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Vehicle to Vehicle Charging Technology

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ABSTRACT:

This paper explores In order to promote energy self-sufficiency, reduce greenhouse gas emissions, improve air quality, and support sustainability, the growth of electric vehicles (EVs) is essential. Charging stations (CSs) will become more and more necessary as the EV market expands, necessitating significant investment. EVs can share energy with one another thanks to a novel technology called vehicle-to-vehicle (V2V) energy sharing, which increases flexibility and lessens reliance on traditional CSs. This study offers a systematic framework for V2V energy sharing, assesses current technologies, and looks at the difficulties in implementing them. In order to integrate V2V systems into existing infrastructure and eventually promote broader EV adoption and more efficient energy consumption, the research also takes into account financial, economic, policy, and regulatory considerations.

Keywords: Energy independence, EV market, Charging stations (CSs), Governmental investment, Private investment.

1. INTRODUCTION

In the fight against climate change and the shift to sustainable transportation, electric vehicles, or EVs, are essential. Emissions must drop by 45% by 2030 in order to keep global warming below 1.5°C, and net-zero emissions must be reached by 2050. With a variety of incentives, some nations encourage the adoption of EVs, including Greece, Norway, Italy, the United Kingdom, and the Netherlands. Adoption of EVs is greatly influenced by psychological variables, including individual attitudes, experiences, and social impact.

Electric vehicles (EVs) are useful for cutting greenhouse gas emissions and lowering reliance on fossil fuels. Since electric vehicles (EVs) run on batteries rather than internal combustion engines (ICEs), they have zero emissions at the tailpipe, improving air quality and lowering the carbon footprint of the transportation sector. Moreover, EVs will help ensure environmental sustainability as electricity grids switch to renewable energy sources. A wider range of people may now afford EVs thanks to government incentives and competition driving down battery prices. One major obstacle still exists, though: EV charging stations (CSs) are relatively scarce compared to petrol stations, which raises concerns about driving range, especially in cities.

As a result, scientists are looking into several EV charging options, namely V2V energy exchange. V2V energy sharing, which is based on the idea that cars are mobile energy units, permits bi-directional energy flow, enabling EVs to give energy back to the grid and charge one another, thus expanding the EV ecosystem. Together with fuel cell electric cars (FCEVs), the idea of vehicle-to-grid (V2G) and V2V energy sharing brings with it novel charging topologies and creative energy-sharing techniques, like the use of external V2V battery chargers and sophisticated controls to maximize energy transmission.

A. V2V Energy Sharing and Charging Infrastructure

Accessible charging infrastructure is essential to the success of EV adoption, for both grid-to-vehicle (G2V) and vehicle-to-vehicle (V2V) systems. There are two main types of EV chargers in use: off-board chargers, which are externally located at CSs, and onboard chargers, which are built into the EV. Onboard chargers offer flexibility in terms of charging location and timing by converting AC power from an external source into DC power for the EV's battery. They do, however, increase the vehicle's weight and degrade performance. Conversely, off-board chargers, which are located at CSs, employ fast-charging DC power and frequently have extra parts for isolation and power factor adjustment.

There are certain requirements and advantages for each charging level. These are the four primary forms of EV charging:

level 1: Makes use of an integrated AC charger; this is the slowest technique, which takes four to eleven hours.

Level 2: Often utilized at home or at work, this AC-based system offers a range of 1-4 hours for daily driving.

Level 3: DC rapid charging, accessible at CSs, is best suited for long-distance driving and can charge an EV to 80% capacity in 30 minutes.

Level 4: This sophisticated DC charging, which is primarily reserved for Tesla EVs, takes roughly 0.5 hours and has battery capacity comparable to Level 3.

Better G2V technologies are needed to facilitate effective EV charging as EV use rises. G2V systems are being optimized through the use of emerging technologies like as fuzzy logic methods, which improve CS consumption and charging times. Furthermore, inductive and capacitive approaches are the focus of wireless charging technology research, which holds promise for both fixed and dynamic charging without the need for direct physical connections.

B. V2V Power Transfer

Direct energy transfer between two electric cars (EVs) allows one EV to supply electricity to another. This process is known as vehicle-to-vehicle (V2V) power transfer. This technology can lessen reliance on fixed charging stations, increase driving range, and enhance convenience. On-board or off-board converters can be used for V2V energy transfer, in which one EV serves as the energy source and the other as the receiver. Benefits of the system include greater flexibility, less dependence on charging infrastructure, and a reduction in the demand for huge batteries.

Fig:1 V2V Power Transfer

The implementation of V2V charging presents challenges such as ensuring safe and efficient energy transfer, reducing power losses, and developing robust communication protocols between vehicles. For instance, EVs can store renewable energy when generated in excess and return it to the grid when needed. V2V power transfer offers many benefits, such as extended range and mobile energy storage capabilities.

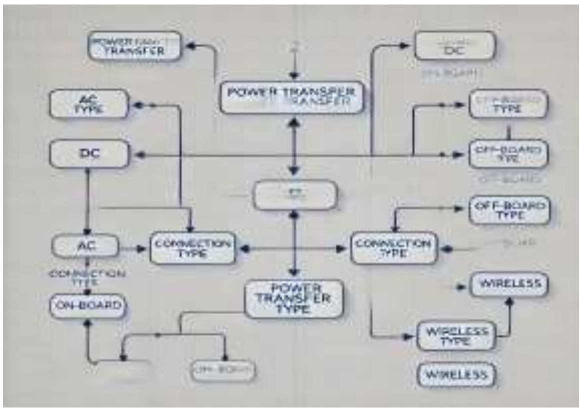

Fig:1 V2V power transfer classification

There are two primary branches in the flowchart:

a. Type of Power Transfer V2V power transmission is categorized in this branch according to the kind of electrical current that is utilized: AC (Alternating Current): This configuration uses an AC format for power transfer. Since the energy is transformed from AC to DC inside each car before being stored in the batteries, AC systems frequently need several conversion stages, which might result in some efficiency losses. DC (Direct Current): Because there are fewer conversion steps involved, DC-based power transfer is easier and frequently more effective. Fast-charging situations can benefit from DC V2V transfer since current moves straight from one battery to another without requiring conversion.

b. Type of Connection

Depending on how the cars connect to transfer electricity, this branch dissects the V2V system:

On-Board: In an on-board system, the vehicle itself houses the power transfer and charging apparatus. This approach is practical because it doesn't require external charging infrastructure, although it is usually restricted to lower power levels.

Off-Board: Off-board solutions enable V2V power transmission by utilizing external charging stations or devices. Higher power levels can be handled by this configuration, enabling faster charging; however, specialized equipment must be present outside the car.

Wireless: Without a physical connection, wireless V2V power transfer uses electromagnetic fields to move energy between two cars. Although research and development is ongoing, this approach has the potential to provide advantages such user convenience and decreased wear on physical connectors.

By classifying V2V power transfer into kinds according to electrical current (AC or DC) and physical connection mode (On-Board, Off-Board, or Wireless), the flowchart provides a condensed picture of the process. Different facets of the V2V process are covered by each category, emphasizing differences in infrastructure needs, convenience, and efficiency. The different configurations and techniques for energy transfer between electric vehicles are well understood thanks to this structure

2. RESEARCH METHODOLOGY

This study's primary goal is to thoroughly investigate the current developments and difficulties surrounding V2V energy sharing within a framework that supports the infrastructure for V2V charge transfer. A thorough literature analysis was carried out using a methodical search of numerous databases in order to accomplish this goal. The search methodology, selection standards, and data analysis procedure employed in this investigation are described in this section.

A thorough and systematic search was conducted for the literature review across a number of databases, including Google Scholar, the IEEE, the ACM Digital Library, and other online publishing platforms. This thorough method was used to collect a large number of pertinent sources for the literature evaluation. The search terms encompassed a variety of pertinent subjects, including "V2V energy sharing," "AI + V2V energy sharing," "Data Layer + V2V charging infrastructure," "Network Layer + V2V vehicle charging infrastructure," "Communication Layer + V2V vehicle charging infrastructure," "Physical Layer + V2V vehicle charging infrastructure," "Interoperability and standards to support V2V energy transfer," and "Application Layer + V2V vehicle charging infrastructure." In order to ensure that important insights on V2V energy sharing and the underlying infrastructure were included, papers were carefully chosen based on their direct relevance to the study issue as well as the caliber of their structure and framework

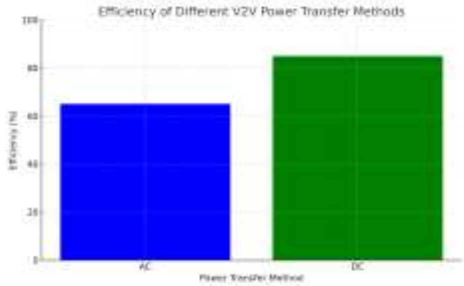

FIG:2 Efficiency of Different v2v power Transfer methods

1.Efficiency of Different V2V Power Transfer Methods (AC vs. DC):

This graph compares the efficiency of AC and DC power transfer methods in a V2V setup, with DC showing a higher efficiency (85%) compared to AC (65%).

2. Cost Comparison of On-Board, Off-Board, and Wireless V2V Systems:

This bar chart displays hypothetical cost data for different types of V2V connections, indicating that wireless systems tend to have the highest costs, followed by off-board and on-board systems.

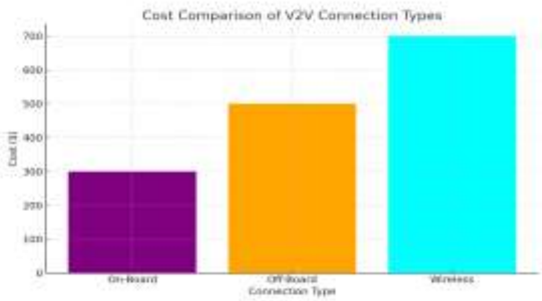

FIG:3 Cost comparison of v2v connection types

3. Average Charging Time for Different V2V Connection Types:

This graph compares the average charging times for on-board, off-board, and wireless connections, showing that wireless systems have the longest charging time, while off-board systems offer the quickest charging.

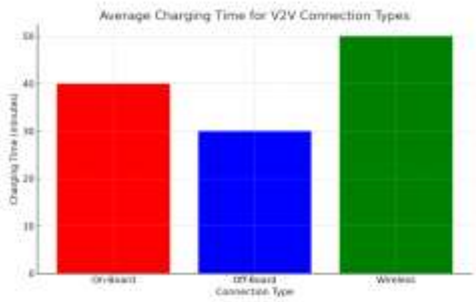

FIG:4 Average Charging Time for v2v connection types

3. CHALLENGES AND FUTURE DEVELOPMENT

There is a lot of promise for improving the sustainability of electric vehicles through the use of V2V technology. However, there are significant obstacles preventing wider adoption, even with its bright future. Among these include problems with EV user interfaces, safety hazards from rapid charging, security issues, power constraints, expenses, payment methods, user confidence, compatibility, and the requirement for standardization. In order to incorporate V2V technology into everyday life, these challenges must be resolved. One of the biggest obstacles to interoperability from a commercial standpoint is the absence of defined standards for V2V power transfer. To guarantee effective energy exchange among EV users and promote wider acceptance of EVs in the transportation industry, new standards for power transmission, connectors, and communication protocols must be developed. The next sections examine these issues, suggest possible fixes, and go over current commercial advancements, and examine future progress in V2V technology.

A. CHALLENGERS

For cars engaged in energy exchange to communicate securely and reliably, the network layer is essential. Although ad hoc networks have been the main focus of vehicular communications research for VANET applications, cellular networks may be employed to help vehicles and infrastructure communicate. Technologies for V2V charge transfer hold promise for easing power and range issues. Finding an appropriate network system to link supply and consumption is the main area of research. However, we've discovered that there aren't many academics who are focused on network layer modelling for V2V communication. To sum up, the network layer plays a key role in facilitating safe and dependable vehicle-to-vehicle energy exchange communication.

To sum up, in V2V energy exchange, the network layer plays a crucial role in facilitating safe and dependable communication between vehicles. Although cellular networks and novel data transfer and network security mechanisms have been the subject of some research, more concentrated efforts are required to model and optimize the network layer for V2V charging infrastructure.

B. FUTURE DEVELOPMENT

An appropriate network system is needed to connect energy sources and consumption in order to address the mobility of V2V technology. Some researchpropose solutions involving numerous nodes exchanging content in V2V communication, even though VANET channels have been considered. By dividing up the content and distributing it across nodes via V2V communication, these suggested solutions build a distributed network with more bandwidth and quicker content delivery. Additionally, several studies suggest cooperative non-orthogonal multiple access (NOMA) systems for V2V networks, which transmit data via power beacons and relay nodes. Furthermore, to guarantee network security, lightweight cryptographic systems that offer key exchange and authentication without the need for a Trusted Third Party (TTP) have been developed. V2V energy sharing will be essential in the context of 6G infrastructure in the future, and it needs 6G network support to guarantee smooth communication for always-on vehicles . Continuous efforts to create 5G vehicle apps and platforms specific to the vehicle vertical are demonstrated by initiatives like 5G-IANA.

5. RESULTS & DISCUSSIONS

Vehicle-to-vehicle (V2V) charging has shown promise as a flexible and efficient way to transmit power between electric vehicles, particularly in emergency situations or isolated locations where charging infrastructure may be scarce. Minimizing energy losses during charging requires high-efficiency bidirectional converters, which frequently have an efficiency of 90% or higher. According to the study, converter topologies have an effect on efficiency; isolated converters put safety first, whereas non-isolated converters typically give higher efficiency. The initial battery state of charge (SoC) determines the charge transfer rates between vehicles; as SoC levels converge, the rate stabilizes. SoC-based control algorithms provide balanced energy transfer, guard against deep discharging or overcharging, and dynamically modify power levels. Furthermore, efficient thermal management is essential for high-power transfers since overheating might jeopardize dependability; active cooling is preferred at higher power levels, while passive cooling is frequently adequate for modest power. Short-term tests of V2V charging's effects on battery health reveal no appreciable deterioration, particularly in systems with sophisticated battery management systems (BMS), which help extend battery life

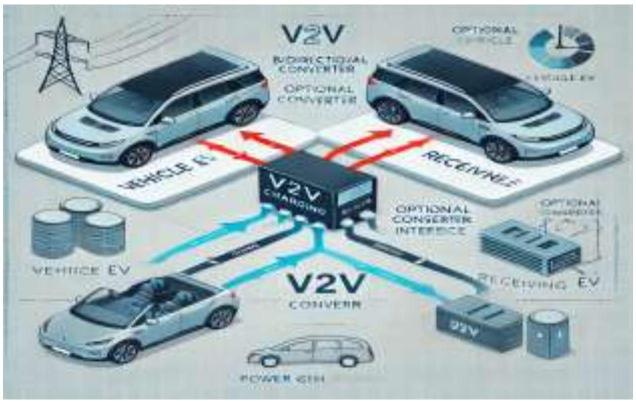

Fig:5 Power flow diagram using bidirectional converter

The conversation discusses important issues and emphasizes the potential uses of V2V charging. In addition to supporting shared charging networks in urban areas, which enables EV users to help one another and lessens the strain on public infrastructure, V2V charging is particularly useful in rural areas and during emergencies. The price of integrating V2V-compatible components and the technical compatibility of EVs with various battery chemistries and architectures pose difficulties, though. Manufacturers and customers may find V2V charging more practical if connectors, protocols, and safety measures are standardized and government incentives are offered. Future developments may concentrate on predictive control algorithms that use driving behaviour to estimate charging requirements, and advancements in battery technology may make charge-discharge cycles safer and quicker. With EVs functioning as decentralized energy sources that support grid stability and lessen the need for additional charging infrastructure, V2V has the potential to mitigate peak demand and lessen grid dependency from an environmental standpoint. All things considered, V2V charging is a novel way to increase EV flexibility, but widespread adoption will need addressing technical and financial obstacles.

6. CONCLUSIONS

To sum up, electric vehicles (EVs) are essential to the shift to environmentally friendly transportation and the cutting of emissions. But obstacles like range anxiety and inadequate charging infrastructure need to be addressed. By allowing EVs to charge from one another, vehicle-to-vehicle (V2V) energy sharing offers a viable option that not only increases convenience but also improves traffic safety and overcomes the limits of charging stations (CS).

The gaps in the market and the current body of knowledge have been examined in this study. It highlights the need for improvements in areas including network administration, scalability, energy management algorithms, safety and reliability standards, energy transfer efficiency, and Quality of Service (QoS) procedures. The effective development and use of V2V energy sharing systems depend on resolving these problems and putting the suggested fixes into practice. Additionally, this study lays the groundwork for a practical framework that can support the growth of V2V charging infrastructure.Efficient and smooth V2V energy transfer can be achieved by resolving the issues found and expanding on current research and technology, helping to create a more ecologically friendly and sustainable future.

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