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Review of Reliability Analysis of Distribution Network Connected with Distributed Generation

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ABSTRACT- An increase in worlds energy consumption the demand for electricity also increases. As we know conventional energy sources are depleting day by day and need to conserve what is existing and to explorethe alternative source of energy.The ideal allocation and sizing of distributed generation in distributed networks has always been difficult for utilities as well as customers in order to reap the greatest benefits feasible in light of environmental, economic, and technical issues. For DG placement and sizing, several simulative, analytical, heuristic, and hybrid techniques are applied, to get improved accuracy. With an emphasis on reliability and loss minimization, this paper analyses a review of the literature on several techniques for DG integration into the distribution system.

Index Terms – Distributed Generation (DG), Distribution System, reliability, Simulation techniques, renewable energy.

I. INTRODUCTION

An increase in population intern increases electricity demand which is resulting in continuous depletion of the long-established power generation sources [22].To deliver electricity to the customer in a dependable, decent, and economical way, power system reliability is crucial. The answer to this is DGs. Both renewable and nonrenewable energy sources can be used to power DGs. We are all aware of the shift in the electric distribution system towards renewable energy sources. The distribution system can benefit from the integration of renewable energy resources based on DGs because they are emission-free, readily available, abundant in nature, and so on [5]. Placement and size of DGs increase reliability, voltage profile, and load variations by reducing losses. Moreover, it helps to reduce harmonics, sag, and swells on the transmission and distribution side of the power system. Both utilities and customers benefit from the installation of DGs [22].

Distribution system losses are responsible for almost 70% of all losses in the power system [4]. DGs incorporated into the distribution system will be a smart choice to reduce losses. Moreover, this will result in lower operational, fuel, and repair costs [3]. Evaluation of the quantity and quality of DGs to be installed in the electricity system is also crucial for the system's efficient operation. As a result, power may flow in both directions [22].

If not installed in the correct area, DG technologies have various drawbacks that might result in higher losses, poor power quality, and other problems [2]. There are numerous methods that can be used to solve these issues. This research [3] provides a review of DG integration simulation approaches used in various literatures with a focus on distribution system loss reduction and reliability enhancement.

II. DISTRIBUTED GENERATION

1.1 Overview of DG technologies

Distributed generation refers to many technologies that generate electricity nearby or on-site.DG is defined as "less than 50-100 MW" by the International Conference on Large High Voltage Electric Systems (CIGRE) [23]. Distributed generation can use conventional ornon-conventionalenergy sources. According to their capacity for producing electricity,various classes of DGs are listed in table 1 [5].

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TABLE 1

Distributed generation: Types based on the capacity [5]

Sl.no	Class of DG	Capacity range
1	Micro DG	1kw-5kw
2	Small DGs	5kW≤5MW
3	Medium DGs	5MW≤50MW
4	Large DGs	50MW≤300MW

1.2 Impacts of DG Integration

A distribution system reliability is improved by the installation of DG. The current distribution system can be used to its full potential if DG is distributed optimally.If reliability improvement is to be maximized, the DG's position must be such that it gives customers the maximum access in terms of customer numbers, overall demand, and customer priority. As a standby or backup supply, DG is prerequisite**.**

1.3 Evolution of reliability indices in the presence of DG's

The evaluation of the distribution systems reliability is based onnumber of reliability indices, which includes the average failure rateλ, average interruption time U, average interruption duration r, system average interruption duration index (SAIDI), customer average interruption duration index (CAIDI), average service availability index (ASAI), average service unavailability index (ASUI), expected unserved energy (EUE) and expected outage cost (EOC)[6,7,8,9].

III. DISTRIBUTED GENERATION INTEGRATION IN A DISTRIBUTION SYSTEM

The methodologies listed below can be used to examine how DG integration affects electrical systems., analytical, classical, meta-heuristic, hybrid, and artificial intelligence techniques. The solution to DG integration has been shown using a variety of ways. Many studies are conducted utilizing modelling techniques and appropriate software to determine the effects of distribution generation integration on various parameters in the distribution system.

1.4 Analytical techniques

The term "analytical methodology" describes a set of procedures for resolving problems by modifying an appropriate mathematical model for the current dilemma. The answer is obtained usingnumerical solution. These methods provide good speed, lower accuracy, and faster processing. Small and uncomplicated systems are most suited for analytical methods [2,4,22].

In order to increase the reliability of the RBTS bus-2 system, with and without considering distributed generation in Grid connected mode. The reliability has been evaluated feeder wise, each feeder is considered as separate micro-Grid with grid connected mode. Also, the sizing and placing of DG is considered in the reliability enhancement is presented in [10].

In order to recover the interrupted supply in remote locations of a distribution network, an overview of the reliability impact of DG and energy storage technologies is provided in [11].

A typical distribution system is taken into account, and to demonstrate the systems increased reliability, various components like fuses, disconnectors are gradually added to the system and is demonstrated in [12].

1.5 Classical techniques

To identify an ideal solution with more precision than analytical methods, Classical techniques use optimization strategies for larger distribution systems. Several methods can be used to examine the placement strategy and DG's capabilities. [14] is an illustration of a goal to lower annual energy losses with improved reliability and voltage profile. A voltage profile and to improve reliability while reducing system power loss is presented in [13].

1.6 Meta-Heuristic techniques

There are more metaheuristic and heuristic approaches than analytical and conventional ones utilised to solve the DG allocation problem. These strategies can offer an effective, precise, and ideal solution that is built on clever, intelligent techniques. They produce the best solution for difficult challenges. The genetic algorithm, particle swarm optimization, fuzzy logic, and other significant techniques are used to solve DG integration difficulties.Literature reviews and illustrations of several of these techniques is reviewed in [4,5,18,22].

1.7 Hybrid technologies

[15] describes a multi-objective method for more reliably choosing the best position and

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size for numerous distributed generation (DG) units inside the distribution network.

The goal of [16] is to calculate the reliability of the mesh-grid representation of the network, allocate a specified reliability value, and improve reliability by considering the impact of DG on the IEEE 33 and 69-bus distribution systems.

To increase the reliability and voltage profile, it is recommended in [17] to allocate and size DG units optimally to reduce electrical losses in the primary distribution network.

1.8 Artificial Intelligence techniques

The most modern methods are those based on artificial intelligence. They are referred to as intelligent approaches since these strategies can obtain an effective, precise, and ideal solution in a clever manner.

Artificial Bee Colony (ABC) algorithm-based reliability improvement of radial distribution system with dispersed generation is given in [19].

[20] presents a method for increasing reliability utilising artificial intelligence's evolutionary processes.

TABLE 2
Different DG Planning Methodologies on Reliability

Sl.no	Approach	Algorithm	Objective	Test System	Ref
1	Analytical	Iterative method	Loss reduction, voltage profile enhancement, and reliability	RBTS bus-2	[10]
2	Analytical	Islanded mode	The reliability impact of DG and energy storage technologies	15 kV distribution network feeder	[11]
3	Analytical	Load point indices and system indices	To improve the reliability of the distribution system	RBTS bus-2	[12]
4	Classical	Ordinal Optimization	Minimize lossand reliability improvement	69-node distribution system	[14]
5	Classical	Dynamic Programming	To improve reliability and voltage profile	A practical 132/33kV distribution system	[13]
6	Meta-heuristic	Two parameters based alpha model technique (TPBAMT), alternative model-creating technique (AMCT) and proposed fuzzy fault tree-based technique (PFFTBT)	Reliability enhancement of power system	IEEE bus-21 and bus-22	[18]
7	Hybrid	Evolutionary Programming and Particle Swarm Optimization	Minimize power lossand improve reliability and voltage.	33-bus RDS	[17]
8	Hybrid	Sensitivity analysis	improving the reliability by allocating a targeted reliability value.	IEEE-33 And 69-bus	[16]
9	Artificial Intelligence	Artificial Bee Colony	Reliability improvement	Radial distribution	[19]

				system	
10	Artificial Intelligence	Artificial neural network	Distribution system reliability	Roy Billinton Test System (RBTS)	[21]

1.9 Outcomes of review on various techniques

This paper illustrates the significance of DG integration into the distribution system and its impact on distribution system reliability. The major goal is to increase the distribution systemsreliability through DG integration,advantages of DG integration are loss reduction, improved voltage profiles, improved power quality, and other related economic and environmental advantages. In this paper, the numerous methods for researching DG integration have been compiled. For huge and complicated systems, the analytical method is not computationally efficient. The classical methods are more effective and are applicable to huge systems. Large and complicated systems are a good fit for meta-heuristic methods. The optimal solution is more effective and trustworthy when it is a mix of two or more optimization techniques.Artificial intelligence techniques are the most recent techniques and it is capable to get comparatively accurate solution.

IV. CONCLUSION

The methodologies for analysing the integration of distributed generation that aid in improving reliability, reducing power loss, and improving voltage profiles will be the main focus of this paper. By incorporating renewable energy sourceson to DG units, this also minimises investment with low operational and maintenance costs and reduced greenhouse gas emissions. For allocation and sizing, a number of analytical, classical, meta-heuristic, and hybrid optimization techniques are also adapted. Analytical methods are good for simple systems but not for complex system. The classical methods can be used for complex distribution systems and are more systematic. For extremely massive systems, meta-heuristic and hybrid approaches are ideally suited. They operate with excellent accuracy. Hence to conclude, the primary goal of this paper is to increase the distribution system reliability.

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