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Investigation and Analysis of Reliability Improvement of Distribution Network with Distributed Generation System

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Abstract: *The reliability of power supply to customers is an important factor in the design, planning and operation of a distribution network. This study analyzed the effect of Distributed Generation (DG) on the reliability of distribution network of Yola Electricity Distribution Company (YEDC). Three different feeders were used as case study. The great majority of service interruptions that affect customers are caused by problems on the distribution system. For the analysis, data has been collected from YEDC. Currently, customer served are affected by frequent power interruptions. The reliability of the network was improved when DG units were integrated into the network. The results revealed that the YEDC can better satisfy their customers with DG in the network. The reliability indicators used for analysis in this study are System Average Interruption Frequency Index (SAIFI), Customer Average Interruption Duration Index (CAIDI), Customer Average Interruption Frequency Index (CAIFI), Average Service Availability Index (ASAI), Expected Energy Not Supply (EENS), Average Energy Not Supply (AENS) and Average System Unavailability Index (ASUI). Generally, the results indicate that there was 45% improvement in the reliability of the distribution networks.*

Keywords: *Feeders, Customer, Distribution, Energy, Network, Power*

1.0 INTRODUCTION

One of the main objectives of the Electric Power System (EPS) is to provide electricity at the lowest possible cost to society, ensuring both an acceptable quality and reliability of the energy supply. However, regardless of how it was designed or operated, an EPS is subject to non-deterministic events that can compromise the regularity of service and power quality (Abud *et al.*,2023). The impacts of DG on the EPS have been widely discussed in the literature. Mulenga et al (2020) presented reviews on DG hosting capacity (HC), which is typically calculated in terms of power quality, protection, overvoltage, equipment overload. As the demand of consumers continues to rise, power utilities are expected to satisfactorily meet this demand.

The objective of every power utility is to supply electricity in a manner that is cost effective and reliable to customers. The benefit of good planning and maintaining of reliable electricity supply to customers is that there will be reduction in the price of interruptions of power supply to customers. An electricity utility company in a deregulated environment has the main objective of increasing the market value of its services to customers. This can be achieved by supplying reliable electricity at lower operation and maintenance cost and the construction of new electricity infrastructures at lower cost. All these factors will help to bill the customers at a lower rate which will likely lead to customer satisfaction (Idowu1, *et al.*, 2021). There are so many ways by which a utility company can achieve this objective

The generated electricity that is presently available in Nigeria is not adequate to meet customers demand due to electricity infrastructures that are old and not being properly maintained. As a result, power supply to industrial consumers as well as commercial and domestic customers is not stable. Distributed Generation (DG) is expected to play a progressively significant role in the future of power systems. Distributed generation is defined as a small-scale generation unit, i.e. 10MW or less that can be interconnected at or near the customer load (Lin, *et al.*, 2011). In addition to aiding as backup power sources, DGs are becoming more and more popular because they have little emission levels, low sound levels and high effectiveness. Power system reliability is one of the most important features in the power system operation. For improving the supply reliability in distribution systems, various methods are suggested. Among these methods are tree trimming, installing animal guards, replacing overhead bare conductors by covered conductors or underground cables, advanced protection and automation schemes. Furthermore, distributed generation (DG) option contributes a important role in the improvement of the electricity service reliability. Distribution Reliability indices assessed in this work are; System Average Interruption Frequency Index (SAIFI), System Average Interruption Duration Index (SAIDI), Customer Average Interruption Frequency Index (CAIFI), Average Service Availability Index (ASAI) and Average Service Unavailability Index (ASUI) (Abud, *et al.,* 2023). The aim of this work is to employ the use of distributed generator to improve the reliability of a distribution network.

2.0 Literature Review

This work analyses the reliability improvement effect of DG on distribution system by comparing the system reliability indices before and after connection of DG. Several literatures have reported on studies carried out on the advantage of integrating distributed generators into distribution network. DG is an alternative way to generate electricity by integrating generator units into distribution network in order to provide electricity to customers. A lot work carried out shows that in power system, distribution network is liable for the highest percentage of outages experienced by the customers. Thus, by incorporating distributed generation (DG) into the distribution network will minimize capital investment for the weakest or reinforcement-required network, especially upgrading network component. There are many types of technologies for DG such conventional DG, which is powered by fossil fuel (e.g. natural gas or diesel fuel) and renewable DG, such as solar cells and wind-powered generation. DG typically defines the production of electricity at or near the load demand/customer. Distributed Generation (DG) refers to the decentralized production of electricity from various small-scale energy sources located close to the point of use. DG systems are typically installed by individuals, businesses, or communities to meet local energy needs and reduce reliance on centralized power plants. Some common examples of DG include; Solar photovoltaic (PV) panels installed on residential rooftops are among the most widespread forms of DG Gevorgian, and O'Neill, 2016). Small wind turbines installed on the rooftops of buildings or in urban areas are another example of DG. These turbines harness wind energy to generate electricity for local use. While less common than solar PV, rooftop wind turbines are used in certain regions where wind conditions are favorable, contributing to the diversification of energy sources and enhancing grid resilience (Tummala, *et al.*,2016).

Reliability refers to a system's ability to perform its required function under given conditions for a stated time interval. From a power distribution system's point of view, its function is to supply electrical energy to final customers without interruptions and within accepted tolerance margins i.e. acceptable values for voltage and frequency (Adefarati *et al,* 2014).Scheduled and unscheduled events disrupt normal operating conditions and can lead to outages of the components in the system and interruptions to power supply. The unscheduled events may be as a result of oversights during installation or maintenance operations, component failures and faults (Adefarati *et al*, 2014). Pombo *et al.* (2015) presented a work which shows that the optimal number and location of switching devices are determined to improve network reliability and equipment cost.

Shah, *et al.,* (2015) a linearized model for optimal design and operation of energy hubs was proposed, considering reliability constraints. An energy hub receives different energy carriers then converts, stores, and delivers the energy by using a variety of energy converters and storage elements in the network (Nitin, *et al*., 2015). The author emphases on testing various indices and using active methods for the optimal placement and sizing of the DG unit by reducing power losses and voltage deviation. Whether the impact of the DG is positive or negative on the system will depend on the location and size of the a 33-bus radial distribution system has been taken as the test system. Raju, *et al.,* (2015) studied an analytical method for assessing distribution system reliability with the connection of DG. The Results revealed that location of DG and its effect in distribution reliability. The author also indicates that when DG is placed close to substation, the impact of the distributed generation on reliability is slight.
Reliability of a power distribution network is the probability that the network will continuously deliver electricity to its consumers without compromise on the quality of the power being delivered (Bhavaraju *et al*., 2015). Equipment outages and consumer interruptions are the primary focus of distribution reliability. In normal operating conditions, all components in the distribution substation (except standby) are energized and by implication all customers are energized. Furthermore, according to IEEE, the definition of reliability is simply the ability of a network or component to perform its intended functions under stated conditions for a specified period of time.Accordingly, the results of the reliability and availability analysis can be obtained for a larger part of the network, or extended to the whole network, in order to identify the influence and impact of a particular component on the reliability of the system in which this component is used (Gupta et al, 2015).

Nweke *et al.*, (2016) proposed analytical method for optimal location of distributed generators on the Nigerian network aims at minimizing active power loss. The results revealed that there is significant improvement in the voltage profile. However the study did not includes the reliability of the system. Sedighizadeh (2019) presented a techniques known as Imperialist Competitive Algorithm for Reconfiguration of Distribution Systems to Improve Reliability and Reduce Power Losses. The objective functions include minimization of power losses and reliability indices. The suggested technique was tested on the 33-bus and 69-bus test systems. However, the reliability would have improved more if DG's were considered.

Power distribution systems are responsible for approximately 90% of all service interruptions experienced by customers. Therefore, it is important to understand how the distribution system behaves and the effect that every element that composes it has in terms of system reliability; an accurate evaluation of power distribution reliability is essential to identify design weaknesses and areas within the system that require special attention (Gao. *et al,* 2019). The impact of element failure will depend on the element's statistical parameters and system design (Gonen. 2019). Initially, the reliability concepts evolved from analysing the ability of the network components (individual components, or groups of components) to operate without faults and as intended during their lifetime.

Sreevidya, *et al*., (2019) examined the influence of DG on the reliability of the distribution network. The author used IEEE 33 Bus distribution network for the study. Method known as Modified Particle swarm optimization was used for optimal location of DGs and ETAP software was used to model and estimate the reliability indices. Results achieved indicated that the reliability of the system increases with increase in the number of DG, however only one type of DG (solar) was considered. Distributed generation (DG) or embedded generation refers to generation applied at the distribution level (Hassan and Radman, 2019). DG units can be directly connected at the distribution substation or dispersed throughout the power distribution system (Brown, 2002). Due to their small size distributed generators can be placed close to load consumption, typically DG present sizes of up to 5 MW (IEEE STD 1547 applies for generators under 10 MW) however, utilities can limit the rated power of generation units according to their own operation policies (Jabr and Pal, 2019).Costs reduction and efficiency improvement in small-size generators have turned distributed generation into an attractive option for utilities and independent producers (Gozel and Hocaoghu, 2019). While the independent producer seeks to maximize its profits, utilities are concerned with exploiting the benefits of DG and improving system performance. The connection of distributed generation to the distribution system can be used for supporting voltage, reducing losses, providing backup power, providing ancillary services, or deferring distribution system upgrade. Aspects to be considered when embedding DG into a distribution system are the great variety of generating technologies, or the intermittent nature of some renewable sources (Gozel and Hocaoghu, 2019).
It is also important to remark the challenges and negative impacts that the connection of distributed generation can carry. Power distribution systems were not designed to host local generation; as a consequence of this design limitation, distributed generation can disrupt normal system operation (Gozel and Hocaoghu, 2019). One of the most important concerns is the formation of undesired islands within the system; under this condition an isolated section of the circuit is continued to be served by a local generator. Rei and Schilling, (2008) studied Monte Carlo simulation requires larger computational effort but is very versatile to model random behaviour of components. It may be easiest way to evaluate adequately higher order contingencies of bulk system. To improve the computational speed. Hemansu and Anuradha (2019), studied evaluation of power system reliability with nonchronological load by Monte Carlo simulation (MCS) technique using Pspice. Power system Reliability was found out in terms of Probability of system success from the probability of system failure using Monte Carlo simulation. The simulation results showed that the proposed simulation method significantly estimate the reliability of given system.

3.0 Methodology

The data for the network were obtained from Yola Electricity Distribution Company (YEDC). three feeders were selected in each of the four states namely; Adamawa, Borno, Taraba and Yobe. Reliability Indices are calculated for three feeders in each state. The data includes failure frequency, duration of failure, number of customers and total load.

The procedure developed for this research may be defined as a Monte Carlo method aimed at estimating the reliability indices related to frequency of interruptions, duration of interruptions, non-supplied energy. It can be applied to distribution systems (either overhead or underground) with or without distributed generation.The procedure may be summarized as follows:

Step 1: Run the test system for one year using time-driven simulation and a constant time step (e.g., 1 hour) with or without distributed generation

Step 2: Estimate in advance all the random values related to the failures to be simulated for one year.

Step 3: Run the test system again. Reliability indices are updated once this sequence of events is finished.

Step 4: Repeat the procedure from step 2 as many times as required to obtain accurate information for reliability index calculation.

3.1 Reliability Indices

System reliability will be quantified by means of the customer interruption indices. The following indices are calculated at the end of every execution of the Monte Carlo method.

i). The System average interruption frequency index is given by equation (1)

$$SAIFI = \frac{Total\ No.of\ customers\ interrupted}{Total\ No.of\ Customers\ served} = \frac{\sum \lambda_i N_i}{\sum N_T} \quad (1)$$

Where, N_i is the number of interrupted customers for each interruption event, λi is the number of interruptions and N_T is the total number of customers served in the area.

ii). The System Average Interruption Duration index is given by equation (2)

$$SAIDI = \frac{\sum Customer\ Interruption\ DUrations}{Total\ Number\ of\ Customer'sserved} = \frac{\sum r_I Ni}{N_T} \quad (2)$$

Where, N_i is the number of interrupted customers N_T is the total number of customer served in the area and r_I as the outage duration for each interruption event.

iii). The Customer average interruption duration index is given by equation (3)

$$CAIDI = \frac{SAIDI}{SAIFI} \quad (3)$$

iv). The Average System Availability Index (ASAI) is given by equation (4)

$$ASAI = \frac{Cutomer\ Hours\ of\ Service\ Availability}{Customer\ Hours\ of\ Service\ demand}$$

$$ASAI = \frac{\sum(r_i\ x(N_T\ x\ 8760 - \sum(r_i\ xNi)}{N_T\ x\ 8760} \quad (4)$$

Where, N_i is the number of interrupted customers for each interruption event, N_T us the total number of customers served in the area and r_i is the outage time for each interruption event. Where 8760 is the number of hours in a year

v). The Average system unavailability index is given by equation (5)

$$ASUI = 1\text{-}ASAI \quad (5)$$

vi). The Energy not supplied and the average energy not supplied are given by equation (6) and (7)

$$ENS = \sum L_i r_i \quad (6)$$

vii). The Average Energy not supplied (AENS);

$$AENS = \frac{\sum Total\ Energy\ Curtailment}{Total\ number\ of\ customers\ served}$$

$$AENS = \frac{\sum L_i\ x\ r_i}{N_T} \quad (7)$$

Where L_i is the load interrupted due to each outage N_T is the total number of customers served in the area and r_i is the outage time for each interruption event. The flow chart for assessing reliability with and without DG is presented in fig.1.

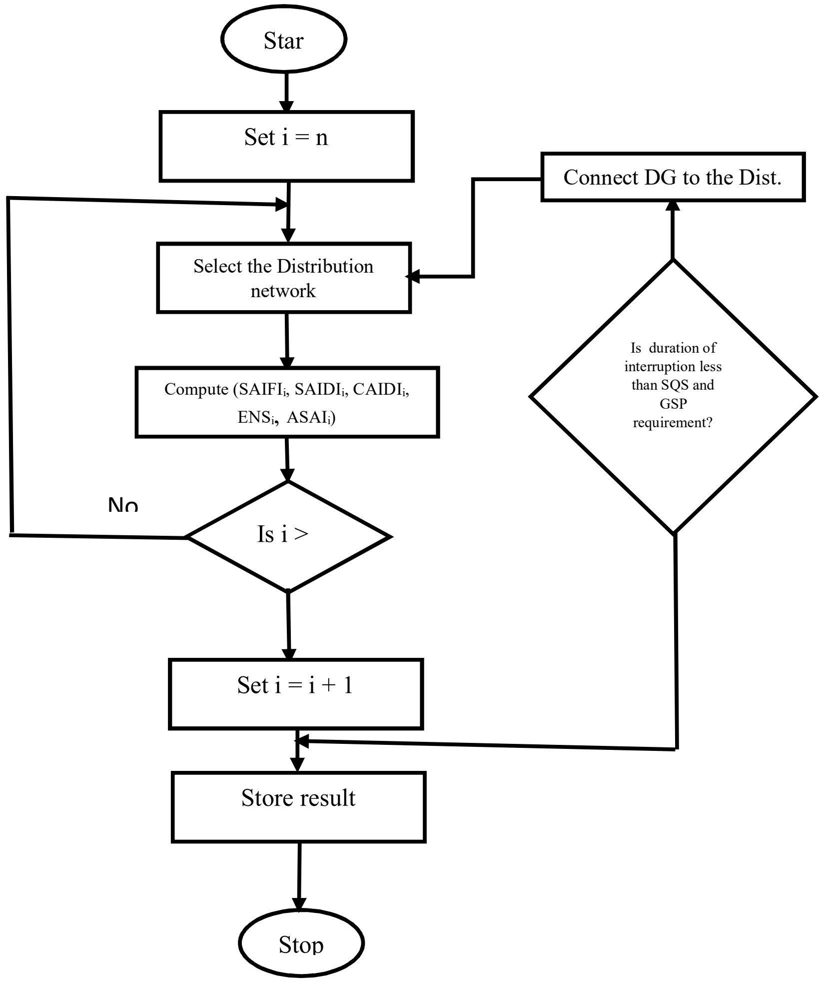

Figure 1.: Flow Chart for the Assessment Reliability with DG and without DG

3.2 DG Allocation

The reliability indices are calculated using MCS technique for the base case, which no DG connected in the network and DG Were connected later to investigate the reliability performance of the network with alternative supply at the end of main feeder lines, which operate after faults longer than 3 h accordance with Security and Quality of Supply (SQS) and Guaranteed Standard of Performance (GSP) (Mohd, *et al.*, 2020). However, for these work DG will operate after a fault exceed 1hr.

4.0 RESULTS

After the simulation was carried out using the Monte Carlo method, the followings were obtained as the indices. The results of the Indices were obtained by feeding in the earlier stated formulae to the simulation software and defining what each parameter in the formulae represents and which data it should hold.

Three feeders were selected from each state capital for the reliability assessment, the data used covered the year 2019.The results are presented as case I, II, III and IV for Borno, Yobe, Taraba and Adamawa respectively.

It can be observed from the simulation that there is an improvement on the Distribution Network when Distributed Generators are connected to the grid. There is a great reduction in the power that is lost on the distribution network, not only in the power that is lost but it cut across other parameters as it can be seen that there is improvement on the on the energy that is not supplied and also the number of interruptions.

Case I: Borno Feeders

Three feeders namely; Lagos Street feeder, flour mill feeder and Teaching Hospital feeder was considered for this study, and outage data for one year was used for the analysis. The result obtained from Borno feeders shows that the base case reliability indices is higher in Teaching hospital feeder, Due to the large number of interruptions. The feeder has the highest SAIDI of 102.775 and decrease to 53.55 when DG was connected. The table 1 shows the simulation result of Borno feeders with DG and without DG.

Table 1: Reliability indices of Some Selected Borno feeders with and without DG

		Reliability Indices						
Feeder Name		**SAIFI**	**SAIDI**	**CAIDI**	**ASAI**	**ASUI**	**ENS**	**AENS**
Lagos Street	**Without DG**	30.666	68.466	2.232	0.906	0.093	10259.68	2.479
	With DG	17.333	36.863	2.126	0.949	0.050	5601.081	1.353
Teaching Hospital	**Without DG**	31	102.775	3.315	0.859	0.140	28317.99	6.688
	With DG	17.5	53.554	3.060	0.926	0.073	16114.52	3.805
Flour Mills	**Without DG**	30.833	67.282	2.182	0.907	0.092	62719.86	16.778
	With DG	18.333	20.596	1.123	0.971	0.028	14016.18	3.749

The result revealed that, the SAIFI on lagos street feeder before DG connection was 30.667 (f/cust. yr) drop to 17.33 (f/cust.. yr) when is DG was connected. The expected energy not supplied was 10259.68 MW hr/yr, but in the presence of DG it reduces to 5601.081 MW hr/yr. ASUI was 0.09379 p.u without DG and it reduce to 0.0505 p.u with DG.

For Teaching Hospital feeder, The result indicate that the reliability indicate was improvement in their presence of DG on this feeder. SAIDI and SAIFI without DG was 102.775 hr/cust/yr and 31 f/cust/yr respectively, while with the connection to DG the indices reduce to 53.554 hr/cust/yr and 17.5 f/cust/ yr, it shows that the SAIFI drop by 44.4%. CAIDI also reduce to 3.060 hr /cust. interrupt from 3.315 this shows significant improvement.

Flour Mill feeder, it recorded the highest AENS in all the feeders with a value of 16.779 MWhr/yr before the connecting to DG and it reduced to 3.7496 MWhr/yr, it also has the highest availability index of 0.97178 when DG was connected to the feeder. SAIDI improved by 69.4% with DG connection while SAIFI improved by 40.5% with DG connection. Generally, the ENS is higher in almost all the three feeders because the number of customers connected is the number of customers interrupted.

Case II: Yobe Feeders

Analysis was made on three feeders in Yobe State, the distribution energy resource considered was solar energy, two feeders Damaturu, Gujba and Machina feeder was used for the assessment as shown in table 2.

Table 2: Reliability indices of Some Selected Yobe feeders with and without DG

Reliability Indices								
Feeder Name		**SAIFI**	**SAIDI**	**CAIDI**	**ASAI**	**ASUI**	**ENS**	**AENS**
Damaturu	**Without DG**	31.250	108.579	3.474	0.851	0.148	74844.91	12.366
	With DG	17.833	51.931	2.912	0.928	0.071	34291.5	5.666
Gujba	**Without DG**	30.750	77.850	2.531	0.893	0.106	47846.73	29.033
	With DG	17.083	30.387	1.778	0.958	0.041	16903.42	10.256
Machina	**Without DG**	32.083	87.433	2.725	0.880	0.119	71383.66	27.668
	With DG	17.750	38.464	2.167	0.947	0.052	29630.79	11.484

The result of Damaturu feeder shows that CAIDI without DG was 3.4745 hr/cust/intrupt, however, when DG was connected it reduce to 2.9120 hr/cust/intrupt, this shows 16.2 % improvement. The system availability was also increase from 0.8412 to 0.9289 with DG on the feeder. The expected energy not supply was as high as 74844.9 MW. hr/yr without DG, but it reduces to 34295.5MW hr/yr when DG was connected that is 54.2 % improvement in power lost.

Gujba feeder was the second feeder considered for the assessment, the result obtained shows that the SAIDI was 77.850 hr/cust/yr without DG while the index reduces to 30.3875 hr/cust/yr with DG connection. CAIDI was 2.5317 hr/cust. yr without connection to DG and reduced to 1.7787 hr/cust/yr with DG, this improved the CAIDI by 29.7 %. The average energy not supply was 29.033 MW hr/cust/yr without DG connection while it reduces to 10.2569 MWhr/yr with DG connected.

The result of Machina feeder revealed that SAIFI was 32.0833 in the base case analysis,but after DG integration the index reduces to 17.75. It can be seen from the result that the availability and unavailability index recorded before connection to DG was 0.88022 and 0.11977 respectively, and 0.947309 and 0.052691 after connecting to DG. The customer average interruption index almost reduces from 2.7251 hr/cust.

intrupt to 2.1670 hr/cust. yr with DG connection, it improves by 20.5%. In general, almost all the indices have been improved.

Case III: Taraba Feeders

Reliability assessment carryout on three feeders in Taraba state, namely; Jalingo, Zing and Mutum Biyu feeder. The simulation result obtained are presented as in table 3.

Table 3: Reliability indices of Some Selected Taraba feeders with and without DG

		Reliability Indices						
Feeder Name		**SAIFI**	**SAIDI**	**CAIDI**	**ASAI**	**ASUI**	**ENS**	**AENS**
Jalingo	**Without DG**	32.333	123.425	3.817	0.830	0.169	102181.6	18.807
	With DG	17	28.771	1.692	0.960	0.039	21055.02	3.875
Zing	**Without DG**	30.666	82.662	2.695	0.886	0.113	93903.15	19.321
	with DG	17.833	35.755	2.005	0.851	0.148	93897.22	19.320
Mutum Biyu	**Without DG**	31.666	82.451	2.603	0.887	0.112	59163.23	8.991
	With DG	17.416	44.405	2.549	0.939	0.060	24623.62	3.742

The result of Jalingo feeder shows that the system average interruption duration index (SAIFI) without connecting to DG was 32.3333 hr/cust./yr and 17 hr/cust./yr after connecting to DG, this shows meaningful improvement when the feeder is connected to DG. CAIDI was high without DG in the range of 3.8172 hr/cust./intrupt but when DG was connected it reduce significanly to 1.6924 hr/cust. intrupt. Availability index (ASAI) increase from 0.830924 without DG to 0.960587 with DG connection, while the unavailability index decrease from 0.169076 to 0.039413 after connecting to DG. The power lost the customers i.e AENS before connecting to DG was 18.8075MW hr/cust./yr and dropped to 3.875394MW hr/cust./yr with DG connection, this shows that there is improvement in the supply as compared to when there is no DG connected.

For Zing feeder. the result of obtained revealed that SAIDI with base case was 82.6625 and reduced to 35.7556 which improved by 56.7% after the connecting to DG. Also, CAIDI reduced from 2.695516 hr/cust. Intrupt and this shows that interruption to customer has been reduce by 2.0050 hr/cust. Intrupt. ENS also droped from 93903.15MW hr/yr to 93897.22MW hr/yr when connected to the distributed generation.

For Mutum Biyu feeder, the result shows that there was significant improvement in the energy not supplied from59163.23 MW hr/yr to 24623.62 MW hr/yr after DG connection.SAIFI was 31.666 with the base case analysis while it reduced to 17.4167 with DG connection,also SAIDI shows great improvement after intergration of distributed generator on the feeder,it record 82.45 before DG connection and reduced to 44.4058 when DG was connected.

Case V: Adamawa Feeder

Reliability assessment was conducted on three feeders in Adamawa, and hydro power was used as the distributed energy resources in order to improve the performance of the feeders. The feeders considered for the assessment are Jimeta feeder, faro feeder and Jambutu feeder. Table 3 shows the reliability indices of some selected Adamawa feeders with and without DG.

Table 4: Reliability indices of Some Selected Adamawa feeders with and without DG

Reliability Indices								
Feeder Name		**SAIFI**	**SAIDI**	**CAIDI**	**ASAI**	**ASUI**	**ENS**	**AENS**
Jimeta	**Without DG**	31.583	74.47	2.358	0.897	0.102	101196.9	29.079
	With DG	17.083	25.1	1.469	0.965	0.034	37688.44	10.830
Faro	**Without DG**	30.5	83.02	2.721	0.886	0.113	50945.5	28.303
	With DG	17.25	49.741	2.883	0.931	0.068	19852.23	11.029
Jambutu	**Without DG**	32.5	115.516	3.554	0.841	0.158	151132.3	70.821
	With DG	17.916	51.635	2.881	0.929	0.070	60942.36	28.557

For Jimeta feeder, the result obtained shows that SAIDI and SAIFI without DG connection was 74.5758 hr/cust./yr and 31.58333 f/cust./yr respectively, and improvement was observed when DG was connected to the line in the range of 25.1hr/cust./yr and 17.0833f/cust./yr respectively. CAIDI was obtained as 2.3580 without DG and 1.4692 with DG connected to the feeder. ENS was also 101196.1 MW hr/yr and it reduces to 37688.44 MW hr/yr when DG was connected, it improves the energy supply by 62.7%. The availability and unavailability without a DG were 0.897978 much 0.102022 respectively. And it increases to 0.965616 and 0.034384 respectively when DG was connected, in conclusion there was improvement on the feeder when DG was connected.

For Faro feeder, the result indicates that SAIDI and SAIFI are 83.02 hr/cust./yr and 30.5 f/cust./yr without DG, and 49.74167 hr/cust./yr and 17.25 f/cust./yr with DG connection respectively. The energy not supply (ENS) improved by 61%, since it dropped 50945.5MW hr/yr to 19852.23MW hr/yr with DG connection. Average energy not supply (MW hr/cust./yr) before DG connection was 28.30306 MW hr/cust. yr and decreases to 11.02902 MW hr/cust. yr with DG, with improvement of about 61%.

For Jambutu feeder, analysis on the feeder indicate that SAIDI before DG connection was 115.5167 hr/cust./yr and 51.635hr/cust./yr with DG shows 55.3% reduction. SAIFI (f/cust. yr) decreases from 32.5f/cust.yr to 17.9167 f/cust.yr without DG and with the DG respectively. Energy not supply before DG connection was 151132.3MW hr/cust yr and 60942.36 MW hr/cust yr with DG, which improved the system with 59.7%. Availability of supply before DG connection was 0.841758 and it increase to 0.929267with DG connection, while the in-availability index was 0.158242 and 0.070733 without DG and with DG Connection respectively.

5.0 CONCLUSION

This research has presented a methodology that can simulate the operation of distribution network with Distributed Generation and evaluate the status of the system reliability in such a network. Montel Carlo simulation method using Matlab software was used to determine the status of reliability indices of the system. The reliability improvement is important effect of DGs in emerging active distribution networks. Reliability is measured by reliability indices SAIDI, ASAI, CAIDI, SAIFI, and AENS. Electrical power distribution reliability can be improved from different aspects, from planning to operation and maintenance.The obtained results shows that DGs installation resulted in reliability improvement. SAIDI improved by 69.4% while SAIFI improved by 40.5% with DG connection. CAIDI improved by 29.7 %. ASAI increase from 0.830924 without DG to 0.960587 with DG connection, while the unavailability index decrease from 0.169076 to 0.039413 after connecting to DG.The placement of DG into LV networks show improvement in terms of reliability performance in all the feeders under study.

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