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A Review on Vehicle-to-Grid (V2G) Technologies Towards Smart Grid for Distribution Networks

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Abstract

This paper focuses on various electric vehicle charging and discharging technologies in distribution networks, alongside Vehicle-to-grid(V2G) grid technology since there are numerous pros to the V2G application that can be utilized in electric vehicles. This V2G technology offers numerous advantages, including a reduction in fossil fuel use resulting in lower carbon emission, reactive power support, active power regulation, and load balancing via valley filling. Despite these benefits of V2G technology, there are also some drawbacks, including limited potential effects of V2G on the grid, communication overhead between EVs and the grid, and infrastructure changes in the distribution network. Furthermore, an in-depth examination of the methods of indirect controlled charging and discharging in a distribution network (DN), delay charging and discharging, intelligent charging and discharging controlled charging and discharging, and uncontrolled charging is also discussed. Our research paper emphasizes and illustrates how important charging and discharging processes, vehicle aggregation strategies, and their optimization are to the financial benefits of V2G technologies. Moreover, this paper summarizes the difficulties related to V2G technology, the effect of electric vehicles on distributed networks, and critical issues associated with EV integration, including technical, environmental, operational, and economic challenges that require further research to ensure the successful implementation of V2G systems in the future.

Keywords
Electric Vehicles, Distribution Networks, Vehicle to Grid, Plug in Electric Vehicle, Renewable Energy Source

1. Introduction
As the world moves towards an energy-efficient and more ecologically friendly economy, worries about global warming, air pollution in big cities, and reliance on fossils fuels are growing. Due to disproportionate amount of fossil fuels, energy business and transportation networks are important players in managing these problems. Many attempts are being made to create new energy technologies in order to reduce reliance on traditional energy supplies as a consequence of this study. With the help of electric car technology, this problem can be solved. By substituting electric motors for internal combustion engines, electrical vehicles provide a workable way to electrify significant segments of the transportation and energy industries. According to current study, EVs are more advantageous than other conventional energy-saving strategies since they are simple to install and offer a more ecologically friendly atmosphere. Using electric cars (EVs) that run on renewable energy is seen to be crucial for e-mobility and for lowering greenhouse gas emissions(Lin et al., 2010).EVs are being researched as possible ways to lessen environmental pollution on a worldwide scale. Conventional power plants and compared to EVs, battery storage technologies are less capable of overcoming these obstacles on their own. Although the infrastructure supporting EVs is still relatively young, they present a potential opportunity for grid stabilization. Technological advances in EVs have led to the development of electric vehicle aggregators that can connect to the grid and offer competitive and interesting charging and discharging strategies. By transferring demand from peak to off-peak hours, energy storage devices can lower power costs. Vehicle-to-grid (V2G) technologies, which are battery-based, act as energy storage devices for the grid's peak loads(Habib et al., 2018).Large capacities are necessary for large-scale distribution grids, and V2G technologies are ideally suited for these needs. They can therefore function as an auxiliary service to the grid in the event of varying demand patterns. Performance-wise, V2G plants outperform conventional power plants. These elements work together to make voltage-to-frequency (V2G) control common. Batteries are also probably a lot more efficient than most other types of energy storage. In order to reduce the impacts of stress on the power grid and maintain power balance and stability, V2G technology is mainly focused on coordinating charging and discharging and maintaining an equilibrium charging plan. Vehicle-to-grid (V2G) technology is one creative solution that has arisen at the nexus of the energy and transportation sectors (Mahobiya et al., 2023).The use of electric vehicles (EVs) as a distributed energy storage source is known as "vehicle-to-grid" (V2G). Grid-to-Vehicle (G2V) systems allow EVs to be linked to the grid for charging. This allows for the storage of extra power during periods of low demand and the release of that energy back into the grid during periods of high demand. EVs can be linked to the grid and utilized as a source of energy storage thanks to V2G technology (Ullah et al., 2023).The EVs may be utilized to supply power to the grid when it needs extra energy. This energy can be utilized as a backup for conventional energy sources or as extra energy during times of high demand. The grid can then be powered by this stored energy as needed. V2G technology offers several advantages. Lower power prices can be achieved by reducing the requirement for conventional energy sources by utilizing EVs as a source of energy storage (Yorozu et al., 2008). Furthermore, V2G technology can help reduce emissions by reducing the requirement for fossil fuels. Finally, by supplying extra energy during times of high demand, V2G technology can aid in enhancing the grid's dependability. Although V2G technology is still in its infancy, it has the power to completely alter how we consume and store energy. The way we consume and store energy will probably change significantly as technology advances and becomes more extensively used (Young et al. 1989).

1.1 Objectives and Contribution

Vehicle-to-grid(V2G) technology aims to use electric vehicles (EVs) as a distributed energy resource that can be both communicate and operate as a mean of transportation with the electrical grid(Eves & Valasek, 2023). The following succinctly describes the primary goal and contribution of V2G to the distribution network:

- Vehicle-to-grid(V2G) technology aims to use electric vehicles (EVs) as a distributed energy resource that can be both communicate and operate as a mean of transportation with the electrical grid (Eves & Valasek, 2023). The following succinctly describes the primary goal and contribution of V2G to the distribution network:
- The impact of charger-discharger techniques, such as intelligent scheduling, delayed charging and discharging, and regulated and uncontrolled charging and discharging, on power systems are compared.
- Investigates several methods for grid-connected electric vehicle charging and discharging.
- The potential, difficulties, and technology of electric vehicle technology linked to a V2G system are explored in this article along with their application to electric vehicles in a V2G context.
- When assessing Vehicle-to-Grid Systems, take into account battery deterioration, harmonic distortion, and electric vehicle load patterns.
- A thorough examination of the various power flows and charging/discharging techniques for electric vehicles.

2. Literature Review

The integration of electric vehicles (EVs) into modern power systems has been extensively explored in the literature, driven by global concerns about climate change, fossil-fuel dependency, and urban air pollution. Early studies highlight the environmental benefits of EV adoption and emphasize their role in reducing greenhouse gas emissions, particularly when powered by renewable energy sources (Lin et al., 2010). As research evolved, Vehicle-to-Grid (V2G) technology emerged as a central focus, positioning EVs as distributed energy storage units capable of both charging from and discharging to the grid. Foundational works by Kempton and Tomic conceptualized V2G as a grid-support mechanism, and subsequent studies demonstrated its potential in peak shaving, renewable integration, voltage and frequency regulation, and ancillary service provision (Habib et al., 2018; Mahobiya et al., 2023). A substantial body of research further examines controlled charging strategies—including intelligent, delayed, and indirect controlled charging—which mitigate the negative impacts of uncoordinated charging on distribution networks by reducing voltage deviations, feeder congestion, and power losses (Das et al., 2020). Intelligent charging and optimization-based strategies, often mediated by EV aggregators, have been found to enhance economic benefits for both users and utilities while improving operational flexibility. The role of aggregators has received significant scholarly attention, as they enable coordinated management of large EV fleets and facilitate participation in electricity markets through techniques such as game theory and stochastic optimization(Mastoi et al., 2023). Despite these advancements, researchers identify several challenges, including communication latency, battery degradation, inadequate charging infrastructure, regulatory gaps, and limited real-world V2G deployments, all of which constrain the practical impact of V2G systems. Battery degradation should be included directly in V2G optimization. Khallil et al. present a degradation-aware OPF framework for second-life batteries that captures capacity fade, internal resistance growth, and SoH dynamics (Khallil et al., 2025). The literature therefore calls for more empirical studies, better models for battery aging under bidirectional charging, unified global standards, and deeper analysis of V2G performance in highly renewable and distributed energy environments to support the large-scale implementation of V2G technologies.

3. System Overview

3.1 Vehicle-to-grid system

EVs can use Vehicle-to-Grid (V2G) to charge and discharge bidirectionally on the grid. When a grid outage occurs due to a natural disaster or other unforeseen events, the technology enables "vehicles with the capability of recharging stored power from the grid or into a building or local power distribution system(Kingma & Welling, 2013)." EVs may be used to offer a range of grid services as they become more and more V2G-enabled. When capable, they can be used to offer a range of grid services for a variety of stakeholders, including emergency managers, legislators, and even individual officials, they might be viewed as invaluable tools. In the event of a power outage, these devices may be employed as backup generators, which can power specific buildings—such as hospitals, emergency shelters, and other crucial facilities—or even an entire neighborhood(Liu, 2023). Because transportable energy storage systems are utilized for emergency planning, preparation, and response, they therefore enhance the resilience of the infrastructure. An electric vehicle (EV) often has several benefits, such as improved charging system efficiency, reduced reliance on oil, and lower CO2 petrol emissions. The ability of electric cars to link to the grid using vehicle-to-grid (V2G) technology is one of its special advantages. Vehicle-to-grid (V2G) applications, which provide direct vehicle access to the distribution network, are restricted in the use of electric vehicles. The ability of a car to provide direct power transfer into the DN is essentially a V2G application, which is only achieved by EV. We may construct an entire array of instantly available distributed energy storage devices with the aid of the V2G concept. This idea brings several battery kinds and uses shown in Figure 1 to the market(Aktar et al., 2023).

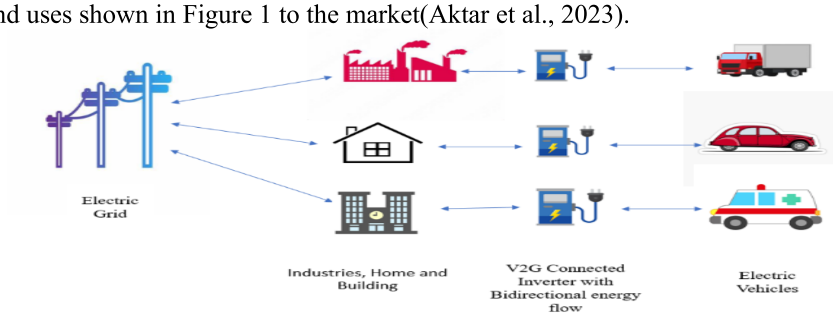

Figure 1. Application of vehicles to grid technology

Figure 2 below illustrates the many criteria that EVs adhere to. We examine the two main ties needed to put the V2G idea into practice(Yilmaz & Krein, 2012).

- The first is the power connection, which is utilized to transfer electrical energy into and out of the car.
- The second one is made up of the logic and control connections that allow us to send feedback signals indicating when and how power should be provided

To put this concepts into practice, some power electronics components and a programmed code must be incorporated into EVs' design. EVs have the ability to function as a distributed storage device in addition to being a load (Mahobiya et al., 2023). When EVs are connected to DN, the vehicle's battery may be utilized to supply electricity to the grid during periods of high load, increasing system dependability.

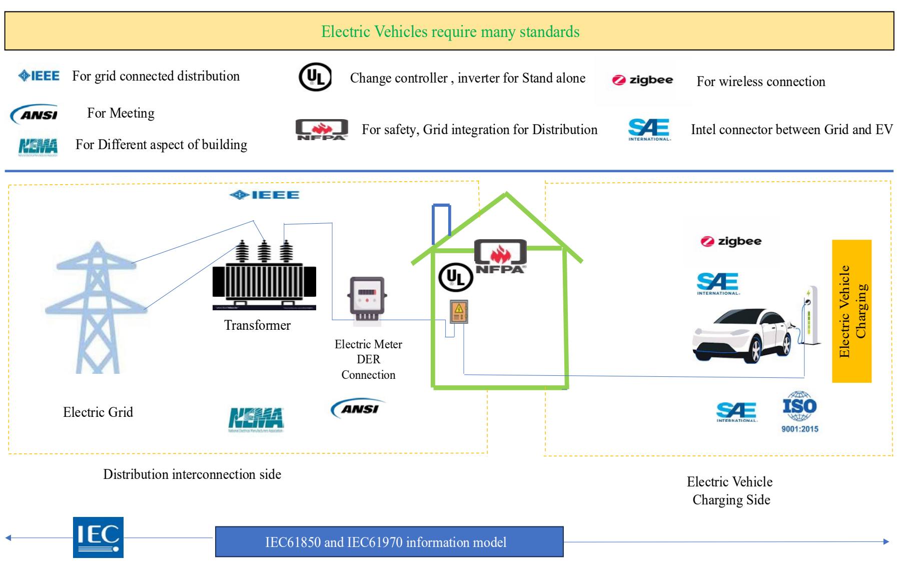

Figure. 2. Different standards followed by EV

Figures 3 and 4 illustrate main ancillary services provided by a fleet of EVs and smart grid properties and goals respectively. In a power system, ancillary services are required to guarantee power transmission from source to buyer, supply and demand balance, and grid reliability(Mastoi et al., 2023) ,(Das et al., 2020).When a V2G system is bidirectional, it can provide improved ancillary services, more effective load management, frequency regulations and regulation, peak power maintenance efficient spinning researves.Aggregators are designed to create a cluster of EVs and provide a larger, more manageable load for the service provider. A group of these EVs is utilized for the deployment of supplementary services and splining reserve. They function as a distributed energy resource (Eves & Valasek, 2023; Ullah et al., 2023).

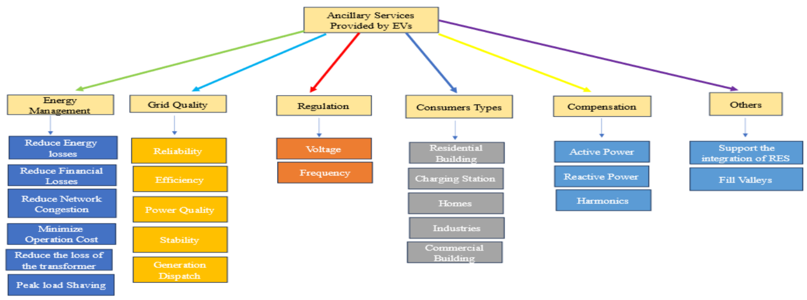

Figure 3. The main ancillary services provided by a fleet of EVs

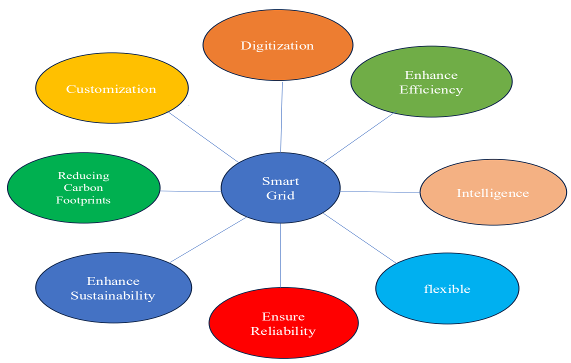

Figure 4. Smart grid properties and goals

3.2 Vehicle to grid requirement and power flow

A V2G system's components and electrical flow are depicted in Figure 5.Six main subsystems make up the system: 1) Energy supplies and a power company 2) A separate aggregator and system operator 3) Locations and infrastructure for charging 4) The exchange of electrical energy in both directions between every PEV and the ISO or aggregator Smart metering and control both on and off the ship 6) The PEV itself, complete with battery management and charging(ur Rehman, 2022; Yumiki et al., 2022).PEVs with V2G connections may often charge or feed energy into the grid while they are connected and parked. The three elements required for the concept to function are a communication channel with the grid operator, a power connection to the grid, and suitable metering; a significant amount of information interchange is necessary for an efficient power transaction (Yumiki et al., 2022)(Tostado-Véliz et al., 2022). In order to report battery status and receive orders, communications must often be bidirectional. Implementing intelligent metering and information control that is aware of battery capacity and state of charge is challenging. There have been proposals for off-board and on-board smart meters that can support V2G techniques. Smart metering can assist integrate PEVs with renewable energy sources and make PEV loads adjustable. Using a field area network, on charging stations, sensors and smart meters may interact with the control center to exchange data and monitor conditions. Services like dynamic resource tracking and charging rate modifications to monitor power pricing, frequency or power regulation, and spinning reserves depend on control and communication.

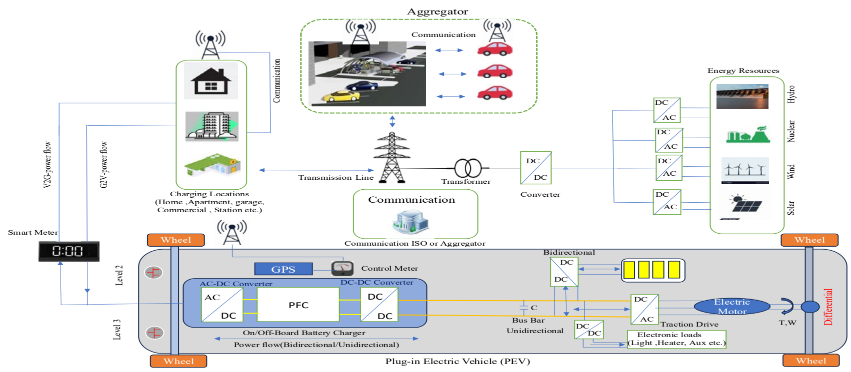

Figure 5. The components and power flow of a V2G technology

The term "vehicle-to-grid" (V2G) describes how an electric car and the electrical grid communicate through a communication system. The power grid operator utilizes the communication facility to manage and control the power flow between the electric vehicle battery and the power grid in order to achieve the desired advantages. Generally, the goals of V2G management are to increase revenue, lower emissions, and enhance grid power quality. Figure 6 shows the power flow for vehicle to grid system(V2G).

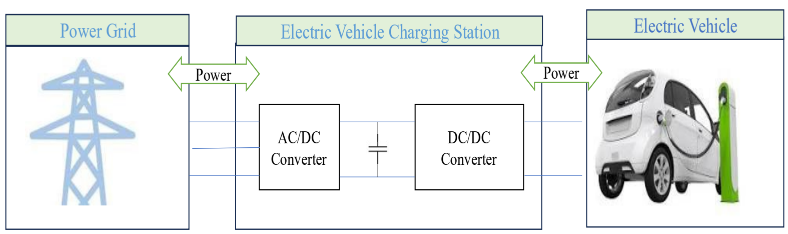

Figure 6. Power flow for vehicle to grid(V2G) system

3.3 V2G charging and discharging strategies

The size and capacity of the battery have a significant role in determining the initial cost of an electric vehicle. A few key variables, such as the effect on DNs, financial expenses, and the advantages of electric vehicles in terms of emissions, mostly depend on the kind of car, the battery's properties, the methods used for charging and discharging, and the frequency of charging and recharging. Reducing the dimensions and weight of the battery can boost its overall efficiency. The average amount of energy used by an EV will grow when battery size rises beyond a certain point. As a result, the high-power charging of EVs will raise the peak power consumption(Mastoi et al., 2023). Each EV may provide between 560 and 910 W to a system's load during peak hours; the amount of power added primarily relies on the charging method and charger size. Charging profile is a major aspect that impacts the DNs when the car is charging. The manner in which the electric vehicles are charged from the power grid significantly affects the voltage levels. Studying the strategy and control techniques for charging these electric cars is therefore necessary(Rahman et al., 2023). We consider different type of strategies for charging and discharging Figure.7 which manage the time and frequency of EVs.

- Uncontrolled charging and discharging method
- Controlled charging method
- Delay charging and discharging method
- Intelligent charging and discharging method
- Indirect charging and discharging method
- Bi-directional charging and discharging method

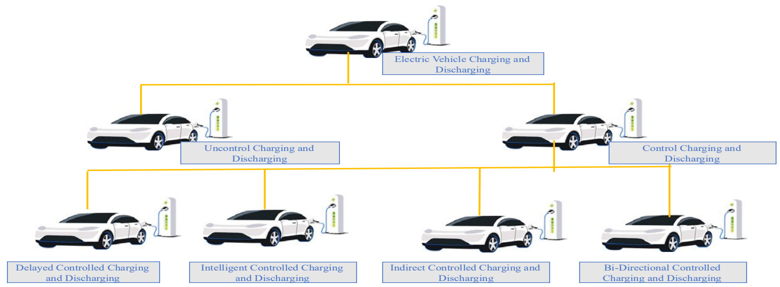

Figure 7. Eclectic vehicles method of charging and discharging

3.3.1 Uncontrolled Charging and Discharging Method

It is not planned for electric cars to be charged or discharged in uncontrolled circumstances. Without any control, electric cars are linked to the grid and charge instantly during peak and off-peak hours. Uncontrolled charging and discharging expose the grid's extremely basic structure. As a result, vital system information is not sent to the grid operator, which has an adverse effect on battery state-of-charge (SOC), operational efficiency, power quality, and grid stability(Yu et al., 2022). Industrial EV charging and discharging has a significant effect on the grid. Electric vehicle storage components provide up new opportunities by boosting the dependability of renewable energy sources(Yu et al., 2022). Load modelling is necessary to comprehend EV charging loads and track the cars' charge-discharge management. When a vehicle plugs into an electric outlet, it either charges quickly or, in the case of uncontrolled charging, after the user sets a delay. Due to this delay, owners of vehicles will now be able to charge their vehicles during off-peak hours. It is typical for the charging process to go on until the battery or the automobile are fully charged(Srivastava et al., 2010).

3.3.2 Controlled Charging and Discharging Method

In recent years, the practice of carefully controlling the discharge of electric vehicles (EVs) has gained popularity(Sadeghi et al., 2020). After these procedures have been synchronized, the operator may quickly and simply create the charging and discharging schedule to satisfy drivers' charging requirements and adhere to the operation's goals while preventing power quality issues and destabilizing disruptions (Young et al.,1989). The control, load duration, and charging extent of chargers that are directly controlled are among their limits. Conversely, indirect controlled methods are not limited in this way. The charging process should be managed by these systems as well as any external parameters. By controlling how quickly a vehicle charges, this technique may be able to maintain the energy cost and avoid grid overload (Das et al., 2020).

3.3.3 Delay Charging and Discharging Method

By purposefully delaying the start of the charging or discharging process in electronic circuits, delayed charging and discharging techniques are applied. These techniques are used for a number of purposes, including as minimizing inrush currents, enhancing efficiency, and guaranteeing the secure and regulated functioning of equipment or systems(Eves & Valasek, 2023). During the day, the utility charges variable rates for electricity: during off-peak hours, when EV owners are urged to charge their cars, costs are low, and during peak hours, when EV owners are discouraged from charging their cars, prices are high. This approach (i.e., charge at EV charging time) controls the EV charge at the charger's maximum power rating, not the charging power(Sadeghi et al., 2020). EV owners can take advantage of low-cost hours to charge their cars at a reduced cost by designing the daytime power tariff costs accordingly. Consequently, off-peak, indirectly regulated, or time-of-use pricing are terms used to describe this pricing strategy (Das et al., 2020; Habib et al., 2018).

3.3.4 Intelligent Charging and Discharging Method

In order to optimize the charging and discharging processes in electronic devices or systems, intelligent charging and discharging methods make use of sophisticated control algorithms, sensing technologies, and feedback mechanisms. The objective is to guarantee safe and dependable operation, increase efficiency, and prolong battery life[(Mahobiya et al., 2023)(Ding et al.,2022). These methods often employ microcontrollers, sensors, and smart algorithms to make real-time decisions based on the conditions of the system(Kingma & Welling, 2013). By carefully regulating the rates at which batteries charge and discharge, these techniques aim to maximize battery life and prolong its lifespan. They also improve efficiency, which minimizes energy losses during charging and discharging and leads to higher overall system efficiency. Lastly, they reduce costs by optimizing energy usage, which can help lower the total cost of ownership for battery-powered systems and reduce electricity bills. Finally, they enhance grid stability in grid-connected applications. Finally, they support grid stability and reliability. They enable vehicle-to-grid (V2G) capabilities, which are necessary for enabling vehicle-to-grid (V2G) capabilities (ur Rehman, 2022) (F. Mwasilu, 2014)

3.3.5 Indirect Controlled Charging and Discharging Method

When using indirect controlled charging and discharging techniques, electronic systems or devices' charging and discharging operations are managed and regulated by external control system (Yumiki et al., 2022)(F. Mwasilu, 2014). These methods use external controllers typically microprocessors or dedicated control circuits instead of depending only on the built-in features of the charging or discharging circuit to dynamically adjust parameters like voltage, current, and charging rates based on real-time feedback and monitoring. A solution that is more complex and flexible is made possible by indirect control, which makes it possible to optimize battery performance, avoid overcharging or over discharging, and modify charging rates in response to changing circumstances(C. Roe, 2008). It is anticipated that certain charging loads may shift to off-peak times when capacity is available to avoid system overloads due to rising energy bills. One indirect way to control this is to load shift. As a result, EV users might plan the distribution of spatial loads according to the self-determination criterion(M. Hussain, 2020).

3.3.6 Bi-directional Charging and Discharging Method

Compared to intelligent charging and draining, bidirectional charging has a clear benefit. Most of the energy used by electric cars is supplied by the grid because they are usually parked for 90–95 percent of their lifespan. When utilized in this way, V2G helps lessen the detrimental effects of charging and discharging on the grid(Habib et al., 2018), (ur Rehman, 2022). To improve its long-term advantages, V2G offers a number of intelligent bi-directional charging capabilities, including connection/disconnection, soft start/stop, auto charging, and discharging. Bidirectional V2G facilitates better EV adoption, the integration of renewable energy in smart grids, and a more precise match between supply and demand. Both electric and hybrid electric cars are capable of offering these services(F. Mwasilu, 2014). When required, they may also lower the power at which they charge. The grid side uses pulse width modulation, space vector control, and bi-directional charging to regulate the voltage and current switching frequency(M. Hussain, 2020).

3.4 V2G Technology Challenges

The broad use of V2G technology is not without its difficulties(Habib et al., 2018). For instance:

- Since there is aren’t many EVs on the road right now, V2Gs possible effects on the grid are minimal.
- The integration of V2G systems into the grid is depended upon the resolution of certain technological and regulatory issues.
- Since some EV batteries would not be able to withstand the wear and tear of frequent charging and discharging, they could not be suitable for use in a V2G system.
- Though V2G technology is still in its infancy, it has the potential to have a significant impact on the electric power system (Table 1).

Table 1. Charging and discharging methods under controlled and uncontrolled

Charging Type	**Controlled charging and discharging**	**Uncontrolled charging and discharging**
Advantages	Effective distribution network Exceptionally low maintenance cost. A better range of ancillary service is offered. There is a reduction in peak power. The demand profile has been smoothed.	Easy and simple to use. During peak time, the system is quickly embraced.
Disadvantages	The readiness of the customer is essential. A variety of controlled techniques are needed in various critical situation. Reduce the state of charge (SOS) of the battery more quickly. Losses in the grid have increased. Complex network.	Electricity prices are high. Electricity prices are high. Voltage fluctuations of great magnitude. Grid elements are found to be overloaded and negatively impact the grid.
Impact on the grid	Decrease in the price of power. Grid components have less work to do. Deterioration of power quality The management of peak loads is simple. Grid and load may be coordinated with ease. Power grids have become more reliable and stable.	The cost of electricity is high. Uncertainty increases. Grid elements are overloaded. Power losses are high.

3.4.1 Grid Related Problems with EV Intregation

EVs are gaining popularity as a substitute for conventional gasoline-powered automobiles. To guarantee that EVs are successfully integrated into the grid, a few possible issues with them need to be resolved(Clement-Nyns, 2011). The effect of EVs on the grid is one of the main problems. Because EVs need a lot of power to charge, when too many EVs are charging at once, the grid may get overloaded. Power outages and other issues may result from this. Furthermore, the grid needs to be able to support the extra demand from EVs, which might be challenging in some places(Sadeghi et al., 2020). The implementation of scholarly methodologies to evaluate the influence on the grid might potentially address this issue. The price of charging EVs is an additional concern. It can be costly to charge an electric vehicle (EV), particularly if the electricity is supplied by a conventional power plant. Because of this, prospective customers may find EVs less alluring as they are reluctant to incur the additional expense sectors (Mahobiya et al., 2023). It can also be challenging to estimate the cost of charging an EV because power rates might change based on the time of day. Scheduling the charging period is one way to get around this restriction(Clement-Nyns, 2011). Finally, range anxiety is a problem. The restricted range of electric vehicles (EVs) may cause drivers to worry about running out of juice while driving. Potential customers may be greatly discouraged by this as they could be reluctant to acquire an EV if they are concerned about running out of electricity. All things considered, there are a few possible issues with EVs that need to be resolved to guarantee their smooth integration into the grid. These consist of range anxiety, charging costs, and the effect on the grid. EVs can replace conventional gasoline- powered cars as a practical option by resolving these problems(Yumiki et al., 2022) (S. Habib, Kamran, M., & Rashid, U., 2015) .

3.4.1 Electric Vehicle Impacts on Distribution Network

EVs have a positive or negative effect on the grid. Positively, EVs can contribute to lower emissions and better air quality. In addition, the manufacturing of batteries utilizes more water and produces a significant amount of pollution than fuel-powered cars(Lin et al., 2010), (S. Habib, Kamran, M., & Rashid, U, 2015) (Zheng, 2023). Additionally, as power is frequently produced domestically, EVs can aid in reducing reliance on foreign oil. Furthermore, as electricity is often less expensive than petrol or diesel, EVs can contribute to lower transportation costs. The fact that EVs need a lot of power to charge might be a drawback for the grid (Mastoi et al., 2023) (Yumiki et al., 2022)(F. Mwasilu, 2014). This may result in a rise in the demand for power, which would be problematic for utilities that are already having trouble keeping up with demand at its highest. Furthermore, because EVs may consume a lot of power at once and produce variations in voltage and frequency, they might jeopardize the stability of the grid. Furthermore, one may consider environmental concerns to be adverse effects of EVs. Lastly, because EVs require a lot of charging stations, which might be challenging to establish in some places, they can complicate the distribution of electricity. EVs have both good and negative effects on the grid overall. They can aid in lowering pollutants and enhancing air quality, but they can also burden the system and lead to issues with energy distribution and stability. Thus, before introducing EVs, utilities should thoroughly assess the possible effects of EVs on the grid(S. Habib, Kamran, M., & Rashid, U., 2015; Wang, 2022).

4. Conclusion and Future Work

This study examines EVs with V2G systems and various charging techniques, and by examining how charging affects DNs, it evaluates the advantages and drawbacks of V2G technology. Major elements of the electric grid/DN, such as stability, losses, efficiency, and dependability, are improved by V2G systems. The report also outlines the primary prerequisites, advantages, and difficulties related to a V2G deployment. For the V2G to function well, intelligent grid connectivity, intelligent EV-grid operator communication, and intelligent metering are required. Although V2G is more cost-effective for grid operators and EV owners, it does have an effect on EV lifespan. cost-effective for grid operators and EV owners. When a vehicle is equipped with V2G capabilities, it may provide a range of functions such as controlling active power, providing reactive power, balancing load using valley fills, filtering current harmonics, reducing peak load, and generating income by cutting utility running costs. Ancillary services like voltage and frequency management and spinning reserve may be made possible by these qualities. Along with other difficult concerns, V2G brings with it modifications to the whole DN infrastructure, substantial communication between EVs and the grid, battery deterioration, and other technological issues. The tactics used for vehicle aggregation and charging/discharging determine the economic benefits of V2G technology. Additionally, this article analyzed a number of charging strategies, such as intelligent scheduling, delayed charging and discharging, off-peak charging and discharging, regulated charging and discharging, and uncontrolled charging and discharging. Charging techniques are coordinated to obtain the best time and power demand. Intelligent charging and discharging technologies improve the technical stability, efficiency, and dependability of a distribution network by lowering energy expenses, voltage variations, spikes in transformer power, and line currents. As a result, the most beneficial and effective course of action for grid operators and EV owners is synchronized charging. Owners of EVs and distribution grid operators will undoubtedly pay close attention to the advantages of EVs in the near future.

In this work, we offer charging and discharging planning methodologies and some new views on V2G service inspection. We consider energy trading services that leverage trading platforms to meet end-user demands to be important areas for future study. Based on the evaluation results, a number of crucial and detailed recommendations are made for the advancement and future research paths of V2G technical development:

- To encourage EV drivers to engage in electrified transportation networks, particularly the V2G system, social factors should be taken into account.
- Efficiency must be taken into consideration while designing charge scheduling algorithms for V2G applications in order to maximize their efficacy.
- Without a doubt, V2G systems that use smart charging have lower system costs.
- More study is required because, while EVs might be used as a distributed storage system to absorb excess renewable energy, smart chargers' economic feasibility has not yet been shown.
- During the construct of smart grids, it is recommended to establish V2G strategic plans, expand basic research on V2G, and take equipment and operational circumstances into consideration.
- The behavior of steady-state, transient, and dynamic processes, capacity forecasts, V2G modelling, and related disciplines all require a lot of study.
- At present, it is impossible to quantify the exact effect of V2G on battery life. Further investigation is required to ascertain whether employing reactive power adjustment at a higher power level impairs battery performance.
- Subsequent advancements may take into account the impact that EV charging modes have on system dependability.
- To achieve the operational requirements of high-voltage, high-power, and high-frequency systems, a number of concerns and obstacles need to be solved.
- Voltage drops occur when all-electric vehicle chargers operate in V2G mode, Therefore, factors related to detection and control have been overlooked, necessitating more research.

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