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New multi-stage and stochastic mathematical model for maximizing RES hosting capacity - part I: problem formulation

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Abstract— This two-part work presents a new multistage and stochastic mathematical model, developed to support the decision-making process of planning distribution network systems (DNS) for integrating large-scale «clean» energy sources. Part I is devoted to the theoretical aspects and mathematical formulations in a comprehensive manner. The proposed model, formulated from the system operator's viewpoint, determines the optimal sizing, timing, and placement of distributed energy technologies (particularly, renewables) in coordination with energy storage systems and reactive power sources. The ultimate goal of this optimization work is to maximize the size of renewable power absorbed by the system, while maintaining the required/standard levels of power quality and system stability at a minimum possible cost. From the methodological perspective, the entire problem is formulated as a mixed integer linear programming optimization, allowing one to obtain an exact solution within a finite simulation time. Moreover, it employs a linearized ac network model which captures the inherent characteristics of electric networks and balances well accuracy with computational burden. The IEEE 41-bus radial DNS is used to test validity and efficiency of the proposed model, and carry out the required analysis from the standpoint of the objectives set. Numerical results are presented and discussed in Part II of this paper to unequivocally demonstrate the merits of the model.

Index Terms— Distributed generation, distribution network systems, energy storage systems, integrated planning, stochastic programming, variability and uncertainty.

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