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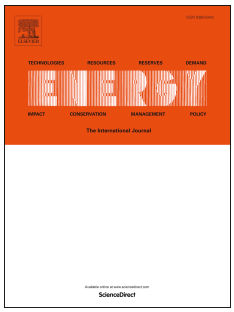

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CVaR Risk-Based Optimization Framework for Renewable Energy Management in Distribution Systems with DGs and EVs

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Abstract**—**A method based on chance constrained second-order cone programming (CCSOCP) is presented for the optimal risk value control of power loss in distribution systems with the distributed generation (DG) of renewable energy systems and electric vehicles (EVs). The charging power of the EV is seen as a random variable, and the risk value of the power loss – due to the uncertainties in the power output of distributed generation of renewable energy systems and charging power of electric vehicles – is studied. Moreover, a second-order cone programming based method is also presented to constrain the potential risk of power loss to an acceptable range by optimally coordinating the power output of DG and the EV charging power in a distribution system. A conditional value at risk (CVaR) model for the power loss of distribution systems is presented and CVaR is taken as a constraint to control the risk value of power loss due to uncertainties in DG and EV charging. The results of a test on a 69-node system are used to verify the validity of the risk control method proposed in this paper.

Key words**—**distribution systems; risk value control of power loss; distributed generation (DG); electric vehicles (EV); chance constrained second-order cone programming **(CCSOCP)**

1. Introduction

The large application of renewable energy, energy storage and electric vehicle (EV) is a development trend of distribution networks. At the user sides, renewable energy, energy storage and electric vehicles are typically used in a distributed way, and this will have a great influence on the power supply capability, voltage quality and power loss of the distribution networks. Generally, the output or input power of a great number of distributed generation (DG) systems, distributed storage (DS) systems and electric vehicles at different nodes in different time periods have great uncertainties and randomness, the problem the power supply capability, voltage quality and power loss becomes more prominent, more serious and more difficult to control with great risk for the operation of the distribution networks.

The normal operation of a large power grid is the key to ensuring the continuous and reliable supply of electric power. However, the existence of various disturbances greatly increases the potential risk of the normal operation of the power grid. The failure of the components, such as overhead lines and transformers, is a kind of disturbance, which causes the network to operate in the abnormal state. Moreover, it is a potential risk, resulting in cascading failures and outage accidents. Power flow transfer in a power grid is a kind of disturbance, which often leads to the cascading tripping of certain components in the power grid, and is also a potential risk of power outages. Changes in load, regulation of operation mode of power grids, reactive power and voltage coordinative control, will cause a change or power flow shift, which may result in the overload of other components of the grid.

It is a significant trend for DG systems and EVs to penetrate in distribution systems with even accelerated growth. This trend