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On the identification of failure prone feeders in the Nigerian power system network using VFTM technique

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Abstract
The power system network in Nigeria is presently characterized with various failures across all the arms of the sector and if this continues it may be difficult to compete with the western world in terms of industrialization. The globalization of any country, therefore, depends on the state-of-the-art technology and this is directly proportional to a well formidable and reliable power sector. This paper, therefore, seeks to identify the weak feeders in the network that should be prioritize and giving urgent attention to using the Principle of Pareto PP. Data for the study was collected for a period of five years (2011-2015) at the Transmission Company of Nigeria TCN, Benin City, Edo State. The data have been analyzed using the Vital Few Trivial Many VFTM Technique. Also, statistical analysis was carried to determine how far away the mean from the standard deviation is. The obtained results have been interpreted graphically on the excel software and from the findings, feeders that require major attention with respect to operation and maintenance are: Guinness, Koko, Ikpoba-Dam and Switch Station 33kV feeders respectively.

Keywords: PP, Nigeria, feeders, TCN, priority

1. Introduction

Sustainability in electrical power sector is a key ingredient that can guarantee rapid industrial growth in any nation [1, 2]. The Power System Network in Nigeria PSSN is one that is characterized by poor generation, long transmission line, decaying infrastructure at the distribution end, weak protection system, radial grid system, system insecurity, energy theft, vandalization to mention but few. These anomalies contribute to an increase in failure rate within the system. Ironically, various programme to improve on the Electric supply of the nation are been set up over the years, but a corresponding improvement in the system's reliability is yet to be recorded. According to [3], the primary source of energy in Nigeria far outweighs the demand of the consumers hence, the problem of poor generation of electricity is not supposed to be a topic of discussion in Nigeria. It is therefore, necessary for studies to be carried out within the PSSN in order to identify the feeders within a given network that needs improvement in order to guarantee sustainability in the sector.
This aim of this paper therefore, is to use the Principle of Pareto PP to identify the links that are weak within a given a network i.e the 20% feeders that constitutes 80% of the failures from the Transmission Company of Nigeria, TCN, Benin City, Edo State. The feeders used for the case study are: Koko, GRA, Guinness, Ikpoba-dam, Switchstation, Nekpenekpen and Etete 33kV feeders respectively.

2. Principle of Pareto

The Principle of Pareto PP also known as the 80/20 rule is a management tool that helps to identify the "cause" and "results" within any context of its application. The PP helps to identify and rank the influencing factors within a given scenario of event. It is also a decision-making tool that detects the smaller fraction of an event that yields a significant success rate in a system. The PP is of the opinion that emphasis should be laid on the critical segment of an event rather than on the less-critical segment and by doing this, the critical portion is resolved and reliability is improved on [4].
With respect to Power System Network PSN, PP can be used to identify the weak link either in the generation, transmission or distribution arm of the sector i.e it can identify the 20% events that constitutes 80% of the problems emanating from the network [5, 6]. For the purpose of this research, the 20% feeders that causes 80% of the failures emanating the PSSN using the TCN, Benin City, Edo State shall be determined.

3. Data and Method

In order to carry out the data analysis, outages data were collected from TCN, Benin City for a period of five years (2011-2015) as shown in Table 1-5, The failures recorded in each of the feeders is ranked from the highest to the lowest and their corresponding cumulative frequency is determined bearing in mind that our priority is to identify the critical feeders in the network.
The mean, standard deviation, coefficient of variation and cumulative frequency of the network is calculated using equation 1-4

$$\mu = \frac{\sum F_i}{F} \quad (1)$$

$$\sigma = \sqrt{\frac{\sum (F-\mu)^2}{F}} \quad (2)$$

$$CV = \frac{\sqrt{\frac{\sum (F-\mu)^2}{F}}}{\frac{\sum F_i}{F}} \quad (3)$$

$$CF = \frac{Frequency\ Count\ of\ Feeder\ 1}{Frequency\ Count\ of\ Feeder\ 7} \times 100 \qquad 4$$

4. Results and Discussion

Table 1-5 show the feeders, FDR, the Outages OTG, the Frequency counts of the feeder, FRQ as well as the cumulative frequency. For the year 2011-2015 while Table 6 gives the summary of the events. While Table 7 shows the values of the calculated mean, standard deviation as well as the CV. Likewise, fig. 1-5 shows the various plot on the excel environment using the PP for the year 2011-2015 while fig 6 is a summary of the plot.

Table 1: Table of OTG and CF for 2011

S/N	FDR	OTG	FRQ	CF
1	GUI	644	644	30.0
2	KOK	354	998	46.5
3	IKP	353	1351	63.0
4	ETE	292	1643	76.6
5	SST	214	1857	86.6
6	NKP	154	2011	93.8
7	GRA	133	2144	100.0

Table 2: Table of OTG and CF for 2012

S/N	FDR	OTG	FRQ	CF
1	GUI	639	639	29.8
2	KOK	578	1217	56.7
3	IKP	291	1508	70.2
4	ETE	262	1770	82.4
5	SST	163	1933	90.0
6	NKP	148	2081	96.9
7	GRA	66	2147	100.0

Table 3: Table of OTG and CF for 2013

S/N	FDR	OTG	FRQ	CF
1	GUI	621	621	26.4
2	KOK	607	1228	52.3
3	IKP	360	1588	67.6
4	ETE	342	1930	82.1
5	SST	157	2087	88.8
6	NKP	139	2226	94.7
7	GRA	124	2350	100.0

Table 4: Table of OTG and CF for 2014

S/N	FDR	OTG	FRQ	CF
1	GUI	625	625	27.6
2	KOK	475	1100	48.5
3	IKP	348	1448	63.9
4	ETE	293	1741	76.8
5	SST	280	2021	89.1
6	NKP	134	2155	95.1
7	GRA	112	2267	100.0

Table 5: Table of OTG and CF for 2015

S/N	FDR	OTG	FRQ	CF
1	GUI	162	162	25.4
2	KOK	109	271	42.5
3	IKP	103	374	58.7
4	ETE	91	465	73.0
5	SST	76	541	84.9
6	NKP	54	595	93.4
7	GRA	42	637	100.0

Table 6: Table of OTG and CF for 2016

S/N	FDR	OTG	FRQ	CF
1	GUI	2468	2468	25.9
2	KOK	2339	4807	50.4
3	IKP	1327	6134	64.3
4	ETE	1275	7409	77.6
5	SST	1015	8424	88.3
6	NKP	596	9020	94.5
7	GRA	525	9545	100.0

Table 7: Showing Calculated Mean and Deviation

FDR(MDISP)	μ	σ^2	σ	CV
GUI	538.2	35454.2	188.3	0.35
KOK	424.6	32785	181.1	0.43
IKP	291	9439	97.2	0.33
SST	256	7464	86.4	0.34
ETE	178	4554	67.5	0.38
NKP	125.8	1336	36.6	0.29
GRA	95.4	1244	35.3	0.37

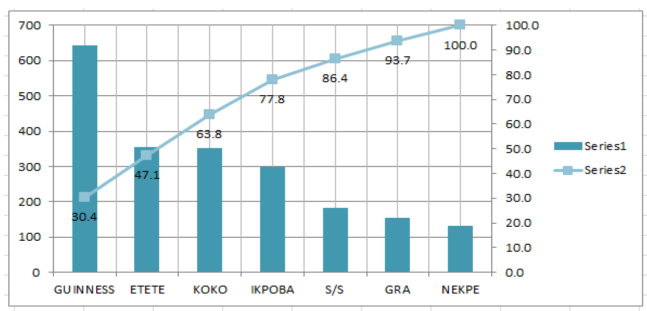

Fig 1: Pareto Graph for 2011

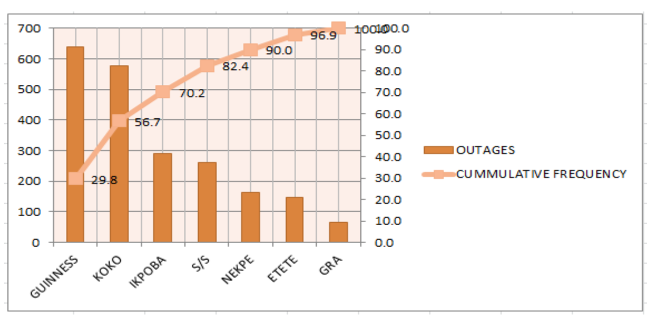

Fig 2: Pareto Graph for 2012

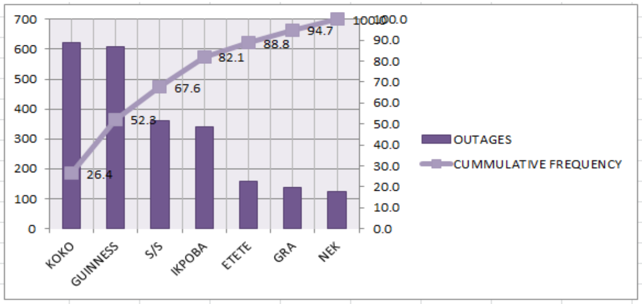

Fig 3: Pareto Graph for 2013

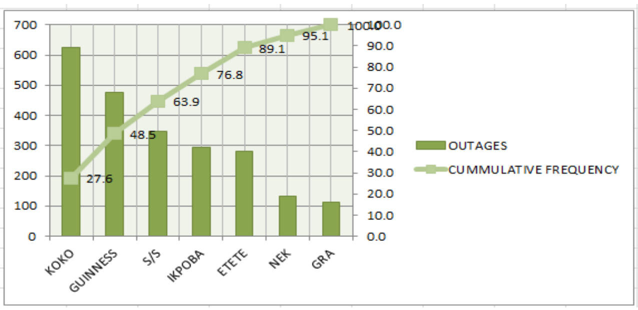

Fig 4: Pareto Graph for 2014

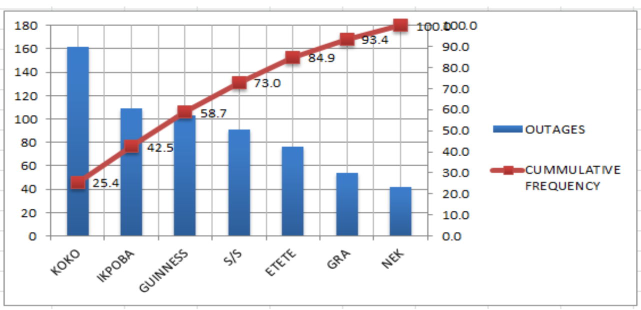

Fig 5: Pareto Graph for 2015

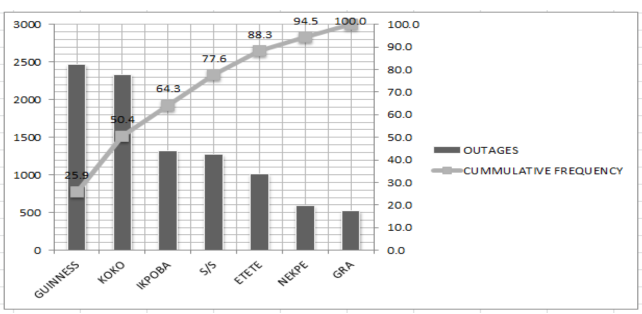

Fig 6: Pareto Graph for 2011-2015

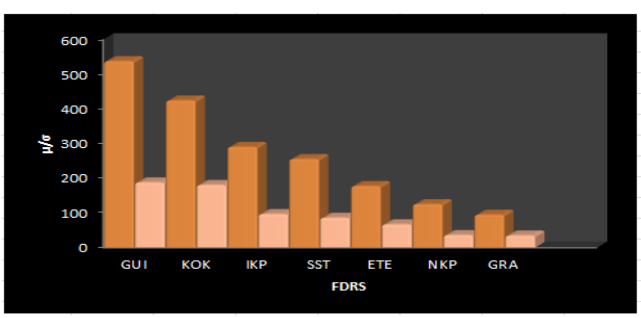

Fig 7: Graphical Interpretation of μ and σ

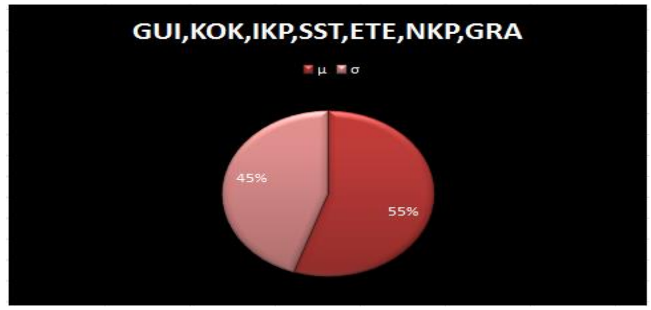

Fig 8: Summary of Graphical Interpretation of μ&σ

From the graphical analysis shown above, it is observed that the PP was able to identify the significant feeders that require attention. These feeders according to fig 6 are Guinness, Koko, Ikpoba-dam as well as Switchstation in that order. This was achieved by making a parallel line from the 80% point on the y-axis that runs parallel to the x-axis until a point of intersection is obtained. The feeders to the left of this point are the priority feeders that require attention while the feeders to the right are those with less important cause although, according to [7], these values are not absolute. The feeders to the right are termed feeders with less significant failures but studies [8] have shown that none of the feeders within the network of interest is operated within standard. This is an indication that all the feeders in the network require attention but the PP has been able to help us identify the vital feeders that requires more attention while [9] suggests a more recent maintenance technique that can be adopted to improve on the system's reliability. The interpretation in fig. 7 was able to show how close the mean is to the standard deviation for the respective feeders under the period of investigation while fig 8 summarizes the obtained results from fig. 7.

6. Conclusion

The paper has carried out a study on the identification of primary distribution feeders that are prone to failure within a given network. Part I gives a brief overview of the state of power infrastructure in Nigeria, while Part II introduces us to the principle that was used for the study. Part III gives the methodology used for the study as well as the process of data collection while the results obtained from the study was discussed in Part IV and finally, Part V concludes the study. The results from this paper, therefore, validates the analysis of [10] showing that the weak link in the network are Guinness, Koko, Ikpoba-Dam and Switchstation feeders.

7. References

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