Multi Objective Optimization Placement of DG Problem for Different Load Levels on Distribution Systems with Purpose Reduction Loss, Cost and Improving Voltage Profile Based on DAPSO Algorithm

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ABSTRACT:

Along with economic growth of countries which leads to their increased energy requirements, the problem of power quality and reliability of the networks have been more considered and in recent decades, we witnessed a noticeable growing trend of distributed generation sources (DG) in distribution networks. Occurrence of DG in distribution systems, in addition to changing the utilization of these systems, has provided the opportunity for these companies to be able to design systems with lower costs. In this paper, the problem of placement and capacity determination of DG were carried out using multiple methods. The main objectives of issue were improving the voltage profile, losses reduction and reduce the cost of operation that were carried out based on an economic function. Using the multiple methods to improve some purposes and utilization of weighting coefficients provided an appropriate plan. DAPSO algorithm was used for optimization and various experiments carried out on real network.

KEYWORDS: DAPSO Algorithm, Distribution Network, Distributed Generation

INTRODUCTION:

In recent years, in order to provide the power of network, the use of distributed generation sources increased. It is due to the characteristics of DG such as small size, low investment cost, proximity to location of consumption and no need to expand the networks of generation and transmission. They significantly reduce investment costs of power supplying due to load growth. Due to the competition and restructuring of the power systems and issues such as restrictions on the construction of power transmission lines, high sensitivity to the environment, consumers greeted services with high reliability, etc. it is expected that DG systems have an important role in the future [1]. Due to the declining DG resources price, these sources are expected to play an important role in the future of distributed systems. Besides, the presence of DG in distribution systems increases the complexity of the problem of designing and developing these systems and makes it inefficient the use of existing methods for solving that problem. So, with the existence of DG, the issue of designing and development of distribution systems needs to be reviewed and it takes new models and methods for solving it. Some studies have been done for DG placement. In a paper, DG placement based on distribution system voltage stability is studied [2]. In this method, those buses which are more sensitive to the failure of the voltage are determined based on current flow linkage analysis. Then, the distributed generation sources are placed at specified bus location and power losses and voltage are measured. Another study offers an analytical method for determining the location and optimal size of the sources of power loss reduction in power systems. In this paper, the aim of applying DG is a power loss reduction in the distribution system. Study in both constant and time-varying load is done. In this case, DG applied by distribution companies for providing power due to load growth has been studied [4]. The purpose of applying these sources in the distribution systems is to minimize the cost of investment and utilization of new equipment to provide load posts, transformers, feeders and DG. The optimization is performed by GAMS software. Placement of DG on power networks using multi-objective algorithm (MPSO) or (multi objective) to minimize the economic cost of production is discussed [5]. In this paper, two objective functions are written: first function for minimizing the cost of producer and second one for minimizing the environmental emissions. MPSO is used to simultaneously minimize the cost and the thermal emission by changing the location and size of DG. In the other paper, the target is a multi-objective optimized locating of distributed productions using Simulated Annealing [6]. The proposed method defines the optimized location and size in a calculating time less than (GA) and (TS). Also, the main purpose of this paper is to minimize the real power losses and environmental emissions. In a paper, a comprehensive methodology for DG placement with consideration of the limitations of utilization, upside network and communication Feeders is discussed and the combined method is used for optimization [7]. Finally, various experiments have been tested on the network to show the effectiveness of the method. In a paper, placement and determination of size of DG by reducing losses and improving voltage profiles using ABC algorithm is conducted [8]. Restrictions on utilization and the electricity in the upside source are considered. In this paper, the problem of determining a location and suitable capacity of DG, using a multiple method, in the distribution network was investigated. Due to the complexity of the selected target function, using powerful algorithms for solving this problem is essential. So, two algorithms (DAPSO, PSO) are used for the optimization. Finally, the results have to be compared. Voltage profile improvement, loss reduction, the cost of investment reduction and utilization are the main objectives of the plan. To demonstrate the efficiency of the algorithm and method, various tests were performed on a real network.

1- FORMULATION OF THE PROBLEM:

Considering the main objectives of the problem, formulation to determine the location and optimal capacity of DG is done with regard to the constraints and necessary restrictions. To provide a practical and economical design, multiple methods of weighting coefficients are used.

$$Min K_T = \{\beta_1.K_{npf} + \beta_2.K_{P.Ls} + \beta_3.K_{ncs}\}$$

2.1- VOLTAGE PROBLEM:

This function represents the voltage difference between different buses of the network and its reference value. In fact, it states the network voltage drop which is an important element in the quality of the network. The objective is to minimize the voltage drop in the network.

$$Min\ k_T = \beta_1.f_{ypf}\ |V_{ref} - V_i\ |$$

$$K_{npf} = \frac{k_{pf}}{k_{npf}}$$

Kpf: base voltage drop after installing

DG ‹K_{bpf}: base voltage drop before installing

DG ‹K_{npf}: normalized amount of voltage profile

V_{ref}: reference voltage

V_i: voltage of i^{th} bus

2.2- NETWORK LOSSES PROBLEM:

The aim of this section is reduction and minimization of network losses. For this purpose, the following equation can be used:

$$mi\,k_{ls} = .\sum_{df=1}^{ndf}\sum_{i=1}^{nb}\sum_{j=1}^{nb}\mu(i,j)\times\theta(i,j)\times I^2(i,j,dk)$$

$$K_{nls} = \frac{k_{ls}}{k_{nls}}$$

$\mu(i,j)$: variable indicating whether or not the relationship is between buses

n_b: number of buses

k_{ls}: The loss of function in the presence of DG

k_{bls}:losses function without DG

$K_{n.ls}$: normalized losses function

$\theta(i,j)$: impedance of the line between buses i, j

I(i,j): the amount of current flowing between i, j

2.3- RESPECTIVE COST PROBLEM:

The purpose is minimization of costs. These costs include the fixed costs of the initial investment costs and variable costs include the cost of maintenance and utilization of DG. The following equation can be used to express the total cost:

$$Min\ K_{cs} = \{\sum_{i=1}^{ng}SC(\alpha(j)) + \sum_{t=1}^{nt}(\phi_{pw})^t\sum_{t=1}^{ng}[MC(\alpha(j)) + OPC\ (\alpha(j))]\times 8760 + \sum_{t=1}^{nt}$$

$$PW_{ss} = \sum_{i=1}^{nlp}PW_l(i) + \sum_{j=1}^{nf}PW_{ls}(j) - \sum_{k=1}^{ndg}P_{DG}(\beta(k)$$

$$\phi_{pw} = \frac{1+Infr}{1+Intr}$$

$\alpha(j)$: represents the capacity of DG

Zero indicates that DG is not installed in the desired location.

ng: number of candidate locations for installing DG

SC: the cost of installing DG in candidate place that is determined according to the candidate.

Nt: planning period (years)

ϕ_{pw}: economic factor for conversion costs that are spent during the period to their current value.

I_{ntr}: the annual interest rate

I_{nfr}: annual inflation

Mc(α(i)): maintenance costs

OPC (α(i)): utilizing costs of DG (i), which is affiliated with the DG.

PROVISIONS GOVERNING THE ISSUE:

- Provisions relating to the active and reactive power**:**

$$Q_{DGi}^{\min} \leq Q_{DGi} \leq Q_{DGi}^{\max}$$

$$P_{DGi}^{\min} \leq P_{DGi} \leq P_{DGi}^{\max}$$

- Losses provisions:

$$\sum P_{loss}(withDG) < \sum P_{loss}(withoutDG)$$

THE FINAL OBJECTIVE FUNCTION

By considering above formulations and governing provisions, the final objective function can be expressed as:

$$K_I = K_t + C_P.\sum_{ilc} Hi$$

$$H_i = \begin{cases} 0 & G_i \leq b_i \\ (G_i - b_i)/b_i & otherwise \end{cases}$$

The second part of the penalty function associated with each member, shows the model regarding the provisions cross.

, represents amount of inactivity of $\sum_{ilc} Hi$ particle and Cp is penalty coefficient (a huge number).

2- DAPSO ALGORITHM:

Community algorithm or particles congestion is an optimization algorithm based on the collective intelligence, which was introduced first by Kennedy and Eberhart**.** This algorithm is inspired by the moving mass of birds and fish, and due to its ability to respond in a short time with high quality, is considered by researchers. By developing research, they discovered that the social behavior model for members of this class with some terms could also serve as a powerful optimization method. A preliminary version of this method was assigned only for solving continuous nonlinear optimization problems. With the development of new algorithms, DAPSO algorithm was proposed which is the improved model of PSO algorithm. In PSO algorithm, each particle is following two values: a proper response that the particle has earned and a proper response that other particles have received. After commencement of searching, searching speed becomes zero and causes them to be stuck in local optimums. Inertia weight factor in the proposed algorithm is modified as follows to stop this process that is a function of other parameters:

$$v_i^{k+1} = \omega v_i^k + c1r1(XPbest_i^K \_ X_i^K) + c2r2(XGbest_i^k - X_i^k)$$

$$X_i^{k+1} = X_i^k + v_i^{K+1} \quad ,i = 1,2,...n$$

In this algorithm, the inertia weight factor is influenced by the developmental state and with the evolutionary speed coefficient and the coefficient of particle, aggregation is presented as follows:

$$h_i^k = \frac{\min(F(pbest_i^{k-1}), F(pbest_i^k))}{\max(F(pbest_i^{k-1}), F(pbest_i^k))}$$

Where $F(pbest_i^k)$ is $pbest_i^k$ propriety level. This parameter takes into account the history of each particle. It means that to have more speed, "h" should be smaller.

$$s = \frac{\min(F_{kpbest}, \overline{F})}{\max(F_{kpbest}, \overline{F})}$$

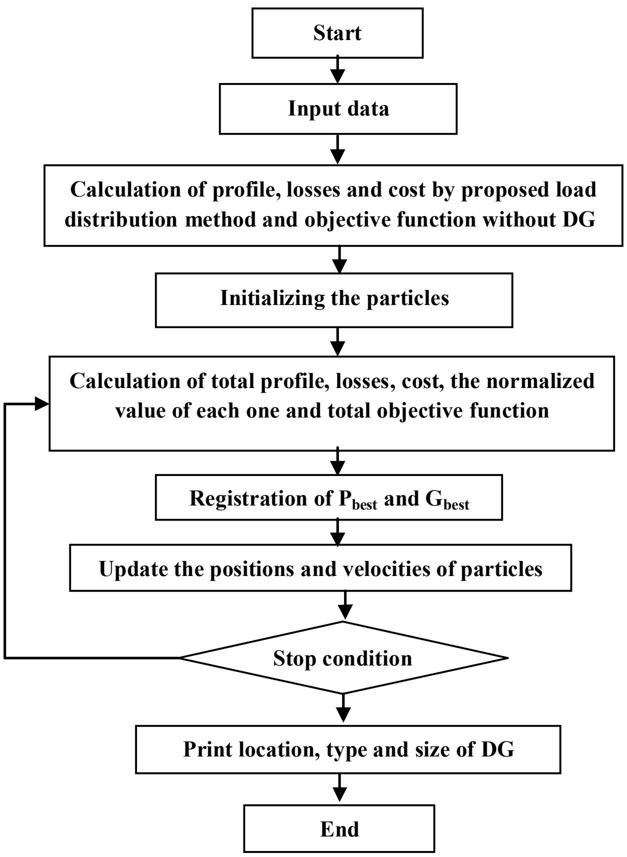

Figure.1. Flowchart of PSO algorithm to solve the problem

3- CASE STUDIES:

To show the effectiveness of the proposed algorithm, the problem for a real network (Tehran Network) is shown in Figure 2. Data networks are shown in tables.

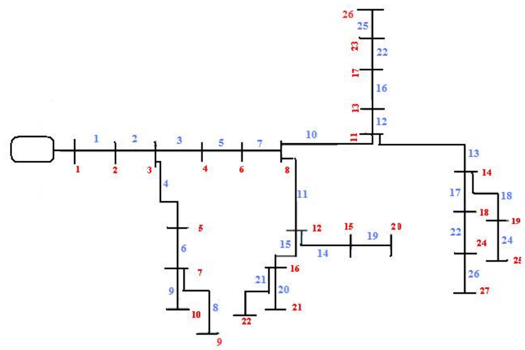

Figure.2. Tested Network

4.1- FIRST EXPERIMENT

The effect of weighting coefficients (a1 = .2, a2 = .5 and a3 = .3)

As the results show, the presence of DG could improve the desired goals, considerably.

Voltages, losses and expenses with DG were significantly improved compared with the case without DG. It should also be noted that considering the importance coefficient chosen for the purposes, it will have a greater impact on the final objective function. Hence, the algorithm is trying to improve the objective more. In this experiment, because the importance coefficient of losses function is further, the greatest impact occurs on losses. Comparison of various algorithms is also given in the table. It should be noted that the load of network is variable. Due to lack of facilities for moment estimation of load in order to high performance, the load problem is considered at three levels (high, medium and low).

Table1. Results of the first experiment

Parameters	Before installing DG	After installing DG (using algorithms)	
		PSO	DAPSO
Function of normalized voltage profiles ($F_{n.\ Proof}$)	1	0.4512	0.4501
The actual value of the voltage profile in terms of per unit (F_{prof})	3.4486	1.556	1.5522
Normalized loss function ($F_{n.loss}$)	1	0.373	0.3824
The actual amount of the loss function kw (F_{loss})	1203	448.719	460.027
Normalized cost function ($F_{n.cost}$)	1	0.7808	0.7636
The actual value of the cost function $ (F_{cost})	10^7*8.2068	10^7*6.407	10^7*6.2627
Normalized value of the objective function (F_{fit})	1	0.4914672	0.478941
DG installation locations	-	8و10و13و15و17و19و21و22و23و24و27	8و10و13و15و17و19و21و22و23و24و27
DG capacity	-	2و1و1و2و3و1و2و4و1و2و3	2و1و1و2و2و1و2و3و1و2و2

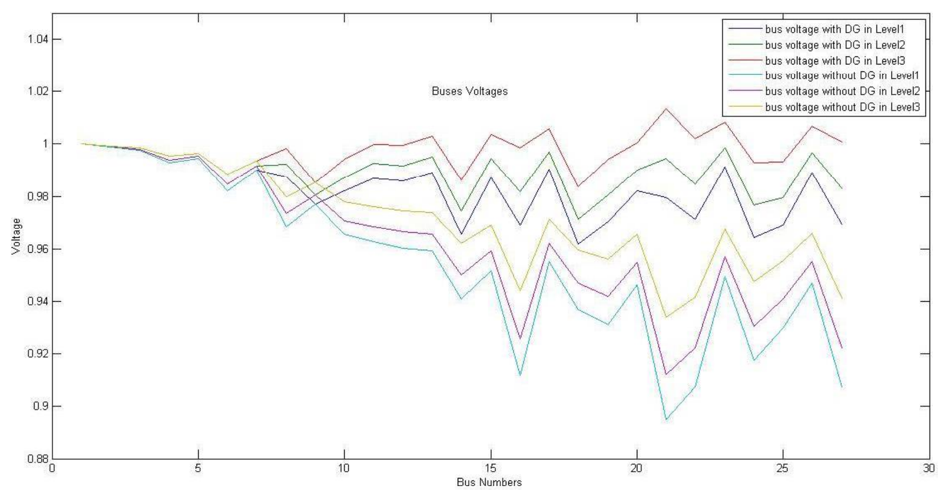

Figure .3. Comparison of the voltage profile before and after installation of DG for PSO algorithm

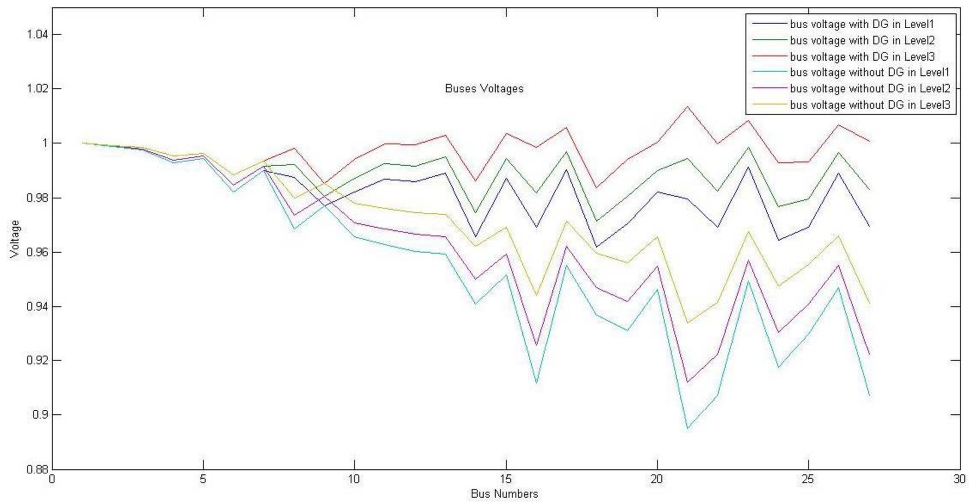

Figure.4. Comparison of the voltage profile before and after installation of DG for DAPSO algorithm

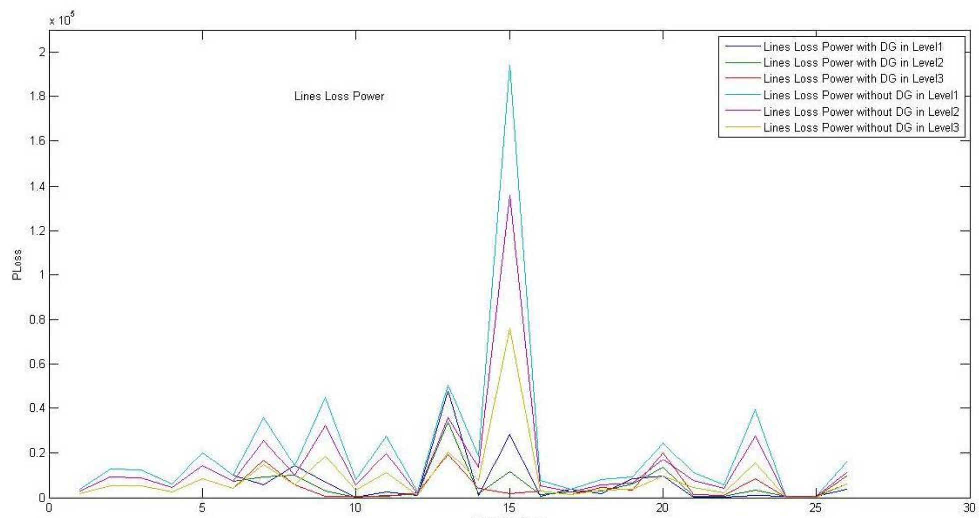

Figure.5.Comparison of the line losses before and after installation of DG for algorithm DAPSO

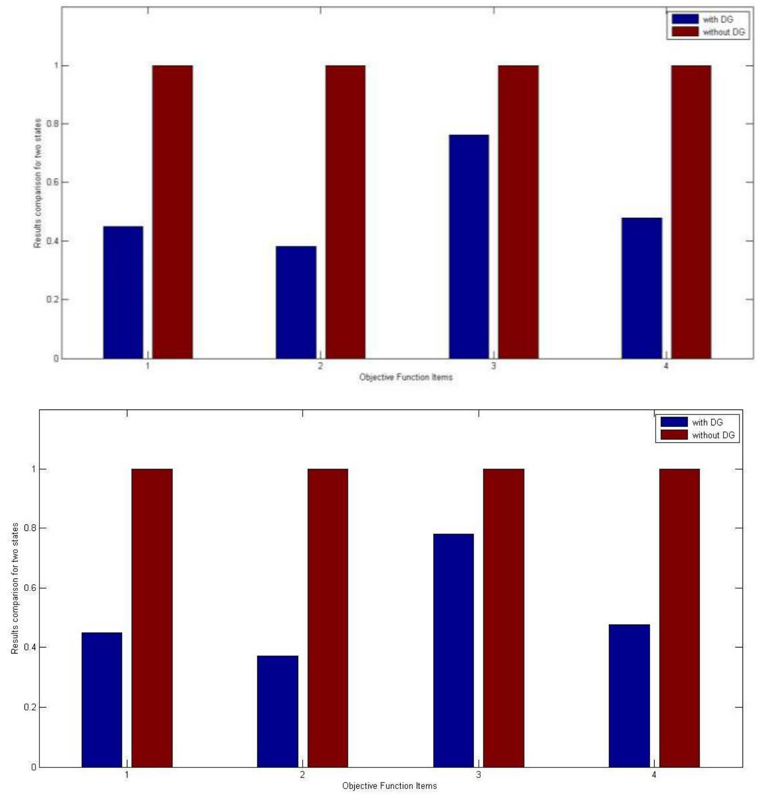

Figure.6. Comparison various parts of the objective function before and after installation of DG for 1) DAPSO 2) PSO algorithms ** (Column 1: normalized voltage profile, column 2: Losses, column 3: Cost function, column 4: the total value of the normalized objective function)

(A_3=.3, A_2=.2, A_1=.5):

4.2- SECOND EXPERIMENT:

In this test, to demonstrate the efficiency of algorithm, important factor of objectives has been changed. As the results show, due to the further importance of voltage, the algorithm tries to improve the voltage profile in order to further improvement of overall function. The results of these experiments are presented in the following figures:

Table2. Results of the second experiment

Parameters	Before installing DG	After installing DG
Function of normalized voltage profiles ($F_{n.\ Proof}$)	1	0.4005
The actual value of the voltage profile in terms of per unit (F_{prof})	3.4486	1.38
Normalized loss function ($F_{n.loss}$)	1	0.5904
The actual amount of the loss function kw (F_{loss})	570	336.5
Normalized cost function ($F_{n.cost}$)	1	0.6593
The actual value of the cost function $ (F_{cost})	$8.2068*10^7$	$5.41*10^8$
Normalized value of the objective function (F_{fit})	1	0.5161
DG installation locations	-	8و10و13و15و17و19و21و22و24و27
Type of DG installed at each location.	-	2و2و2و3و4و1و2و4و2و2

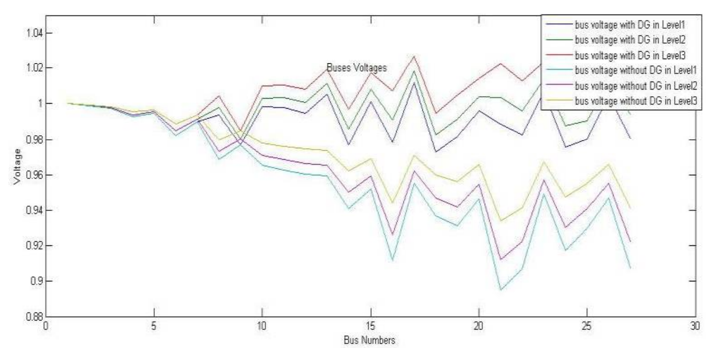

Figure.7. Comparison of the voltage profile before and after installation of DG for DAPSO algorithm

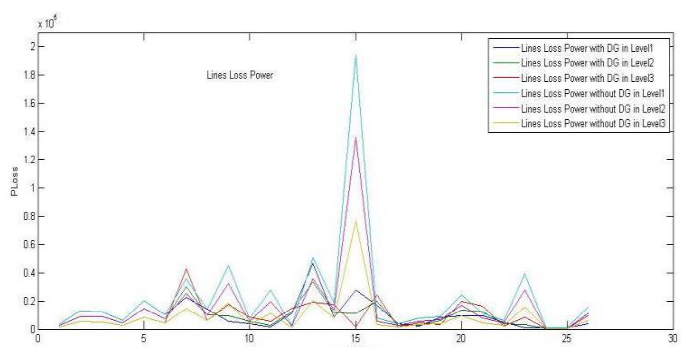

Figure.8 . Comparison of the line losses before and after installation of DG for algorithm DAPSO

4- CONCLUSION:

Due to the competition and restructuring of the power systems and issues such as restrictions on the construction of power transmission lines, high sensitivity to the environment, consumers greeted services with high reliability, etc. it is expected that DG systems have an important role in the future. In this paper, the optimal placement of distributed generation sources in the multi - objective form by using of weighting coefficients was taken. First, the problem is optimized by two kinds of algorithms and then, results are compared with each other. Obtained results can be stated as:

- Different levels of load regarding the realities of the load which are variable and useful for the most practical solution.
- Voltage profile with DG, losses and expenses have been significantly improved that are well displayed in charts and graphs.
- Weighting coefficients used in the experiments showed that considering the coefficient selected for each of the three targets (voltage, losses, and cost), the most important objective will be improved. Because it has the greatest impact on the objective function.
- Comparing PSO and DAPSO algorithms, DAPSO algorithm gives better results than PSO algorithm due to its nature.
- Circumstances indicate the suitability of the algorithm for the Changes.
- For example, by changing the weighting coefficients, the algorithm also has changed itself well for offering better results.

5- REFERENCES:

[1] Y.G. Hegazy, M.M.A. Salama, and A.Y. Chikhani, "Adequacy assessment distributed generation system using Mont carlo simulation," *IEEE Transactions on Power system*, vol.18, no.1, 2003, pp.48-52

[2] C. Wang and M. H. Nehrir:" Analytical Approaches for Optimal Placement of Distributed Generation Sources in Power Systems", IEEE *trans. on Power Sys., Vol. 19, No. 4, november 2004.*

[3] H. Hedayati, S. A. Nabaviniaki, and A. Akbarimajd,: "A Method for Placement of DG Units in Distribution Networks", *IEEE trans. on Power Delivery, Vol. 23, No. 3, July 2008.*

[4] W. El-Khattam, Y. G. Hegazy and M. M. A. Salama, "An Integrated DistributedGeneration Optimization Model for Distribution System Planning", *IEEE trans. On Power Sys., Vol. 20, No. 2, may 2005.*

[5]. Prakomchai Phonrattanasak Department of Electrical Engineering North Eastern University Khonkaen, Thailand 40000" Optimal Placement of DG Using Multiobjective particle Swarm Optimization ".IEEE , Mechanical and Electrical Technology (ICMET) , 2nd international conference , 2010 , pp.342 - 346 .

[6]. T. Sutthibun and P. Bhasaputra Department of Electrical and Computer Engineering Faculty of Engineering Thammasat University, Patumthani 12120, Thailand " Multi-Objective Optimal Distributed Generation Placement Using Simulated Annealing". Electrical Engineering / Electronics Computer Telecommunications and Information Technology (ECTI – CON) , international conference , 2010 , 810 – 813 .

[7] M.H. Moradi , M. Abedini, "A combination of genetic algorithm and particle swarm optimization for optimal DG location and sizing in distribution systems" Electrical Power and Energy Systems 34 (2012) 66–74

[8] Fahad S. Abu-Mouti, M. E. El-Hawary "Optimal Distributed GeneratioAllocation and Sizing in Distribution Systems via Artificial Bee Colony Algorithm" IEEE Trans. Power, VOL. 26, NO. 4 OCTOBER 2011 , pp. 2090-2101.