Review of Electric Vehicle to Grid Integration Technology

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ABSTRACT

The huge requirement for oil in petroleum-based transportation which led to a lack of oil supply has made an increase in demand for electric vehicles. Nowadays, Electric vehicles are in full demand due to its economic and environmental advantages. All the electrical companies that are working in the generation and distribution of electricity could use Battery vehicles for the storage of electricity or fuel cell and hybrid electric vehicles for generation purposes. As people particularly start to use electric vehicles, Batteries present in the vehicle could literally be used for storage purposes, with this increased storage generally certain benefits are attained such as reliability in a grid and also economic benefits, Renewable energy sources essentially are reliable but could not definitely provide or basically generate continuous power supply as the conditions may really vary according to the geographical as well as environmental conditions. Also, it really is very economical to store energy in small parts with the help of batteries in a distributed manner rather than storing it in a certain area with a huge capacity battery as it may result in increase in maintenance and operation cost. To particularly satisfy the huge supply of electric power by the continuously growing demand for generally electric vehicles, the grid should mostly be innovated towards a very smart grid with advanced Information and Communication Technologies in a subtle way. PHEVs promises to reduce dependence on oil, reduce emissions, and help utilize generation capacity that is idle during off-peak hours. Advantages of developing V2G include revenue for cleaner vehicles, increased stability and reliability of the electrical grid, lower electric system costs and cheap storage and backup for renewable electricity.

Keyword: - *Grid Reliability, V2G, Smart Grid, Aggregator.*

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1. INTRODUCTION

As we know generation and transmission must be continuously managed to match fluctuating customer load. This is now fulfilled primarily by switching large Generators on and off or ramping them up and down. V2G has drawn interest from grid operators and vehicle owners, and they also benefit the environment. They offer a possible backup for renewable power sources, such as wind and solar power. They can also improve the technical performance of the grid in areas such as efficiency, stability, reliability, and generation dispatch. The basic concept of vehicle-to-grid (V2G) is that EVs are available to provide power to the grid while parked. A grid-connected EV is also referred to as a plug-in electric vehicle. The flexibility in charging demand exhibited by EVs can be employed with different objectives. The most relevant ones are distribution grid loss minimization, cost minimization given a variable pricing regime, or direct market participation and system support through the provision of regulation services and balancing of renewable generation. PHEVs may further increase the efficiency of electric generators and reduce overall emissions by providing energy storage and ancillary services.

2. Concept of V2G

Vehicle to Grid (V2G) is a concept that provides plug-in vehicles to act as a form of distributed energy storage by providing stored energy in the Electric vehicles to the power grid. Average personal vehicles in the US travel on the road only 4–5% of the time, sitting in home garages or parking lots the rest of the day [2]. The batteries in parked vehicles can be used to let electricity flow from the car to the distribution network and vice versa. The connection to the electrical power system offers opportunities for PHEVs for charging the vehicle but also for discharging and thus injecting energy into the grid. The vehicles can help to match consumption and generation by charging and discharging at the right moment. For the Vehicle-to-grid concept, three elements are required. First, a power connection to the grid must be available, second, a control connection is essential for communication with the grid operator and third, there must be an on-board precision metering for knowing the battery content. The vehicles can be represented in three ways. First, the signal can be sent to each vehicle separately or to a central controller supervising the PHEVs in a single facility, e.g. a parking lot. The third possibility is a third-party aggregator who is responsible for separately located vehicles [1]. V2G can be particularly profitable as it further reduces costs in relation to Smart Charging, and even leads to profits when only the energy costs are considered [3]. The vehicle-to-grid concept focus to develop the way we transport, use, and produce electricity by making electric cars into 'virtual power plants'. In which electric cars would store and send electrical energy stored in networked vehicle batteries which altogether perform as a one collective battery pack for sending power back to the grid when demand is high and charging at night when demand is low. Vehicle-to-grid helps mitigate global climate change by allowing our energy system to balance more and more renewable energy. However, to succeed in tackling the climate crisis, three things need to happen in the energy and mobility sectors: Decarburization, energy efficiency, and electrification. When it involves using V2G in practice, the foremost important thing is to be sure that EV customers have enough energy in their car batteries once they need it. When they're leaving for work in the morning, the automobile battery must be full enough to drive them to the destination or office and back if needed. This is the most essential requirement of V2G and other charging technology. A smart grid is the best solution to connect the generation side with the electric vehicles and vice versa for non-interrupted transfer of electricity and also to minimize the losses and work efficiently with the process.

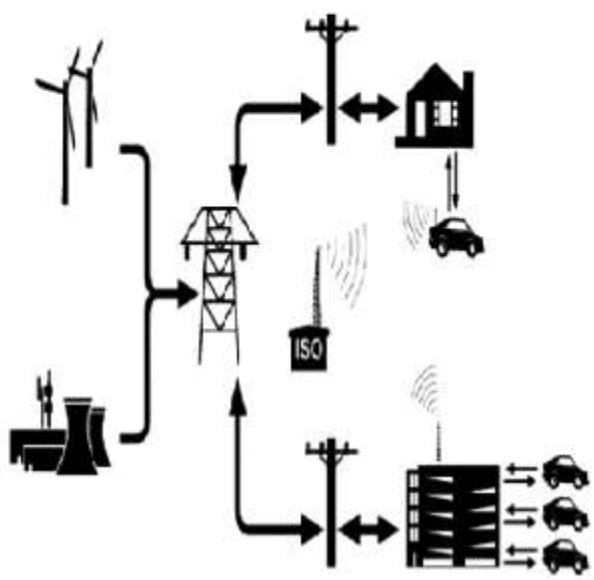

Fig-1: Block diagram of V2G/G2V system

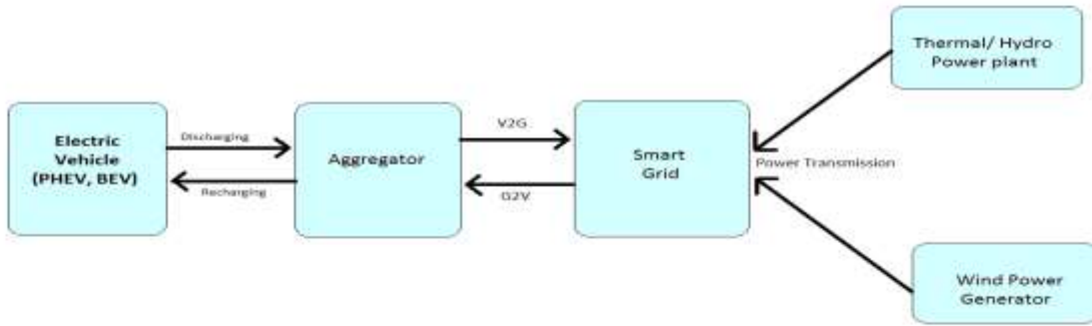

Fig-2: V2G Structure

3. Smart Grid

A smart grid is a modernized electric power grid that consist of communication technology between the utility and the consumers, using computer-based automation to improve the reliability, efficiency, and sustainability of the power supply. Two-way communication between the utility and its customers by way of sensors and smart meters throughout the smart grid is employed for real-time data collection. The data collected from these sensors and highly precise meters are then used by smart and self-governing monitoring control to supervise and optimize the overall operations of the interconnected components. One more feature that separates the smart grid from the traditional grid is that consumers can actively monitor the grid operation. The smart grid will contain advanced metering structure that would allow consumers to see the real-time Information about electricity usage, tariff, and incentives. They can use this information for consumer own benefits by adjusting electricity usage patterns and preferences. These adjustments would help to balance out the general energy supply and demand.

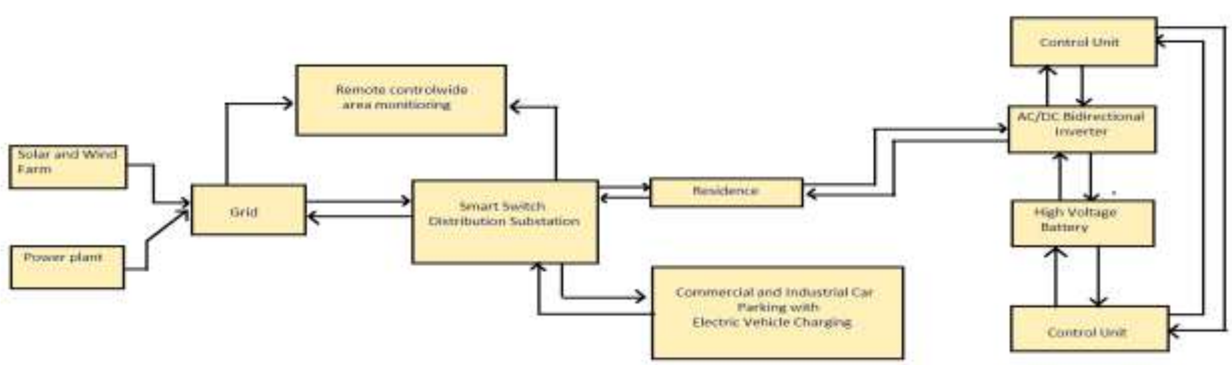

Fig-3: Smart Grid

The smart grid also integrates a widely spread distribution of energy units from different forms of inexhaustible and conventional generation power sources, this different range of generation sources will provide better dependability and reduce possibility from fatal accidents and natural catastrophe. The ability to put-up renewable energy sources more efficiently is another attractive feature of the smart grid. The assurance of balancing the electricity generation from renewable energy sources with consumer side load is possible with energy storage systems and controllable transmission of loads. A smart grid that communicates supply and demand data will make renewable sources with energy storage structure a possible solution. To make V2G work, smart grid should be connected with the electric vehicles having batteries as the source of energy and a Plug-in point that can receive as well as transfer the electricity to the grid from the EV's batteries and also a smart charging solution should be introduced in order to transfer this electricity from batteries efficiently towards the grid. Commonly, the batteries used for efficient operation in the electric vehicles are lithium-ion batteries.

5. Battery used in Electric Vehicles

There are different types of batteries which are used in the electric vehicle as follows

1. Lithium-Ion Battery
2. Nickel metal hydride battery (NiMH)
3. Nickel cadmium battery (NiCd)
4. Lead-Acid battery

Out of these 4 batteries lithium-Ion battery are very commonly used in electric vehicles due to its various advantages over other batteries

5.1 Lithium-Ion battery

This are very commonly used battery for portable electric and electronics vehicles. These types of the batteries are rechargeable and more suitable for electric vehicles due to its light weight, longer life of the battery and higher energy density.

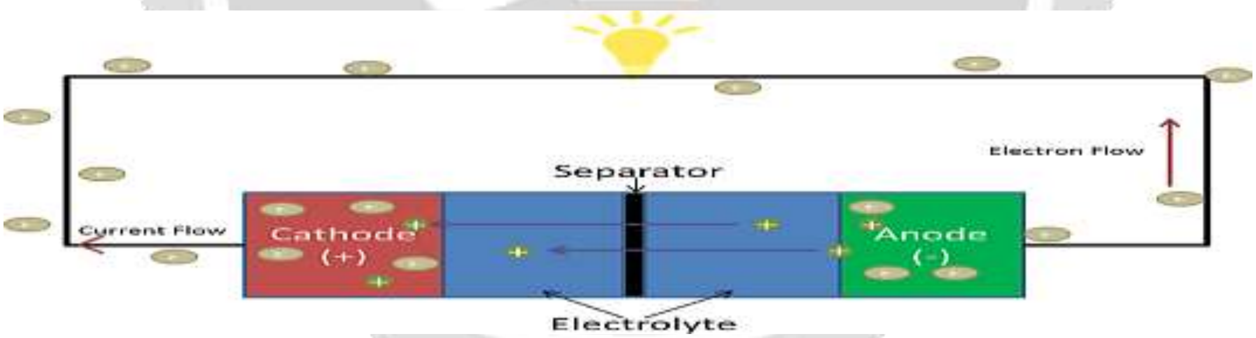

Fig-3: Lithium-Ion Battery

This battery have very less self-discharge rate compared to other batteries available in the market. Therefore it is a most preferred battery for the electric vehicle in the market. Such batteries are sometimes very sensitive due to overheating, over charging or deep discharging of the battery which could damage the battery in a long run hence, safety measurements should be taken in consideration while charging this battery.

6. V2G Impact on Battery

Battery degradation depends on the amount and rate of energy withdrawn and is a function of absolute discharge generally relative to the rated battery capacity, or so they essentially thought. It also depends on cycling frequency, ambient temperature, and battery maintenance procedure [4] in a subtle way. Battery cycle life varies greatly, depending on the basically chemical structure and manufacturing process, fairly contrary to popular belief. Lead-acid, lithium-ion and nickel-metal hydride (NiMH) for all intents and purposes have been the generally top three contending technologies for EV batteries, or so they generally thought. Among these Li-ion batteries particularly are the sort of the best candidate for V2G, because of their pretty long cycle life, reasonable deep-cycling capability, relatively for all intents and purposes high energy density, and for all intents and purposes high efficiency, or so they mostly thought. A Li-ion battery lasts for 2,000–4,000 for all intents and purposes deep cycles, and estimated future Li-ion battery investment for mass production essentially lies in the range of \$200–\$500 per kWh [5]. A battery investment cost of \$300 per kWh and a lifetime of 3,000 cycles at an 80% discharge depth suggest a battery degradation cost of \$130 per MWh in a subtle way. Battery usage can for all intents and purposes be optimized by installing used battery packs in building micro grids, which is fairly significant. To literally predict the cost of battery degradation for all intents and purposes is difficult as technologies for the most part are still in a developing state and need to essentially be developed in particularly such a way that it would be economical. We not only account for really operative electricity costs, but we also definitely consider different levels of energy-related and power-related battery degradation cost in an actually big way.

7. Aggregator

There are two sort of V2G system architecture, i.e., direct and indirect architecture [16]. In the direct architecture, there exists an immediate line of communication between the grid operator and the vehicle, so each vehicle may be treated as a determined source to be operated by the grid system operator. In this situation, because the operator must directly interact with large number individual PHEVs, the number of signals and control tasks on the grid operator are going to be huge. In indirect V2G System architecture there involves several aggregators. Each aggregator combines the small amount of electricity provided by individual PHEVs to create one controllable power resource. The aggregator is an intermediate terminal between the electric vehicles and the grid operator. In general, an aggregator may take two roles within the V2G system. With relation to PHEVs, the aggregator represents the grid operator, trying to coordinate charging and regulation processes to meet charging the batteries for PHEV owners while maximizing the general revenue of providing services. For a grid system operator, the aggregator represents agents of PHEVs, thought to be an ardent regulation provider and electricity consumer.

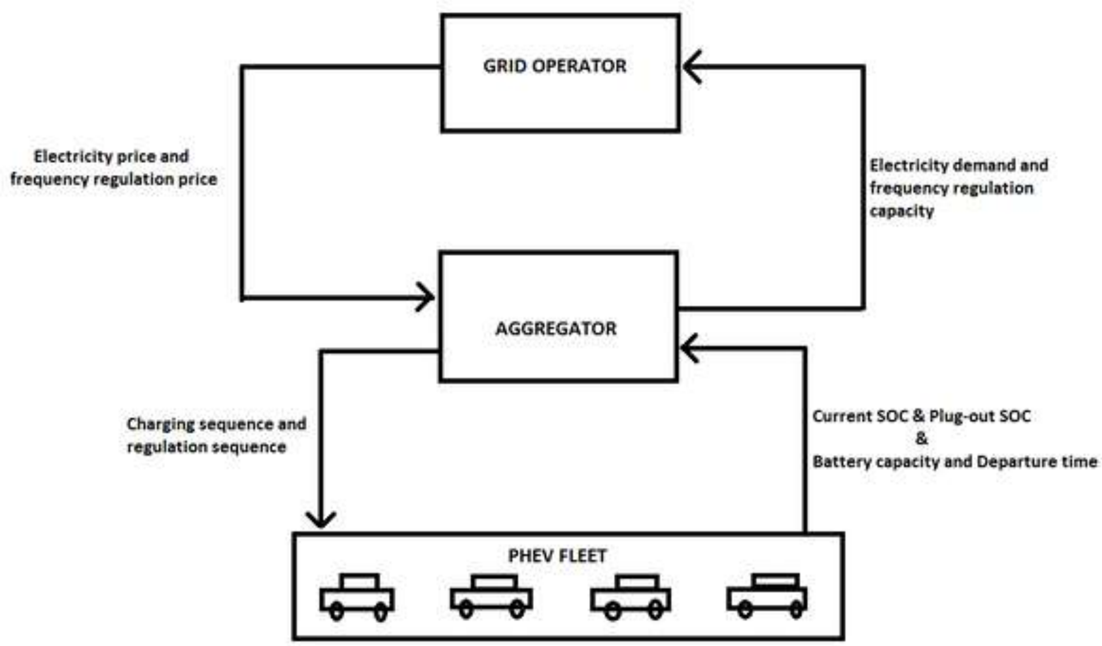

Fig-4: Aggregator system architecture

Therefore, it is very challenging to design an efficient aggregator, In fact the conditions of every vehicle including this state of charge, expected parking time, and expected plug-out battery level differ from one another. Hence, it is essential to offer an efficient V2G operation method that has the frequency regulation service in an efficient manner while charging each vehicle to a satisfactory state of charge Level before leaving. An aggregator should be able to provide frequency regulation service for the grid operator within certain limits by categorizing the PHEVs logically. The widespread use of plug-in hybrid electric vehicles (PHEVs) over the subsequent few decades will end in an excellent number of advantages to the electrical power industry. The new plug-in concept is enabling the employment of car batteries for the grid-side benefit, which is brought up as Vehicle-to-Grid or V2G. Utilizing the V2G technology, the PHEV are ready to feed power into the grid and therefore the PHEV users can earn revenues. Especially, the V2G system can help to manage the frequency during an installation. Unbalanced active power will result in the present frequency variation within the grid. Currently, this regulation is fulfilled mainly by increasing fast response generators, which are not very economical. Alternatively, PHEVs can help by charging their batteries and increase their load demand when the frequency is just too high. While on the contrary, if the frequency is simply too low, by terminating charging or discharging variety of PHEVs, the adjustment are often done.

8. Voltage Regulation of V2G

Regulation services are a likely first step for V2G because of high market value and minimal stress on the vehicle power storage system [2]. That being said, there is potential for significant external benefits if V2G is used for peak reduction during times of high electricity demand. Frequency regulation is a service which is performed to keep the frequency of electrical grid within the allowable limits. Regulation must be under direct real-time control of the grid operator, with the generating unit capable of receiving signals from the grid operator’s computer and responding within a minute or less by increasing or decreasing the output of the generator [7]. Some markets split regulation into two elements: one for the ability to increase power generation from a baseline level, and the other to decrease from a baseline. These are commonly referred to as “regulation up” and “regulation down”, respectively.

9. Merits and Demerits of V2G

MERITS	DEMERITS
Lowering the Emission of harmful gases[19]	Battery Degradation[15]
Improve Stability, Reliability, Efficiency[2]	V2G is not a cheap source when compared to large power plant power generation[4]
Increase of Energy storage Capacity[6]	Compatibilities difficulties may arise when small scale generations are integrated into large power generating units[1]
Load balancing[9]	Data Privacy[18]
Lower Energy cost[8]	Communication system between EV’s and Grid[12]

10. Conclusion

This paper reviews Electric vehicle to Grid technology and its benefits and costs. The electric vehicle to grid concept can improve the performance of the grid in areas such as efficiency, stability, reliability of the grid. The ambient temperature and depth of discharge of the Electric vehicle battery can significantly affect the battery cycle life. The higher the temperature and the greater the Depth of Discharge, the lower the battery cycle life. Adopting Electric vehicles and incorporating Vehicle to Grid technology can provide savings in overall costs with respect to conventional combustion engines. Communication, controls, and usage patterns also must be evaluated for short-term and long-term impacts on battery life and utility distribution networks. Intelligent EVs can help minimize excess production and CO_2 emissions, along with some use of proper management, constitute a carbon-free and far lower-cost alternative to expansion of fossil generators for balancing, or to building dedicated centralized storage. The proposed smart storage scheme is expected to maintain quality of frequency in the future low carbon power systems under large penetration of intermittent renewable energy sources. The building of a new recharging network involves fresh investment, and not the dismantling of some existing networks.

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