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Optimal Charge and Discharge Management of Electric Vehicle Based on Multi-Objective Programming Model

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Abstract: With the development of the economy, the energy consumption in the transportation sector and the environmental pollution problems, the market is now actively promoting electric vehicles. The promotion of electric vehicles hopes to solve resource problems. According to the analysis of electric vehicle energy utilization, on the one hand, the impact of electric vehicle charging behavior on the power grid is studied. On the other hand, the influence of electric vehicle charging and discharging behavior on the optimization problem of new energy charging station and power grid is studied.

1. Introduction

With the development of modern science and technology, family cars are gradually entering thousands of households. The transportation sector consumes about half of China's oil resources, and at the same time generates a large amount of greenhouse gases, causing serious environmental pollution. The emergence of electric vehicles can effectively solve related problems. . Study the adverse effects of disordered charging of electric vehicles on the distribution network, realize reasonable power distribution, and solve energy problems. The energy of electric vehicles is mainly the use of grid energy. The development of electric vehicles is also inseparable from the power system. In daily life, the charging and discharging behavior of electric vehicles is characterized by strong disorder, and there is a problem of high usage rate at the same time. Problems related to the distribution network, such as increased peak-to-valley difference, voltage drop and increased grid loss, but electric vehicles can be used as a mobile battery to contribute to the coordination of power grids and assist other energy sources to develop and mitigate Energy consumption issues.

2. Electric Power Consumption Analysis

According to the charging record of 100 electric vehicles in a certain area, the distribution law of charging behavior characteristics of electric cars is analyzed. Principal component analysis and Xinqin number theorem are used to analyze the charging behavior characteristics of electric vehicles and the charging power of random variables. Excluding the situation that the electric vehicle does not flow current after connecting the charging pile, that is, the electric vehicle can use the power when it is connected to the power grid. The electric vehicle is not affected by the natural environment such as the weather. It is assumed that the electric vehicle is put into use immediately after the equipment is purchased. Consider storage depreciation, while the purpose of electric vehicles is not for sale.

Firstly, the data is preprocessed, the data with excessive difference is excluded, and the principal component analysis model is established [1]. The distribution law of the charging behavior characteristics of electric vehicles is analyzed, and then the charging time of electric vehicles is analyzed according to the Xinqin number theorem. The power consumption of the large-scale electric vehicle is obtained, and the obtained electricity consumption is checked by the t-test. The main symbols used in the text are explained, and some of the symbols that are not present are explained below [2].

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2.1. Analysis of electric vehicle charging behavior

According to the charging of 100 electric vehicles, the charging start time, charging connection duration/h, charging amount/kWh, quantitative analysis of the data, analysis and random events are converged according to the probability, and the electric power is solved according to the stability that occurs when a large amount of data occurs randomly. The relationship between the number of cars and the annual electricity consumption. The electric vehicle's one-day charging record is integrated, and the three-dimensional relationship between the charging start time, the charging connection time, and the charging power kWh is established as shown in the figure [3]:

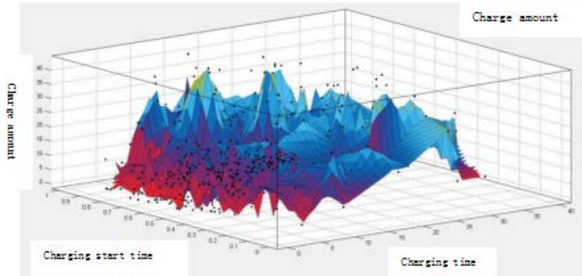

Fig.1. Three-dimensional relationship diagram

Then, for the charging behavior characteristics of electric vehicles, according to the factors affecting the behavior, using principal component analysis to find the main influencing factors, first matrix the data, for data standardization, calculate the covariance matrix, sort the feature quantities, and then get The contribution rate of the feature root. The relevant feature values are obtained as follows:

$$115.9080, 22.1167, 0.0371 \tag{1}$$

The first two principal components contribute 99.95%, Select the first two principal components. The equation is as follows:

$$\begin{aligned} y_1 &= 0.0037x_1 + 0.6894x_2 + 0.7244x_3 \\ y_2 &= -0.0012x_1 + 0.7244x_2 - 0.6894x_3 \end{aligned} \tag{2}$$

From this analysis, the charging behavior of the electric vehicle is mainly related to the charging connection duration and the charging power. According to the above data, the charging behavior of the electric vehicle is mainly based on the charging power and the charging connection duration. When the electric vehicle is charging, when the charging power kW is small, the charging connection duration is increased, and when the charging power kW is large, the charging connection duration is decreased. The charging behavior characteristics of the electric vehicle are mainly related to the charging power and the charging connection duration, and thus can also be analyzed, but the charging event of the electric vehicle is random, the charging time is mainly that the electric quantity reaches saturation, and then the charging behavior is ended, and most of the charging behavior is also completed. Consumer charging is based on whether or not the time is sufficient, whether to continue charging, and in the processing of data, it is found that consumers are charging frequently on weekends.

The charging start time, the charging connection duration/h, and the charging amount/kWh of the electric vehicle charging record are extracted, and the charging start time and the ending time of the electric vehicle are calculated, and the charging power (kW) of the user is obtained by using the matlab for one hour. , get the electricity consumption per unit time, and find that the peak period of power consumption is 10-15 [4].

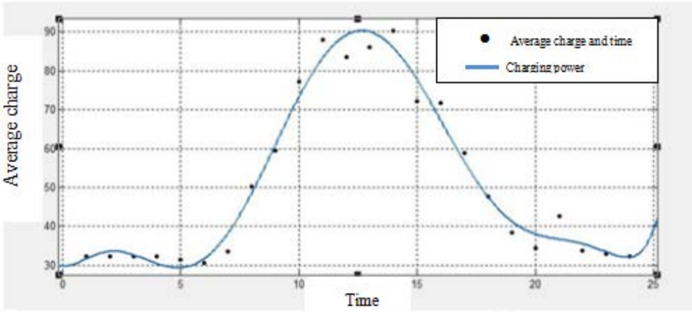

Fig.2. Average power consumption

2.2. Forecast electric vehicle power consumption

According to the principal component analysis model and the three-dimensional relationship diagram of the data, the charging behavior of each electric vehicle is independent random events, and has certain mathematical expectations. The user tends to converge on the charging behavior, which approximates 10-15. The charging behavior is obviously peaked and subject to the commute time distribution. Modeling based on the stability and frequency of occurrence of large amounts of data:

$$\lim_{n\to\infty} p\left\{\left|\frac{1}{n}\sum_{k=1}^{n} L_k - \mu\right| < \varepsilon\right\} = 1 \quad (3)$$

$$\lim_{n\to\infty} p\left\{\left|L_n - \mathrm{a}\right| < \varepsilon\right\} = 1 \quad (4)$$

Using Matlab, the annual electricity consumption range of 10,000 vehicles is 50349085-53655000.

Due to the unknown, the range of electricity used will be obtained by T test, Modeling:

$$\mathrm{t} = \frac{\sqrt{n}(\bar{m} - \mu_0)}{s} \quad (5)$$

Using Matlab test[h,sig,ci]=ttestbl,m,0.5,0),Reduce the annual electricity consumption range of 10,000 vehicles to(50645835,53206571) ..Predict the charge and discharge of 10,000 electric vehicles, and give the annual electricity consumption of electric vehicles as shown below.

3. New Energy Charging Station and Grid Power Exchange

In combination with the exchange of electricity prices and photovoltaic power generation of new energy charging stations and grid power, in the case of full utilization of photovoltaics and allowing for the abandonment of light, discussions are made. If the cost of photovoltaics is added, if the station is fixed at a charging price of 1.5 yuan/kWh. Randomly take the owner's charge 24 hours a day, the profit of the charging station is the cost of selling electricity to the grid and users minus the cost of purchasing electricity from the grid. A model for the profit establishment of the charging station is analyzed.

First, assume that the external resources are fully utilized, that is, the full use of photovoltaics, combined with the exchange price of new energy charging stations and grid power, and the amount of photovoltaic power generation, using the electric vehicle charging record on Thursday. Considering the cost factor of PV, considering the full utilization of PV, the maximum profit of the charging station in the next 24 hours will be analyzed and an optimization model will be obtained. The PV can then be selected to utilize or build a model, allowing for the selection of resources. Finally, combined with the above analysis, the transformation, according to the principle of profit maximization, combined with charging electricity price, new energy charging station to sell electricity to the grid and purchase electricity price, analyze and establish a mixed integer programming model..

3.1. Full use of photovoltaics

In the absence of consideration of the cost of photovoltaics, q_i represents the charging of electric vehicles during the Thursday period. When there is no PV output, the new energy charging station exchanges energy with the grid. When there is PV output, the mathematical model is established according to the PV output and user charging requirements:

$$W = 1.5\sum_{1}^{24} q_i + b_i * \left(\sum_{i=5}^{19} G_i - q_i\right) \quad (6)$$

Use Excel to solve $W \approx 2307.8$ yuan.

Considering the cost of photovoltaics, the profit of the charging station fluctuates with the change of photovoltaic cost, and establishes the mathematical model of adding photovoltaic cost: $W = 1.5\sum_{1}^{24} q_i + b_i * \left(\sum_{i=5}^{19} G_i - q_i\right) - \sum_{i=5}^{19} G_i a$ Taking into account the lowest value of electricity sales price, the highest value of electricity purchase price is the main factor affecting profit, according to PV output, PV cost, Annex 1 data and the electricity sales and purchase price in Schedule 3, get 24 hours on Thursday charging station The maximum profit varies with PV costs as shown:

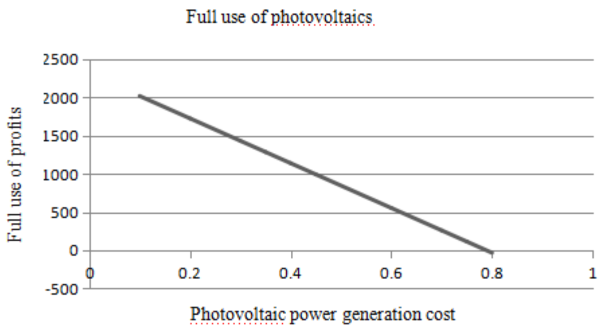

Fig.3. Profit trend graph with increasing cost of recovery

3.2. Allowable light analysis based on 0-1 planning

Ignore the cost of photovoltaics and allow the light to be abandoned. For new energy charging stations, if the photovoltaic power supply is lacking, the electricity is sold from the power grid. If the photovoltaic output is rich, only the production of electric vehicles can be satisfied. Create a mathematical model: $W = 1.5\sum_{1}^{24} q_i$.

The profit is $W = 1836.495$ yuan.

When the cost of photovoltaics is lower than the price of electricity sold, the new energy charging station can choose to sell electricity after meeting the service for electric vehicles.

When the cost of photovoltaics is higher than the price of electricity sold, when the cost of photovoltaics is less than the price of electricity purchased, the new energy charging station can choose to abandon the light after meeting the service for electric vehicles; when the cost of photovoltaics is greater than the price of electricity purchased, choose to abandon the light and choose to electrify electricity. Online shopping.

In the absence of photovoltaic production, choose to purchase electricity. Based on the above analysis, a target programming model based on 0-1 integer is established:

$$\max W = 1.5Q - Ga - i(Q - G)g + (1 - i)(G - Q)s \quad (7)$$

$$\begin{cases} i = 0, G > Q \\ i = 1, Q > G \\ 0 \le a \le 0.8 \\ 0 \le G \le 2925 \end{cases} \quad (8)$$

Assume that MATLAB is used to obtain profit dollars, and as the cost of photovoltaics increases, profits decrease.

According to the analysis of the results obtained, if the cost of photovoltaic output is reduced and the profit is increased, the new energy charging station should seek solutions to solve the problem of photovoltaic charging cost, reduce the cost of investment and increase profits.

4. Electric Vehicle Sales Analysis

Finally, according to the consideration, if the EV is used, the electric energy exchange (charging or discharging) directly with the power grid through the charging pile may cause the power flow to be greatly weakened, thereby reducing the impact of the power grid, according to the lowest network loss of the power grid and the electric vehicle. The owner of the vehicle spends at least the goal and designs the optimal solution for charging and discharging. In combination with EV parking in residential areas and the exchange of electrical energy, consider the range of electric vehicle charging and discharging power not exceeding 5 kW, electric vehicle battery capacity. Solve the problem of excessive peak value of the valley, thereby reducing the active network loss of the power grid, reducing the charging cost of the electric vehicle owner, increasing the discharge revenue, and establishing a multi-objective planning model.

The random charging behavior of electric vehicle owners is mainly based on time. With the fluctuation of time, the peak and low periods have impact on the grid and waste energy. Considering changing the owner's consumption mode to establish a multi-objective optimization model, and giving the optimal charging and discharging scheme.

4.1. Multi-objective optimization model

The random charging behavior of electric vehicle owners affects the peak value of the grid, causing damage to the grid, stimulating the owner to consume during the trough, and selling at the peak period to reduce the impact damage caused by the peak period of the grid [5]. When changing the mode of consumption of car owners, when considering the principle, the principle of electric vehicle is the lowest. Therefore, when solving the problem, the problem is bundled and analyzed [6]. For the model, the minimum cost of the electric car owner is the starting point, and the peak-cutting valley is realized. Reduce the impact damage caused by the peak period of the grid, and at the same time the energy waste caused by the low valuation. Let fc be the charging capacity of the owner, and fd is the mathematical model for the owner to sell electricity [7]:

$$F_a = F_0 + \sum_{i=1}^{24} f_c - \sum_{j=1}^{24} f_d , \begin{cases} 10 \le F_a \le 50 \\ i \ne j \end{cases} \quad (9)$$

$$F_a = F_0 + \sum_{i=1}^{24} f_c - \sum_{j=1}^{24} f_d , \begin{cases} 10 \le F_a \le 50 \\ i \ne j \end{cases} \quad (10)$$

4.2. Grid scheduling advice

The charging power is related to the working time of the electric vehicle owner, stimulating the owner to improve the charging time, and charging some potential users to the low valley value, thereby reducing the peak period. The highest value of discharge electricity price and the lowest charge price, the price difference is much different, through the electricity price to achieve smooth control of charge and discharge power, but some electric vehicle owners get revenue from it, generate additional expenditure on the grid, can limit the user discharge power, constrain some users . The new energy charging station can study the cost, improve the active power loss of the power grid, and use renewable energy to achieve green environmental protection.

5. Conclusion

Based on the cost of the electric vehicle owner, in order to solve the problem of active power loss of the power grid, it is hoped to achieve peak clipping and valley filling, and at the same time improve the impact caused by the owner of the vehicle over time 10~15. In the case of eliminating bad data, multi-objective planning is mainly used in pursuit of optimal solutions. Using the main program analysis to analyze the behavior of the owner, the main characteristic of the owner's behavior is the charge of electricity (kWh), based on the analysis of the behavior of the owner of big data under the Xinqin big data. Only a certain day's data is taken when taking numerical analysis, and there may be errors in the presence of a large amount of data. And did not consider the electric car owners riding routes and routes, and did not combine with the actual riding problems.

Combined with the actual car owner travel needs, and should consider the impact of the charging station on the road, how to better provide services. Also consider the cost issues that new energy charging stations should consider, as well as future expected benefits. Especially in real life, the influence of many unknown factors on the model should be more on-the-spot analysis of the model. And as more and more electric vehicles appear, it is necessary to establish a reasonable match between the power grid and the electric vehicle.

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