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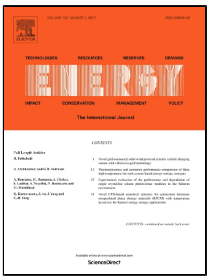

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A two-stage framework for multiobjective energy management in distribution networks with a high penetration of wind energy

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Abstract

The integration of renewable energy sources (RESs) in distribution networks has brought great challenges to the volt/var management due to their intermittency and volatility. This paper proposes a two-stage energy management framework of distribution networks to facilitate the accommodation of high wind energy penetration. In the proposed framework, the volt/var management problem is formulated and decomposed as a two-stage energy scheduling optimization model with different time frames considering the uncertainties of wind energy and load forecasts. In the first stage, a scenario-based stochastic day-ahead scheduling model is formulated to optimize the 24-hour charging/discharging scheme of energy storage system (ESS) and power generation of diesel generator (DG) in order to minimize the expected operation cost. Based on the stochastic optimal scheduling results in the first stage, the second stage implements the multiobjective volt/var optimization (VVO) to determine the optimal real-time operation of volt/var control devices, considering the costs of adjusting the control devices (CACDs). The proposed method has been fully evaluated and benchmarked on a 69-bus distribution network under various operational scenarios to demonstrate its superiority on various performance metrics and further confirm its effectiveness and efficiency for distribution networks to accommodate a high penetration of wind energy.

Highlights

A multiobjective VVO is proposed for distribution networks with RESs.
A two-stage energy management framework is used to accommodate the wind energy.
ESS is utilized to reduce the network loss and maximize economic benefits.
ESS degradation cost and CACDs are considered in the volt/var management.

Keywords

Distribution networks, energy management, energy storage system, wind energy, volt/var optimization.

1. Introduction

Rapid development and advancement in smart grid technologies have enabled the renewable energy sources (RESs), especially the wind energy, to be grid-integrated in distribution networks with increasingly high penetration [1]. Annual wind energy production is growing significantly and has reached around 4% of worldwide energy consumption [2-4]. Now there are over two hundred thousand wind turbines (WTs) in onsite operation, with a total installed capacity of 432,000 MW at the end of 2015 [5]. Wind energy, as an alternative to the fossil fuels, is a clean and sustainable energy source without greenhouse gas

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