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Review Article

# Review of optimal siting and sizing techniques for distributed generation in the distribution system

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## ABSTRACT

The installation of DG in the distribution system is challenging for the technical, economic and environmental aspects. The smaller scale generation technologies are developed for minimum cost and today's competition. The range capacities from a few kilowatts to 100MW. The optimal siting and sizing of DG in the distribution system improve the reduces the losses, improves the voltage and improve the economics of the system. However, to find the optimal solution for multi-objective problems, the different optimization methods are studied. This paper study the impact of DG onthe distribution system, Distributed generation, a different approach for optimal siting and sizing impact on utilities and the customers.

***Keywords***: *Distributed Generation, Optimal siting and sizing.*

## INTRODUCTION

In electric power system power is transferred at high voltage over a considerable distance. The power is delivered to the customers through Distributed Generation. The Distributed Generation is made with large buses and lines with high R/X ratio. Moreover, Distribution system losses are high as compared to the transmission system losses. The methods to reduce the losses in the systems are re-configuration and capacitors placement. Recently the growing interest in using Distributed Generation to supply increasing load. The appropriate size and placement of Distributed Generation reduce the losses, improves the voltage and increase the system reliability. Distributed generation is important to improve the distribution system performance. The distribution system operation and design are normally based on radial power flow. DG is an important role in the distribution system because of small size, low cost,and environmental concern. The installation of DG in the distribution system impact the voltage and the power flow in the system. Thisoccurs in the positive and the negative impact on the distribution system of the characteristics of the DG. So, the proper planning is important for the DG placement in the distribution system. DG is the renewable power generating source.The proper installation of DG in distribution system improves technical, economic and environmental benefit. The optimal placement of DG in the distribution system reduces the losses, improves the voltage and improves the economic benefit of the system.

## DISTRIBUTE GENERATION

The general definition of DG could be an electrical energy source connected directly to the directly to the distribution system or the load. The DG purpose is to provide active power. The electrical power research institute defines the DG rating is from a fewkilowatts to 50MW. The introduction of DG in the distribution system impact the customs and the utility equipment [1]. The ranges of capacities from a few kilowatts to 100MW and which includes microturbine, fuel cell, photovoltaic system, wind energy system, diesel engine gas turbine,and battery storage. Trends are moving towards the smaller scale generation producing near and transporting over small distances at low voltage.

The positive impact of DG in the radial distribution system:

1)It reduces the losses in the system

2) It improves the system reliability

3) Improves the power quality and provides the voltage support.

4) The capacity is released from the system because of DG

## IMPACT OF DG IN DISTRIBUTION SYSTEM

Because of lower cost DG installation is increase day by day which bring a lot of technical and economic impact tothe power system.

The impact of DG in the distribution system is classified into three:

i)Environmental impact of DG Units

ii)Economic impact of DG Units

iii) The technicalimpact of DG Units

### i)Environmental impact of DG units

The DG installation reduces the greenhouse gas emission. The central power generation emits large carbon mono-oxide, sulfur oxides, particulate matter, hydrocarbon and nitrogen oxides. These pollutants are not harmful to the environment. Many types of

research have confirmed that large-scale use of DG technologies substantially cuts emission. As a result, DG installation may affect reduced health care cost. It reduces the construction of large power plant and transmission lines to which reduces the public opposition [2].

**ii)The economic impact of DG Units**

It is independent of the imported fuels. It improves the industries with additional employment. The addition installation cost of cable, switchgear, voltage regulating systems are reduced. Reduced operation and maintenance cost [3].

**iii)Technical impact of DG Units**

The installation of DG reduces the cost and the installation of DG in the distribution system make a technicalimpact on the distribution system

**A) Power Flow**

Power flow is the basic tool to study the operation and planning of the power system. The power flowing through the power system is unidirectional. The power flow is not unidirectional from the substation to loads with the installation of DG in the power system

**B)Power loss**

The distributed generation is used to reduce the losses in the power system. The losses are depending on the flow of current and resistance of the conductor. The improper allocation of DG in the distribution system increases the losses in the system. So, the optimal siting and sizing of DG in the distribution system reduces the losses in the system

**C) Voltage regulation**

The installation of DG in the distribution system increases the voltage profile. The optimal siting and sizing of DG in the distribution system improve the voltage profile.

**D) Islanding**

Islanding may occur the section of the distribution system supported by distribution system is separated distribution system during the transient. The islanding may occur between the distributed generation and the distribution system. The implementation of relays in the circuit reduces the islanding in the system.

**Techniques for optimal siting and sizing of DG in the distribution system**

To maximize the benefit of DG, it is necessary to identify the optimal location and sizing of DG in the distribution system. The optimal siting and sizing result in a reduction of power losses,improvement of voltage profile, cost, improves the system reliability and improves the voltage stability.

The major techniques and methods that are used for sizing and siting of DG can be categorized as follows:

**Cuckoo search Algorithm**

Cuckoo search is a meta-heuristic technique which is motivated by a replication scheme. The method based on the behavior of the cuckoo which is a special bird which lay their eggs in the nest of host bird (crow another species of bird) in this process some hosts birds can engage with direct conflict with the cuckoos. The cuckoos are usually very specialized in the pretense in colors and impression of the eggs of a few chosen hosts.The cuckoo search algorithm is used to minimize the losses and voltage fluctuations in the radial distribution system. The first objective is to reduce the voltage violations and the secondary objectives is to reduce the daily percentage of energy losses. The test is analyzedin the 12-bus radial distribution system. The probabilistic nature of the hourly loads is simulated by applying Normal Distribution with the standard deviation of 20%. From the observation, the voltage magnitude of Bus-12 is the critical one. The percentage of energy loss is reduced from 0.92-1.01%. Then the optimal siting and sizing of DG in the distribution system areanalyzed by multi-objective cost function from the above subproblems. The only one point is considered for DG placement. The future work is to increase the location of DG in the distribution system. It is suitable for single and multi-objective functions[4].

**Particle Swarm Optimization**

The particle swarm optimization is used to analyze the optimal siting and sizing. The Type I DG is supplying active power only,e.g., photovoltaic, fuel cells. The Type II DG supplying reactive power only, e.g., synchronous compensator, capacitors,etc. Type III DG is supplying both active and reactive power, e.g., synchronous machines. The only optimization is used in this method to minimize the losses in the system. The test is conducted in the 33-bus and 69-bus radial distribution system. In PSO, particles move through the search space to keep itself in the best position.The exact formula calculates the optimal size of DG. The result is compared with the analytical method. The PSO gives a better result than the analytical method. The site and size of DG are obtained from the PSO. The Type I distributed generation gives a better result than the Type II. It improves the voltage and reduces the losses in the system [5].

**Genetic Algorithm**

A genetic algorithm is a heuristic search algorithm based on the concept of natural selection and genetics. The technique is inspired by natural evaluation such as crossover, mutation,and selection. The test system is the IEEE three generator and nine node grid structure. The objective function is to minimize the loss cost in the test system. The generating cost of DG is 0.7Yuan, generating the cost of thermal power is 0.3 Yuan. The multiple DG placement is made with the genetic algorithm. The research only concentrates on minimizing the cost loss in the system. It doesn't tell about the operation and maintenance cost of the system [6].

**Fuzzy Evolutionary programming algorithm**

The optimal siting and sizing of DGin the distribution system by evolutionary programming algorithm. The test is carried out in the IEEE-34 bus radial distribution system.Loss and voltage sensitivity indices

evaluate the optimal siting. The optimal sizing of the system is measured with the minimization of capital cost of DG and power loss cost. The multiple locations of DG placement reduce the loss from the single DG[7]

**Selective Particle Swarm Optimization**

SPSO analyzes the optimal siting and sizing of the radial distribution system,and the result is compared with the PSO method. The objective function is to reduce the Power loss reduction index(PLRI). An advanced version of SPSO was developed by Khalil and Gorpinich,where search space is undertaken as selected space by approving the sigmoid transformation of velocity function and upsurge the superiority solution. The test is conducted in the 12-Bus and 33-Bus radial distribution system.In the 12-Bussystem, the real power loss is reduced to 43.438% for PSO,and the real power loss reduce to 49.18%. So, the SPSO gives a better result than the PSO[8].

**Bat Algorithm**

The Bat Algorithm analyzes the optimal allocation of DG. Bat algorithm was introduced by Yang (2010). The basic concept is based on the echolocation of microbats. Based on these bats are searching for maximum potential prey. The test is conducted in the 33-Bus radial distribution system. The multiple distribution placementsare carried out in this paper. The result is compared with the PSO,GA/PSO.The Bat algorithm gives the better result than the PSO and GA/PSO in loss reduction. The bus locations are different from the other method.The voltage profile of the system increases[9]

**Bees Colony Algorithm**

The Bee Colony algorithm analyzes the optimal location and sizing of DG. Artificial Bee Colony (ABC) algorithm developed by Karaboga for optimizing numerical problems in optimal allocation of DG in the distribution system. In the ABCalgorithm, the colony of artificial bees contains three group of bees they are employee bees and unemployed bee. In the ABCalgorithm, the position of food source decides the solution to the optimization problemand the nectar amount of food source corresponding to the quality of the associated solution. The test is conducted in the 33-BUS radial distribution system.The loss saving in the 33-Bus radial system is 92.1175W at the 2.4886MW size. The Bee Colony Algorithm gives the better result than the PSO and SPSO [10].

**Exact solution methods**

The optimal siting and sizing of the radial distribution systemsare analyzed with the exact solution method. The exact solution methods are "branch and bound" and "dynamic programming" which split the complex problem into a partial problem for efficient calculation. The F/B method is used in the paper to optimize the problem. A simple 6-node mode is tested in the system. The system is tested with real power and reactive power injection. The system is also tested with the combination of both real and reactive power injection. Both real and reactive power injection gives a better result than the other injection. The loss reduction in the real power injection is 72.8% at node 5. The loss reduction in the reactive power injection is 18.4% at node 5. In both real and reactive power injection the losses reduction is 89.8% on node 5[11].

**Stud Krill Algorithm**

The optimal siting and sizing ofDG in the radial distribution system are analyzed by Stud Krill Algorithm. The objective function is to reduce the power loss in the system,and various constraints are considered in the system like the voltage limit DG real power generation limit, power balance. Stud Krill herd Algorithm is a generic reproduction scheme, called selection and crossover(SSC) operator, into the KH during the krill updating process. SSC operator is employed only to take the newly generating better solution for each krill individual. The proposed method is tested in the 33-bus, 69-bus,and 94-bus radial distribution system. The result shows the real and reactive power loss reduces and the voltage profile improves. This method increases the accuracy of the global optimality [12].

**Harmony search**

The optimal siting and sizing of DSTATCOM in the radial distribution system are analyzed by the harmony search algorithm. The objective is to minimize the losses in the system. There is much work focused on the optimization issues concerning power systems, such as cost minimization. A modified HS algorithm is proposed to handle non-convex economic load dispatch of real-world power systems. The economic load dispatch and combined economic and emission load dispatch problems can be converted into the minimization of the cost function. The test is conducted in the 33-Bus radial distribution system.The total cost saving is better than the immune algorithm[13]

**Monte Carlo simulation**

The Monte Carlo simulation analyzes the optimal siting and sizing of DG in the distribution system. The objective function is to minimize the investment cost, operating cost, maintenance cost, network loss cost,and capacity adequacy cost. Monte Carlo simulation embedded genetic algorithm approach is employed to solve the optimization problem. In this fitness function is formed by the objective function and penalty constraint together. The chromosomes are developed by population size. Updating the population size of chromosomes by mutation and crossover operators according to the specified crossover probability and mutation probability. The objective functions are developed for each chromosome. Select best chromosome base on the above procedure and obtain the optimal siting and sizing of DG. The test is conducted in the IEEE 37 - node distribution feeder. Under the chance-

constrained programming framework, a new mathematical model is developed to handle some uncertainties, such as the stochastic output power of a PEV, that of a wind generating unit, that of a solar generating sources, volatile fuel prices used by a fueled DG, and future uncertain load growth in the optimal siting and sizing of DGs[14].

## Conclusion and future work

The present work focuses on the optimal siting and sizing of DG in the distribution systems. The study shows the DG in the distribution system reduces the losses, voltage profile improvement, system reliability, and economic benefit to the system.The DG in the distribution system makes the technical and economic impact to the system. The DG installation reduces the installation of new lines and uses the peak load period. The protection devices used by the distribution system is reduced because of the DG placement. The stand-alone and islanding application of DG is part of future research. The economic analysis of the distribution system is doesn't analyze in this research.

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