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Risk assessment of feeders in power system network using FCT

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Abstract
In this paper, risk assessment was carried out in the Nigerian Power System Network NPSN using the Transmission Company of Nigeria TCN Benin City as a case study. The risk assessment was carried out using historical data collated from the station of interest for a period of five years (2011-2015) on the seven 33kV feeders in the station. Using the Feeders' Criticality Technique FCT, the risk level of each of the feeders was estimated, recorded and the summarized results interpreted graphically using spreadsheet. The following Average Criticality Values ACVs: 419.8, 359.6, 162.3, 31.5, 15.7, 7.7 and 4.7 were estimated for Koko, Guinness, Ikpobadam, Switchstation, Etete, Nekpenekpen and GRA feeders respectively. From the analysis, the duo of Koko and GRA feeders were identified as the weakest and strongest link in the network. From the estimated ACVs, none of the feeders could be said to possess a negligible risk value hence an improvement in the operation and maintenance of the feeders is necessary. The paper, therefore, can serve as guide for sound maintenance judgment and could also help in the identification of risk in the system by operators.

Keywords: assessment, critical, feeder, maintenance, reliability, risk

1. Introduction

The NPS is presently characterized by mismanagement and policy paralysis (Airoboman *et al*, 2016) leading to energy stagnation in the country (Amaize *et al*, 2016) [1, 7]. The blame of energy shortage in the country has often been placed in the table of vandals by the concerned authority (Danielle, 2016; Talatu, 2017) [3, 4]. Although this may be true to an extent, however, in a country where the thermal plant produces about 80% (Sunday, *et al*, 2014) [5] of its generation capacity, one would have envisaged adequate security of the system. However, the drivers of the sector take advantage of the actions of vandals to cover up for their poor performance. As a result of energy stagnation and poor system reliability in the country, most businesses are run on generators while the power from the grid is kept as a standby unit (Christie, *et al* 2015; Airoboman *et al*, 2016) [6, 1, 7] In (Ise Olorunkanmi, 2014) [8], a total of $5.3 billion is spent annually by 60 million Nigerians on generators while (Hassan & Hamam, 2017) [9] asserted that it takes the sum of $1,100 to purchase, operate and maintain a small sized generator by an average family annually. From the foregoing, it can be said that the system is weak thereby requiring urgent action for optimum performance. As a result of this anomaly, the NPS has lost most of its revenue to generator dealers within and outside the shores of the country.

Fig 1: A Distribution Line Exposed to Risk (South-West) Nigeria

2. Risk Assessment

In (Wenyuan *et al*, 2006) [11], it was asserted that reliability and risk are inversely proportional. A system exposed to critical condition is prone to safety consequence which involves loss of synchronization that could lead to loss of equipment and pose a threat to personnel and environment. A failed item in a system is best replaced by evaluating the cost of replacement against the time and this can be; before, after or allowing the system to run to failure due to a negligible consequence (Wenyuan *et al*, 2007) [11], In (Yssaad *et al*, 2012) [12] the authors affirmed that when carrying out a criticality analysis on a system or equipment, an existing failure data could either be used or by experience from a crew who understands the system. Risk assessment and evaluation should, therefore, be included in reliability studies for the purpose of robustness as well as for a sound maintenance judgment (Selvik & Aven, 2011) [13]. Furthermore, (Yang *et al*, 2016) [14] identified that the present risk evaluation method according to literatures is not robust enough owing to varying conditions, these conditions according to (Bruno *et al*, 2010) [15] are inadequacy and insecurity of the system because the obtained result may not be used for a general risk assessment of the system, however, (Li, 2005) affirms that if the system indices is based on historical failure data then such analysis can be said to be adequate because it factors into consideration both adequacy and security. From the foregoing, it is evident that risk assessment study is paramount based on the gap in literatures (Airoboman *et al*, 2017; Jose *et al*, 2001) [18] and especially in Nigeria where only little work has been done in this area. This paper, therefore, will determine how critical are the 33kV feeders that emanates from the Transmission Company of Nigeria, Benin City based on historical data using quantitative technique.

Fig 2: A Transmission Line Exposed to Risk (North-West) Nigeria

3. Methodology

Five years historical data was collated from the logbooks of TCN, Benin City. The FCT was calculated using the calculated indices of reliability. The obtained results was summarized using a 5*5 matrix and eventually, the ACV was determined from the developed matrix. Equations 1-5 were used in the study to determine the various parameters of interest of the individual feeders.

Generally,

$$RPN = O \times S \times D \tag{1}$$

$$F_C = F_i \times F_{LOF} \tag{2}$$

$$F_i = 1 - e\left[-t\sum_{i=1}^{t}\lambda_i\right] \tag{3}$$

$$F_{LOF} = T_{OH} - e\left[-t\sum_{i-1}^{N}\lambda_i * T_{OH}\right] \tag{4}$$

$$\text{Reliability} = \frac{T_{OH} - D_T}{T_{OH}} \tag{5}$$

RPN = Risk Priority Number
O = Failure Occurrence
S = Failure Severity
D = failure Detectability
F_C = Feeder's Criticality
S_i = Feeder's Importance
F_{LOF} = System's Likelihood of Failure
T_{OH} = Total Operation Hour

How important a feeders is, happens to be a function of the occurrence of failure i.e the bigger the probability of failure, the more important the feeder. Failure in a feeder is also said to be severe if it is difficult to detect. The more difficult it is to detect a failure, the longer the downtime. For the purpose of this research, therefore, it was assumed

that the likelihood of failure in the feeder is a function of downtime. This study utilizes the historical data approach in accordance with (Bruno *et al*, 2010) [15] to determine the criticality of the feeders. The paper, therefore, utilizes results from the reliability indices to determine the risk level of GRA, Koko, Guinness, Nekpenekpen, Switchstation, Etete and Ikpobadam feeders respectively. The numeric values in the 12*5 matrix is the measure of the probability of failure while the 5*12 matrix is a function of the feeders likelihood-of-failure for the various feeders for five years and finally, a multiplication on these matrices according to equation 6 was carried out. The obtained results was given as a 5*5 matrix for each of the feeders and the overall results was summarized in Table 2.

Table 1: Reliability Values of the Feeders

Feeders	Year	Outage	Downtime	Availability	Reliability
GRA	2011	3	9.3	0.9873	0.9862
Guinness	2011	63	148.5	0.7506	0.7790
Koko	2011	41	135.7	0.7769	0.7981
Switching station	2011	16	19.8	0.9727ssss	0.9705
Nekpenekpen	2011	17	9.6	0.9869	0.9857
Ikpoba dam	2011	31	127.3	0.7936	0.8106
Etete	2011	17	17.6	0.9758	0.9738
GRA	2012	66	153.7	0.9842	0.9825
Guinness	2012	639	1878.6	0.7376	0.7855
koko	2012	578	2264.8	0.6599	0.7415
Switching Station	2012	148	417.8	0.9668	0.9523
Nekpenekpen	2012	163	208.8	0.9775	0.9762
Ikpoba Dam	2012	291	1498	0.8097	0.8290
Etete	2012	262	273.5	0.9657	0.9688
GRA	2013	139	360.5	0.9556	0.9588
Guinness	2013	607	2074.1	0.7198	0.7632
Koko	2013	621	2784.5	0.5767	0.6821
Switching Station	2013	157	476.3	0.9548	0.9456
Nekpenekpen	2013	124	342.1	0.9688	0.9609
Ikpoba DAM	2013	342	1583.4	0.7954	0.8192
Etete	2013	360	651.6	0.9233	0.9256
GRA	2014	112	159.1	0.9794	0.9818
Guinness	2014	475	2122.2	0.7099	0.7577
Koko	2014	625	1984.9	0.7081	0.7734
Switching Station	2014	280	398	0.9610	0.9546
Nekpenekpen	2014	134	249.6	0.9710	0.9715
Ikpoba Dam	2014	293	1045.8	0.8989	0.8806
Etete	2014	348	291.6	0.9647	0.9667
GRA	2015	54	63.7	0.9957	0.9913
Guinness	2015	103	573	0.9328	0.9215
Koko	2015	162	812	0.9495	0.8887
Switching Station	2015	76	179	0.9802	0.9755
Nekpenekpen	2015	42	128	0.9813	0.9825
Ikpoba DAM	2015	109	506.7	0.9632	0.9306
Etete	2015	91	92.3	0.9958	0.9873

$$S_C = \begin{bmatrix} 1-e\left[-t\sum_{i=1}^{t}\lambda_i\right] & \cdots & 1-e\left[-t\sum_{i=1}^{t}\lambda_i\right] & \cdots & 1-e\left[-t\sum_{i=1}^{t}\lambda_i\right] \\ \ddots & \vdots & \vdots & \ddots & \vdots \\ \vdots & \ddots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \ddots & \vdots & 1-e\left[-t\sum_{i=1}^{t}\lambda_i\right] \\ \vdots & \vdots & \vdots & 1-e\left[-t\sum_{i=1}^{t}\lambda_i\right] & \vdots \\ \vdots & \vdots & \vdots & \vdots & \ddots \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & 1-e\left[-t\sum_{i=1}^{t}\lambda_i\right] & \vdots & \vdots \\ \vdots & 1-e\left[-t\sum_{i=1}^{t}\lambda_i\right] & \vdots & \vdots & \vdots \\ 1-e\left[-t\sum_{i=1}^{t}\lambda_i\right] & \cdots & 1-e\left[-t\sum_{i=1}^{t}\lambda_i\right] & \cdots & 1-e\left[-t\sum_{i=1}^{t}\lambda_i\right] \end{bmatrix} \begin{bmatrix} T_{OH}-e\left[-t\sum_{i=1}^{N}\lambda_i * T_{OH}\right] & \cdots\;\cdots\;\cdots\;\cdots\;\cdots\;\cdots\;\cdots\;\cdots\;\cdots\;\cdots & T_{OH}-e\left[-t\sum_{i=1}^{N}\lambda_i * T_{OH}\right] \\ \vdots & \ddots\;\vdots\;\vdots\;\vdots\;\vdots\;\iddots\;\ddots\;\vdots\;\vdots\;\vdots & \vdots \\ T_{OH}-e\left[-t\sum_{i=1}^{N}\lambda_i * T_{OH}\right] & \vdots\;\ddots\;\vdots\;\vdots\;\iddots\;\vdots\;\vdots\;\ddots\;\vdots\;\vdots & T_{OH}-e\left[-t\sum_{i=1}^{N}\lambda_i * T_{OH}\right] \\ \vdots & \vdots\;\vdots\;\ddots\;\iddots\;\vdots\;\vdots\;\vdots\;\vdots\;\ddots\;\vdots & \vdots \\ T_{OH}-e\left[-t\sum_{i=1}^{N}\lambda_i * T_{OH}\right] & \cdots\;\cdots\;\cdots\;\cdots\;\cdots\;\cdots\;\cdots\;\cdots\;\cdots\;\cdots & T_{OH}-e\left[-t\sum_{i=1}^{N} OH\right] \end{bmatrix} \tag{6}$$

$$G_{LOF} = \begin{bmatrix} 0.0215 & 0.0000 & 0.0235 & 0.0326 & 0.0210 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & 0.0156 & \vdots & \vdots & \vdots \\ \vdots & \ddots & 0.1022 & \vdots & \vdots \\ \vdots & \ddots & \ddots & 0.0012 & \vdots \\ \vdots & \ddots & \ddots & \ddots & 0.0185 \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ 0.0138 & \cdots & \cdots & \cdots & 0.0095 \end{bmatrix}$$

$$GU_{LOF} = \begin{bmatrix} 0.2190 & 0.1484 & 0.1528 & 0.2168 & 0.1921 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & 0.3991 & \vdots & \vdots & \vdots \\ \vdots & \ddots & 0.1923 & \vdots & \vdots \\ \vdots & \ddots & \ddots & 0.2833 & \vdots \\ \vdots & \ddots & \ddots & \ddots & 0.1126 \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ 0.2210 & \cdots & \cdots & \cdots & 0.0095 \end{bmatrix}$$

$$SS_{LOF} = \begin{bmatrix} 0.1022 & 0.0060 & 0.0408 & 0.0385 & 0.0374 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & 0.0077 & \vdots & \vdots & \vdots \\ \vdots & \ddots & 0.0405 & \vdots & \vdots \\ \vdots & \ddots & \ddots & 0.0455 & \vdots \\ \vdots & \ddots & \ddots & \ddots & 0.0022 \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ 0.0295 & \cdots & \cdots & \cdots & 0.0266 \end{bmatrix}$$

$$KO_{LOF} = \begin{bmatrix} 0.1528 & 0.1484 & 0.2732 & 0.3287 & 0.3173 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & 0.2533 & \vdots & \vdots & \vdots \\ \vdots & \ddots & 0.3183 & \vdots & \vdots \\ \vdots & \ddots & \ddots & 0.1682 & \vdots \\ \vdots & \ddots & \ddots & \ddots & 0.0524 \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ 0.2019 & \cdots & \cdots & \cdots & 0.1208 \end{bmatrix}$$

$$NK_{LOF} = \begin{bmatrix} 0.1300 & 0.1223 & 0.1787 & 0.1333 & 0.1362 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & 0.1879 & \vdots & \vdots & \vdots \\ \vdots & \ddots & 0.1754 & \vdots & \vdots \\ \vdots & \ddots & \ddots & 0.1775 & \vdots \\ \vdots & \ddots & \ddots & \ddots & 0.0001 \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ 0.0295 & \cdots & \cdots & \cdots & 0.0266 \end{bmatrix}$$

$$IK_{LOF} = \begin{bmatrix} 0.0225 & 0.0176 & 0.0141 & 0.0266 & 0.0231 \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ \vdots & 0.0128 & \ddots & \ddots & \vdots \\ \vdots & \ddots & 0.0080 & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0.00256 & \vdots \\ \vdots & \ddots & \ddots & \ddots & 0.0339 \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ 0.01894 & \cdots & \cdots & \cdots & 0.0754 \end{bmatrix}$$

$$ET_{LOF} = \begin{bmatrix} 0.0220 & 0.0424 & 0.0193 & 0.0134 & 0.0290 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & 0.0667 & \vdots & \vdots & \vdots \\ \vdots & \ddots & 0.0080 & \vdots & \vdots \\ \vdots & \ddots & \ddots & 0.0278 & \vdots \\ \vdots & \ddots & \ddots & \ddots & 0.0064 \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ 0.01894 & \cdots & \cdots & \cdots & 0.0754 \end{bmatrix}$$

$$G_i = \begin{bmatrix} 0.0 & \cdots & \cdots & \cdots & 30.0 & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ \vdots & \vdots & \vdots & 13.1 & \ddots & 17.6 & \vdots & \vdots & \vdots & \vdots & \vdots & 30.5 \\ \vdots & \vdots & 13.5 & \ddots & \ddots & \ddots & 0.0 & \vdots & \vdots & \vdots & 101.0 & \vdots \\ \vdots & 0.8 & \ddots & \ddots & \ddots & \ddots & \ddots & 5.5 & \vdots & 5.3 & \ddots & \vdots \\ 6.7 & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & 0.6 & \cdots & \cdots & 0.0 \end{bmatrix}$$

$$GU_i = \begin{bmatrix} 0.0 & \cdots & \cdots & \cdots & 138.0 & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ \vdots & \vdots & \vdots & 144.8 & \ddots & 136.8 & \vdots & \vdots & \vdots & \vdots & \vdots & 91.9 \\ \vdots & \vdots & 167.1 & \ddots & \ddots & \ddots & 186.3 & \vdots & \vdots & \vdots & 382.2 & \vdots \\ \vdots & 105.0 & \ddots & \ddots & \ddots & \ddots & \ddots & 256.6 & \vdots & 223.3 & \ddots & \vdots \\ 129.1 & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & 4.9 & \cdots & \cdots & 0.0 \end{bmatrix}$$

$$KO_i=\begin{bmatrix} 0.0 & \cdots & \cdots & \cdots & 117.0 & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ \vdots & \vdots & \vdots & 159.5 & \ddots & 226.7 & \vdots & \vdots & \vdots & \vdots & \vdots & 141.7 \\ \vdots & \vdots & 213.9 & \ddots & \ddots & \ddots & 155.8 & \vdots & \vdots & \vdots & 419.1 & \vdots \\ \vdots & 97.9 & \ddots & \ddots & \ddots & \ddots & \ddots & 116.1 & \vdots & 243.5 & \ddots & \vdots \\ 213.2 & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & 6.3 & \cdots & \cdots & 0.0 \end{bmatrix}$$

$$SS_i=\begin{bmatrix} 0.0 & \cdots & \cdots & \cdots & 198.0 & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ \vdots & \vdots & \vdots & 60.6 & \ddots & 63.6 & \vdots & \vdots & \vdots & \vdots & \vdots & 7.3 \\ \vdots & \vdots & 27.2 & \ddots & \ddots & \ddots & 16.2 & \vdots & \vdots & \vdots & 163.5 & \vdots \\ \vdots & 54.3 & \ddots & \ddots & \ddots & \ddots & \ddots & 12.4 & \vdots & 9.7 & \ddots & \vdots \\ 25.1 & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & 2.7 & \cdots & \cdots & 0.0 \end{bmatrix}$$

$$NK_i=\begin{bmatrix} 0.0 & \cdots & \cdots & \cdots & 16.7 & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ \vdots & \vdots & \vdots & 1.9 & \ddots & 24.9 & \vdots & \vdots & \vdots & \vdots & \vdots & 22.6 \\ \vdots & \vdots & 5.4 & \ddots & \ddots & \ddots & 7.9 & \vdots & \vdots & \vdots & 24.1 & \vdots \\ \vdots & 29.5 & \ddots & \ddots & \ddots & \ddots & \ddots & 32.1 & \vdots & 13.9 & \ddots & \vdots \\ 15.5 & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & 1.8 & \cdots & \cdots & 0.0 \end{bmatrix}$$

$$ET_i=\begin{bmatrix} 0.0 & \cdots & \cdots & \cdots & 51.6 & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ \vdots & \vdots & \vdots & 8.1 & \ddots & 29.6 & \vdots & \vdots & \vdots & \vdots & \vdots & 7.6 \\ \vdots & \vdots & 31.0 & \ddots & \ddots & \ddots & 19.5 & \vdots & \vdots & \vdots & 224.4 & \vdots \\ \vdots & 15.2 & \ddots & \ddots & \ddots & \ddots & \ddots & 16.3 & \vdots & 34.6 & \ddots & \vdots \\ 19.5 & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & 1.6 & \cdots & \cdots & 0.0 \end{bmatrix}$$

$$IK_i=\begin{bmatrix} 0.0 & \cdots & \cdots & \cdots & 109.5 & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ \vdots & \vdots & \vdots & 116.8 & \ddots & 180.2 & \vdots & \vdots & \vdots & \vdots & \vdots & 73.4 \\ \vdots & \vdots & 117.9 & \ddots & \ddots & \ddots & 63.9 & \vdots & \vdots & \vdots & 172.9 & \vdots \\ \vdots & 95.1 & \ddots & \ddots & \ddots & \ddots & \ddots & 64 & \vdots & 71.8 & \ddots & \vdots \\ 91.5 & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & 10.9 & \cdots & \cdots & 0.0 \end{bmatrix}$$

4. **Discussion of Results**

Table 2: Table of ACV

S/N	Feeders Nomenclature	Feeder By Feeder Criticality	Feeders Matrix	Feeders ACV
1	**GRA**	$\begin{bmatrix} 5.195 & 3.542 & 7.471 & 2.756 & 1.165 \\ 3.541 & 4.410 & 6.742 & 2.337 & 1.102 \\ 7.813 & 6.735 & 29.004 & 7.504 & 3.361 \\ 3.222 & 2.336 & 7.502 & 4.576 & 1.519 \\ 1.808 & 0.689 & 2.294 & 1.260 & 1.170 \end{bmatrix}$	$C_G=\begin{bmatrix} C & S & C & S & N \\ S & S & C & S & N \\ C & C & C & C & S \\ S & S & C & S & N \\ N & N & S & N & N \end{bmatrix}$	**4.781**
2	**Guinness**	$\begin{bmatrix} 5.195 & 3.542 & 7.471 & 2.756 & 1.165 \\ 3.541 & 4.410 & 6.742 & 2.337 & 1.102 \\ 7.813 & 6.735 & 29.004 & 7.504 & 3.361 \\ 3.222 & 2.336 & 7.502 & 4.576 & 1.519 \\ 1.808 & 0.689 & 2.294 & 1.260 & 1.170 \end{bmatrix}$	$C_{GU}=\begin{bmatrix} C & C & C & C & S \\ C & C & C & C & S \\ C & C & C & C & S \\ C & C & C & C & S \\ S & S & S & S & N \end{bmatrix}$	**359.6**
3	**Koko**	$\begin{bmatrix} 225.950 & 342.138 & 387.790 & 275.011 & 85.385 \\ 355.546 & 734.936 & 808.436 & 543.467 & 229.679 \\ 415.839 & 819.155 & 1156.360 & 661.644 & 284.542 \\ 308.732 & 554.032 & 661.556 & 539.351 & 226.312 \\ 92.691 & 199.981 & 211.761 & 184.861 & 190.062 \end{bmatrix}$	$C_{KO}=\begin{bmatrix} S & S & S & S & N \\ S & C & C & C & S \\ S & C & C & C & S \\ S & C & C & C & S \\ N & S & S & S & S \end{bmatrix}$	**419.8**
4	**Switchstation**	$\begin{bmatrix} 141.456 & 65.613 & 31.334 & 42.453 & 20.687 \\ 65.817 & 37.497 & 24.491 & 18.777 & 6.905 \\ 34.029 & 24.504 & 57.142 & 21.381 & 11.818 \\ 44.767 & 18.788 & 21.390 & 25.846 & 15.216 \\ 22.176 & 5.973 & 6.509 & 13.058 & 10.484 \end{bmatrix}$	$C_{S/S}=\begin{bmatrix} C & C & S & C & S \\ C & C & S & C & N \\ C & S & C & S & S \\ C & S & S & S & S \\ S & N & N & S & S \end{bmatrix}$	**31.5**
5	**Ikpobadam**	$\begin{bmatrix} 140.023 & 168.714 & 188.709 & 133.156 & 64.946 \\ 179.410 & 312.945 & 284.863 & 182.785 & 115.253 \\ 204.297 & 284.833 & 364.273 & 203.261 & 106.089 \\ 144.816 & 182.811 & 203.307 & 148.523 & 77.864 \\ 62.889 & 95.146 & 81.961 & 67.625 & 59.967 \end{bmatrix}$	$C_{IK}=\begin{bmatrix} S & C & C & S & S \\ C & C & C & C & S \\ C & C & C & C & S \\ S & C & C & S & S \\ S & S & S & S & S \end{bmatrix}$	**162.3**
6	**Etete**	$\begin{bmatrix} 6.692 & 5.445 & 15.277 & 5.765 & 1.129 \\ 6.075 & 12.331 & 25.739 & 9.443 & 3.553 \\ 21.128 & 29.972 & 134.962 & 29.399 & 6.807 \\ 5.964 & 9.443 & 22.269 & 12.197 & 3.295 \\ 0.983 & 3.141 & 2.791 & 2.730 & 2.967 \end{bmatrix}$	$C_{ET}=\begin{bmatrix} S & S & S & S & N \\ S & S & C & S & N \\ C & C & C & C & S \\ S & S & C & S & N \\ N & N & N & N & N \end{bmatrix}$	**15.718**
7	**Nekpenekpen**	$\begin{bmatrix} 5.635 & 5.057 & 7.244 & 5.809 & 2.590 \\ 5.324 & 7.033 & 8.851 & 6.102 & 3.297 \\ 11.861 & 16.821 & 30.445 & 16.104 & 10.214 \\ 6.211 & 6.099 & 10.276 & 9.039 & 4.364 \\ 2.730 & 2.377 & 3.252 & 3.912 & 4.261 \end{bmatrix}$	$C_{NK}=\begin{bmatrix} S & S & C & S & S \\ S & S & C & S & S \\ C & C & C & C & C \\ S & S & C & C & S \\ S & S & S & S & S \end{bmatrix}$	**7.796**

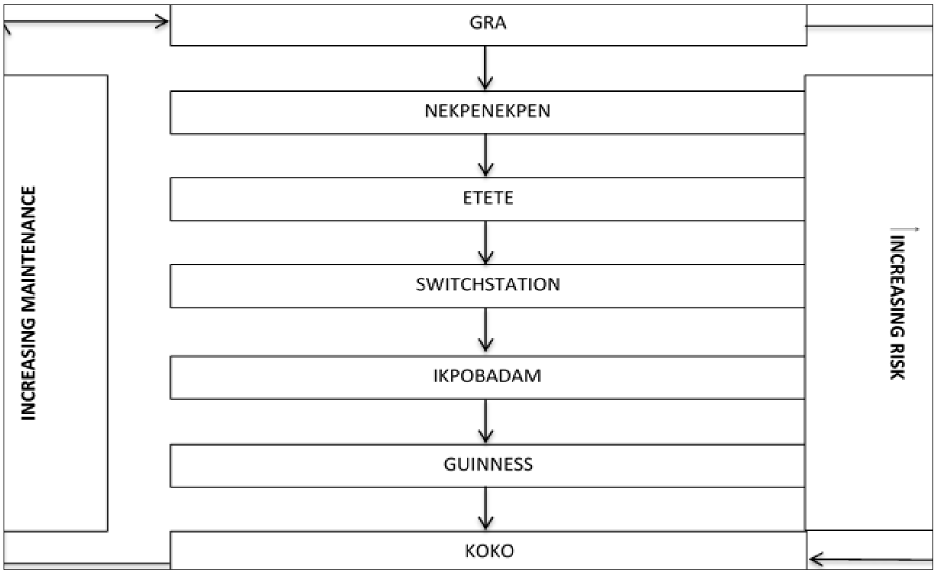

Fig 3: Criticality Level

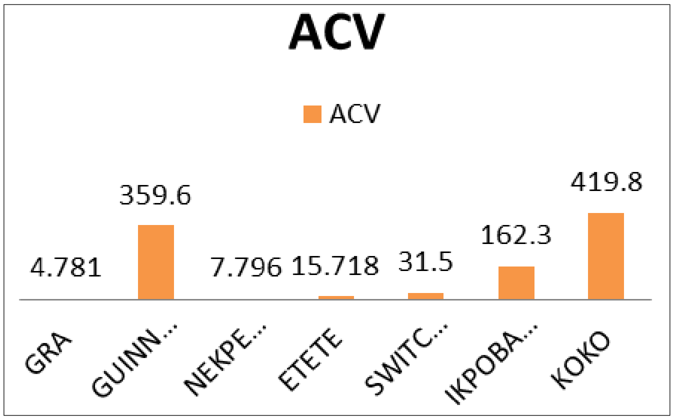

Fig 4: Summarized Results of Feeders ACV

Conclusion

This paper has discussed the risk assessment in a power system network using 33kV feeders emanating from TCN, Benin City, Nigeria. The paper could, therefore, serve as a guide for system's operators and engineers when it comes to transmission line planning, expansion and in the determination of the type of maintenance technique suitable for a particular feeder**.**

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