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Impact of Optimal Allocation of Distributed Generation in Integrated Distribution System

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Abstract— *Integration of renewable energy sources based distributed generation (DG) units provides maximum potential benefits to conventional distribution systems. The power injections from these renewable dispersed generation units located close to the load centers to provide an opportunity for system voltage support, reduction in energy losses and reliability improvement in system. Therefore, the allocation of DG units should be carefully determined with the maximum parameters consideration of different planning incentives. This paper presents impact of DG on system for real power loss reduction, voltage profile improvement, substation capacity. Power flow analysis is carried out by using feeder loss sensitivity general search method in MATLAB platform for IEEE-33 bus test system.*

***Keywords-* Distributed Generation, Power Loss Minimization, Newton Raphson method.**

I. Introduction

Electricity is an essential requirement for all of our daily life. It has been so recognized as a basic human need and it is critical complexity on which the country's economic development depends. With ever growing population in world, increasing in living standard of the humanity, modernization, industrialization of the developing countries, the global demand for energy is expected to increase rather significantly in the present and near future.

Due to limitation on fossil fuel resources, alternative solutions to present large power stations are under high priority in recent days to meet growing energy demand of the future, [1], [11], and [12]. Also large power stations are discouraged due to many environmental concerns. On the other hand, these renewable energy resources have been considered as the best alternative to traditional fossil fuels. The sizes of renewable energy based electricity generators would be very small as compared to large fossil fuel based power plant. Technically, they are suitable for installation at low voltage sided distribution system, near loads centers.

Distributed generation (DG) also called decentralized or dispersed generation. The dispersed generation generally refers to small-scale (typically 1kW - 50MW) electric power generators that produce electric power at a site near to the load. DG's share has been increased in the power system from the last few years. DG has many advantages [3], [4], [5] such as it increase the power capacity in power system, it reduces the power losses in power system, and it increases the voltage profile of the distribution system as it is in radial nature.

Minimizing losses reduction in distribution system have great initiatives, [7],[13] and activated due to the increasing greater cost of supplying electricity, the shortage in fuel with ever-increasing cost to produce more power, and even the global warming concerns. One of the methods is to minimize power losses is optimal allocation of distributed generation. To place distributed generation optimally in system

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[3], [4] and [5] is by employing the feeder loss sensitivity factor for. This paper proposes a method for selecting the suitable location and correct size of DG for minimizing the system losses and improves the system performance characteristics.

Many researches are discussed and analyzed, [6], [9], [10], [17] for DG sizing and placing. In this paper, an intelligent search algorithm is made and results are tested and verified in this paper on the case of well known standard 33-bus test system by using MATLAB software with considering appropriate multi-objective functions in system for system enhancement intern system security and DG placing are mentioned.

II. Overview Of Electrical Disribution System

The part of power system which distributes electric power for local use is known as distribution system. In general, the distribution system is the electrical system between the substation fed by the transmission system and the consumer's metering system. It generally consists of feeders, distributors and the service mains.

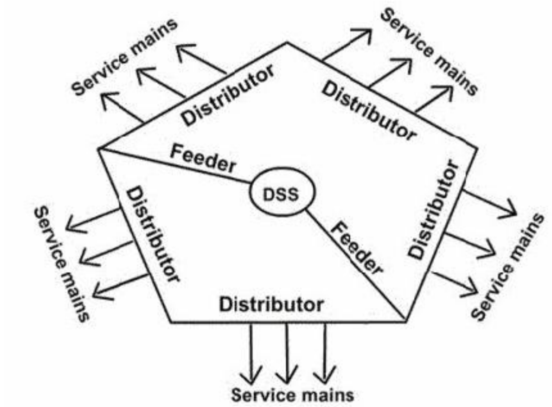

Fig. 1: Single line diagram of a typical low tension distribution system

A. Feeders: A feeder is a conductor, which connects the sub-station (or localized generating station) to the area where power is to be distributed. Generally, no tapping are taken from the feeder so that the current in it remains the same throughout. The main consideration in the design of a feeder is the current carrying capacity.

B. Distributor: A distributor is a conductor from which tapping are taken for supply to the consumers. The current through a distributor is not constant because tapping are taken at various places along its length. While designing a distributor, voltage drop along its length is the main consideration since the statutory limit of voltage variations is ± 10% of rated value at the consumer's terminals.

C. Service mains: A service mains is generally a small cable which connects the distributor to the consumer terminals.

III. Problem Formulation

The objective of this work is to find the best location and size the distributed generation unit which results in maximum decrease in power loss and greater benefits to the system.

There are many objective functions for the adequate DG placement. The optimizing techniques shows their efficiency towards the membership functions and are found, it can be maximizes by past experiences and new systematic techniques, [16], [17] as follows;

$$\sim_{pq}(n) = \frac{\left[X_q(n) - \min_{yep_\sim}(n)\right]^i}{\left[\max_{yep_\sim} X_i(n) - \min_{yep_\sim} X_i(n)\right]} \qquad (1)$$

$$\sim_{pq}(n) = \frac{\left[\max_{yep_\sim} X_q(n) - X_q(n)\right]^i}{\left[\max_{yep_\sim} X_q(n) - \min_{y\in p_\sim} X_q(n)\right]} \qquad (2)$$

The maximization the objective functions in optimization process is represented in equation 1 and the minimization the objective functions in optimization process in equation 2.

Where; $\alpha_{pq}(n)$ represents the true membership function; $X_q(n)$ is the starting value; min $X_q(n)$ is the not optimized minimum value, and min $X_q(n)$ is the not optimized maximum value and finally β_q is the stipulated weight of the objective function. The objective functions [2], [18], [20] are represented in argument wise and are minimizes the objective function to find out the voltage magnitude in all buses in system.

The minimized index is made and predicts the ranking of the adequate DG placement in distribution system.

$$U(y) = \arg\min \alpha_{pq}(n) \qquad (3)$$

$$N^0 = \arg\max U(n) \qquad (4)$$

Where; U(n) represents the exact end index, find out by using the minimum objective function, α_{pq}. The DG placing ranking is expressed as N^0, [16], [18], [19] and [20]. The results are shown in the table I, places the DG where there is voltage profile violates the limits in the system. By considering the voltage limits in reliably, emergency and finally maximum voltage limits to place DG adequately. The optimal DG placing can be identified, [18] and locate the DG with their ranking based on these limits on the objective functions.

IV. Solution Methodology

A. For optimal location of DG

The optimal location of DG is primal importance in system. The analysis is carried out as; Firstly voltage sensitive nodes are identified by penetrating DG at all the buses having capacity of 25% of the total feeder loading capacity. Then voltage sensitivity index (VSI) is calculated. When DG is connected at bus j, Voltage Sensitivity Index for bus j is defined as;

$$VSI_j = \sum_{p=1}^{n} \frac{(1-V_p)^2}{n} \qquad (5)$$

Where V_k is voltage at p^{th} node and n is the number of nodes.

The bus with least voltage sensitivity index is taken as optimal location for the placement of DG.

B. For optimal size of DG

After identification of optimal location for DG placement, the optimal size is determined; here firstly by placing DG at a bus having minimum VSI. Then the size of the DG is varied from minimum value to a value equal to feeder loading capacity in constant steps by keeping power factor of DG constant. The rating of DG is varied until minimum loss in the system is achieved. The DG size corresponding to minimum system loss is taken as optimal size of DG, [3], [4].

V. Test Case Study And Numerical Results

The system under study is an IEEE-33 bus network having system voltage of 12.66 kV and the total real and reactive power demand of 3.715 MW and 2.3 MVAR respectively. The IEEE-33 bus test system is shown below. The methodology is used for the analysis of test system is expressed in [20].

The test case was analyzed by choosing voltage index parameter for 33 bus system. The voltage magnitudes are found using feeder selective general search method and results of all nodes of the system are evaluated and are shown in table I.

TABLE I
SYSTEM VOLTAGE MAGNITUDE AT ALL BUSES IN P.U

Bus. No.	|V|	Bus No.	|V|
1	1.0000	18	0.913
2	0.997	19	0.997
3	0.983	20	0.993
4	0.975	21	0.992
5	0.968	22	0.992
6	0.950	23	0.979
7	0.946	24	0.973
8	0.941	25	0.969
9	0.935	26	0.948
10	0.929	27	0.945
11	0.928	28	0.934
12	0.927	29	0.926
13	0.921	30	0.922
14	0.919	31	0.918
15	0.917	32	0.917
16	0.916	33	0.917
17	0.914	--	---

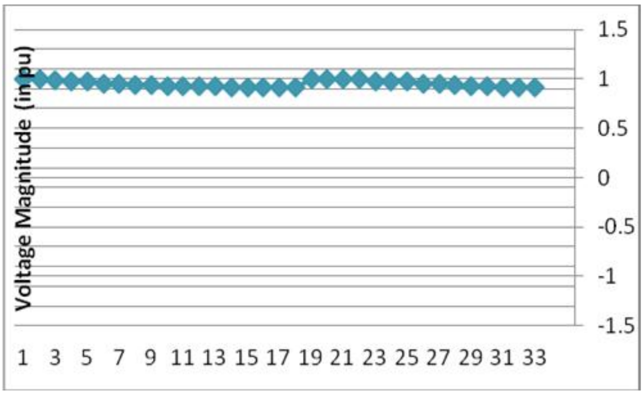

Fig. 2: Variation of Magnitude in distribution system buses

The simulated results are using the general search method of DG placement. Hence, the voltage level in

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all nodes made with acceptable limits by placing DG in voltage violated nodes. Several papers are presented with considering the objective function with voltage level of entire feeder. In this work, identifying the DG placing is made based on voltage level of all nodes in the network and also in feeder based on multi objective function. This work represents the priority ranking basis for DG location, [18], [20].

The results from table II clears, where the voltage sags and distributed generation are placing in feeder bus in maintaining voltage magnitude throughout the system the doubts of placing the DG's in a feeder to maintain the voltage profile throughout the system, other hand achieving the constraints of quality in the system.

TABLE II

FEEDER SELECTIVE DG PLACEMENT BASED ON VOLTAGE DEVIATION IN (%)

Sl. No.	Feeder	Bus	Voltage Variance (%)	Ranking (N^0)
1	1	1-18	6.25	2^0
2	2	19-22	0.6542	4^0
3	3	23-25	2.7045	3^0
4	4	26-33	7.653	1^0

And also the following two cases are considered in analysis:

Case 1: DG is operated at power factor 0.9 lag.

Case 2: DG is operated at unity power factor.

First base case load flow (without DG) analysis is done to calculate the bus voltage magnitudes and total network power loss in the radial distribution system (RDS). Further, load flow with DG capacity of 25% of the total feeder loading capacity is carried out to find VSI at various buses. Figure 3 shows the variation of VSI at various buses. As seen from figure 3, bus number 16 is having the lowest voltage sensitivity index of value 0.0306. Therefore, bus number16 is to be considered as the optimal location for the DG placement.

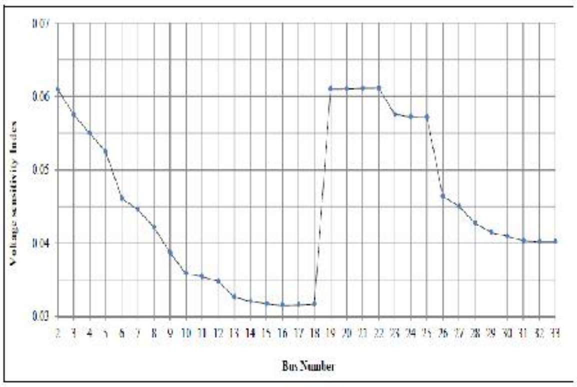

Fig. 3: Variation of VSI at various buses

To find the optimal DG size, DG working at 0.9 power factor lag (for Case 1) and unity power factor (for Case 2) is considered and its size is increased from 0.5 MVA to 4.0 MVA in step of 0.5 MVA. Fig. 4 shows the variation of power loss with distributed generation size.

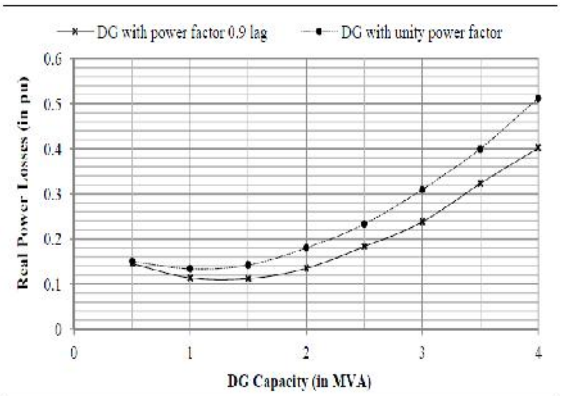

Fig. 4: Variation of power losses for different cases

From fig. 4, it can be observed that the power losses are varying non-linearly with respect to generator capacity. The losses first decrease to some minimum values and then increase with increment in DG capacity. Table III shows optimal size of DG obtained and Table IV shows the improvement in system performance for different cases.

TABLE III

OPTIMAL SIZE OF DG FOR DIFFERENT CASES

Case	DG Size
Case I	1.5 MVA at 0.9 power factor lag
Case II	1.0 MVA at unity power factor

The feeder 1 contains total of 18 feeders, and the average voltage maintaining throughout the feeder is 0.90727, with a total voltage deviation of 6.25% in it. In feeder 2, with 3 buses the average voltage of 0.96875, with very least voltage deviation of 0.6542%. In third feeder, with 3 more buses with voltage variance of 2.7045% with voltage of 0.97366. And feeder with 8 buses with voltage variance of 7.653% with voltage profile of 0.935875. In table II, U(n) represents the exact end index, find out by using the minimum objective function, γ_{ki} and N^0 is adequate ranking found by using the equations 3 and 4. Where highest feeder voltage deviation expressed as first ranking priority to place distributed generation in system to maintain stable system. So, from table II, the ranking are simulated and represented for the system for adequate DG placing.

TABLE IV
IMPROVEMENT IN SYSTEM PERFORMANCE FOR DIFFERENT CASES

Parameters	Base Case	Case 1	Case 2
Active Power Losses	0.0021	0.0011	0.0014
Reactive Power Losses	0.0014	0.0008	0.0009
Real Power from Substation	0.0393	0.0248	0.0285
Reactive Power from Substation	0.0244	0.0172	0.0239

All the above values are in pu.

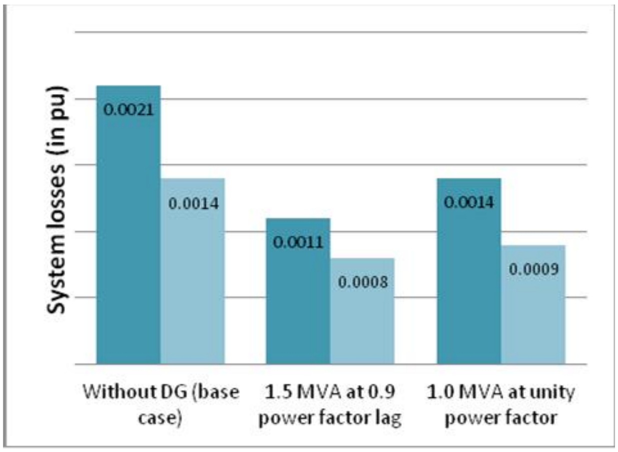

Fig. 5: Active and reactive power losses

From the figure 5 and table III, it is evident that the base case (without DG) total real and reactive power losses are0.0021 pu and 0.0014 pu, respectively, whereas these losses for the optimal DG of size 1.5 MVA at 0.9 power factor lag results in the more loss reduction compared to optimal sizes and power factor of DG of 1.0 MVA at unity power factor. Therefore, higher power loss reduction in distribution networks in the presence of DG depends on the optimal size, location and also on the power factor (DG technology). Table IV also shows the comparison of substation capacity release caused in different cases as a result of the penetration of DG. It can be seen that for the case 1 substation capacity release is more as compared to case 2.

VI. CONCLUSION

Distributed generation is one of the new trends in power system used to support the increased energy demand. Distributed Generation refers to an electrical power source connected directly to the distribution network or on the consumer side of the meter. Distributed generation provides an enhanced power quality and high reliability of distribution system. By employing the distribution generation in distribution system, results in line loss reduction and voltage profile improvement. In present work a simple and efficient technique to implement DG at optimal is suggested. This method has been applied to IEEE 33-bus test system; there is a remarkable improvement in voltage profile as well as reduction of losses in the system. The minimum voltage before implementing DG was 0.9038 pu, after DG implementation it improves to 1.0281 pu for DG of 1.5 MVA at 0.9 pf lag and 0.9713 pu for DG of 1.0 MVA at unity pf. Further, initially the system was having active and reactive power of 0.0021 pu and 0.0014 pu and subsequent to DG implementation the active and reactive power losses have come down to 0.0011 pu and 0.0008 pu for DG of 1.5 MVA at 0.9 pf lag, and 0.0014 pu and 0.0009 pu for DG of 1.0 MVA at unity pf.

This integration analysis tool is made important in planning and operation of system. And also represents the advantages of DG impacts, penetration and its effects on system network including futuristic network restructuring.

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REFERENCE

[1] P. Chiradeja and R. Ramkumar. An approach to quantify the technical benefits of distributed generation. IEEE Transaction on Energy Conversion. 2004, 19 (4): 764-773.

[2] D. Singh, D. Singh and K.S. Verma. Multi-objective optimization for DG planning with load models. IEEE Transactions on Power Systems. 2009, 24 (1): 427-436.

[3] S. Ghosh, S.P. Ghoshal and S. Ghosh. Optimal sizing and placement of DG in network system. International Journal of Electrical Power and Energy Systems. 2010, 32 (8): 849-856.

[4] Ziari, G. Ledwich, A. Ghosh, D. Cornforth and M. Wishart. Optimal allocation and sizing of DGs in distribution networks. Proc of IEEE Power and energy society general meeting. 2010:1-8.

[5] J.V.B. Subramanyam and C. Radhakrisna. Distributed Generation placement and sizing in unbalanced radial distributionsystem. World Academy of Science, Engineering and Technology. 2009, 52: 737-744.

[6] N. Acharya, P. Mahat and N. Mithulananthan. An analytical approach for DG allocation in primary distribution network. International Journal of Electrical Power and Energy Systems. 2006, 28 (10): 669–678.

[7] T. Griffin, K. Tomsovic, D. Secrest, A. Law; Sitting of dispersed generation systems for reduced losses; in Proc. 33rd Annu. Hawaii Int. Conf. Systems Sciences, 2000.

[8] V.H. Méndez, J. Rivier, J.I. de la Fuente, T. Gómez, J. Arceluz, J. Marín, A. Madurga; Impact of distributed generation on distribution investment deferral; International Journal of Electrical Power and Energy Systems, Vol. 28, Issue: 4, pp. 244-252; May, 2006.

[9] Kyu-Ho Kim, Yu-Jeong Lee, Sang-Bong Rhee, Sang-Kuen Lee, Seok-Ku You; Dispersed generator placement using fuzzy-GA in distribution systems; Dept. of Electr. Eng, Ansan Coll. of Tech, South Korea, Power Engineering Society Summer Meeting, 2002 IEEE, Vol 3, pp. 1148- 1153; 2002.

[10] K.Nara, Y.Hayashi, K. Ikeda,T.Ashizawa; Application of tabu search to optimal placement of distributed generators; Power Engineering Society Winter Meeting, Vol 2, pp. 918-923; January, 2001.

[11] W. El-Khattam, M.M.A. Salama; Distributed generation technologies, definitions and benefits; Department of Electrical and Computer Engineering, University of Waterloo, 200 University Avenue West,

[12] Waterloo, Ont., Canada; 14 January 2004. W. T. Poore, T. K. Stovall, B. J. Kirby, D. T. Rizy, J. D. Kueck, J. P. Stovall, "Connecting distributed energy resources to the grid: their benefits to the der owner/customer, the utility, and society". Oak Ridge National Laboratory / U.S. Department of Energy. 2002.

[13] J. Choi, J. Kim, "Network Reconfiguration at the Power Distribution System with Dispersed Generations for Loss Reduction", in Proc. 2000 IEEE Power Engineering Society Winter Meeting, Vol. 4, pp.2363-2367.

[14] A. Barin, L. F. Pozatti, L. N. Canha, F. A. Farret, R. Q. Machado, A. R. Abaide, C. Carvalho, C. E. M. Fernandes, "Analysis of the Impact of Distributed Generation Sources on the Operational Characteristics of the distribution Systems for Planning Studies", presented at 19^{th} International Conference on Electricity Distribution, 2007.

[15] Alexandre Barin, Luciane Neves, Ricardo Q.M., Alzenira R.A., Elisandra M., Gustavo Arend, "Analysis of the impacts of distributed generation sources considering the appropriate choice of parameters in a multi-objective approach for distribution system panning", IEEE Transaction, 978-1-4244-1744-5/08, 2008.

[16] Alexandre Barin, Luciane Neves, Ricardo Q.M., Alzenira R.A., Felix F, Cassio C., "Analysis of multi-objective method applied to distribution generation system ", Powereng, April, Setibul, Portugal, 2007.

[17] S A.H. Mantway, M M. Al-muhaini, "Multi-objective BPSO algorithm for distribution system expansion planning including distributed generation", IEEE transactions, 2008.

[18] Somashekar D.P, Shekhappa G. Ankaliki, T. Ananthapadmanabha, "Analysis of distributed generation sources considering of parameter for distribution system operational planning" International Journal of Emerging Technology in Computer Science & Electronics, Volume 14, Issue 2 –April 2015.

[19] Gopiya Naik S., D. K. Khatod, M. P. Sharma, "Optimal Allocation of Distributed Generation in Distribution System for Loss Reduction" IPCSIT Vol. 28, pp.42-46, 2012 Press, Singapore.

[20] Somashekar D.P, Shekhappa G. Ankaliki, T. Ananthapadmanabha, "Analysis and effect of distributed generation placing in distribution system operational planning, Asian journal of Engineering and Technology Innovation, Vol. 2016, Issue 3, Jul. 2016.