Available online www.ejaet.com

European Journal of Advances in Engineering and Technology, 2022, 9(8):33-40

Review Article ISSN: 2394 - 658X

A Review on Integration of Vehicle to Grid Technology in the Distributive Network

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ABSTRACT

In the last ten years, the number of electric vehicle has increased dramatically and so is the power requirement to charge these vehicle. At one end Electric Vehicle can be a boon to reducing greenhouse emissions, they can provide a number of advantage including lower pollution levels and lower oil imports cost but at the other end, managing EV charging will be critical in the future decade to boost the adoption. According to global EV outlook report, by 2030 there will be 250 million electric vehicle on the road. The 16000 GWh of energy that can be stored in EV battery could actively provide energy to the grid at suitable times via vehicle to grid (V2G) Technology. This paper reviews the overview, integration and impacts of the vehicle to grid technology when integrated in the network.

Key words: Electric vehicle, Vehicle to Grid technology, Renewable sources

1. INTRODUCTION TO ELECTRIC VEHICLE

Electric vehicles can minimise pollution to safeguard the environment in our cities and lessen people's reliance on gasoline. The development of electric vehicle technology has thus become one of the global goals. Analyzing how electric vehicles affect the power grid is crucial, and the model for charging electric vehicles serves as the basis for simulation. Further the study introduced and studied the electric car battery and charger model's characteristics. Proper battery and charger models are advised for various research needs [1].

Electric vehicles (EVs) have developed quickly in a number of places thanks to ongoing, systematic, and scientific backing from pertinent national policy and research. Additionally, as smart grid technology advances, electric power will become the urban energy source of choice, which will significantly increase the appeal of EVs. Determining whether future large-scale EVs will use battery replacement charging or plug-in charging is of utmost importance. The research developed an evaluation system based on a collection of thorough indices to achieve this goal. Additionally, each index analysis is based on a prediction of future EV size [2].

Researchers have given electric vehicles (EVs) a lot of attention in the twenty-first century as a green mode of transportation, sparking a number of thorough investigations. The number of EVs will increase significantly as high-storage batteries are developed, and because of their unpredictable charging and discharging patterns, power grids will face new difficulties in maintaining their stability and safety. The paper provides a brief introduction to several aspects of electric vehicles (EV), including studies on governmental legislation, charging methodologies, key concepts, the effects of charging, and solutions to related problems. Discuss the trend of EV in light of the current development status and issues [3].

Electric vehicles (EV) have become more prevalent in the transportation industry. This mode of transportation is likely to displace internal combustion engine (ICE) cars in the near future, as the current trend indicates. Varieties of technologies exist in each of the primary EV components today or have the potential to do so in the future. EVs have a big potential to affect the environment, the power grid, and other connected areas. With sufficient EV penetration, the current power system could experience severe instability, but with the right management and coordination, EVs could become a significant factor in the successful deployment of the smart grid [4].

Point of comparison	Electric Car	Petrol Car
Buying cost	Expensive	Cheaper than EV's
Maintenance cost	Low	High
CO_2 Emissions	Close to zero	High
Range	Higher range in the city than highways	Higher range in the highways than city roads
Fuel costs	Low	High

Since EVs can significantly reduce greenhouse gas emissions from the transportation sector, there may be enormous environmental benefits as well. Before completely displacing ICE vehicles, EVs must overcome a few significant challenges.

The globe is currently experiencing severe pollution problems brought on by older cars with IC engines. Therefore, the world is adopting a new trend of electric automobiles, which are cleaner and more efficient than conventional vehicles (IC engine vehicle). One of the most important areas of research for industrialists in recent years has been the electrification of transportation. Electric cars (EVs) are displacing conventional internal combustion engine automobiles on the market [5].

The growing popularity of EVs leads to an increase in charging stations, which has a big influence on the grid. To minimise the drawbacks of EV charging and maximise the advantages of EV grid integration, a plethora of operating strategies as well as grid integration techniques are being developed. In his research, The advancements in electric vehicles and its personalization over time to this point have been made. This study focuses on the many batteries that are used in electric vehicles (EVs), as well as the advantages and disadvantages of the various driving systems and charging methods developed recently to support the development of EVs [2]-[5].

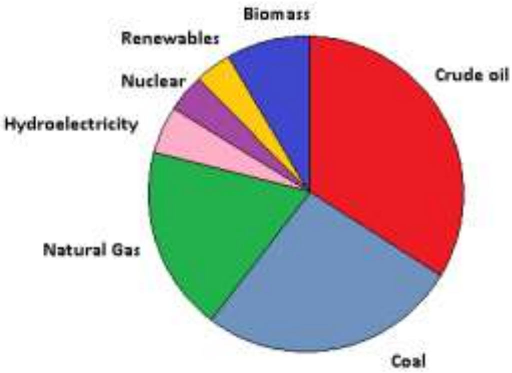

Fig. 1 World primary Energy Consumption by fuel type

The above figure shows the Energy consumption by fuel type, the maximum energy is consumed by the crude oil fuels and then followed by coal. The crude oil includes vehicles fuelled by crude oil, which in turn will create the GHG emission in the environment.

2. OVERVIEW OF VEHICLE TO GRID TECHNOLOGY

Due to the large percentage of renewable energy output in the smart grid, there will be new difficulties in balancing the supply and demand for electricity. Voltage regulation is one way to enforce power balance. The majority of power plants run traditional regulatory services, which are also quite expensive. More reliance on EVs would result from the growing social consensus in favour of environmentally friendly transportation. A fleet of EVs can act as a massive energy buffer, absorbing extra power from the smart grid or delivering electricity to make up for a deficiency, thanks to the inbuilt rechargeable batteries in EVs.

This suggests that a collection of EVs is a workable substitute for supporting the regulation functions of a smart grid. V2G is a dynamic system, nevertheless. Each EV autonomously connects to the system and disconnects from it. In this study, we use a queuing network to represent an assembly of EVs. We can estimate the capacities for regulation up and regulation down independently thanks to the queueing network's topology. A new V2G business model can be made possible by using the projected capacities to help set up the regulatory contract between an aggregator and a grid operator [6].

The idea is to use the power from the idle vehicles to provide load shedding and peak shaving and many other functions. The vehicle batteries can be fully charged during low-demand hours and the flow can be reversed at any time according to the requirements. This can be fulfilled by utilizing the concept of 'smart grid' which is an electricity network capable of processing the information, manages the electricity flow to fulfil the end users varying power demand and is able to provide communication between generation sources and end users. This concept works on the balance the 'off-peak' and 'peak' demand. The Vehicle can get charged during off-peak hours and can sell it back to the grid during peak hours [7].

The V2G operation's framework, services, and difficulties. A new technology called V2G enables power transfer between vehicles and the electrical grid. Based on the power transfer between the power grid and the EV, this technology can be divided into two categories: unidirectional V2G and bidirectional V2G. Both V2G types can offer the power grid a variety of services, including supplementary services, peak load cutting, load levelling, and a fix for the intermittent nature of renewable energy. Additionally, this article discusses the optimization strategies, goals, and restrictions for the V2G implementation. The V2G energy management requires the optimization technique since it must account for the complicated power system restrictions and accomplish a number of goals [8].

In order to adapt to different situations, V2G's realization methods can be divided into four categories. The four key technologies involved are summarised as follows:

- Power electronics technology,
- Battery management technology,
- Intelligent charging and
- Discharging management technology,
- V2G intelligent scheduling technology.

In addition, V2G's development paths are equipment integration, high efficiency, and low cost, which will integrate the Smart Grid with the trend toward intelligentization and informationization. When building a smart grid, designate a V2G strategic plan, increase V2G basic research, and take more equipment and operating conditions into consideration. Building infrastructure for electric vehicles and using many real-time regulating techniques with uncertainty, such as frequency regulation, voltage adjustment [9].

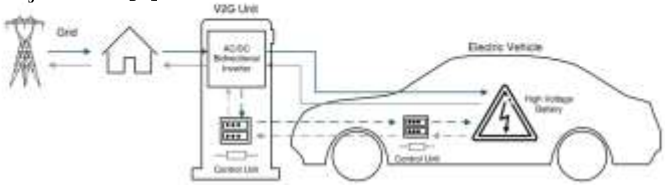

Fig. 2 The V2G model

Adoption of V2G systems may result in a useful source of energy storage, expedite the use of renewable energy sources, and give rise to a range of transmission and distribution grid services, and advance battery innovation and research.

Therefore, it is a subject deserving of solid, solid technical (and economic) investigation. However, we contend that a V2G research agenda is still lacking, and significant sociotechnical hurdles still exist. The proportion of studies that concentrate on technical issues and use technical approaches looks overly high and unbalanced, notwithstanding the difficulty in determining the ideal mix, as shown by the enormous number of socially pertinent research problems that remain unanswered [10].

The V2G technology has been well received by the public, however further development of this technology is required. People's psychology has a big role, therefore EVs must be well-liked and have a positive reputation. Therefore, administrators must win over the public and develop programmes for encouragement. For instance, in some nations, electric vehicles are tax-free, while in others, people are educated about the advantages of V2G technology, which makes use of Li batteries, mobile energy stations, and ultra-capacitors, to encourage their use [11].

In contrast to the technology now used in IC engine vehicles, the new technology of EV in the field of transportation. In an electric vehicle (EV), the wheels are propelled by an electric motor that is powered by the EV's built-in battery bank. High vehicle-to-wheel efficiency as a result of the electric motor's involvement is one of the EV's main advantages.

In the literature, well-to-wheel efficiency is also ranked highly. Other benefits include the absence of pollution and the elimination or reduction of greenhouse gas emissions with EV [12].

The two main factors influencing automotive development worldwide are energy conservation and environmental management. The clean and green environment produced by electric vehicles addresses these two criteria. A thorough description of EV types and their difficulties is provided. Although this green car has benefits, implementing the typical charging infrastructure and battery presents its own difficulties. By installing more charging stations in both public and private locations, the charging network can be decongested [13].

EV technology, the current need for it, its advantages over conventional vehicles, as well as the difficulties it must overcome to reach widespread adoption and social acceptance. The market for EVs now and projections for the future were also addressed. Various charging technologies were discussed, including conductive charging, the traditional method of charging, and new charging techniques like wireless charging and battery swapping, which may have possibilities in the future. It was reviewed the harm that EVs might do to electric power systems if unrestricted EV charging is implemented [14].

All aspects of deploying EVs were analysed, including their supporting functions for the grid in the car to grid system, by analysing a precise and thorough literature review (V2G). Additionally, we investigate the smart grid's integration of the electrified fleet with renewable energy sources (RESs) and assess any potential effects on the electricity network. Additionally, we list the benefits and drawbacks of integrating the V2G technology with the power network. The major goal of his study is to classify the four key topics that the V2G system has an impact on the power grid based on their proposed methodologies for future studies. Although there are some review papers on this subject, this area of research lacks a clear direction for future research and investigations. Additionally, a thorough analysis of the V2G-related literature is still lacking [15].

3. INTEGRATION OF VEHICLE TO GRID TECHNOLOGY

It is the first to explicitly model V2G technologies and their potential long-term dissemination using a thorough energy system model. According to the findings, V2G systems may have the power to significantly affect the energy and transportation sectors by encouraging the use of alternative vehicle technology, lowering wasteful investment in conventional generation, and aiding in the construction of renewable electricity sources. As a result, further research into this technology is necessary to determine how to promote the potential spread of V2G technologies and, more crucially, how to solve some of the major technological and social concerns [16].

An aggregator for V2G frequency regulation is developed in this study with consideration to the ideal control method. To maximise the revenue, a mathematical performance metric was developed. The battery's energy capacity was taken into account during formulation, and weight functions were used to indicate the energy constraint. For each vehicle, the best charge control strategy was sought using dynamic programming, and simulations were used to confirm that the outcomes were optimal. Additionally, a system that successfully modifies the relationship between the revenue and the ultimate SOC control was provided [17].

The potential financial gain of employing plug-in hybrid electric cars as a grid resource is investigated. When the vehicle-to-grid (V2G) service is utilised solely for peak reduction, there is minimal financial incentive for individuals, but when the V2G service is used for frequency regulation, there is a large possibility for financial gain. We suggest that these two applications for V2G technology are not incompatible with one another and that a "dual-use" program might exist to make use of V2G simultaneously for both of these purposes.

Further it was proposed, V2G might be utilised for peak reduction on days with high energy demand and poor ambient air quality to achieve the maximum environmental advantages while also being used for regulation on a daily basis to ensure profits. The individual's profits in this kind of dual-use programme are comparable to or even larger than those realised in either of the single-use plans. [18]

The concept of V2G is quite enticing. And it appears convincing in many respects at first glance. However, a closer examination of the economics and practical difficulties associated with implementing some of the various V2G system versions reveals that they are not now commercially viable. Underpinning the concept of vehicle-to-grid (V2G) technology is the premise that electric vehicles serve as a decentralised and under utilised energy storage facility, and in the case of plug-in hybrid electric vehicles (PHEVs), as a source of power generation. The total energy storage capacity provided by the 1.8 million electric vehicles is substantial and accessible the most of the day [19].

The Electric vehicle power system operation from vehicle-to-grid (V2G) control has the potential to provide frequency regulating service (EVs). A decentralised V2G control mechanism is suggested for EVs to participate in primary frequency control while taking charging requirements from EV consumers into consideration in this article [20].

The V2G has a wide range of uses and offers many options for dependable power generation and storage. V2G also offers a longer-term strategy in which the environment is taken into serious consideration. It still receives a lot of criticism, though. The main causes of this criticism are the high initial cost, the absence of government assistance, and the manufacturers' and consumers' aversion to change. Most people's perspectives can be characterised as narrow and careless since they only examine the current situation while dismissing the potential benefits of V2G in the future [21].

Electric vehicles (EVs) are becoming more and more integrated into power systems, which presents new difficulties for the distribution networks. Congestion issues can arise at various distribution network locations in a variety of circumstances. The cable heat limit, bus voltage violations, and power transformer limits will be the most important ones [22].

The voltage profile is significantly enhanced when distribution network technique is used in the event of coordinated charging with V2G capability. Additionally, there is a large reduction in loss when network reconfiguration is used. Additionally, network reconfiguration with coordinated electric vehicle charging lowers operational costs in two ways: by minimising loss and by lowering the need to import electricity during peak hours. Consequently, the approach for reconfiguring the distribution network facilitates the incorporation of electric vehicles into it [23].

An overview of the conditions that must be met for the wireless communication system to successfully integrate V2G. The poll concentrated on efforts now being made to make the most of EVs while keeping them connected to the power grid and other cars. It was attempted to determine which wireless technologies are V2G compatible out of the box and what difficulties and opportunities result from recently announced use cases [24].

It was concluded in the paper that society would benefit greatly from a VGI transition. It effectively turns transportation issues centered on vehicles into a part of the answer for the conundrums of environmental degradation and sustainable development. The change could enable automobiles to cut GHG emissions, accommodate low-carbon energy sources, increase the efficiency (and profitability) of electricity grids, and save money for owners, drivers, and other users [25].

The additional V2G cycling reduces battery life, the basic approach used in current V2G pilot studies—in which an EV is depleted and charged online without taking battery degradation into account—is not commercially viable. A clever control algorithm with the aim of maximising battery life can, however, turn this around. The worst case scenario in such an approach is that a battery declines as if there were no V2G because the control algorithm only permits access to the battery's stored energy if there are no negative effects on battery longevity. This strategy depends on the creation of precise battery prognostic models and ongoing research into the factors that contribute to, regulate, and affect battery degradation.

Policy-wise, the expected EV expansion presents a big opportunity for V2G to contribute significantly as a grid service. V2G can facilitate the reduction of carbon when combined with jurisdictions that have made commitments to using renewable energy. Installing the platform and grid upgrades is a crucial first step, but developing the right compensation model will be difficult and important for V2G to develop further. In the end, the methodology proposed by Uddin and Dubarry in conjunction with the establishment of a new, open market to collect and trade grid services may result in the unrestricted expansion of V2G as a future grid service [26].

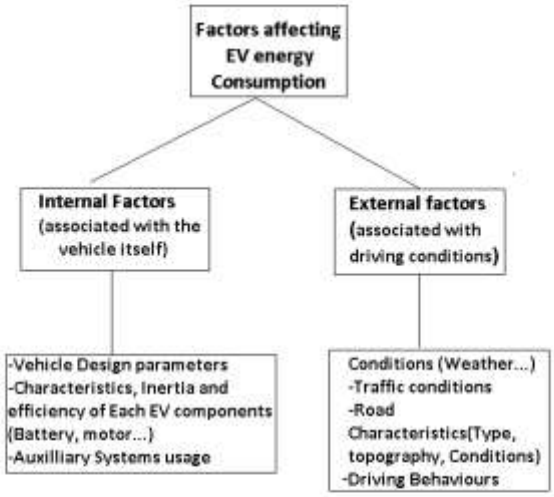

Fig. 3 Electric vehicle energy consumption

4. IMPACT OF VEHICLE TO GRID TECHNOLOGY

A technical study was performed to see how well cars could perform their primary role of transportation while still being able to supply power. To determine which vehicle types best matched electric markets, we also looked into four significant electricity markets. We created equations to characterise the time and power that are available, as well as the price and market worth of these forms of power, in order to study these quantitatively. They provided a mathematical understanding of how electric drive cars can integrate into the electrical grid as well as techniques for calculating predicted revenue and expenditures as a result [27].

This paper showed that there are many benefits to switching to V2G technology. Reducing petroleum use would improve national security and lessen the wealth transfer to oil-producing nations while protecting oil-importing economies from price spikes and market shocks. Additionally, it would significantly enhance environmental quality by replacing harmful emissions and the resulting harm to human health, the environment, and the climate. Additionally, PHEVs, a necessary step toward V2G technology, offer drivers the chance to save money by using electricity as a fuel rather than gasoline [28].

This paper overviewed the current PHEV research, battery technology, battery charger specifications, and the idea of V2G are provided in his study. Peak shaving, load levelization, and frequency regulation are uses for aggregated PHEV. Further it focuses on the advantages of combined PHEV for maintaining short-term voltage stability. To analyse the effects of combined PHEV when supplying power, a short-term voltage stability index is used [29].

For both overnight charging and a simulation of 24 hours, uncoordinated charging causes voltage issues. By putting a voltage constraint in the optimization problem and making the charger's power flow bidirectional, these voltage issues can be solved. Voltage control implementation is the first step toward PHEV grid support. Voltage issues may be partially resolved by integrating a voltage controller into the charger [30].

The requirements, advantages, difficulties, and tactics for V2G interfaces of both individual PEVs and vehicle fleets were analyzed. It also discussed the influence of V2G technologies on distributed systems. These systems' components, unidirectional/bidirectional power flow technologies, individual and aggregated architectures, charging/recharging frequency, and charging/recharging methods were all covered. When PEVs are equipped with sufficient on-board power electronics, a power link to the grid, communication and control amongst grid operators, and intelligent on-board metering systems, they can function as stored energy resources and operate as a reserve against unplanned outages [31].

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One of the most effective ways to reduce pollution from fossil fuels is to use GEVs. They also present the power grid with a number of opportunities and problems, which results in the development of V2H, V2V, and V2G. The following significant topics have been covered in-depth in this paper: novel concepts pertinent to GEVs; operational frameworks for V2H, V2V, and V2G systems; modelling of household electrical appliances; GEVs; and pertinent power electronics and battery technologies for GEVs. The optimization of V2G functioning has also been the subject of a case study [33].

This study examines the advantages and limitations of V2G technology by examining the effects of charging on DNs while taking into account EVs with a V2G system and various charging procedures. Major aspects of the electric grid/DN, such as dependability, efficiency, losses, and grid stability, are improved by the V2G system. The main criteria, benefits, and difficult problems for a V2G implementation are also covered in the study [34].

EVs can enhance the performance and efficiency of the power grid by acting as a responsive load or generator in addition to being used for clean transportation. EVs typically spend a large amount of time in parking during a typical day and have an energy storage capacity that is typically greater than what their owners typically need. The potential financial savings from EV participation in a V2G scheme have been looked into in this article [35].

In his paper, the cost-benefits of the EV for three public services—the school bus, the waste collection truck, and the municipal bus—are investigated and quantitatively assessed. These services are strong candidates for possible electrifications, according on the preliminary investigations of the missions with the mobility model and the grid support capabilities [36].

In this study, they've created various V2G technology simulations on a specific system. To determine how much energy the EVs will be able to supply the load demand during each failure or outage, the energy not supplied to the system in each circumstance was estimated. The reliability status under the base scenario and following the application of the V2G technology were compared [37].

Discussed the majority of potential techniques of charging one vehicle connected to one dwelling. The reduction of the vehicle's charging expense is the common goal of all the best algorithms. As a result, over 1000 usage scenarios and four different Daily Energy Price (DEP) profiles were used to study seven effective solutions. Optimal Logical Control (V2G-OLC), a novel V2G technique based on logical command sequence, has been presented [38].

This paper discussed that in addition to positive overall net revenues from V2G services, a healthy growth of V2G applications depends on the equitable distribution of advantages among participants. The electric utilities' profits Vehicle users in V2G peak shaving services are larger than zero when more than three times as much electricity is being supplied into the grid at its highest price. The valley cost the more electric car fleets that take part in V2G. The more peak shaving load there is for a service, the more money the users will make [39].

This paper described a number of the technological obstacles that a V2G system might encounter both now and in the future. While none of these difficulties strictly speaking prevent an EV from taking part in V2G, they can reduce the effectiveness of V2G, reduce the utility of the EV, and even pose a hazard to the EV owner or power systems. These obstacles may also have an impact on other sociotechnical system components. For instance, despite the fact that we have demonstrated above that battery degradation is unlikely to affect an EV's effectiveness in meeting daily driving requirements, buyers might believe that V2G introduces an unneeded risk [40].

In this paper the advantages and difficulties of the vehicle to grid (V2G) approach for distributed grids were analysed. When equipped with sufficient power to deliver, bi-directional power electronics, a V2G connection, proper communication and control with the grid operator, and smart metering systems, electric vehicles can serve as energy storage devices during grid disruptions. PEVs operating in V2G mode can assist the grid by acting as active-reactive power regulators, peak reduction mechanisms, load balancing by valley filling, voltage/frequency controllers, and ancillary service providers [41].

This paper proposed a control mechanism for intelligent EV car park systems is provided for EV charging and discharging. By regulating the charging and discharging activities when EVs are parked inside, the intention is to reduce the cost of the electricity used for the parking lot. The potential for V2G benefits is suggested by the results of thorough simulation studies, although this depends on a variety of variables, including the cost of battery degradation, the rebate price, the FIT, and the starting SOC of the EV [42].

5. CONCLUSION

An overview of vehicle to grid technology was presented in this paper. Integration of vehicle to grid technology in the grid was also reviewed along with its impact on the network when integrated.

Review of numerous difficulties the integration. Although many efforts are being made to integrate, there are still some issues that must be resolved. Future research is needed on a number of concerns, including energy management in relation to microgrids, instability brought on by bulk car charging, and vehicle charging schedules that prevent system overload.

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