DG PLACEMENT BASED ON FORWARD-BACKWARD SWEEP METHOD

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ABSTRACT

The enormous value of electricity consumption in various residential, commercial, industrial and agricultural sectors leads to load generation imbalances, brownouts, cascade blackouts and large-scale power outages. Therefore, the use of decentralized generation units (DG) based on renewable energy sources is rapidly increasing to meet the undelivered electricity demand and reduce greenhouse gas emissions. Meanwhile, optimal placement of DG units in radial grids is crucial to minimize total active power losses and voltage drops. This project deals with the backward-forward sweep (BFS)-based methodology for the optimal assignment of DG micro systems in radial distribution systems with the aim of minimizing the total active power losses of the overall system. The allowable range limit of the voltage and the performance criteria of the feeder are considered as optimization constraints. The simulation of the BFS-based DG placement method is performed on the IEEE-33 distribution network to study its performance in different scenarios.

Keywords: Distributed generation, distribution system, demand, backward-forward sweep

1.INTRODUCTION

The primary function of the distribution system is to connect the bulk electric power grid to customers requiring service at voltages lower than that of the transmission and sub-transmission systems. Among the three main functions of the electric utility such as generation, transmission and distribution, the distribution system plays the key role in the quality of service to consumers. The main components of a distribution system are

- Distribution Substation
- Primary Distribution Systems
- Distribution Transformers
- Secondary Distribution Systems

Distribution substations are hubs for the termination and reconfiguration of sub-transmission lines and transformers that step down voltage to the primary distribution levels. Primary distribution systems deliver power from distribution substations to distribution transformers. Operating voltages can belong to the 15 kV class (e.g. 11 kV, 12.47 kV and 13.8 kV). Distribution transformers convert primary distribution voltages to useful voltages. Typical sizes range from 5kVA to 2500kVA. Secondary distribution systems deliver power from distribution transformers to customer service entrances. Voltages are typically 120/240V single phase or 277/440V three phase.The primary distribution includes three basic configurations as specified by

- Radial Distribution System(RDS)
- Loop or Mesh System
- Network System

RADIAL DISTRIBUTION SYSTEM

The radial distribution system is an economical system and is widely used in sparsely populated areas. It has only one power source for a group of customers. Automatic reclosing devices are used to reclose the feeder if the fault is transient. The isolation fuses are located on branches from radial branches, allowing unaffected parts of a branch to remain in service. The radial distribution system has a number of advantages compared to other systems. Ease of construction, planning and operation. Low initial investment costs and economical system. The radial distribution system also has disadvantages such as

B. a short circuit, blackout and broken power line will cause a power interruption to all loads located remotely on the fault side of the substation because they depend on a single distribution board and a feeder at the end of a distribution board will be heavily loaded as it is very close to the distribution station. The loads connected to the distributors would be exposed to large voltage fluctuations when the load on the distributor changes.

2.PROBLEM FORMULATION

The main goal of this work is to solve the power loss problem caused by the transmission system. This can be solved by optimally allocating the decentralized generation systems in the areas close to the consumers. The limitations of distribution power systems differ from the rest of the power systems. Because DGs have clear opportunities to place themselves in strategic locations throughout the system, they can reap the benefits of local support. Thus, there are all improvements in the overall performance of the system. To find the optimal mapping of distribution system placement, we use a method called the forward and backward sweep method. Through this method we find the performance loss incurred by the system with the use of DGs and without using DGs.

3.LITERATURE REVIEW

Many power system engineers have researched and published their research on reducing losses, improving voltage profile and maximizing cost savings in RDS. Nowadays, the penetration of decentralized generators (DGs) in power systems is increasing due to the restructuring of the power system, the deregulation of power markets, global warming and the energy crisis [1]. In addition, the integration of DGs into power supply systems offers several advantages, such as: B. Improvement of the voltage profile, additional services, power quality and reliability improvement, energy saving, reduction of losses and feed-in congestion [2]. Many types of research have focused on the optimal assignment of DGs in distribution systems. Gkaidatzis et al. [3] presented a particle swarm optimization (PSO) algorithm for location determination and sizing of DGs considering load variations. In this study, the total active power losses are minimized while respecting the feeder capacitance limitation and allowable voltage range limitation. In [4] the simultaneous allocation of DGs and capacitors is optimized using a genetic algorithm to minimize their capital investment and maintenance costs, energy losses and the risk of unmet demand[5].Sequential quadratic programming (SQP) and branch-and-bound method are integrated to solve a non-convex mixed integer nonlinear programming problem to achieve better solutions in less computation time than exhaustive load flow (ELF), improved analytic (IA) and PSO algorithms. Poornazaryan et al. [6] Combined Cuckoo search method with a binary imperialistic competition algorithm to minimize active power losses and improve voltage stability considering 50% fluctuations in active and reactive loads. In [7], optimal locations and capacities of DGs are determined by triangular number technique and hybrid bigbang crunch with multiple objectives to minimize operating costs, power losses, greenhouse gas pollutant emissions, and maximize safety margin for voltage stability. In [8] a teach-learn algorithm for the optimal placement of DGs in radial distribution systems in a way that the voltage profile is improved compared to genetic and PSO algorithms was proposed. A multi-objective approach for optimal DG allocation [9] aims to mitigate feeder congestion and maximize energy saving by interrupting both active and reactive power consumption of flexible loads considering their interrupting costs using a genetic algorithm will. In [10], implementing a reverse-forward sweep load flow algorithm coupled genetic algorithm, DGs are efficiently assigned and sized depending on voltage stability constraints. The optimal allocation of combined DG placement and capacity allocation using intelligent algorithms [11], genetic, PSO and gravitational search algorithms are studied to find a good scenario with minimal DG installation costs. In [12], optimal capacities of non-dispatchable photovoltaic (PV) power generation technology are determined to achieve a trade-off between minimum loss and maximum voltage stability using a weighted rank-sum ratio method. Kayal and Chanda [13] used a PSO algorithm to select optimal locations and sizes of solar photovoltaic arrays and wind turbines in three radial distribution systems of 12, 15, and 33 buses. In this research, reducing the grid losses and improving the voltage stability index of the whole system are considered as optimization goals. It has been found that solar PV parks and wind turbines in lagging power factor mode of operation result in greater improvement in voltage stability in all buses. It is obvious that the voltage magnitude of all buses increases with the participation of DGs in active and reactive power compensation. In [14], non-switchable DGs such as solar PV panels and wind turbines and switchable energy sources such as biomass and biogas fueled gas turbine power generation cycles are optimally placed in the 51-bus radial distribution network. The Analytic Hierarchy Process (AHP) is used in the PSO algorithm to solve a multi-objective optimization problem that includes energy losses, supply current capacity limit, voltage stability, and emission reduction aspects. In [15], the symbiotic organism search algorithm based on the symbiotic relationship between different biological species is shown to be computationally more efficient and faster than PSO, teach-learn algorithm, cuckoo search optimization, artificial bee colony method, gravity and stochastic fractal search approaches. Monte Carlo simulation (MCS) was developed by Sadeghi and Kalantar [16] to model variable yields of solar and wind farms in the dynamic planning of a 9-bus radial distribution network. The covariance matrix adjustment evolution strategy determines the optimal planning scenario with maximum revenue using penalty and incentive factors. In [17], long-term forecasts of loads and annual fluctuations of renewable energy source-based power generation plants are integrated with optimal reconfiguration and DG placement studies. The objectives of the optimization problem include line switching costs, power losses, investment and maintenance costs of DGs, and emission costs of DGs and upstream power system. Table 1 summarizes a taxonomy of different algorithms presented for the optimal location and sizing of DGs in distribution feeders. As already mentioned, various optimization algorithms have been implemented in distribution systems to find good placements and optimal sizes of DGs, improve voltage stability, and reduce system power losses. But a search method with less computational time and effort, without needing the membership function of fuzzy logic, the huge search space of MCS, the crossing and mutating processes of genetic algorithm, and the initial population of metaheuristic algorithms has not been proposed by scientists.This paper aims to present a novel forward-backward sweep (BFS) based optimal DG placement strategy for radial distribution networks. In this method, the number and capacity of the DGs are considered as known parameters. The total active losses are considered as a target function. First, one of the Directorates-General is selected. Its active and reactive power generation is included in the second (related to the active power consumption) and third (related to the reactive power consumption) column of the bus data matrix. Then, BFS load flow is solved and total real power losses are calculated as a component of loss matrix in the 1st raw and 1st column. In loss matrix, a number of rows and columns are equal to the number of buses and DGs. Afterward, 1st DG is assumed to be installed on bus 2. A similar analysis is carried out and energy losses are computed as 2nd row and 1st column of loss matrix. When all buses are evaluated for placement of the 1st unit, 2nd DG is assumed to be located at buses 1 to N, respectively. where N refers to a number of nodes in the test distribution system. This process is repeated for all DGs and loss matrix is formed. Finally, the minimum values of columns are determined. If the minimum value of column i occurred in the jth row of loss matrix, bus j will be selected as a good place for installation of ith DG.

4.FORWARD AND BACKWARD SWEEP METHOD

The main goal of the experiment is to solve the power loss problem caused by the transmission system. This can be solved by optimally allocating the decentralized generation systems in the areas close to the consumers. The limitations of distribution power systems differ from the rest of the power systems. Because DGs have clear opportunities to place themselves in strategic locations throughout the system, they can reap the benefits of local support. Thus, there are all improvements in the overall performance of the system. To find the optimal mapping of distribution system placement, we use a method called the forward and backward sweep method. Through this method we find the performance loss incurred by the system with the use of DGs and without using DGs. In the MATLAB codes, the IEEE 33 bus radial distribution system [26] is tested to allocate three distribution generating units with active and reactive generating capacities of 70, 240, 545 kW and 36, 63, 250 kVAr, respectively. In the first iteration of the proposed approach, the DG unit 1 is on bus 1. The BFS power flow calculation is implemented on the updated node information matrix. The real power loss is then calculated and stored as the 1st row and 1st column of the loss matrix. The loss matrix is defined as active loss. In the 2nd iteration, DG unit 1 is located at node 2 and the power flow calculation is performed. The active loss of the benchmark system is calculated and stored as the 2nd row and 1st column of the loss matrix. The same method is considered for 2nd and 3rd DGs. As can be seen from the loss matrix, when the 1st DG unit is installed on bus 18, the total active power loss is minimal and equal to 166.3765 kW. In addition, the 17th and 32nd class buses are a good choice for the installation of 2nd and 3rd DG.

5.MATHMETICAL MODELLING

It is supposed that the power injection to the bus i is equal to S_i given by (1), the value of the active /reactive power injected to the bus i is equal to the real/reactive load of this bus plus the sum of the power transmitted through the node i to other adjacent busses.

$$S_i = S_{D,i} + \sum_j S_j \qquad (1)$$

By considering the negative active and reactive power consumptions of the DG unit in bus i, its net demand can be calculated as (2)

$$S_{D,i} = P_{D,i} - P_{DG,i} + j(Q_{D,i} - Q_{DG,i}) \qquad (2)$$

The current injected to the load i at iteration k+1 can be calculated based on its appearance power $S_{D,i}$ and voltage magnitude at iteration kV_i^k,as stated in equation (3). where, $J_{D,i}^{k+1}$ is the current injected to the bus i in iteration k+1. The voltage of the node i at scenario k is stated as V_i^k.

$$j_{D,i}^{k+1} = \left(\frac{S_{D,i}}{V_i^k}\right)^* \qquad (3)$$

In the backward sweep of the load flow analysis, the current in the line m-i at iteration k+1 is calculated as (4).

$$i_{m,i}^{k+1} = j_i^{k+1} + \sum_j i_{i,j}^{k+1} \qquad (4)$$

In the forward sweep, the voltage of the up-stream bus m at iteration k+1 depends on the value of the voltage drop in the transmission line, which connects the buses i and m to each other, as well as the voltage of the down-stream node i, as formulated by (5).

$$V_m^{k+1} = V_i^{k+1} - i_{m,i}^{k+1} \times Z_{m,i} \qquad (5)$$

If the convergence constraint (6) is satisfied for all buses, the backward and forward sweeps will be stopped. Therefore, the voltage of the bus j will be equal to V_j^{k+1} and the current of the branch i to j will be equal to $i_{i,j}^{k+1}$.

$$\left|V_m^{k+1} - V_j^k\right| \leq \epsilon \qquad (6)$$

Total active power loss, bus voltage limit, and feeder current capacity

The total real power loss of the distribution grid, F_{loss}, is calculated from (7). In which, $g_{i,j}$ is the conductance of branch i to j. In addition, nl refers to the number of the transmission lines. The voltage angle of the bus i is defined as θ_i . According to (8), the lower (V_i^{min}) and upper (V_i^{max}) bounds of the bus voltage magnitude are considered as 0.9 and 1.05 per unit, respectively. Similarly, the current of the line b is limited by the maximum flow Imax b , as formulated by the inequality constraint (9).

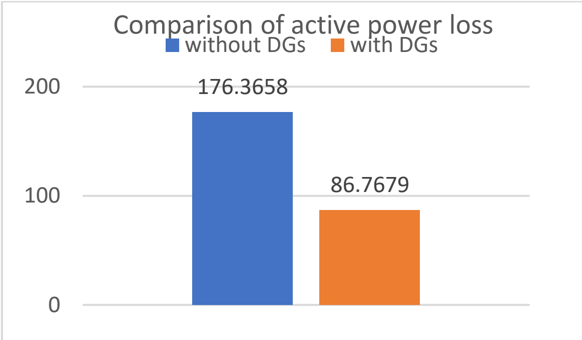
$$F_{loss} = \text{Min} \sum_{i,j=1,i\neq j}^{n_j} g_{i,j}[V_i^2] + V_j^2 - 2V_iV_j\cos(\theta_i - \theta_j) \qquad (7)$$

$$V_i^{min} \leq V_i \leq V_i^{max} \qquad (8)$$

$$I_b \leq I_b^{max} \qquad (9)$$

6.Comparison of Active Power Loss

When implementing the IEEE 33 BUS radial distribution system by the forward and reverse method. The programs were written in MATLAB and simulated there. The files we create store the data in the form of .m files. The simulation performed so far delivers the output in Excel format. Through the comparison, we can see that there is a visual difference between active power loss. Power dissipation is a critical topic of discussion, and this fact will make the outputs drastically different. In addition, each method such as BIBV and FBS systems focuses on improvement. All methods involve reducing active power loss. As we can see, the active power loss is relatively higher than the active power loss when the system is connected to the DGs. Therefore, we can clearly see the visual difference between the losses. When the system is not used by the DGs, the active power losses are striking 176 when using the DGs by this method, we can indeed see a drastic decrease in the active power losses.



7.CONCLUSION

The forward-reverse load flow calculation was used to find the active power factor loss in the radial distribution system. Each iteration assumes that there is a DG unit on one of the buses. The BFS power flow algorithm is then executed according to the line and updated bus data matrices. The active power loss is determined and displayed in the loss matrix. The numerical results showed that the proposed DG assignment algorithm is faster and more accurate than other recently published methods due to its fewer iterations and lower active power losses.

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