Integration impacts of Distributed Generation on distribution system for Reliability Assessment

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Abstract: New trends in power system include the placement of the distributed generators (DGs) to overcome the drawbacks of the conventional power system, as the DG's can be connected near to the load points. Hence, the placement of DG is an important factor to be considered for the analysis due to its positive as well as negative impacts. To study the integration impacts of DG, In this paper analysis is carried out on different reliability indices to show the effect of DG at 50 and 75% penetration levels at different busses. When DG is integrated to system reliability is the point to be considered for the analysis as supply of power to the load without interruption is the motto. The analysis is carried out under Matlab platform on standard 10 bus radial distribution system.

IndexTerms* - *Distributed Generation, Reliability indices, system performance.

I. INTRODUCTION

The electrical distribution networks are affected by disturbances and failures due to environmental as well as human issues. The invention of DG will enhance the reliability of the system by improving the energy supplied. This is advantageous to the services where the interruption in energy is unacceptable, like in health and industrial sectors. The improvement in the reliability can be measured in terms of the reliability indices.

The reliability assessment is an important method for the planning and operation of the distribution network. This analysis is capable to calculate the interruption profile of the system at the customer end on the basis of the topology and the component reliability data. The main objective of the distribution network is to supply electrical energy from a substation to the customer point as economically as possible with the level of reliability in the reasonable level and good quality of service to the users.

There are mainly two methods of evaluation- analytical and simulation. The way of methodology which uses the input data by which the reliability indices are evaluated is different in both the techniques. In the analytical approach, the system is represented by the simplified mathematical models. The equations are derived and the reliability indices are calculated using simple mathematical solutions. The system performance at the customer end is used for the reliability evaluation of the system.
The capability to deliver the power uninterrupted is called as the reliability. The power distribution network as the continuity in the service is an important factor of consideration. This can be defined by a series of system indices and three basic load point indices. The average failure rate ('λ'), average outage time ('r') and average annual unavailability or average annual outage time ('U') are the three basic load point data. This data can be used to analyze the performance of the considered system.

- *Reliability indices evaluation procedure*

The reliability indices such as SAIDI, SAIFI, SAIVI, and ASAI in the system are evaluated by considering λ_i, U_i, and r_i of all sections and laterals in the distribution system. In this section after identifying the above-said parameters, the unavailability of load point L is given by $\sum\lambda_i$ is calculated. This is explained as below.

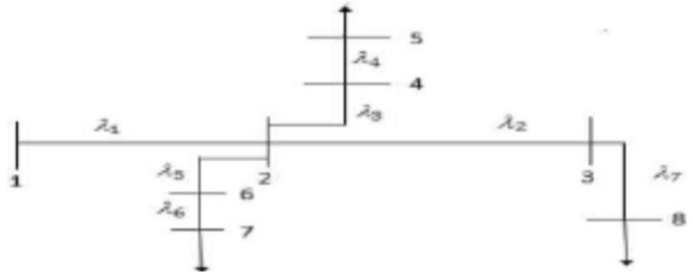

Fig 1 Typical Distribution circuit

$\lambda_{L2} = \lambda_1$

$\lambda_{L3} = \lambda_1 + \lambda_2$

$\lambda_{L4} = \lambda_1 + \lambda_3$

$\lambda_{L5} = \lambda_1 + \lambda_3 + \lambda_4$

$\lambda_{L6} = \lambda_1 + \lambda_5$

$\lambda_{L7} = \lambda_1 + \lambda_5 + \lambda_6$

$\lambda_{L8} = \lambda_1 + \lambda_2 + \lambda_7$

Where λ is a failure rate of line and λ_L represents the load point indices.

II. Problem Formulation

The optimal DG integration in this paper concentrates on the improvement of Reliability indices, Reduction of active power losses and Reduction of voltage deviation.

The main objective is to improve the system reliability by optimal integration of DGs under certain conditions. In literature the reliability analysis is carried out based on the basic and standard performance indices, such as system average interruption duration index (SAIDI), system average interruption frequency index (SAIFI) and energy not supply index (AENS) in order to improve the system performance to improve the reliability of the power system. In this proposed work logarithmic voltage deviation (LVDI) and system average voltage interruption index is considered for optimal placement of DG in the distribution system for different cases as mentioned below.

The following basic equations are used for the calculation of load point reliability indices

$$\lambda L = \sum_{i=0}^{n} \lambda i \quad \ldots\ldots (2.1)$$

$$rL = \frac{\sum_{i=0}^{n} \lambda i * ri}{\sum_{i=0}^{n} \lambda i} \quad \ldots\ldots (2.2)$$

$$UL = \lambda L * rL \quad \ldots\ldots (2.3)$$

Where

i= feeder sections connecting the load points to the supply.

λ_l = Average failure rate at load point L

r_L = Average outage time at load point L

U_L= Average annual unavailability or average annual outage time at load point L

2.1 System Average Duration Index (SAIDI)

The average time of customers interrupted information can found by SAIDI

$$SAIDI = \frac{\sum_{i=0}^{n} Ui * Ni}{\sum_{i=0}^{n} Ni} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2.1)$$

2.2 System Average Interruption Frequency Index(SAIFI)

It is the average number of interruptions per customer per unit time also defined as the ratio of a total number of interruptions to the total number of customers served.

$$SAIFI = \frac{\sum_{i=0}^{n} \lambda i * Ni}{\sum_{i=0}^{n} Ni} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2.2)$$

2.3 Average Service Unavailability Index (ASUI)

It is the ratio of service availability of a total number of customer hours during a year to the customer hour demanded.

$$ASAI = \frac{\sum_{i=0}^{n} Ni * 8760 - \sum_{i=0}^{n} Ui * Ni}{\sum_{i=0}^{n} Ni * 8760} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2.3)$$

Where

Ni = number of customers at load point I, i=1, 2, 3, , , , , n

λi = failure rate at load point I, i=1,2,3,,,,, n

Ui = λ*r, where r is the outage time and 8760 is the number of hours in calendar year.

2.4 System Average Interruption Voltage Index (SAIVI)

$$SAIVI = \frac{Total\ number\ of\ customers\ affected\ by\ voltage\ sag\ at\ their\ load\ points}{\text{Total number of customers served}}$$

2.5. To find the optimal size of DG

The penetration level of DG is chosen based on the following equation.

$$\boldsymbol{PLDG}\% = \frac{\boldsymbol{Size\ of\ DG}}{\boldsymbol{Total\ demand}} * \mathbf{100} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (\mathbf{2.4})$$

Where,
PLDG = penetration level of DG

III. *METHODOLOGY*

Procedure for DG integration

Step 1: Read the data of the test system.

Step 2: Calculate the actual size of DG for a particular penetration level using eq 2.4

Step 3: Integrate DG at bus2 in the test system.

Step 4: Calculate all the reliability indices

Step 5: The above steps are repeated for remaining load busses one by one.

IV. RESULTS AND DISCUSSION

The analysis is carried out on 10 Bus radial feeders as shown in fig 2. having 10 laterals which feed the load. The total active power load on the feeder is 47.5 MW. The active failure rate of the 11 kV lines is taken as 0.0065f/yr-km, switching and repair time are assumed to be 1 and 5 hours respectively. Load, number of customers and length of respective laterals are shown in table 1.

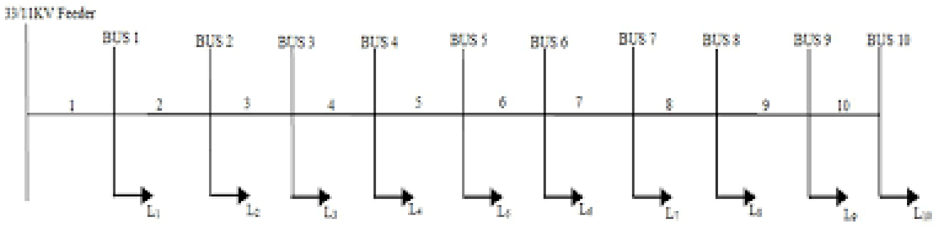

Fig.2. Standard 10 Bus RDS for Reliability studies

Table 1: Load and customers and length of respective laterals

Laterals/section	Load(MW)	NO. of Customers	Length (kms)
1	3	50	1.0
2	4.5	70	0.85
3	6	100	0.8
4	5	80	0.75
5	2	30	0.65
6	5.5	70	0.65
7	6	100	0.80
8	3	50	1.0
9	4.5	70	1.0
10	8	100	0.75

Table 2 Values of Reliability indices at 50% DG Penetration for Standard 10 BUS RDS

Load Point	At 50% DG Penetration					
	LOSS	PLRI	SAVI	SAIFI	SAIDI	ASAI
1						
2	0.513	0.3667	0.527	1.38	3.75	0.9995
3	0.417	0.4852	0.472	1.43	3.53	0.9996
4	0.389	0.5198	0.467	1.41	3.53	0.9996
5	0.498	0.3852	0.499	1.53	3.39	0.9996
6	0.319	0.6062	0.444	1.55	3.42	0.9996
7	0.45	0.4444	0.437	1.51	3.33	0.9996
8	0.378	0.4099	0.513	1.32	3.57	0.9995
9	0.256	0.684	0.459	1.47	3.65	0.9999
10	0.356	0.5605	0.431	1.41	3.71	0.9996

Table 3 Values of Reliability indices at 75% DG Penetration for Standard 10 BUS RDS

Load Point	At 75% DG Penetration					
	LOSS	PLRI	SAVI	SAIFI	SAIDI	ASAI
1						
2	0.499	0.38398	0.498	1.33	3.31	0.9995
3	0.399	0.50742	0.451	1.39	3.49	0.9996
4	0.371	0.54202	0.431	1.37	3.47	0.9997
5	0.367	0.42347	0.473	1.49	3.29	0.9999
6	0.299	0.63089	0.411	1.51	3.39	0.9996
7	0.413	0.49008	0.401	1.49	3.25	0.09998
8	0.318	0.48397	0.477	1.29	3.21	0.9995
9	0.212	0.73831	0.419	1.43	3.23	0.9999
10	0.311	0.61605	0.411	1.37	3.12	0.9996

Table 2 and 3 shows the values of different reliability indices and corresponding power losses and power loss reduction index values at all the load points for 50% and 75% of DG penetration respectively.

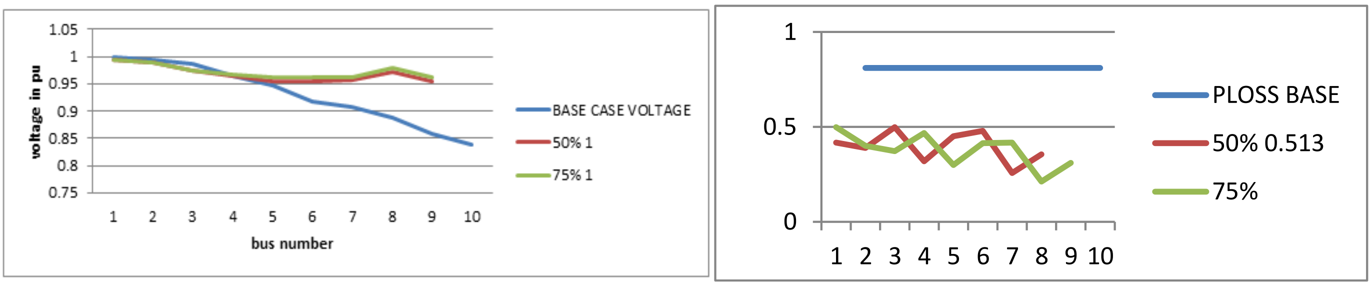

Fig 3. Voltage and power loss Profiles at Different Penetration levels of DG for Standard 10 BUS RDS

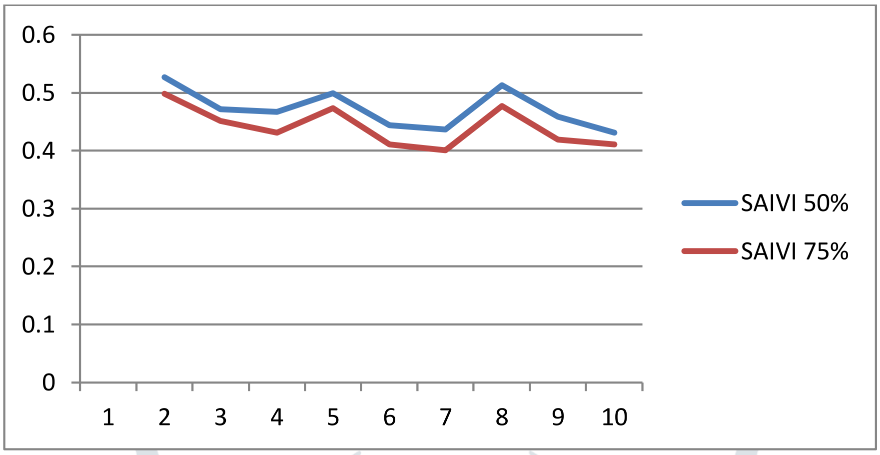

Fig.4: SAIVI values at different penetration levels of DG for Standard 10 BUS RDS

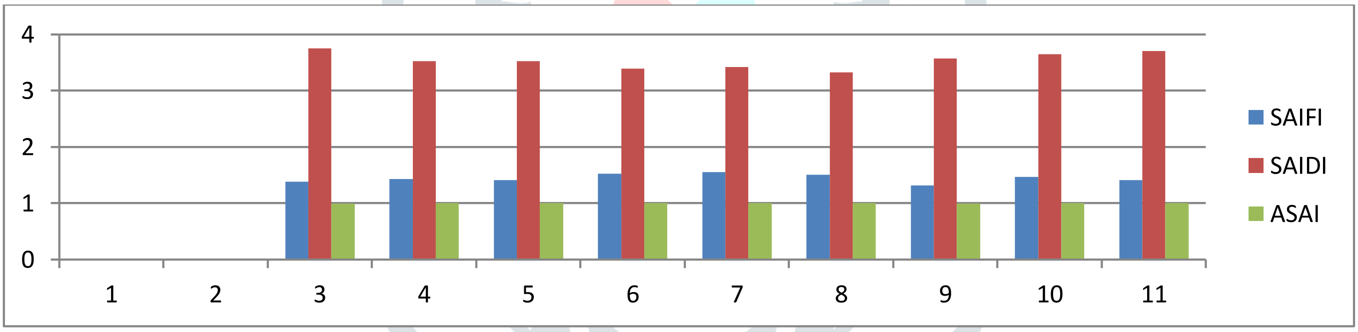

Fig.5. Different Reliability indices values at 50% penetration level of DG for Standard 10 BUS RDS

Voltage and power loss Profiles and SAIVI and Values of different reliability indices at Different Penetration levels of DG for Standard 10 BUS RDS are shown Figures 3,4 and 5 respectively.

V. CONCLUSION

The impact of integrating DG of selected penetration level at all nodes of the test system is analyzed. A set of reliability indices including indices based on interruption and improvement indices are calculated. The system average interruption voltage index (SAIVI) is calculated to show the total number of busses affected by the voltage sag. The values of the reliability indices are evident of the change in the system operation for supplying continuous power. This study helps to decide the integration of DG with particular penetration level and better location. Further, the analysis can be extended for optimal placement of DG for location and sizing.

REFERENCES

[1]. R Billinton And R N Allan, Reliability Evaluation Of Power System, 2nd Edition, Berlin, Germany, Sringer-Verlag

[2] A H Etemadi And M Fotuhi Firuzabad, "Distributed System Reliability Enhancement Using Optimal Capacitor Placement," Iet Generation Trans. And Distr., Vol2, No.5, Pp 621-631, Sep 2008

[3] D Elmakis, "New Computational Method In Power System Reliability", Berlin, Germany: Springer Verlag, 2000

[4]. R Allan And R Billinton, "Probabilistic Assessment Of Power Systems," Proc Ieee, Vol88, Pp140-162, 2000

[5]. P M Costa And Ma Matos, "Assessing The Contribution Of Microgrids To The Reliability Of The Distributed Networks," Elect Power System Res, Vol79, No2, Pg 382-389

[6]. A Volkanovski, M Cepin And B Avko, "Application Of The Fault Tree Analysis For Assessment Of Power System Reliability," Rel. Eng. Syst. Safety, Vol 27, Pg 721-736, 1999

[7]. T F T Sao And H C Chang, "Comparative Case Studies For Value Based Distribution System Reliability Planning," Elec, Power. Syst. Res., March 2004

[8]. R Gupta And L Goel, "Reliability Impact Of Sub Transmission And Radial Configuration On The Distribution System", Elect. Mach. Power. Syst., 1999

[9]. C T Su And G R Lii, "Reliability Design Of Distribution System Using Modified Genetic Algorithm," Elec Power Syst Res., Jan 2002

[10] A A Chowdary And D E Custer, "A Value Based Probabilistic Approach To Design Urban Distribution System ", Ijeps, 2005, Vol27