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Exploration of Charging Technology for New Energy Electric Vehicles

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Abstract: As the global consensus on reducing carbon emissions and environmental protection strengthens, electric vehicles, as a kind of clean energy transportation, have received great attention in terms of market demand and technology development. Based on the impact of the "double carbon" target, carbon emissions will officially peak by 2030, and carbon neutrality can be fully achieved by 2060, which provides strong policy support for the development of electric vehicles and their charging technologies. In addition, the large-scale development of electric vehicles promotes the transformation of the energy industry to low-carbon, electrification, and intelligence, and the charging technology, as the key infrastructure for the popularization of electric vehicles, its technological innovation and optimization and upgrading are of great significance for promoting the development of the entire new energy vehicle industry. Therefore, this paper explores the charging technology of new energy electric vehicles through the assessment of the actual needs of industry development, policy orientation, promotion of technological innovation and market potential.

Keywords: Electric vehicle; charging technology; technological innovation; optimization and upgrading.

1. Introduction

In recent years, along with the continuing seriousness of the global environmental warming problem, many energy crisis problems have arisen, which makes the public pay great attention to them. In industrial construction, how to effectively deal with these problems, the new energy technology should be widely researched and utilized [1]. For example, in the continuous development of the automobile industry, new energy technologies are widely studied and utilized. For example, in the process of continuous development of the automobile industry, some researchers have begun to put the research goal on the research and development of pure electric vehicles. Pure electric vehicles are not only scientific but also environmentally friendly in the process of specific issues. Charging technology is a key factor affecting the performance, safety, convenience and economy of new energy vehicles. Through continuous technological exploration and innovation, we can solve many problems in the current charging technology, such as long charging time, low charging efficiency, high charging cost, etc., so as to promote the further development of the new energy vehicle industry. Consumers' demand for charging convenience and speed is increasing. Through the exploration of charging technology, these market demands can be met and the market competitiveness of new energy vehicles can be improved. The widespread use of new energy vehicles can change the degree of dependence on the use of oil, in addition to reducing energy loss and excessive energy emissions, helping to realize the diversification of the energy structure and sustainable development. Renewable energy can be combined with charging of new energy vehicles to achieve clean utilization and efficient conversion of energy. The exploration of charging technology for new energy vehicles is of great significance nowadays, which not only helps to promote the development of new energy vehicle industry and optimize the energy structure, but also improves the level of urban infrastructure construction, promotes scientific and technological innovation and industrial upgrading, as well as promotes environmental protection and sustainable development [2].

2. Current Status of Domestic and International Research

Overview of leading technologies in Europe and the United States, Europe has launched a supercharging network plan to realize high-speed charging and grid synergy; Tesla in the United States has led the layout of supercharging stations and adopted liquid-cooled cables to improve charging rates. Japan has developed wireless charging technology to realize dynamic road charging and extend the range of electric vehicles, and has also adopted high-efficiency heat dissipation technology on fast charging piles to ensure stable operation of the equipment. However, the Japanese automotive industry has missed the opportunity to develop pure electric vehicles and lost its once dominant position because of the differences in the development strategies advocated by the Japanese automotive industry, as well as the current international mainstream trajectory and the relative backwardness of its infrastructure. In order to reverse the unfavorable situation, Japan will take 2022 as the first year of pure electric vehicles, and under the "dual-wheel" drive of government and enterprises, take technological innovation as the driving force, increase the strength of industrial policy and infrastructure construction, and accelerate the strategic transformation of new energy vehicles [3].The Japanese government will make 2022 the first year of pure electric vehicles to reverse the unfavorable situation.

China has made a number of world-class technological breakthroughs in electric vehicles and has become the current source of tram technology in the world. In May 2023, the number of China's applications reached 7,640 out of 20,798 applications for technology patents in the world, with an overall share of 36.7%. In 2018-2023, China's solid-state batteries in the world's overall patent applications in each year

the proportion of the increase reached 20.8%, its rate of increase to the world's first. At the level of solar cell R&D, the number of applications for China's patents alone has reached 126,400, which is the first in the world. From specific cases, BYD's self-developed blade battery is the world's leading level in terms of space cost, energy density, range, life and charging time. The world's first battery heat pump direct cooling and heating technology, through the long cell flattening, no module structure design significantly improves space utilization, so that the weight to energy density ratio of the previous generation increased by 9%, the volume to energy density ratio increased by 50%, and the safety is very high [4]. It is also extremely safe.

In addition, the Chinese government has put forward the "dual-carbon" goal and strongly supported the development of new energy electric vehicles by introducing a series of incentives, such as subsidies for vehicle purchases and exemption of purchase tax, which effectively promoted the innovation and market application of charging technology. Highlights of enterprise R&D achievements, domestic enterprises have made significant achievements in the field of charging technology, such as Huawei has launched a high-voltage fast charging solution, which significantly shortens the charging time; BYD is committed to the research and development of high-energy-density batteries, to improve the range and charging efficiency. Charging infrastructure is perfect, the State Grid and other companies to accelerate the layout of the charging pile network, especially along the highway and urban centers, formed a charging service system covering a wide range of outdoor charging to meet the growing demand for outdoor charging. With the application of new technologies such as wireless charging and fast charging, the domestic charging technology is developing in the direction of being more convenient, efficient and intelligent, providing better charging experience for users and contributing to the overall development of the new energy vehicle industry [5]. The charging technology in China is developing in the direction of more convenient, efficient and intelligent.

3. Current Status of Charging Technology for New Energy Vehicles

3.1. Existing mainstream charging technologies

3.1.1. Wired charging technology

Wired charging technology: electric vehicle wired charging technology, also known as contact charging, is divided into two categories of AC charging and DC charging, are used between the plug and socket metal parts in direct contact to conduct electricity [6]. The charging technology is also known as contact charging technology.

Electric vehicle AC charging is commonly known as "slow charging", corresponding to the charging facilities for the AC charging pile, you can directly use the household electricity input 220V AC power [7]. The corresponding charging facility is an AC charging post, which can directly use 220V AC input from household electricity. Since the battery of an electric vehicle cannot accept AC charging directly, it must rely on the on-board charger (OBC) to convert the household 220V AC into DC and raise the voltage to the required charging voltage level of the battery to complete the process of charging the battery. The advantages of adopting AC charging mode are that the charging current and power are relatively low, which has less impact on the life of the battery, and charging in the low demand of electricity, the cost is cheaper, and can directly use the standard 220V AC power supply, and the cost of setting up charging piles is also more economical. However, the shortcoming of AC charging is that the charging rate is slower, usually, after the electric car runs out of power, it takes about 8 to 10 hours to be fully charged using the AC charging pile, and it needs to be charged with the help of the car charger. As a result, AC charging posts are more suitable for installation in private residential parking spaces or corporate parking lots.

DC charging of electric vehicles is commonly known as "fast charging", the corresponding charging facilities for DC charging piles, fixed installation outside the electric vehicle and AC grid connection, the input voltage of three-phase four-wire AC380V ± 15%, and then through the rectifier to make the output for adjustable DC power [8]. The output is adjustable DC through rectification. DC charging facilities provide DC power with a wide range of voltage and current adjustment, which is sufficient to match the demand for fast charging. The significant advantage of this mode of charging is the high efficiency of charging, with a full charge for a domestic electric car typically taking as little as thirty minutes. However, the disadvantages of DC charging include its high voltage and high current characteristics, which may sacrifice the number of charge/discharge cycles of the battery and cause some damage to the battery, thus shortening its service life. In addition, DC charging posts are more expensive to build and more complicated to install. This type of charging pile is suitable for setting up in public areas and service stations on highways, which is equivalent to the EV version of gas stations.

3.1.2. Wireless charging technology

Electric vehicle wireless charging technology can be categorized into inductive charging and resonant wireless charging by principle. The inductive wireless charging design has been widely used [9]. Inductive wireless power technology has many advantages. Inductive wireless power supply technology has many advantages, for example, its working frequency band is low, generally between tens and hundreds of hertz range, can realize the kilowatt level of wireless energy transmission can be more effectively realized. In the short distance energy transfer, its output efficiency can exceed 95%. Resonant wireless charging technology mainly uses the power grid in the presence of electric energy, and through the higher frequency inverter and rectification of the filter through the overall process, so that industrial frequency alternating current can ultimately be transformed into a high-frequency alternating current. This power is then transmitted directly to the radiating coil through power amplification and impedance matching circuits [10]. When the overall frequency of the transmitting coil system matches its self-resonant frequency, a relatively large current source is generated in the coil, which allows the current in the magnetic field to be continuously strengthened. The rectification filtering and the electrical energy present in the receiving coil are used to meet the requirements for charging the load battery. In addition, in order to ensure the overall stability of the system and the operational requirements of the system, the introduction of the feedback control link is a link that cannot be ignored. The wireless charging used in electric vehicles can be divided into static and dynamic wireless charging technologies according to the technology mode. Static wireless charging technology refers to the electric vehicle static wireless charging process, the electric vehicle to

maintain a stationary state, the vehicle pickup coil coupled with the ground under the transmitting coil to obtain power, the whole process of the coupling coefficient remains unchanged [11]. The coupling coefficient remains unchanged throughout the process. Static radio power technology for electric vehicles is now mature, and this technology reduces the physical losses caused by plugging and unplugging charging ports; there is no sparking phenomenon during charging due to non-contact charging; and the operation is automated, which makes the process simple and rapid, and facilitates the establishment of automated charging stations. However, like wired charging, static wireless charging technology still faces problems such as high charging frequency, limited driving range, large battery capacity and high cost. Dynamic wireless power supply for EVs, i.e., the vehicle obtains energy through a specific paved road while traveling. This mobile charging method can significantly alleviate the driver's concern about driving distance, realize the vehicle to continuously replenish energy while driving, reduce the number of charging times, increase the range, and can be equipped with lighter battery packs, thus improving safety and convenience [12]. Dynamic wireless power technology eliminates the need for vehicle owners to wait at charging stations, saving both time and space. However, the technology is still in the experimental research stage, the technology is not mature enough, and the construction cost is also high. The R&D direction of domestic and foreign research organizations is to build a dynamic wireless charging system with high charging power, high transmission efficiency, low electromagnetic radiation and low cost.

3.2. Battery replacement technology

In the field of energy replenishment for electric vehicles, battery replacement technology occupies a central position. Compared with traditional conductive charging, battery replacement has significant advantages in terms of speed and user experience, as pre-charged battery packs greatly shorten the waiting time for vehicle owners, which not only greatly saves time costs, but also mitigates the potential impact of battery replacement on the power grid. However, the challenges facing battery replacement technology should not be overlooked, mainly in the limitations of the range of vehicle models it serves and the need for gradual optimization of the service facilities at most of the replacement stations, including the issue of service instability.

3.3. Charging technology advantages and disadvantages

Advantages of AC charging in wired charging technology: the installation and operation cost of the charger is low, which is conducive to extending the service life of the EV battery, improving the charging efficiency of the EV, and does not have high requirements on the power grid. Disadvantages: The shortcomings of AC charging are reflected in its slower charging rate. Normally, after the battery is depleted, it takes about 8 to 10 hours for an EV to be fully charged using an AC charging post, and this process also needs to be accomplished by the vehicle's built-in charger. The advantage of DC charging is that it can quickly replenish an EV with a large amount of power in a short period of time, significantly reducing the time required for charging and improving charging efficiency. Disadvantages: DC charging requires higher charging power and more complex charging equipment, as well as higher requirements for grid stability and battery durability.

Advantages of static wireless charging in wireless charging technology: The development of static wireless charging technology has matured, in which the static wireless fast charging technology for SUVs (sport utility vehicles) with charging power of 20kW or more has been able to meet the standardization requirements [13]. Disadvantages: Static and wired charging are the same as wired charging. Disadvantages: Both static and wired charging have more frequent charging, shorter range, larger batteries and higher costs. Advantages of dynamic wireless charging technology: dynamic wireless charging refers to the charging mode used in the actual operation of the car, can effectively increase the battery range, can reduce the battery capacity and volume, effectively increase the battery range, extend its service life, enhance the user experience. Disadvantages: The construction of radio wave charging facilities requires a large investment in equipment and the installation of a large number of radio wave transmitters on the ground, which is costly. Secondly, the radio wave charging process may produce electromagnetic radiation, which will affect human health and the environment, so it is necessary to take corresponding safety measures, such as choosing low-radiation equipment, optimizing the transmitter power, and so on.

Advantages of battery replacement technology: faster and more efficient, the pre-charged battery significantly reduces the waiting time for the vehicle owner to recharge the battery. In addition, battery replacement technology reduces the burden on the electricity network. The centralized collection and distribution of batteries through charging stations contributes to the orderly and consistent management of the grid. However, the range of vehicle models served by this technology is still limited, and the battery stock at charging stations needs to be strengthened, with supply fluctuating from time to time.

3.4. Charging Technology Comparison and Summary

From the charging efficiency than, the more traditional wired AC charging technology charging efficiency is the slowest, DC charging technology can quickly provide electric vehicles with the required power, thereby reducing the time required for charging and optimizing the charging efficiency, and static wireless charging and dynamic wireless charging charging to the charging efficiency is not as good as the existing mature DC fast-charging technology, but its technology is also maturing.

From the safety and security of charging, the traditional AC slow charging its security is the highest, and DC fast charging technology on the power grid as well as the battery's capacity requirements are extremely high, its security is low, wireless charging technology faces the impact of electromagnetic radiation, but its technological development can reduce the capacity and volume of the battery is limited to increase the battery range.

From the point of view of system integration optimization, wireless charging technology has the advantages of convenience, high efficiency, etc. The completion of the wireless charging integrated system is conducive to improving the reliability and effectiveness of charging.

From the standardization of charging, if a systematic replacement power station is built to unify the replacement batteries of new energy vehicles, the replacement battery technology, which can save time and effort, to ensure the

range of various charging vehicles.

3.5. Charging Frontier Technology

3.5.1. Automatic charging robots

Britain's leading Lotus carmaker recently unveiled a charging device with a power of up to 500 kilowatts, which is equipped with an intelligent robotic arm capable of automating the charging gun's access and removal operations. Meanwhile, Hyundai has also developed an automatic charging robot that can connect and disconnect the charging cable instead of the car owner. In addition, Volkswagen and the charging technology company "Electric Vehicle Safe Charging" jointly developed a robot that can independently charge the car. These charging robots are mounted on a 4-wheeled base and consist of a robot and a power storage unit, both equipped with extremely sophisticated sensors, scanners and 3D camera technology. The robots can be summoned to move to the vicinity of the electric car using an app on a smartphone or a system configured in the car. The robot can then use a robotic arm to assist in charging. After the charging task is completed, the robot can also pull out the cable and then close the port door, leaving the vehicle after all operations are completed.

3.5.2. Advances in DC fast charging technology

StoreDot, a developer of batteries for extreme charging technology, has announced that it will roll out extreme charging technology in 2024 [14]. In late 2023, the Polaris brand announced to the public that the upcoming Polaris 5 prototype vehicle will be equipped with StoreDot's innovative Quick Charge technology (or XCF for short). This technology makes the Polaris 5 the first electric vehicle model to be equipped with a fast-charging battery. The XCF technology adds 100 miles (approximately 161 kilometers) to the driving range in just five minutes [15]. The technology continues to advance. As the technology continues to advance, StoreDot predicts that this charging time will be reduced to four minutes by 2026 and just three minutes by 2028. storeDot announced that 15 of the world's top Original Equipment Manufacturers (OEMs) have completed testing of the batteries under adapted conditions, and that the results confirm that the batteries perform exceptionally well even through Even after 1,000 rapid charging cycles, the battery's performance remained stable and did not degrade. With Volvo and Daimler now investing in StoreDot, it is likely that more and more electric vehicle brands will introduce this fast-charging technology in the future.

3.5.3. Innovations in battery replacement technology

Quick and Easy Battery Replacement Stations mean that the electric vehicle user arrives at a battery replacement station and replaces the depleted battery with a fully charged battery pack. The process can be completed in as little as five minutes, making it a convenient, efficient and time-saving alternative to traditional plug-in charging. As of October 2023, the Chinese company Azalea has completed 30 million swaps. Azalea has 30 power exchange stations across Europe and intends to roll out the technology to the UK this year. Not to be outdone, other EV manufacturers are planning to offer power swapping services. Car giant Stellantis, the parent company of car brands such as Fiat, Vauxhall, Jeep and Maserati, has partnered with San Francisco-based Ample to launch a battery replacement fee-based service [16]. Ample has developed modular batteries that can be used in many different types of electric vehicles, and the batteries can be moved around with the stations on demand, allowing for expansion, and shortening the construction time of the stations to just three days, and Ample is planning to expand its network of switching stations to other countries.

4. Exploring the Future Development Direction of Charging Technology

4.1. Optimizing the layout of facilities

Using data analysis and modeling, we accurately grasp the charging time, charging power demand, travel distance and route and other usage behaviors of electric vehicle users, and then analyze the travel characteristics and demand distribution to predict the charging demand and formulate a scientific and reasonable charging station layout strategy. For example, the clustering algorithm is used to divide users into different groups, and the location and capacity of charging stations are determined for the charging demand of different groups [17]. The charging stations are located in the same place as the charging stations. At the same time, it makes full use of data such as traffic flow conditions and further optimizes the layout of charging stations in combination with the actual driving conditions of vehicles. Intelligent planning and management of charging infrastructure not only improves the utilization rate and efficiency of facilities, but also monitors the use of charging infrastructure in real time and carries out intelligent scheduling according to user demand and the state of charging infrastructure, effectively avoiding overuse or idling of charging facilities. When a charging station is busy, the system can automatically adjust the power distribution of charging piles according to the predicted demand, realizing the optimal allocation of charging resources. At the same time, combined with the intelligent charging payment and reservation system, it provides users with a convenient and efficient charging experience and reduces their waiting time.

4.2. Technological innovation and standardization

In terms of technological innovation, focus should be placed on the research, development and promotion of technologies such as fast charging and wireless charging to meet users' needs for efficient and convenient charging and to promote the popularization of electric vehicles. Unified charging interface standards and communication protocols should be established to ensure the compatibility and interoperability of the charging infrastructure, so that electric vehicles of different brands and models can be charged smoothly. At the same time, uniform charging power and current standards should be formulated to ensure the safety and stability of charging facilities. Through the promotion and implementation of standardization, the construction and operation and maintenance costs of charging facilities will be reduced, the user experience will be improved, and the foundation for the healthy development of charging infrastructure will be laid.

4.3. Policies and Incentives

The government should establish clear goals and plans for charging infrastructure construction, refine construction targets and timetables, and raise the importance of charging infrastructure construction at all levels of government. At the same time, the government should also introduce procurement subsidy policies to promote the construction of charging infrastructure in public areas. To encourage

enterprises and individuals to participate in the investment, financial support and tax incentives, such as charging subsidies and loan incentives, should be provided to reduce the pressure on the purchase, installation and operation of charging infrastructure.

5. The Development of New Energy Charging Technology Today and Its Existing Measures

The exploration of new energy electric vehicle charging technology is not only a symbol of technological progress, but also an important cornerstone for promoting green mobility and sustainable development. Under the dual challenges of global climate change and energy crisis, new energy electric vehicles, with its clean and efficient features, will eventually evolve into a black heart trend of the automobile industry's sustained and rapid development in the future. The in-depth study and continuous optimization of the charging problem of the "heart" of electric vehicles will inevitably play an important role in the future use and sale of trams.

First of all, in terms of charging efficiency, improving charging speed and safety is an eternal pursuit. As the current mainstream charging methods, AC slow charging and DC fast charging have their own unique advantages. Although the charging speed is slow, AC slow charging is low-cost and easy to install, which is very suitable for the daily charging needs of families and workplaces. DC fast charging, on the other hand, has become the preferred choice for long-distance travel and rapid energy replenishment due to its efficient and fast charging characteristics. In recent years, with the continuous development of wireless charging technology, although it is still facing some technical difficulties, its convenience and safety undoubtedly provide new possibilities for future charging methods, making people full of expectations.

In terms of the construction of charging facilities, the layout and optimization of public charging stations is the key to enhancing the convenience of charging. By scientifically planning the location and number of charging stations, the utilization rate of charging facilities can be maximized to meet the charging needs of users. Meanwhile, technical standards and specifications for charging facilities are also an important foundation for ensuring charging safety and efficiency. Governments and relevant institutions are actively promoting the development and improvement of relevant standards to promote the standardization and normative development of charging technology and provide strong support for the popularization of electric vehicles.

In addition, the optimization of charging efficiency is also an important direction in the exploration of charging technology for new energy electric vehicles. The research and development of high-efficiency charging equipment and the optimization of charging algorithms can further improve the charging speed and increase the overall conversion efficiency of energy. For example, the emergence of advanced technologies such as the 800V platform and 5C charging not only greatly shortens the charging time, but also improves the safety and stability of the charging process. Meanwhile, the application of intelligent charging management systems has also greatly improved charging efficiency and user experience. Through the Internet of Things, big data and other technical means, remote monitoring, intelligent scheduling and data analysis of charging facilities are realized, making the charging process more intelligent and convenient.[17]

Of course, charging safety and security is also a part that cannot be ignored in the exploration of charging technology for new energy electric vehicles. Overload, short circuit, battery failure and other safety risks in the charging process need to be highly emphasized. In order to ensure the safety and reliability of the charging process, we need to configure perfect safety protection facilities, establish emergency troubleshooting processes, and strictly comply with relevant safety norms and standards. Only in this way can we effectively prevent and respond to safety issues that may arise during the charging process and ensure the safety of users' lives and properties.

6. Conclusion

In summary, the exploration of new energy electric vehicle charging technology is a process of continuous development and improvement. With the continuous progress and popularization of technology, we can expect more exciting innovations and developments in the field of new energy vehicle charging in the future. At the same time, the cooperation of the government, social organizations, electric vehicle manufacturers, electric power departments and battery manufacturers will also provide strong support for the research and development and application of charging technology, and jointly promote the vigorous development of the new energy electric vehicle industry.

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