Optimal Placement and Sizing of Distributed Generation and Capacitors: A Review

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Abstract- In power system both real and reactive power have an important role. While real power does the work and reactive power maintain the system voltage profile within the specified limit. Control of both real and reactive power is necessary to make a stable and reliable operation of the system. Placement of Distributed generation (DG) controls the real power flow of the system and minimizes the system real power loss while connecting the shunt capacitor system reactive power flow is optimized and system voltage will be within the specified limit. DG is the electricity generation from renewable energy resources that are located near to the consumer side. This paper illustrates a review of earlier work carried out in this field. Various meta-heuristic algorithms, analytical method, and their results are discussed briefly in this paper.
Keywords – Distributed Generation, Shunt capacitor bank, Meta-Heuristic algorithm, GA, PSO

I. INTRODUCTION

The main goal of power system is to deliver the power at each location of the power system network economically and reliably. Before generating electrical energy only conventional energy resources are used. These conventional resources are coal, hydro, nuclear. Those generators deliver power widely distributed different types of users connected through long transmission and distribution networks. In nowadays the central power plant is becoming weakening. The Weakening of the central power plant is due to environmental issues and also due to a reduction in conventional resources. As a result transmission and distribution costs are also gradually increasing. Then the distributed generation comes into the picture and it offers a solution to many of these new challenges. DG in simple terms can be defined as small scale generation or decentralized generation that is neither centrally planned nor centrally dispatched. DG’s are used near to the load side and they use energy sources such as solar photovoltaic, wind generators, fuel cells, gas microturbines, etc and its capacity is also less than 100 MW. The Capacitors supply the reactive power to the load and also improves the system voltage profile. The Capacitor is also come under 2nd type DG. When we connect the DG and capacitors to the system we have a serious effect on the system power losses, system voltage profile. For achieving the serious effect on the system after connecting DG and capacitor we have to select the optimal size and optimal location of DG and capacitors during connecting it at the distribution system. Many researchers have done the work on this relevant topic for recent years for optimal placement and sizing of DG and capacitors. Several types of research have been done in recent past on optimal siting and sizing of DG and shunt capacitor bank (SCB). Different methodologies have been used to optimally allocate proper size of DGs. These methodologies include analytical tools, optimization methods or artificial intelligent based algorithms. In [1] loss reduction sensitivity and voltage improvement sensitivity method is used to determine the best location for DG connection. In ref [2] presented a comprehensive review and Comparison of various DG schemes used by utilities for mitigation of voltage dips in power networks. Optimal location and sizing of distributed generation in a distribution networks using Genetic Algorithm (GA) is discussed in [3]. In ref [4] also genetic algorithm (GA) based method has been used to determine the optimal location and size of the DG’s. In Ref. [5] the authors determine the optimal placement of DG and capacitor by voltage stability index technique to minimize the both real and reactive power loss. In [7] an improved reinitialized social structures PSO algorithm has been developed for optimal placement of multiple DGs in a micro grid to minimize the real power loss within voltage and power generation limits. The authors in [6] reconfigure the distribution network using ant colony search algorithm to minimize the system losses. In Ref. [8] authors determined the optimal location of DG’s for uniformly distributed load and uniformly increasing load. The analytical approach has been demonstrated in [9] to find the optimal size and location of DG to minimize the real power losses and enhancement in voltage profile. In [10] a combination of genetic algorithm (GA) and particle DG swarm optimization algorithm is used for finding optimal location and size of DG in distribution system. In [11] also the author used the “Moth-Flame optimization algorithm” is used for finding optimal DG location and size in distribution system. A hybrid approach for optimal placement of DGs of multiple types has been discussed in ref [12]. In ref [16] the author uses the PSO technique for the placement of Distributed Generators (DG) in the radial distribution systems to reduce the real power losses and real and reactive power compensation. Author in ref [21] use a hybrid approach based on GA and moth swarm algorithm known as genetic moth swarm algorithm they also use multi-objective function as optimize total cost per year by reducing real power losses and cost of installing capacitor. Author in ref [22] uses multi-objective evolutionary algorithm based on decomposition (MOEA/D) for optimal placement and sizing of DG and SCB. Author in ref [19] used sensitivity method to find optimal location of DG and SCB and used GA optimization tool to find the size of DG and SCB.

This paper illustrates a review of some previous work in the area of DG placement and the approaches used by researchers for finding optimal location of DG for various purposes. In addition, this paper also discusses the key issues. No attempt is made here to prove the effectiveness of the solution technique applied by researchers for optimal placement of DG.

II. DIFFERENT TYPES OF DG

Distributed energy resource (DER) systems are small-scale power generation or storage technologies (typically in the range of 1 kW to 10,000 kW) used to provide an alternative to or an enhancement of the traditional electric power system.

In Ref. [7] the author defines that there are four types of DG exists. The types of DG are illustrated below.

Type I

DG capable of injecting real power only, like photovoltaic, fuel cells etc. is the good examples of type-I DG.

Type II

DG capable of injecting reactive power only to improve the voltage profile fall in type-II DG, e.g. kVar compensator, synchronous compensator, capacitors etc.

Type III

DG is capable of injecting both real and reactive power, e.g. synchronous machines.

Type IV

DG capable of injecting real but consuming reactive power, e.g. induction generators used in the wind farms.

In most of the cases for optimal placement problem of DG type-I DG is considered before. Now a days the researchers consider both DG and capacitors for optimal placement problem.

III. PURPOSE OF CONNECTING DG and CAPACITOR

The main objectives of using DG and Capacitor in power system are to minimize power losses, and to improve voltage profile, and improve system reliability. Real and reactive power both plays a crucial character in power system. Real power does the useful work and reactive power is for improve the voltage profile and maintain the voltage within a range. Dew to decrement in the natural resources for power generation such as coal, nuclear and also due to development in technology and also for reducing the environmental pollution DG placement attract the attention of researcher for work in this particular field. Many researchers had worked on this topic for many years because optimal placement of DG and SCB is always a challenging task.

IV. REVIEW OF PREVIOUS WORKS IN THIS AREA

Many researchers had done so much work in this field from the decade because optimal placement and sizing of DG and capacitor is a very challenging issue. If we don't put the DG and SCB at optimal location then there will be no effect on the real power loss and also no effect on the voltage profile improvement. Some of the techniques approaches used for placement of DG optimally to achieve certain objective by various researchers have been mentioned in below.

Sl. No	Method used	Objective function	Number of bus system	Either DG or SCB or both simultaneously	Minimum voltage at bus before connecting the unit	Voltage improvement after connecting the unit	Ref
1	Meta heuristic approach PSO Algorithm	Power loss minimization	33 and 69 bus system	Both DG and SCB simultaneously	For 33 bus at bus 18 voltage is 0.9038 p.u For 69 bus at	For 33 bus minimum voltage at bus 18 voltage will be 0.9570 p.u	16

					bus 65 voltage is 0.9092 p.u	For 69 bus minimum voltage at bus 27 voltage will be 0.9724 p.u	
2	Analytical+ PSO method	Minimize distribution loss	33 and 69 bus system	Both DG and SCB	For 33 bus at bus 18 voltage is 0.905 p.u	For 33 bus after one and two type I DG placement 0.943 p.u and 0.962 p.u respectively After one and two type II DG placement 0.9177 p.u and 0.931 p.u respectively	12
3	Meta heuristic approach Moth flame method	Minimize power loss	33 bus system	Only DG	At bus 18 voltage is 0.9295 p.u	At bus 18 and voltage will be 0.9571 p.u	11
4	Loss reduction sensitivity method and voltage improvement	Minimizing total power loss	IEEE 24 bus system	Only DG	At bus 18 and voltage is 0.93 p.u	At bus 1 , bus 6 and bus 22 Voltage is 1 p.u	1
	method						
5	Meta heuristic approach Slap swarm optimization method	Minimizing total power loss, generation costs and generation emission	IEEE 33 and 69 bus radial distribution system	DG and SCB	At bus 18 for 33 bus system and bus voltage is 0.91 p.u At bus 62 for 69 bus system and bus voltage is 0.911 p.u	At bus 7 for 33 bus system and bus voltage is 0.9918 p.u At bus 65 for 69 bus system and bus voltage is 0.9971 p.u	17
6	Sensitivity analysis based heuristic	Minimizing the real power loss	IEEE 12 and 33 bus system	DG and SCB	For 12 bus system bus voltage is	For 12 bus system DG with upf and capacitor	18

	method and quadratic curve fitting method				0.94414 p.u at bus 12 For 33 bus system bus voltage is 0.9065 p.u at bus 18	bus voltage is 0.9815 p.u at bus 8 For 33 bus system DG with upf and capacitor bus voltage is 0.96003 at bus 30	
8	Genetic algorithm	Minimizing total cost	28 bus System	DG and SCB	Here cost analysis is done so total cost before placing is 7108454 $/P.p	Total cost after placement is 4985172 $/P.p	20
9	Genetic algorithm and moth swarm algorithm	Power loss minimization	IEEE 33 and 69 bus system	DG and SCB	At bus 18 for 33 bus system and voltage is 0.9036 p.u For 69 bus system at bus number 64 and voltage is 0.9092 p.u	At bus 18 and voltage is 0.9938 p.u for 33 bus system At bus 28 and voltage is 0.9976 p.u for 69 bus system	21
10	Multiobjective evolutionary algorithm	Minimizing Real and reactive power loss	IEEE 33, 69, 119 bus system and practical 83 bus system	DG and SCB simultaneously	At bus 18 for 33 bus system and voltage is 0.9032 p.u For 69 bus system at bus number 64 and voltage is 0.9094 p.u	For 33 bus system at bus 18 for 1 DG and 1 SC and bus voltage is 0.935 p.u For 69 bus system at bus 28 for 1 DG and 1 SC and bus voltage is 0.9711	22
						p.u	
11	Ant Lion Optimization Algorithm	Minimizing Real and reactive power loss	IEEE 33,69 bus system	Only DG	At bus 18 for 33 bus system and voltage is 0.9040 p.u For 69 bus	For 33 bus system at bus 18 for 1 PV cell and bus voltage is 0.9503 p.u	23

					system at bus number 64 and voltage is 0.9102 p.u	For 69 bus system at bus 27 for 1 PV cell & bus voltage is 0.9679 p.u	
12	Genetic Algorithm(G A)	Minimize the cost and maintain the voltage within permissible limit	70 bus system	Locally controlled voltage regulator(V.R)	Before V.R placement minimum voltage occurs at bus 36 and minimum voltage is 0.86 p.u	After V.R placement minimum voltageoccurs at bus 29 and minimum voltage is 0.885 p.u	2
13	Chaotic Artificial Bee Colony (CABC) algorithm	Multi-objective function consists of voltage profile enhancement, active power loss minimization and improvement of VSI	38 and 69 bus system		For 38 bus system for mixed load at bus 18 and minimum voltage is 0.952 p.u For 69 bus system for mixed load at bus 65 and the voltage is 0.92 p.u	For 38 bus system for mixed load at bus 18 and minimum voltage is 0.99 p.u For 69 bus system for mixed load at bus 65 and the voltage is 0.97 p.u	24

V. CONCLUSION

In this paper, different types of distributed generation and technologies used for distributed generation are discussed. In addition, a review of research work carried out for optimal placement and sizing of distributed generation and capacitor to achieve certain objectives by various researchers has been presented. The main aims of using DG and capacitors in a power system are to minimize the real power loss in the system and also enhance the system stability and system bus voltage profile.

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