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Tri-level coordinated transmission and electrical energy storage systems expansion planning under physical intentional attacks

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Abstract-

In this paper, a model for tri-level coordinated expansion planning of transmission and electrical energy storage systems (ESSs) is proposed to decrease the destructive effects of physical intentional attacks. In order to implement the actions of the system planner (SP), attacker, and system operator (SO), the optimization problem is modeled as a planner-attacker-defender problem. In the first level, the SP determines the optimal coordinated expansion planning of transmission networks and ESSs. In the second level, having enough knowledge about the network, the attacker wants to inflict the maximum damage. In the third level, the SO endeavors to minimize the damage to the network by exploiting correcting actions, such as load shedding and generators and ESSs re-dispatch. To confront the mathematical complexity of the presented model, we propose a mathematical model to convert the tri-level problem to a single-level mixed integer linear programming problem. The model is implemented on Garver and modified IEEE 30-bus test systems, and numerical results are provided for various case studies. The obtained numerical results are compared by literature. The numerical results show the effectiveness of the model to reduce power systems vulnerability.

Index Terms- Linear programming; Energy storage systems; Transmission expansion planning; Intentional attacks

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