RENEWABLE DISTRIBUTED RESOURCES FOR OPTIMIZING THE TECHNO-ECONOMIC PERFORMANCE OF THE DISTRIBUTION NETWORKS VIA MGOA NATURE-INSPIRED OPTIMIZATION ALGORITHM

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Overview

The massive increase in the penetration of Distributed Generation (DG) units in traditional Electric Distribution Networks (EDNs) forces the distribution companies' operators to enhance the technical performance of EDNs while considering economic perspectives. This challenge paves the way for developing a multi-objective optimization platform to tackle the techno-economic problems while respecting system uncertainties as well as the operational policies of distribution companies.

Nature-inspired methodologies are particularly effective at addressing and solving the complex challenges in various areas of engineering, such as energy management systems, maximum power point tracking for both photovoltaic and wind energy systems, and parameter identification for renewable energy systems. These challenges are tackled by transforming them into optimization problems with complicated nonlinear constraints.

Many researchers have addressed the implementation of distributed generation resources within the distribution networks by introducing several techniques for enhancing their performance. However, it is noted that the past studies have been applied to a limited number of small-scale IEEE benchmark test systems and did not introduce large-scale or realistic case studies committed to real operating limitations. The DG units' operating power factor has been set as a fixed value and not a variable vector that needs to be optimized, and the weighting coefficient values of the fitness function have been selected randomly without a prior study. Several methodologies have successfully solved the DG optimization problem. However, these methods did not mitigate the optimal mix of the four DG units' types, and the DG units' maximum penetration capacity have not been determined regarding the branches' security constraints. In addition, the optimization of the required investment costs for the new DG unit's installation is set as an objective at the same time while enhancing the dynamic performance.

This paper attempts to address the above-mentioned issues of the previous researches. In addition, the current research has succeeded in (i) Employing Nature-Inspired algorithm for solving four different categories of distributed resources allocation and sizing problem. (ii) Presenting a new Modified Grasshopper Optimization Algorithm (MGOA). (iii) Constructing a new objective function to improve the voltage stability, reduce the active power losses and minimize the overall additional costs. (iv) Considering variable DGs' operating power factor as an optimization vector, in addition to some additional system's regulatory constraints, including (a) DG' penetration level, (b) DG' operating power factor and (c) system's voltage profile. (v) Validating the proposed approaches by applying them to IEEE test systems (300 buses), beside a real part of the distribution system from the Egyptian grid to prove their effectiveness in solving different characteristics of complex systems.

Methods

As a motivating solution for this multi-objective problem, this paper introduces the application of modern nature-inspired algorithm as multi-objective optimization technique for enhancing the techno-economic performance of EDNs through the integration of multiple types of Renewable Energy Resources. Grasshopper Optimization Algorithm (GOA) is inspired through these creatures complex social contact network that equips themselves with a specific predatory strategy. GOA has been employed and comined with Genetic Algorithms (GA) to develop Modified Grasshopper Optimization Algorithm (MGOA) for minimize the active power losses, enhance the Fast Voltage Stability Index, and reduce the total costs, considering the penetration level specified margin as well as the framework of the DG units' operating power factor constraints. The proposed algorithm has been integrated with Newton Raphson load flow equations under MATLAB environment and applied on various benchmark IEEE test systems 300-bus and a realistic part of the Egyptian distribution network (171-bus) is also introduced as a practical, applicable case study.

Results

Applying the modern proposed techniques to the distribution systems have demonstrated that the voltage stability is improved up to 36% and voltage levels enhanced up to 12% compared to base case, while these methodologies has corrected their voltage profile. whereas, the original cases failed in keeping voltage boundaries at all busbars. Furthermore, the active power losses are significantly reduced for the above-mentioned systems up to 26.5% compared to base case.

Conclusions

Results proved the effectiveness of the proposed optimization algorithm in addressing the multi-objective siting and sizing problem for the different types of renewable resources into complex distribution systems. However, Improved Grasshopper Optimization Algorithm proved its superiority in determining the best solution compared to others, in addition, it converges in minimum time and number of iterations.

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