COMPARISON OF VARIOUS TECHNIQUES FOR FINDING OPTIMAL SIZING & PLACEMENT OF DISTRIBUTED GENERATION UNITS

Surbhi Bakshi
surbhi_pec@yahoo.com
Deptt. of Electrical Engg, PEC University of Technology, Chandigarh, India

Abstract: E***lectrical power from a close-by fuel source depending on the type of availability like the solar concentration, wind speeds etc generated by distributed Generation (DG) Units. to reduce the strain on the main supply line. This Increases reliability and reduces cost of power generation and saves non-renewable power resources. This concept of power generation would lead to a greener way which is environment friendly and healthier lifestyles. Therefore, finding a position for the DGU which is economically viable, through a suitable size and minimization of losses is of utmost importance. In this paper, the comparative analysis of various techniques for optimal sizing and placement of Distributed Generators (DG) in distribution networks is done.***

Index Terms: Distributed generation (DG), optimization techniques

1. INTRODUCTION

Today Electricity is most important by which, we cannot live. Electricity become a part of every home through large scale distribution systems, in which power travels over large distances from the source, which is normally situated at places which are at quite a distance from the residential areas, to mainly reduce the stunting effects of pollution on a neighborhood. The distribution system is normally radial without installed distributed generation units [8]. The power is supplied to the radial distribution network through the transmission line at the Grid Supply Point (GSP).Power flows only in a single direction, that is, from transmission line to the distribution system. Since in the recent past, there have been an increasing number of generation units being connected to thedistribution system that is, a Generation unit at the customer side of the meter; such units are called Distribution Generation Units(DGU) [5-8]. The positioning and the magnitude of the generated power supplied to the distribution system by the DGU have an influence on the daily workings of the whole system. It can either make it more efficient or decrease the efficient operation of the system which could adversely affectthe stability of the system [9-12].Large power supplied by a DGU can even reverse the direction of flow

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of current. Therefore, finding a position for the DGU which is economically viable, through a suitable size and minimization of losses is of utmost importance.

2. DISTRIBUTED GENERATION

Distributed generation (DG), is the process of generating electricity from many small energy sources and connecting it directly to the distribution network or on the customer's side of the meter [4-8]. It can also be called as onsite generation, dispersed generation, decentralized generation, decentralized energy or distributed energy. From the definition, the DG includes those generating units that cannot supply reactive power and are located close to the customer or the end user.DGU kinds are based on the classification of the powerresource available in the vicinity of the location such asbiomass, biogas, solar and wind. They can be micro-turbines,solar cells, fuel cells and Combined Heat and Power (CHP).Each of them is defined by a particular characteristic likeproducing only real or reactive power.

Distributed Generation (DG) is a small generator spottedthroughout a power system network, providing the electricitylocally to load customers [10]. DG can be an alternative source of power supply forindustrial, commercial and residential applications. DGmakes use of the latest modern technology which is efficient,reliable, and simple enough so that it can compete withtraditional large generators in some areas [11].Placement ofDGs is an interesting research area due to economical reason.Distributed generation systems (such as fuel cells, combustion engines, microturbines, etc) can reduce the system loss and defer investment on transmission anddistribution expansion. Appropriate size and optimallocations are the keys to achieve it [13-18].

3.CALCULATION OF POWER LOSS

The objective function of DG sizing and placement is tominimize the power loss of the system. The objective function,*f(x)* is the result of the total loss of the system, $P_{LOSS}$to beminimized, as follows:

$$f(x) = min\left(\sum_{j=1}^{line} P_{LOSS}\right) \quad \text{(i)}$$

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Where,*line* is the number of lines (connecting cables) in thedistribution system.Power loss (P_{LOSS}) whichconnected with a unity power factor of DG is derivedanalytically and represented by the following equation.

$$P_{LOSS} = \sum_{i=1}^{n}\sum_{j=1}^{n}\begin{bmatrix} \frac{R_{ij}}{V_iV_j}\cos(\delta_i-\delta_j)\left[P_{DG_j}P_i - P_{L_j}P_i - Q_{L_j}Q_i\right] - \cdots \\ \frac{R_{ij}}{V_iV_i}\sin(\delta_i-\delta_j)\left[P_{DG_j}Q_i + Q_{L_j}P_i - P_{L_j}Q_i\right] \end{bmatrix} \quad \text{(ii)}$$

where,

$V_j\angle\delta_j$ the complex voltage at the bus jth;
R_{ij} the ijth element of resistance;
$P_i$and P_j the active power injections at the ith and jth busses, respectively;
$Q_i$and $Q_j$the reactive power injections at the ith and jth busses, respectively;
P_{DGj} the DG active power injections at the jth bus;
n the number of busses.

Being known that, the total active power loss of the systemwill be at the minimum if the partial derivative of $\boldsymbol{P_{LOSS}}$withrespect to the active power injection from DG, $\boldsymbol{P_{DGj}}$at bus *j* isequal to zero.

$$\frac{\partial P_{LOSS}}{\partial P_{DGj}} = 0 \quad \text{(iii)}$$

4.ALLOCATON OF DG FOR VOLTAGE PROFILE IMPROVEMENT & LOSS MINIMIZATION

Optimal allocation (sizing & sitting) of DG at the existing distribution network is very important factor in the planning and operation of active distribution network as optimum DG location can improve voltage profile and to minimize power loss. Voltage profile of a system can be improved by introducing DG unit because DG can provide a portion of real and reactive power to the load locally [17]. Power loss in a system depends on numerous factors such as system configuration, such as level of losses through transmission and distribution lines, transformers, capacitors, insulators etc. There are two categories of power losses, one is real power loss and another is reactive power loss. Real power loss is caused due to the resistance of lines and reactive power loss is caused due to reactive elements. Real power loss reduces the efficiency of transmitting energy to customers. Reactive power loss is also important. Reactive power flow in the system needs to be maintained at a certain level for sufficient voltage level. It is possible to transfer real power to customers through transmission and distribution lines.Optimum location of DG in a distribution network can provide several benefits such as voltage profile improvement, loss minimization, power quality improvement, contributing for frequency regulation and actingas spinning reserve in main system [19].

5.OPTIMIZATION TECHNIQUES

I.Analytical Technique: Analytical techniques represent the system by a mathematical model and evaluate it using direct numerical solution [9].

II.Genetic Algorithm[21-22]:Genetic Algorithms (GA) has become increasingly popular in the recent times. Genetic algorithms belong to the larger class of evolutionary algorithms (EA), which generate solutions to optimization problems using techniques inspired by natural evolution, such as inheritance, mutation, selection, and crossover. In a genetic algorithm, a population of strings (called chromosomes or the genotype of the genome), which encode candidate solutions (called individuals, creatures, or phenotypes) to an optimization problem, evolves toward better solutions.

III.Heuristic Techniques:A heuristic is an algorithm that locates optimal or near optimal solutions to a problem without concern for whether the solution can be proven to be correct [13].

IV.Meta-Heuristic Techniques[6]: A meta-heuristic is an iterative generation process which can act as a guide for its subordinate heuristics to efficiently find the optimal or near optimal solutions of the optimization problem.

a.**TabuSearch**[14]:Tabu search is a meta-heuristic approach which has dramatically changed the ability to solve a host of optimization problems.

b.**Particle Swarm Optimization**[2,15]: Particle swarm optimization (PSO) is a population based stochastic optimization technique developed by Dr. Eberhart and Dr. Kennedy in 1995, inspired by social behavior of bird flocking or fish schooling. PSO shares many similarities with evolutionary computation

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techniques such as Genetic Algorithms (GA). The system is initialized with a population of random solutions and searches for optima by updating generations. However, unlike GA, PSO has no evolution operators such as crossover and mutation. In PSO, the potential solutions, called particles, fly through the problem space by following the current optimum particles.

c. Ant Colony Optimization[23]: Ant colony algorithms are based on the behavior of social insects with an exceptional ability to find the shortest paths from the nest to the food sources using a chemical substance called pheromone.

d.Simulated Annealing[16]: Simulated Annealing (SA) is a generic probabilistic meta-heuristic for the global optimization problem which locates a good approximation to the global optimum of a given function in a large search space. It is often used when the search space is discrete.

V. Genetic Algorithm Hybrid Approach: Genetic Algorithm has been found to be very effective in area of DG allocation; however it is not very efficient in determining the absolute optimum. Therefore it is not the obvious choice when the high quality solutions are desired. To overcome this drawback, GA is combined with other techniques in order to improve its efficiency.

Table:Comparison of Various Techniques

Optimization Approach	Benefits	Drawbacks
Analytical Technique	Computing time is short. Easy to implement. Non -iterative in nature. Unlike other techniques, does not pose convergence problems	When the problem becomes complex, the assumptions used in order to simplify theproblem may override the accuracy of the solution. Lacks Robustness.
Genetic Algorithm	Can rapidly locate solutions, evenfor large search spaces. Works with discrete and continuous parameters. Very useful for complex and loosely defined problems. No derivatives needed.	Repeated fitness function evaluation for large and complex problems may be time consuming. Lack of accuracy, not suitable when a high quality solution is required.
Tabu Search	Has explicit memory. Allows non-improving solution to be accepted in order to escape from a local optimum.Tabu search obtains solution, that rival and often surpass the best solutions previously found by other approaches.	Too many parameters to be determined Number of iterations could be very large Global optimum may not be found, depends on parameter Settings

Particle Swarm Optimization	No overlapping and mutation.Simplified calculation.Adopts the real number code, and it is decided directly by the solution.	Can not work out the problems of scattering and optimization.
Ant Colony Algorithm	Inherent parallelism.Positive Feedback accounts for rapid discovery of good solutions.	Theoretical analysis is difficult Sequences of random decisions (not independent)Probability distribution changes by iteration. Time to convergence uncertain (but convergence is guaranteed)
Simulated Annealing	Ease of implementation. Ability to provide reasonably good solutions for many combinatorial problems. Robustness	

This comparison has shown a critical review of various techniques which have been employed to address the issue of Distributed generation sitting and sizing with respect to various objectives.

6. CONCLUSION

This paper presents the comparative analysis of various methods and techniques available for the optimal placement of distributed generation resources & for minimizing losses is done. The DG of different kinds of energy systems allows for the integration of renewable and nonconventional energy resources. As DG technologies improve and cost decrease, their use is expected to rise.However, this may lead to a compromise in solution quality and computational time. A hybrid of two or more approaches can however, offer a better option by incorporating the benefits of approaches and discarding the drawbacks.

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