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Robust optimal scheduling for distributed energy storage system considering uncertain frequency change

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Introduction

With the rapid development of distributed renewable energies, the number and severity of the active power disturbances that affect frequency stability have increased. The distributed energy storage system (DESS) characterized by high flexibility and dispatchability can provide distribution network with frequency regulation services after disturbances. This paper proposes a robust optimal scheduling approach for DESSs considering uncertain frequency changes.

Methods

A robust optimization model is established to minimize the network loss and adjust the operating point of DESSs for frequency stability. The AC power flow constraints are introduced into the optimization model. And the second-order cone relaxation method is used to deal with the nonlinear constraints through relaxation variables. Based on the column-and-constraint generation method, the relaxed second-order cone optimization model is solved, and scheduled DESS power is attained.

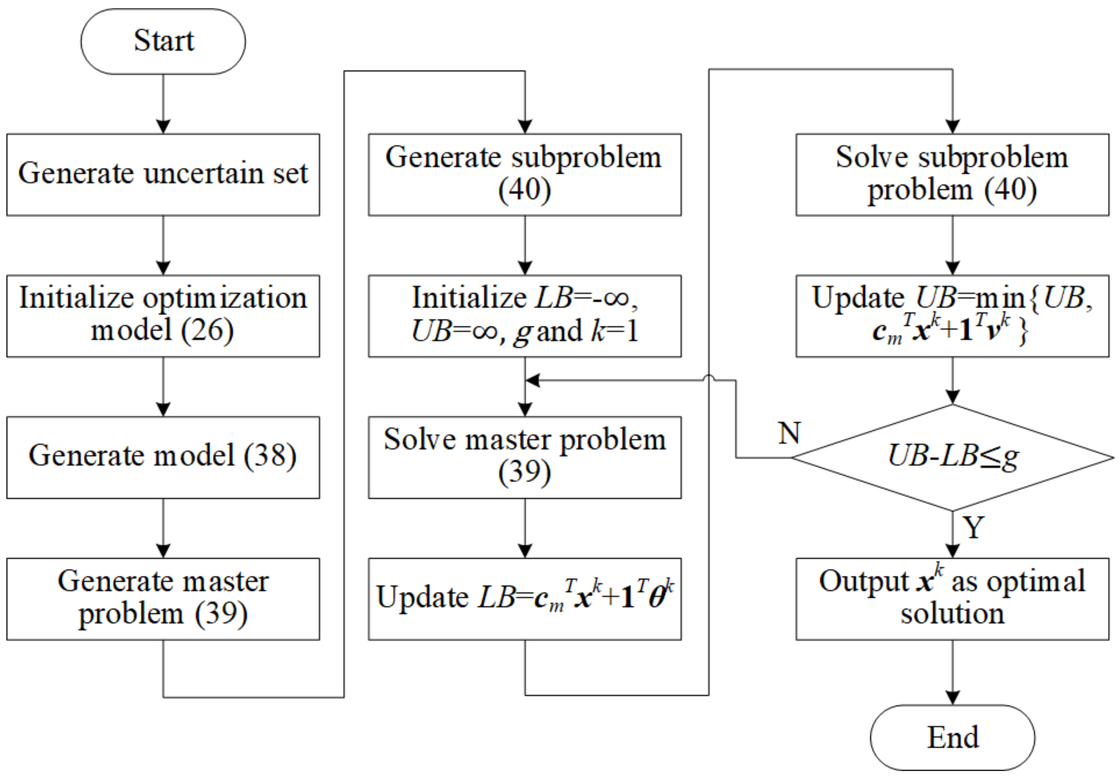

Fig. A1 Flowchart of the solution method.

Results

In the case study, the modified IEEE-30 bus system is considered. A wind farm is deployed at Bus 2, and two DESSs are deployed at Bus 8 and 10. With the proposed scheme, the operation power of the DESSs is shown in Fig. A2, and the optimized network loss is 37.81 MW. It is clearly seen that the power and SOCs are maintained in the specific range. The network loss of the deterministic scheme is 38.87 MW. In contrast, the proposed scheme is useful to decrease the network loss.

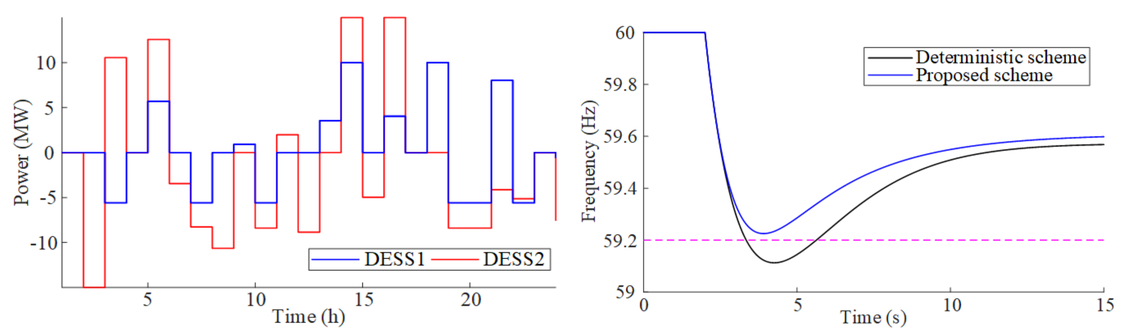

Fig. A2 Output of the DESSs and frequency dynamic response.

The system frequency dynamic response is shown in Fig. A2. It is obvious that the proposed scheme is useful to improve frequency nadir. The frequency nadir of the proposed scheme is 59.23 Hz. However, the frequency nadir of the deterministic scheme is just 59.11 Hz.

Conclusions

The DESSs are scheduled optimally to minimize network loss and reduce uncertain frequency change. A robust optimization model is established with AC power flow constraints. In order to solve the problem, the second-order cone relaxation method and column-and-constraint generation method are employed. The case study shows that the proposed scheme is useful to decrease network loss and improve frequency nadir.