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ScienceDirect

Energy Procedia 105 (2017) 2472 – 2477

Energy Procedia

The 8th International Conference on Applied Energy – ICAE2016

Coordinated Dispatch of Active Power Distribution Network Containing Large-scaled Distributed Generation and Electric Vehicle

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Abstract

Regarding the coordinated dispatch of active power distribution network containing large-scaled distributed generations (DGs) and electric vehicles (EVs), this paper proposes a coordinated dispatch method based on voltage iteration. A model for coordinated dispatch that can optimize the node charging power of EVs and the output of DGs is established. Then the network loss in the optimization objective is simplified by the static voltage which obtained in the previous optimization iteration. Meanwhile, the nonlinear restrictions between power and voltage are simplified by the sensitivity equation, also based on the static voltage. Finally, an iteration method is proposed to correct the static voltage used in the simplified model. The coordinated dispatch method proposed in this paper is verified by the IEEE33 node test system.

Keywords: active power distribution network; coordinated dispatch; static voltage; sensitivity equation; iteration

1. Introduction

Renewable energy power generation and EV have incomparable advantages in alleviating energy crisis and reducing people's reliance on conventional fossil energy. However, integration of large-scaled DGs to the radial distribution network and the load flow changes will inevitably affect the operating mode in distribution network [1,2]. It is worthy to note that reasonable charging control of EVs not only shifts the peak load [3,4], but also absorbs surplus energies of DGs during peak outputs and hence increases the allowable capacity [5,6] of DGs in distribution network. Therefore, it is highly significant to study coordinated dispatch of active power distribution network containing large-scaled DGs and EVs.

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doi:10.1016/j.egypro.2017.03.715

At present, the coordinated dispatch research mainly focuses on the economic dispatch in regional power grid. A coordinated strategy between the wind participants and EV owners to increase their revenues and incentives is proposed in [7]. A model is established in [8] to analyse CO_2 emission reduction both in the power grid and transport sector. A multi-time synergistic dispatch model for the PEVs and wind power is studied in [9], aiming at minimizing the load variance. A business model based on coordination among EV users, aggregators, electric companies and wind farms is proposed in [10]. However, the coordinated dispatch researches mostly analyse the power balance problem from the perspective of transmission network. It is worth noting that reasonable strategy of the EV charging and DG output to achieve the economic operation in the distribution network system, is important to the dispatch center for the further power generation plan.

This paper proposes an optimized dispatch method based on voltage iteration. A model for coordinated dispatch of active power distribution network is established. Then the network loss and the nonlinear restrictions are simplified to obtain a linearly constrained convex quadratic programming model. Finally, an iteration method is proposed to correct the static voltage to obtain the optimal solution. The coordinated dispatch method proposed in this paper is verified by the IEEE33 node test system.

2. Coordinated dispatch model of DGs and EVs

In this section, the optimal charging of EVs and the active power curtailment ability of DGs are utilized to establish a model for coordinated dispatch in active distribution network. This model aims to provide optimized strategy which satisfies the routine demands of EVs, absorb DGs output and reduce the operating costs.

2.1. Optimization Objective

In a distribution network containing large-scaled DGs and EVs, it is necessary to fully explore the dispatch ability and establish a model for the operational economy and safety. The control variables of the coordinated dispatch model are the charging load of nodes which provides this service for EVs and the active power of DGs at various periods within a day. The optimization objective primarily includes two parts, as shown in (1), network loss and dispatch cost of DGs. Paper [11] proves that load variance and network loss are closely related. Optimizing network loss is equivalent to optimization the load variance which can achieve the peak load shifting.

$$\min f = \Delta T \sum_{t=1}^{N_T} \left(C_{loss}(t) P_{loss}(t) + \sum_{i=1}^{N_{DG}} C_{i,DG}(t) P_{i,DG}(t) \right) \tag{1}$$

Where, ΔT is the time period, N_T is the number of dispatch periods, $C_{loss}(t)$ and $P_{loss}(t)$ are the unit loss cost and total loss during period t; N_{DG} is the number of DGs; $C_{i,DG}(t)$ and $P_{i,DG}(t)$ are the unit power cost and restricted power of i^{th} DG during period t.

2.2. Equation constraints of EV charging energy

Considering the driving peak of EVs always around 8 o'clock, in this model 90% of EVs should finish the charging before 8 o'clock in the morning under the optimal charging mode

$$\Delta T \sum_{t=1}^{N_T} P_{i,\mathrm{EV}}(t) = \Delta T \sum_{t=1}^{N_T} P_{i,\mathrm{EV}}^{0}(t) \times 90\% \tag{2}$$

Where, $P^0_{i,\mathrm{EV}}(t)$ and $P_{i,EV}(t)$ are the charging power of node i during period t before and after coordinated dispatch.