A COMPARATIVE ANALYSIS OF OPTIMAL DISTRIBUTED GENERATION PLACEMENT IN POWER DISTRIBUTED NETWORKS

[1]Monika Joshi, [2]Dr. Samina Elyas Mubeen
[1]M-tech scholar Power System, [2] HOD Electrical Engineering
[1,2]REC, Bhopal, India

ABSTRACT: The unification of distributed generation (DG) units in power distributed networks has become progressively vital in recent year. The most motive of the optimum dg placement (ODGP) is to produce the most effective locations and size of dg's to optimize electrical distribution network operation and coming up with taking under consideration DG capability constraints. Since the on top of objective is mixed-integer downside. The traditional ways don't seem to be appropriate for mixed-integer issues. Thus objective of this work is to use the Genetic rule for decisive the optimum location and size of DGs to be put in simultaneously for step-down of value and losses. Genetic rule may be a random search technique for improvement, which simply tackle the mixed-integer kind of issues. The effectiveness of the genetic algorithmic program to unravel the weight unit allocation and filler are incontestable through examples. The results for the best locations and filler of DGs to be put in in distribution system are bestowed. Since system losses area unit reduced by best placement of DGs, thus the potency of the system will increase and improves the voltage profile and stability.

KEYWORDS: Distributed Generation (DG), Distribution Systems Optimization, Optimal Distributed Generation Placement (ODGP),

I. INTRODUCTION

The size and quality of the fashionable day facility have exaggerated considerably because of the ever increasing demand of electrical power. Thus to produce the increasing demand and to take care of the client satisfaction, alternate techniques ought to be thought-about by the facility provide corporations. In recent days the increasing considerations over the environmental problems demand the seek for property sources of energy. During this direction the distributed generation (DG) that is each environmental friendly and can also solve the matter of serving the increasing demand of power plays an awfully vital role.

In the past, because of the "economy of scale" the facility generating stations were usually giant and their capacities were within the vary of 150- one thousand MW. Clearly, such huge power stations need giant facilities, together with land and personnel required to work, and high opportunity cost. Moreover, since these huge power stations can't be created nearer to load centers for a few obvious reasons, there was a necessity for long further High Voltage (EHV) or immoderate High Voltage (UHV) transmission lines, together with transmission substations. Kind of like power stations, these transmission lines associated substations want an ample quantity of cash in style, construction, operation and maintenance. The extended structure of those transmission lines makes them susceptible to natural hazards like serious wind, snowstorms and lightning. These natural hazards, in some cases, become the most important reason for partial or full black out of the facility system triggered by some line outages. These conditions superimposed with economic and environmental pressures have, within the recent past, been dynamical the generation approaches of ancient wattage utilities. A number of the economic and environmental factors related to giant power plants area unit listed below:

- Environmental impacts
- Transmission right of way problems
- High investment and long term planning
- Land requirement for power plant Construction and Resettlement

By considering the on top of factors, one among the simplest alternatives for a modification within the ancient approach of generation and delivery arrangement is to introduce distributed and spread generation, which may be handily settled nearer to load centers. This trend may be a deregulated electricity market, wherever competition is introduced in generation, transmission and distribution. This provides decigram applications a really favorable market. Folks with associate degree interest of getting their own electricity generating facility will do this and therefore the remainder of the facility, once their consumption, may be sold-out for the good thing about all. This releases the govt. burden of investment within the generation sector and will end in a discount in electricity value and improve the standard of provide. [1]. this paper proposes taxonomy of ODGP models and ways, giving a unifying description of a comparatively sizable amount of works dedicated to the topic. This review is a guide to assist researchers and facility engineers on the obtainable decigram placement models and methodologies. This paper introduces qualitative assessment of ODGP models and ways, providing the contribution of all of the reviewed ODGP works. This paper is organized as follows. Sections II and III define and classify the printed models and ways, severally. Section IV discusses the contribution of the reviewed works. Section V suggests future work concepts, and Section VI concludes.

A. DISTRIBUTED GENERATION

DG may be outlined as a small-scale generating unit settled near the load being served. Decigram issues with renewable energy supply like wind turbines, electrical phenomenon, micro-turbines, fuel cells, geothermal, biomass energy, and ocean energy and storage energy devices like batteries.

The distributed generation consists of little generators within the capability starting from ten power unit to fifty MW in a very distribution system that are scattered throughout an influence system to supply power required by customers. They'll give power to one home, business or industrial facility. spread generation may be a set of decigram, with the capability starting from ten to 250 power unit, that is connected to the distribution network up to eleven or one hundred ten or 132 kilovolt. [2]

DG offers an extended list of advantages, which may be, primarily, classified into 3 broad classes, namely, economical, technical and environmental benefits. Economic benefits cowl saving world fuel, saving transmission and cost and reducing wholesale electricity value. On the opposite hand environmental benefits embody low noise and low emission. Technical benefits cowl a good type of problems like peak load saving, smart voltage profile, reduced system losses, improved continuity and responsible ness, removal of some power quality issues and relaxed thermal constraints of Transmission and Distribution (T&D) feeders.

Both the distribution company and/or the client will, in theory, invest in and operate units. As a result of the supply of such a versatile possibility of decigram as associate degree energy supply at the distribution voltage level, the distribution network is currently being reworked from a passive network to an energetic one. This growth and wish for additional versatile electrical systems, dynamical regulative and economic situations, energy savings, environmental impact and therefore the got to defend sensitive masses against network disturbances are providing impetus to the event of spread generation and storage systems supported a spread of technologies. Specifically, the term decigram implies the employment of any standard technology that's sited throughout a utility topographic point to lower the value of services. The decigram as associate degree energy supply within the distribution network can play a big role operational, structure, style and up gradation problems. Decigram technologies, their edges and ideas, and their valuable result on the electricity market create it a reputable different within the distribution system designing. [1]

The importances of decigram is currently being more and more accepted and understand by power engineers. the aim of those plants is to address the growing demand of electricity in sure areas and render sure activities sell-sufficient in terms of power production, therefore achieving energy savings from distribution system designing purpose of read, decigram may be a possible different for brand new capability particularly within the competitive electricity market surroundings.

II. MATHEMATICAL FORMULATIONS

A. General drawback Statement

The typical ODGP drawback deals with the determination of the optimum locations and sizes of decigram units to be put in into existing distribution networks, subject to electrical network operative constraints, decigram operation constraints, and investment constraints. The ODGP may be a advanced mixed number nonlinear improvement drawback.

B. Objective

The objective operate of the ODGP may be single or multi objective. the most single-objective functions are: 1) step-down of the full power loss of the system; 2) step-down of energy losses; 3) step-down of system average interruption du- ration index (SAIDI); 4) step-down of cost; 5) step-down of voltage deviations; 6) maximization of decigram capacity; 7) maximization of profit; 8) maximization of a benefit/cost ratio; and

9) Maximization of voltage limit load ability (i.e., the utmost loading which will be provided by the facility distribution system whereas the voltages the least bit nodes square measure unbroken at intervals the limits).

<u>ODGP multi objective formulations may be classified as:</u>

1) Multi objective operate with weights, wherever the multi objective formulation is reworked into one objective operate victimization the weighted add of individual objectives;

2) Goal multi objective index, wherever the multi objective formulation is reworked into one objective operate victimization the goal programming method;

3) Multi objective formulation considering over one usually contrastive objectives and choosing the simplest com- promise answer in a very set of possible solutions.

C. NO. Of DG's

Depending on the amount of DGs to be put in, the ODGP drawback is classed as: 1) single decigram or 2) multiple DGs installation.

D. DG's Variables

The following style variables (unknowns) square measure or else computed for every DG: 1) location; 2) size; 3) location and size;

4) Type, location and size; 5) variety, location and size; and 6) variety, type, location, and size. Decigram kind refers to decigram technology, e.g., wind, solar, biomass, fuel cell, and diesel.

As associate example, allow us to take into account the above-named second case wherever the planning variable is just the decigram size. This specific category of ODGP drawback is extremely attention-grabbing within the sensible grid system, wherever the usage of renewable energy is anticipated to in- crease. However, placement of those renewable DGs is greatly influenced by the natural atmosphere. Therefore, it's vital to work out the dimensions of renewable energy once the position is mounted [76], [81].

E. Load Variables

The load profile is modelled in ODGP as: 1) one-load level; 2) Multi-load level; 3) time-varying; 4) probabilistic; and 5) fuzzy.

The load may be either distributed on the lines, or targeting the network buses. Just in case of targeted load, the subsequent modelling alternatives exist: 1) constant power; 2) variable power that depends on the magnitude of bus voltage; 3) Probabilistic; and 4) fuzzy.

F. decigram Technology

DG may be rotating devices (synchronous or asynchronous machines) directly coupled to the network, or they'll be rotating or static devices interfaced via electronic converters. Once connected to the facility system, these decigram technologies have completely different impacts on facility operation, control, and stability [86], [87]. As an example, inverter-based decigram units have voltage management capability. Moreover, they impact system harmonic levels over synchronous-based decigram. On the opposite hand, directly coupled rotating decigram units have a far a lot of profound result on protection coordination than converter-interfaced decigram units. Thus, these facility impacts of decigram technology have an effect on the dimensions and optimum placement of decigram [82], [83].

G. Constraints

The most common constraints within the ODGP formulation are: 1) power flow equality constraints; 2) bus voltage or drop limits; and 3) line or electrical device overloading or capability limits—moreover, the subsequent constraints are thought of in some ODGP models: 4) total harmonic voltage distortion limit; 5) short-circuit level limit; 6) responsibility constraints, e.g., GHB SAIDI; 7) power generation limits, 8) budget limit, 9) decigram with constant power factor; 10) decigram penetration limit; 11) most variety of decigrams; 12) restricted buses for decigram installation; and 13) separate size of DG units.

III. NUMERICAL METHODS

1) Gradient Search:

Gradient explore for the optimum filler of DGs in meshed networks, ignoring and considering fault level constraints, is projected in [1] and [17], severally.

2) Linear programming (LP):

record is employed to resolve ODGP models in [15] and [21], achieving most dg penetration and most dg energy harvesting, severally.

3) Consecutive Quadratic Programming (SQP):

SQP is applied to resolve ODGP while not and with fault level constraints, in [53] and [10], severally.

4) Nonlinear Programming (NLP):

A distinct probabilistic generation-load model with all potential operational conditions is reduced into a settled model that's resolved employing a mixed whole number nonlinear programming (MINLP) technique for optimally allocating either solely wind weight unit units [54], or differing kinds of weight units [44].

5) Dynamic Programming (DP):

DP is applied to resolve Associate in Nursing ODGP model that maximizes the profit of the distribution network operator (DNO) and considers lightweight, medium, and peak load conditions [58].

6) Ordinal improvement (OI):

Associate in Nursing OO technique is developed in [40] for specifying the locations and sizes of multiple weight units specified a trade-off between loss reduction and DG capability maximization is achieved.

7) Thoroughgoing Search:

The ODGP is resolved by Associate in Nursing thoroughgoing search that seeks the weight unit location that optimizes the target perform (maximization of reliable ness or reduction of system power loss) for a given weight unit size [18].

A. Heuristic ways

1) Genetic rule (GA):

GA Associate in nursing an improved whiteface ranch rule (variant of GA) area unit projected in [2] for DGs optimum filler. GA is applied to resolve Associate in Nursing ODGP drawback with reliable ness constraints in [19]. GA is employed to resolve Associate in Nursing ODGP that considers variable power focused load models [36], distributed hundreds [35], and constant power focused hundreds [35], [41].].

2) Tabu Search (TS):

The ODGP drawback is resolved by the TS technique for the case of uniformly distributed hundreds [4]. TS at the same time solve ODGP and optimum placement of reactive power sources [24]. A continual random ODGP model is resolved by a GA additionally as by a combined TS and scatter search [65].

3) Particle Swarm improvement (PSO):

PSO is applied to resolve Associate in Nursing ODGP model in distribution system with non-unity power issue considering variable power load models [63]. Associate in nursing improved PSO is projected for optimum placement of assorted weight unit varieties that inject real power and inject or absorb reactive power [55]. A hybrid GA and PSO is usually recommended in [71].

4) Hymenopterans insect Colony Optimization:

Associate hymenopterans insect colony system (ACS) rule is projected to resolve the ODGP [34].

5) Artificial Bee Colony (ABC):

Associate alphabet technique, with solely 2 management parameters to be tuned, is projected in [66].

6) Differential Evolution (DE):

The optimum weight unit locations area unit computed supported progressive bus voltage sensitivities and also the optimum weight unit sizes area unit calculated by First State [78].

7) Harmony Search (HS):

The optimum weight unit location relies on loss sensitivity factors and also the optimum weight unit size is obtained by HS rule [80].

8) Sensible Heuristic Algorithms:

A heuristic approach Places one weight unit supported the ranking of the energy not provided index or the ranking of the ability losses within the network lines [72]. A heuristic cost-benefit approach for ODGP to serve peak demands optimally in an exceedingly competitive electricity market is introduced in [7]. A heuristic value-based approach determines the optimum location of one weight unit by minimizing the system reliable ness value [69]. Sensitivity analysis and loss sensitivity analysis of power flow equations together with a security strained improvement technique [13]. A heuristic technique calculates the regions of upper chance for location of weight unit plants [46]. The ODGP for tiny distribution networks is resolved by a heuristic technique in [52]. The ODGP is resolved by a heuristic repetitious technique in 2 stages, during which agglomeration techniques and thoroughgoing search area unit exploited [77]. Sensitivity takes a look at computes the optimum location and a heuristic curve-fitted technique provides the optimum size of weight unit [59]. Heuristic ways for filler wind farms supported modes of voltage instability area unit developed in [76].

IV. EVALUATION

Analytical ways area unit simple to implement and quick to exe- cute. However, their results area unit solely indicative, since they create simplified assumptions as well as the thought of only 1 grid loading photo. Among the offered numerical ways for ODGP, the foremost economical area unit the nonlinear programming, the consecutive quadratic programming and also the ordinal improvement ways. The most advantage of the thoroughgoing search technique is that it guarantees the finding of the worldwide optimum; but, it's not appropriate for large-scale a system, that is additionally a drawback for dynamic programming technique. Heuristic methods are usually robust and provide near optimal solutions for large, complex ODGP problems. Generally, they require high computational effort. However, this limitation is not necessarily critical in DG placement applications. Heuristic ways in which unit of measurement usually durable and provide near optimum solutions for giant, sophisticated ODGP issues. Generally, they have high machine effort. However, this limitation is not basically crucial in weight unit placement applications.

V. CONTRIBUTION OF THE REVIEWED WORKS

Table I describes the main contribution of the published ODGP works reviewed in this paper in a chronological order.

Table I Taxonomy and contribution of the reviewed optimal DG placement Models

REF. NO.	NO. OF DG'S	DESIGN VARIABLES	LOAD PROFILE	LOAD MODEL	OBJECTIVE	OBJECTIVE FUNCTION	PUBLISHED	CONTRIBUTION
64	Single	Location + Size	One load level	Variable power	Multiple	Multi Objective	2011	Multi objective ODGP, considering voltage rise issue and voltage dependent load, is solved by an interactive trade off methods.
65	Multiple	Type + location + size	Probabilistic	Probabilistic	Single	Min cost	2011	A continuous stochastic ODGP model considering wind power volatility and load uncertainty utilizing the moment method.
66	Multiple	Location + size	One load level	Constant power	Single	Min power loss	2011	An ABC method is proposed to compute the optimal DG unit's location, size, and power factor.
67	Multiple	Type + location + size	Probabilistic	Probabilistic	Multiple	Multi objective with weights	2011	A monte carlo simulation embedded GA solve an ODGP with uncertainties represented by probability distribution functions.
68	Multiple	Location + size	Multi load level	Constant power	Single	Min cost	2011	Simultaneous allocation of DGs and remove controllable switches considering a quantized multilevel load model.
69	Single	Location	One load level	Constant power	Single	Min cost	2011	The optimal location of DGs is based on system reliability cost that is evaluated by a probabilistic approach.
70	Multiple	Location + size	One load level	Constant power	Single	Max voltage limit load ability	2011	An ODGP model that maximizes the voltage limit load ability is solved by a heuristic method based on continuation power flow.
71	Multiple	Location + size	One load level	Constant power	Multiple	Multi objective with weights	2012	ODGP is solved by a hybrid GA-PSO, Where the GA searches the site of DG and the PSO optimizes the size of DGs.
72	Single	Location	Multi load level	Constant power	Single	Min power loss	2012	An ODGP method based on the ranking of non-supplied energy and a method based on the ranking of power losses in lines.
73	Multiple	Number + location + size	One load level	Constant power	Multiple	Goal objective index	2012	ODGP, with a precise DG power flow model for wind turbines, is formulated as a single objective goal programming problem.
74	Multiple	Location	Multi load level	Constant power	Single	Max profit	2012	ODGP is formulated as a bi-level programming problem solved by Chu-beasley GA codified to avoid non-feasible solutions.
75	Multiple	Location + size	One load level	Constant power	Single	Min cost	2012	A hybrid model, which employs discrete particle swarm optimization and optimal power flow, is proposed for the ODGP problem.
76	Multiple	Size	One load level	Constant power	Single	Max DG capacity	2012	Method to increase wind penetration level by placing new wind generation at voltage stability strong wind injection buses.
77	Multiple	Location + size	Time varying	Constant power	Multiple	Multi objective with weights	2012	A two stage iterative method exploiting information on the time varying voltage magnitude and loss sensitivity factor at each node.
78	Multiple	Location + size	One load level	Constant power	Single	Min power loss	2012	ODGP considering voltage stability is solved by differential evolution in conjunction with incremental bus voltage sensitivities.
79	Multiple	Location + size	One load level	Constant power	Single	Min power loss	2013	An improved analytical method compute the optimal location and size of multiple distributed generation units.

80	Multiple	Location + size	Multi load level	Constant power	Single	Min power loss	2014	Network reconfiguration and optimal DG placement are dealt simultaneously and solved by harmony search method.
81	Multiple	Size	Time varying	Probabilistic	Single	Min cost	2014	ODGP considering the uncertainty and variability associated with the output power of renewable DG as well as load.
82	Multiple	Type + location + size	Time varying	Probabilistic	Single	Max voltage index	2015	ODGP to improve voltage stability considering the probabilistic nature of both the renewable resources and the load demand.
83	Multiple	Type + location + size	Multi load level	Constant power	Single	Max DG capacity	2015	ODGP of inverted based and synchronous based DGs considering standard harmonic limits and protection coordination constraints.

VI. CONCLUSION

This paper presents an intensive description of the state-of- the-art models and improvement ways applied to the ODGP drawback, analyzing and classifying current and future analysis trends during this field. The foremost common ODGP model has the subsequent characteristics: 1) installation of multiple DGs; 2) the look variables square measure the placement and size; and 3) the target is that the diminution of the whole power loss of the system. The answer methodologies for the ODGP drawback square measure classified into 3 major categories: analytical, numerical and heuristic ways. The foremost oftentimes used techniques for the answer of the ODGP drawback square measure the genetic formula and varied sensible heuristic algorithms. Future analysis areas embody coordinated designing, dynamic ODGP, uncertainties and random improvement, active network management, and islanded operation.

VII. FUTURE ANALYSIS

1) Coordinated designing.
2) Dynamic ODGP.
3) Uncertainties and random improvement
4) Active network management (ANM
5) Islanded operation
6) Appurtenant services.
7) Additional enhancements in strategies

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