INTERNATIONAL JOURNAL OF GREEN ENERGY
https://doi.org/10.1080/15435075.2023.2288330

Hybrid technique for optimal placement and sizing of distributed generation units considering real and reactive power injection

Rayes Ahmad Lone [a,b], Sheikh Javed Iqbal [a], and Ahmed Sharique Anees [b]

[a]Department of Electrical Engineering, National Institute of Technology, Srinagar, India; [b]Department of Electrical Engineering, Islamic University of Science and Technology, Kashmir, India

ABSTRACT

Distributed generation resources have played a major role in strengthening the performance of the distribution network (DN). Strategically placing and sizing these resources can relieve the stress on distribution line, fostering a more reliable and sustainable energy supply for a greener tomorrow. The literature outlines various optimization techniques, each with its pros and cons based on the methodology used. Some of these techniques are unable to find out the size and placement of DGs that can supply both active and reactive power, while others have a low rate of convergence and the probability of falling into local optima. This research presents a hybrid technique (AT-GSA) based on an analytical and grid search algorithm that can solve the aforementioned problems. Here the goal is to minimize power losses in the DN while enhancing the DN's voltage profile and voltage stability index (VSI). IEEE 33-bus and IEEE 69-bus systems are being used to validate the proposed technique. The findings indicate that by injecting real and reactive power, the IEEE 33-bus and IEEE 69-bus systems experienced a reduction in losses of 88.26% and 93.21%, respectively, compared to base losses. The average absolute error (AAE) of the voltages shows a substantial decrease, declining from 0.0561 and 0.0268, respectively, to 0.0062 and 0.0069. The VSI for each DN has also shown a substantial increase in comparison to the reference case.

ARTICLE HISTORY
Received 23 June 2023
Accepted 21 November 2023

KEYWORDS
Distributed Generation (DG); optimum size and location; total power losses; Distributed Energy Resources (DERs); Voltage Profile (VP); Loss Sensitivity Factor (LSF)

1. Introduction

In recent years, there has been a substantial increase in the overall electricity generation from renewable energy sources (RES), as they offer effective solutions to address energy demands and climate change challenges. RES has also reduced the supply-demand imbalance, as the completion time of these plants is much shorter than that of hydroelectric or thermal power plants. A substantial percentage of renewable energy generation has come from distributed generation (DG) units, which are mostly placed near the load in the form of rooftop solar or wind. In addition to providing energy, DGs may be seen as a possible remedy for a number of problems that power networks face, like high power loss, low power quality, poor reliability, and congestion in the transmission network (Lata and Vadhera 2020; Zhang et al. 2022). However, its inappropriate deployment can lead to negative effects like more power losses, weak protection coordination, voltage unbalance, reverse power flow (RPF), and others (Shafiullah, Arif, and Oo 2018). The inappropriate type, size, and placement of DGs may also impact the quality of power and fault current at the point of common coupling (PCC) (Mohapatra, Babu, and Mohanty 2016). Therefore, optimal utilization of these units is an important problem that must be examined while integrating them into the DN. DGs can be effectively employed to enhance the reliability and voltage stability of DN while simultaneously minimizing power loss and voltage deviation (Gebru et al. 2021). So, DG installation is an optimization problem with multiple objectives, and optimizing many objectives at once is challenging because every objective is crucial across multiple units and scales. Because of the possibility of conflicting objectives, an exact multi-objective formulation is mandatory. However, various multi-objective formulations with distinct goals may be combined into a single-objective problem by giving each goal a different weight or applying a penalty to the problem. In recent years, various researchers have explored the impact of DG size and position on power losses, power flow, RPF, VP, and others. An extensive number of optimization strategies, both single- and multi-objective, were used to figure out the ideal placement and size for each and every DG. Several diverse algorithms are used by various optimization techniques, each of which has its own problem formulation, strategy, and assumptions. Both IEEE 33-bus and IEEE 69-bus systems were used to test and verify the majority of the techniques. The merits and demerits of any given method depend on the nature of the data and the system being investigated. The optimization function in the problem of allocating DG is typically characterized as non-linear or subject to stochastic variations. Across various formulations, the primary goal remains consistent: to reduce power losses and enhance VP while adhering to all power constraints, voltage, and others. In addition to these, the advantages of optimization include a higher loading margin, higher power quality and load factor, and enhanced VSI (Naderipour and Abdul-Malek 2020). Many optimization algorithms, drawing inspiration from genetic processes, the intelligence of swarms, and the neural systems of

CONTACT Rayes Ahmad Lone rayes.lone@islamicuniversity.edu.in Department of Electrical Engineering, National Institute of Technology, Srinagar, India
This article has been corrected with minor changes. These changes do not impact the academic content of the article.