# REVIEW ON DISTRIBUTED GENERATOR PLACEMENT BY OPTIMIZATION USING SWARM INTELLIGENCE

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***Abstract-*** Deregulation of the electricity sector has created many opportunities to develop new technologies. Dispersed generation is one of those technologies to meet the ever-increasing demand of electricity. The term "Dispersed Generation" refers to small-scale electric generation units close to the point of consumption. The advantages could be maximized by proper positioning of DG units at optimum location with ideal capacity and suitable type of DG unit. Distribution generation allows collection of energy from many sources and may give lower environmental impacts and improved security of supply. The applications of distributed generation (DG) models is raising in current smart grids and power devices. A significant issue with DGs is their particular optimal area and dimension within the circulation system. This paper involves the use of particle swarm optimization (PSO) in conjunction with genetic algorithms suggested for sizing and optimal placement of DG models to be able to decrease network blockage. The purpose of such models includes minimization of the operation and investment costs and voltage profile improvement. The IEEE 30-bus test program can be used to illustrate the potency of the recommended comparison with ANN. The proposed approach decreases the cost and loss due to its global and local forecast.

***Keywords:*** *Distributed or Dispersed generation, Deregulated generation, Transmission and Distribution.*

## I. INTRODUCTION

The use of renewable technologies is usually restricted to areas with low load and population densities. The distribution networks in such areas are constructed or designed to provide the increasing demands of the consumers that tend to decrease with transmission system distance. So, the use of such a network provides a great interest to the regulators of the industry and its utility [13]. This concept covers the additional benefits related to the distributed or dispersed types of compatible resources in the distinct locations of the network. These resources include small storage or modular based generation. Depending upon the changes done in the electrical industry, the use of such small portable or modular generation types provides a great interest. The rising issues of siting the big station plants, an increase in demand have made such modular resources as an additional benefit attracting the consumers based on the methods or the ability to change the projecting conditions [14]. This basically provides dispersed forms of small modular installations very close to point-of-end use. Hence, the dispersed or distributed network has become a major electrical energy driven source in the present as well as the future-based generation. So, the main reason to use such dispersed systems relies on the following fact:

- The deregulation of power has encouraged the public investment in order to continue the power demand. This has resulted in breaking investments for the power development.
- The emergence of new technologies with large profitability, benefits, and smaller ratings.
- The rising demands and the saturation of the networks that already exist.

The distributed resources should be located optimally to minimize the line loadings, reactive power need, and the losses of the network [49, 64]. The whole process of optimization should actively work on land costs, availability of the site, maintenance costs, plant operations conditions, etc.

### *1.1 DG: Deregulated Environment*

The process of distributed generation in a deregulated environment plays a significant role in fulfilling the energy demands of future providing the free environment and the flexibility to its users in developing and planning the type of installation required as per the load critical conditions. It has the capability to serve as an alternate possible solution with a great potential. The continuous improvement in DG technology helps in providing electricity to its consumers in a very cost-effective nature. In case of competitive (wholesale) deregulated environment, the users owing their DG's responds to very high price swings in order to decrease the price volatility. The DG's operated on utility are considered as the most suitable option for the process of planning. In emergency conditions, some part of the whole load is shifted on an isolated type of generator which provides some relief to the burden faced by utility [3, 4]. If a small unit of DG fails, it does not affect the reliability of the working operation.

### *1.2 DG: Technologies*

*1. Microturbines:* Microturbines promise low emission levels, but the units are currently relatively expensive. Obtaining reasonable costs and demonstrating reliability will be major hurdles for manufacturers. Microturbines are just entering the marketplace, and most installations are for the purpose of testing the technology.

*2. Reciprocating engines:* The engines range in size from less than 5 to over5,000 kW, and use diesel, natural gas, or waste gas as their fuel source. Reciprocating engines are being used primarily for backup power, peaking power, and in cogeneration applications.

*3. Photovoltaics:* Commonly known as solar panels, photovoltaic (PV) panels are widely available for both commercial and domestic use. Panels range from less than 5 kW and units can be combined to form a system of any size. They produce no emissions, and require minimal maintenance.

*4. Industrial combustion turbines***:** A mature technology, combustion turbines range from 1 MW to over 5 MW. They have low capital cost, low emission levels, but also usually low electric efficiency ratings. Development efforts are focused on increasing efficiency levels for this widely available technology. Industrial combustion turbines are being used primarily for peaking power and in cogeneration applications.

*5. Wind turbine systems:* Wind turbines are currently available from many manufacturers and range in size from less than 5 to over 1,000 kW. They provide a relatively inexpensive (compared to other renewables) way to produce electricity, but as they rely upon the variable and somewhat unpredictable wind, are unsuitable for continuous power needs.

*6. Fuel Cells:* Fuel cells are not only very efficient but also have very low emission levels. A fuel cell operates like a battery. It supplies electricity by combining hydrogen and oxygen electrochemically without combustion. The few fuel cells currently being used provide premium power. There are several types of fuel cells. Proton exchange membrane fuel cells are now days the most commercially available type. They have the highest energy density per volume rate and their prices are expected to fall fast because they are being adapted by the automotive industry for transportation use [8].

***1.3 DG Installations: Barriers***

The DG installation barriers are categorized into three parts described in the below section [12].

*1. Economic Barriers:* These represent a major type of barrier to the process of installing a DG. In the present scenario, the DG owner gets a large amount of profit from the power that is generated, whereas the operator of the DG (DGO) with whom the unit is connected to the grid faces the problems related to cost upgradation and unpredictable implications of the power supplied to the grid. Therefore, the DGO considers it as a matter of nuisance rather than a benefit or opportunity. Moreover, it does not help the independent customers or householder to expect the working of such generation units on the daily basis.

*2.Technical Barriers:* This basically represents the barriers related to power quality (PQ) issues as the concept of PQ denotes a very powerful tool of the electrical engineering field. In relation to DG, the PQ issues include the flickering level, amplitude of the steady state voltage, and the presence of harmonics faced or experienced by the users [12].

*3. Protection:* Such type of distribution systems has to perform like a host to deal with a distributed form of generation and this poses various implication related to protection based on unwanted islanding, selectivity, reliability, and short-circuit (SC) levels. So, while implementing the DG's these upper and lower limits should be strictly kept in mind.

***1.4 Need for DG planning***

Legislature of Republic of India has brought different rules to satisfy the interest regardless of it 56% of family units still don't access the electrical form of energy [9, 10]. As appeared in table 1, presently India has network or grid associated complete introduced limit (total capacity installed) of 212 GW for the generation of power and it is assessed that to the ascent at a normal yearly development rate at 8 %, its electricity generation installed would reach up to 779 GW inside two decades. To satisfy the enormous interest of extended grid operation and centralized electricity generation does not represent a great alternative. The power generation in a distributed form, in light of privately offered vitality sources and proposal of such an extra power into the rural grid of electricity, can be a significant piece of the answer for reliable electricity supply of power to rural populace [9]. DG is spotless and consistent so it is great from the view of condition-based perspective, which makes it a superior choice. In this way, with an eye on supported GDP development of 8% and to accomplish the objectives of power generation in upcoming a very long time as appeared in Table1, DG appears as could be expected under the circumstances.

**Table 1:** Projected demand of energy

| Year | Installed Capacity (GW) (For 8% GDP Growth) |
|---|---|
| 2011-12 | 220 |
| 2016-17 | 306 |
| 2021-22 | 425 |
| 2026-27 | 575 |
| 2031-32 | 779 |

***1.5 DG Planning Methodologies***

In order to evaluate the configurations plans for DG. The planning is based on various considerations and the selection is done with the help of attributes described by existing at a specific time [59]. The attributes are selected, considering the cost of the capital, injecting profits into grids (peak-load), and energy not served (annually).

*1. Standard Market Design: SMD:* The penetration and placement level of DG represents a major issue both for the utility and the owner of the DG. As a commodity, the cost of electricity relies on the market-based model. The restructured power markets have been developing very slowly with some standards, and one such kind of standard is SMD (standard market design). The main feature of this design is the LMP scheme (locational Marginal Price). The issues related to placing the units of DG relies on the nodal basis of LMP's. The placing of DG optimally needs to find certain strategic locations in accordance with the consumer cost level of energy. Here, the level of penetration for DG explains the percent of demand that is supplied (economically) on the total basis [2]. In this type of technique, the electricity cost from the grid is presented by the LMP (nodal) scheme while the DG electricity cost mainly depends on its capacity, types, etc. The first method is to locate DG (economically) at the feasible place and the level of penetration is incrementally computed with the help of OPF (optimal power flow). The mechanism of OPF is used in scheduling the generations in MW and minimizes the generation cost [7, 8].

*2. Power Flow Software: PSS/E:* PSS/E represents a software-based tool used globally by the participants of the electrical transmission process. This powerful tool with its advanced dynamics and the probabilistic analysis helps in providing the planning operator a wide range of strategies or methodologies for designing and operating a reliable form of network. This software provides vast advancements in the field of technology such as fault analysis, power flow, limit analysis, a dynamical form of simulation, open access, and the reduction in the network [5, 6].

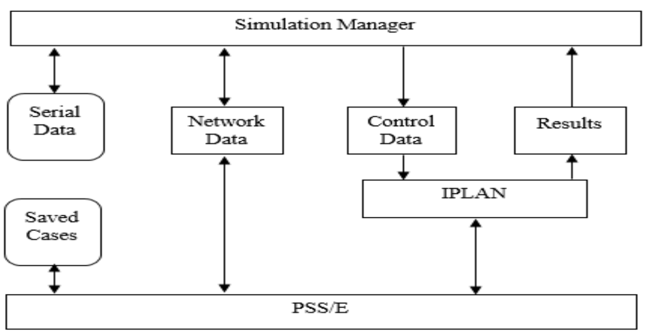


**Figure 1.10:** Data Flow Process

*3. Gradient & Second Order Method:* The gradient and the second order methods are basically used for generating the solutions optimally. This type of planning involves the process of formulating the function of power cost that is minimized when subjected to inequality and equality type of constraints. The method or programming based on OPF tries to find the losses at lower levels, but the losses in total may not represent the global minima mainly due to the constraint's generation costs [1]. So, the major reason to use such type of methods is to reduce the effects of line loadings that arise from the network losses and to gain maximum benefit from the process. The cost and the benefit functions are illustrated as follows:

$$Benefit^{DG} = k_A\left(\Delta P_{loss}^{avg} + \sum_{i=1}^{N_G} DG_{gen,i}^{avg}\right) * CPV_1 + (CIC^{DG} - CIC^0) * CPV_2 \dots\dots\dots..(1)$$

$$Cost^{DG} = \left(\sum_{i=1}^{N_G} Cost_{inv,i}\right) + \sum_{i=1}^{N_G}\left(Cost_{oper} + Cost_{main,i}\right) * CPV_1 \dots\dots\dots\dots\dots\dots.(2)$$

Where, CPV←a Cumulative present value that provides a discount for costs in the future. For the cost of operating and power loss, cost reduction, and the maintenance, the parameter $CPV_1$ usually inherits the rate of interest, inflation rate, and life of product based economically and for the parameter (CIC), the $CPV_2$, in addition to load growth rate, it takes the same attributes as for parameter $CPV_1$. After the calculation of the cost and the benefit functions, some of iterative methods the the such as genetic algorithm, ANN, PSO optimization are performed for obtaining the best results.

*4. Multi-Attribute Decision Making:* The problems of decision making based on MADM methodology is generally solved by the transformation process of n-dimensional vector quantity into a scalar quantity with the use of a function named multi-attribute utility function, popularly known. It consists of weighting parameters in association with attributes selection and the single utility function. It is separated into a series based on an assessment of the attributes or values which represents its linear additive form, as the single attribute contribution to utility (composite) does not depend on other values of the attribute. In general, the utility function, the linear additive model is given as:

$$Ut(x) = \sum_{i=1}^{n} w_i * Ut_i(x_i) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.(3)$$

Where $Ut(x)$← Composite Utility which is characterized by vector-based attributes

$x = [x_{i.....}x_n]$; $Ut_i(x_i)$← denotes the function of single utility w.r.t $i^{th}$ attribute, and $w_i$ is parameter (weightia a a ng) for the $i^{th}$ attribute. Thus, this method is based on the two of its productive methods named weighting parameter and the individual utility function.

## II. RELATED WORK

Henrique S., et.al [1] proposed the study with the main objective of demonstrating the DG analysis as a voltage and volt/var control (reactive power control) instrument or equipment in the test performed on the distribution system. A control equipment was used that consisted of inverter frequency of the photovoltaic generation system which operated with traditional equipment performing a voltage control. Here, a software named Open Distribution System Simulator (OpenDSS) was in use for attaining the desired results along with a standardized (IEEE 13-bus) system. Janmejay Sharma, et.al [2] conducted a review planning of distribution generation relating to the networks of distribution and the distinct performance levels based on power system analysis like minimizing the losses generated by the real and the reactive power of the system which enhances or updates the system's stability, load ability, security, reliability, capacity of transferring the power, flexible operation bandwidth, reduce short circuit capacity and the oscillations, provides support of real and the reactive power, and provides great environment friendly transmission. The research basically relies on the current status DG planning from different perspectives of the system. It is a very useful approach for the researchers to deeply analyze the performance of the system. Molzahn, et.al [3] conducted a survey of certain optimized applications of distributed algorithms and the control of power systems. Specifically, this research reviewed the distributed algorithms based on solutions in online and offline modes. The use of offline method was based on an optimal power flow (OPF) issue whereas the online mode was for a solution (real-time) of OPF, optimal wide-area control optimal voltage control, and optimal frequency control problems. Rajendran, et.al [4] conducted a study based on distinct types of DGs with the optimized single or multiple installations that were used to regard the growth annually in the system of the load, with the satisfaction of system constraints (operational). A pre-determined growth in the annual system load was considered with the main aim of reducing or minimizing the system loss of the total real power, and it consisted of determining the sizing and the optimal location of the DG using a configuration (hybrid-form) of weight-improved particle swarm optimization, generally known as WIPO along with GSA that is gravitational search algorithm jointly forming hybrid an algorithm based on WIPO-GSA. A 33-bus radially distribution system was taken to observe the effects of the growth rate of load. The results illustrated that there was a good improvement in the capacity of carrying a load of feeder-based sections, a huge reduction in real and reactive power loses, and an enhancement in voltage profile of the system. Here, at the same time, the economic benefits of DG on the annual growth of the system were established. Abapour, et.al [5] proposed a model that determined the location, investment of time, and optimal size for DG units. A modeling approach based on the present scenario has been used for determining the uncertainty of load growth rate and the energy price. In order to demonstrate the merits of DG planning, the result of the process was compared with the static models along with a comparison of active network DG planning with that of a mode based on a passive operation. Additionally, a technical comparison and evaluation were done between passive, active and conventional networks. The model has been proposed was applied 33-bus system based on a radial distribution network. The study indicates that the use of AM results in minimizing the losses and the cost function effectively as compared to the passive type management. Muñoz-Delgado, et.al [6] proposed a study based on planning problem with the multi-stage expansion of distribution system where the financial investment in distributed generation and distribution network have been considered jointly. The expansion of the network was comprised of various alternatives for the transformers and the feeders. Similarly, the DG installation was based on various alternatives for wind and other conventional type's generators. Here, the approach basically consists of different types of set-nodes for the installation of the generator. Therefore, the expansion plan that has been optimized helps in identifying the best suitable location, alternative, and installation time for the candidate's assets. Usually, this model was driven by minimizing total cost's present value (net-value) that included the cost linked to its maintenance, investment, unserved energy, production, and the losses. The energy losses cost was modeled by linear approximated method prices. Consisting of an additional feature which was based on radial conditions that uniquely tailored to entertain the distribution generation presence and the problems linked with transfer nodes. The results have shown the optimization issue enlightened a linear program mixed-integer method where the process of convergence (finite) relying on optimization process was guaranteed, with the availability of the software. This methodology out-performs the proposed approach. Wen-Shan, et.al [7] presented reviews on some of the populous renewably based distributed generation locating methods that include the Optimal Power Flow, Mixed-Integer Non-linear Programming 2/3 Rule, Analytical Methods, Hybrid Intelligent System, and various intelligent optimization techniques. Each and every method represented its exceptional potential and feature for the promotion of distributed generation in accordance with renewable energy systems. Edward J., et.al [8] addressed several types of possibilities which handled issues on grid planning processes. Effects on voltage control, grid protection, and fault levels are investigated and described. Such aspects were illustrated in addition of simulation techniques on the already existed grid distribution. The study demonstrated that in the case of a compact form of grid distribution, the problem of voltage control does not occur likely but the issues related to fault levels and the false tripping needs a special care. South Asia Energy Unit [9] This archive means to encourage further talk of the fundamental strides to actualize and standardize the proposed plans of action and to present the important approach and administrative changes it exhibits the alternatives accessible to the utility to address the issue of making power available to rustic regions. It further builds up the monetary structure for recognizing markets that are alluring to DG&S and the money related instruments for guaranteeing that the model turns out to be financially reasonable for speculators just as utilities. It likewise outlined the national and worldwide points of reference for upgrading power access through different models that include DG in mode i.e. grid-connected or off-grid private-area cooperation as franchisees. YG. Hegazy et.al [10] exhibited a Monte Carlo-based strategy for the sufficiency appraisal of DG frameworks. The state term examining approach was utilized in this study to display the working narratives of the introduced DGs. A general strategy to evaluate the capacity of the framework control ability to satisfy the total need was displayed and actualized in a regular contextual investigation where a few units of DG were running in parallel inside a sample-based distribution framework and the framework edges, the normal measure of unsupplied burdens were assessed utilizing simulation of Monte Carlo method. The outcomes acquired were displayed and novel viewpoint to energy management to distribution frameworks was talked about.

Table.1 Existing Scheduling Model

| Author's Name | Year | Methodology Used | Proposed Work |
|---|---|---|---|
| **Henrique S., *et.al*** | 20182 | Open Distribution System Simulator (OpenDSS) | Proposed the study with the main objective of demonstrating the DG analysis as a voltage and volt/var control (reactive power control) instrument or equipment in the test performed on the distribution system. |
| **Molzahn, *et.al*** | 2017 | Offline method | Conducted a survey of certain optimized applications of distributed algorithms and the control of power systems. |
| **Rajendran, *et.al*** | 2017 | Weight-Improved Particle Swarm Optimization along with gravitational search algorithm (WIPO-GSA) | Conducted a study based on distinct types of DGs with the optimized single or multiple installations that were used to regard the growth annually in the system of the load, with the satisfaction of system constraints (operational). |
| **Wen-Shan, *et.al*** | 2013 | Optimal Power Flow, Mixed-Integer Non-linear Programming 2/3 Rule, Analytical Methods, Hybrid Intelligent System, and various intelligent optimization techniques | Presented reviews on some of the populous renewably based distributed generation locating methods. |
| **Bhowmik, S., *et.al*** | 2000 | An algorithm has been developed by considering an objective function (non-linear) with both the linear and non-linear type of constraints for radial distribution system | Described a new planning method for the distribution system. |

S. Ropenus et.al [11] When distributed electricity supply surpasses a particular level, it can no longer be ignored in planning and operation of the electricity networks. Therefore, improvements of the regulatory framework of the electricity networks were required along with the growth of the electricity supply from distributed generation. This paper reviewed the current regulation of the grids with respect to distributed generation in EU-15 Member States and compares the different systems. Several barriers were identified. T. C. Green, et.al [13] presented a methodology for the sizing and the siting of the DG constraint system based on the security. The case of optimal siting was determined by analyzing the sensitivity of the power row equations. A method known as siring method was used for penetration level of generation, set of loading conditions, and power factor formulated such that it worked as a constraint problem of optimization based on security. The use of optimal generation site information was considered to optimize the reliability of the system via the indices obtained from the reliability calculations. In order to design such a method for solving the re-closing positions, a genetic algorithm was used. Bhowmik, S., et.al [12] described a new planning method for the distribution system. In order to obtain an optimized solution, an algorithm has been developed by considering an objective function (non-linear) with both the linear and non-linear type of constraints for radial distribution system at a very large extent. Here, the objective function was optimized through the reduction in cost functioning operation. Further, a three-step iteration was performed. The first step includes the substation optimization process which determined the substation sites number with its exact location, the second step covered the feeder optimization which determined the feeder number with the actual original route and the final stage represented the reliability of system node.

## IV. CONCLUSION

The results likewise indicate that DG devices definitely form a successful tool in dropping the loading of transmission lines. Moreover, with right direction as presented in the paper, DG units are effectively useful in reduction of program losses while increasing the reliability of the program simply by improving stresses and refining the entire voltage profiles on the transmission network path. The proposed methodology presents the reduced amount of cost as indicated by power factor.

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