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Effect of faulty section isolation process on the reliability of DG connected Distribution System

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Abstract: *The present energy problem may be overcome by Distributed Generation (DG) using distributed renewable energy sources. DG helps to improve the reliability of the distribution system. When DG is used as back up generation, the reliability improvement of distribution system depends on the isolation process of the faulty section as well as the staring process of the DG. This paper studies the effect of isolation process of the faulty section from the healthy section as well as effect of starting process of DG on the reliability of distribution system.*

Keywords: *Distributed generation, back up generation, reliability, distributed energy sources, passive network, bulk supply point, islanding operation, isolation process.*

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I. Introduction

The problems developed from centrally located power plants can be overcome by Distributed Generation (DG) using distributed renewable energy resources such as wind, biomass, tidal, mini hydel, geothermal, solar etc. The non-renewable energy sources like gas, diesel etc may also be used for DG. DG is located at customer side. It provides support to the distribution network. The penetration of DG converts passive network into active network. In this case, power flow and voltage are determined by the generation and loads [1]. Due to the sufficient penetration of DG, the power flow becomes reverse [2].

DG provides support to the distribution system. It is connected to the grid at distribution level voltage. It is used for back up generation. In this case, these are started after any interruption and isolation of faulty section. DG can also be used to operate during high demand and switch off during low demand.

The consumers need continuous energy supply. The use of DG helps to increase the reliability of the system. In case of islanding operation, there are two types—intentional and unintentional islanding operation [3]. The ability of DG to supply the load demands completely during interruptions depends on the availability and capacity of DG [4].

The system reliability depends on the capacity of DG, location of DG, isolation process of faulty section and starting process of DG. The reliability will be maximum if DG is located optimally in the distribution network. Optimum location of DG depends on the system, load distribution and factors considered like load curtailment scheme and use of renewable energy sources affect the sensitivity of reliability to varying location but do change the optimum location [5]. There are several papers published on optimal locations of DG. Paper [6] gives the optimal location for connecting DG with the distribution network to minimize the power loss. In paper [7], the authors discussed a method for optimal DG units’ allocation and sizing in order to maximize a benefit/cost relation.

There are many other factors which affect the reliability of the system. These are -- failure rate of the different components, isolation process for the faulty section, whether the circuit breaker (main CB) installed at the section connecting the bulk supply point trips for fault at any section or trips only for fault of the section at which it is installed, whether DG is auto-starting or manually starting. Electrical utilities take care of all these to meet the growing demand of reliable energy [8]. This paper studies the affects of the type and location of switches on the reliability of the system as well as of the individual loads. It also examines the impact of disconnect switches and circuit breakers on the network reliability. In paper [9], switch placement schemes are proposed for forming self-supported areas after fault isolation to improve system reliability for radial distribution system with DG under fault conditions. In this paper, the switch placement problem is formulated as a non-differentiable, multi-objective optimization problem. In paper [10], the authors have showed that the radial distribution line with DG but without disconnects has no any impact on reliability. The power system is modeled in terms of segments in paper [11]. A segment is a group of components and its entry component is a switch or protective device.

Aim and Objective:

In this paper, customer related reliability indices of a radial distribution system with DG are evaluated by using load point indices. The method proposed in [12] is used here to find out the load point indices when the CB installed at the section connecting the 11 KV bulk supply point is tripped for fault at any section. New method is adopted when this CB does not trip for fault at any section other than at the section connecting the 11 KV bulk supply point. This new method is applied under two conditions – a) when the DG is auto-starting and b) when the DG is not auto-starting.

Distribution System Reliability:

Two main aspects of distribution system reliability are system adequacy and system security. Rate (or frequency) of failure λ_s, average outage time (or average duration of failure) r_s and annual outage time U_s[13] are the three basic customer related indices for the reliability analysis of distribution system.

$$\lambda_s = \sum \lambda_i$$
$$U_s = \sum \lambda_i r_i$$
$$r_s = U_s/\lambda_s$$

These indices are used to get the customer related additional indices --- SAIFI, SAIDI, CAIDI, ASAI, EENS etc.

Methodology and Problem Definition:

In this research work, new models are adopted to get the value of frequency of failure (λ), the average duration of failure(r) and annual duration of outage (U) at load points. These three customers' related indices are used to get the other additional customers' related indices under two conditions.

A radial distributor consists of sections and lateral distributors. In this research work, disconnects are installed properly in every section including the laterals. Here, study is performed under two conditions. In one condition, the main CB trips for fault at any section of the distributor. In the other condition, the main CB does not trip for fault at any section of the distributor. It trips only when there is a fault at the section at which it is it is installed. The CB which is installed at the section connecting the bulk supply point is identified as main CB. Here, lateral distributors are considered with separate lateral protection for each lateral distributor.

1) Main CB Trips

If main CB trips for fault at any section, and if failure rate of section and lateral is only considered then

$$\lambda_i = r\, L_T + r_i^{/} \text{ ------ (i)}$$

r = Failure rate of section
L_T = Total length of all sections
$r_i^{/}$ = Failure of lateral connected to load point i
λ_i = Failure rate at load point i

The annual outage time for the load point i can be calculated by adding the affect of outage of all sections on that point plus the outage time of lateral connected to that point as shown in (ii). Here, DG is started manually.

$$U_i = r\, L_e\, R + r\,(L_T - L_e)\, R^{/} + r_i^{/}\, r^{//} \text{ --- (ii)}$$

r = Failure rate of the section
L_T = Total length of all sections in meter
L_e = Length of affected section (sections) due to failure
R = Repairing time of the section
$R^{/}$ = Switching time of the section (or DG)
$r_i^{/}$ = Failure of lateral connected to load point i
$r^{//}$ = Repairing time of lateral

2) Main CB does not Trip

If main CB does not trip for fault at any section other than the section at which it is installed, then

$$\lambda_i = r\, L_e + r_i^{/} \text{ ------ (iii)}$$

r = Failure rate of section
L_e = Length of affected section (sections) due to failure to which load point i is connected.
$r_i^{/}$ = Failure of lateral connected to load point i
λ_i = Failure rate at load point i

In this case, U_i can be calculated under two conditions as given below.

A) When DG Is Started Manually

For this condition annual outage duration for the load point i can be calculated by adding the affect of outage of all sections on that load point plus the outage time of lateral connected to that load point as shown in (iv). In this case the DG is not auto – starting i.e. it is to start manually as soon as the bulk supply is off.

$$U_i = r\, L_e\, R + \sum F_{ps} S_g + r_i^{/}\, r^{//} \text{ --- (iv)}$$

r = Failure rate of the section
L_e = Length of affected section (sections) due to failure
R = Repairing time of the section
$\sum F_{ps} S_g$ = Summation of product of failure of previous section(s) and starting time of DG
F_{ps} = Failure rate of previous section
S_g = Starting time of DG
$r_i^{/}$ = Failure of lateral connected to load point i
$r^{//}$ = Repairing time of lateral

2) When DG is started Automatically:
If DG is auto – starting i.e. if it starts as soon as the bulk supply is off then annual outage duration will be

$$U_i = r\, L_e\, R + r_i^{/}\, r^{//} \quad \text{--- (v)}$$

r = Failure rate of the section
L_e = Length of affected section (sections) due to failure
R = Repairing time of the section
$r_i^{/}$ = Failure of lateral connected to load point i
$r^{//}$ = Repairing time of lateral

In this case also, there is an improvement in unavailability (U_i) due to auto started DG. It helps to improve the reliability of the system.
Average outage time (or average duration of failure) r_i of load point i for the different conditions can be determined by using the values of λ_i and U_i for respective condition as shown in (xi).

$$r_i = U_i/\lambda_i \quad \text{------------- (vi)}$$

The basic indices are important from an individual customer's point of view. The additional indices which provide overall information of the system are SAIFI, SAIDI, CAIDI, ASAI, EENS, AENS etc. In our study, the basic indices as well as additional indices are calculated under two condition – i) CB installed at the section connecting the bulk supply point trips at the time of fault at any section of the feeder and CB connected to a lateral trips only when there is a fault at that particular lateral ii) CB installed at the section connecting the bulk supply point does not trip at the time of fault at any section of the feeder but it trips when there is a fault at the section connecting the bulk supply point and CB connected to a lateral trips only when there is a fault at that particular lateral. In this case, the starting of the DG is not automatic and the starting time is 0.5 hr.

II. Case Study

For reliability analysis, one network as shown in Fig. 1 is considered. This is a residential distribution network of Chandmari – Milonpur[14] area in Guwahati, Assam. The network is having three junction points. The first junction, J1 is among the sections 2, 3 and 17. The second junction, J2 is among the sections 17, 18 and 19 and the third junction, J3 is among the sections 9, 10 and 12. The reliability analysis is performed under the following conditions:
1) Main CB Trips
2) Main CB does not Trip

In the 2nd case, the reliability analysis is performed under two conditions:
a) Auto started DG
b) Manually started DG
Following assumptions are made for reliability analysis:
a. The radial system is having 23 sections and 22 load points and 22 loads.
b. Disconnects installed against each section are 100% reliable. Appropriate disconnect operates in case of a fault in a section and isolates the faulty section with next adjacent load point from the healthy sections.
c. Separate fuse-gears are installed against each lateral. These are 100% reliable. Appropriate fuse-gear blows in case of a fault on a lateral distributor.
d. DGs are 100% reliable.
e. For reliability analysis active power is considered.
f. No technical aspect is considered here, only reliability analysis is performed.
g. The repairing time for section is 4 hr and for lateral is 2 hr. The switching time for section and lateral is 0.5 hr.
h. In case of manual starting, starting time of DG is 0.5 hr.
i. Failure rate for section is 0.0056 f/m yr.
j. DGs are applied at the end of distribution line and have the sufficient capacity to meet the load demand.

With main CB trips and does not trip, the following situations will arise at sections forming the junctions as shown in Fig. 1:

At junction 1:
a) When there is a fault at section 2, section 2 is only isolated.
b) When there is a fault at section 3, section 3 is isolated with isolating load at point B.
c) When there is a fault at section 17, section 17 is only isolated.
At junction 2:
d) When there is a fault at section 17, section 17 is only isolated.
e) When there is a fault at section 18, section 18 is isolated with isolating load at point Q.
f) When there is a fault at section 19, section 19 is isolated with load at point R.
At junction 3:
g) When there is a fault at section 9, section 9 is isolated with load at point H.
h) When there is a fault at section 12, section 12 is isolated with load at point K.
i) When there is a fault at section 10, section 10 is isolated with load at point I.
The reliability data are presented in Table 1, 2 and 3. Table 1 presents the length of the section, Table 2 shows the failure rate of laterals and Table 3 shows the loads at different loads points.

III. Results

The reliability data presented in Table 1, 2 and 3 are used for calculation of the system reliability indices for the system shown in Fig. 1. The Table four shows the results. The calculations have been done with the DG in the system under three conditions. The results are analysed in four sections A, B, C and D.

A) Reliability indices when main CB trips for fault at any section and manually started DG (Process 1):

There is no any change of SAIFI for different locations of DG in the distribution system. But failure rate at load points are different. From our study, it is found that failure rate at load points are different depending on the failure rate of lateral. But SAIDI and CAIDI are different for different locations of DG. These are minimum for location of DG at X. The improvement of SAIDI for location of DG at X with respect to the locations at Y and Z are 6.95% and 21.65% respectively. The improvement of CAIDI for location of DG at X with respect to the locations at Y and Z are 6.66% and 20.00% respectively. EENS is also minimum for the location of DG at X than for its locations at Y and Z. The improvement of EENS for location of DG at X with respect to the locations at Y and Z are 6.87% and 21.4%.

B) Reliability indices when main CB does not trip for fault at any section other than the section at which it is installed and manually started DG (Process 2):

In this case also, there is no any change of SAIFI for different locations of DG in the distribution system. But failure rate at load points are different. From our study, it is found that failure rate at load points are different without depending on the failure rate of lateral. SAIDI and CAIDI are different for different locations of DG. At X, these are minimum. The improvement of SAIDI for the location of DG at X with respect to the locations at Y and Z are 10.15% and 31.19% respectively. The improvement of CAIDI for location of DG at X with respect to the locations at Y and Z are 10.91% and 31.19% respectively. EENS is minimum for the location of DG at X. The improvement of EENS for location of DG at X with respect to Y and Z are 9.9% and 31.15% respectively.

C) Reliability indices when main CB does not trip for fault at any section other than the section at which it is installed and auto started DG (Process 3):

In this type SAIFI is not same for three locations of DG in the distribution system. SAIFI is minimum for location at X and maximum for location at Z. It is because, for location of DG at X minimum number of sections affected by the failure than for location of DG at Y and Z. The improvements of SAIFI for location of DG at X with respect to the location at Y and Z in this process are 6.96% and 33.3%. SAIDI and CAIDI are minimum for the location of DG at X. The improvement of SAIDI with DG location at X with respect to Y and Z are 9.45% and 41.5% respectively. CAIDI improvement is 2.27% and 6.25% respectively. EENS improvement is 9.2% and 40.53% respectively.

D) Comparison of the three processes:

In case of Process 3, it is low for all location of DG than Process 2 and Process 1. SAIFI (5.247 interruption/customer. yr) is the lowest for the location of DG at X in Process 3. There is no any improvement of SAIFI in Process 1(25.932 interruption/customer. yr for all location of DG). There is also no any improvement of SAIFI in Process 2(9.735 interruption/customer. yr for all location of DG). SAIFI improvement for the location of DG at X, Y and Z in Process 3 with respect to location at X, Y and Z in Process 2 is 85.53%(X), 73.46%(Y) and 39.1%(Z) respectively. This improvement in Process 3 with respect to Process 1 is 394.22% (X), 362.08% (Y) and 270.72% (Z). SAIFI improvement for the location of DG at X, Y and Z in Process 2 with respect to Process 1 is 166.4% (for X, Y and Z).

SAIDI is different for all location of DG for all processes. In case of Process 3, it is low for all location of DG than Process 2 and Process 1. SAIDI (925.4Minute/customer yr.) is the lowest for the location of DG at X in Process 3. The improvement of SAIDI for the location of DG at X, Y and Z in process 3 with respect to the location of DG at X, Y and Z in Process – 2 is 14.41%, 15.14% and 6.67% respectively. The improvement of SAIDI for the location of DG at X, Y and Z in process 3 with respect to the location of DG at X, Y and Z in Process – 1 is 66.9%, 63.1% and 43.8% respectively. The improvement of SAIDI for the location of DG at X, Y and Z in process 2 with respect to the location of DG at X, Y and Z in Process – 1 is 45.89%, 41.66% and 34.87% respectively.

CAIDI is also different for all location of DG for all processes. In case of Process 3, it is high for all location of DG than Process 2 and Process 1. CAIDI (60.00 Minute/customer intr.) is the lowest for the location of DG at X in Process 1. The increase of CAIDI for the location of DG at X, Y and Z in process 3 with respect to the location of DG at X, Y and Z in Process – 2 is 61.46%, 50.00% and30.76% respectively. The increase of CAIDI for the location of DG at X, Y and Z in process 3 with respect to the location of DG at X, Y and Z in Process – 1 is 193.33%, 181.12% and 159.72% respectively. The increase of CAIDI for the location of DG at X, Y and Z in process 2 with respect to the location of DG at X, Y and Z in Process – 1 is 81.67%, 87.5% and 98.61% respectively.

In case of ASAI, it is highest for the location of DG at X, Y and Z in Process 3 than the location of DG at X, Y and Z in Process 2 and Process 1. The improvement of ASAI for location of DG at X in Process 3 is maximum. This improvement of ASAI helps to reduce the EENS. In case of DG at location X in Process 3, it is the lowest. In case of Process 2, EENS for location of DG at X, Y and Z is Less than in Process 1.

IV. Conclusion

DG plays an important role in improving the reliability of the distribution system. The reliability improvement depends not only on the location of DG in the distribution system. It also depends on the isolation process of the faulty section as well as the starting process of the DG. The reliability improvement will be maximum if the CB installed at the section connected to the bulk supply point does not trip for fault at any section other than the section at which it is installed and the DG connected at far end is auto starting. In this case failure of one section has minimum affect on the other sections. It helps to reduce the load point failure rate. Thus in this process, SAIFI is having low value. SAIDI, EENS are decreased due to the low value of SAIFI. But with the decrease of SAIFI, CAIDI increases. Because, low SAIFI means that total no. of customer interruption ($\sum \lambda_i N_i$) is low and CAIDI is inversely proportional to total no. of customer interruption. Thus with the decrease of SAIFI, CAIDI increases.

Reference

[1]. Dahiya, S., Jain, D. K. and Kumar, A.: " Power Quality Issue of Embedded Generation ", POWER INDIA CONFERENCE, 2006 IEEE

[2]. Jenkins, N., Allan, R., Crossley, P., Kirschen, D., Strbac, G.: "Embedded Generation", Published by the Institution of Electrical Engineers, London.

[3]. Aslanzadeh, S., Jamali, S.:" Study of Distributed Generation Type and Islanding Impact on the operation of Radial Distribution System", UPEC 2007,pp. 1216-1221.

[4]. Al – Muhaini, M., Heydt, Gerald T.: " Evaluating Future Power Distribution System Reliability Including Distributed generation " IEEE Transaction On Power Delivery, Vol. 28, No. 4, pp. 2264-2272. October 2013

[5]. Banerjee, B., Islam, S. M.:"Reliability Based Optimum Location of Distributed Generation", Electrical Power and Energy System, 33(2011), 1470 - 1478

[6]. Wang, C., Nehir, M. H.:"Analytical Approaches for Optimal Placement of Distributed Generation Sources in Power Systems", IEEE Transaction on Power System, Vol. 19, No. 4, pp. 2068-2076 November 2004.

[7]. Borges, Carmen L. T., Falcao, Djalma M.: "Optimal distributed generation allocation for reliability, losses, and voltage improvement", Electrical Power and Energy Systems 28 (2006), pp. 413–420.

[8]. Heidari, A., Agelidis, V. G., Naderi, M. S.:"Effects of Switch Type and Location on the Reliability of Power Distribution Systems Considering Distributed Generation", Published in Industrial Technology (ICIT), 2013 IEEE International Conference, DOI: 10. 1109 / ICIT. 2013. 6505759, pp. 710-715.

[9]. Mao, Y., Miu, Karen N.: "Switch Placement to Improve System Reliability for Radial Distribution Systems with Distributed Generation", IEEE Transactions on Power Systems, Vol. 18. No. 4, pp. 1346-1352.

[10]. Waseem, I., Pipattanasomporn, M., Rahman, S.: "Reliability Benefits of Distributed Generation as a Backup Source", Power & Energy Society General Meeting 2009, PES, '09, IEEE.

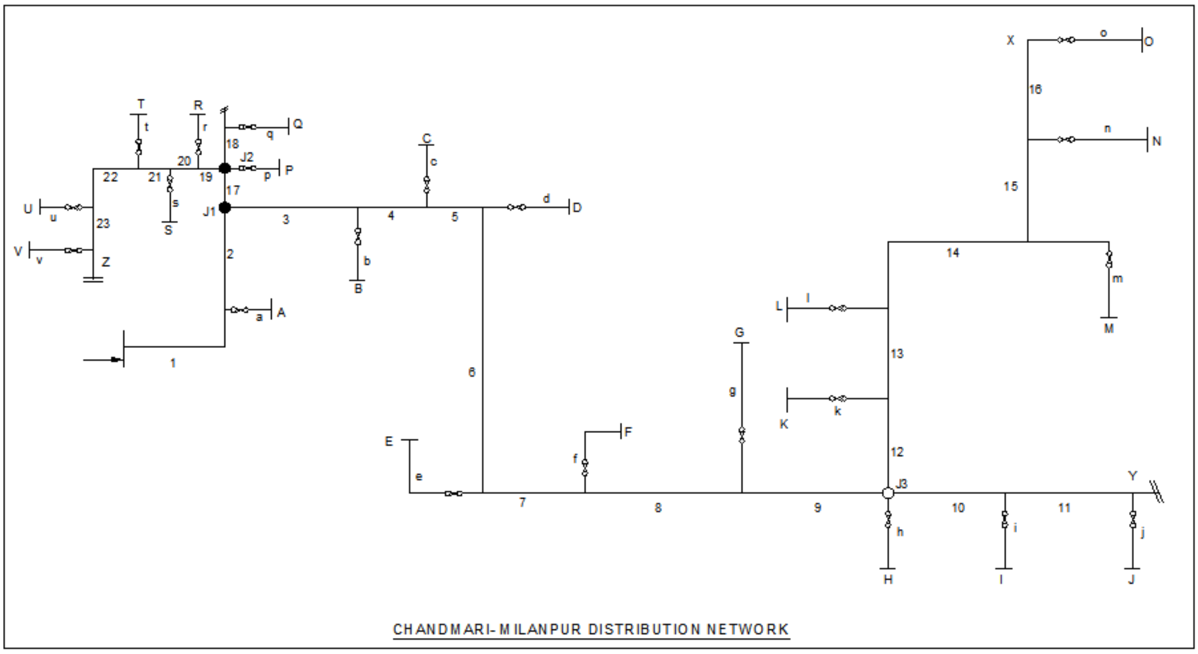
[11]. Zhu, D., Broadwater, Robert P., Tam, Kwa-Sur, Seguin R., Asgeirsson, H.: Impact of DG Placement on Reliability and Efficiency With Time – Varying Loads", IEEE Transactions on Power Systems, Vol. 21, No. 1, pp. 419-427.

[12]. Das, B., Deka, Dr. Bimal C.:" Impact of Distributed Generation on Reliability of Distribution System", International Organization of Scientific Research Journal of Electrical and Electronics Engineering, Volume 8, Issue 1, (Nov. - Dec. 2013), PP 42-50.

[13]. Billinton, R., Allan, Ronald N.: "Reliability Evaluation of Power System", Published by Plenum Press, New York.

[14]. Das, B., Deka, Dr. Bimal Chandra:"Impact of isolation process of faulty section on reliability of distribution system connected with distributed generation", International Journal of Power and Energy Conversion, Vol. 9, Issue No. 1, 2018

Fig.1: Distribution System For Study



Reliability Data:

TABLE-1

Section	Length	Section	Length	Section	Length
1	180m	9	300m	17	400m
2	150m	10	50m	18	30m
3	50m	11	30m	19	50m
4	40m	12	50m	20	30m
5	50m	13	40m	21	1000m
6	300m	14	300m	22	25m
7	40m	15	150m	23	500m
8	350m	16	50m	----------	

FAILURE RATE OF LATERAL;

TABLE-2

Lateral	Failure rate	Value
a	λa	4
b	λ_b	2
c	λc	3
d	λ_d	4
e	λ_e	3
f	λ_f	2
g	λ_g	1
h	λ_h	4
i	λ_i	3
j	λ_j	4
k	λ_k	3
l	λ_l	2
m	λ_m	3
n	λ_n	4
o	λ_o	3
p	λ_p	2
q	λ_q	3
r	λ_r	4
s	λ_s	3
t	λ_t	1
u	λ_u	4
v	λ_v	3

LOADING DATA

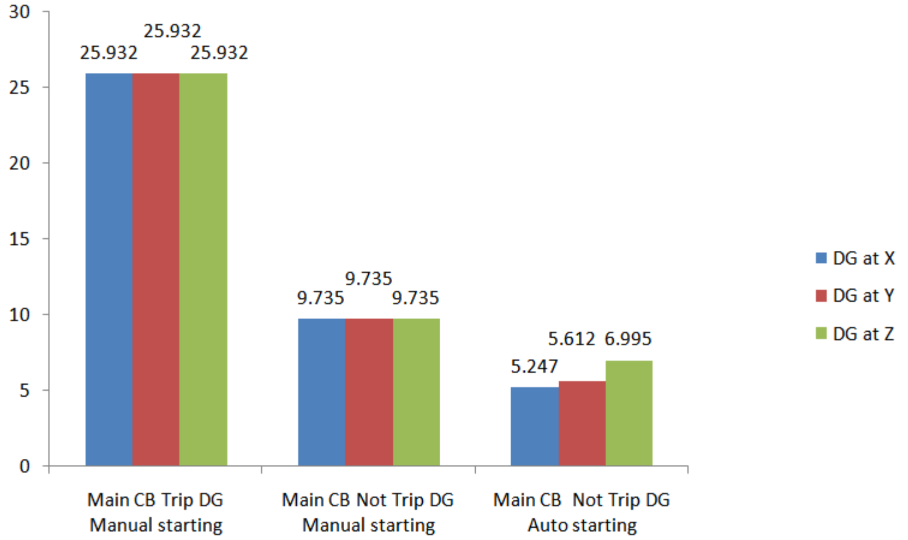
TABLE-3

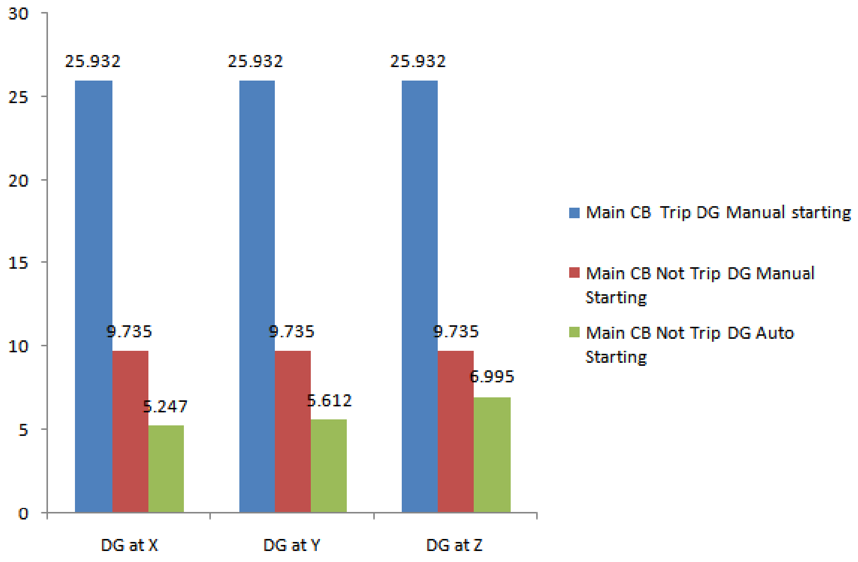
Load points ---- From A to V for 23 sections

LOAD POINTS	LOAD IN KW	NO OF CUSTOMER
A	190	95
B	238	110
C	238	110
D	238	110
E	238	110
F	60	30
G	238	110
H	24	01
I	238	110
J	238	110
K	476	220
L	300	135
M	238	110
N	238	110
O	95	45
P	238	110
Q	60	30
R	95	45
S	238	110
T	455	190
U	95	45
V	238	110

TABLE – 4

	Main CB trip DG Manual Starting			Main CB not trip DG Manual Starting			Main CB not trip DG Auto Starting		
	DG at			DG at			DG at		
	X	Y	Z	X	Y	Z	X	Y	Z
SAIFI	25.932 Int/cus. yr	25.932 Int/cus. yr	25.932 Int/cus. yr	9.735 Int/cus. yr	9.735 Int/cus. yr	9.735 Int/cus. yr	5.247 Int/cus. yr	5.612 Int/cus. yr	6.995 Int/cus. yr
SAIDI	1544.7 Min/cus. yr	1652.2 Min/cus. yr	1879.1 Min/cus. yr	1058.8 Min/cus.yr	1166.3 Min/cus. yr	1393.2 Min/cus. yr	925.4 Min/cus. yr	1012.9 Min/cus. yr	1306.2 Min/cus. yr
CAIDI	60 Min/cus.int	64 Min/cus.int	72 Min/cus.int	109 Min/cus.int	120 Min/cus.int	143 Min/cus.int	176 Min/cus.int	180 Min/cus.int	187 Min/cus.int
ASAI	0.997065	0.996861	0.996506	0.997995	0.99779	0.997436	0.998249	0.998044	0.997613
ASUI	0.002935	0.003139	0.003494	0.002005	0.002210	0.002564	0.001751	0.001956	0.002387
EENS	121847.1 Kwh/yr	130220.5 Kwh/yr	147978.6 Kwh/yr	83875.24 Kwh/yr	92248.605 Kwh/yr	110006.73 Kwh/yr	73395.44 Kwh/yr	80214.44 Kwh/yr	103146.5 Kwh/yr
AENS	56.51537 Kwh/cus.yr	60.399 Kwh/cus.yr	68.6357 Kwh/cus.yr	38.9032 Kwh/cus.yr	42.7869 Kwh/cus.yr	51.02353 Kwh/cus.yr	34.04241 Kwh/cus.yr	37.20521 Kwh/cus.yr	47.8416 Kwh/cus.yr

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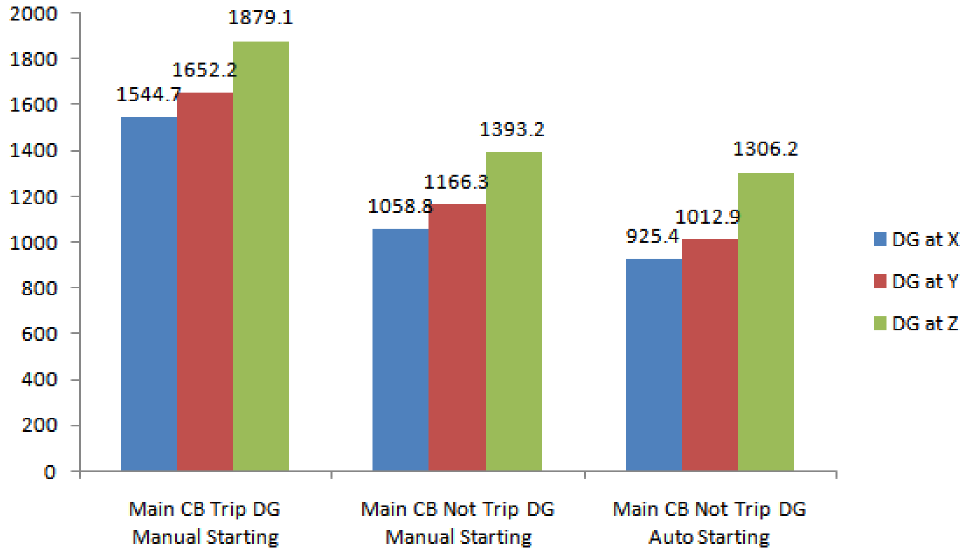
20
15
10
5
0
25.932
25.932
25.932
9.735
9.735
9.735
5.247
5.612
6.995
DG at X
DG at Y
DG at Z
Main CB Trip DG Manual starting
Main CB Not Trip DG Manual Starting
Main CB Not Trip DG Auto Starting

SAIFI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1600
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1200
1000
800
600
400
200
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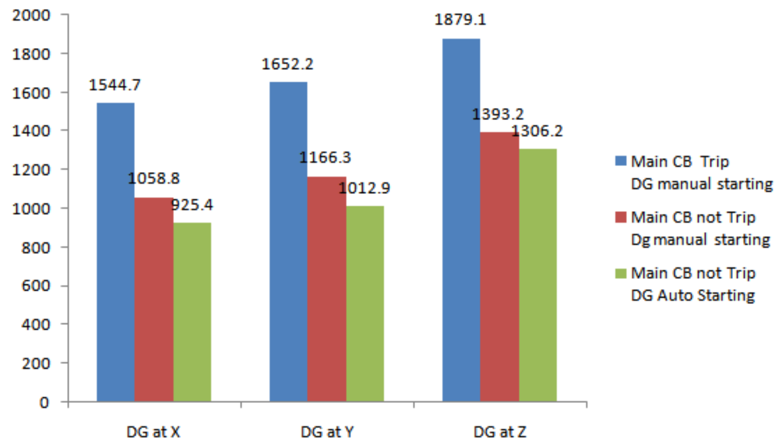
1652.2
1879.1
1058.8
1166.3
1393.2
925.4
1012.9
1306.2
Main CB Trip DG Manual Starting
Main CB Not Trip DG Manual Starting
Main CB Not Trip DG Auto Starting
DG at X
DG at Y
DG at Z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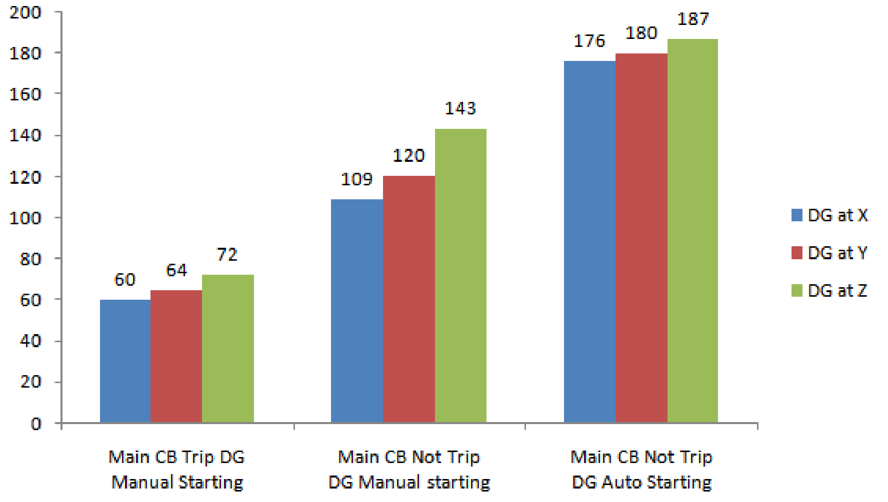
925.4
1652.2
1166.3
1012.9
1879.1
1393.2
1306.2
DG at X
DG at Y
DG at Z
Main CB Trip DG manual starting
Main CB not Trip Dg manual starting
Main CB not Trip DG Auto Starting

SAIDI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120
100
80
60
40
20
0
60
64
72
109
120
143
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180
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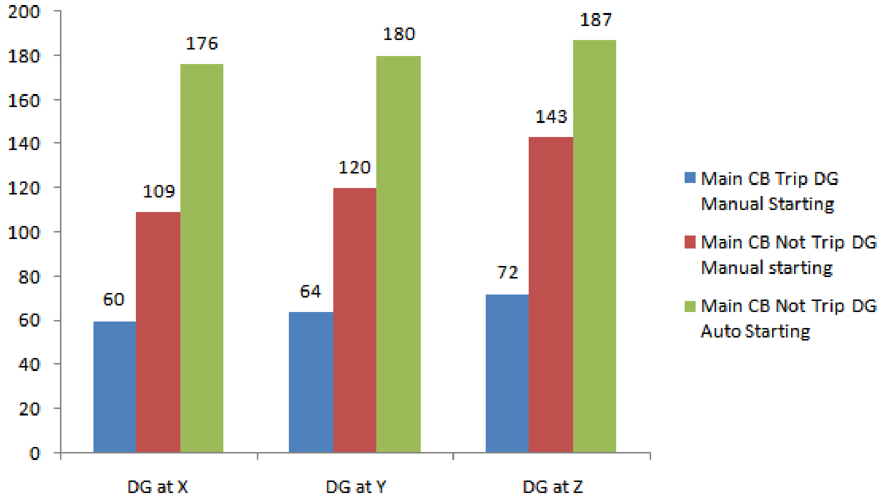
Main CB Trip DG Manual Starting
Main CB Not Trip DG Manual starting
Main CB Not Trip DG Auto Starting
DG at X
DG at Y
DG at Z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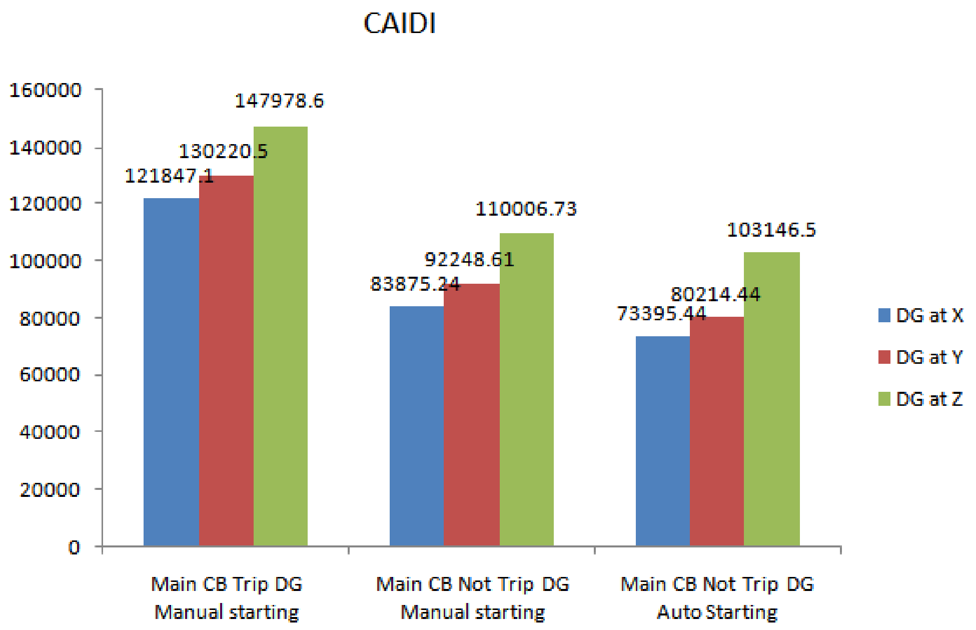
160
140
120
100
80
60
40
20
0
60
109
176
64
120
180
72
143
187
DG at X
DG at Y
DG at Z
Main CB Trip DG Manual Starting
Main CB Not Trip DG Manual starting
Main CB Not Trip DG Auto Starting


CAIDI
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140000
120000
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80000
60000
40000
20000
0
121847.1
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83875.24
92248.61
110006.73
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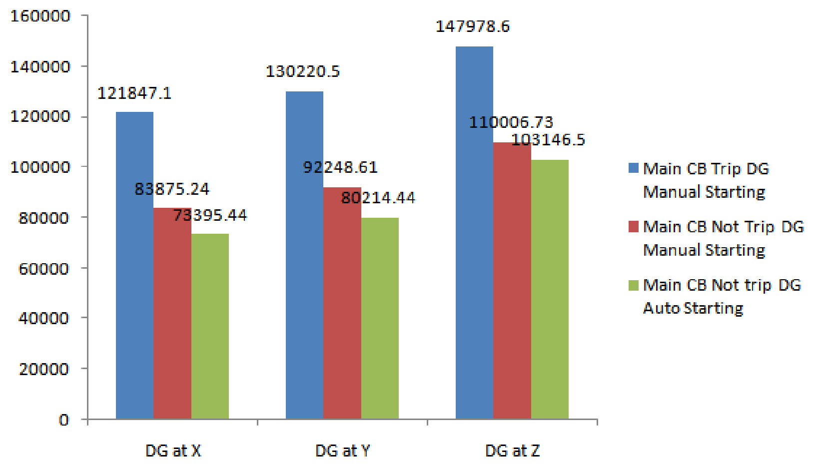
Main CB Trip DG Manual starting
Main CB Not Trip DG Manual starting
Main CB Not Trip DG Auto Starting
DG at X
DG at Y
DG at Z



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Basudev " Effect of faulty section isolation process on the reliability of DG connected Distribution System." IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) 13.1 (2018): 01-10