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FEASIBILITY STUDY ON REVERSE CHARGING OF NEW ENERGY VEHICLE BATTERIES IN THE CONTEXT OF CARBON PEAK AND NEUTRALITY GOALS

Energy

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ABSTRACT

In the search for green and sustainable development today, a good model of development for society is using social resources reasonably. According to the exploration of the supply and demand of electricity and the development trend of the new energy vehicle market, we have developed a feasibility study on the reverse charging of new energy vehicle batteries. By the study, we will use the new energy vehicle as an energy storage medium to regulate the supply and demand of the electricity market, establishing a systematic regulation network and leading the development of related industries and promoting the concept of resource conservation and green and sustainable development together all the time on the strategy of carbon peak and neutrality goals.

KEYWORDS

new energy vehicles, reverse charging, double carbon background, charging pile

INTRODUCTION

Since the 21st century, the world's energy system has undergone major changes in response to climate change, and on 22 September 2020, President Xi Jinping proposed the dual-carbon concept of "carbon peaking and carbon neutrality" at the 75th session of the United Nations General Assembly [1]. With daily and annual electricity loads in China's major cities ranging from 1,000 to 2,000 MW and 10,000 to 30,000 MW respectively [2], the peak-to-valley difference in electricity consumption is a huge source of energy waste, and it is vital to reduce this waste. Many studies have suggested that energy storage systems can be used to regulate peaks and fill valleys to achieve energy saving and emission reduction. Combining previous research and the future development trend of new energy vehicles, we propose the idea of using new energy vehicles as the storage medium and using the new energy vehicle battery reverse charging technology to integrate new energy vehicles into the energy storage network.

CURRENT STATUS OF RELEVANT RESEARCH AND TRENDS

In order to reduce energy wastage due to the difference between peak and valley electricity consumption, measures such as changing the production sequence, staggering electricity consumption, and adjusting the load using time-of-use tariffs and pumped storage power stations to adjust peaks and fill valleys can be taken [3]. Among these, pumping storage power stations have a fast start-up speed, flexible operation, high reliability of power generation and can also undertake tasks such as frequency regulation, phase regulation, accident backup and black start [4]. However, they are highly geographically dependent and cannot be built in areas with small water level drop.

To cope with this situation, large-scale battery energy storage systems (BESS) can be used instead of pumped storage power plants for the purpose of peak and valley regulation. By using BESS to cut peaks and fill valleys, power grid company can postpone equipment capacity upgrades, improve equipment utilization and save on equipment renewal costs; power consumers can use BESS to cut peaks and fill valleys and gain economic benefits from the difference in peak and valley tariffs [6].

At the same time, electricity-to-gas technology can convert excess electricity in low valley hours into natural gas that can be easily stored on a large scale and reused in peak hours through the generation of electricity by gas turbine units, which has a large storage capacity and a long discharge time, and can effectively consume large-scale wind power and achieve a long time and wide range of spatial and temporal transfer of energy[7]; 9The construction of charging piles aims to significantly improve the level of charging technology, significantly enhance the interconnection and interoperability of charging networks, and further optimize the development environment and industrial pattern of charging infrastructure[9]; Reverse chargers can transfer electricity from vehicles to the existing grid or use vehicles to power specific electronic devices[11]. Using the above technologies, new energy vehicles can be connected to a large-scale energy storage system and then to the grid, thus creating a mobile and distributed energy storage system.

Based on the above literature analysis, there is a deeper understanding of peak and valley regulation methods. However, it's still a lack of theoretical basis for the feasibility of practical application of reversible charging systems for new energy vehicle batteries, and a complete and feasible implementation plan needs to be proposed and eventually applied, so the exploration of this area is very promising.

BASIC SYSTEM ARCHITECTURE

(ⅰ) Power generation side

The main forms of power generation on the power generation side are nuclear power generation, wind power generation, hydro power generation, biomass energy power generation, solar power generation and thermal power generation. According to carbon peak and neutrality goals mentioned above, the share of thermal power generation will be significantly reduced, and nuclear power generation, wind power generation, hydro power generation, biomass power generation and solar power generation will become the main forms of power generation in the future. In addition, considering the uncertainty of wind power, the geographical limitations of hydro power, the time and climate limitations of solar power and the site limitations of biomass energy power generation, we believe that nuclear power will be the main form of power generation in the future, with other forms of power generation co-existing.

In view of the above, we find that nuclear power generation is basically stable in time, but at the same time, when multiple forms of power generation are connected to the electric grid, the electric grid will fluctuate with uncertainty due to the different characteristics of each power generation curve, resulting in an imbalance between supply and demand, so we need to rely on a smarter grid for real-time monitoring and regulation at the powergeneration end. With the monitoring and real-time scheduling of the smart grid, the balance between supply and demand is achieved, conserving energy and ensuring the economy of the renewable part of the overall power generation.

(ⅱ) Power supply side

1. Connect with the smart grid at the power generation end to establish a perfect real-time power monitoring and dispatching system. Set up a real-time monitoring system to facilitate the dispatching of electricity at various locations, and make corresponding regulation according to real-time data, achieving the energy interaction system from the electricity network to the charging station network.

2. use a time-of-use tariff. Through real-time monitoring of the smart grid, the tariff can be adjusted lower during low load periods for new

energy vehicle users to buy and charge, and increased during high load periods to buy electricity from users and supply it to enterprises or users in demand. In this way, it can effectively alleviate the waste of excess power generation at the power generation end during low load periods, and also reduce the power generation capacity of power generation enterprises during high load periods, reducing the cost of power generation and waste of resources, further realizing the environmentally friendly strategy.

3. Build a charging station network with two types of charging points to meet users' choices. The first type is storage type, when the new energy vehicles are not charging (including the new energy vehicles are fully charged or temporarily unable to charge) and the electricity demand is not high, the excess electricity can be stored in the charging stations. **The second type is the direct charging type**, which can be used when the new energy vehicles are charging during low periods, and can be used to charge the new energy vehicles directly through the direct charging piles in contact with the electric grid. **In addition, both types of charging points also have the ability to reverse charging the electric grid, allowing the surplus electricity from the new energy vehicles to the electric grid.**

4. Build an energy storage network of new energy vehicles. Absorb a large number of new energy vehicle users into the energy storage network of new energy vehicles, so that the number of users will be enough to achieve the goal of load regulation, and then sell the excess power during the period of low electricity consumption and recover the power during peak period of high electricity consumption by means of time-of-use prices, so as to achieve the purpose of adjusting the generating capacity in different period at the power generation end and ensure to reduce the energy consumption at the power generation end. A decentralized customer network and a large number of customers will give us strong support in regulating electricity consumption during peak periods and storing energy during low peaks, with increasing the flexibility of regulation.

USER SIDE

1. establish a client app, in which users can check the price of electricity in real time and buy or sell electricity intuitively (including paying the electricity costs, income from electricity sales, etc.), realizing real-time energy connect the charging station network and the new energy vehicle network in real time. According to our survey on the use of fuel cars, we found that most cars are idle, about 20 hours per day, so it can be deduced that new energy vehicles are idle most of time. Therefore, users can use the idle time of new energy vehicles to charge and sell electricity to generate additional income and reduce the waste of resources in the societal level. Within the app, users can not only check real-time electricity prices at any time, but can also control the operation of buying and selling electricity at long bowls and decide on their own transactions in real time.

2. build personal energy storage charging stations. For those who do not wish to sell their electricity to power grid, they can purchase a personal charging point to buy electricity and store it in the charging point during low load periods, and then use it in their own homes during peak periods, thus relieving the pressure on power grid during peak periods and reducing the consumption of power during low peak periods. These personal energy storage charging stations can also be used to buy electricity remotely and intelligently by using the client app mentioned above.(Figure 1 for the user side)

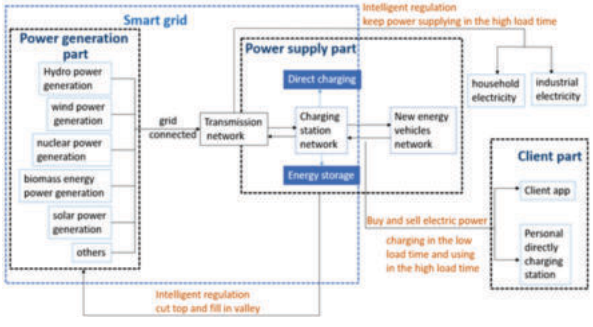

Figure 1 : General system framework

FEASIBILITY STUDIES

(i) Feasibility of the construction of charging posts.

China's new energy vehicle industry development plan (2021-2035) proposes that it will speed up the construction of charging and transferring infrastructure, rely on "Internet plus" smart energy, enhance the level of intelligence, and encourage the application of electric power conversion mode, and strengthen the research and development of new charging technologies, such as intelligent and orderly charging, high-power charging, wireless charging, etc. The State invests about ten billion dollars each year in the popularization of charging piles, because of the special characteristics of charging piles, they are similar to the gas pumps in traditional gas stations, and can be fixed to the ground or walls and installed in public buildings (public buildings, shopping malls, public car parks, etc.) and car parks in residential areas, which greatly reduces the expenses of charging piles. In terms of policy, the state has opened up the charging pile market to private capital to speed up the popularity of charging piles.

The construction of a large number of charging piles will provide the feasibility of charging and discharging interactive media for the reverse charging of new energy vehicle batteries.

(ii) The layout of the new energy vehicle industry has accelerated.

New energy vehicles are in the stage of vigorous development, the state pointed out that by 2025 new energy vehicle sales reached about 20% of total new car sales. And it will accelerate the layout of the development of the new energy vehicle industry, striving to after 15 years of sustained efforts, China's new energy vehicle core technology to reach the international advanced level, for new energy vehicle battery distributed energy storage to provide the basis for energy storage.

(iii) The economic viability of the project.

On the basis of the smart grid, time-of-use pricing is introduced based on the characteristics of the time of day, with electricity being sold during peak periods and bought during low periods. The customer can earn a price difference for the different time slots, while the supplier can reduce energy waste and ease the peak load, resulting in a win-win situation for all parties.

Based on the 5.51 million new energy vehicles in China in the first quarter of 2021, the average battery capacity of each vehicle is 30kwh. According to the data, each vehicle is placed for about 20 hours per day. At the same time the peak, flat and low periods of electricity consumption are around 8, 7 and 9 hours respectively (see Figure 3). In order to achieve peak and trough regulation, taking into account the economic benefits, it is most appropriate to buy in the low hours and sell in the high hours. Note that the average peak hour and trough tariffs are RMB 1.2/hour and RMB 0.25/hour respectively (see Figure 4).

It is calculated that all the new energy vehicle batteries can store about 165,300,000kwh of electricity, which can meet the daily electricity consumption of 165,300,000 households, and a total of RMB 15,703,000 can be earned, with an average daily benefit of RMB 28.5 per vehicle. (Note: The average daily electricity consumption of a household is 10 degrees)The analysis of the above data shows that the economic benefits achieved through reverse charging technology with the new energy vehicle battery as the storage intermediary are considerable and also solve the problem of energy waste.

Table-1: Data Relating To New Energy Vehicles And Household Electricity Consumption

Ownership of new energy vehicles (ten thousand vehicles)	551
Average battery capacity of new energy vehicles(Kwh)	30
Average daily idle time for cars(h)	20
Average daily household electricity consumption(Kwh)	10

Table-2: Details Of Electricity Consumption Periods

The period of power consumption	hours(h)
Peak periods	8
Low periods	9
Other periods	7

Table-3: Details Of Period Tariffs

time-of-day tariff	Yuan(¥)
power price of peak loads	1.2
power price of flat loads	0.75
power price of valley loads	0.25

CONCLUSION

By studying the relevant literature of domestic and foreign scholars, this paper creatively proposes the establishment of a reliable and complete electric load regulation system from the power generation side to the power supply side to the customer side using the reverse charging of new energy vehicle batteries as the medium. It also analyses the system in terms of the feasibility of charging pile construction, the accelerated development of the layout of the new energy vehicle industry and the feasibility of the economic benefits of the project from both qualitative and quantitative analysis, demonstrating the completeness of the system and the feasibility of building the system.

At the same time, the study found that there are several limitations in the construction process of the system as follows. (1) In this system, the frequency of charging and discharging of new energy vehicles has increased significantly, and under a certain number of times the battery can be charged and discharged, it's life will be shortened significantly to about 7% of the original. (2) New energy vehicle battery reverse charging technology is not mature enough. Few companies are currently using reversible charging technology in new energy vehicles, but some companies have successfully used reversible charging technology in vehicles and to supply electricity to household systems, such as Valeo Automotive. (3) At present, most of the charging facilities are public charging piles, which are small in number and do not have the ability to reverse charging, and cannot support a large charging and discharging system for new energy vehicles. (4) In the future, there will be a large number of new energy vehicles interacting with the grid in real time, posing a huge challenge to the stability of the grid and to demand management on the customer side.

Future research on the reverse charging system for new energy vehicle batteries can be carried out from the above-mentioned limitations and gradually improved into a more reliable and complete system to jointly contribute to green ecological and sustainable development and the achievement of the dual carbon goal.

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