Exploitation of Ancillary Service from Energy Storage Systems as Operational Reserve

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Introduction

Based on the above backgrounds, application of ESs as a provider of flexibility services is so desirable for system operators. As shown in Fig. 1, this application depends on its sequential dispatches; consequently, the ignorance of such dependency can cause large errors in the stored energy.

Table I. Specifications of Test Cases

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Figures & Tables

Fig. 1. Effect of critical operation on ESs' energy.

Fig. 2. Cost curves and different wind penetrations.

Results

The proposed SN-UC model is implemented using CPLEX in general algebraic modeling system (GAMS), as a laptop with Intel Core 2.4 GHz and 8 GB of RAM. The RTS-24 test system based on data in [3] is used to evaluate the performance of the proposed model. This test system includes 12 generators, two wind farms, and ESs with the capability of deployment regulation reserves. Two levels of Normal Wind Penetration (NWP) and High Wind Penetration (HWP) are considered to collect the impact of penetration of wind power on experiment results. The load curve of the test system and hourly wind power are shown in Fig. 2.

The six cases are defined in Table I based on different conditions of wind penetration, ESs' participation as a reserve provider, and application of reserve coordination on ESs. The basic model of all cases in SN-UC with considering the cost of energy and reserves. These cases are defined to show the performance of various approaches to ESS's reserve use.

Case Study

The adequate reserves to address wind power fluctuations is displayed in Fig. 3. It can be seen, in Case 1 and 2, relatively, close values are displayed by ESs in different penetration of wind power. The reason is that the reserves of ESs is used more successfully without sufficient reserves, which the model does not consider any coordination for reserve deployments. This matter is visible in Cases 1-2 and 3-2, which represents a comparison between reserve deployments in different ESs participation. Furthermore, in Cases 1-3 and 2-3, the large shares of required upward and downward reserves are depicted by the deployment of ESs.

ESSs' Stored Energy within Scenarios

For a more detailed analysis of ESs' energy in different scenarios, Fig. 5 compares cases for C4 and C6. ESs can be seen, in both Cases 4-1 and 4-2, the stored energy will be dramatically dropped into large negative values. As shown by (12) and (13), the deviation of the ESs' energy from the optimal recharging, by applying the proposed coordination. Hence, the remaining deviations can be compensated by appropriate real-time decisions.

Conclusions

This paper developed a coordinated model for the exploitation of operational reserves from ESs to address wind energy fluctuations in an SN-UC problem, in two levels of insufficient reserves in ESs' compensation, the model coordinates the values of re-dispatch and the base units. Based on the results, the following conclusions are reached:

- The proposed model successfully deployed the operational reserves from both generators and ESs, while the expected values of ESs' reserves are achieved in the base units.

References