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Optimal Location of Diffused Generation in Distribution Network by PSO Optimization Method

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ABSTRACT

Recent developments in diffused generation technology and using them in distribution networks level , have provided an opportunity for enjoying their advantages in utilization improvement of distribution networks. Some of the advantages of diffused generation sources include: loss reduction, voltage profile improvement, network reliability increase. To achieve these goals, location problem i.e. capacity determination the number and optimal position of diffused generation sources is very important. In this paper our purpose is optimal location of diffused generation sources to reduce loss and voltage range improvement in distribution networks by sing particles society optimization (PSO) method. Our optimization method in this paper is a multipurpose optimization method. In other words, our purpose is loss reduction or with buses voltage range balancing to optimal values typically nominal values) by optimal location of generation sources. Studied networks of this paper are 13 and 33 bus standard network and used software for simulation is MATLAB software.

KEYWORDS: diffused generation, optimal location, algorithm, particles

INTRODUCTION

Especially with privatization developing trend and electricity market competition ,in recent distribution networks, distribution companies primary purpose is utilization ,maintenance and network development cost reduction and network and subscribers reliability increase in the same time.one of the best methods to respond to the load growth and satisfying a distinct level of reliability is using diffused generation sources .according to one definition ,diffused generation is used to the generation up to 10 megawatt which has accessibility to distribution network .diffused generation units technology includes :photovoltaic ,wind turbines , piles ,small gas turbines and micro turbines sterling generator-motors internal combustion motors . . ,.

It is expected that diffused generation expand rapidly and generate a significant part of the world's future electricity generation. this expansion in applying diffused generation units can have different reasons such as: paying attention to the environment ,system s loss reduction ,system s capacity discharge ,utilization cost reduction related to the load curve peak cycle ,load coefficient and voltage profile improvement ,delay or obviating the need for system expansion ,network efficiency and reliability improvement. Since distribution systems are typically designed to be used radially, sources connection to the distribution system can have severe effects on flow, power and voltage conditions and system s equipment's and these effects may improve or worsen system operation which depends on system conditions and installed diffused generation sources characteristics. so, achieving above-mentioned advantages is practically more complicated.to achieve these advantages ,diffused generation should have suitable size and should be installed in proper places.

In this paper ,particles society optimization method is used to find the size and optimal location of different kinds of diffused generation sources. Most researchers have used evolutionary methods to find diffused generation sources optimal location which is used to improve voltage resistance and profile and reduce distribution system loss.

2. indices selection and examination to install DG

DG installation without study has negative effects on distribution networks. To avoid the negative effect of diffused generations on systems different parameters , there should be general and comprehensible standards to control , install , and locate these production . according to our selection of the following objectives , objective function will be determined .

1.2 index of voltage profile improvement

One of the benefits of using DG is voltage profile improvement and keeping voltage in its accepted limit in the consumer terminal .using DG provides a part of active and reactive load and reduces the flow in transfer line and as a result enhances the consumer s voltage amplitude.

2.2 index of loss reduction

In heavy load conditions, the lines are very important. so that its cost is imposed to the consumer with higher price. It is obvious that line loss is due to power transfer in transfer lines. So by using DG lines power transfer can be reduced and as a result its related loss will be reduced too .depend on the DG s power and conditions , the possibility of line loss increase exists.

3.2 index of system load increase.

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One of the other advantages of DG is using transfer active and reactive power reduction (nominal power) of transfer lines. This leads to the capacity increase f transfer lines and avoids building and expansion of new lines and other similar installations like transfer and distribution posts, as a result , related costs will be reduced.

4.2 index of reliability

One of the objectives of using diffused productions, is system s reliability improvement. But it does not mean that we consider it as an independent objective since reliability will be affected any objective for which DG is used. Of course, it may be generally possible to consider all these objectives as a subset of system reliability for a distribution network.

5.2 index of voltage resistance

In the network, voltage resistance is directly related to system s ability in network is required reactive power provision. In other words ,system s reactive power reservation increase will cause higher degree of voltage resistance.

6.2 environmental index

By using DGs and generating electric energy, emission of greenhouse gas and other environmental contaminants will be much less in comparison with traditional technology. So by considering DGs contamination percentage, we can use optimal sources. But in our country, this index is not an important index.

Now, by considering above mentioned cases and by aiming two objectives of voltage profile and loss reduction, all indices are provided, because we have loss reduction with lines flow reduction and as a result reliability and discharge of the lines which are more consistent with diffused generation usage. In this theses ,the objective function is defined as a set of these two indices(loss reduction and voltage profile). So our objective function is a multipurpose function which has significant differences with single-index objective function which will be discussed later.

7.2 loss reduction index

For effective operation of power system, power loss reduction is needed. Distribution system loss will be computed by equation (1-4):

$$(1\text{-}2)\ P_{Loss} = \sum_{i=1}^{N_{sc}} |\, Ii\,|\hat{}2 * ri \quad (1\text{-}2)$$

The objective of solving this problem is minimizing total power loss so that the objective function to be like:

$$F_1 = P_L = \sum_{i=1}^{N_{sc}} Loss_k \quad (2\text{-}2)$$

This problem bonds are as follows:

Power balance bond:

$$\sum_{i=1}^{N_{sc}} P_{DGi} = \sum_{i=1}^{N_{sc}} P_{Di} + P_L \quad (3\text{-}2)$$

Generation area of active and reactive power of diffused generation

$$P_{DGi}^{\min} \le P_{DGi} \le P_{DGi}^{\max} \quad (4\text{-}2)$$

$$Q_{DGi}^{\min} \le Q_{DGi} \le Q_{DGi}^{\max} \quad (5\text{-}2)$$

System loss area:

$$\sum Loss_k(withDG) \le \sum Loss_k(withoutDG) \quad (6\text{-}2)$$

Line loading area:

$$\left|I_{ij}\right| \le \left|I_{ij}\right|^{\max} \quad (7\text{-}2)$$

IA: branch tolerance flow

8.2 index of voltage profile improvement

It should be noted that voltage profile index in distribution systems includes voltage increase or decrease. Although in transfer network in generators terminal of electricity generation, there is standard and suitable profile voltage, but in distribution network feeders are often radial. So voltage profile in final buses has a remarkable reduction which can have a lot of negative effects for consumers. With regard to the mentioned parts, finding the location and optimal size of diffused generation sources is very important to improve these indices.

$$F_2 = \sum_{i=1}^{N} \left|V_i - V_{i,ref}\right| \quad (8\text{-}2)$$

Voltage limit of it bus

$$: \left|V_i\right|^{\min} \le \left|V_i\right| \le \left|V_i\right|^{\max} \quad (9\text{-}2)$$

Another limitation which can be expressed in these units location is installation limitation in some buses which has various causes. Another limitation which is considered here, is the limitation of maximum installation power.

3. Objective function of this problem

The problem formula contains objective function, bonds and a s ation variables. For discrete optimization problems objective function definition is technically simple. Because it has no need , differential, convex or steady. In fact objective function be defined without knowing how it has been achieved.

Note :if various indices are considered, objective function should be defined as a weight sum of indices. For example ,since distribution network indices include :loss reduction and voltage profile improvement, a suitable objective function can be as follows:

$$objective\ function = w_1\left[\frac{F_1}{F_{10}}\right] + w_2\left[\frac{F_2}{F_{20}}\right] \quad (1\text{-}3)$$

F1: loss index after DG installation
F10: (PL) loss before installation
F2: voltage profile index after installation
F20: voltage profile before DG installation

This objective function weights are selected according to the relative importance. It is common to choose the weight sum total equal to one, so that primary objective function is equal to one. For example if objective function is selected as a simple sum of these two indices, so loss index improvement takes an important part of final answer , because loss reduction is higher than the other index. To solve this problem, each index can be normalized according to its primary value (loss before installation) so that 10%loss improvement has equal value in comparison with 10%voltage profile improvement. Finally, devoted weights to these normalized indices show the relative importance. For example choosing w1=0.5 and w2=0.25 causes loss improvement to be two times more important than voltage profile improvement. By choosing one for primary objective function value , values can be considered as per unit.

By combining above statements , total cost function of size and location determination of diffused generation sources can be presented as follows:

$$F_{Total} = w_1 F_{1,pu} + w_2 F_{2,pu} \quad (2\text{-}3)$$

For optimization of above-mentioned statements, particles society optimization algorithm(peso) is used. In above equation, w1 and w2 parameters are weight coefficient which their coefficient determination depends on the importance and value of each presented index of objective function.

1.3 fitness function calculation

Since our purpose is minimizing objective function with positive values, and objective function values are small numbers , so if we define fitness value as equal to the objective function value, it causes the differences not to be remarkable. Therefore, we consider fitness value as a reverse of objective function.

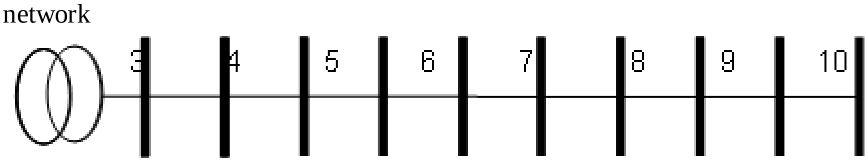
$$Fitness = \frac{1}{objective\ function}$$

4. Numerical study

1.4. ten feeder bus

The first studied network is a simple radial distribution feeder in one of the oil production factories of Agajari oil and gas company (national oil company of south oil-rich areas)with nominal voltage level of 11kw and nominal power of 10MVA which its single-line diagram is shown in figure (1-5).

Figure (1-4).studied 10 bus network



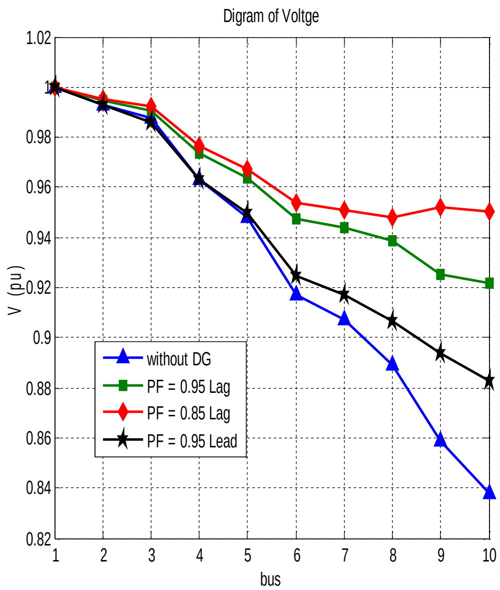
Related data to buses loads and buses connection lines are presented in table (1-5).

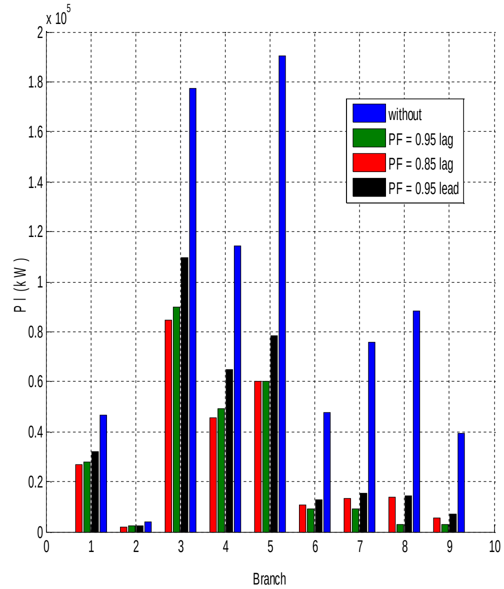
From	To	R(pu)	X(pu)	P(kW)	Q(kVAR)
1	2	1233/0	4127/0	1840	460
2	3	0140/0	6051/0	980	340
3	4	7463/0	2050/1	1790	446
4	5	6983/0	6084/0	1598	1840
5	6	9831/1	7276/1	1610	600
6	7	905/0	7886/0	780	110
7	8	0552/2	1640/1	1150	60
8	9	7953/4	7160/2	980	130
9	10	3434/5	0264/2	1640	200

For a reasonable comparison of other studied methods results in other papers , their assumptions and conditions have been applied here to meke an accurate and exact comparison.
Note :in all tables , Q and P are attached to the last bus(TO)

2.4. voltage profile improvement index

By considering above-mentioned information, we assume that install two DG sources with power limit of 400 to 1200KW in the network. By setting parameters related to the particles society optimization (PSO) algorithm and by entering data which is related to the network and DG sources , the results of running the program are presented in figures (2-4) and (3-4).

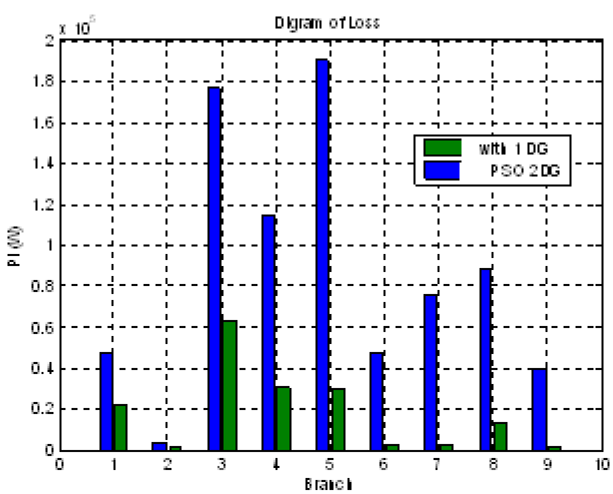




By installing two DG units with generation capacity of 1200KW , in boses 6 and 9 , respectively , voltage profile for different power coefficients of DG sources is presented in figure (2-5 . in figure (2-4) , voltage profile is depicted comparatively for 4 different states , as it is shown in figure (2-4) , DG sources power coefficient has a great effect on voltage profile. Figure (3-4) shows loss comparison in each branch.

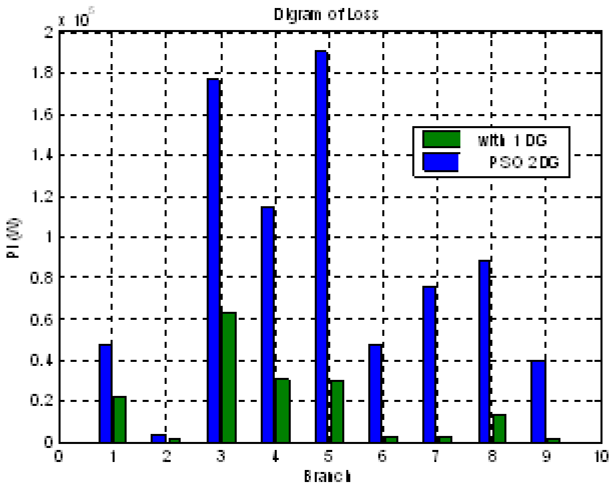
3-4 loss reduction index

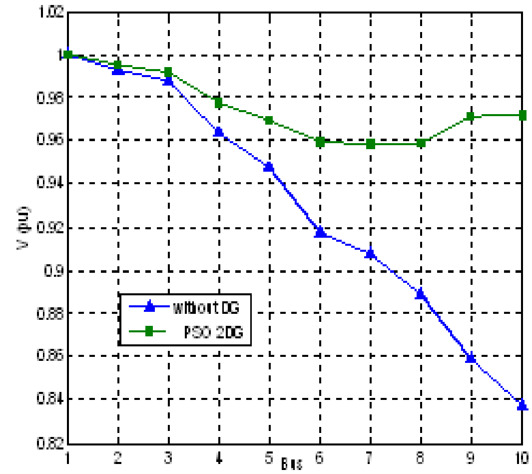
By considering above data for loss reduction index , by installing two DGs with power coefficient of 0.95 ,particles society optimization (PSO) suggests boses 6 and 9 with capacities 1500 and 2000KW , respectively.



4-4 loss reduction index and voltage profile improvement

Now ,by considering these two indices , first we normalize these indices and then weights of this objective function are selected according to the relative importance of each index.
It is very common to select one for weights sum total .so that the primary objective function value becomes one too. Here ,for loss index 6% and for voltage profile , 4% are considered.
Suggested location and size for DG ,arebosses 6 and 9 with capacities 1500 and 2000KW respectively which are offered by particles society optimization (pso).



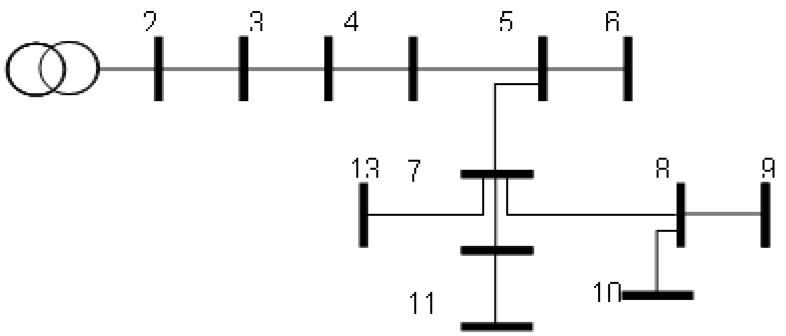


5-4

feeder13buses

For observing the results of diffused generation sources installation , to improve indices in distribution networks , 63.20KW post with transformer power 30 MVA was used which its single-line model is presented in figure (8-4).

Data of connecting branches between buses and imposed load on each bus is presented in table (2-4).



From	To	R(pu)	X(pu)	P(kW)	Q(kVAR)
1	2	176/0	138/0	890	468
2	3	176/0	138/0	628	470
3	4	045/0	035/0	1790	446
4	5	089/0	069/0	1112	764
5	6	045/0	035/0	474	344
5	7	116/0	091/0	1342	1078
7	8	073/0	073/0	920	292
8	9	074/0	058/0	766	498
8	10	093/0	093/0	622	480
7	11	063/0	05/0	690	186
11	12	068/0	053/0	1292	554
7	13	062/0	53/0	1124	480

To find PDGOPT value , we apply this value discretely to the objective function , and in final answer, in a similar way, we show the optimal answer to the discrete form in the output , because as we know , output power of generators are special values or values with discrete Module.

Now if we choose a DG from Modules 200 , 500 , 1000 , 1500 , 2000 and if we choose power coefficient 0.99 (i.e approximately 1) the results will be as follows.

5.particles society optimization (PSO) comparison with genetic algorithm method (GA)

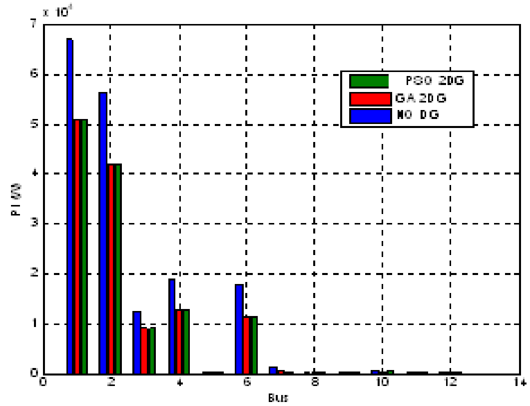
1-5 voltagr profile improvement index

Considering conditions of reference(1) , i.e,installing two DGs with power coefficient 09 and with capacity of 300-9000KW shows that PSO results are more optimal than GA. Moreover data related to the genetic algorithm parameters are presented in table (1-5)

$$\left.\begin{array}{l} DG_{site} = 7 \,,\, P_{DG} = 900\ (kW) \\ DG_{site} = 10 \,,\, P_{DG} = 900\ (kW) \\ f = 0.1728 \end{array}\right\} \rightarrow PSO \quad \left.\begin{array}{l} DG_{site} = 10 \,,\, P_{DG} = 900\ (kW) \\ DG_{site} = 12 \,,\, P_{DG} = 900\ (kW) \\ f = 0.1732 \end{array}\right\} \rightarrow GA$$

Pop. size	Selection method	Cross over	Mutation	Algorithm Termination Condition
100	Normalized Geometric Selection	Simple Xover	Binary Mutation	Maximum Number of generation

As it can be seen , in PSO method by installing two DGs in buses7 and 10 , fitness function value is 0.1728. in genetic algorithm , by installing two diffused generation sources with capacity of 900KW in buses10 and 12 , fitness function value is 0.1732. so PSO has a better fitness function in comparison with GA. By comparing power loss diagram and voltage profile diagram , it can be understood that power loss has remarkable reduction after diffused generation source installation and voltage profile has improved.

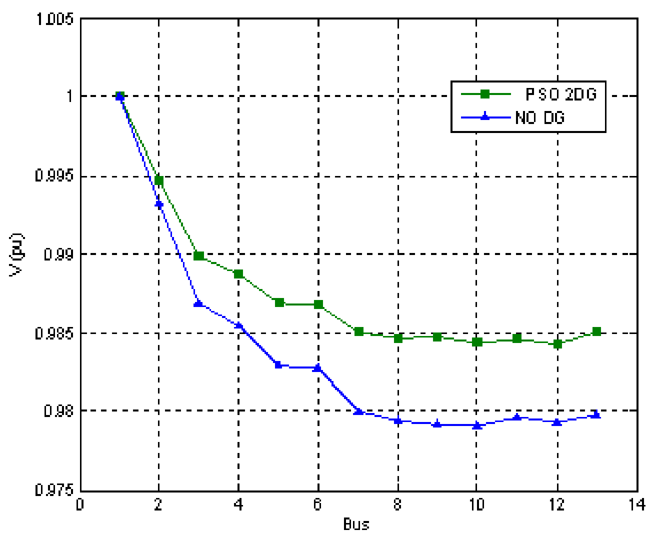


2-5 loss reduction index and voltage profile improvement

To compare the results of this section , we use reference (1) and locate a DG with 3200KW capacity active power and 0.02 reactive power .

$$\left.\begin{array}{l} DG_{site} = 7, P_{DG} = 1600\,(kW) \\ DG_{site} = 12, P_{DG} = 1600\,(kW) \end{array}\right\} \rightarrow PSO \quad \left.\begin{array}{l} DG_{site} = 9, P_{DG} = 1600\,(kW) \\ DG_{site} = 13, P_{DG} = 1600\,(kW) \end{array}\right\} \rightarrow GA$$

Now , we have the same conditions with two DGs with similar capacities of active power 1600 KW and reactive power 0.01.



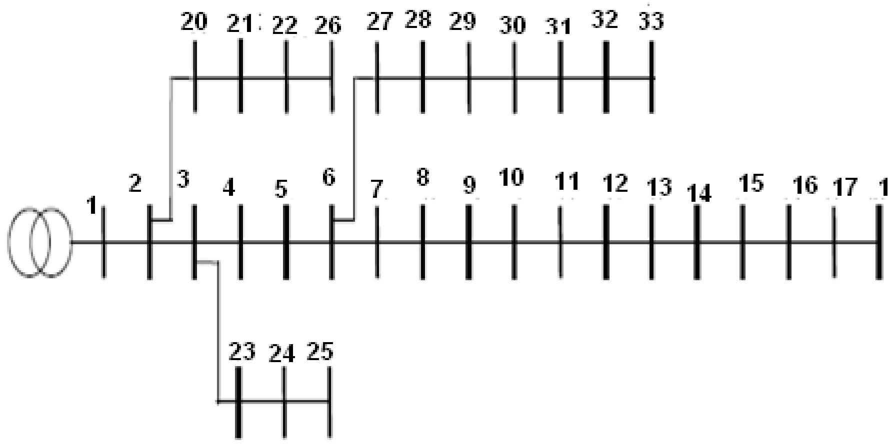
In table (2-5)all results have been summarized.

Index	Method	Bus	DGSize (kW)	Bus	DGSize (kW)	Ploss(kW)
Load distribution analysis						51/175
Two methods comparison	PSO	7	900	10	900	8/123
	GA	10	900	12	900	9/121
Two methods comparison	PSO	7	1600	12	1600	25/131
	GA	9	1600	13	1600	45/129

By considering the results after installing two diffused generation sources with 9000KW capacity , it can be understood that power loss had been 175.51 before source installation. But now , by installing 9000kw sources, power loss has reduced to 123.8KW.and by installing two diffused generation sources with 1600KW capacity , power loss has reduced to 131.25KW.

3-5 feeder 13 bus

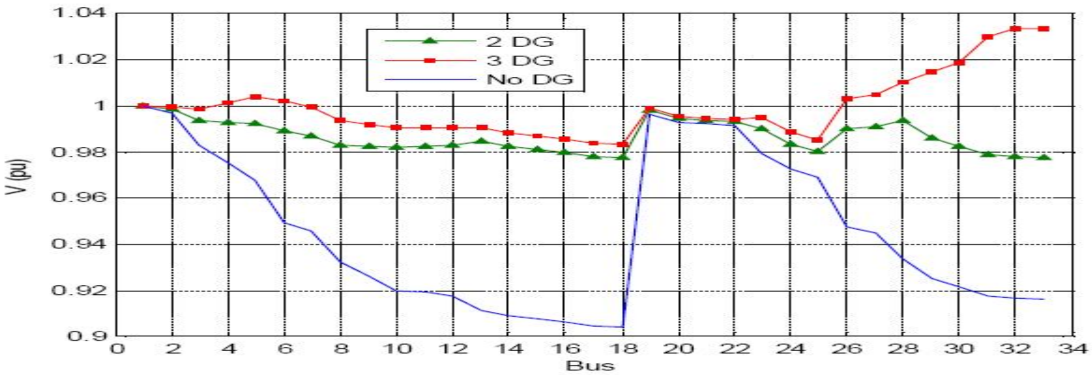
A studied 33bus 12KV network and a transformer with nominal power of 10 MVA, from reference (5) is considered. Figure (12-5) shows this 33 bus network.



FROM	TO	R(p.u)	X(p.u)	P(kW)	Q(kVAR)
1	2	0922/0	0470/0	100	60
2	3	4930/0	2511/0	90	40
3	4	3660/0	1864/0	120	80
4	5	3811/0	1941/0	60	30
5	6	8190/0	7070/0	60	20
6	7	1872/0	6188/0	200	100
7	8	7114/1	2351/1	200	100
8	9	0300/1	7400/0	60	20
9	10	0440/1	7400/0	60	20
10	11	1966/0	0650/0	45	30
11	12	3744/0	1238/0	60	35
12	13	4680/1	1550/1	60	35
13	14	5416/0	7129/0	120	80
14	15	5910/0	5260/0	60	10
15	16	7463/0	5450/0	60	20
16	17	2890/1	7210/1	60	20
17	18	7320/0	5740/0	90	40
2	19	1640/0	1565/0	90	40
19	20	5042/1	3554/1	90	40
20	21	4095/0	4784/0	90	40
21	22	7089/0	9373/0	90	40
3	23	4512/0	3083/0	90	50
23	24	8980/0	7091/0	420	200
24	25	8960/0	7011/0	420	200
6	26	2030/0	1034/0	60	25
26	27	2842/0	1447/0	60	25
27	28	0590/1	9337/0	60	20
28	29	8042/0	7006/0	120	70
29	30	5075/0	2585/0	200	600
30	31	9744/0	9630/0	150	70
31	32	3105/0	3619/0	210	100
32	33	3410/0	5302/0	60	40

4-5 voltage profile improvement index

Simulation results for two and three DGs are as follows:



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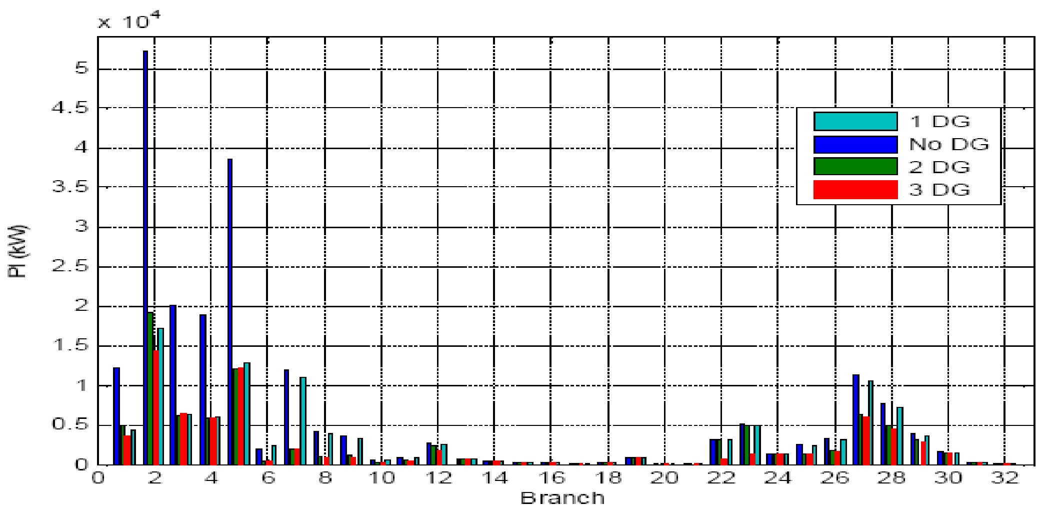
By installing diffused generation sources in buses of the network , it can be understood that voltage profile is presented in figure 96-5) before diffused generation source installation. After installing two diffused generation sources with capacities 1.1079 megawatt and 0.8348 Megawatt for buses 22 and 27 respectively , voltage profile in the form of a curve has been improved by triangular signs and loss power has reduced from 221.4346 to 91.2417KW. by installing 3 diffused generation sources with capacities 1.0774 , 0.7597 and 1.0205 respectively , in buses 10,22and 29 , voltage profile in the form of a curve has been improved by rectangular signs and power los has reduced to 71.1691 KW. As it can be seen in figure above , there is not much difference in in two and three DGs installation but increasing DGs number is not economically beneficial.

5-5 loss reduction index

Now according to reference (3) , we want to locate just DGs which generate active power. Simulation results with particles society optimization(PSO) are presented in table (4-5).

method	Bus	DGSize (MW)	Bus	DGSize (MW)	Bus	DGSize (MW)	Ploss(kW)
Load distribution analysis							4346/221
GA	11	4934/2					2531/114
							2678/116
			PSO	12	4934/2		
GA	20	1079/1	24	8348/0			2457/90
	PSO	22	1079/1	27	8348/0		2417/91
GA	10	0774/1	21	7597/0	27	0205/1	0875/71



CONCLUSION

Finally simulation results of some IEEE sample networks were compared with other methods in in different papers. And this method efficiency regard to the diffused generation source location was studied in order to improve voltage profile and reduce loss. Following results were achieved:

1. Since our objective is loss reduction in the network and approximating voltage in all buses to the predetermined values , location algorithm will be able to determine maximum coefficient of permissible influx of diffused generation sources to achieve above objectives hen there is no limitation in installation capacity.
2. PSO has a simpler programming than Genetic algorithm method and also needs a shorter time for calculations.

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