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A Review on Reliability for an Optimal DG Placement & Sizing for a Radial Urban Distribution System

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ABSTRACT

An increase in population results in abandonment of consumption of power which results in increased energy usage and environmental considerations to reduce the climate change have transitioned the trend forward into distributed energy sources. Since the existing power system is susceptible to numerous types of losses, distribution system reliability assessment has becoming an important consideration. Reliability of a system is the ability to provide an uninterrupted power supply with the quality of power to the consumer and is ordinarily assessed through the proper intimation. Many simulation model, analytical models, and heuristics have been developed to increase accuracy and integration in Placement of distributed generator and its allocation. In this regard, a comprehensive review of the literature concentrating on various approaches for Distributed Generation integration into the distribution network focusing on reliability and power quality issues is analysed in this paper. More simulation techniques used during literary works using various software are given importance. To arrive the conclusions of the real time network these simulation techniques provide the system administrators a ready tool to carry out research in the distribution system.

KEYWORDS: Distributed Generation (DG), Distribution System, simulation techniques and renewable energy.

1. INTRODUCTION

Nowadays, to minimize the carbon footprint in the environment government bodies are encouraging and supporting renewable energy sources. Henceforth the number of studies on the integration of distributed resources to the grid has gradually risen. In addition to environmental advantages, Power losses are diminished, bus voltages are refined, and reliability of system, stability, quality of power, and ease of understanding are enhanced by distribution generation [26]. In fact, improper placing and sizing of Distributed Generators in distribution networks may result in higher system complexity and the issue of protection system co - ordination. Distribution system losses account for approximately seventy percent of all losses in the electrical power system [21]. Distributed Generators that can be integrated into distribution feeders are a great way to cut distribution losses is an excellent option. Distributed generators can even be powered by conventional or non-conventional sources of energy. Moreover, as an environmental concern expands, non conventional energy-based Distributed Generators have become more popular [2]. Distribution Generations are comparatively tiny power generation units that are electrically connected directly to distribution network and therefore can produce electricity from any non-convectional source of energy. The entering of Distribution Generation is continuously growing due to increase electricity system reliability of net-zero carbon footprint, cleansed environment, diverseness in generation fuel, small construction time, enhanced efficiency of the grid and compliant initial cost. As there is a demand from consumer side for consistent and high-quality supply of power, assessment of the influence of Distributed Generation system integration to improve the system effectiveness, mainly reliability, and also loss reduction attaining more importance in the present day distribution system environment. Enhancement in reliability & Power quality issues can be obtained by optimal selection, placement, and sizing of Distribution Generations. This leads to improved voltage level, improved power quality, and improved system load capability, as well as increased system security. Renewable energy-based DGs will have the advantage of lower maintenance requirements, numerous environmental benefits; lower reliance on foreign energy sources leads to a cleaner environment, and so on. The voltage profile, real power line setback, and reactive power line setback can all be improved by properly retrieving and assigning Distributed Generation [25]. DG technologies are incorporated with some drawbacks, if not installed at proper locations and may lead to various problems viz. increased losses, protection coordination problems, power quality issues, etc... These problems of optimal selection, sizing, and sitting of DGs have been approached within literature using several techniques. Analytical techniques fit well for comparatively tiny distribution systems but not well for complex systems. For large and complex systems, various meta-heuristic techniques have been already developed. Which provide excellent results. Weighted multi-objective function with power performance criteria for tracking down the most sensitive bus in the Distribution network in terms of the power quality perturbation [29].Many simulation techniques are adopted by using different power system simulation software which is used to arrive at suitable conclusions based on the simulation outcomes. The review on Distributed Generation integration simulation techniques adopted by various scholars concentrating on the reduction of loss, increasing the distribution system's reliability has been presented in this survey. Simulation studies are attained high importance, especially for real-time systems to gain insight into the performance of new technologies and operational aspects of a distribution system. These results are used by the network operators to predict the system performance in presence of Distributed generators and to assess the system's reliability.

2. DISTRIBUTED GENERATION

2.1. Overview of DG Technologies:

The interlinking of power sources to distribution systems is known as distributed generation. Rootstock for the distribution generation can be conventional or non-conventional energy sources. Availability In such instances, energy storage is used in conjunction with distributed generators to ensure supply reliability. Hybrid generation systems, which integrate diverse energy sources, are gaining a foothold in modern power systems.

TABLE 1

Distributed Generation Class Based on Capacities & Technology

Sl. No.	Class Of DGs	Capacity Range	Distributed Generation Technology
1	Micro DG	1kW-5kW	Solar PV, Micro hydro, Wind turbines, Fuel cells.
2	Small DGs	5kW≤5MW	Small hydro,Fuel cells,Wind turbines,Tidal, Biomass,IC engines
3	Medium DGs	5MW≤50MW	Solar thermal & PV, Geothermal, Biomass, IC engines, Hydrogen energy systems.
4	Large DGs	50MW≤300MW	Solar thermal & PV, Hydrogen energy systems, Hydro.

2.2. Impact of DG:

This same electrical power system structure is significantly altered by the interconnection of Distributed Generators. Therefore the performance of existing system can be varying according to the type, size, and location of the interconnected Distributed Generation. The influence of Distributed Generation interconnection on power system quality needs to be analysed properly. Distributed Generators units are classed into 3 types as per the absorption of true and reactive power. The first type of distributed generator unit makes an attempt to inject true and reactive power into the connected system. The second type injects true power into the system but absorbs reactive power. The third involves injecting only true power and has no reactive power. Power flow analysis controls the power output of distributed generators when they have been connected to the distribution system. End-users who use DG could indeed reduce their monthly consumption electricity bills through net metering.

3. DISTRIBUTED GENERATION INTEGRATION IN A DISTRIBUTION SYSTEM

Available methods for analysing the impact of DG integration into the electrical system can be broadly classified into Analytical techniques, classical techniques (non- heuristic), simulation techniques, meta-heuristic techniques, and hybrid approach. Numerous techniques have been illustrated for the solution of DG integration. All of these techniques will be having an invaluable achievement to placement of Distributed Generators and tailoring in a distribution network. Various available algorithms under the above techniques are given in the literature [21, 22 & 28] except for simulation techniques. Many works are carried out to study the impact of Distributed Generations integration into the distribution system concerning different parameters using simulation procedures using appropriate software.

3.1. Analytical Techniques:

The Analytical technique refers to the methods which are used to troubleshoot by manipulating suitable mathematical modelling for the occurred crisis. It is the mathematical representation of the system under research. Direct numerical solution is being used to obtain the solutions. This method contributes appropriate speed with less factual along with fewer data processing. These are ideally suited for miniature and less complicated system [21]. Analytical techniques are not well suited for larger systems, due to their less effectiveness in computation. Certain importance modelling method in order to analyze Distribution generations Fusion constitute Two/Third golden rule, perceptive factor analysis; Eigen-value based analysis, iterative methods, etc. Considerable types of methods are been described in literature for solving the ideal Distributed generation placing and sizing. [23]. Use of a voltage sensitivity index to decide optimal DG position, size, and type is demonstrated, and loss elimination is revealed in [3] for 14-bus IEEE system using the analytical method & [27] for IEEE 6-bus & Civanlar 16 bus Distribution systems using fast approach. The influence of element disrupts the reliable of the Distribution network with the addition of the DGs. It is observed using the fault hazard method analysis in real-time distribution system in Indonesia [12]. [15] exemplifies a method to identify the optimal location and effective size of the Distributed generation based on loss sensitivity factor and improvements of voltage profile, so that the impact of DG placing involves complete power system losses and voltage of a distribution system is scrutinized, and the method is dependable for 33-radial bus networks of the system.

3.2. Classical Techniques:

Classical techniques include optimization methods that are applied to larger distribution systems for finding an optimal solution with better accuracy compared to analytical methods. These enhancements methods strategies are used to the emerged problem formulate to maximize or minimize as per the given set of conditions and within the range of constraints. This methodology is developed for the optimal placing of Distributed Generators in the distribution network. These techniques include linear programming, dynamic programming, sequential quadratic programming, optimal power flow, continuous power flow, etc. Many of these techniques are illustrated in the literature and reviewed in the literature works [21, 22 and 23].

3.3. Metaheuristic techniques:

Metaheuristic techniques are based on smart intelligent methods and these methodologies are capable of providing precise, effective, and optimal solutions for Distributed Generator placement. These methodologies have been evolved from artificial intelligence techniques and are most suitable for solving complicated problems in various fields. These are robust techniques and result in near-optimal solutions for complex problems. Some of the important algorithms adopted for solving DG integration problems are genetic algorithm, particle swarm optimization (PSO), fuzzy logic, artificial bee colony, ant colony optimization etc. Several of these techniques are illustrated in the literature and reviewed in the literature works [21, 22, 23]

3.4. Hybrid Techniques:

These techniques are using a combination of the two or even more optimization algorithms to mitigate the problem and find the best location for Distributed Generators. These Techniques include a combination of flower pollination algorithm (FPA), Genetic algorithms with fuzzy logic, firefly algorithm, invasive weed optimization etc. [21].

3.5. Simulation Techniques:

The simulation technique is a modelling approach that indicates sufficient information regarding the system performance under different conditions. The solution for the given problem is obtained by modelling the system using various different tools and carrying out the simulation under different scenarios of the practical importance of distribution systems. A simulation modelling technique is applied when an analytical formulation of a real problem cannot be achieved to the desired level. The simulation modelling approach provides results for specific use cases and conditions. The use cases are defined and specified by system planners and distribution network operators (DNOs). In order to balance the effect of numerical calculations, the simulation should be run many times for use cases with different sets of conditions and constraints, the simulations should be run again and again. These simulation techniques especially are accurate when the results are examined in real-time working systems under valid input presupposition. For better analysis, the analytical approach is preferred over the simulation approach, since the reality of the modelled system is validated using the simulation approach. A validated simulation result is acceptable in most of the case studies. Simulation techniques maybe Monte Carlo simulation, Markov modelling and simulation using suitable software. These simulation results will provide sufficient information regarding the system performance under various conditions of importance and case study results will serve as a reference for future works. For the study the influence of DG integration in a distribution network, a handful of experimentations have been carried out by considering simulation studies of the test system under different scenarios.

TABLE 2
An overview of Different DG Integration Simulation Techniques

Sl No	Test Sys tem	Objective	Approach	Softwares Used	Parameters Consi dered
1	RBTS bus-2	Influence of Distributed Generation on Distribution network Reliability	Simulative	Dlg SILENT Power Factory	Optimal DG size and improvement in reliability indices.
2	IEEE 33 bus system	DG Positioning and Sizing in Radial Distribution Networks	Simulative	MATLAB	Distributed generators optimal placement and sizing
3	IEEE 33 bus	Combined Energy losses, voltage profile, and pollution emissions	Simulative	MATLAB	Distributed generators optimal placement and sizing
4	IEEE 33 bus system	Providing the requisite True and reactive power support while diminishing system real and reactive power loss	Simulative	MATLAB	Distributed Generators optimal placement and sizing
5	IEEE 14 bus system	Focused on load bus selection Loss reductions and voltage sensitivity	Analytical	MATLAB	Optimal DG size and type
6	IEEE 33 bus system	To lessen power loss while boosting voltage level and reliability	MetaHeuristic for sizing & siting, Simulation for reliability evaluation.	ETAP	Optimal DG location, size and improvement in reliability indices.
7	5 bus system	Minimization of power loss and improvement of voltage profile	Simulative	MI-POWER	DG optimal placement and sizing
8	IEEE 14 bus system	Improvement in voltage profile, reduction in losses and improvement in reliability	Simulative	ETAP	Optimal location and size
9	IEEE 34 bus system	Minimization of system losses and improvement in reliability	Analytical	MATLAB	Optimal location and size
10	RBTS bus-2	Improvement of reliability of the system	Simulative	ETAP	Optimal location, size and number
11	Real time feeder (Pujon feeder)	Improvement in reliability indices	Analytical	MATLAB	Relocation/addition of sectionalizes in presence of DGs

12	Real time feeder (Thanyaburi feeder)	Improvement in reliability indices	Simulative	Dig SILENT Power Factory	DG location and size
13	5 bus system	Improvement in reliability indices with loss reduction and voltage profile improvement	Simulative	MI-Power	Optimal location and size
14	RBTS bus-2 system	Improvement in reliability indices	Simulative	ETAP	Optimal location and size
15	33 bus radial system	Reduction of True power losses is and the improvement of voltage profile	Analytical	MATLAB	Optimal location and size
16	RBTS bus-2 system	Loss reduction and voltage improvement along with protection coordination	Simulative	ETAP	Optimal location and size
17	29 bus NE plan test system	Voltage profile advancement and power minimisation	Simulative	NEPLAN	Optimal DG size and type
18	RBTS bus-2 system	Improvement in reliability with DG and applying DSM	Analytical	MATLAB	Reliability with DG and DSM

Different test systems are considered in research and various scenarios are simulated to arrive at the conclusions. Based on the literature survey, Table-II provides the overview of different techniques along with test systems considered, objective considered in Simulation studies are carried out using ETAP in [6,8,10,14,16,],using NEPLAN[17], DIgSILENT Power Factory in [1,12], using MI Power in [7,13] and using MATLAB in [2,3,4,5,9,11,15,18].. Along with the objective of improving of reliability of the the system, system power loss reduction, and voltage profile enhancement has been considered as the objective in [2, 3, 4, 6, 7, 12, 14, 15, 17]. The concept of DSM has been considered in [5, 16]. Solar PV has been the choice of DG in most of the literature. Energy storage has been considered in [1], micro-hydro in [10], Diesel generator in [17], and wind in [5, 8, 9, 12, 13, and 17].

4. CONCLUSION

The current study will focus on techniques for analyzing the incorporation of distributed generation's influence on reliability of distribution system and power quality problems, with a particular emphasis on simulation techniques for optimal placement and sizing of distributed energy sources. The paper epitomises a significance of Dg placement into the distribution system and its impact on distribution system reliability. The ultimate focus of distributed generation is to improve distribution system reliability, as well as many other Distributed Generation benefits such as improvements in power flow, losses of energy, regulation of voltage, protection for short circuit currents system design, reliability, stability, and quality of power, and environmental benefits. There are diverse techniques available for analysing the effect of the DG integration and those have been epitomized in this article. Analytical techniques are quite ideally adapted to smaller and simple systems since they are faster to execute and require minimal computation times. However, their results are only expressive as it is based on a hypothesis. The classical techniques are more systematic and can be applied to complex distribution systems. Heuristic techniques are more practical and result in near-optimal solutions for complex Distribution Generators allocation and sizing problems in the distribution system. Even though these techniques are well developed for various test systems, the simulation techniques are helpful for network operators to have a picture of the impact of DG integration in order to verify that DG integration positively impacts systems by lowering the power losses and voltage regulation improvement through optimal distributed generation location and sizing.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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