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# Development of charging technology for new energy vehicles

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**Abstract.** In the context of a global energy shortage, new energy vehicles are gradually becoming the mainstream trend of future automotive development. The development of fast and safe charging methods will bring a better experience to new energy vehicle users and gradually solve the problem of mileage anxiety for new energy vehicle users. At present, the main charging method of new energy vehicles is wired charging, but this charging mode charging time is slow and due to the external influence of the charging environment, causing the battery to overcharge the car's spontaneous combustion phenomenon, the application of wireless charging and power exchange technology to the future charging technology, wireless charging can bring higher charging efficiency and power exchange technology can bring similar to the fuel car replenishment energy experience. This paper first introduces the meaning of the three charging technologies and analyses their advantages and disadvantages. The three charging methods are described separately for wireless charging technology and compared with each other to arrive at the most suitable for future development. By comparing these three charging technologies, it can be seen that wireless charging technology is more suitable for the development trend of unopened new energy vehicle charging technology, and finally, the difficulties that need to be overcome for the future development of wireless charging are briefly described. This paper has important implications for developing new energy vehicle charging technology and popularizing the use of new energy vehicles.

**Keywords:** charging method of new energy vehicles, wired charging, wireless technology, power exchange technology.

## 1. Introduction

In 2020, China set the goal of "carbon peaking and carbon neutrality", promoting the development of clean energy as a mainstream trend and introducing a number of policies to drive the development of new energy vehicles. As the core power battery of new energy vehicles, there is an urgent need to develop efficient charging technology, improve the safety of charging and extend the life of the battery. By developing better charging technology, a solid foundation will be laid for expanding the market share of new energy vehicles, the reduction of energy losses, and completing the dual carbon policy. The main charging method nowadays for new energy vehicles is wired charging, which adds a certain amount of time, cost and risk to the user's use due to its slower charging speed and possible safety hazards of charging compared to fuel vehicles. As the new energy vehicle battery itself can only accept DC charging, while in daily use, it is mostly AC charging, it needs to be converted by the onboard charger before charging the power battery, so its charging time is longer [1]. During the charging process of new energy vehicles, due to the high temperature of the charging environment, users using unsuitable

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chargers for charging or not disconnecting the charging equipment for a long time after a full charge, etc., irreversible damage may be caused to the health of the battery, resulting in the overcharging of the car, which in turn induces the thermal runaway of the car, and in serious cases, may also trigger the spontaneous combustion of the car [2]. The development and innovation of charging technology are now taking place worldwide in response to this charging shortage. Currently, there are two types of wired charging: DC charging and AC charging, using charging piles or other charging equipment to replenish the power battery. Wireless charging uses magnetically coupled resonance technology, which transforms electrical energy through a coupled magnetic field to recharge the power battery with high conversion efficiency and shortens the recharge time compared to wired charging.

The power exchange technology removes the power battery and puts in a new one for replenishment. The replenishment experience is similar to that of a fuel car, which greatly shortens the charging time and better relieves the mileage anxiety of users. By analyzing the charging times, modes, and costs of the three, this paper explains the charging technologies that are more suitable for future new energy vehicles.

## 2. Wired charging technology

Wired charging refers to the process of transferring electrical energy to the vehicle's battery pack using a physical connection in order to restore the battery's power. This method can be categorized into two primary modes: AC charging and mainstream charging [3]. AC charging is mainly 220v AC for household use, with a charging current of 10A or 32A, using a constant-current, constant-voltage mode to deliver the current. Users can use the portable charging cable given with the purchase of the car for AC charging, which takes around 14-25 hours [4] and can be carried with them to ease the charging pressure when traveling long distances. Alternatively, users can apply for the installation of a fixed charging post for AC charging, which takes around 8-10 hours [4]. The advantages of AC charging are that the charging current and power are very low and there is less wear and tear on the battery life of the EV; however, the disadvantages are that the charging time is too long to quickly replenish the electricity for the EV and the charging cable is not conducive to portability, different charging interfaces for different cars and the limitations of the charging posts that can be used. DC charging usually requires a high current of 125-250A to charge the battery, usually using a three-phase AC input [3]. The advantage of DC charging is that the power can be replenished quickly, and the charging time of the battery can be shortened. The disadvantage is that it can cause damage to the battery and reduce its service life. It is also more expensive to build charging ports for fast charging. Fast-charging posts are prone to accidents and have higher maintenance and operation costs later.

Wired charging is currently the mainstream charging method for most new energy vehicles due to its wide distribution of charging posts and the convenience of charging methods. However, the disadvantages of wired charging, such as slower charging speeds and charging posts that are not easily portable, create a problem of mileage anxiety for users.

## 3. Wireless charging technology

There are three types of wireless charging technology: electromagnetic induction, magnetically coupled resonance and radio wave.

The electromagnetic induction type transmits electrical energy wirelessly via the principle of electromagnetic induction. It is similar to a transformer and consists of a magnetic core with a primary and secondary coil. When the primary coil comes into contact with the AC power supply, an induced voltage is generated in the secondary coil due to the principle of electromagnetic induction, and this transmits electrical energy to the power cell, enabling the wireless transmission of electrical energy [5]. However, it has the disadvantage that it can only transmit over short distances, and as the transmission distance increases, the transmitting and receiving coils become misaligned, and the efficiency decreases sharply, making it difficult to apply to wireless charging in cars [6]. A block diagram of the system for electromagnetic induction transmission of electrical energy is shown in Figure 1.

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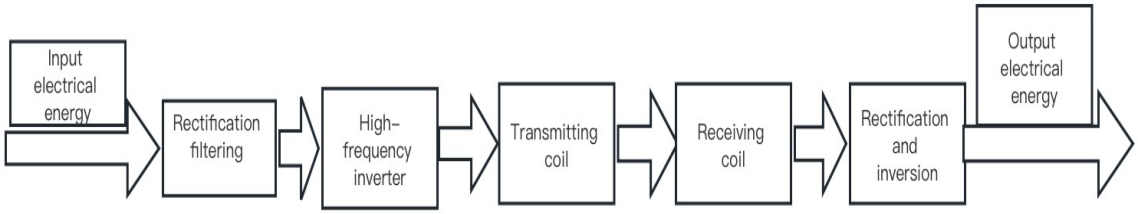


**Figure 1.** Block diagram of an electromagnetic induction system（Photo credit: Original).

The magnetically coupled resonance technology facilitates the transfer of electrical energy from a power source to a circuit. This process involves the conversion of the energy into high-frequency alternating current, which is then transmitted to a separate transmitting coil. Subsequently, a receiving coil, configured to resonate at the same frequency as the transmitting coil, absorbs the energy. The received signal is subsequently rectified, filtered, and ultimately used to wirelessly recharge the power battery, which enables the efficient wireless charging of the battery, effectively completing the charging process [5]. The advantage of this system is that it not only has a long transmission distance but also has a conversion efficiency of up to 90% or more [5] and can wirelessly charge multiple devices simultaneously. A block diagram of the system for magnetically coupled resonant transmission of electrical energy is shown in Figure 2.

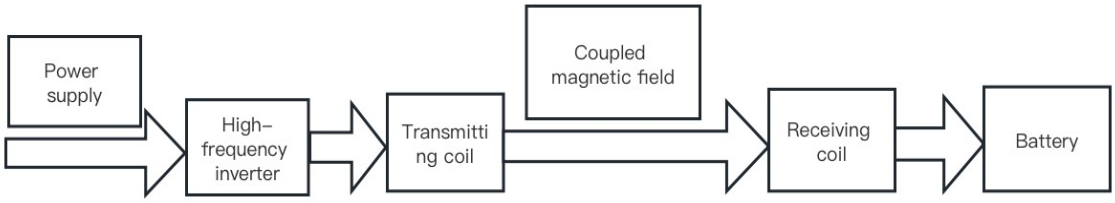


**Figure 2.** Block diagram of a magnetically coupled resonant system（Photo credit: Original).

The radio wave type transmits electrical energy using radio waves, which are converted into electromagnetic waves and then converted into electrical energy employing a receiving device. The most important part of this approach is the antenna, through which electrical energy conversion and transmission occur. After passing through the transmitting device, the electrical energy is converted into electromagnetic waves, which are received by the radio waves after the receiving device has adjusted its angle, after which the electromagnetic waves are converted into electrical energy and stored in the power cell [5]. Although this method has a long transmission distance and high conversion efficiency, the electromagnetic waves generated during the transmission process can impact human health, so it is not widely adopted in wireless charging methods [5]. A block diagram of the system for radio-wave type transmission of electrical energy is shown in Figure 3.

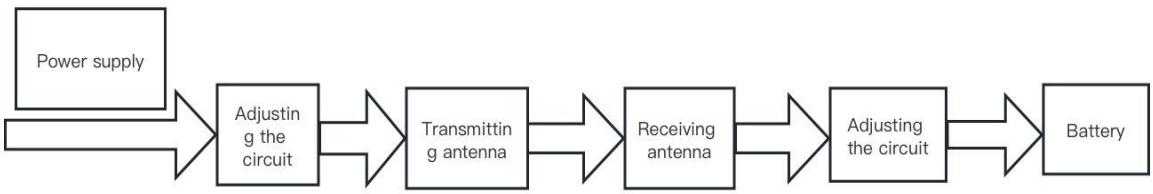


**Figure 3.** Block diagram of radio-wave type system（Photo credit: Original).

Of these three wireless charging methods, the magnetically coupled resonance type is most likely to be used in future new energy vehicles. This method has a longer transmission distance and a higher

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conversion efficiency than the electromagnetic induction method, allows the charging of several devices at the same time and does not generate electromagnetic waves that may be harmful to humans during the transmission process, making it more likely than the radio wave method to be used.

Magnetically coupled resonant wireless charging can overcome the disadvantage that wired charging chargers or charging posts are not easily portable, are equipped to reach a wider audience than swapping technologies, and are not influenced by different car brands. Moreover, the wireless charging device can be buried underground, greatly enhancing safety. In the future, a wireless charging highway can be built to achieve charging while using the car, which will completely solve the mileage anxiety problem of users. The disadvantage is that the charging standards for new energy vehicles are not uniform; there are five existing charging standards, namely PMA standard, A4WP standard, Qi standard, Wi-Po technology and iNPOFi technology [5]. A complete home version of a wireless charging unit costs about US$2,500 to US$3,000, and then a wired charging post costs only US$300 to US$500 [5]. The higher cost of use makes wireless charging popular and mass production is still some way off.

## 4. Power exchange technology

Switching technology is currently a way of replenishing the power of new energy trams. It replenishes the power of new energy vehicles quickly and quickly by separating the power battery from the vehicle to exchange electricity using specific mechanical equipment. In the use of power exchange technology, a separation between vehicle ownership and battery ownership is implemented, with a flowable business model for the power battery, with ownership going to the company that changes the station. The use of battery leasing reduces the cost of purchasing a new energy vehicle for the user and avoids the problem of rapid depreciation of used vehicles [7]. The two commonly used power exchange methods are chassis power exchange and split-box power exchange. Both technologies require advanced intervention in the design of the vehicle structure. Chassis power exchange does not change the weight of the front and rear axles of the vehicle, and the process is fully automated, but it requires changes to the chassis structure, a complex packaging process, a high degree of standardization and high application costs [7, 8]. At present, taxis mostly use chassis for rapid replenishment of electrical energy because taxis require high efficiency for electrical energy replenishment and regular maintenance of the power battery, and the battery standard in taxis is more uniform, with a vast market prospect and easy to form a sustainable business model [7]. Split-box power exchange is mainly used in light trucks, coaches and other large commercial vehicles. The battery of the whole vehicle is divided into 6 to 8 battery boxes, and the change time is around 8 to 10 minutes, but it also requires advance intervention in the design of the vehicle model, and the overall truss is used to unload upwards to replace the battery [7].

The advantage of the power exchange technology is that it can quickly replenish electricity, solve the problems of range and mileage anxiety, etc. The fast power exchange technology can significantly reduce the charging time and give users a replenishment experience similar to that of a fuel car; Secondly, it can reduce the cost of purchasing a car and promote the market share of new energy vehicles; consumers can purchase a car by combining only the bare car and leasing the power battery; and operators can implement closed-loop management of the power battery of new energy vehicles [9], which can update the power battery with better performance promptly and also reduce the pollution to the environment and centralize the disposal of the eliminated power battery; Moreover, users can regularly replace the power battery with a better performing one, so that the new energy vehicle battery can be updated in time for better results. The disadvantage is that the upfront cost of setting up a power exchange station is high, with an average construction cost of RMB 4-5 million [7], and a large amount of manpower costs are invested in the operation of the exchange technology at a later stage, resulting in a longer profit cycle; Secondly, the technical standards are not perfect, the power battery models and standards used by major brands are very different [10], such as battery size, interface and other aspects there are big differences, can not be a unified replacement battery, making the power exchange technology can only be applied in the same brand of cars, there are big limitations.

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## 5. Conclusion

After research and study, wired charging is less capital-intensive, and the popularity of charging posts is more widespread between different brands. Wireless charging efficiency is higher, and wireless charging than the exchange technology construction and input costs will also be less, do not need to devote a large number of exchange engineers to maintain operations, the subsequent profitability of the situation is considerable, and wireless charging can promote a wide range of brands, market influence. The replenishment experience of power exchange technology approximates that of a fuel car, the time to replenish electricity is greatly reduced, and the commercial value of the battery is separated from the car, reducing the cost of purchase and facilitating the rapid spread of new energy vehicles. In the future, wireless charging technology is most likely to be used in the charging of new energy vehicles. Compared to wired charging, its high-efficiency charging mode greatly shortens the replenishment time, and the range of car brands popularized by wireless charging is wider than that of power exchange technology, and there is no need to invest in corresponding engineers for power exchange technology in the operation of wireless charging stations at a later stage, reducing the cost of building stations at an earlier stage and investing at a later stage.

In future applications, wireless charging will have to overcome the disadvantage of the high cost of its charging devices and gradually achieve mass production of the devices.With the popularity of wireless charging technology, the power supplement of new energy vehicles will enter a new era. This paper has important implications for the development of charging technology and the popularisation of new energy vehicles.

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