Research on the potential of mobile energy storage for electric vehicles

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Abstract: In the context of China's current vigorous development of electric vehicles, China ranks first in the world in terms of production and sales of electric vehicles. While electric vehicles can effectively reduce the country's foreign oil dependence, they can also play the energy storage attribute of electric vehicles and further participate in regulating the electric load. Moreover, as the number of electric vehicles increases, their role as mobile energy storage will play an increasingly large role in regulating the charging and discharging of the power grid. The country has introduced a number of energy storage promotion policies in the past two years, and from a long-term perspective, electric vehicles as mobile energy storage will reduce the overall cost of electricity storage, and have greater flexibility and lower cost advantages compared to other energy storage methods.

Keywords: Electric vehicle; Vehicle Grid integration; Energy Storage

1 Current Electric Vehicle Market Situation

In the last three years, car ownership has tripled. China, in particular, accounts for 53% of global EV sales in 2021, and China is the double leader in EV production and sales among the world's major economies, which is shown in Figure 1. In December 2021, electric vehicles accounted for 19% of the penetration of new vehicle sales . Along with the growth in electric vehicle sales is the declining cost of batteries due to scale, with the cost of lithium batteries now down from $1,000/kWh a decade ago to $150/kWh today, a drop of 85%. It is expected that by 2025, the overall cost of electric vehicles will be lower than that of traditional vehicles, and the sales of electric vehicles will further explode at that time . According to the national standard GB/T 32960, electric vehicles in China are required to report data to the national new energy vehicle big data platform in real time, which ensures the data security guarantee of electric vehicle quantity and operation characteristics, and is of great significance for long-term electric vehicle development.

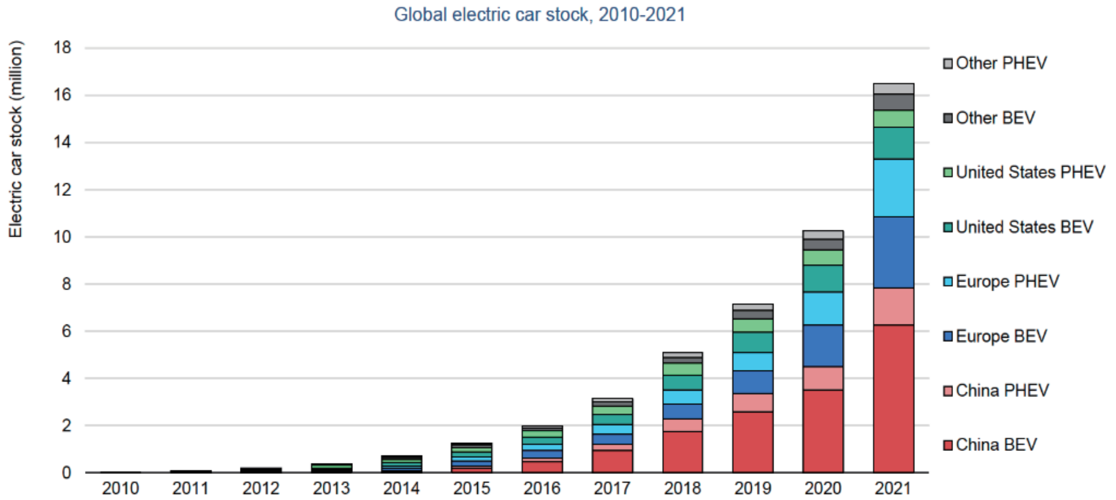

Figure 1 Electric vehicle stock across the world(2010-2021)

2 The impact of EVs on the electric system through vehicle-grid collaboration

By the end of 2021, China has 302 million vehicles, and if all of them are replaced by electric vehicles, the daily energy consumption of electric vehicles will increase by 3 billion kWh according to the standard of 10 kWh per day. In particular, the charging behavior of electric vehicles mostly occurs in the evening during the peak hours of electricity consumption, which will intensify the pressure on the power system, and as the number of electric vehicles continues to grow, the power system will face increasing challenges . Moreover, given that electricity is not suitable for large amounts of storage, especially in the future, the continued increase in installed photovoltaic capacity, the growth of the electricity load in the evening hours and the withdrawal of photovoltaic generation will further aggravate the peak-peak gap. Lawrence Berkeley Lab research shows that future uncontrolled charging of large numbers of EVs will have a significant impact on the power system (Figure 2), and that controlled bi-directional charging and discharging of EVs will completely rewrite the power load curve .

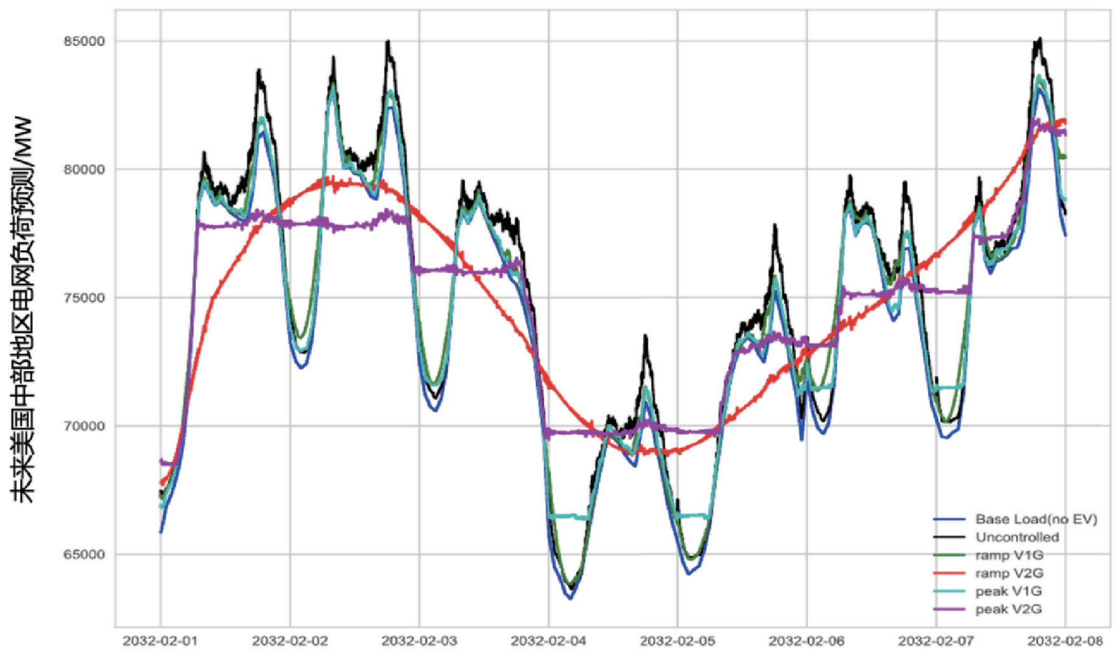

Figure 2 The EV charging influence on existing electricity grid

Achieving the dramatic adjustment of the grid load curve by EVs as illustrated by the large red curve (V2G demand response) in the figure above will be a long-term process. Until then, the first thing that can be easily achieved is to adjust the load on the grid by means of orderly charging, especially to avoid further increasing the load on the already high load on the grid during the evening rush hour. The Shanghai area already requires new charging piles to have the function of orderly charging, which provides the basic conditions for the popularization of orderly charging. One-way orderly charging is used to migrate the electric load, and two-way charging and discharging of electric vehicles couples the energy-consuming properties of the vehicles with the energy-storage properties, which helps to further adjust the load of the grid and improve the security of the grid.

3 Forecasting the potential of EVs of different sizes for mobile energy storage

By the end of 2021, China's installed energy storage capacity will be 45 GW, and if EVs are used as storage systems, each vehicle will have a power of 7kW, which is commonly used in the market today, then the 302 million EVs mentioned above will turn into a staggering 2,100 GW of mobile energy storage capacity, which is nearly 50 times the size of energy storage at this stage . How to fully utilize the mobile energy storage potential of electric vehicles will play a crucial role in the security of the power system. As of the end of April 2022, the nation's installed power generation capacity is 2,410 GW. In terms of scale, when electric vehicles become fully popular, their mobile energy storage capacity will be an important part of the power system. Two prerequisites are needed for the full potential of electric vehicle energy consumption and storage: the accumulation of electric vehicle ownership and the improvement of electric vehicle charging and discharging control capability, and China has a great first-mover advantage in both aspects .

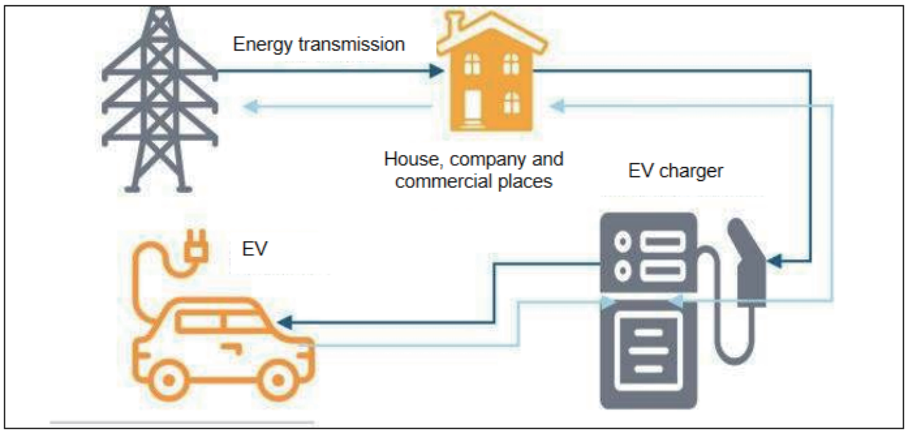

Figure 3 Overview of V2G operation

Electric vehicles, as energy storage units, will participate in power regulation in a distributed energy way. At the same time, the problem facing EVs is that in different scenarios, the scale of EVs varies, resulting in different ways of participating in the grid. For example, for customers living in more remote areas, EVs cannot be integrated with the surrounding distributed energy sources, so EVs can only participate in the household's electricity consumption by accessing the microgrid. However, for densely populated areas, when more mature charging and discharging facilities are used, EVs can participate in power trading, demand response, etc. through aggregation, making full use of the peak-to-valley difference in electricity prices to achieve the lowest operating costs. Therefore, in this field of research, it is necessary to follow different scenarios and different scales of electric vehicles to develop corresponding vehicle-net interaction control strategies.

4 China will be the pioneer in the scale operation of vehicle-net synergy

China's EVs have already achieved rapid growth due to multiple factors such as cost reduction and government encouragement brought by scale, and China accounts for 53% of global EV sales in 2021. Vehicle-grid synergy needs to be based on scaled electric vehicles, together with supporting measures for the power system, especially the grid system, to truly realize the synergy of intelligent charging and discharging control for the power system. Considering the privatization and limitations of foreign power supply enterprises, it is difficult for foreign countries to conduct large-scale vehicle-grid synergy operation at this stage from the perspective of business model . China has a unique advantage in this field. Following the rapid growth of the number of electric vehicles in China, China can realize a larger demonstration operation in the commercialization of vehicle-net synergy, and will also build the world's largest vehicle-net synergy integration network. However, how to integrate the vehicle-net synergy and explore the potential of electric vehicle energy storage attributes is a challenge for the industry .

In addition to the leading number of electric vehicles, the construction of charging infrastructure in China is also at the forefront of the world. Electric vehicles are divided into two modes of replenishment in the form of charging pile charging and power exchange stations for power exchange, and by the end of September 2022, the number of charging piles reached 4.5 million units and the number of power exchange stations was 1,800. With supportive policies, China's replenishment energy industry is in a rapid growth trend in both aspects of construction. The higher number of charging piles ensures further growth of electric vehicles, and China is making relevant investments and construction in the area of power exchange stations, including those for pure electric passenger cars and heavy-duty electric trucks. With the growth of scale, it is an important promotion for the subsequent development of vehicle network synergy.

5 The Conclusion

Vehicle network synergy needs to connect users, EV manufacturers and grid systems to realize data sharing and management in multiple fields. In the process of multi-domain synergy, the challenges are mainly as follows: 1) Electric vehicle storage depends on the upgrade of charging and discharging communication and control technology, and users need to have timely access to grid tariff information and flexibility to choose the most suitable charging and discharging package. 2) Electric vehicle storage will inevitably accelerate the decay of power battery capacity, which will be the key to the lack of active participation in vehicle network synergy. (3) Additional initial investment may pose obstacles to the promotion of vehicle-net synergy. (4) The electric power system has the problem of low enthusiasm for the development of vehicle-grid synergy because of the power quality. Although the majority of users do not use this part of the cycle life, it is about the warranty of the battery.

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