International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 01 | Jan 2021 www.irjet.net p-ISSN: 2395-0072

Introduction to Power Distribution Network Reconfiguration Techniques

Ahmed syed[1], A. Raghu Ram[2]

[1]*Research Scholar & JNTUH CEH*
[2]*Professor, Dept. of EEE & JNTUH CEH*

---***---

Abstract - *Power distribution system perform significant role in neoteric society. As the size and capacity of power systems increases, it becomes more complex which reduces the reliableness of such systems. Radial Distribution network reconfiguration is becoming an expedient solution for improving distribution network performance. Configurations can be changed manual or automatic switching operations, so that all loads are catered, power loss reduced, system safety is increased and power quality is improved. Network reconfiguration also reduces overload on the network components. Changes to the network configuration are made by opening sectionalizing switches and closing tie switches. These switches are designed to maintain the network's radiality and keep all loads excited. Many researchers have tried to solve the problem of restructuring the power distribution network using different techniques. This paper presents an extensive study on network reconfiguration to bring up a clear idea for future research.*

Key Words: Distribution Network reconfiguration, Heuristic, Metaheuristic, Power loss, Test System.

1. INTRODUCTION

Reconfiguration of the power distribution system has come a long way from the first slow and heuristic predominantly single use modes of computation to modern and versatile stochastic reconfiguration methods equipped with high speed simulator and the latest imaging software. If one looks at the large number of papers written on this subject in the last three decades, reconfiguration of distribution system is certainly one of the most rapped problems for researchers. Distribution network reconfiguration methods for radial distribution have two basic problems firstly networks are very big combinatory solving space, secondly provision for a very quick loss estimation technique in order to test each of these configurations repeatedly and continuously.

The incremental development of smart/intelligent distribution system , with the penetration of Distributed Generation (DG) and latest Flexible Alternating Current Transmission Systems (FACTS) equipments to ensure a highly efficient distribution of power, the availability of new techniques for meta heuristic optimization and the increasing stochastic environment have actually led to the development of distribution network reconfiguration methods more tougher. Therefore the first aim was to minimize active power loss and load balancing of feeder. New distribution network reconfiguration method serves many other functions with a strong emphasis on reliability enhancement and power quality. With this, this paper aims to study and identify the distribution reconfiguration methods thoroughly by retracing the evolution of the process with incremental distribution system automation and the creation of an intelligent grid. The following features are presented in this analysis. It follows the emergence from the early single objective methods to modern multifunctional methods. Reconfiguration methods are categorized and the chronological study is comprehensive. It offers existing research patterns and future recommendations for research.

2. DISTRIBUTION NETWORK RECONFIGURATION METHODS

The methods for distributing network reconfiguration are classed into three categories: (1) heuristics (2) metaheuristic and (3) mathematical optimization approaches. A fourth group incorporates the hybrid strategies based on the three first approaches. Heuristic approaches are the most common, primarily because these strategies often yield rapid reconfiguration results and draw on operational experience in the distribution network so that they are easy to formulate. These methods do not always give global optimal values, however, but metaheuristic distribution network reconfiguration methods require enough time to formulate and are often complicated. These methods of reconfiguration are based upon the genetic algorithm, simulated annealing, ant colony search, harmony search, tabu search, particle swarm optimization, etc. Mathematical Optimization methods, otherwise, known as deterministic methods and the examples of this approach are linear programming, quadratic programming, nonlinear programming etc.

The Distributing Network Reconfiguration approach can be classified into two categories: (a) branch exchange (BE) method and (b) sequential switch open method (SSO). In the branch exchange method, all split switches must be open with the closing of all tie line switches. In the second category, one or any number of combinations of network tie line switches is closed first to form a mesh-like system, and then the partial switches are successively opened to restore the radial configuration.

The Distributing Network Configuration [DNR] problem, which Merlin and Back [1] had in 1975, was detected as a

Minimum Spanning Tree [MST] with a minimum total active power loss. The single most significant objective has still today been to mitigate the power loss [PL]. Indeed, under normal situations, the primary aim of DNR is to reduce PL and restore emergency services [SR].

2.1 Heuristic Methods

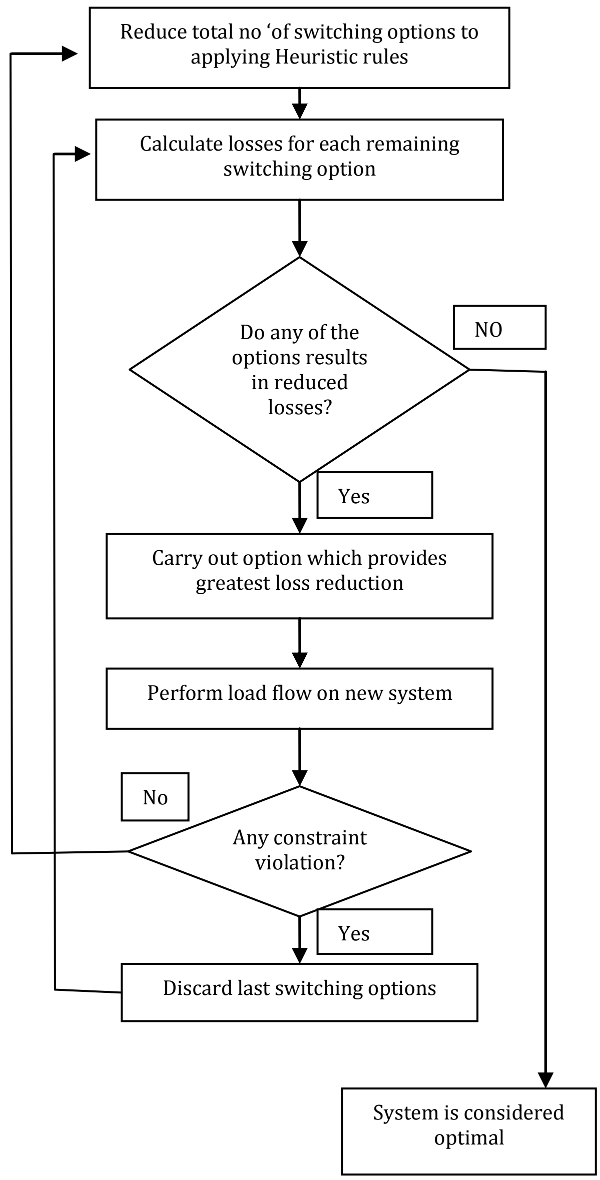
The majority of the papers assessed consider the Distributing Network Reconfiguration issue as a single objective of loss minimization subject to current, voltage and radiality constraints.

Authors in [1] proposed Dynamic switches set heuristic algorithm. Which relies on the development and change of a dynamic open switches set. This set is modified at every level of the algorithm to exhibit branch exchange approach. This method guarantees connectivity, radiality constraints and decreases the convergence calculation effort. The sequence for switch maneuvers to modify system topology was determined by this methodology. Bit by bit, the evolution of voltage has improved and the active power losses of the system minimized.

In [2], A new heuristic method, uniform voltage distribution based constructive algorithm, suitable for optimal reconfiguration of distribution networks. The method for optimal expansion of the sub-network is discussed here. The approach relies on the even distribution of voltage to the final nodes. When a strictly resistive radial distribution network is designed to supply all the end loads with exactly the same voltage, the configuration of the radial distribution network is optimum globally.

Authors in [3] have been presented the knowledge-based medium voltage distribution network heuristic algorithm. Within the planning setting the primary implementation of the proposed algorithm could also be used for operational studies. In the event of failure of the line, transformer or high voltage, the algorithm provides a reconfiguration mechanism that minimizes the undelivered power of the line. As an algorithm, characteristics such as low processing time and interpretability of the solutions deal with complex and large-scale real distribution networks.

Abul'WafaJ et al. [4] have dealt with a new approach based on established heuristic rules and built a load flow algorithm that gives exact branch currents, node voltages and device power loss. The new approach this algorithm reduces the problem of combinatorial exploratory switching to a workable one and reduces the number of switching combinations. The tie branches and their adjacent branches are considered the best combination of them with less computational effort. The switching combinations of the network are shown to be much closer to the lower potential of the tie switch in each loop. This algorithm provides an optimal solution with few switching operations, load flow execution and processor required time is less.



F

Figure1. Flow chart of Heuristic search method

Several methods are taken in literature as Distributing Network Reconfiguration deals with more than one objective. The significant methodologies are examined here

[5] Presents The binary particle swarm optimization (BPSO) technique is utilized to decide the ideal arrangement of switches in the configuration to increase the reliability at the load points, and decrease real power loss in the system. When determining the reliability at load points, probabilistic models of the distribution system components were considered. Minimal cut sets are first defined between the source and load points and then the predicted power availability is estimated using the joint failure probability distribution of the components related to the cut set. One of

the contributions to this paper is the issue of allocation in a multi-objective environment taking account of the reliability and power losses of the distribution system.

[6] This paper provides an efficient approach to determining the switching schemes for feeder reconfiguration, based on optimization of the particle swarm using integer coded. For feeder reconfiguration, the enhanced integer coded particle swarm optimization algorithm is proposed. The algorithm can escape from optimal local solution by applying enhanced integer coded particle swarm optimization integrated with local optimal list. For solving the feeder reconfiguration problems, the convergence speed can be increased.

Authors in [7] proposed IMOEA (Interval Multi-objective Evolutionary Algorithm) for DFR (Distribution Feeder Reconfiguration), and we use interval analysis to perform configuration evaluation taking into account the uncertainty of power demanded by customers. Variability in load demand to identify robust configurations IMOEA-DFR successfully finds robust and reliable configurations in terms of safety and fully complies with power demands and constraints.

[8] The article presents a non-reviewed genetic algorithm for evaluating a minimum loss network configuration in distribution networks. It not only explores passively whether a review exists, but uses the indication that a research technique can be actively modified and turned into an adaptive mutation operator without parameters The extended crossover mode was used to create higher quality solutions than traditional crossover. The approach suggested quickly offers a more likely solution to achieve an optimal solution globally.

Authors in [9] network reconfiguration in distribution networks for loss minimization an updated simulated annealing technique has been presented. An efficient stochastic method was presented in combination with a series of simplified line flow equations in order to speed up the rinsing process. With accurate network reconfiguration, the line failure of distribution networks can be substantially reduced. As further switching operations are carried out, the rate of loss reduction increases. If the operational constraint of the voltage of each node is not taken into account, the resulting optimum configurations of the network do not in all cases violate the voltage limit. The suggested approach often produces the good overall performance.

Young-Jae Jeon et al. [10] suggested improved simulated annealing algorithm for network reconfiguration in large distribution systems. To improve simulated reduction performance, a polynomial time cooling system based on statistical calculation during the search was used. The agitation-based process creates network configurations related to the topology and temperature system, which allows the solution area to be separated from high temperatures and consolidated in the region of attraction at lower temperatures. The legitimacy and viability of the proposed approach was shown in a 148-bus system.

The authors of [11] have discussed the feasibility of using a neural network to solve the problem of redesigning real-time distribution system. Artificial Neural Network (ANN) uses only one neural network and provides the ability to determine the most suitable locations. The use of clustering methods is suggested to minimize the number of input data of the ANN in order to enhance the output and structure of the ANN. A clustering approach for the training sets is the best performance to achieve, which leads to a most efficient source of knowledge for ANN. The result is an ANN with improved overall performance capability and the opportunity to determine high-quality and low-loss topologies.

[12] A new and effective Tabu search method was implemented in this article to solve the problem of optimal loss reduction distribution network reconfiguration, formulated as a not linear, mixed integration programming issue. A new "upward-node expression" variable approach is introduced, and an efficient scheme to limit each test solution to radial network formats is being integrated. The other elements of the proposed Tabu search method are discussed in depth, including neighborhood design, feature design and tabu list. Three sample systems with different network sizes have been evaluated.

[13] This article suggests Modifying Tabu Search (MTS) algorithm based on the method for reconfiguration of the distribution system. Tabu search algorithm is introduced with some modifications such as dynamic tabu list with variable size according to the system size. Moves are applied to diversify process searches and improve local search for the effectiveness of Tabu looking to achieve the global solution. The effects of load change are put into consideration to display the capabilities of algorithm to work at different load levels.

Chung-Fu Chang *et al.* [14] have proposed a technique utilizing the ant colony search algorithm (ACSA) is proposed to settle the feeder reconfiguration and capacitor arrangement issues. The benefits of the ACSA are the ability to search and optimize in parallel. This strategy was propelled by observing the ant colonies behavior. The ACSA utilized in this paper utilizes counterfeit ants, which somewhat have memory and are not totally visually impaired, subsequently can be applied to the feeder reconfiguration and capacitor arrangement issues in which switches are discrete. Local update rules are in place to ensure optimal solution.

Authors in [15] have proposed a new search operator that combines the concept of pheromones and a cross-genetic algorithm in ant colony optimization and applied it to solve the problem of reconfiguring the distribution system for loss minimization. The various edge that make up the solution in the search space. This information has been effectively used to guide the crossover operator to a better solution. The outcomes introduced in this paper show the capacity of pheromones to improve the search execution of the hybrid algorithm. The future work could incorporate executing the proposed calculation in conveyed improvement structure to apply on very large distribution systems.

S.V.L.Narasimham *et al.* [16] have presented harmony search algorithm (HSA) is applied to upgrade radial distribution systems with targets of improving the voltage profile and limiting real loss. The proposed algorithm can combine to ideal solution rapidly with better exactness contrasted with different strategies referenced in the literature. The convergence rate curve confirms that the HSA method can more efficiently search the optimal or near-optimal solution for network reconfiguration problems. In addition, it can be observed from the results of 33-bus and 119-bus systems that the proposed method is the best in the solution as well as the CPU time. In the proposed technique, the size of arrangement the vector is equivalent to the quantity of tie switches in the network. This strategy is valuable for examining existing systems, helps in arranging future systems, and is particularly reasonable for large scale practical system.

[17] In this paper, a new method has been proposed to reconfigure and install the DG units simultaneously in the distribution system tested on 33 and 69-bus systems at three different load levels viz., light, nominal and heavy. The results show that the concurrent network reconfiguration and DG installation method is more effective in reducing power loss and improving voltage configuration compared to other methods. The effect of the number of DG installation positions on the reduction of power loss is studied at different load levels. The improvement is decreasing as the positions are increased from one to four at all load levels. However, the percentage of loss reduction for size DG is highest when the number of DG installation positions is three.

Taher Niknam *et al.* [18] introduced a new evolutionary algorithm based on Honey Bee Matching Optimization (HBMO) for the Multi-Objective Distribution feed reconfiguration problem. The proposed algorithm used the idea of Pareto optimality. It gets a few non-dominant arrangements permitting the system operator to practice his or her personal inclination in choosing any of those answers for execution. In the evolutionary algorithm, queens are considered as the non-dominant solutions. To control the size of the repository, fuzzy-based clustering was utilized. A predictive evolutionary algorithm is suitable for use in the large-scale integer optimization problems as the optimal feed reconfiguration problem. It needn't bother with complex numerical programming. In addition, the HBMO algorithm takes advantage of being independent of the initial status of the network switches.

2.3 Mathematical Optimization methods

Mathematical Optimization methods known as deterministic methods and linear programming, quadratic programming, are examples of this approach, Nonlinear programming and so on.

The authors of the paper [19] proposed Two new optimization models are presented in this article, Mixed Integer Linear Programming (MILP) and Mixed Integer Conical Programming (MICP), both of which are suitable for network reconfiguration The MICP model gives an accurate measure of network loss and is convex in terms of its continuous variables; this means that mixed integer programming software can easily be used to find a network configuration that is globally optimal. The MILP model is based on a narrow polyhedron representation of conical constrictions In both models, the radiality of the lattice is enforced by spanning-tree constraints that allow power to flow backwards from the DG; in addition, the maximum number of switching operations can be easily enforced Computational experience with modern mixed integer optimization software shows that for networks with up to 830 nodes, both MICP and MILP can be used to find an approximate feasible solution with an optimality gap of no more than 5% in less than 30 seconds; however, MICP finds the initial feasible solution much faster and is therefore more suitable for online applications involving large distribution networks.

3. RESULTS AND DISCUSSION

Looking at the large number of articles available in the literature on DNR methods, it is felt that it is necessary to review the most commonly used test systems and the reported reconfiguration results. Here, some of the most commonly referred to test DS and reconfiguration results of these systems are considered.

33-Bus System

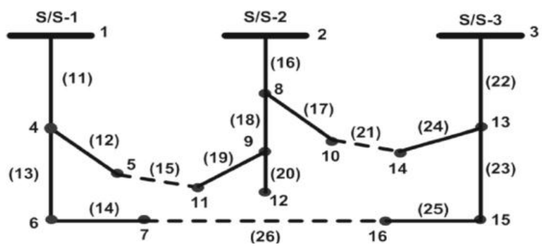


Figure 2. Test System –I before configuration

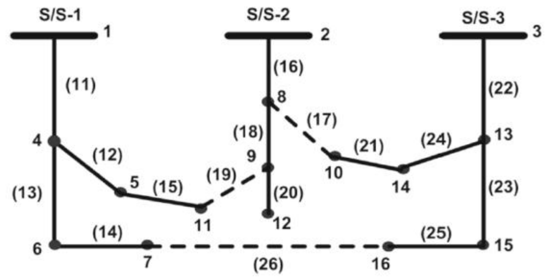


Figure 3. Test System –I after configuration

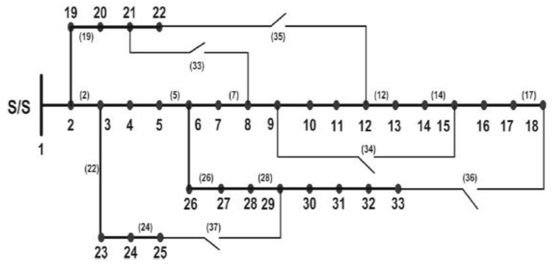


Figure 4. Test System –II

The test system is extremely common for validating reconfiguration methods and findings among researchers. In the literature, however, there are two topologically similar 33 bus structures that cause ambiguity. In fact, in terms of line details, there is little difference between the two. The load and tie-line information is similar. The first 33 bus systems in this paper are called the Test System-2 (usually known as the Baran and Wu system). The test system System-2 was introduced by Baran and Wu [21] (Fig. 4). The figure (as stated in [21]) was redrawn and most researchers adopted a small change in bus numbers. The branches are indexed as 1 below the corresponding end Bus and tie lines as shown in the Figure. 4. The cumulative active and reactive charges are respectively 3715 kW and 2300 kVAr. The power and the voltage of the foundation are 10 MVA and 12.66 kV. The machine line and load data can be found in [21]. The total current loss in power in the original network is 202.65 kW, with branches 33, 34, 35, 36 and 37 available, by author's process.

66-Bus System

This 12.66 kV test system was implemented by Baran andWu [21] (Fig. 5). There are 69 (11-43), 70 (13-21), 71 (15-46), 72 (50-59), and 73 (27-65) branches of the original network. The cumulative active and reactive loads are respectively 3802.19 kW and 2964.6 kVAr. The base power and voltage are respectively 10 MVA and 12.66 kV. There is a global minimum value of 99.6 kW, with lower values recorded by many researchers. Again, it has shown that heuristic approaches are much quicker.

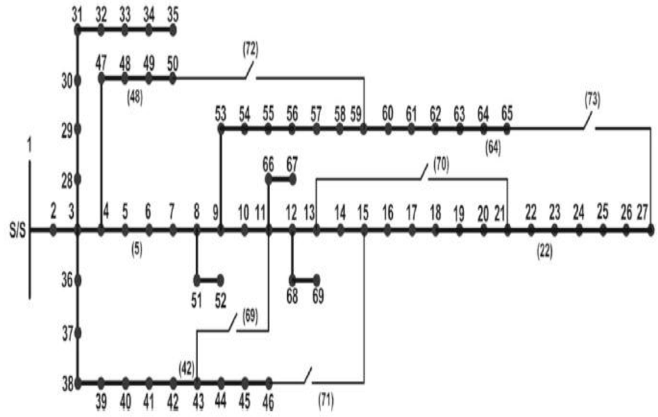


Figure 5. Test System-III

4. CONCLUSIONS

This review has distinguished the different strategies that researchers have adopted in resolving the DNR problem. The study found that heuristic methods converge primarily very rapidly to provide an optimal configuration but cannot guarantee an optimal global value and in some situations, these processes are not independent of the initial configurations. Even though many metaheuristic methods were suggested, Genetic algorithm (GA) DNR strategies are the most commonly used and successful of all metaheuristic DNR methods. Although meta-heuristic methods typically provide guaranteed optimal global performance, computing time is long to converge. In certain cases, heuristics are combined in order to improve the speed of convergence to ensure that it is suitable for applications in real time. In addition, meta-heuristic approaches based on population are favored.

REFERENCES

[1] E. J. De Oliveira, G. J. Rosseti, L. W. De Oliveira, F. V. Gomes, and W. Peres, "New algorithm for reconfiguration and operating procedures in electric distribution systems," Int. J. Electr. Power Energy Syst., vol. 57, pp. 129–134, 2014, doi: 10.1016/j.ijepes.2013.11.038.

[2] A. Bayat, "Uniform voltage distribution based constructive algorithm for optimal reconfiguration of electric distribution networks," Electr. Power Syst. Res., vol. 104, pp. 146–155, 2013, doi: 10.1016/j.epsr.2013.06.010.

[3] A. González, F. M. Echavarren, L. Rouco, T. Gómez, and J. Cabetas, "Reconfiguration of large-scale distribution networks for planning studies," Int. J. Electr. Power Energy Syst., vol. 37, no. 1, pp. 86–94, 2012, doi: 10.1016/j.ijepes.2011.12.009.

[4] A. R. Abul'wafa, "A new heuristic approach for optimal reconfiguration in distribution systems,"

Electr. Power Syst. Res., vol. 81, no. 2, pp. 282–289, 2011, doi: 10.1016/j.epsr.2010.09.003.

[5] B. Amanulla, S. Member, S. Chakrabarti, S. Member, S. N. Singh, and S. Member, "Reconfiguration of Power Distribution Systems Considering Reliability and Power Loss," vol. 27, no. 2, pp. 918–926, 2012.

[6] W. Wu and M. Tsai, "Application of Enhanced Integer Coded Particle Swarm Optimization for Distribution," vol. 26, no. 3, pp. 1591–1599, 2011.

[7] C. Henrique, N. De Resende, M. Henrique, and S. Mendes, "Electrical Power and Energy Systems Robust feeder reconfiguration in radial distribution networks," Int. J. Electr. POWER ENERGY Syst., vol. 54, pp. 619–630, 2014, doi: 10.1016/j.ijepes.2013.08.015.

[8] N. Con, "Determination of Power Distribution Genetic Algorithm," vol. 28, no. 4, pp. 3638–3648, 2013.

[9] H. Chang and C. Kuo, "Network reconfiguration in distribution systems using simulated annealing," vol. 29, pp. 227–238, 1994.

[10] Y. Jeon, J. Kim, J. Kim, and J. Shin, "An Efficient Simulated Annealing Algorithm for Network Reconfiguration in Large-Scale," vol. 17, no. 4, pp. 1070–1078, 2002.

[11] H. Salazar, S. Member, R. Gallego, and R. Romero, "Artificial Neural Networks and Clustering Techniques Applied in the Reconfiguration of Distribution Systems," vol. 21, no. 3, pp. 1735–1742, 2006.

[12] P. Taylor, K. K. Li, T. S. Chung, G. J. Chen, and G. Q. Tang, "Electric Power Components and Systems A Tabu Search Approach to Distribution Network Reconfiguration for Loss Reduction A Tabu Search Approach to Distribution Network Reconfiguration for Loss Reduction," no. August 2013, pp. 37–41, doi: 10.1080/15325000490228414.

[13] A. Y. Abdelaziz, F. M. Mohamed, S. F. Mekhamer, and M. A. L. Badr, "Distribution system reconfiguration using a modified Tabu Search algorithm," Electr. Power Syst. Res., vol. 80, no. 8, pp. 943–953, 2010, doi: 10.1016/j.epsr.2010.01.001.

[14] C. Chang, "Reconfiguration and Capacitor Placement for Loss Reduction of Distribution Systems by Ant Colony Search Algorithm," vol. 23, no. 4, pp. 1747–1755, 2008.

[15] A. Ahuja, A. Pahwa, B. K. Panigrahi, and S. Das, "Pheromone-Based Crossover Operator Applied to Distribution System Recon fi guration," pp. 1–8, 2013.

[16] H. S. Algorithm, R. S. Rao, S. Venkata, L. Narasimham, M. R. Raju, and A. S. Rao, "Optimal Network Reconfiguration of Large-Scale Distribution System Using," vol. 26, no. 3, pp. 1080–1088, 2011.

[17] R. S. Rao, K. Ravindra, K. Satish, and S. V. L. Narasimham, "Power Loss Minimization in Distribution System Using Network Recon fi guration in the Presence of Distributed Generation," vol. 28, no. 1, pp. 317–325, 2013.

[18] T. Niknam, "Expert Systems with Applications An efficient multi-objective HBMO algorithm for distribution feeder reconfiguration," Expert Syst. Appl., vol. 38, no. 3, pp. 2878–2887, 2011, doi: 10.1016/j.eswa.2010.08.081.

[19] R. A. Jabr, S. Member, R. Singh, B. C. Pal, and S. Member, "Minimum Loss Network Recon fi guration Using Mixed-Integer Convex Programming," vol. 27, no. 2, pp. 1106–1115, 2012.

[20] P. Delivery, "Distribution Automation, Feeder Reconfigur- Minimization, Linear Programing, ation," vol. 6, no. 4, pp. 1922–1933, 1991.

[21] M. E. Baran and F. F. Wu, "Optimal capacitor placement on radial distribution systems," IEEE Trans. Power Deliv., vol. 4, no. 1, pp. 725–734, 1989, doi: 10.1109/61.19265.