Optimization techniques applied for optimal planning and integration of renewable energy sources based on distributed generation: Recent trends

Abdurrahman Shuaibu Hassan\textsuperscript{1*}, Yanxia Sun\textsuperscript{1*} and Zenghui Wang\textsuperscript{2}

Abstract: Numerous potential advantages to the requirements and effectiveness of the supplied electricity can be accomplished by the installation of distributed generation units. In order to take full advantage of these benefits, it is essential to position the Distributed Generation (DG) units in appropriate locations. Otherwise, their installation may have an adverse effect on the quality of energy and system operation. Several optimization techniques have been created over the years to optimize distributed generation integration. Optimization techniques are therefore constantly changing and have been the main attention of many fresh types of research lately. This article evaluates cutting-edge techniques of optimizing the issue of positioning and sizing distributed generation units from renewable energy sources based on recent papers that have already been applied to distribution.

ABOUT THE AUTHORS
Abdurrahman Shuaibu Hassan received the B.Eng in Electrical Engineering from Kano University of Science and Technology Wudil 2011, M.Tech Degree in Electrical Electronics Engineering, from Sharda University Greater Noida India in 2015. HS Shuaibu is currently a Doctoral candidate at university of Johannesburg since 2018 - date. His scientific work is focused on Renewable based distributed generation.

Yanxia Sun received her joint qualification: DTech in Electrical Engineering, Tshwane University of Technology, South Africa and PhD in Computer Science, University Paris-EST, France in 2012. She has therefore an approach that brings together computing and electrical engineering. She has more than 10 years teaching and research experience and an associate professor now in University of Johannesburg.

Zenghui Wang received the B.E degree in Automation, Naval Aviation Engineering Academy, China, in 2002 and Ph.D. degree in Control Theory and Control Engineering, Nankai University, China, in 2007. Currently he is a Professor in the Department of Electrical and Mining Engineering, University of South Africa (UNISA), South Africa.

PUBLIC INTEREST STATEMENT
Several optimization techniques have been created over the years to optimize the integration of distributed generation. Optimization techniques are therefore constantly changing and have been the main attention of many fresh types of research lately. This article evaluates cutting-edge techniques of optimizing the issue of positioning and sizing distributed generation units from renewable energy sources based on recent papers that have already been applied to the distribution system. Furthermore, this article pointed out the environmental, economic, technological and regulatory drivers that lead to a rapid interest in the DG system based on renewable sources. According to the investigation carried out, the area of artificial intelligence techniques is still receiving attention than conventional optimization techniques for optimal DG planning in a power distribution network system from different point of view. Computational techniques in hybrid optimization techniques convergence take place faster than the conventional optimization techniques.
system optimization. Furthermore, this article pointed out the environmental, economic, technological and regulatory drivers that lead to a rapid interest in the DG system based on renewable sources. A summary of popular meta-heuristic optimization tools discussed in table form with merits and demerits to increase fresh prospective paths to multi-approach that have not yet been studied.

Subjects: Environmental Studies & Management; Mathematics & Statistics; Engineering & Technology

Keywords: distributed generation (DG); renewable energy sources (RES); optimization techniques (OPT); optimal allocation DG

1. Introduction

Traditional power generation is currently unable to satisfy the ever-increasing worldwide demand for electricity. About 16% of the world’s population still lives without electrical energy due to poor network construction (Report, Global Status, 2017). Subsequently, a power supply system needs to accommodate these changes for a better quality of user experience (“Ekpa, T. K. 1*, Sani, S.2, Hassan, A. S.3 and Kalyankolo, Z.4 1, Journal of the Nigerian Association of Mathematical Physics Volume 48 (Sept. & Nov., 2018 Issue), Pp347-352 © J. of NAMP ON,” n.d.). Unfortunately, distributed generation (DG) has proven to be a feasible alternative solution in this view were electricity is produced close to the load centers. Although DGs have several environmental and economic advantages, in the distribution system, they impose various operational problems. These may include, but not restricted to, power relaying problems created by inverse power flow, the problem of voltage increase and power quality issues (Lam & Varbanov, 2011; Manfren et al., 2011; Quadri et al., 2018). DG is a small scale electrical power generation units connected directly to the loads or consumer meter side (Hydro, Alternate and Energy Centre, 2016). Various researchers and countries have adopted a different definition for DG (Approach, 2007) defines distribution system as a failure of a digital system that has not existed in your system and can solve other unstable decisions within the given computer system. Historical background on the concept of DG was proposed by (Public et al., 2014), which categorized DG as a small device that allows electrical power energy to be generated by using renewable energy sources. In (Friedman, 2002), DG defined as a small modular plant place close to the load for the purpose of electricity generation and storage technologies within the grids. Ref (Martin, 2009) classified DG as a point where electricity is generated at the point of its use. The electrical power research institute (EPRI) defined DG as a few kW to 50 MW (Rajkumar Viral & Khatod, 2012). For Details in various DG, definition see Martin (2009), Abou El-Ela et al. (2010) and van Gerwen (2006). However, different types of renewable energy DG technology categories were highlighted in (Østergaard et al., 2001; Pepermans, 2005). Many authors characterized DG as a generation connected on the distribution side that ranges from a few kW to a few tens of MW, as shown in Table 1(Theo et al., 2017; Treatment, Vacuum-steam-vacuum Decontamination, 2015; M. H. Moradi & Abedini, 2012; P. Prem Prakash & Khatod, Table 1. Shows the different types of DG categories and ratings for future application [10-13]

| S/No | Type of distributed generations (DG)                      | Capacity             | DG ratings                              |
|------|------------------------------------------------------------|----------------------|-----------------------------------------|
| 1.   | Micro-distributed generation                              | ~ 1 W < 5 kW         | Solar Technology                        |
| 2.   | Small distributed generation                               | 5 kw < 5000 kW       | Biomass, Bioenergy, fuel cell & wind turbines |
| 3.   | Medium distributed generation                              | 5 MW < 50 MW         | Geothermal energy                       |
| 4.   | Large distributed generation                               | 50 MW<300 MW         | Hydrogen fuel energy                    |
The DG capacity per year is reported to be growing from 47 GW to 142 GW in the period of 2000 to 2012 worldwide due to huge investment, and the total target is to reach 200 GW and 206 USD billion by the year 2020 (Ehsan & Yang, 2018a) as shown in Figure 1. DG has become a feasible solution to rural areas where the cost of transmission and distribution is extremely high, and this making DG more popular. In (Davis & Ieee, 2002), comparison between distributed resources and the traditional power system in terms of transmission and distribution system, to check efficiency, losses, voltage profile, reliability, emissions, and power quality was studied and the author findings concluded that investment cost in distributed resources is lower compared to the traditional system. The technologies adopted in distributed generation comprises a small gas turbine, fuel cells, micro-turbines, wind, solar energy, and hydro-power. Figure 2, shows a distinct difference between the central utility of today and distributed utility of tomorrow. In the development of traditional power plants, there are technical and environmental limitations such as fuel sourcing, global sourcing, emissions and localized pollution. Moreover, the unsafe market for fossil fuel has pushed the electricity market in searching for new sources of energy (Mahmoud et al., 2016). Adding DG to the energy scheme decreases electrical power losses to achieve greater reliability of the system (Hassan et al., 2018). However, a U-shape trajectory is presented by the DG penetration rate versus power loss. The non-optimal positioning of DG can, therefore, boost power losses and
thus enhanced the voltage profile to support the permissible limit (Quezada et al., 2006). However, utilities are already subjected to technical and non-technical issues. Therefore, an optimum placement and sizing renewable DG are required to minimize the power system losses, boost reliability and stability and enhancement of voltage profiles. Authors in this field have contested that DG capacity and locations are very important in improving the distribution system performance (Hemdan & Kurrat, 2008), and the authors finding were based on the presence of renewable DG such as (solar, wind and fuel cell), increases the load of the network system.

There are various approaches carried out in literature to find the optimal position for the integration of DG into the distribution network system. Various objective functions (Bus cumulative magnitude and voltage deviation) are developed and solved. In (Borges & Falcão, 2006), the objective function formulation is the maximization of cost-benefit of DG integration to the investment cost. The benefits were to reduce the net electrical losses and the investment cost as well as installation costs. A multi-objective technique based on a genetic algorithm was studied by (Ochoa & Harrison, 2011) to determine optimal power flow to accommodate renewable energy sources by minimizing total energy losses. In (Q. Qianyu Zhao et al., 2019), the objective function is to investigate the uncertainty of DGs and loads, power generation cost and environmental cost of different renewable DG integration. A multi-objective optimization problem applied based on a double trade-off procedure – constrained approach for simultaneous minimization of DG integration by considering, cost energy, cost of energy not served and cost of grid energy purchased. The proposed methodology is capable of solving of maximizing network performance by optimizing some elements like voltage quality and harmonic distortion (Carpinelli et al., n.d.). In (“Optimal Placement of Multi-Distributed Generation Units Including Different Load Models Using Particle Swarm Optimisation.”, 2011), a multi-objective index used to optimize the short-circuit level parameter which will affect the sizing and location of the DG. The effects of load model size investigated by D. Singh et al. (2009), based on multi-objective function using various indices. It is observed based on the model that the effects of load models can significantly disturb planning and sizing DG. Fuzzy logic-based planning by considering uncertainty modeling to incorporate the DG within the electrical power distribution is proposed in (Ganguly et al., 2013), the objective was the application of a Petro-based approach for total optimization of cost of planning, reliability and risk of, constraints fully minimized. In (Hydro, Alternate and Energy Centre, 2016) analytical approach-based techniques proposed for optimal sizing and sizing DG for a balanced radial system. The model identifies the buses in the network to be compensated by reducing the power losses with single DG placement in DN. Growing interest in the application of DG optimization techniques deploy by the use of renewable energy sources is extended all over the globe, it is examined that one quarter of that energy is witnessed in Europe, Asia and part of United States of America (Abdmouleh, Gastli, Ben-brahim et al., 2017). Despite the advantages derived from DG integration from renewable energy source research shows that utilities suffer a great system loss, from inappropriate placement and sizing (Griffin et al., 2000; Mithulananthan et al., 2004). Proper mathematical optimization techniques provide solutions for boosting the reliability of this utilities deployed. Table 5 summarized DG technologies by bringing out benefits of each sources in terms of (emission, voltage profile, cost of packing, cost of installation, reliability improvement and power quality).

This research paper presents a vast choice on the current diversity of optimization methods applied to the aspect of planning and integration of renewable-based DG. The major objective is to focus on solving the problem of optimal placement and sizing DG from renewable energy sources. In addition, other factors affecting DG planning are reviewed and discussed in detail. This study will provide general knowledge to researchers for further exploration.

2. Prevalence weakness in DG growth
Optimal allocation of distributed generation has received much attention recently due to its various importance. However, it becomes an exacting task in integrating the DG into an existing network system. This challenging effect arises, because the integration of DG changes the entire system behavior from active to passive. Many authors have pointed out the importance of placing
DG in an optimum position. In (Murty & Kumar, 2015; Tan et al., 2013; Ugrani & Karatepe, 2013), DG properly installed in an optimum position will enhance the voltage profile of the electrical power distribution network. If installed at the best location and the proper size, they will minimize power losses and maximization of system voltage stability (Aman et al., 2012; Kalambe & Agnihotri, 2014; Kansal et al., 2013; Murty & Kumar, 2015; Pepermans et al., 2005; Vijay & Singh, 2015). Ref (Lopes et al., 2007), pointed out the benefits of integrating the DG by using renewable energy sources (wind, solar, biomass and so on), which regulates environmental effects like emission control. In (Allan et al., 2015), review various literature on different DG technologies on how to control the emission. DG serves as an alternative source in assisting the rural side, where the cost of transmitting and distribution of power system is high see details (Karki et al., 2008). If properly installed at the proper location will relieve the issues of uncertainty loading of the feeders (Zeinalzadeh et al., 2015; Muthukumar & Jayalalitha, 2016). Inappropriate optimum allocating and sizing the DG can lead to a negative impact of all the advantages mentioned (P. Prem Prakash & Khatod, 2016). It has become necessary to size and allocates the DG in an optimum position, since the advancement in the technology is rapidly growing by cutting various costs, boosting efficiency and enhancing the voltage profile within the power distribution network. Despite the availability and environmental friendly of these energy sources, the institute of electrical electronics engineer-ing (IEEE) has set various rules to follow in integrating distributed energy sources (DER) in the distribution system. Table 3 provides the IEEE 1547 series towards achieving a sustainable environment, Table 4 provides voltage and frequency acceptable rate in operating DER in the distribution system. Most of the benefits of employing DG in existing distribution networks have both economic and technical implications and they are agnate. However, the major driving factors increased in penetration of DG integration issues are classified into three categories: environmental, regulatory and economic factors.

3. A. environmental aspect

In environmental aspects, the broad penetration of distributed generation in the distribution network is of major significance. DG-based fossils fuel dissipates a lot of environmental emissions and leads to unresolved issues. However, the DG implementation and only restricted measurements are characterized by a wide range of fuel energies, advanced techniques and operating patterns (Greene & Hammerschlag, 2000). The utilization of fossils-based DG energy sources leads to the largest emission of Greenhouse (GHG) gas emission such as (water vapor, carbon dioxide, nitrous oxide and hydrofluorocarbons), which resulted in environmental concerns and climate change. Environments and creatures are affected worldwide, this has led to the search of non-polluting resources and more efficient technologies that will solve environmental problems and reduction in the price of fossil energy (Chaitusaney, 2014). The integration of DG on large scale produces various types of emissions, as electricity generation is always the major contributor to these emissions. Statistics have shown that in the united states of America that electricity production from non-renewable DG sources has resulted in one-quarter of nitrogen oxide (NOx), carbon monoxide and sulphur dioxide (SO2) (States, n.d.). However, despite this negative environmental impact from the non-renewable energy sources, DG could have positive impacts of integrating renewable energy sources into the electrical power network which will reduce the gaseous emission mentioned above. Various literature exists on the use of renewable energy sources to reduce gaseous emission see (M. Chen & Cheng, 2012; Liew et al., 2017; Di; Somma et al., 2016; Cao et al., 2016; Akorede et al., 2010; Abdallob & El-Shennawy, 2013). Table 3(a-b) are environmental standard value for pollutant and penalty emission control (M. Chen & Cheng, 2012) and Table 4, shows potential emission reduction of Carbon (IV) oxide and electricity emission to be achieved in 2030 ([PNNL] Pratt et al., 2010).

4. B. economic aspects

DG’s interconnection to the traditional electrical power system needs additional underground cable installation so that DG can be integrated into the new scheme. In addition, the incorporation of DG into the new scheme can lead to certain problems such as; voltage flicker, harmonics introduction, the inverse operation of the energy system flows and protection challenges see (AFOREDE et al., 2010; Barker & De Mello, 2002; Hadjsaid et al., 1999), for details. Such issues
must be properly addressed to achieve the maximum benefits of the reliability of the distribution system (A. K. Singh & Parida, 2017a). Summary of these challenges is better explained in Table 4(a) (Zubo et al., 2016). In addition to these economic benefits, DG still represents the world energy through reduction of cost, saving transmission and distribution.

5. C. Technical aspect
DG technical element covers a broad range of issues such as peak load shaving, excellent voltage profile, decreased system losses, enhanced system continuity and reliability, and some power quality issues that are filtered out. The total reduction in the loss of energy system may be of concern to some utilities in developing nations, as some of these utilities lose up to 20% of their complete energy generation (A. K. Singh & Parida, 2017b). The major technical benefit to be derived from DG, if well addressed is as follow:

- The total reduction in line losses.
- Boosting system reliability and power system security.
- Increased system efficiency.
- Relieving congestion in the transmission and distribution system.

6. D. Regulatory policy
It appears that the creating of suitable approaches is so significant to help in the coordination of the distributed generation into an appropriate distribution system because of the nonappearance of clear legislative guidelines (Niwas et al., 2009). Nowadays particular attention is paid in the European zone on how to tackle the effects of climate change and have a strong body that will promote the use of clean energy towards achieving secured energy (Cossent et al., 2009). Table 2 summarizes some weaknesses of DG.

---

### Table 2. Weakness of DG in various aspects.

| Commercial aspect                  | Technical aspect                      | Environmental aspect | Regulatory aspect |
|------------------------------------|---------------------------------------|----------------------|-------------------|
| Recovering the cost of implementation | Power quality and voltage flicker | Emission characteristics | Policy regulation |
| Incentive scheme                   | Stability and protection              | Control of power plants | -                 |
| Market pool creation               | The reverse flow of the power system  | Power quality issues  | -                 |

### Table 3. Shows emission characteristics of several electric generations in (g/kWh)

| Technology               | SO2   | NOx     | CO2     | CO     |
|--------------------------|-------|---------|---------|--------|
| Thermal power plant      | 6.48  | 2.88    | 623     | 0.1083 |
| Micro-gas turbine        | 0.000928 | 0.6188 | 184.0829 | 0.1702 |
| Fuel cell                | 0     | <0.023  | 635.04  | 0.0544 |
| Photovoltaic             | 0     | 0       | 0       | 0      |
| Wind                     | 0     | 0       | 0       | 0      |

### Table 3. Shows the environmental standard value for pollutant emissions

| Emission | SO2   | NOx     | CO2     | CO     |
|----------|-------|---------|---------|--------|
| Value    | 0.75  | 1.00    | 0.002875| 0.125  |
| Penalty  | 0.125 | 0.250   | 0.00125 | 0.020  |
7. Review of optimization techniques applied on DG’s based on optimal placement and sizing

Optimal allocation techniques solve problems linked to sizing and appropriate positioning of DG’s by enforcing various mathematical optimization objective features with many technical operational limitations, implementing distinct computational methods with the account of distinct DG kind based on power factor (PF) and multiple numbers of units. This study presents a trend on research publications since the early 2000s to date and further summarized as following in block diagram for easy understanding. These objectives are considered as single or multiple for Optimal Allocation of DG in the presence of equality and non-equality constraints. Figure 3 summarizes the review approach of the optimal allocation of DG in the form of a block diagram.

Optimal allocation and sizing of DG are not a linear method; rather they are solved as a non-linear optimization method. The optimal allocations of DG are mathematically modeled in the form of mixed-integer non-linear programming (MILP). The majority of the literature survey carried out are basically methodologies to investigate the optimal allocation of renewable-based DGs in the distribution system for minimizing power loss and cost associated.

The authors in (Wong et al., 2019), present a novel progress approach for optimal and sizing distributed generation with the placement of control storage in order to investigate the challenges of deploying Energy storage system in the distribution system. In Ref (Sedighi, 2010), authors applied Particle Swarm Optimization (PSO), for optimal sitting and sizing of DG in the distribution system as

| Table 4. Summary of these challenges is better explained in table |
|-----------------------------------------------|----------------|----------------|----------------|
| Technical                                      | Environmental | Commercial     | Regulatory     |
| Voltage effects                                | Cost of implementation | Rising appropriate regulatory policy |
| Power quality issues                           | Creating a market pool | -               |
| Protection and control                         | Establishment of incentive | -               |
| Stability effect                               | -               | -               |

| Table 4. Potential emission reduction of carbon (IV) oxide and electricity emission to be achieved in 2030 ([PNNL] Pratt et al., 2010) |
|-----------------------------------------------|----------------|----------------|
| Mechanism                                     | Reduction in electricity energy and CO2 emission. (Direct (%)) | Indirect (%) |
| Transmutation effect of consumer information and feedback systems. | 3 | - |
| Joint marketing of electrical energy efficiency and demand response application. | - | 0 |
| Categorization of analytics in the residential, small and medium building. | 3 | - |
| Quantification and ratification for energy Efficiency programs (M&V). | 1 | 0.5 |
| Shifting load to more efficient generation | <0.1 | - |
| Conversion voltage reduction and advanced voltage control | 2 | - |
| Support perforation of renewable energy sources such as; wind and solar generation (25% renewable portfolio standard) RFS | <0.1 | 5 |
| Support additional electric vehicles and plug-in hybrid vehicle system | 3 | - |
| Type of technologies | Size in (kW) | Electrical Efficiency (%) | Overall Efficiency (%) | Emissions (g/kwh) | Cost of packing ($/kW) | Installation cost in ($/kW) | Cost to Generate electricity (kWh) | Cost of co-generation | Reliability | Power quality |
|----------------------|--------------|---------------------------|------------------------|------------------|------------------------|-----------------------------|----------------------------------|-----------------------|-------------|---------------|
| Non-Renewable technologies | | | | | | | | | ✓ | ✓ |
| Reciprocating Engines/spark Ignition | 30-5,000 | 31-42 | 80-89 | NOx: 0.7-42 CO: 0.8-27 | 300-700 | 150-600 | 7.6-13.0 | 6.1-10.7 | ✓ | ✓ |
| Diesel | 30-5,000 | 26-43 | 85-90 | NOx: 6-22 CO: 1-8 | 200-700 | 150-600 | 7.1-14.2 | 5.6-10.8 | ✓ | ✓ |
| Dual fuel | 100-5,000 | 37-42 | NOx: 2-12 CO: 2-7 | 900-1300 | 250-600 | 11.9-18.9 | 10.0-16.8 | ✓ | ✓ |
| Micro turbines Propane, natural gas and Bio-gas | 30-1000 | 20-30 | 60-75 | NOx: 9-12 ppm CO: 9-12 ppm | 1000-5000 | 250-600 | 11.9-18.9 | 10.0-16.8 | ✓ | ✓ |
| Industrial turbines | 1000-5000 | 20-40 | 70-95 | NOx: 25-200 ppm CO: 7-200 ppm | 200-850 | 150-250 | 8.7-15.8 | 5.8-12.2 | ✓ | ✓ |
| Small fuel cells | 1-300 | 30-50 | 80-100 | NOx: 0.007 CO: 0.01 | 1000-5000 | 400-1000 | 21.9-33.3 | 20.7-33.3 | ✓ | ✓ |
| Phosphoric acid | 200 | 40 | 84 | NOx: 0.007 CO: 0.01 | 3000-4000 | 360 | 18.6-22.8 | 17.0-21.2 | ✓ | ✓ |
| Renewable energy technology | | | | | | | | | ✓ | ✓ |
| Wind | 5-1,000 | - | - | - | 1,000,3600 | 500-4,000 | 6.2-28.5 | 18.0-36.3 | X | ✓ |
| Solar thermal | 1000-80,000 | 30-40 | 50-75 | - | - | - | - | - | X | ✓ |
| Photovoltaic | 5-5,000 | - | - | - | 5000-10,000 | 150-300 | 18.0-36.3 | - | X | ✓ |
| Geothermal | 5000-100,000 | 10-32 | 35-50 | - | - | - | - | x | X | ✓ |
| Biomass gasification | 100-20,000 | 11-25 | 60-75 | 1500-3000 | - | - | - | - | x | X |
well as boost the voltage profile and total harmonic distortion reduction. Also in Rugthaicharoencheep and Sirismumrannukul (n.d.), an investigation was carried out by the authors to determine the importance of optimal reconfiguration of feeders within a given distribution system using a fuzzy logic approach, in order to minimize power loss, feeder balancing, and switches operation.

Ref (Soudi, 2013); studied the optimal planning of DG considering the significant and cost associate in order to improve power quality and greater reliability of the system. (Kaur et al., 2014); proposed a mixed-integer nonlinear programming technique for optimal placement of multiple DGs in a distribution network power loss minimization. Proposes a multi-objective optimization for sitting, sizing and placement of the DG in an optimal position to minimize power loss, voltage variation as well as stability. Angarita et al. (2016) also presented a novel for optimal allocation of DG in distribution system the major objective is the minimization of electrical power loss and regulate voltage profile. Subramanyam et al. (2018); presented an optimized dual-stage approach for setting and sizing fuel cell in DGs for effective system minimization. Ref (Hung et al., 2010), proposes an analytical optimization to determine size and power factor correction in the active primary distribution network to reduce losses associated with deploying DGs in DN. Hassanzadehfard and Jalilian (2018) proposes an optimization technique for proper sizing and locating renewable-based DG considering load growth in the active distribution system. The major finding is the placement of solar and wind in optimal place in DN to reduce operational cost, maintenance cost as well as Greenhouse gas emission. Badran et al. (2017) focused on optimization techniques for network reconfiguration considering different methodologies to alleviate total power loss in the distribution system. Also, Abou El-Ela et al.’s (2010) major findings were an investigation on using genetic algorithms for maximal placement of DG in the network system in order to boost voltage profile, spinning reserve control as well as a reduction in total power line losses. Karimi et al. (2016) proposes a multi-objective stochastic approach for integrating DG in the distribution network by considering economical, technical and environmental aspects by considering uncertainty. Major findings by authors were how safe is it to integrate DGs in DN to determine optimal location and size by considering some environmental parameters. Taylor (n.d.) carried out a cost-benefit analysis to determine the optimal position to place DG in DN. The investigation is in terms of placement of DG in an optimal position by considering the size of the DG and capacitor. In ref (Kumawat et al., 2017), perform a swarm intelligence-based optimization for the planning of DG in DN to minimize annually energy loss. Findings by the author were to observe the behavior of a nonlinear electrical load with time-varying characteristics to obtain the real load in the DN. Also in (Kanwar et al., 2016; Tilbo et al., 2017), carried out optimization techniques for optimal placement of DG in the distribution system considering network reconfiguration, shunt capacitor and DG in the radial distribution system. Hassanzadehfard and Jalilian (2016) proposes a novel met the heuristic mathematical objective for placement of multiple DGs in an optimal position within the distribution system to minimize the cost associated with deploying DG. (S. Singh,
applied a particle swarm optimization algorithm to find the best location to place their DG within the given electrical distribution network, the aim is to minimize total power losses and enhanced voltage profile. Reliability indices topology was adopted by Siddappaji and Thippeswamy (2017), to determine the best placement of DG in a distribution system for total power loss reduction using a fast decoupled method. Authors in (A. R. Gupta, 2017), investigated the effect of placement of multiple DG and STATCOM in the radial distribution system. This will help in mitigating the effect of power quality, and harmonics introduce by non-linear loads in a radial system. Authors in (Y. Aien et al., 2016, 2014; Grechuk & Zabarankin, 2018; Jordehi, 2018; Soroudi & Amraee, 2013; Yuan Zhao et al., 2015), carried out a review on a different aspect of uncertainty modeling of DGs. The applied method can be summarized in figure 4.

8. A. Various DG planning models

Uncertainties and fluctuation are the primary difficulties related to Renewable energy technologies, particularly with non-consistent accessibility of wind, sun based and hydro sources. To suit the incorporation of an enormous offer of variable energy sources, it is critical to have fitting arranging devices ready to enhance the reconciliation of variable renewable energy sources. Numerous advancement systems identified with vitality issues when all is said exist in the literature, for example, intelligent search techniques. In central, searching for the ideal site and limit the search of Distributed Generation is typically modeled as a non-linear optimization hurdle. Different limitations and objective constraints are first set. The advancement strategy helps in decision making by creating an optimal solution from a decrease in initial set up of variables.

Figure 4. Various metaheuristic optimization algorithms [195].
Comprehensively, there are two ways to deal with the issues, by precise strategies, for example, Mixed-Integer Linear Programming (MILP) which is generally exceptionally modeling, however, requires inordinate processing time and difficult to actualize on genuine size issues, and heuristic techniques which depends on improving the issue and offering fulfilling arrangements. In this area, a straightforward definition of the most widely recognized issue is introduced, which is to locate the ideal DG size and location for the bus that minimizes the total power loss (Abdmouleh, Gastli, Ben-brahim et al., 2017). It is important to assign distributed generation units at optimal places with appropriate sizes to reduce negative impact in terms of economic, technical and environmental factors. Several advantages of placing DG in an optimum position include; Enhancing voltage profile, stability and reliability increased, minimization of total power loss and power quality issues. In this section, various approaches will be discussed in detail.

DG’s are classified into four major distinct group based on their terminal performance in terms of real and reactive power delivering capability as follows:

1. Type 1: DG capable of injecting P only.
2. Type 2: DG capable of injecting Q only.
3. Type 3: DG capable of injecting both P and Q.
4. Type 4: DG capable of injecting P but consuming Q.

Photovoltaic, microturbines, fuel cells, which are integrated into the main grid with the help of converters/inverters are good examples of Type 1. Type 2 could be synchronous compensators such as gas turbines. DG units that are based on synchronous machines (cogeneration, gas turbine, etc.) fall in Type 3. Type 4 is mainly induction generators that are used in wind farms.

9. B. Analytical approach

Analytical approaches usually used for numerical approximation. The analytical algorithm approach for determining optimal DG size, location and installation has been reported in the literature by different authors (Aman et al., 2012; Gözel & Hakan Hocaoglu, 2009; Hedayati et al., 2006; Hung et al., 2010). Yarahmadi and Shakarami (2018) propose an analytical solution for optimal allocation of wind-based in radial distribution by partial derivative taking into account distinct time and voltage-dependent load using a multi-objective index for efficient placement of the DG wind in an optimum location. The objective goals were based on the use of the Rayleigh pdf model to determine the nature of the wind penetration, the result obtained was tested on 33 and 69 bus system. In ref (Wang & Hashem Nehrir, 2004), the authors propose an iterative method based on analytical to determine the best location to place a DG in a radial distribution network. The objective was to minimize power loss in the network system. Placement of the DG was analyzed in a radial feeder system, the location of the bus site was obtained from the different combination of the load’s sources, and finally, an analytical system was applied to generate the bus admittance matrix in the distribution system and tested on IEEE 6 and 30 bus system. Ref (Acharya et al., 2006), used exact loss formula-based analytical expression for placement of the DG in an optimum location to minimize total power loss in the primary distribution system. The basic objective was to calculate optimum size and methodology to place the DG in the best location to minimize system losses. A mathematical objective was formulated in (Khatod, 2015), to determine the optimal setting and sizing of the DG based on the analytical approach in the radial distribution network to minimize power loss on the system. The novelty of the work is the application of a simple analytical formula to minimize power system losses, with the presence of active and reactive components, and the result obtained was tested on 15 bus systems and found to fit the objective as proposed.

10. C. 2/3 rule

The 2/3 rule also known as the golden rule, it is a well-known analytical technique used for optimal allocation of DG. Optimally used for placement of shunt capacitors in a radial distribution system based on power flow. Here the size of the capacitor placement based on the DG is 2/3 of the...
incoming capacity generated is size to fit 2/3 length of the line in the system. This rule is applicable where the load is uniformly distributed in a radial network see (Rau & Wan, 1994; Willis, 2002) for details on the golden rule.

11. D. Sensitivity analysis-based approach
These techniques are basically used to find the exact location of the distributed generation based on sensitivity index node identification, and tend to find the feasible location for our DG in order to minimize total power loss (Murty & Kumar, 2015), also applied in (Rau & Wan, 1994). However, various literature has reported on the use of analytical analysis based on the sensitivity factor due to its simplicity (Acharya et al., 2006; Gozel et al., 2005; Hung et al., 2010; Kashem et al., 2006; Murty & Kumar, 2015). Authors in (Khatod et al., 2013), propose a sensitivity analysis technique based on active and reactive power, to give the best location for placement of the DG thereby reducing the computational time.

11.1. Linear and non-linear programming (MINLP)
The first set of iteration to solve non-linear programming is setting the direction of the search a linear programming problem is characterized by linear functions of unknowns, the objective of linear programming is that the unknown is linear and the constraints are linear inequalities. However, the popularity of linear programming depends on the primary formulation of the analysis. The concept of non-linear programming has been reported by different authors in the literature (Luenberger, 1973; Jaravel et al., 2019; Ballesteros-Pérez et al., 2019; Rueda-medina et al., 2013; A. Kumar & Gao, 2010; Felix F. Wu et al., 2005; Cerone et al., n.d.). However, the mathematical concept of solving advanced models is mixed-integer non-linear programming (MILNP). Mixed-integer non-linear programming refers to optimization problems with continuous and discrete variables, the constraints imposed are in the form of a non-linear function. MINLP has a wide range of applications including finance, engineering, and manufacturing process. MINLP has been used by the various authors to determine the optimal size and location of DG in an electric power distribution system as discussed by (Home-Ortiz et al., 2019; Nemati et al., 2018; Paaso et al., 2014; Popović et al., 2014). They can be used to solve load models having the time-varying function by converting loads in the form of discrete probabilistic to deterministic generating load model as reported by (El-saadany & Atwa, 2010). Despite the benefits of MINLP in solving the DG allocation and sizing problem, there exist some drawbacks of having a large number of decision variables and longtime computation.

12. E. Dynamic programming
Dynamic programming was first introduced in the 1940s by Richard Bellman aiming in solving the problem in which the optimum decision variable is sequential in nature. The dynamic word represents a time-varying function problem applied in mathematical optimization to solve problems in the form of optimal decisions. In (Khalesi et al., 2011), proposes a multi-objective function-based dynamic programming to determine a feasible location to place our DG within the distribution network to minimize power loss and improvement in the reliability of the system. Also, Chen et al. (2017) develops an optimization strategy based on dynamic programming to address energy management problems, as they suffer recently due to the expansion of a number of variables. The objective was to design a new optimization strategy for energy management in combined heat and power (CHP) with hybrid energy storage and delivered based on the Dynamic programming approach. The DG allocation problem can be formulated as follows:

\[
 f_n(k_n, L_n) = Z_n(L_n) + \text{Max} \sum_{l=n+1}^{N_{\text{loc}}} M_L(X_l)
 \]  

Subjected to:

\[
 \sum_{l=n+1}^{N_{\text{loc}}} X_l = K_n
 \]

Here; \( N_{\text{loc}} \): Number of potential nodes
13. F. Meta-heuristic approach

A meta-heuristic approach is an iterative approach that guides a subornative heuristic, combine artificially intelligent and mathematical optimization for solving a complex problem vastly than the classical method, generally used to find an approximate solution where the classical have failed. However, meta-heuristic approach can be summarized in Figure 4. Several meta-heuristic approaches for optimal allocation and planning of DG have been studied by various authors in the distribution network system. Such as, artificial bee colony (Mohandas et al., 2015; Kefayat et al., 2015; C. K. Choton K Das et al., 2018), Cuckoo search algorithm (Yuvaraj & Ravi, 2018; S. Sudabattula and Kowsalya 2016; Nguyen & Truong, 2015; Devabalaji et al., 2018), Symbiotic organism search (B. Bikash Das et al., 2016), harmony search (Kayalvizhi & Vinod, 2018; Maleki & Pourfayaz, 2015; Rastgou et al., 2018), bacteria foraging (Kaveh et al., 2018; S. Devi & Geethanjali, 2014; Devabalaji & Ravi, 2016), Bat algorithm (Sureshkumar Sudabattula & Kowsalya, 2016; Yammani et al., 2016), Whale optimization (D. B. D. B. Prakash & Lakshminarayana, 2018), Stud Krill herd (ChithraDevi et al., 2017), Grey wolf optimizer (Lakum & Mahajan, 2019; Yahiaoui et al., 2017), Firefly algorithm (Fister et al., 2013; Othman et al., 2016). Equation (2) is applied for solving classical optimization and is applied to the position of vectors of PSO.

\[ X_{id} = X_{id} + \text{sign}(2(k - 0.5))\gamma v_{\max_d} \]

where \( X_{id} \) is the dimension of the vector particle;

\( v_{\max_d} \) is the dth dimension of the maximum vector.

\( K \) is the random variable selection in \([0,1]\) and \( \gamma \) is a constant value in the range of \([0,1]\).

14. G. Simulated annealing

Simulated annealing process begins in 1983 by Galett, vecchi and since its inception to date; it has reported being used widely due to its simplicity. It is in the form of probability function which allows new solutions to pass or reject, in order to avoid been trapped in a non-optimum position. Various literature has captured the use of simulated annealing for details (“A Solution to the Optimal Power – Ow Using Simulated Annealing” 2003; Friesz et al., 2008; Popović et al., 2014) Kamal EL-Sayed (2017) has applied simulated annealing optimization for minimization of power losses and enhancing the voltage profile. In ref (Sutthibun & Bhasaputra, n.d.), a multi-objective optimal placement of DG based on simulated Annealing was performed in order to reduce power system losses, control emission and contingency. The model was tested on IEEE 30 bus and there was a total power reduction up to 43% compared with the system without DG. Multi-objective optimal planning of DG using simulated annealing was proposed in (Dharageshwari & Nayanatara, 2015), to reduce total power loss and improvement in voltage profile. Suitable fast convergence was attained by the placement of multiple DG and tested on the IEEE 33 bus and efficiency of the system improved, reduction in system losses and cost reduction.

15. H. Tabu search (TS)

Tabu search is a global Meta-heuristic optimization for controlling embedded systems. The search was proposed in 1986 by Glover and McMillian, based on human memory efficiency to solve the optimization problem. The basic principle of this search is on adaptive memory exportation that allows an anomic way of searching a solution until a better result is obtained (Hilal, 2017; McMillian & Glover, 1986). A genetic-based on tabu search was proposed by (Sutthibun & Bhasaputra, n.d.), for optimal placement and allocation of DG in the distribution network. The objective of the algorithm is to minimize power frequency losses and harmonic power losses in a distribution network system, and the proposed methodology was applied to the IEEE-14 and 34-node test systems. Thus, the proposed methodology is efficient for solving the DG allocation problem in the distribution system.
16. Shuffled frog leaping (SFLA)
SFLA is used based on the behavior of the frogs in rotation to search for food (Eusuff et al., 2006). In (Afzalan et al., 2012), optimal placement of the DG in radial distribution was achieved by SFLA and the result obtained was tested on 33 radial bus systems. In ref (Moazzami, 2017), a proposed methodology based on an improved shuffled frog leaping algorithm (MSFLA) to achieve optimal placement and size of DG and distributed statistic-synchronized compensator (D-STATCOM). The result was tested on the IEEE-33 bus and compared with the ones derived from the genetic algorithm and shows to be more effective than the existing one.

17. J. Artificial bee colony (ABC)
Artificial bee colony (ABC) algorithm is an optimization technique that simulates the foraging behavior of honey bees, and have been applied successfully too many problems. ABC is classified under swarm intelligence algorithms and develop in 2005 by karaboga. Ref (C. K. Choton K Das et al., 2018), proposed an algorithm based on ABC for optimal placement of distributed energy storage system in the distribution system to minimize power losses, line loading, mitigation of network demand and general improvement of the voltage profile. The result obtained using the ABC algorithm was compared with particle swarm optimization (PSO) and found to perform better and faster convergence. ABC algorithm was proposed in (Abu-mouti & Member, 2011), for optimal sizing of DG, power factor and location to minimize total real power loss in the distribution system and was compared with the PSO approach and found ABC offered a better quality solution with the fastest convergence.

18. K. Other promising heuristic optimization algorithms
However, other authors proposed a heuristic algorithm which is a powerful tool for optimal allocation, sizing, and placement of distributed generation problems in the distribution system.

• Biogeography-Based Optimization (BBO) is an evolutionary algorithm that optimizes a function by stochastically iterative function. It describes a number of behaviors linked to that of fish, birds, and insects. BBO was introduced by Dan Simon launched BBO in 2008. An optimal location based on BBO for sizing of solar photovoltaic DG in the radial distribution system was proposed by (Duong et al., 2019), by minimizing power loss and maintain a normal voltage, while controlling the effect of harmonics distortion not to exceed the limit. Results obtained were compared with genetic algorithm and particle swarm optimization and artificial bee colony it shows that the new algorithm is faster and less time to converge.

• Bacterial Foraging Optimization Algorithm (BFOA) The algorithm is stimulated by foraging properties of E. coli bacteria. Permitting to this, bacteria search the food in such a manner to maximize the obtained energy per unit time. The isolated bacterium also convey to others by transporting a signals. In this process, bacterium take decision for searching food after examine two preceding factors in this, the bacterium moves by taking small steps at the time of searching the nutrients known as chemotaxis (Prabha et al., 2015).

• Invasive Weed Optimization Algorithm (IWO) This algorithm was first presented by Mehrabian and Lucas in 2006. It is based on mathematical stochastic optimization algorithm. The technique is inspired by sensation of inhabitancy of invasive weeds in nature is based on weed biology and ecology Invading of weeds of cropping system is done by means of dispersal. Every invading weed takes the unused resources in the field and matures to the flowering weed and yields new weed autonomously (Prabha et al., 2015).

• Imperialist Competitive Algorithm (ICA) This is one of the latest meta-heuristic algorithms suggested to address socio-politically inspired mathematically optimization issues. Ref (Eisapour-moarref & Amir, 2017), ICA was proposed for multi-objective location and sizing DSTATCOM in the distribution system considering uncertainty in loads. The proposed algorithm tested on IEEE 33 and 69 bus system and there was total loss reduction, voltage profile improvement, feeder load balancing and cost reduction in the distribution system.
Lightning Search Algorithm (LSA) is a new effective meta-heuristic optimization method for solving real numerical optimization concepts. LSA is inspired by the natural phenomenon of lightning and based on the mechanism of step ladder propagation. Ref (Thangaraj & Kuppan, 2017), proposed a multi-objective simultaneous placement of DG and DSTATCOM based on LSA for minimizing total power loss and voltage deviation, tested on IEEE 33 and 69 bus system and there was a significant improvement when the new algorithm was tested.

Firefly Algorithm (FA) is a meta-heuristic algorithm that is inspired based on the flashing behavior of fireflies. The firefly’s flash acts as a signal system to seduce other fireflies (Nadhir, 2013). In (Taylor et al., n.d.), optimal planning of distributed generation in the distribution system was achieved through the FA algorithm with the objective of minimizing power loss and voltage control.

Dragonfly Algorithm (DA) is a new meta-heuristic optimization, which is based on simulating the swarming behavior of dragonfly and was developed by Mirjalili in 2016. In (Suresh & Belwin, 2018), DA was used for optimal placement of DG unit size at different power factor in order to reduce power loss in the distribution system and enhancement of the voltage profile of the system.

19. Overall review of studies on optimization of the distribution system

Considering and reviewing the study work on the issue of optimizing the distribution system, the following threads are described as deficiencies and directions for future works. Additionally, Table 6 includes merit and de-merit of different research work discussed.

- The majority of the research work carried out the optimization of distribution networks based on renewable energy sources did not consider uncertainty only a few. However, taken these uncertainties into consideration gives the distribution network system a strong realistic solution that paves a way to a practical distribution network.

- Meta-heuristic optimization algorithms control parameters are not well fit and this has a significant impact on their computing efficiency. For the optimization problem on hand, there is a need to revise in literature in order to have a strong parameter for the meta-heuristic problem.

- In distribution system nowadays used plug-in vehicles as a new concept in the distribution network configuration. They are large loads that can have a drastic effect on the effectiveness of the distribution system. However, some studies were conducted to assess their impact on the problems of optimizing the distribution system. There is still a gap for a full assessment of the effects of the plug-in car scheme used in the distribution network system.

- Many literature studies focused on Lagrangian relaxation (LR), but the solution obtained in each iteration is not really feasible. Therefore, there is a need for more research on the LR parameters because the performance of the distributed algorithm depends on the parameters to achieve faster convergence.

- The impacts of communication inertia on the convergence performance of the algorithm have not been fully explored in literature studies. The problem of optimal resistance existing in communication infrastructure for designing strong communication needs to be responded to in order to have wide adoption in distributed optimization in the future.

- Generally, distribution network system is large-scale integration, most of the existing optimization techniques study focuses on small-scale distribution. For fitness and validation, purpose optimization techniques should be considered.

- Regardless of the significance offered by distribution optimization planning, most of the utilities present in advanced countries experience challenges in integration. Educating modern distribution system utilities with merits and de-merits will lead to a more practical system.

- However, newer heuristic techniques such as Bacterial Foraging Optimization Algorithm (BFOA), Shuffled Frog Leap Algorithm (SLFA), Invasive Weed Optimization Algorithm (IWO) and Simulated Annealing (SA) Algorithm may appear to be promising in the future.
Table 6. Gives a brief comparison of the merits and demerits of the main approach study of distributed generation placement

| DG placement method                      | Merits                                                                 | Demerits                                                                 | References                                                                 |
|------------------------------------------|------------------------------------------------------------------------|--------------------------------------------------------------------------|---------------------------------------------------------------------------|
| Analytical method                        | - it is a simple and easy technique with high computational time       | - Handles only single objective of the distributed energy resource at a time and lack robustness | (Lakshmi & Chaithanya, 2012)                                              |
| 2/3 rule/Golden rule                     | - simple to use for approximate techniques with uniform load          | - not suitable for non-uniform load                                       | (Willis, 2002)                                                           |
| Optimal power flow                       | Highly used for computational problems and time efficiency             | Problems are formulated in a closed way and difficult to incorporate     | (Pearmine et al., n.d.; Gabash & Pu, 2012; C. J. Dent et al., 2010; C. Dent, 2009) |
| Mixed integer and non-linear programming | - Very exactness and high computational time reliability              | Solutions are difficult to understand                                  | (M. Kumar et al., 2018; Jabr et al., 2012; Parisio & Gielmo, 2011; Mashayekh et al., 2017; Home-Ortiz et al., 2019) |
| Simulated Annealing                      | - statistical guarantee in finding an optimal solution                 | - Relatively slow if the cost function is expensive to compute          | (Aly et al., 2010; Vallem et al., 2006; Nahman & Perić, 2008)             |
| Particle swarm optimization (PSO)        | - Higher probability efficiency in obtaining the optimal solution      | - However, sometimes difficult to define initial parameters             | (Guadix et al., 2018; Nazari-heris et al., 2018)                         |
| Tabu search (TS)                         | - capable of handling complex iteration problems                      | - High computational time due to many iterations.                        | (Maciel & Padilha-Feltrin, 2009; Nara et al., 2002)                      |
| Ant colony search optimization (ACSO)    | - capable of giving a rapid solution                                  | - Difficulty in theoretical analysis.                                   | (Sheidæi et al., 2008)                                                   |
| Artificial bee colony optimization (ABCO) | - simplicity, flexibility and robustness.                              | - Effectively slow in sequential processing.                             | (A. Gupta et al., 2017; Dixit et al., 2016)                               |
| Firefly search Algorithm                 | - codes are easy to understand.                                       | - Slow convergence speed.                                               | (Othman et al., 2016)                                                   |
20. Conclusions and future scope work

In this research work, the existing work carried out on optimization of the distribution network system has been reviewed from its point of view, in terms of the optimization algorithm, objectives, decision variables employ and models applied.

The sequence of this research has regarded over the past 10 years an extensive evaluation of mathematical optimization in the power energy system and implementation of these techniques in planning and operating issues of DG’s. Additional to the various trends, it has been noted that the area of artificial intelligence is still the best technique evolving mathematical optimization of distributed energy sources (DER). However, the following conclusion is drawn from this article as follows:

- The area of artificial intelligence techniques is still receiving attention than conventional optimization techniques for optimal DG planning in a power distribution network system from a different point of view.
- Computational techniques in hybrid optimization techniques are faster and convergence faster than the conventional optimization techniques employed in optimal planning Distributed generation in a distribution network system.
- An analytical approach is not computationally difficult for a simple system but not suitable for a system with a large and complex network system.
- Meta-heuristic and hybrid optimization techniques are observed to be more suitable for a large and complex system as they provide optimum solutions to both single and multi-objective problems.
- It is further observed that for optimal distributed generation and sizing based on meta-heuristic optimization techniques such as: ABC, BBO, SFLA, ICA, and LSA are performing significantly well and may seem to be reassuring in the future.

The following recommendation for future scope area of research is as follows based on the literature survey.

- The stochastic study should be adopted for optimal planning of the distribution network with the sporadic nature of distributed generation should be considered.
- Assessment of different types of DG and flexible ac transmissions (FACTS) controller planning in a static and realistic model by artificial intelligent (AI) techniques should be considered.
- A comparison of various different types of DG and FACTS planning via static and real-time models by the concept of hybrid AI should be considered in further research.
- Renewable energy sources based on DG units with battery storage option and their importance were not considered in this research.
- Operations of the DG in standalone mode should be considered in the future research scope.

Acknowledgements

This research is supported partially by South African National Research Foundation Grants (No. 112108 and 112142), and South African National Research Foundation Incentive Grant (No. 95687 and 114911), Eskom Tertiary Education Support Programme Grants, Research grant from URC of University of Johannesburg, and the Grant of Global Excellence and Stature (GES) of University of Johannesburg.
Funding
This work was supported by the University of Johannesburg [Grants (No. 112108 and 112142), and South African National Research Foundation Incentive Grant (No. 95687 and 114911)].

Author details
Abdurrahman Shuaibu Hassan1
E-mail: ysun@uj.ac.za
Yanxia Sun2
E-mail: ysun@uj.ac.za
Zenghui Wang3
1 Department of Electronic and Electrical Engineering Science, University of Johannesburg, Auckland Park 2006, Johannesburg, South Africa.
2 Department of Electrical and Mining Engineering, University of South Africa, Florida 1710, South Africa.

Disclosure statement
The authors of this research hereby declared that there were no potential conflicts of interest in this research.

Citation information
Cite this article as: Optimization techniques applied for optimal planning and integration of renewable energy sources based on distributed generation: Recent trends, Abdurrahman Shuaibu Hassan, Yanxia Sun & Zenghui Wang, Cogent Engineering (2020), 7: 1766394.

References
Abdallah, L., & El-Shennawy, T. (2013). Reducing carbon dioxide emissions from electricity sector using smart electric grid applications. Journal of Engineering (United States), 2013. https://doi.org/10.1115/2013/845051.
Abdmouleh, Z., Gastli, A., Ben-brahim, L., Haouari, M., & Al-emadi, A. (2017). Accepted manuscript Renewable energy eisever. https://doi.org/10.1016/j.reneene.2017.05.087.
Abou El-Elra, A. A., Allam, S. M., & Shatla, M. M. (2010). Maximal optimal benefits of distributed generation using genetic algorithms. Electric Power Systems Research, 80(7), 869–877. https://doi.org/10.1016/j.epsr.2009.12.021.
Abou-mouti, F. S., & Member, S. (2011). And sizing in distribution systems via artificial bee colony algorithm. 26(6), 2090–2101 IEEEEXPLORE. doi: 10.1109/T-PES.2011.2158246.
Acharya, N., Mahat, P., & Mithulananthan, N. (2006). An analytical approach for DG allocation in primary distribution network. International Journal of Electrical Power and Energy Systems, 28(10), 669–678. https://doi.org/10.1016/j.ijepes.2006.02.013.
Aftab, E., Taghiikhan, M. A., & Sedighizadeh, M. (2012). Optimal placement and sizing of DG in radial distribution networks using SFLA. International Journal of Energy and Engineering, 2(3), 73–77. https://doi.org/10.5923/j.ij.eee.20120203.03.
Alen, M., Hajebrami, A., & Fellow, M. F.-F. (2016). A comprehensive review on uncertainty modeling techniques in power system studies. Renewable and Sustainable Energy Reviews, 57, 1077–1089. https://doi.org/10.1016/j.rser.2015.12.070.
Alen, M., Rashidinejad, M., & Fotuhi-firuzabad, M. (2014). On possibilistic and probabilistic uncertainty assessment of power flow problem. A Review and A New Approach, 37, 883–895. https://doi.org/10.1016/j.rser.2014.05.063.
Akorede, M. F., Hizam, H., & Poursaeedi, E. (2010). Distributed energy resources and benefits to the environment. Renewable and Sustainable Energy Reviews, 14(2), 724–734. https://doi.org/10.1016/j.rser.2009.10.025.
Allan, G., Eramenko, I., Gilmartin, M., Kockar, I., & Peter, M. (2015). The economics of distributed energy generation: A literature review. Renewable and Sustainable Energy Reviews, 42, 543–556. https://doi.org/10.1016/j.rser.2014.07.064.
Aly, A. I., Hegazy, Y. G., & Alsharkawy, M. A. (2010). A simulated annealing algorithm for multi-objective distributed generation planning. IEEE PES General Meeting, PES, 2010, 1–7. https://doi.org/10.1109/PES.2010.5589950.
Aman, M. J., Jasmon, G. B., Mokhils, H., & Bakar, A. H. A. (2012). Optimal placement and sizing of a DG based on a new power stability index and line losses. International Journal of Electrical Power and Energy Systems, 43(1), 1296–1304. https://doi.org/10.1016/j.ijepes.2012.05.053.
Angarita, O. F. B., Leborgne, R. C., Silva-Gazzano, D. D., & Bortolosso, ca(2016). Power loss and voltage variation in distribution systems with optimal allocation of distributed generation. 2015 IEEE PES Innovative Smart Grid Technologies Latin America, ISGT LATAM 2015, 214–218. https://doi.org/10.1109/ISGT-LA.2015.7381156.
Approach, A. A. (2007). Distributed systems: an algorithmic approach. Taylor and Francis group LLC.
Badran, O., Mekhilef, S., Mokhils, H., & Dahalan, W. (2017). Optimal reconfiguration of distribution system connected with distributed generations: A review of different methodologies. Renewable and Sustainable Energy Reviews, 73(February), 854–867. https://doi.org/10.1016/j.rser.2017.02.010.
Ballesteros-Pérez, P., Elamrousy, K. M., & Carmen, G.-C. (2019). Non-linear time-cost trade-off models of activity crashing: Application to construction scheduling and project compression with fast-tracking. Automation in Construction, 97 (August 2018), 229–240. https://doi.org/10.1016/j.autcon.2018.11.001.
Barker, P. P., & De Mello, R. W. (2002). Determining the impact of distributed generation on power systems. I. Radial Distribution Systems, (c), 1645–1656. https://doi.org/10.1109/pes.2000.868775.
Borges, C. L. T., & Falcoo, D. M. (2006). Optimal distributed generation allocation for reliability, losses, and voltage improvement. International Journal of Electrical Power and Energy Systems, 28(6), 413–420. https://doi.org/10.1016/j.ijepes.2006.02.003.
Cao, Y., Wang, X., Yong, L., Tan, Y., Xing, J., & Fan, R. (2016). A comprehensive study on low-carbon impact of distributed generations on regional power grids: a case of jiangxi provincial power grid in China. Renewable and Sustainable Energy Reviews, 53, 765–778. https://doi.org/10.1016/j.rser.2015.09.008.
Carpinelli, G., Celi, G., Mocci, S., Piló, F., & Russo, A. (n.d.). Optimisation of embedded generation sizing and siting by using a double trade-off method. IEEE Proc-Generation Transmission Distribution, 152, 503–513. https://doi.org/10.1049/ip-gtd.
Cerone, V., Fosson, S. M., &Rigruto, D. (n.d.). A linear programming approach to sparse linear regression with quantized data. (arxiv:1903.07156v2 [math.OC] UPDATED). Arkiv Optimization and Control, 1–13. https://doi.org/10.1049/ark.1903.07156v2.
Chaitusayone, S. (2014). Key issues for integration of renewable energy and distributed generation into thai power grid. 2014 International Electrical Engineering Congress, IEEECON 2014. https://doi.org/10.1109/IEEECON.2014.6925967.
Chen, M.-Y., & Cheng, S. (2012). Multi-objective optimization of the allocation of DG units considering.
technical, economical and environmental attributes. 12, 233–237 State Key Laboratory of Power Transmission Equipment & System Security and Technology, Chongqing university. https://www.semanticscholar.org/paper/Multi-objective-Optimization-of-the-Allocation-of-Chen-Cheng/4667a40ee8f1888d6c6f2e3d9304b49d275306

Chen, X. P., Hewitt, N., Li, Z. T., Wu, Q. M., Yuan, X., & Roskilly, T. (2017). Dynamic programming for optimal operation of a biofuel micro CHP-HES system. Applied Energy, 208(October), 132–141. https://doi.org/10.1016/j.apenergy.2017.10.065

ChithraDevi, S. A., Lakshminarasimman, L., & Balamurugan, R. (2017). Studyl knif herd algorithm for multiple DG placement and sizing in a radial distribution system. Engineering Science and Technology, an International Journal, 20(2), 748–759. https://doi.org/10.1016/j.estech.2016.11.022

Cossent, R., Gómez, T., & Pablo, F. (2009). Towards a future with large penetration of distributed generation: Is the current regulation of electricity distribution ready? Regulatory recommendations under a European perspective. Energy Policy, 37(3), 1145–1155. https://doi.org/10.1016/j.enpol.2008.11.011

Das, B., Mukherjee, V., & Das, D. (2016). DG placement in radial distribution network by symbiotic organisms search algorithm for real power loss minimization. Applied Soft Computing Journal, 49, 920–936. https://doi.org/10.1016/j.asoc.2016.09.015

Das, C. K., Bass, O., Kothapalli, G., Mahmoud, T. S., & Habibi, D. (2018). Optimal placement of distributed energy storage systems in distribution networks using artificial bee colony algorithm. Applied energy, 232(April), 212–228. doi:10.1016/j.apenergy.2018.07.100

Davison, M. W., & Jee, F. 2002. Distributed resource electric power systems offer significant advantages over central station generation and T & D power systems part II, 62–69. Power engineering society summer meeting IEEE.

Dent, C. (2009). Capacity analysis using network analysis for DG integration. June (pp. 8–11).

Dent, C. J., Ochoa, L. F., Harrison, G. P., Bialek, J. W., & Member, S. (2010). Efficient secure AC OPF for distributed generation uptake capacity assessment. 25 (1), 575–583. IEEE Transactions on power system/IEEE-INST Electrical Electronics Engineering 2010. doi:10.1109/TPWRS.2009.2036809

Devbalaji, K. R., & Ravi, K. (2016). Optimal size and siting of multiple DG and DSTATCOM in radial distribution system using bacterial foraging optimization algorithm. Ain Shams Engineering Journal, 7(3), 959–971. https://doi.org/10.1016/j.asej.2015.07.002

Devbalaji, K. R., Yuvaraj, T., & Ravi, K. (2018). An efficient method for solving the optimal siting and sizing problem of capacitor banks based on cuckoo search algorithm. Ain Shams Engineering Journal, 9(4), 589–597. https://doi.org/10.1016/j.asej.2016.04.005

Devi, S., & Geethanjali, M. (2014). Application of Modified Bacterial Foraging Optimization Algorithm for Optimal Placement and Sizing of Distributed Generation. Expert Systems with Applications, 41(6), 2772–2781. https://doi.org/10.1016/j.eswa.2013.10.010

Dharagheswari, K., & Nayanatara, C. 2015. Distributed generations in IEEE 33 bus radial system using simulated annealing. 2015 International Conference on Circuits, Power and Computing Technologies [ICCPCT-2015], no. 2014: 1–7. https://doi.org/10.1109/ICCPCT.2015.7159428.

Dixit, M., Kundu, P., & Jariwala, H. R. 2016. Optimal placement and sizing of DG in distribution system using artificial bee colony algorithm. 2016 IEEE 6th International Conference on Power Systems, ICPS 2016. New Delhi, India. https://doi.org/10.1109/ICPS.2016.7584010.

Duong, M. Q., Pham, T. D., Nguyen, T. T., & Doan, A. T. 2019. Determination of optimal location and sizing of solar photovoltaic distribution generation units in radial distribution systems MDPI ENERGIES. https://doi.org/10.3390/en12010174.

Ehsan, A., & Yang, Q. (2016a). Optimal Integration and planning of renewable distributed generation in the power distribution networks: A review of analytical techniques. Applied Energy, 210(July 2017), 44–59. https://doi.org/10.1016/j.apenergy.2017.10.106

Ehsan, A., & Yang, Q. (2016b). Optimal placement and planning of renewable distributed generation in the power distribution networks: A review of analytical techniques. Applied Energy, 210 (October 2017), 44–59. https://doi.org/10.1016/j.apenergy.2017.10.106

El-saadany, E. E., & Atwo, E. F. (2010). Probabilistic approach for optimal allocation of wind- based distributed generation in distribution systems. Vol. 5, October 2009, 79–88. https://doi.org/10.1049/ielt-rpg.2009.0011.

El-Soeyd, K. S. (2017). Optimal location and sizing of distributed generation for minimizing power loss using simulated annealing algorithm. Journal of Electrical and Electronic Engineering, 5(3), 104. https://doi.org/10.11648/j.eeje.20170503.14

Eusuff, M., Lansey, K., & Pasha, F. (2006). Shuffled frog-leaping algorithm: a memetic meta-heuristic for discrete optimization. Engineering Optimization, 38 (2), 129–154. https://doi.org/10.1080/03052150500384759

Fister, I., Yang, X. S., & Brest, J. (2013). A comprehensive review of firefly algorithms. Swarm and Evolutionary Computation, 13, 33–46. https://doi.org/10.1016/j.swevo.2013.06.001.

Friedman, N. R. (2002). Distributed energy resources interconnection systems. Technology Review and Research Needs, [September] 1–163. http://www.nrel.gov/docs/fy02osti/32459.pdf.

Friess, T., Terry, J. C., Ho, K.-L., Mehta, N. J., Tobin, R. L., & Anandalingam, G. (2008). A simulated annealing approach to the network design problem with variational inequality constraints. Transportation Science, 42(1), 18–26. https://doi.org/10.1287/trsc.26.1.18

Gobash, A., & Pu, L. (2012). Active-reactive optimal power flow in distribution networks with embedded generation and battery storage. IEEE Transactions on Power Systems, 27(4), 2026–2035. https://doi.org/10.1109/TPWRS.2012.2187315

Ganguly, S., Sahoo, N. C., & Das, D. (2013). Multi-objective particle swarm optimization based on fuzzy-pareto dominance for possibilistic planning of electrical distribution systems incorporating distributed generation. Fuzzy Sets and Systems, 274(4), 47–73. https://doi.org/10.1016/j.fss.2012.07.005
Gerwen, R. V. (2006). Power quality and utilisation guide: distributed generation and renewables. Power Quality and Utilisation Guide Distributed Generators and Renewable Energy Development Association of Engineering and Technology endorsed Training Provider.

Gözél, T., & Hakan Hocaoglu, M. (2009). An analytical method for the sizing and siting of distributed generators in radial systems. Electric Power Systems Research, 79(6), 912–918. https://doi.org/10.1016/j.epsr.2008.12.007

Gözél, T., Hocaoglu, M. H., Eminoğlu, U., & Balliçi, A. (2005). Optimal placement and sizing of distributed generation on radial feeder with different static load models. 2005 International Conference on Future Power Systems, 2 pp. 6, Amsterdam, 16-18 November. https://doi.org/10.1109/FP2005.204319

Grechuk, B., & Zabarankin, M. (2018). Direct data-based decision making under uncertainty. European Journal of Operational Research, 267(1), 200–211. https://doi.org/10.1016/j.ejor.2017.11.021

Greene, N., & Hammerschlag, R. (2000). Small and clean is beautiful: exploring the emissions of distributed generation and. Science, 290(5499), 50–60. https://doi.org/10.1109/HICSS.2000.926773

Griffin, T., Tomsovic, K., Secrest, D., Low, A., & Corp, A. (2000) Placement of dispersed generations systems for reduced losses. c, 1–9. doi:10.1109/HICSS.2000.926773

Guadix, J., Cortés, P., Muñuzuri, J., & Onieva, L. (2018). A discrete particle swarm optimisation algorithm to operate distributed energy generation networks efficiently. International Journal of Bio-Inspired Computation, 12(4), 226. https://doi.org/10.1016/j.ijbici.2018.10017840

Gupta, A., Ratra, S., & Tiwari, R. (2017). Artificial bee colony based optimal allocation of micro-turbines for voltage stability improvement of distribution systems. 2017 Asian Conference on Energy, Power and Transportation Electrification, ACEPT 2017 2017-Decem: 1–4 Singapore. https://doi.org/10.1109/ACEP.2017.8168541

Gupta, A. R. (2017). Effect of optimal allocation of multiple DG and D- STATCOM in radial distribution system for minimising losses and THD, 0–4. IEEE.

Hadjjaid, N., Conard, J. F., & Dumas, F. (1999). Dispersed generation impact on distribution networks. IEEE Computer Applications in Power, 12(2), 22–28. https://doi.org/10.1109/67.755642

Hassan, A. S., Adabara, I., & Ronald, A. (2018). Design and implementation of an automatic power supply from four different source using microcontroller design and implementation of an automatic power supply from four different source using microcontroller, no. In July (pp. 2019). International Journal of Electrical and Electronic Science, American Association for Science and Technology.

Hassanzadehfard, H., & Jalilian, A. (2016). A novel objective function for optimal dg allocation in distribution systems using meta-heuristic algorithms. International Journal of Green Energy, 13(15), 1624–1634. https://doi.org/10.1080/15435075.2016.1212355

Hassanzadehfard, H., & Jalilian, A. (2018). Electrical power and energy systems optimal sizing and location of renewable energy based dg units in distribution systems considering load growth. 101 (January 2017), 356–370 International energy of green energy T&F. https://doi.org/10.1080/15435075.2016.1212355

Hedayati, H., Nabolivinski, S. A., & Akbarimajd, A. (2006). A new method for placement of dg units in distribution networks. 2006 IEEE PES Power Systems Conference and Exposition, PSCE 2006 - Proceedings, 23(3), 1906–1909. https://doi.org/10.1109/PSCE.2006.296204

Hemdon, N. G. A., & Kururat, M. (2008). Distributed generation location and capacity effect on voltage stability of distribution networks. 25(c), 1–5 IEEE. doi: 10.1109/AISPC.2008.4460571

Hilal, A. E. (2017). Meta-Heuristics. Springer.

Home-Ortiz, J. M., Melgar-Dominguez, O. D., Pourakbari-Kasmaei, M., & Mantovani, J. R. S. (2019). A stochastic mixed-integer convex programming model for long-term distribution system expansion planning considering greenhouse gas emission mitigation. International Journal of Electrical Power and Energy Systems, 108(December 2018), 86–95. https://doi.org/10.1016/j.ijepes.2018.12.042

Hun, D. Q., Mithulananthan, N., & Bansal, R. C. (2010). Analytical Expressions for DG Allocation in Primary Distribution Networks. IEEE Transactions on Energy Conversion, 25(3), 814–820. https://doi.org/10.1109/TEC.2010.2044416

Hydro, A., Laiti, E., and Energy Centre. 2016. An analytical approach for optimal sizing and placement of distributed generation in radial distribution systems (I LP; D; RI LD76), 1–5 International Conference on Power Electronics, Intelligent Control and energy systems (ICPEICE3-2016) IEEE. https://doi.org/10.1109/ICPEICE3.2016.7853119

Jabr, R. A., Singh, R., & Pal, B. C. (2012). Minimum loss network reconfiguration using mixed-integer convex programming. IEEE Transactions on Power Systems, 27(2), 1106–1115. https://doi.org/10.1109/TPWRS.2011.2180406

Jaravel, T., Hao, W., & Ihme, M. (2019). Error-controlled kinetics reduction based on non-linear optimization and sensitivity analysis. Combustion and Flame, 200, 192–206. https://doi.org/10.1016/j.combustflame.2018.11.007

Jordeh, A. R. (2018). How to deal with uncertainties in electric power systems? A review. Renewable and Sustainable Energy Reviews, 96(July), 145–155. https://doi.org/10.1016/j.rser.2018.07.056

Kalambé, S., & Agnihotri, G. (2014). Loss minimization techniques used in distribution network : Bibliographical survey. Renewable and Sustainable Energy Reviews, 29, 18–200. https://doi.org/10.1016/j.rser.2013.08.075

Kansol, S., Kumar, V., & Tyagi, B. (2013). Optimal placement of different type of DG sources in distribution networks. International Journal of Electrical Power and Energy Systems, 53(1), 752–760. https://doi.org/10.1016/j.ijepes.2013.05.040

Kanwar, N., Gupta, N., Niazi, K. R., Swarnkar, A., Kanwar, N., Gupta, N., Niazi, K. R., & Swarnkar, A. 2016. Electric power components and systems optimal allocation of distributed energy resources using improved meta-heuristic techniques optimal allocation of distributed energy resources using improved meta-heuristic techniques5008 (June) Electrical Power Components system. https://doi.org/10.1080/15325008.2016.1172682

Karimi, M., Reza, M., Oskuee, J., & Javad, M. (2016). Optimal planning of distributed generation with application of multi-objective algorithm including economic, environmental and technical issues with considering uncertainties. International Journal of Ambient Energy, 1–9. https://doi.org/10.1080/01430750.2016.1222955
Korki, S., Mann, M. D., & Salehfar, H. (2008). Environmental implications of renewable distributed generation technologies in rural electrification. *Energy Sources, Part B: Economics, Planning and Policy*, 3(2), 186–195. https://doi.org/10.1080/15567240601507507

Kashem, M. A., Member, S., Le, A. D. T., Negevitsky, M., & Ledwich, G. 2006. Most dangerous jobs 2, 1–8. IEEE. https://doi.org/10.1109/T-ED.1974.17899.

Kaur, S., Kumbhar, G., & Sharma, J. (2014). Electrical power and energy systems A MINLP technique for optimal placement of multiple dg units in distribution systems. *International Journal of Electrical Power and Energy Systems*, 63, 609–617. https://doi.org/10.1016/j.ijepes.2014.06.023

Kaveh, M. R., Hooshmand, R. A., & Madani, S. M. (2018). Simultaneous optimization of re-phasing, reconfiguration and DG placement in distribution networks using BF-SD algorithm. *Applied Soft Computing Journal*, 62, 1044–1055. https://doi.org/10.1016/j.asoc.2017.09.041

Kolayvish, S., & Vinod, V. K. (2018). Optimal planning of active distribution networks with hybrid distributed energy resources using grid based multi-objective harmony search algorithm. *Applied Soft Computing Journal*, 67, 387–398. S1568-4946(18)30125-X. https://doi.org/10.1016/j.asoc.2018.03.009

Kefayat, M., Lashkar Ara, A., & Nabavi Nikl, S. A. (2015). A hybrid of ant colony optimization and artificial bee colony algorithm for probabilistic optimal placement and sizing of distributed energy resources. *Energy Conversion and Management*, 92, 149–161. https://doi.org/10.1016/j.enconman.2014.12.037

Khalesi, N., Rezaei, N., & Haghihal, M. R. (2011). DG allocation with application of dynamic programming for loss reduction and reliability improvement. *International Journal of Electrical Power and Energy Systems*, 63(2), 288–295. https://doi.org/10.1016/j.ijepes.2010.08.024

Khatod, D. K., Pant, V., & Sharma, J. (2013). Evolutionary programming based optimal placement of renewable distributed generators. *IEEE Transactions on Power Systems*, 28(2), 683–695. https://doi.org/10.1109/TPWRS.2012.2211044

Kumar, A., & Gao, W. (2010). Optimal distributed generator location using mixed integer non-linear programming in hybrid electricity markets. *IET Generation, Transmission & Distribution*, 4(2), 281. https://doi.org/10.1049/iet-gtd.2009.0026

Kumar, M., Kumar, A., & Sandhu, K. S. (2018). Optimal location of WT based distributed generation in pool based electricity market using mixed integer non linear programming. *Materials Today: Proceedings*, 5(1), 442–457. https://doi.org/10.1016/j.matpr.2017.11.104

Kumawat, M., Gupta, N., Jain, N., & Bansal, R. C. (2017). Electric power components and systems swarm-intelligence-based optimal planning of distributed generators in distribution network for minimizing energy loss swarm-intelligence-based optimal planning of minimizing energy loss. *Electric Power Components and Systems*, 1–12. https://doi.org/10.1080/15325008.2017.1290713

Lakshmi D. A. C. (2012). A new analytical method for the sizing and siting of dg in radial system to minimize real power losses. *International Journal of Computational Engineering Research*, 2, 31–37.

Lakum, A., & Mahajan, V. (2019). Optimal placement and sizing of multiple active power filters in radial distribution system using grey wolf optimizer in presence of nonlinear distributed generation. *Electric Power Systems Research*, 173 (September 2018), 281–290. https://doi.org/10.1016/j.elspa.2019.04.001

Lopes, J., Peças, A., Hatziargyriou, N., Mutale, J., Djapic, P., & Jenkins, N. (2007). Integrating distributed generation into electric power systems: A review of drivers, challenges and opportunities. *Electric Power Systems Research*, 77(9), 1189–1203. https://doi.org/10.1016/j.epsr.2006.08.016

Luenberger, D. G. (1973). An Approach to Nonlinear Programming. *Journal of Optimization Theory and Applications*, 11(3), 219–227. https://doi.org/10.1007/BF00935189

Maciel, R. E., & Padilha-Feltrin, A. 2009. Distributed generation impact evaluation using a multi-objective tabu search. 2009 15th International Conference on Intelligent System Applications to Power Systems, ISAP ’09 UNEESP Ilha Solteria, Brazil. https://doi.org/10.1109/ISAP.2009.5352997.

Mahmoud, A., Pesaran, H., Dang, P., & Ramachandaramurthy, V. K. 2016. A review of the optimal allocation of distributed generation : Objectives, constraints, methods, and algorithms, no. May Renewable and Sustainable energy reviews.

Maleki, A., & Pourfayaz, F. (2015). Sizing of stand-alone photovoltaic/wind/diesel system with battery and fuel cell storage devices by harmony search algorithm. *Journal of Energy Storage*, 2, 30–42. https://doi.org/10.1016/j.est.2015.05.006

Manfren, M., Caputo, P., & Costa, G. (2011). Paradigm shift in urban energy systems through distributed generation: Methods and models. *Applied Energy*, 88(4), 1032–1048. https://doi.org/10.1016/j.apenergy.2010.10.018

Martin, J. 2009. Microsoft Word - Final Version + Exec Sum - An introduction to distributed generation.Pdf. *Applied Energy*, 187(2017) 154-168. http://vernimmen.com/ftp/An_introduction_to_distributed_generation.pdf.

Moshayekh, S., Studler, M., Cardoso, G., & Heleno, M. (2017). A mixed integer linear programming approach for optimal DER portfolio, sizing, and placement in multi-energy microgrids. *Applied Energy*, 63, 609-617. https://doi.org/10.1016/j.apenergy.2016.11.020

McMillan, C., & Glover, F. (1986). The general employee scheduling problem: An integration of management science and artificial intelligence. *Computers & Operations Research*, 13(5), 583–593. https://doi.org/10.1016/0305-0548(86)90050-X

Mithulananthan, N., Thon, O., & Le, V. P. (2004). Distributed Generator in Power Distribution Placement System Using Genetic Algorithm to Reduce Losses, 9(3), 55–62. https://doi.org/10.1016/j.apenergy.2003.05.001

Movahedi, M. (2017). Optimal locating and sizing of DG and D-STATCOM using modified shuffled frog leaping algorithm, 54–59. IEEE Swarm intelligence and Evolutionary computation (CISECE) Conference.

Mohandas, N., Balamurugan, R., & Lakshminarasimman, L. (2015). Electrical Power And...
Energy Systems Optimal Location And Sizing Of Real Power Dg Units To Improve The Voltage Stability In The distribution system using ABC algorithm united with chaos. International Journal of Electrical Power and Energy Systems, 66, 41–52. https://doi.org/10.1016/j.ijepes.2014.10.033

Moradi, M. H., & Abedini, M. (2012). A combination of genetic algorithm and particle swarm optimization for optimal distributed generation location and sizing in distribution systems with fuzzy optimal theory. International Journal of Green Energy, 9(7), 641–660. https://doi.org/10.1002/1543-5073.20115590

Murty, V. V. S. N., & Kumar, A. (2015). Electrical power and energy systems optimal placement of dg in radial distribution systems based on new voltage stability index under load growth. International Journal of Electrical Power and Energy Systems, 69, 246–256. https://doi.org/10.1016/j.ijepes.2014.12.080

Muthukumar, K., & Jayalalitha, S. (2016). Optimal Placement and Sizing of Distributed Generators and Shunt Capacitors for Power Loss Minimization in Radial Distribution Networks Using Hybrid Heuristic Search Optimization Technique. International Journal of Electrical Power and Energy Systems, 78, 299–319. https://doi.org/10.1016/j.ijepes.2015.11.019

Nadhir, K. (2013). Firefly algorithm for optimal allocation and sizing of distributed generation in radial distribution system for loss minimization, 231–235. IEEE EXPLOR.

Nahman, J. M., & Perić, D. M. (2008). Optimal planning of radial distribution networks by simulated annealing technique. IEEE Transactions on Power Systems, 23 (2), 790–795. https://doi.org/10.1109/TPWRS.2008.920047

Nara, K., Hayashi, Y., Ikeda, K., & Ashizawa, T. (2002). Application of tabu search to optimal placement of distributed generators. (C), 918–923, 978-1-4673-5549-0/13/2013. IEEE. https://doi.org/10.1109/pesw.2001.916995

Nazari-heris, M., Madadi, S., Hajiabbas, M. P., & Mohammadi-ivatloo, B. (2018). Optimization. Springer International Publisher.

Nemati, M., Braun, M., & Tenbohlen, S. (2018). Optimization of unit commitment and economic dispatch in microgrids based on genetic algorithm and mixed integer linear programming. Applied Energy, 210, 944–963. https://doi.org/10.1016/j.apenergy.2017.07.007

Nguyen, T. T., & Truong, A. V. (2015). Distribution network reconfiguration for power loss minimization and voltage profile improvement using cuckoo search algorithm. International Journal of Electrical Power and Energy Systems, 68, 233–242. https://doi.org/10.1016/j.ijepes.2014.12.075

Nguyen, T. T., Truong, A. V., & Phung, T. A. (2016). A novel method based on adaptive cuckoo search for optimal network reconfiguration and distributed generation allocation in distribution network. International Journal of Electrical Power and Energy Systems, 78, 801–815. https://doi.org/10.1016/j.ijepes.2015.12.030

Niwas, S., Version, D., & Congress, E. (2009). Distributed generation in power systems : An overview and 24th Indian Engineering congress NIT.

Ochoa, L. F., & Harrison, G. P. (2011). Minimizing energy losses : optimal accommodation and smart operation of renewable distributed generation. IEEE Transactions on Power Systems, 26(1), 198–205. https://doi.org/10.1109/TPWRS.2010.2049036

Østergaard, J. M., Albadi, H., & El-Saadany, E. F. (2001). Distributed generation: A definition. Electric Power Systems Research, 57(3), 195–204. https://doi.org/10.1016/S0378-7796(01)00101-8

Optimal Placement of Multi-Distributed Generation Units Including Different Load Models Using Particle Swarm Optimisation. 2011 S (March): 760–71. IET Generation,Transmission & Distribution. https://doi.org/10.1049/iet-gtd.2010.0676.

Othman, M. M., El-Khattam, W., Hegazy, Y. G., & Abdelaziz, A. Y. (2016). Optimal placement and sizing of voltage controlled distributed generators in unbalanced distribution networks using supervised firefly algorithm. International Journal of Electrical Power and Energy Systems, 82, 105–113. https://doi.org/10.1016/j.ijepes.2016.03.010

Paaso, E. A., Liao, Y., & Cramer, A. M. (2014). Formulation and solution of distribution system voltage and VAR control with distributed generation as a mixed integer non-linear programming problem. Electric Power Systems Research, (108), 164–169. https://doi.org/10.1016/j.epsr.2013.11.016

Parisi, A., & Gilelmo, L. 2011. A Mixed Integer Linear Formulation For Microgrid Economic Scheduling. 2011 IEEE International Conference on Smart Grid Communications, SmartGridComm 2011 (pp. 505-510). Brussels, Belgium. https://doi.org/10.1109/SmartGridComm.2011.6102375.

Pearmine, R. S., Pearmine, R., Song, Y. H., Williams, T. G., & Chebb, A. (n.d.). Review of primary frequency control requirements on the GB power system against a background of increasing renewable generation identification of a load – frequency characteristic for allocation of spinning reserves on the British electricity grid. IEEE Proceedings online no. 20041079 vol. 152 no. 1, january 2005. 1. https://doi.org/10.1049/ip-gtd

Pepermans, G. 2005. Distributed generation : Definition, benefits and issues DISTRIBUTED GENERATION : DEFINITION, BENEFITS AND ISSUES Pepermans G ., Driesen J ., Haeseldonckx D ., D ’ Haeseleer W ., Belmans R ., no. April. Energy Policy Elsevier, 33(6), 787-798.

Pepermans, G. J., Haeseldonckx, D. D., Belmans, R., & D’haeseleer, W. (2005). Distributed generation: definition, benefits and issues. Energy Policy, 33(6), 787–798. https://doi.org/10.1016/j.enpol.2003.10.004

Popović, Z. N., Dj Kerleta, V., & Popović, D. S. (2014). Hybrid simulated annealing and mixed integer linear programming algorithm for optimal planning of radial distribution networks with distributed generation. Electric Power Systems Research, 108, 211–222. https://doi.org/10.1016/j.epsr.2013.11.015

Prabha, Rama, D., & Jayabarathi, T. (2015). Optimal placement and sizing of multiple distributed generating units in distribution networks by invasive weed optimization algorithm. Ain Shams Engineering Journal. https://doi.org/10.1016/j.asej.2015.05.014

Prakash, D. B., & Lakshminarayana, C. (2018). Multiple DG placements in radial distribution system for multi objectives using whale optimization algorithm. Alexandria Engineering Journal, 57(4), 2797–2806. https://doi.org/10.1016/j.aej.2017.11.003

Prakash, P., & Khodat, D. K. (2016). Optimal sizing and siting techniques for distributed generation in distribution systems: A review. Renewable and Sustainable Energy Reviews, 57, 111–130. https://doi.org/10.1016/j.rser.2015.12.098

Pratt, R. G., Balducci, P. J., Gerkensmeyer, C., Katnapurola, S., Kintner-Meyer, M. C. W., Sanquist, T. F., Schneider, K. P., & Secrest, T. J. (2010).
Ugranli, F., & Karatepe, E. (2013). Multiple-distributed generation planning under load uncertainty and different penetration levels. International Journal of Electrical Power and Energy Systems, 46(1), 132–144. https://doi.org/10.1016/j.ijepes.2012.10.043

Vellom, M. R., Mitra, J., & Patra, S. B. (2006). Distributed generation placement for optimal microgrid architecture. Proceedings of the IEEE Power Engineering Society Transmission and Distribution Conference, Dallas, TX, USA, 1191–1195. https://doi.org/10.1109/TC.2006.1668674.

Vijay, B. P., & Singh, S. P. (2015). Optimal placement of DG in distribution network for power loss. In M. U. NLP & P. L. S. Technique. Energy Procedia (vol. 90). https://doi.org/10.1016/j.egypro.2016.11.211 December 2015444–454.

Viral, R., & Khatod, D. K. (2012). Optimal planning of distributed generation systems in distribution system: A review. Renewable and Sustainable Energy Reviews, 16(7), 5146–5165. https://doi.org/10.1016/j.rser.2012.05.020

Viral, R., & Khatod, D. K. (2015). An Analytical Approach for Sizing and Siting of DGs in Balanced Radial Distribution Networks for Loss Minimization. International Journal of Electrical Power and Energy Systems, 67, 191–201. https://doi.org/10.1016/j.ijepes.2014.11.017

Wang, C., & Hashem Nehrir, M. (2004). Analytical approaches for optimal placement of distributed generation sources in power systems. IEEE Transactions on Power Systems, 19(4), 2068–2076. https://doi.org/10.1109/TPWRS.2004.836189

Willis, H. L. (2002). Analytical methods and rules of thumb for modeling DG-distribution interaction. 1643–1644. https://doi.org/10.1109/Pess.2000.868774

Wong, L. A., Ramachandaramurthy, V. K., Taylor, P., Ekanayake, J. B., Walker, S. L., & Padmanaban, S. (2019). Review on the optimal placement, sizing and control of an energy storage system in the distribution network. Journal of Energy Storage, 21(December 2018), 489–504. https://doi.org/10.1016/j.est.2018.12.015

Wu, F. F., Gross, G., Luini, J. F., & Look, P. M. (2005). A two-stage approach to solving large-scale optimal power flows. IEEE Transaction on Power system, 126–36. https://doi.org/10.1109/pisc.1979.720054.

Yahidioui, A., Fodhil, F., Benmansour, K., Tadjine, M., & Cheggaga, N. (2017). Grey wolf optimizer for optimal design of hybrid renewable energy system PV-diesel generator-battery: Application to the case of djinet city of Algeria. Solar Energy, 158(August), 941–951. https://doi.org/10.1016/j.solener.2017.10.040

Yamamni, C., Maheswarapu, S., & Matam, S. K. (2016). A multi-objective shuffled bat algorithm for optimal placement and sizing of multi distributed generations with different load models. International Journal of Electrical Power and Energy Systems, 79, https://doi.org/10.1016/j.ijepes.2016.01.003

Yarahmadi, M., & Shokarami, M. R. (2018). Electrical power and energy systems an analytical and probabilistic method to determine wind distributed generators penetration for distribution networks based on time-dependent loads. Electrical Power and Energy Systems, 103(December 2017), 404–413. https://doi.org/10.1016/j.ijepes.2018.06.025

Yuvraj, T., & Ravi, K. (2018). Multi-objective simultaneous DG and DSTATCOM allocation in radial distribution networks using cuckoo searching algorithm. Alexandria Engineering Journal, 57(4), 2729–2742. https://doi.org/10.1016/j.aej.2018.01.001

Zeinalzadeh, A., Mohammadi, Y., & Moradi, M. H. (2015). Optimal multi objective placement and sizing of multiple dg and shunt capacitor banks simultaneously considering load uncertainty via MOPSO approach. International Journal of Electrical Power and Energy Systems, 67, 336–349. https://doi.org/10.1016/j.ijepes.2014.12.010

Zhao, Q., Wang, S., Wang, K., & Huang, B. (2019). Electrical power and energy systems multi-objective optimal allocation of distributed generations under uncertainty based on D-S evidence theory and affine arithmetic. Electrical Power and Energy Systems, 112 (October 2018), 70–82. https://doi.org/10.1016/j.ijepes.2019.04.044

Zhao, Y., Fan, F., Wang, J., & Xie, K. (2015). Electrical power and energy systems uncertainty analysis for bulk power systems reliability evaluation using Taylor series and nonparametric probability density estimation. International Journal of Electrical Power and Energy Systems, 64, 804–814. https://doi.org/10.1016/j.ijepes.2014.07.082

Zubu, R. H. A., Mokryani, G., Rajamoni, H.-S., Aghaei, J., Niknam, T., & Pillai, P. (2016). Operation and planning of distribution networks with integration of renewable distributed generators considering uncertainties: A review, no. September. Renewable and sustainable energy review.
