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Increasing Power System Flexibility to Integrate High Share of Renewable Energy

Siyuan Chen, Pei Liu*, Zheng Li

State Key Lab of Power Systems, Department of Energy and Power Engineering, Tsinghua-BP Clean Energy Center, Tsinghua University, 100084 Beijing, China
liu_pei@tsinghua.edu.cn

Abstract

The variability and intermittency of renewable energy brings about technical challenges for its integration. In order to integrate high share of renewable energy, more flexibility is needed in the power system. Among all the flexibility options, taking customer-sited energy storage systems as demand response could be a promising measure addressing both grid needs and customer needs. In order to analyse the effect of customer-sited energy storage systems on renewable energy integration, an integrated power generation and customer-sited energy storage systems expansion planning model is proposed in this paper. The expansion and operation of energy storage systems are based on the objective of reducing total power generation costs. Sichuan province in China is taken as a case study due to its abundant renewable energy resources and increasing renewable energy share in the power system. The results indicate that: 1) demand response provided by customer-sited energy storage could partially replace coal power plants to provide flexibility for integrating high share of renewable energy into power system; 2) The utilization scale of renewable energy could be increased and CO_2 emissions could be reduced significantly. In order to encourage the deployment of customer-sited energy storage systems, more policy support for energy storage technology and electricity market mechanism improvement are needed to enhance the development of customer-sited energy storage systems.

Keywords: Renewable energy integration, Customer-sited energy storage, Modelling and optimization, Power generation expansion planning

1. Introduction

Renewable energy is expected to be the fastest growing source of energy, contributing half of the growth in global energy supplies and becoming the largest source of power by 2040 (BP, 2019). However, renewable energy output is highly dependent on weather conditions, which means it is variable and non-dispatchable. More flexibility is needed in the power system to balance the fluctuation of renewable energy in parallel with higher share of renewable energy. There are a range of measures to increase the power system flexibility including flexible power generation, demand side management, grid ancillary services, energy storage, power-to-gas and vehicle-to-grid (Lund et al., 2015). Among these measures, energy storage technologies have recently drawn much attention as a promising flexibility provider due to the technical maturity and decreasing costs (Hadjipaschalis et al., 2009). Existing researches mainly focus on using energy storage to provide flexibility on the supply side. However, if an energy storage system is located along the point of generation, its operation is tied to this individual facility and the potential utility is severely limited. Moreover, energy storage on the supply side

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