/outages and W is outage duration to customers. Data collected were inputted and the reliability results are contained in Table 7 below.

Table 1: Summary of Outage Occurrences and Categories (January-December, 2011)

NAME OF SUBSTATION	NO SUPPLY	LOW VOLTAGE	OVER VOLTAGE	WIRE CUT	J&P FUSE CUT	TOTAL (OUTAGES/YEAR)
AGIP	31	74	7	14	6	132
MOBIL	59	78	4	3	3	147
OLUJODA	49	87	9	8	29	182
IRONA	56	71	6	9	7	149
MOFERERE	38	79	5	14	9	145
OLD OFFICE	43	91	12	8	5	159
OMISANJANA 1	88	75	3	8	3	177
OMISANJANA 2	49	34	1	1	2	87
AKURE MOTOR PARK	74	34	1	1	5	115
ILE-ABIYE	32	12	4	7	2	57
ADESHINA	77	32	2	3	3	117
ELEMURE	55	34	6	3	0	98
OKE-ONIYO	65	13	1	1	1	81
ADURALERE	77	9	2	1	1	90
SPORTLESS	54	18	4	3	1	80
TOTAL	847	741	67	84	77	1816
MEAN	56.5	49.4	4.5	5.6	5.1	121.1

Table 2: Summary of Outage Duration and Categories (January-December, 2011)

NAME OF SUBSTATION	NO SUPPLY	LOW VOLTAGE	OVER VOLTAGE	WIRE CUT	J&P FUSE CUT	TOTAL OUTAGES DURATION (HRS)
AGIP	401	368	32	48	32	881
MOBIL	488	435	25	45	30	1023
OLUJODA	520	486	22	50	244	1322
IRONA	350	533	48	110	98	1139
MOFERERE	320	600	66	130	85	1201
OLD OFFICE	550	495	102	65	20	1232
OMISANJANA 1	489	460	65	120	64	1198
OMISANJANA 2	420	140	30	22	25	637
AKURE MOTOR PARK	542	210	20	30	60	862
ILE-ABIYE	350	120	35	30	39	574
ADESHINA	345	210	45	60	30	690
ELEMURE	580	87	45	45	0	757
OKE-ONIYO	452	130	28	30	60	700
ADURALERE	478	120	20	59	30	707
SPORTLESS	350	765	185	105	24	1429
TOTAL DURATION	6635	5159	768	949	841	14352
MEAN	442.3	343.9	51.2	63.3	56.1	956.8

Table 3: Mean (OF)

NAME OF SUBSTATION	MEAN(OF)					
	Category of Outages					
	NO SUPPLY	LOW VOLTAGE	OVER VOLTAGE	WIRE CUT	J&P FUSE CUT	OUTAGES/ MONTH
AGIP	2.6	6.2	0.6	1.2	0.5	11.0
MOBIL	4.9	6.5	0.3	0.3	0.3	12.3
OLUJODA	4.1	7.3	0.8	0.7	2.4	15.2
IRONA	4.7	5.9	0.5	0.8	0.6	12.4
MOFERERE	3.2	6.6	0.4	1.2	0.8	12.1
OLD OFFICE	3.6	7.6	1.0	0.7	0.4	13.3
OMISANJANA 1	7.3	6.3	0.3	0.7	0.3	14.8
OMISANJANA 2	4.1	2.8	0.1	0.1	0.2	7.3
AKURE MOTOR PARK	6.2	2.8	0.1	0.1	0.4	9.6
ILE-ABIYE	2.7	1.0	0.3	0.6	0.2	4.8
ADESHINA	6.4	2.7	0.2	0.3	0.3	9.8
ELEMURE	4.6	2.8	0.5	0.3	0.0	8.2
OKE-ONIYO	5.4	1.1	0.1	0.1	0.1	6.8
ADURALERE	6.4	0.8	0.2	0.1	0.1	7.5
SPORTLESS	4.5	1.5	0.3	0.3	0.1	6.7
SYSTEM TOTAL	70.6	61.8	5.6	7.0	6.4	151.3
SYSTEM MEAN	4.7	4.1	0.4	0.5	0.4	10.1

Table 4: Mean (OD)

NAME OF SUBSTATION	MEAN(OD)					
	Category of Outages					
	NO SUPPLY	LOW VOLTAGE	OVER VOLTAGE	WIRE CUT	J&P FUSE CUT	OUTAGE DURATION/ MONTH
AGIP	33.4	30.7	2.7	4.0	2.7	73.4
MOBIL	40.7	36.3	2.1	3.8	2.5	85.3
OLUJODA	43.3	40.5	1.8	4.2	20.3	110.2
IRONA	29.2	44.4	4.0	9.2	8.2	94.9
MOFERERE	26.7	50.0	5.5	10.8	7.1	100.1
OLD OFFICE	45.8	41.3	8.5	5.4	1.7	102.7
OMISANJANA 1	40.8	38.3	5.4	10.0	5.3	99.8
OMISANJANA 2	35.0	11.7	2.5	1.8	2.1	53.1
AKURE MOTOR PARK	45.2	17.5	1.7	2.5	5.0	71.8
ILE-ABIYE	29.2	10.0	2.9	2.5	3.3	47.8
ADESHINA	28.8	17.5	3.8	5.0	2.5	57.5
ELEMURE	48.3	7.3	3.8	3.8	0.0	63.1
OKE-ONIYO	37.7	10.8	2.3	2.5	5.0	58.3
ADURALERE	39.8	10.0	1.7	4.9	2.5	58.9
SPORTLESS	29.2	63.8	15.4	8.8	2.0	119.1
SYSTEM TOTAL	552.9	429.9	64.0	79.1	70.1	1196.0
SYSTEM MEAN	36.9	28.7	4.3	5.3	4.7	79.7

Table 5: Values of A and λ (with Load-shedding)

NAME OF SUBSTATION	A						λ					
	Category of Outages						Category of Outages					
	NO SUPPLY	LOW VOLTAGE	OVER VOLTAGE	WIRE CUT	J&P FUSE CUT	TOTAL	NO SUPPLY	LOW VOLTAGE	OVER VOLTAGE	WIRE CUT	J&P FUSE CUT	(OUTAGES/HOUR)
AGIP	0.9211	0.9222	0.9937	0.9906	0.9937	0.8266	0.0066	0.0156	0.0015	0.0030	0.0013	0.0279
MOBIL	0.9040	0.9080	0.9951	0.9911	0.9941	0.7987	0.0125	0.0165	0.0008	0.0006	0.0006	0.0311
OLUJODA	0.8977	0.8973	0.9957	0.9902	0.9520	0.7398	0.0104	0.0184	0.0019	0.0017	0.0061	0.0385
IRONA	0.9311	0.8873	0.9906	0.9783	0.9807	0.7758	0.0118	0.0150	0.0013	0.0019	0.0015	0.0315
MOFERERE	0.9370	0.8732	0.9870	0.9744	0.9833	0.7636	0.0080	0.0167	0.0011	0.0030	0.0019	0.0307
OLD OFFICE	0.8917	0.8954	0.9799	0.9872	0.9961	0.7575	0.0091	0.0192	0.0025	0.0017	0.0011	0.0336
OMISANJANA 1	0.9038	0.9028	0.9872	0.9764	0.9874	0.7642	0.0186	0.0159	0.0006	0.0017	0.0006	0.0374
OMISANJANA 2	0.9173	0.9704	0.9941	0.9957	0.9951	0.8746	0.0104	0.0072	0.0002	0.0002	0.0004	0.0184
AKURE MOTOR P	0.8933	0.9556	0.9961	0.9941	0.9882	0.8303	0.0156	0.0072	0.0002	0.0002	0.0011	0.0243
ILE-ABIYE	0.9311	0.9746	0.9931	0.9941	0.9923	0.8870	0.0068	0.0025	0.0008	0.0015	0.0004	0.0120
ADESHINA	0.9321	0.9556	0.9911	0.9882	0.9941	0.8642	0.0163	0.0068	0.0004	0.0006	0.0006	0.0247
ELEMURE	0.8858	0.9816	0.9911	0.9911	1.0000	0.8510	0.0116	0.0072	0.0013	0.0006	0.0000	0.0207
OKE-ONIYO	0.9110	0.9725	0.9945	0.9941	0.9882	0.8622	0.0137	0.0027	0.0002	0.0002	0.0002	0.0171
ADURALERE	0.9059	0.9746	0.9961	0.9884	0.9941	0.8608	0.0163	0.0019	0.0004	0.0002	0.0002	0.0190
SPORTLESS	0.9311	0.8383	0.9636	0.9793	0.9953	0.7187	0.0114	0.0038	0.0008	0.0006	0.0002	0.0169
SYSTEM TOTAL	13.6941	13.9094	14.8488	14.8132	14.8345	12.1752	0.1791	0.1566	0.0142	0.0178	0.0163	0.3839
SYSTEM MEAN	0.9129	0.9273	0.9899	0.9875	0.9890	0.8117	0.0119	0.0104	0.0009	0.0012	0.0011	0.0256

Table 6: Values of A and λ (without Load-shedding)

NAME OF SUBSTATION	A						λ					
	Category of Outages						Category of Outages					
	NO SUPPLY	LOW VOLTAGE	OVER VOLTAGE	WIRE CUT	J&P FUSE CUT	TOTAL	NO SUPPLY	LOW VOLTAGE	OVER VOLTAGE	WIRE CUT	J&P FUSE CUT	(OUTAGES/HOUR)
AGIP	0.9542	0.9580	0.9963	0.9945	0.9963	0.8994	0.0035	0.0084	0.0008	0.0016	0.0007	0.0151
MOBIL	0.9443	0.9503	0.9971	0.9949	0.9966	0.8832	0.0067	0.0089	0.0005	0.0003	0.0003	0.0168
OLUJODA	0.9406	0.9445	0.9975	0.9943	0.9721	0.8491	0.0056	0.0099	0.0010	0.0009	0.0033	0.0208
IRONA	0.9600	0.9392	0.9945	0.9874	0.9888	0.8700	0.0064	0.0081	0.0007	0.0010	0.0008	0.0170
MOFERERE	0.9635	0.9315	0.9925	0.9852	0.9903	0.8629	0.0043	0.0090	0.0006	0.0016	0.0010	0.0166
OLD OFFICE	0.9372	0.9435	0.9884	0.9926	0.9977	0.8594	0.0049	0.0104	0.0014	0.0009	0.0006	0.0182
OMISANJANA 1	0.9442	0.9475	0.9926	0.9863	0.9927	0.8632	0.0100	0.0086	0.0003	0.0009	0.0003	0.0202
OMISANJANA 2	0.9521	0.9840	0.9966	0.9975	0.9971	0.9273	0.0056	0.0039	0.0001	0.0001	0.0002	0.0099
AKURE MOTOR P	0.9381	0.9760	0.9977	0.9966	0.9932	0.9016	0.0084	0.0039	0.0001	0.0001	0.0006	0.0131
ILE-ABIYE	0.9600	0.9863	0.9960	0.9966	0.9955	0.9345	0.0037	0.0014	0.0005	0.0008	0.0002	0.0065
ADESHINA	0.9606	0.9760	0.9949	0.9932	0.9966	0.9212	0.0088	0.0037	0.0002	0.0003	0.0003	0.0134
ELEMURE	0.9338	0.9901	0.9949	0.9949	1.0000	0.9136	0.0063	0.0039	0.0007	0.0003	0.0000	0.0112
OKE-ONIYO	0.9484	0.9852	0.9968	0.9966	0.9932	0.9201	0.0074	0.0015	0.0001	0.0001	0.0001	0.0092
ADURALERE	0.9454	0.9863	0.9977	0.9933	0.9966	0.9193	0.0088	0.0010	0.0002	0.0001	0.0001	0.0103
SPORTLESS	0.9600	0.9127	0.9789	0.9880	0.9973	0.8369	0.0062	0.0021	0.0005	0.0003	0.0001	0.0091
SYSTEM TOTAL	0.2426	0.4111	0.9123	0.8917	0.9040	-0.6384	0.0967	0.0846	0.0076	0.0096	0.0088	0.2073
SYSTEM MEAN	0.9495	0.9607	0.9942	0.9928	0.9936	0.8908	0.0064	0.0056	0.0005	0.0006	0.0006	0.0138

Table 7: System Reliability Indices

SN	T NAME OF TRANSFORMER	U CUSTOMER POPULATION (NO.)	V INTERRUPTIONS (NO.)	W TOTAL OUTAGE DURATION (HRS)	X TOTAL CUSTOMER INTERRUPTION DURATION =U*W	Y TOTAL CUSTOMER INTERRUPTION (NO.) =U*V
1	Agip	349	132	881	307469	46068
2	Mobil	431	147	1023	440913	63357
3	Olujoda	540	182	1322	713880	98280
4	Irona	345	149	1139	392955	51405
5	Moferere	398	145	1201	477998	57710
6	Old Office	185	159	1232	227920	29415
7	Omisanjana I	256	177	1198	306688	45312
8	Omisanjana II	189	87	637	120393	16443
9	Akure Motor park	216	115	862	186192	24840
10	Ile abiye	349	57	574	200326	19893
11	Adeshina	341	117	690	235290	39897
12	Elemure	211	98	757	159727	20678
13	Oke-Oniyo	325	81	700	227500	26325
14	Aduralere	189	90	707	133623	17010
15	Sportless	232	80	1429	331528	18560
	TOTAL	4556	1816	14352	4462402	575193

SAIDI	979.4561018
SAIFI	126.249561
CAIFI	0.003157201
CAIDI	7.758095109

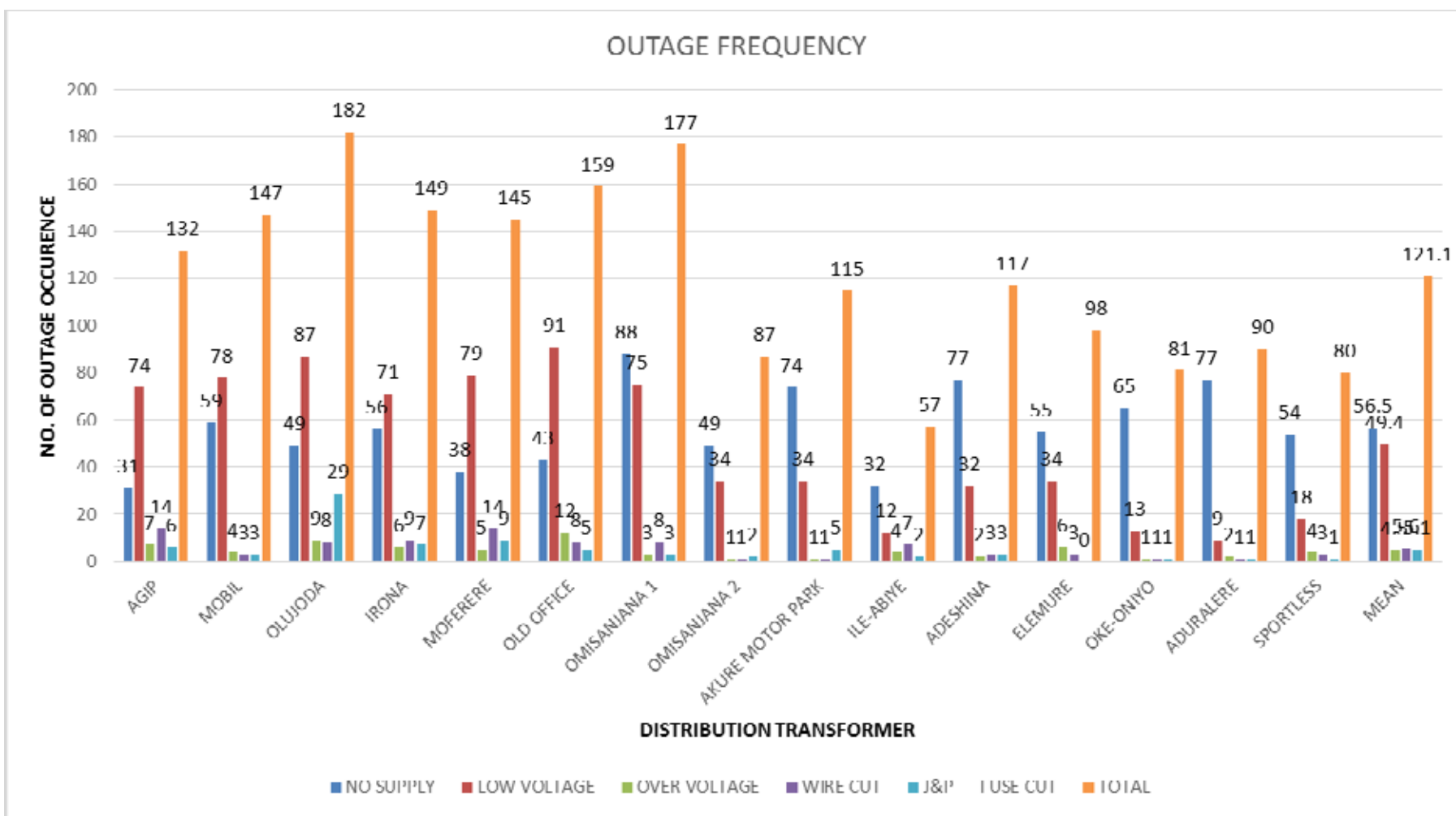


Figure 1: Frequency of Outage Occurrence

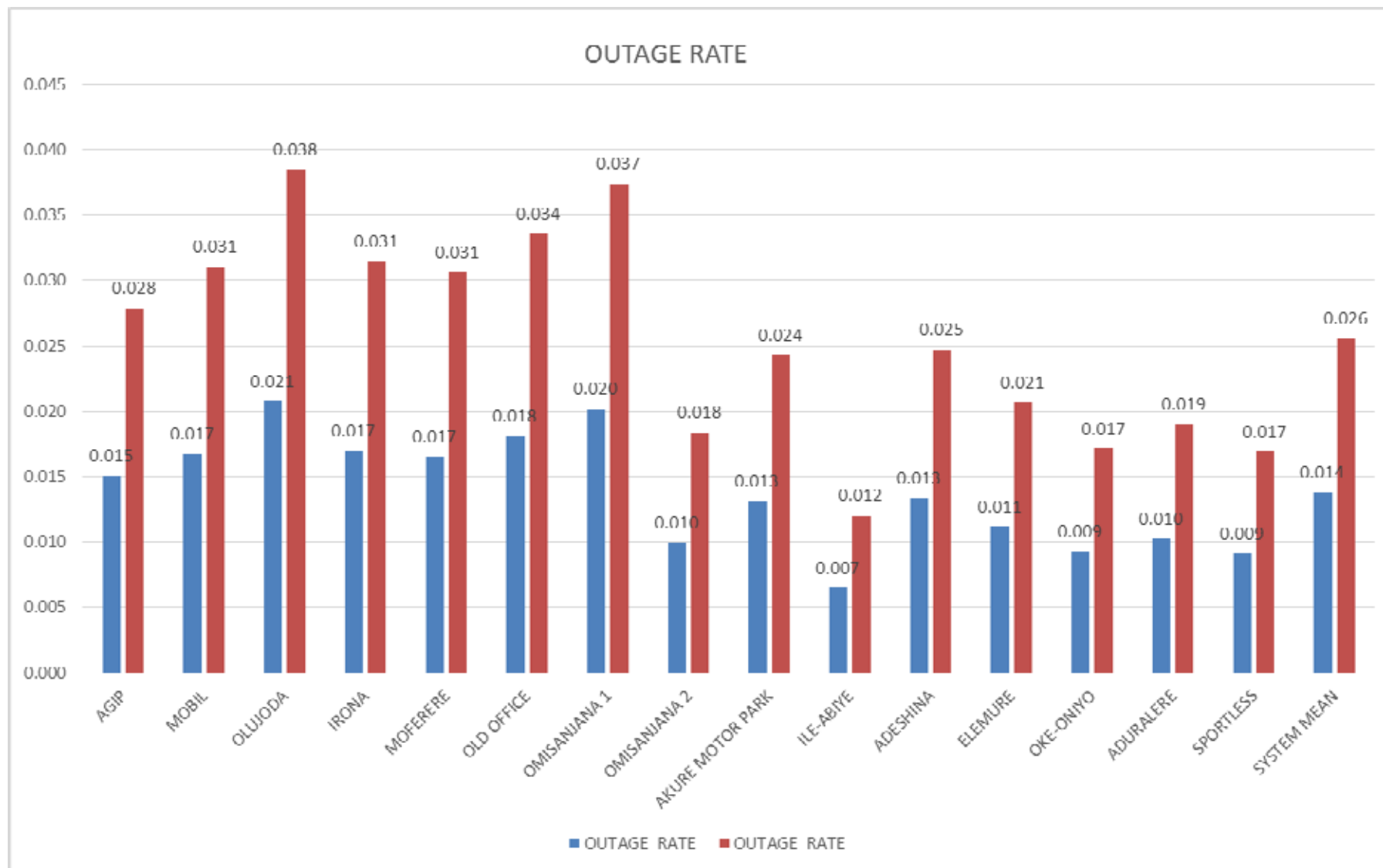


Figure 2: Comparison of LV Network Outage Rate (With or Without Load-shedding)

3 RESULTS AND DISCUSSION

Results obtained on the analysis of LV outages data are presented in Tables 1-6.

From Table 1, the “no supply” and “low voltage” are the major outage categories at 56.5(46.7%) and 49.4(40.8%) events/month respectively. It indicated that both categories are predominant while other categories contributed minimally. This is shown in Figure 1.

Table 1 indicated that the highest or predominant among the LV faults analyzed is “no supply” case. This is a situation where the fuses in the feeder pillar at the substations are burnt. This account for 51.8% of the total faults recorded during the period. The fault is usually occasioned by the rupturing of improvised copper wire used in place of HRC fuses due to phases over-load, bridging of LT wires. Upriser cut between the feeder pillar and the LT line reticulation is also responsible for no supply at the consumer end.

Low voltages at consumers end accounts for 39.3% of the total LV faults analyzed.

Over-voltage is responsible for 2.76% of the LV faults analyzed in this paper. Over-voltage is dangerous to customers and their properties since its value is far above the nominal value useful to the customers. It is usually caused by earth problem, 2- phases’ connection and neutral problem at the substations.

Wire cut also accounts for 2.76% of the faults analyzed. Weak and underrated conductors are responsible for incessant wire cut in the LV networks. Every line has thermal capacity limit set by the maximum current such conductor can carry. As soon as current passing through the conductor exceeds the limit, excessive heating occurs which thereafter leads to the wire-cut.

J&P “D” fuse cut is responsible for 3.38% of the entire faults analyzed. This is as a result of overloading of transformer, use of weak and underrated element fuses, bridging of LT lines, leakage of incomer cable to the ground, and Bulchurz fault within the transformer.

Table 2 contains duration of outages on each fault categories, it indicated that “no supply” has the highest outage duration while “overvoltages” has the least. No supply cases is mostly caused by load-shedding and general outage on the high voltage network.

From the comparison of outage rates with and without load-shedding in Figure 2, it is evident that the major cause of outage at consumers end is load-shedding activities. This is a method adopted to rotate power among feeders/circuits as the generated value is not sufficient to go around at once.

Rate of Outages occurrence of the selected transformers measured with and without the consideration of effect of Load-shedding on the network performance. The results are presented in Tables 5 and 6 respectively. From Table 5, with

load-shedding consideration, the outage rate ranges between 0.012-0.039 events per hour, that is, the transformer with 0.012 outage events/hour would experience two (2) events per week, while the transformers that has highest outage rates of 0.039 events/hour would experience 7 events per week of operation. Average outage rate of any of the transformer is 5 events per week. While Table 6, without load-shedding has failure rate range between 0.0065-0.021 events per hour. The average outage rate is 0.014 events per hour. That is, 3 outage events per week of operation for any of the transformer in the network. This is shown in Figure 2. It is evident from above that the LV system outage rate is too high.

From table 7, the evaluated value for SAIDI indicated that an average customer in the network was out for 979.5hours during the period. It was also confirmed through SAIFI that the average number of time a system-customer experienced outage during the period is 126.2, while CAIFI revealed that average number of interruption per customer interrupted per year/period is 0.00315 times. The CAIDI informed that the average restoration period for an interruption is 7.76hours.

5. CONCLUSION

This research work enabled us to estimate major effect of loadshedding on the LV network outage rate. Admittedly, the outage rate of the LV network/system with load-shedding ranges between 0.012-0.039 outages/hour, while the outage rate without load-shedding ranges from 0.0065-0.021 outages/hour. It is evident from this that load-shedding as a result of insufficient power generation is responsible for most cases of outage events experienced in Ado-Ekiti LV network.

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