Research on the Impacts of Large-scale Electric Vehicles Integration into Power Grid

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Abstract. Because of its special energy driving mode, electric vehicles can improve the efficiency of energy utilization and reduce the pollution to the environment, which is being paid more and more attention. But the charging behavior of electric vehicles is random and intermittent. If the electric vehicle is disordered charging in a large scale, it causes great pressure on the structure and operation of the power grid and affects the safety and economic operation of the power grid. With the development of V2G technology in electric vehicle, the study of the charging and discharging characteristics of electric vehicles is of great significance for improving the safe operation of the power grid and the efficiency of energy utilization.

Key words: Electric vehicles; Vehicle-to-Grid; Charging and discharging; power grid.

INTRODUCTION

The large amount of greenhouse gases emitted by traditional vehicles is the main cause of the greenhouse effect [1]. In the last 10 years, the global emissions of carbon dioxide have increased by 13%, it is expected that global carbon emissions will increase by 30% to 50% by 2050. Facing the great pressure of energy and environment, the global consensus has been reached that the transformation of traffic energy is imperative.

In recent years, many countries are vigorously developing the electric vehicle industry. In January 2011, President Obama pointed out in his state of the Union address that it is estimated that by 2015, the United States will become the first country to have millions of electric vehicles. China also issued a series of laws and regulations to promote the development of electric vehicles, the introduction of relevant policies and the implementation of electric vehicle demonstration pilot projects, to encourage users to use electric vehicles. In the future, electric vehicles will occupy the leading position of traffic travel tools.

The integration into the power grid of large scale electric vehicles has brought new challenges to the security, reliability and economic operation of the power grid [2]. But the electric vehicle can also be used as a special power supply, in the V2G mode, the power can be sent back to the power grid [3]. Therefore, it is necessary to study the impacts of large-scale electric vehicle integration into the power grid, establish its charging and discharging power model, and conduct orderly guidance control for the charging and discharging behavior of electric vehicles.

ELECTRIC VEHICLE POWER SUPPLY MODE

At present, there are two main modes of electric vehicle power supply: charging and battery replacement, and these two modes have different characteristics [4].

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Charging

Electric vehicles need to be supplemented by electric energy after long working. AC charging pile provides alternating current energy, the vehicle charger completes AC / DC conversion, and the charge power is generally less than 7 KW. There are some characteristics of conventional charging: The slow charging takes a long time, the charging current and the charging power are low, which has little effect on the battery life; fast charging takes a short time, but the charging current is very large, which may cause some damage to the battery, and it will also affect the power quality of the power grid, which requires high requirements for the technology and safety of the charging equipment.

battery replacement

When the electric vehicle is running out of battery power, the battery of the electric vehicle is replaced by a battery filled with electricity so that the electric vehicle can continue to run smoothly. The replacement of the entire battery pack can be completed in 5-10 minutes. Compared with the charging mode, the battery replacement mode has a high efficiency and fast effect and can save a lot of charging time. But the battery replacement mode also has some shortcomings: the battery pack needs to be standardized, the replacement of the battery requires professional operation, it may bring high operating costs and other problems. According to the operating characteristics of different cars, the battery replacement mode is more suitable for electric vehicles such as buses and taxis.

At present, the mode of electric vehicle power supply has not yet been unified, and the charge load for charging and battery replacement is still under study [5]. Different mode of replenishment will be suitable for electric vehicles with different charging needs.

THE IMPACTS OF ELECTRIC VEHICLES INTEGRATION INTO POWER GRID

In the future, the capacity of battery will be larger after large-scale application of electric vehicle. The fast charging power of single vehicle will reach more than hundreds of kilowatts, which will exert great power load impacts on regional distribution network [6].

Load Characteristics

The power supply mode of the electric vehicle is divided into the charge of the whole vehicle and the replacement of the battery, the charging time of the battery in the charging station is relatively flexible. The load peak and valley difference can be effectively adjusted by charging the battery in the period of low power trough. As a mobile distributed energy storage unit, electric vehicle can cooperate with other renewable energy sources, such as wind energy and photovoltaic power generation, and coordinate daily load characteristic curve of power grid. The access of electric vehicle to distribution network can provide more controllable load for power grid dispatching, change daily load curve of access point, reduce peak valley difference, and play a role of peak shaving and valley filling. The specific adjustment effect is determined by the load power and load characteristics of the substation.

In the future, with the increasing production and sales of electric vehicles, the impacts of electric vehicles on the daily load characteristics of the distribution network will also increase gradually [7]. If the charge load control of the electric vehicle is coordinated and reasonable, the utilization rate of power plant and power grid equipment can be improved and the economic benefit can be improved. But if the electric vehicle is charged out of order, The distribution network may have a "peak on peak" phenomenon, the peaking power grid distribution network planning greatly increased one disaster after another, and the construction of the power plant and the effects of pressure, power transmission and distribution network operating efficiency, and will lead to the power grid peak load power shortage, when the low load power plant output and excess power supply capacity of the more prominent.

Distribution Network Planning

After the popularization of electric vehicles, the energy stored on the battery of electric vehicles will be distributed as a distributed power supply to the distribution network according to the demand of power grid during the peak load period. Because the number of electric vehicles is huge and has the characteristics of mobility and dispersion, the charging and discharging facilities of electric vehicles will have a great impact on the distribution capacity setting and distribution line selection of power grid planning. Distribution network planning has become more difficult, mainly as follows: the random access of electric vehicle to the grid will affect the load prediction of the system, making the planning of the original distribution system face greater uncertainty, and it is difficult to determine the later power grid planning.

Distribution network equipment

The large-scale use of electric vehicles and the randomness of charging and discharging will cause transient load, which will bring great difficulties to distribution capacity allocation, distribution line selection, relay protection coordination, and directly affect the economy, safety and service life of distribution equipment. In order to meet the short time charging power demand at the peak of the charging peak, a high-grade distribution capacity needs to be configured. When the charging demand is low, the utilization efficiency of the distribution equipment is not high, which causes the waste of resources.

Fast Charging Load on Power Grid

With the continuous maturity of electric vehicle technology, electric vehicles will enter the people's life on a large scale. The fast charging power of the single vehicle will reach hundreds of kilowatts if the fast charging of the 100A is used for the electric vehicle to be supplemented at random. If a number of fast charging operations are carried out at a certain time, it will cause a huge power impact on the local distribution network, causing local overloads in the distribution network of the area, which will adversely affect the power grid. Therefore, in the process of popularization of electric vehicles, the users of electric vehicles should be guided correctly and the charging time should be arranged reasonably. With the development of energy storage technology, we can consider that the energy stored in the energy storage charging station at low time can provide temporary electric power to the electric vehicle, which can not only meet the charging demand of the electric vehicle, but also avoid the impact of fast charging on the power grid.

Network Scheduling and Relay Protection

The receiving end of the traditional distribution network is a passive radiant grid, and its information collection and distribution dispatching are relatively simple. But in the future, the battery of electric vehicle will carry the function of smart grid mobile energy storage unit, which is not conducive to the accurate load prediction of dispatchers, and the dispatching process of distribution will also be complicated, which will increase the difficulty of monitoring and scheduling [8]. At the same time, because the electric vehicle can realize the conversion between energy and vehicle battery and power grid, the distribution network of traditional radiated power supply will radically change, the power flow no longer flows from the substation bus to the user load, and the various protection values and mechanisms of the distribution network will also change. The design of relay protection will become more complex, and the failure to cooperate will lead to the protection malfunction and reduce the reliability.

CONTROL AND UTILIZATION OF ELECTRIC VEHICLE

Electric vehicle ordered charging

Electric vehicle ordered charging refers to the participation of electric vehicles in the form of controllable load, which has been widely concerned as an effective way to effectively avoid the negative impact of large-scale charging of electric vehicles on the power grid. Electric vehicle ordered charging control according to the operation state of power grid electric vehicles, general with optimal economy or impacts on power grids as the optimization objectives, constraints and comprehensive user battery performance considering the charging demand of electric vehicle charging process, coordination, control means for charging time and charging power.

One literature selects a typical distribution network in a town in Virginia [9], USA to analyze the load situation of distribution network under multiple electric vehicle access scenarios. The results show that the peak load will lead to growth and distribution transformer overload of electric vehicle charging, charging through staggered coordinated charging strategy can effectively smooth the load, eliminate the distribution transformer overload, improve grid node voltage level, and reduce the network loss.

Vehicle-To-Grid (V2G)

Vehicle-To-Grid refers to the electric vehicle as a distributed energy storage unit, which is involved in the regulation of the power grid by charging and discharging. Research on V2G in foreign countries started earlier, literature proposed the thought of V2G earlier and carried out the benefit analysis [10]. At present, the research on V2G mainly focuses on the interactive mode, control strategy, cost-benefit analysis and hardware research and development of electric vehicle and power grid.

As a distributed energy storage device, electric vehicle can control its charge and discharge process by coordinating its charging and discharging process, so that it can charge at the peak time of system load and low valley and achieve peak shaving and valley filling [11]. The electric vehicle can also participate in the frequency regulation of the system, compared to the traditional frequency modulation power source, the electric vehicle has a fast response to the frequency modulation. By optimizing the charge and discharge of electric vehicles, we can stabilize the fluctuation of wind and solar power, improve the utilization efficiency of new energy and the ability of grid to accept new energy generation and access. Some studies also show that V2G can provide reliable reserve capacity for the system and can improve the economy of users using electric vehicles, and electric vehicles can also provide reactive power support for power grid.

CONCLUSION

The impacts of electric vehicle integration into the power grid and the research on charge and discharge control and application of electric vehicles are summarized in this paper, the rational deployment of electric vehicle charging facilities is the basic guarantee for the realization of the electric vehicle's large-scale integration into the power grid, considering the charging requirements of different types of electric vehicles, the cost of integration into the grid should be considered and coordinated with the planning of the power grid.

The electric vehicle charging has different effects on the power grid in the short and long term. The charging load has the characteristics that the equivalent power consumption hours are small and the peak and valley difference is obvious. The implementation of electric vehicle charging and discharging control will effectively reduce the burden brought by large-scale electric vehicle integration into the power grid, contribute to the safe and economic operation of the power grid, and enhance the environmental value of electric vehicles. Orderly charging takes advantage of the adjustable and interruptible power load of electric vehicles. With the start of the related work of the smart grid, V2G is becoming a hot spot of research.

The charging load characteristic of electric vehicle is related to the economic level, living habits and seasonal climate, the charging load model of electric vehicle should be based on a lot of statistical data. It is necessary to carry out a lot of meticulous work to make accurate and accurate assessment of the impact of electric vehicles on the various aspects of the power grid after the large-scale application of electric vehicles.

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