Fault And Power Loss Analysis On 11kv Feeder Lines And Cost Implication On Ado-Ekiti Power Distribution Network

P. K. Olulope, A.M. Adebimpe

ABSTRACT: Fault, power loss and increasing demand for power by the various consumers pose a great challenge to the stakeholders in the energy sector. This study presents analysis of fault and power loss on 11kV network in Ado-Ekiti power distribution system. In order to achieve this aim, operational problem involving network unavailability due to fault occurrences and power loss due to outage are valuated and analyzed using descriptive statistical method. In the course of the study, outage events and durations, downtime of disconnected loads and nature of faults were observed and captured for analysis using statistical method. It is alarming, as this study reveals that substantial portion of the total power supplied to Ado-Ekiti in four years was lost as a result of the faults on the four (4) 11kV feeders in the State capital. Analysis of the result shows that frequent open circuit and earth faults are the causes of the losses and the implications on the economy in four years under consideration was estimated at one hundred and eight million, eight hundred and thirty five thousand, nine hundred and sixty eight naira (N108, 835, 968 .00). The percentage contribution of each feeder to the total fault of the network between 2008 and 2011 range from approximately 17% to 31% while the percentage contribution of each feeder to the load loss of the network range from approximately 17% to 33%. It was observed that reduced outage on the feeders and quick response to faults whenever it occurs are the ways of eliminating or reducing the losses.

Keywords: Power, Distribution system, Fault, Outages, Feeders, power loss, Energy, power outage, Ring Main Unit

1. INTRODUCTION

Distribution system is the largest portion of the electrical power system [1]. It can be defined as the part of a power system that distributes power to various customers in ready-to-use form at their place of consumption [2]. Distribution system is the medium through which electric power is conveyed in bulk from the power distribution station to the various end users [3]. It holds a very significant position in the power system since it is the main point of the link between bulk power and consumers [4], [5]. 11kV network links the 33kV primary distribution network to township main and suburb local customer load centres. Ado-Ekiti is fed from 1x15MVA & 1x7.5MVA 33/11kV distribution station through four 11kV feeders. The feeders are: Okesa, Basiri, Ajilosun and Adebayo. At the load points, 17 (50kVA), 43 (100kVA), 28 (200kVA), 32 (300kVA), 6 (315kVA), 57 (500kVA) and 1 (750kVA) distribution transformers further reduce the voltage from 11kV to 415V for customers' consumption. Admittedly, the shocks from the electricity crisis in Nigeria have created some wedges in the national wheel of effective management of industrial and the other socio-economic development programmes in Nigeria [6]. The occurrence of power outages is very high and alarming in Nigeria. There are several areas of national life that power outage should never occur but power outage for several days is common and could happen just anywhere in the country.

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In 2009, the Nigeria presidential palace was not spared and power outage became so frequent that ever since, the state house is powered 24 hours with generators. The last Junior World cup played in Nigeria in 2009 really brought out some embarrassing moments when the whole pitch was thrown into darkness. The Muritala Mohammed International Airport was not spared despite being the main gateway in the south into and out of this country [7], [8]. In the midst of this however, Nigeria's demand for energy and electricity is increasing rapidly [9]. 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 [10]. It must be emphasized that adequate attention should be paid to the power distribution network by subjecting it to review regularly for improvement and efficiency [11].

2. METHODOLOGY

The approach adopted for the study is as follows: Collection of relevant documented information about the Ado-Ekiti distribution network. Such documents include; electrical map, faults records, loading of the feeders, feeder lengths and conductor capacity. The electrical map shows the arrangement of the feeders, connection of ring main unit (R.M.U), span of each feeder and the positions of each distribution transformers and circuit breakers. Fault records show clearly the occurrence of fault on the feeders and how frequent the fault occurs. Inventory of distribution transformers gives a clear picture of names of feeders, voltage level and route length of feeders. Moreover, documented information on feeder loading reveals the loading of each feeder while the feeder length indicates the source and terminal of each feeder. In the course of this study, we had an interactive session with some of the members of staff of the power regulatory body (BEDC), Ado-Ekiti. We asked a number of questions as touching the challenges of the power distribution in the district especially the challenges posed by fault and load loss. They were able to give answers to the questions and made us understand how they have been coping with the challenges. The analysis of the collected data was done in a way as to categorize the faults, number of occurrence between January, 2008 and June, 2011. The causes of the faults on the feeders, the load loss associated with each fault and the economic implication.

2.1 Data Analysis

The collected data was analyzed using numerical statistical technique. The outage events were grouped into monthly and annual aggregates considering the feeders in turn as shown in Tables 1- 4. This includes downtime load loss calculated on monthly basis and analyzed on yearly basis. The downtime load loss $DTLL_m$ was evaluated using equation (1):

$$DTLL_m = P_{supp} \times DT_m \quad 1$$

$$DTLL_a = \sum_{m=1}^{12} DTLL_m, \quad 2$$

where $DTLL_a$ is annual Downtime Loadloss, $DTLL_m$ is Loadloss on month m of the year.

For Okesa feeder in January 2008:

The values of L_i are obtained from Table A.1 of appendix.

$$DTLL_m = (L_7 \times t_7) + (L_{16} \times t_{16}) + (L_{29} \times t_{29})$$

$$= (2.60 \times 0.36) + (0) + (2.58 \times 1.08) + (3.70 \times 0.15) = 4.28MW$$

Analogically, $DTLL_m$ was evaluated for all the feeders and the results presented in Tables 1, 2, 3 and 4.

Table 1: *Monthly Summaries of Downtime Load Loss [MW] Data for 2008.*

FEEDER	MONTHS											
	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
OKESA	04.28	30.02	53.07	37.86	07.11	25.81	23.03	29.20	32.78	21.12	22.84	03.75
BASIRI	18.13	05.20	09.59	30.31	-	27.96	11.28	14.38	11.91	146.55	10.28	23.77
AJILOSUN	08.47	28.87	51.09	78.86	05.54	25.64	12.14	45.67	37.31	56.07	58.67	61.99
ADEBAYO	08.13	80.99	08.52	27.64	27.64	23.93	65.16	-	12.87	88.10	21.12	38.42
TOTAL	39.01	145.08	122.27	174.67	40.29	103.34	111.61	89.25	94.87	311.84	112.91	127.93

Table 2: *Monthly Summaries of Downtime Load Loss [MW] Data for 2009*

FEEDER	MONTHS											
	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
OKESA	57.56	10.20	08.88	23.35	13.57	56.72	10.08	13.01	20.23	00.25	02.94	10.97
BASIRI	19.78	07.03	26.43	-	15.76	00.59	20.16	36.62	05.81	40.21	07.37	09.85
AJILOSUN	17.37	57.06	02.34	60.83	40.68	30.48	51.34	16.79	-	13.28	23.14	70.99
ADEBAYO	07.54	06.78	16.65	23.42	20.80	19.14	11.23	20.59	13.47	18.10	07.23	09.47
TOTAL	102.25	81.07	54.30	107.60	90.81	106.93	92.81	87.01	39.51	71.84	40.68	101.28

Table 3: *Monthly Summaries of Downtime Load Loss [MW] Data for 2010*

FEEDER	MONTHS											
	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
OKESA	47.23	07.27	12.97	10.14	08.74	60.02	122.73	09.87	06.63	00.39	06.56	03.82
BASIRI	93.84	10.42	04.54	15.67	41.26	123.66	28.89	06.61	09.51	44.32	04.25	04.44
AJILOSUN	63.42	10.36	07.11	04.06	45.81	105.85	45.89	19.72	03.67	10.13	02.91	14.03
ADEBAYO	65.07	00.34	04.78	02.87	00.19	50.23	36.09	49.50	02.93	02.79	00.31	08.39
TOTAL	269.56	28.39	29.40	32.74	96.00	339.76	233.60	85.70	22.74	57.63	14.03	30.68

Table 4: *Monthly Summaries of Downtime Load Loss [MW] Data for 2011*

FEEDER	MONTHS											
	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
OKESA	00.17	87.98	39.61	24.62	04.52	00.39	99.90	83.27	19.40	102.83	54.36	90.91
BASIRI	00.11	00.20	03.97	42.52	-	11.36	16.28	06.69	128.73	01.04	36.93	04.22
AJILOSUN	02.83	15.24	09.49	09.65	15.37	21.78	40.15	190.49	50.09	43.05	73.70	86.67
ADEBAYO	00.98	-	03.03	33.30	17.93	07.25	62.70	89.09	86.65	117.11	32.51	137.73
TOTAL	04.09	103.42	56.10	110.09	37.82	40.78	219.03	198.10	284.87	264.03	197.50	319.53

$DTLL_a$ for other feeders was calculated analogically and the results presented in Table 5

Table 5: *Annual Summaries of Downtime Load loss (MW) for 2008-2011*

FEEDERS	YEARS				GRAND TOTAL
	2008	2009	2010	2011	
OKESA	290.87	227.76	296.37	607.96	1422.96
BASIRI	309.36	189.60	387.41	252.05	1138.42
AJILOSUN	470.32	384.30	332.96	558.51	1746.09
ADEBAYO	374.88	174.42	223.49	588.28	1361.07
TOTAL	1445.43	976.08	1240.23	2006.80	5668.54

Table 6: *Summaries of fault frequency on Feeders for 2008-2011*

FEEDERS	YEARS				TOTAL
	2008	2009	2010	2011	
OKESA	59	48	54	143	304
BASIRI	35	43	55	67	200
AJILOSUN	51	54	59	173	337
ADEBAYO	45	50	36	126	257
TOTAL	190	195	204	509	1098

Table 7 shows the summary of the year-by-year revenue loss as a result of the faults on the feeders. Revenue loss = Cost of 1kWh x Yearly Downtime x1000 where 1kWh = N19.20.

Table 7: *Annual Summaries of Revenue Loss (N) for 2008-2011*

FEEDERS	YEARS				GRAND TOTAL
	2008	2009	2010	2011	
OKESA	5,584,704	4,372,992	5,690,304	11,672,832	27,320,832
BASIRI	5,939,712	3,640,320	7,438,272	4,839,360	21,857,664
AJILOSUN	9,030,144	7,378,560	6,392,832	10,723,392	33,524,928
ADEBAYO	7,197,696	3,348,864	4,291,008	11,294,976	26,132,544
TOTAL	27,752,256	18,740,736	23,812,416	38,530,560	108,835,968

3. Results and Discussion

The load loss reading of the four feeders in four years shown in Table 5 reveals that Ajilosun has the highest load loss of 1746.09MW (32.60%) as shown Figure 1. This is followed by Okesa, Adebayo and Basiri. Ajilosun feeder with rated power of 6.3MW has the highest load loss because of the incessant outage of the feeder as a result of fault. It recorded the highest number of outages and in overall accounts for 30.8% of the outages as a result of fault in four years (figure 2). Okesa feeder which is next on the load loss table has a rated power of 5.4MW and second to the highest fault frequency. It also accounts for 27.8% of outages in the period covered by this study. Adebayo feeder with highest customer population and rated power of 4.6MW has a considerable high load loss of 1361.07 MW. This is because of its low fault frequency. Basiri has the lowest load loss because of its low fault frequency. It accounts for the lowest percentage (17.3%) of the outages in the four years under examination.

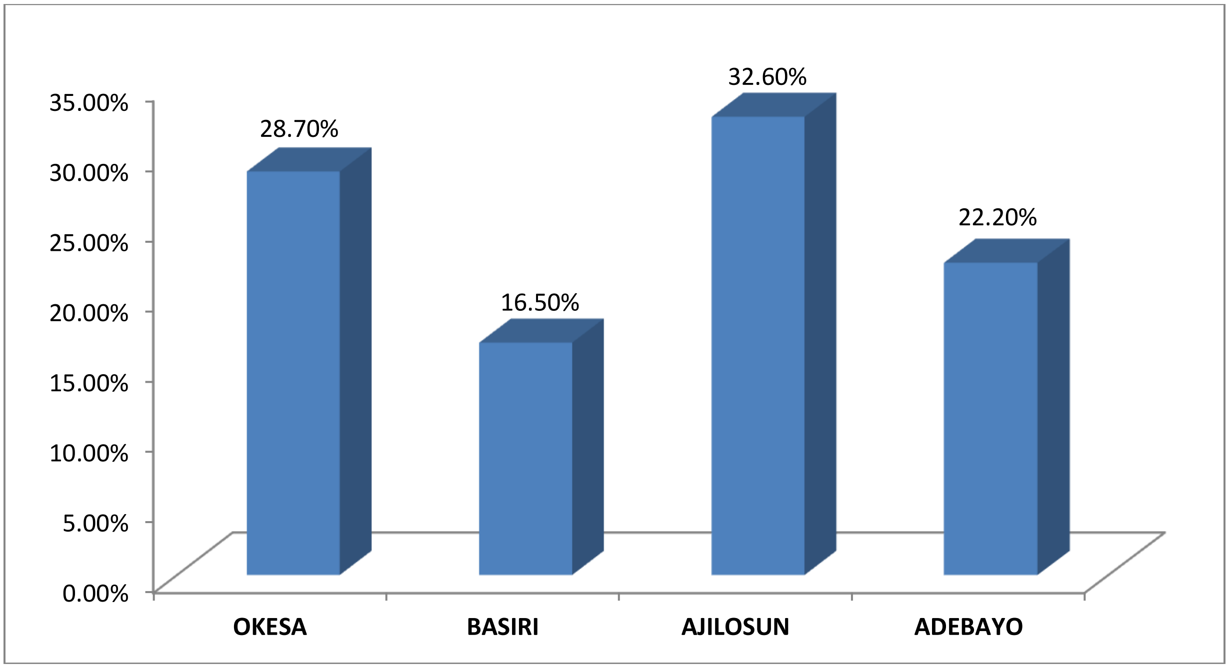

Figure 2: *Percentages of Load Losses in Respective Feeder between 2008 and 2011*

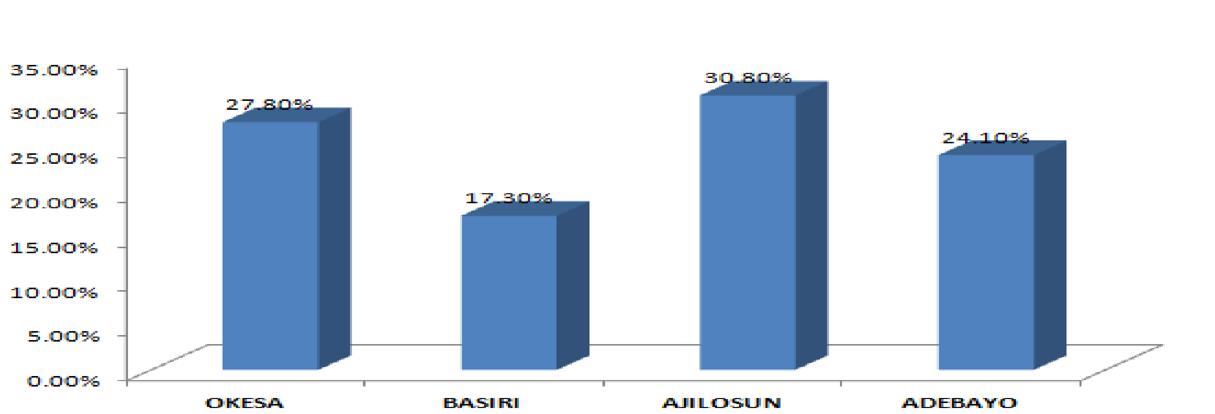

Figure 2: *Percentages of Fault occurrences in Respective Feeders between 2008 and 2011*

3.1 Revenue Loss and Fault

The cost implication of the load loss is presented in Table 8. This shows what the Benin Electricity Distribution Company (formally PHCN) would have saved in Ado-Ekiti power distribution network if the losses were avoided.

Table 8: *Summary of revenue loss in Naira*

Years	2008	2009	2010	2011	Total
Revenue Loss (Million Naira)	27,752,256	18,740,736	23,812,416	38,530,560	108,835,968

As shown in Table 8 above, year 2011 presents the highest revenue loss. In the years under review, about 35.4% of the total revenue was lost in the year 2011, 25.5% of the revenue was lost in 2008, 21.9% of the revenue was lost in 2010 while 17.2% of the total revenue in four years was lost in the year 2009. Considering the cost of generating a unit of energy, this lost contribute to the rising cost of electricity in the land. The percentage contribution of each feeder to the total fault (PCF) of the network between 2008 and 2011 range from 17.3% to 30.8% as shown in Figure 2.

4. Conclusion

It could be seen from the analysis that a substantial part of generated power (5668.54MW) is lost in the distribution system through the 11kV feeders. Faults in the system contributed immensely to the power loss and the cost implication of one hundred and eight million, eight hundred and thirty five thousand, nine hundred and sixty eight naira (N108,835,968.00) reflected that the consumers have been paying for the lost energy because the billing is done on monthly basis. Losses must be reduced to barest minimum in electricity distribution which is the final stage in the delivery of electricity to end-users to make it more efficient.

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APPENDIX

Table A.1: *FAULTS LOG ENTRY ON 11kV FEEDERS IN ADO-EKITI POWER DISTRIBUTION NETWORK (2008) OKESA FEEDER*

MONTH	DATE OF FAULT	TIME OF OCCURRENCE & RESTORATION	DURATION OF FAULT HR : MIN	NATURE OF FAULT	LOAD LOSS (MW)
JAN	07-01-08	0714 – 0750	00 : 36	O/C	2.60
	16-01-08	2340 – 2405	00 : 25	O/C & E/F	-
	21-01-08	2140 – 2148	01 : 08	O/C	2.58
	29-01-08	0532 – 0547	00 : 15	O/C	3.70
FEB	12-02-08	0209 – 0748	04 : 39	O/C & E/F	2.40
	16-02-08	0335 – 0940	06 : 05	E/F	3.20
	22-02-08	1605 -1612	00 : 07	O/C	1.80

MARCH	05-03-08	1715 – 1750	00 : 35	O/C & E/F	2.20
	09-03-08	2039 – 2048	00 : 09	O/C	3.15
	26-03-08	1600 – 1740	01 : 40	O/C & E/F	-
	27-03-08	0805 – 1115	03 : 10	O/C & E/F	3.10
	30-03-08	2204 – 0850	11 : 46	E/F	3.70
APRIL	02-04-08	1010 – 1025	00 : 15	O/C & E/F	2.93
	05-04-08	1906 – 1915	00 : 09	O/C	2.30
	13-04-08	1514 – 1655	01 : 41	O/C & E/F	1.78
	19-04-08	0705 – 1610	09 : 05	O/C & E/F	3.45
	27-04-08	0950 – 1148	01 :58	O/C & E/F	2.20
MAY	01-05-08	1809 – 1853	00 : 44	O/C & E/F	-
	12-05-08	2140 – 2156	00 : 16	O/C	-
	16-05-08	1141 – 1207	00 : 26	O/C	2.95
	29-05-08	1232 – 1440	02 : 08	O/C & E/F	3.05
JUNE	06-06-08	1118 - 1145	00 : 27	O/C	1.60
	07-06-08	1836 - 1940	01 : 04	O/C & E/F	2.05
	12-06-08	1414 - 1633	02 : 19	O/C & E/F	2.15
	18-06-08	2045 - 2115	00 : 30	E/F	4.30
	25-06-08	0432 - 1018	05 : 46	O/C	2.40
	30-06-08	0904 - 1111	02 : 07	O/C	2.00
JULY	02-07-08	1602 - 1700	00 : 58	O/C & E/F	1.80
	09-07-08	1227 - 1615	03 : 48	O/C & E/F	2.90
	13-07-08	0520 - 0928	04 : 08	O/C	2.05
	19-07-08	1324 - 1358	00 : 34	O/C & E/F	-
	27-07-08	1717 - 1850	01 : 33	O/C & E/F	2.65
AUG	01-08-08	0520 - 0848	03 : 28	O/C & E/F	1.95
	02-08-08	1500 - 1837	03 : 37	O/C & E/F	3.40
	09-08-08	1732 - 1847	01 :15	O/C	1.80
	16-08-08	1200 - 1407	02 : 07	O/C & E/F	4.40
	28-08-08	1908 - 1918	00 : 10	O/C	1.70
SEPT	04-09-08	1055 - 1305	02 : 10	O/C & E/F	2.45
	07-09-08	0712 - 1414	07 : 02	O/C & E/F	3.00
	13-09-08	1645 - 1658	00 : 13	O/C	2.10
	21-09-08	0513 - 0826	03 : 13	O/C & E/F	1.90
	27-09-08	1900 - 1911	00 : 11	O/C	3.20
OCT	14-10-08	2025 - 2220	01 :55	O/C & E/F	2.41
	16-10-08	2100 - 2155	00 : 55	O/C & E/F	1.95
	19-10-08	1812 - 1930	01 : 18	O/C & E/F	1.92
	24-10-08	0535 - 1213	06 : 48	O/C	1.11
	25-10-08	1320 - 1335	00 : 15	O/C & E/F	-
		1816 – 1831	00 : 15	O/C & E/F	3.15
	27-10-08	1705 – 2024	03 : 19	O/C & E/F	2.00
NOV	03-11-08	1742 – 1744	00 : 02	O/C & E/F	3.14
	05-11-08	1828 – 1830	00 : 02	O/C & E/F	-
	09-11-08	1804 – 1820	00 : 16	O/C	2.67
	14-11-08	1325 – 1500	01 : 35	O/C & E/F	3.10
	20-11-08	0213 – 0225	05 : 12	E/F	2.75
	25-11-08	1055 – 1209	01 : 14	O/C & E/F	3.58
DEC	06-12-08	1609 – 1812	02 : 03	O/C & E/F	1.80
	07-12-08	0210 – 0223	01 : 13	O/C	-
	21-12-08	1228 – 1330	01 : 02	E/F	-
	27-12-08	2302 – 2305	00 : 03	O/C & E/F	3.20

O/C Overcurrent
E/F Earth Fault