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An optimization planning framework for allocating multiple distributed energy resources and electric vehicle charging stations in distribution networks

Kayode E. Adetunji[a,*], Ivan W. Hofsajer[a], Adnan M. Abu-Mahfouz[b], Ling Cheng[a,*]

[a] School of Electrical and Information Engineering, University of the Witwatersrand, 1 Jan Smuts Avenue, Braamfontein, Johannesburg, 2000, South Africa

[b] Council for Scientific and Industrial Research (CSIR), Pretoria, 0184, South Africa

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Abstract

In developing a sustainable and efficient power systems network while reducing carbon footprint, renewable energy (RE)-based Distribution Generation (DG) units are highly recommended. Furthermore, Battery Energy Storage Systems (BESS) and other passive electronic units are adopted to improve grid performance and mitigate the effects of high variability from RE power. Hence, planning frameworks are developed to optimally allocate these units to distribution networks. However, current planning mechanisms do not consider the relative effect of different allocated units in planning frameworks. To bridge this gap, this paper presents a novel comprehensive planning framework for allocating DG units, BESS units, and Electric Vehicle Charging Station (EVCS) facilities in a distribution network while optimizing its technical, economic, and environmental benefits. The proposed framework uses a recombination technique to generate more solutions by dynamically updating the DG and BESS units' locations in one iteration. A Reinforcement Learning (RL)-based algorithm is introduced to coordinate EV charging that suggests the optimal EVCS location in relation to other units' locations. To cope with the complexity ensuing from searching a larger solution space, a multi-stage, hybrid optimization scheme is developed to produce optimal allocation variables. A category-based multiobjective framework is further developed to simultaneously optimize many objective functions — power loss, voltage stability, voltage deviation, installation and operation cost, and emission cost. Through numerical simulations on the IEEE 33- and 118-bus distribution network, it is shown that the proposed optimization scheme achieves higher metric values than the adopted benchmark optimization schemes. A validation process was also carried out on the proposed multiobjective optimization approach, comparing it with other approaches. Using the Spacing metric, the proposed approach proves to be efficient, depicting a good spread of Pareto optimal solutions.