Role of V2G at Smart Grid Technology

Pooja Gupta[1] Sanjeev Jarariya[2]
[1,2]Department of Electrical & Electronics Engineering
[1,2]Corporate Institute of Science and Technology, Rajiv Gandhi Proudyogiki Vishwavidhyalya, Bhopal, India

Abstract— A variety of renewable energy resources are penetrating more into the power grid, in accordance with the efforts to reduce CO2 emission and reduce the dependence on fossil fuels for energy generation. Almost more than 60% of the world's oil productions are consumed by vehicles on roads. Gas driven internal combustion engines are low efficiency systems that emit several harmful gases and establish an unsustainable and inefficient transportation system. In a study, it is reported that vehicles are responsible for 30% of the world total energy consumptions and 27% of total greenhouse gas emissions. Hence, to eliminate emissions originated from urban life, grid-connected vehicles have been recognized as one of the effective options. In fact, electric vehicles (EVs) reduce CO2 and NOx emissions and increase energy efficiency through using distributed generations (DGs) in the transportation sector. In this paper two case are considered ,first without utility grid connected V2G system and secondly with utility grid connected and with & without V2G what will be the impact of frequency on grid and along with that we have observed the results with different kinds of energy vehicles i.e. their performance and reliability and it is observed that, with V2G the frequency of the grid improved whenever the load demands the supply, also the use of different charging system how impacts the performance of EV. Hence stability of V2G system by using utility grid gets improved which makes it more efficient than other renewable sources of energy.

Keywords: Smart grid, Vehicle-to-Grid (V2G), Electric Vehicles, Power, AC, PEV

I. INTRODUCTION

V2G technology can be defined as a system in which there is capability of controllable, bi-directional electrical energy flow between a vehicle and the electrical grid. The electrical energy flows from the grid to the vehicle in order to charge the battery. It flows in the other direction when the grid requires the energy, for example, to provide peaking power or "spinning reserves. Vehicle-to-Grid (V2G) networks are important components of smart grid (SG), which provide charging service for large-scale plugin electric vehicles (PEVs) and make vehicles as mobile and distributed storage unit accessing to smart grid. For assuring reliable and efficient ancillary services to the power grid, the operator of V2G network need to monitor the up-to-date status of every individual PEVs and evaluate the total current electricity storage capability available. Since the status includes some sensitive information, such as PEV's location, trip data, payment information, battery state, and user preference, etc., the close monitoring tends to raise privacy concerns from the PEV owners about their identities and other relevant information leakage

In addition, the authentication protocol is an indispensable part for V2G networks to ensure only the eligible PEV could access the V2G networks. Therefore, an effective and privacy-preserving authentication scheme is highly needed for V2G networks to keep confidential for user privacy. V2G (Vehicle-to-grid) which achieves bidirectional power flow between EV and power grid, will bring new applications for optimal operation of power systems. One of the most important applications is to offer frequency regulation service

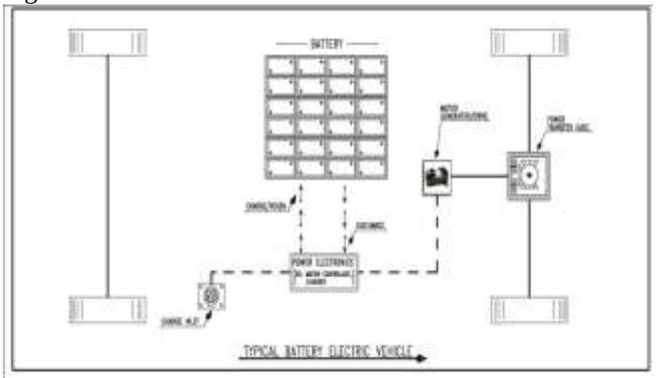

Fig. 1: A BEV

II. LITERATURE SURVEY

Uwakwe Chukwu et. al 2018, Proposed models of V2G as a PQ unit. The power flow study is developed from Newton Raphson's 3-Phase Current Injection formulation. The mathematical basis for voltage studies is presented. Also various impacts on the voltage profile for V2G operations in different modes of operation are investigated. Results indicate that the extent of voltage impact depends on the V2G mode of operation, size of the network and whether the V2G integration is 1-phase or three-phase. This study would be useful in the design, management, and operations of the electric network with significant V2Gs.

Wooyoung choi et. al 2017, has studied about V2G system under the topic "Reviews on Grid-Connected Inverter, Utility-Scaled Battery Energy Storage System, and Vehicle-to-Grid Application – Challenges and Opportunities "The purpose of this paper is to review three emerging technologies for grid-connected distributed energy resource in the power system: grid-connected inverters (GCIs), utility-scaled battery energy storage systems (BESSs), and vehicle-to-grid (V2G) application. The overview of GCIs focuses on topologies and functions. Different functions of utility-scaled BESS are introduced and a comprehensive review is provided for currently operating BESSs that are interconnected at the distribution level. Possible grid support functions of utility scaled BESS are presented.

Farhad Khosrojerdi et. al 2016, has studied about V2G system under the topic "Integration of Electric Vehicles into a Smart Power Grid: A Technical Review" Electrification of transportation system is one of the most promising alternatives to mitigate the dependency of urban life to fossil fuels. However, introducing a large number of grid connected vehicles reveals technical problems affecting the entire power system, especially the low voltage section. In this context, this paper presents a review of technical challenges associated with the integration of Vehicle-to-Grids (V2Gs). These challenges are studied in several subsections of a power system such as the operation of power electronics equipment, supply-demand imbalance, and impacts on voltage and frequency.

Salman Habib et. al 2014, has studied about V2G system under the topic “A Novel Vehicle-to-Grid Technology with Constraint Analysis-A Review” This paper presents a detailed review of a vehicleto- grid (V2G) technology, and analyzes its impacts on power distribution networks. It is shown in this study that a vehicle, equipped with the ability of a V2G application, offers various features such as regulation of active power, support for reactive power, load balancing, current harmonics filtering etc. These features can enable ancillary services including, spinning reserve and control of voltage and frequency. However, the technology of V2G also creates challenging issues, for instance, degradation of batteries, communication overhead between an EV and a grid, changes in whole infrastructure of a distribution network (DN).

This paper focus on following points

- Simulation of smart grid connected V2G system.
- Simulation of smart grid connected V2G system connected to utility grid.
- Comparison between smart grid connected V2G system and smart grid connected V2G to utility grid system.
- Reducing transient from V2G system.
- The V2G control framework is presented for EVs to participate in frequency regulation.
- simulation and discussion to illustrate the effectiveness of the proposed V2G control

III. Flow Diagram to Show Proposed Work

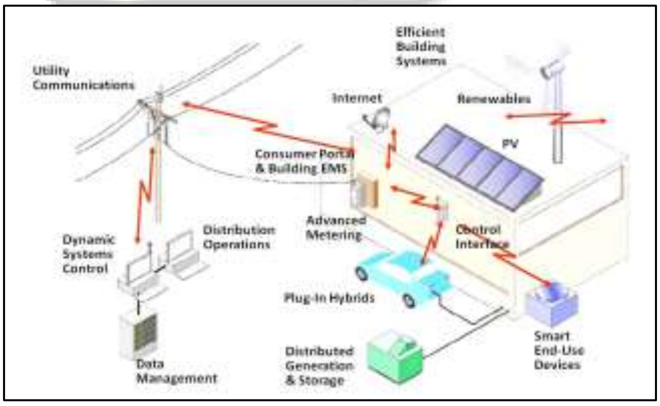

Fig. 2: Energy flow diagram.

A. Grid

Electric grid is a network of synchronized power providers and consumers that are connected by transmission and distribution lines and operated by one or more control centers. The digital technology that allow for two way communication between the utility and its customers, and the sensing along the transmission line is what make the smart grid. Utility Gird is a simple conventional grid. In the utility grid mainly nonrenewal energy sources are considered. In the Utility Grid mainly diesel generator and coal based generator system are included. In this type of grid are not two way communication and two way information system present here.

B. Vehicle to Grid (V2G)

The growing environmental concerns and strive for increased efficiency in private mobility has drawn the attention of car companies and associated entities to manufacture Plug-in electrical vehicle (PHEV) or pure electrical vehicle (PEV) or Electrical Vehicles (EV). The electrification of vehicle feet will reduce oil demands and lessens the carbon emission. The EVs can be integrated to the grid to sell or buy the power from the grid and the concept is called Vehicle-to-Grid (V2G). The V2G plays a prominent role in fulfilling the grid requirements and meet the load demands. V2G can be used for peak shaving or valley filling. The single EV can consume but cannot deliver power to the grid. The group of EVs makes a sizeable difference and delivers power to the grid. The EVs also support the ancillary services like load leveling, voltage regulation, frequency regulation and balancing. The EVs need bidirectional charger to sell or buy power from the grid. Further the bidirectional charger has the direct current (dc) link capacitor which is inherently able to provide the reactive power support to the power grid.

1) Vehicle-to-Grid Operating Modes

Three basic system components are involved that define the environment for recharging a vehicle or discharging energy from the vehicle to the electrical grid: (1) the location where the vehicle connects with the electrical grid, (2) the EVSE to which the vehicle connects, and (3) the electric vehicle that manages the SOC. As seen below, the environment may be a person’s residence, the employer workplace, fleet vehicle parking lots, or a publicly available charging station. The EVSE can be designed to provide alternating current (AC) or DC power to the vehicle. In addition, the EVSE may be designed at several different power levels. The vehicle has several important components that control and regulate the battery charging rates, as well as the battery itself. All of these components play a role in determining the operating modes and functionality discussed in the following subsections

2) AC and DC Charging and their Role in EVs

AC Charging	DC Charging
AC Level 1: 120 volts alternating current (VAC), single-phase, maximum 16 amps (A), maximum 1.9 kilowatt (kW)	DC Level 1: 200 to 450 volts direct current (VDC), maximum 80 A, maximum 19.2 kW
AC Level 2: 240 VAC, single-phase, maximum 80 A, maximum 19.2 kW	DC Level 2: 200 to 450 VDC, maximum 200 A, maximum 90 kW
AC Level 3: to-be-determined, may include AC three-phase	DC Level 3: to-be-determined, may cover 200 to 600 VDC, maximum 400 A, maximum 240 kW

AC will factor considerably in the V2G environment because vehicles are expected to be connected to the electrical grid for relatively long periods of time, whether at the employer’s workplace, in public, or at home. The power transfer capacity from these connections offers significant functional benefit for facility or grid support

A DC fast charging, is used in commercial and public applications and is intended to perform in a manner similar to a commercial gasoline service station, in that additional range is rapidly restored to the vehicle. Typically, DC fast charging could provide an 80% recharge in 30 minutes for 85 to 100-mile range PEVs (approximately 24-kWh capacity).

As batteries continue to increase in capacity, it is anticipated that DC charger power will increase as well to maintain short recharge times for these extended range or higher occupancy vehicles. As larger delivery electric vehicles are produced, it is likely that DC charging will play an important role in their charging activities.

C. Utility Grid Connected With Smart Grid V2G System

Below the different charts shows the proposed work and justified what we want to show here.

– This simulation model have 3 source
1) Diesel generator -15 MW
2) Wind farm -4.5 MW
3) PV Farm- 8 MW

– Load
1) Residential load – 10 MW,PF0=.15,ASM=0.16 MVA
2) 3 ,3 phase RLC load

– V2G
1) 1000 EV

– Transformer
1) 3 Phase Transformer – 25KV/25KV
2) 3 Phase transformer 25KV/600V
3) Grounding transformer

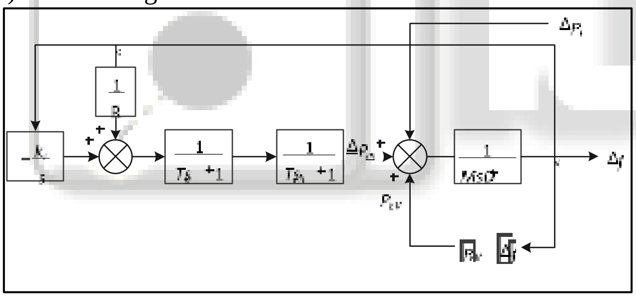

Fig. 3: Block diagram of frequency regulation with EVs

Frequency offest	Max δHzε	Min δHzε	RMS δHzε
Without V2G	0.1426	-0.1538	0.0337
V2G	0.093	-0.0827	0.0188

Comparison of frequency fluctuation.

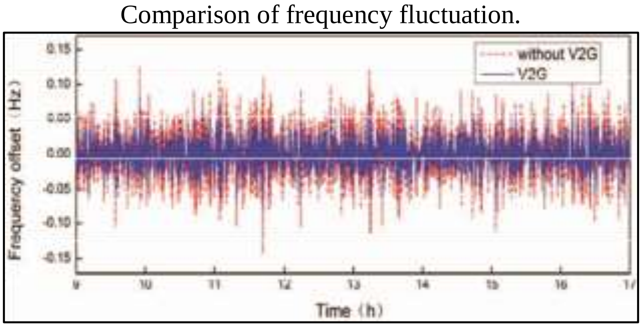

Fig. 4: Fluctuation of frequency deviation

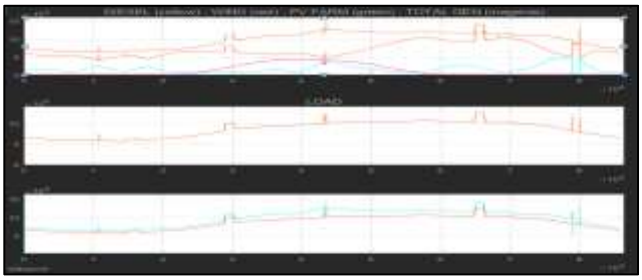

Fig. 5: Total Power of V2G without Utility Grid

IV. Simulation & Result

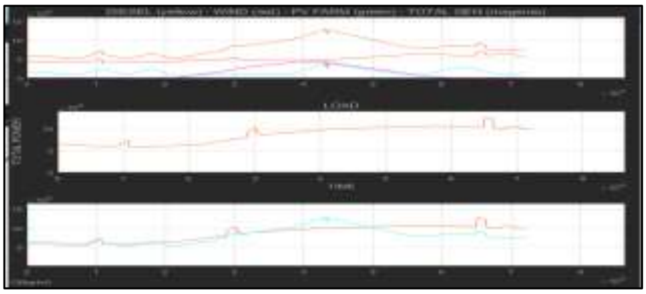

Fig. 6: Total Power of V2G with Utility Grid

It is clear from the graph that there are decreased amount of transients present in the output waveforms of total power of V2G system when Grid is connected. Also the impacts of AC and DC charging are also shown. Graphs of active power, reactive power can also be drawn to show the changes of transients with grid and without grid .But here only we showed the different transient in wind, diesel and total generation with load. The change in frequency shows that whenever extra demands are there then there will be frequency fluctuations and that will be justified by the use of EVs.

V. Conclusion

Whenever the extra power demand are required and the Smart Grid not fulfill power demand so these demand fulfill by V2G system and Utility Grid system. Proposed work implemented on MATLAB/SIMULINK software and shows comparison between the use of V2G to grid and without V2G to grid. From the above simulation results, we can see that the proposed the power scheduling control strategy proposed real-time modified the planned charging scheme, which not only suppressed the fluctuation of the grid system, but also met the charge demand of electric vehicles. The results show that the control strategy proposed in this paper can effectively suppress the frequency deviation of the power grid under the precondition of satisfying the user's charging demand.

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