Considering the electric vehicles to the grid's optimal operation with distributed generation

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Abstract. Based on the current rapid popularization and development of electric vehicles, serious environmental pollution and energy shortage problem, this paper researches the impact of the distribution network with distributed generation when the electric vehicles joining in the optimal operation. First, establishes the model of electric vehicles charging and discharging, then calculates the electric load curve after the electric cars accessed to the distribution network; secondly, establishes the optimization scheduling model with the optimization target of the distribution network's cost minimizing and solves the model by particle swarm optimization algorithm; finally, comes to the conclusion by the respective calculating of the characteristic indexes before and after the distribution network's optimization scheduling.

Introduction

Oil energy's drying up, make people have to devoted to quickly find a new energy instead of traditional energy to achieve the rapid and sustainable development of the society. Therefore, the electric cars, with its energy conservation, environmental protection have become the focus of attention in the modern society from all walks of life. The distributed power begin to mass into the power generation field, and produce a good social efficiency in recent years, and get more and more attention in the development and utilization.

This paper set the electric cars' large-scale access to distribution network disordered charging and discharging as the research object, establishes the electric vehicles' charging and discharging model and optimal operation model of the distributed power, and solves the optimal operation model by particle swarm optimization algorithm, through the optimization of electric vehicles' scheduling management, the distribution's peak load is reduced, peak valley load rate and the line loss are also reduced; at the same time its running efficiency and other indicators are improved.

Optimization scheduling model

The model of electric vehicles charging and discharging. Usually, we assume the electric vehicles' flow of a typical day as the formula(1).

$$d_c = D(n) \tag{1}$$

In which: $D(n)$ is used to describe the charging and discharging vehicles' quantity with the change of time; "t" is time; d_c is the density for filling in electric vehicles[1]. We assume a battery's charging time is Tc, and the time that charging equipments' cost is excluded. So the total power of electric vehicles' charging and discharging time in "t" is only related to the number of the cars within[t-Tc, t]. If we set the power of the electric vehicles to a constant value of p (kW), is the active power to charge and discharge for t time, the total power in time of "t" is shown in (2) and (3).

$$P_S = P \times Int(\int_{t=t\text{-}T_C}^{t} D(n)d(t)) \tag{2}$$

$$P = \frac{Q \times V}{h} \tag{3}$$

In which: Q is the approximate for the current of the battery charging and discharging; h is the efficiency of the charger; $P_S > 0$ stands for charging and $P_S < 0$ for discharging[2].

Optimal operation model of distributed power supply. In the current power generation plan, our target function is the minimum of the total electricity cost including start-up cost and fuel cost. So the final optimal operation model is shown in (4).

$$\min\ f_1 = \min \sum_{j=1}^{T} \sum_{i=1}^{N} \left\{ F_j \left[d_{1j}(i) \right] + S_j(i) \right\} \times U_j(i) + \sum_{i=1}^{T} \sum_{j=1}^{M} M_j \times d_{2j}(i) \tag{4}$$

In which: M_j is the gap of electric cars' price in charging and discharging; $S_j(i)$ is the powersupply's start-up cost; $U_j(i)$ is the condition of the power supply; $d_{2j}(i)$ is the electric quantity of the electric vehicles' battery; $F_j\left[d_{1j}(i)\right]$ is the fuel cost of the power generation.

Considering the distribution network power's balance constraint as (5) and (6).

$$\sum_{i=1}^{N} d_j(i) \times U_j(i) = D(i) + \sum_{j=1}^{M} \Delta D_j(i) \qquad i \in T \tag{5}$$

$$\Delta D_j(i) = \sum_{i=1}^{T} p_j(i,k) \times d_j(i) \tag{6}$$

Distributed power's maximum and minimum output constraint is shown in (7).

$$U_j(i) \times d_{\min,j} \le d_j(i) \le d_{\max,j} \times U_j(i) \qquad i \in T,\ j \in N \tag{7}$$

Particle swarm optimization algorithm. The particle swarm optimization algorithm is applied to the control strategy of electric vehicles, through optimization control, make the electric cars' join to the distribution network more reasonable and effective. And the objective function is the minimum.

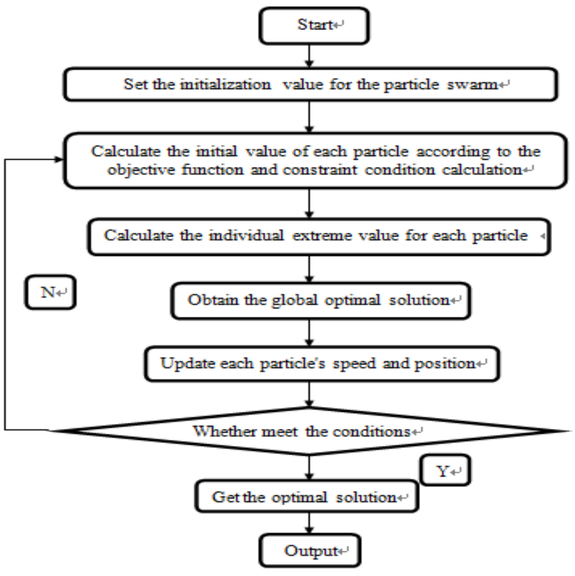

Fig.1 Particle swarm optimization algorithm flow chart

The optimized variables are 24, the location of the variable is $P_i = [P_1, P_2, P_3, \ldots P_{24}]$. Using the penalty function method to deal with the constraint conditions. The flow diagram is shown in Fig.1.

Case study

The area of a region is about 10 square kilometers, have jurisdictions include 3 administrative villages and 9 independent communities. The region's people population is about 100000. Forecast the power load of the electric vehicles after accessing to the distribution network in 2030 as shown in Fig.2.

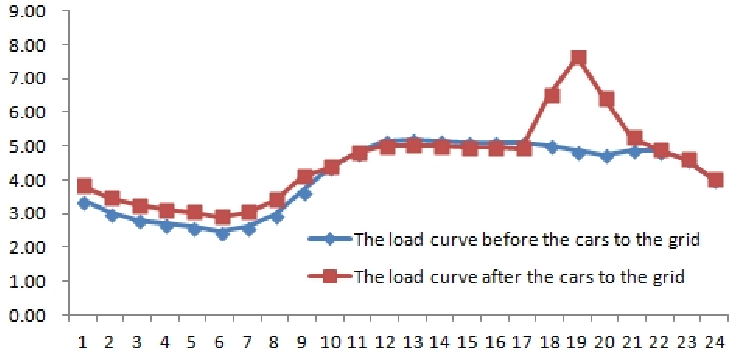

Fig 2 The electric cars' load curve accessing to the grid before and after

Select the IEEE 33 nodes distribution network to build a power system which has two photovoltaic powers U1 and U2 and one wind power U3 accessing to the 33 nodes distribution system. In which 10 and 13 installation node join the photovoltaic powers with largest output of 1.2 MW and 1.7 MW, and in node 17 join the wind power installation with the largest output of 6 MW. At the same time, join the electric vehicles' exchange station connected to 21 and 31 nodes, the different cost of distributed power supply and start-stop condition are as shown in table 1 and table 2.

Table 1. The data of power supply characteristics

power	P	a	b	c
U1	1.2	0.384	25.93	34.76
U2	1.65	0.033	14.30	80.0
U3	6	0.26	19.78	52.65

Table 2. the power supply's state to start and stop

power	State of the power
U1	000000111111111111000000
U2	000000111111111110000000
U3	100000011111111111111110

Calculate the index of the region's distribution network before and after optimization scheduling, the results are as shown in table 3.

Table 3. The contrast indicator before and after optimal operation

	Largest load	peak valley rate	Line loss	Voltage percent of pass
before	56.84MW	45.07%	16.03kW	99.46%
after	53.97MW	42.04%	10.08kW	99.62%

And calculate that the electric cars only exist in the distribution network as load which are not participating in the distributed power optimization scheduling. It is concluded that the load indicators in both cases as shown in table 4.

Table 4. Two cases' load index contrast

	Largest load	peak valley rate	Line loss	Voltage percent of pass
Considering EV	53.97MW	42.04%	10.08kW	99.62%
Not considering EV	54.77MW	44.48%	14.03kW	99.44%

Calculating the total cost after optimization scheduling for one day is RMB 107600. And the power generation cost is RMB 124500 per day that not considering the electric vehicles' exchange power station in scheduling.

Conclusion

This article researches the electric vehicles as the object because of its energy conservation and environmental protection features to be large-scaled popularization and use. Establish the joint optimization scheduling model of distributed power supply. Calculate that once the electric cars access to the optimal control to the distributed power distribution network, the distribution of peak valley difference is reduced, and part of the peak load remove from the peak shift to the low hours, make the power load curve cut the peak to the valley and more smooth. Improve the quality of the distribution network, at the same time, make the power grid operation more stable and more efficient.
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