A COMPARATIVE ASSESSMENT OF DISTRIBUTED GENERATION OPTIMIZATION

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ABSTRACT

In the modern era, distributed generation is one of the alternating methods for the utilization of renewable energy resources which enlighten the future of the green energy generation in electrical power system. Distributed energy generators strengthen the power system via its enormous advantages. These technical, financial and environmental advantages could be achieved through optimal sizing and placement of distributed energy resources with the consideration of equitable function, limiting parameters and exerted optimization techniques. In this paper, an exhaustive review is accomplished for the optimal planning of distributed energy generation with the consideration of distinctive optimization techniques.

KEYWORDS: Distributed Generation, Optimization Techniques, Power Quality, Renewable Energy Sources

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INTRODUCTION

Distributed generation (DG) is different from centralized generation of electrical energy which attributes to an approach having the generation through small units situated near to the ultimate users. DG is also recognized as dispersed generation, embedded generation or decentralized generation. Renewable and non-renewable energy resources can be utilization with respect to their technical, financial and environmental advantages by optimal establishing of DG. The qualities of electrical parameters that can be consigned in electrical power systems are: real power loss, reactive power loss, voltage stability, tap setting of transformer, power factor correction, reliability, fault level and total harmonic reduction with the assimilation of DG.

As far as financial objectives are concerned DG capital costs, operational cost and maintenance cost has been considered for cost reduction and maximization of profit. In this process the objective function includes revenue besides the expenditure, penalty factor for constraints violation, integrated cost parameters, fixed and variable cost parameters.

Interestingly, the environmental pollution has been minimized by maximization the use of renewable energy sources. The integrated generating models have been designed unlike centralized generation which exhibits the possible opportunities in solar photo voltaic system, wind power generation, biogas and other natural energy sources. The emission level of hazardous pollutants can also be the objective parameters in a multi-objective function of DG allocation. The challenges of renewable energy amalgamation are the intermittent nature of energy sources which are thoroughly dependent on the meteorological condition and geographical structure.

In DG planning, the objective function has been optimized with the consideration of various constraints to establish the reliability, stability and utility of the system. As per the desired level of operations the various constraints like load flow, voltage profile, line losses, transformer capacity, short circuit level, power quality, number, size and capacity of DG may be a part of single objective or multi-objective function.

LITERATURE REVIEW

(Jana, 2020) In this paper, authors suggested a prediction based solar power plant used in unbalanced power distribution model. The optimization of DG size and location has also been calculated by using Particle swarm optimization process to envisage the capacity of plant and determined power capacity / day. Process has been originated with the varying load modeling followed by unbalanced distribution system and concluded as probable capacity of DG.

(Kumar, 2020) An artificial process hybrid of Particle swarm optimization algorithm and Grey wolf optimization algorithm has been executed for the voltage profile enhancement and optimized real power losses. Photo voltaic cell, fuel cell and variable capacitor type DG has been selected for optimization process and the results are significant for voltage profile improvement and real power losses reduction.

(Lu, 2020) Simulation test has been conducted on physical 10kV feeder of China for the execution of Cluster Coordinated optimization method which exhibits a bi-level approach; investigating voltage handling capacity of internal constellation reactive generators and employing constellation sovereign optimization. Moreover, complex circuits can be converted into an evident network based on essential observational information and Ohmic parameters and evaluated for every cluster autonomously. Concept of this optimization is basically to choose a fundamental load among two nearby nodes and effectiveness of outcomes have been shown with the comparison of other optimization techniques.

(Rafi, 2020) Heuristic nature inspired algorithm namely Dragonfly-Particle swarm optimization shows the prominent results in the enhancement of power losses and voltage profile. Hybrid optimization techniques exhibits dual approach. Dragon fly for optimization of switching sequence and Particle swarm optimization for DG allocation in view of different scenarios of loss reduction like; only active power or only kVAR or complex power .

(Chang, 2020) A mixed integer nonlinear programming objective function solved by two gear technique i.e. Coyote optimization algorithm for variable load levels to minimize the system power losses and voltage tap changing. This, methodology has started with the load flow analysis shadowed by DG allocation and determined with DG sizing. Furthermore, methodology examined for two type of cases; IEEE 123 bus benchmark and Taipower 137 bus.

(Chai, 2020) Challenges of voltage regulation and power losses has been entertained for HV and MV distribution network by Generalized benders decomposition method and simulation test is carried out in Jinzhai distribution network of China. The compensation of crest voltage has been adopted to get the enhanced results in a master- slave network with the increased preciseness of “LinDistFlow” equation. Unlike other optimization techniques, it facilitates the complete utilization of voltage regulation capacity which will reduce the energy losses during off-grid generation and results in terms of cost saving and computational calculation. Multi-objective function is disintegrated into main universal problem and auxiliary problems to generate an iterative process.

(Santosh, 2020) A DG management approach is proposed supervisor units for controlling and optimizing the operations multiple inverters modules of a power grid to operate simultaneously in different dispatch segments. The proposed supervisory unit facilitates the independent services and subsidiary services to enables the various modes of

operations; maximum real power, power factor improvement subjected to authorize connection / disconnection, constant reactive power and active power.

(Fathabad, 2020) a two-stage data-driven distributed robust optimization model has been executed to overcome the present challenges of intermittency in renewable source integration due to lack of informative characteristics as compared to robust and stochastic optimization approaches. The objective function aims to reduce the capital cost, operation cost and green energy generation by increasing the penetration level of renewable energy. Consequently, the cost saving is 20% via optimal size and allocation of DG.

(Karaaom, 2020) Particle swarm optimization method is investigated on a 22 kV power network of Thailand to reduce the system energy losses because of inappropriate location of DG. Additionally, the load transfer concept is used from maximum demand to minimum demand feeder and for this purpose the tie-switch location is identified through this nature inspired optimization algorithm. Comparative results have been demonstrated for the reduced energy loss and voltage profile rise of 40.38% and 6.59 % respectively in a computational time of 3.13 hour.

(Wang, 2020) To enrich the generating capacity of DG and smoothening the voltage fluctuations, reactive power optimization has been modelled by using General algebraic modeling system approach although the utilization capacity of DG is reduced. The recognized multi-objective function (considering voltage variant, real power loss and DG capacity) is converted into single objective functions which are subjected to various constraints like; power balance, balanced node, line power, node voltage, DG output and Reactive power compensator. The variation of active power, reactive power and node voltage irrespective of load demand has also been demonstrated in optimized results.

(Saidah, 2020) The importance of DG planning and allocation is justified with the help of Particle swarm optimization approach in view of enormous advantages which includes the improved: voltage profile, reliability and power quality. The realization is carried out on BasukiRahmat Surabaya feeder by using Graphical user interface system. Bus injection to branch current and branch current to branch voltage matrix is used for load flow analysis and after that Particle swarm optimization technique is demonstrated for the suitable results.

(Singh, 2020) Cost minimization and voltage regulation has been achieved by trivial alteration in moth search optimization called as corrected moth search optimization. A multi-objective function has been developed via optimal placement of DG and shunt capacitors although concurrently optimizing and controlling the tap position of grid transformer and comparable results are also presented with the other established optimization techniques for IEEE 33 and IEEE 118 test system at different loading conditions (peak, normal and light).

(Yang, 2020) A qualitative merging of Genetic algorithm and Ant colony optimization developed a restructured algorithm named as Genetic ant colony optimization and this approach has been demonstrated for the reduction of energy losses and voltage rise. Load flow analysis is completed by forward backward method and implemented the newly developed technique having faster convergence and free from local optima tracking. Obtained results are compared with the Genetic algorithm and Ant colony optimization techniques and hence concluded with the better voltage level, reduced losses and faster convergence rate.

(Saha, 2020) A multi-objective Modified symbiotic organisms search algorithm has been executed for the optimization of capacity and placement of renewable DG which have the intention of achieving the cost minimization (annual electricity purchase cost, annual investment and operating cost), voltage regulation and annual energy loss

reduction at various load level (constant, residential, commercial and industrial) subjected to various constraints like: power balance equation, node voltage limit and DG capacity limit. Hourly demand variation and voltage regulation curve are also significant for the improved results.

A comparative analysis of DG optimization is presented in Table 1.

CONCLUSIONS

A comprehensive review of DG optimization is demonstrated in this paper with its massive recompenses imperiled to various constraints. These enormous benefits are associated to power quality parameters, economic parameters and atmospheric parameters. The literature is reviewed on the basis of optimization techniques, methodology, test system, optimized parameters, type of generation, enhanced outcomes and compared approaches. The optimization techniques can be classified as classical approaches, nature inspired approaches and hybrid approaches depending on their methodology. Moreover these techniques could be compared for the convergence time, available literature, dimensions of objective function and complexity level of implementation. DG has the potential to exploit the dissemination of renewable energy sources to meet the present challenges due to futuristic safe environmental condition.

Table 1: DG Planning and Optimization

Ref .	Optimization technique	Test system	Evaluated parameters	Optimize d results	Type of energy generation	Enhanced outcomes	Compared approaches
2	Particle Swarm Optimization	IEEE 34	DG capacity (kW)	58.928	Battery bank and solar plant	Average voltage profile, line loss , efficiency	Without DG
3	Particle Swarm Optimization algorithm and Grey Wolf Optimization algorithm	IEEE 33	DG location	6	Photo voltaic cell, fuel cell	Active power loss, voltage profile	Without DG
			DG size (MW)	2.576			
			System losses (kW)	103.966			
		IEEE 33	DG location	30	Variable capacitors		
			DG size (MVar)	1.25			
			System losses (kW)	143.6			
		IEEE 69	DG location	61	Photo voltaic cell, fuel cell		
			DG size (MW)	1.869			
			System losses (kW)	83.9013			
		IEEE 69	DG location	61	Variable capacitors		
			DG size (MVar)	1.328			
			System losses (kW)	152.4			
4	Coordinated optimization	IEEE 123	Network losses (MW)	0.8319	PV	active power loss, voltage profile	Centralized optimization , alternating direction method of multipliers based
			Reactive power losses (MVar)	0.6396			
			Maximum voltage (p.u.)	1.05			

			Calculation time (seconds)	16.69			distributed inter-cluster optimization , cluster coordinated optimization and cluster independent optimization
5	Dragon fly-Particleswarm optimization	IEEE 33, DG=1	DG location	29	DG	Real and reactive power loss, voltage profile	Without reconfiguration of DG
			DG size (kW)	830			
			System losses (kVA)	135.44 + j 83.69			
		IEEE 33, DG=2	DG location	29, 24			
			DG size (kW)	830, 340			
			System losses (kVA)	118.40 + j 81.6			
		IEEE 33, DG=3	DG location	29,24, 20			
			DG size (kW)	830, 340, 720			
			System losses (kVA)	116.7 + j 80.44			
6	Coyote Optimization Algorithm	IEEE 123	System losses (kW)	18.2081	Photo voltaic	System power loss reduction rate and the number of tap changes of the voltage regulators.	Mixed integer linear programming, genetic algorithm, particle swarm optimization, biogeography based optimization, grey wolf optimizer
			Loss reduction ratio (%)	77.01			
			V (p.u.)	0.9939 - 1.0023			
			Fitness value	0.2299			
			Time (second)	4097			
7	Generalized Benders decomposition	HV and MV distribution network	Network losses (MW)	0.6877 , 0.0273 , 0.0463 , 0.055	Photo voltaic	Network losses, voltage profile, cost , power factor	Global centralized optimization, Independent optimization
			Cost (Yuan)	333.1			
8	Distributed generation management algorithm	IEEE 13	Active power, reactive power, power factor	Close to reference value	Photo voltaic	Periods of authorized connection and disconnection , power factor compensation , active power limitation, constant reactive power, reliability	
9	Data-driven distributionally robust optimization	IEEE 33	Total cost	17015 K\$	Renewable DG	Capital cost, operational cost	Robust optimization, Stochastic optimization

10	PSO	22 kV distribution system	Energy loss / day (MWh)	36.38	DG	Energy loss, voltage profile	DG without optimization
			voltage rise (p.u.)	0.97			
11	General Algebraic Modeling System	IEEE 33	Reactive power compensators location	4, 5, 6, 11, 25	wind power, PV	Reactive power planning, voltage stability, active losses.	DG without optimization
12	PSO	IEEE 33	DG location	25	BasukiRahmat feeder system (Surabaya)	Reduce power losses and improve the voltage profile	DG without optimization
			DG size (MVA)	9.5			
			System losses (kW)	1.56			
13	Corrected moth search optimization	IEEE 33	DG location	13, 25, 30	DG	Cost minimization, loss reduction, voltage regulation, penetration level	Harmony Search Algorithm, Fireworks Algorithm, dynamic node priority list-genetic algorithm, improved teaching learning based optimization
			Size (MW / MVar)	1.459, 0.987, 1.795			
			Penetration level	60.65%			
			Power loss (MW)	0.1964			
			Annual energy loss (MWh), Price (USD)	712.2, 64820			
		IEEE 118	Location	33, 38, 52, 71, 80, 96, 109			
			Size (MW / MVar)	2.910, 3.225, 2.677, 4.414, 2.276, 2.159, 4.642			
			Penetration level	49.10%			
			Power loss (MW)	1.4622			
			Annual energy loss (MWh), Price (USD)	5241.3, 478229			
14	Genetic ant colony optimization	IEEE 33	Network loss / kW	139.4715	DG	Network losses, voltage rise	Ant colony optimization, Genetic algorithm
			Average iterations	17.4			
15	Multi-objective modified symbiotic organisms search	IEEE 69	DG location	24, 26, 62	Solar photo voltaic, wind power generation, biomass	Cost minimization, voltage regulation	Multi-objective symbiotic organisms search, non-dominated
			DG size (kW)	540,250, 1325.5			
			Annual energy loss (kWh)	299850			

			Annual investment and operating cost (\$)	783670			sorting genetic algorithm-II
			annual electricity purchase cost (\$)	456420			
			Total voltage deviation	5666			

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