V2G: Vehicle to Grid Technologies- Supply and Conversion: An Overview

By: Yash Gokhale, M.S. Chemical Engineering, Carnegie Mellon University

Introduction

V2G is a technology which enables energy to be pushed back to the power-grid from the battery of an electric car. With the advent of electric vehicles and increased need of using environment-friendly vehicles, V2G seems to be the revolutionary idea which could solve a number of issues. V2G is an extension of the V1G technology, which goes one step further in allowing charged power to be momentarily pushed back to the grid to balance variations in energy production consumption[1].

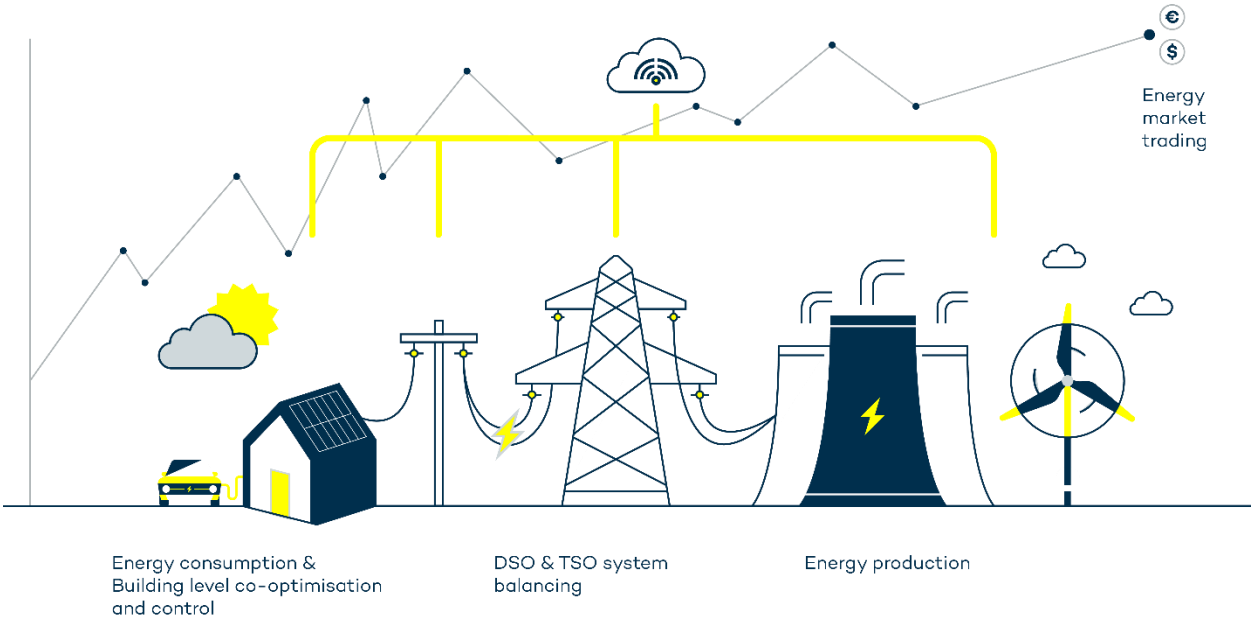

Figure 1: Overview of energy cycle of using V2G technologies[1]

Scenario for Supply

Due to the growing amount of EVs and PHEVs, it would cause a high load on the local electricity networks if all the vehicles are plugged in at the same time. Smart charging is a method to manage the time of charging of EVs. However, V2G links EVs together and puts a

[1] https://www.virta.global/vehicle-to-grid-v2g#:~:text=V2G%20stands%20for%20%E2%80%9Cvehicle%2Dto,energy%20production%20or%20consumption%20nearby.

[2]https://cleantechnica.com/2020/09/05/the-present-future-of-vehicle-to-grid-technology/

significant amount of energy back into the grid at peak times to support the electricity load of other applications[2].

Currently, only a handful of EVs use V2G technology whereas all other vehicles are dependent on CCS (Combined Charging Systems)[2]. Although there is a need for V2G, there is a lack of infrastructure for applying V2G and generalizing it to every possible area. However, with rapid advancements in V2G technologies and developments in EVs, V2G can well be ascertained as growing.

V2G Operating Modes and Functionality[3]

The device used to deliver electrical energy from the grid to the electric vehicle is EVSE (Electric Vehicle Supply Equipment). EVSE has a flexible mechanism which can be designed to provide alternating current (AC) or direct current (DC) with different power levels. Moreover, the vehicle components also play a major role in influencing the efficacy of the modality and functionality of these EVSE.

Three basic components are involved which define the EVSE are:

- The location where the vehicle connects with the electric grid
- The EVSE to which the vehicle connects
- The type of EV that manages the SOC (State of Charge)

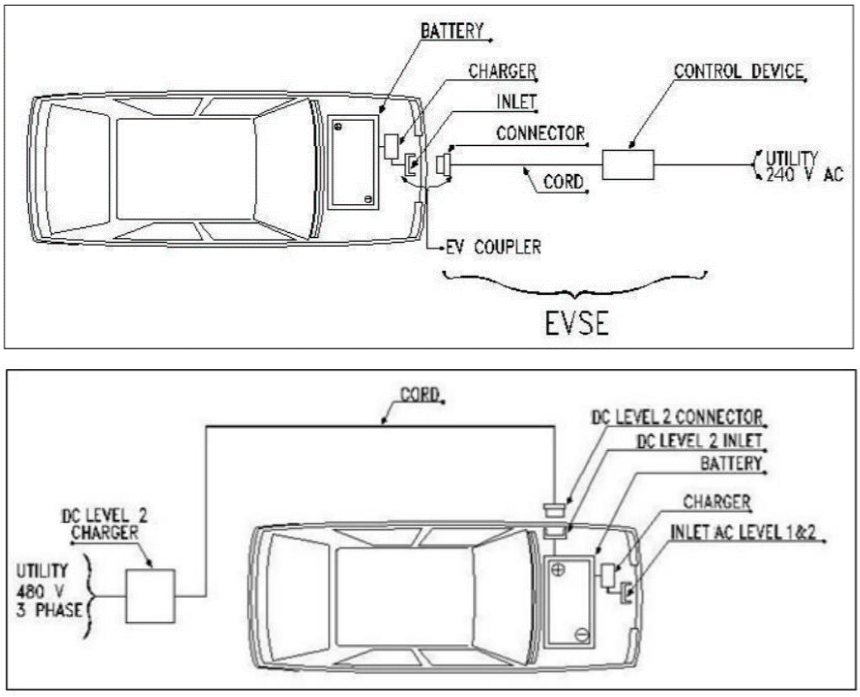

Figure 2: Brief structure of AC/DC supply technologies[3]

[3] https://www.energy.gov/sites/prod/files/2014/02/f8/v2g_power_flow_rpt.pdf

Derived from standard Chinese household electric systems, the proposed bi-directional transfer circuit topology in Figure 3 includes a grid-side converter, a protection circuit and a battery-side converter. This V2G system is capable of operating in three primary modes: charging mode, grid-connected mode and reactive-power consumption mode[4].

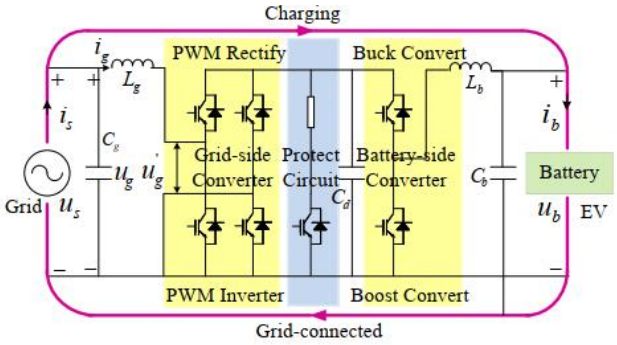

Figure 3: Proposed bi-directional transfer circuit topology for V2G

Applications of V2G

V2G technologies are being used around the world, mainly at the pilot level. NRG Corporation and EVgo has partnered with UCSD to install bi-directional EVSE and V2G-enabled vehicles in the UCSD microgrid. Nuvve Corporation, which licenses the software developed at University of Delaware, has launched a V2G business model in Denmark using Nissan vans. These vans are programmed to limit discharge levels and can be made available for driving at a set point in time, whereas Nuvve uses the battery to help grid operators maintain a constant frequency[5].

Figure 4: Snapshot of a proposed V2G technology[6].

[4] https://www.researchgate.net/publication/282414258_A_Multi-Function_Conversion_Technique_for_Vehicle-to-Grid_Applications
[5] https://www.nrel.gov/docs/fy17osti/69017.pdf
[6] https://thedriven.io/2018/10/19/v2g-whats-the-state-of-play-with-vehicle-to-grid-vehicle-to-home-technology/

Issues and Challenges

Although revolutionary, V2G technologies primarily requires establishment of common standards for smart grids. Moreover, effective communication between EVs, charging stations and smart grids is not currently visible. Lack of communication may lead to inefficient charging and discharging process, leading to results, contrary to intuition[7].

Another hindrance in implementing V2G technologies is that in order to allow utility to draw on energy storage from stationary vehicles, batteries must be subjected to higher amount of stress. As the batteries are one of the most expensive parts of the EV, a damage to the component would lead to further increasing the net overall cost, thereby hampering the motive of using V2G primarily. In addition to the problem of replacing batteries, it is unclear as to who would bear the cost of this replacement (car owners, companies or grid). This uncertainty has also lead to stalling the progress of V2G[8]. Although it is observed that certain mitigating measures can limit the battery degradation to some extent, however the extent of battery degradation can have a large impact on the potency of V2G applications[5].

Conclusion and Future Scope

Implementation of V2G technologies would provide respite to the problem of peak loads and would also help in lowering the operating costs for the customers. A satisfactory financial model needs to be developed to balance the cost benefits for all the stakeholders involved. In addition to that, the problem of battery degradation needs to be solved. Heavy investments are necessary in improving the battery life cycle and its ability to transfer back energy to the grid. Strong impetus should be given by the governing bodies to facilitate the smooth implementation of a charging schedule for the EV owners to reap the benefits of V2G technologies.

V2G technologies have a great future, provided the roadblocks are taken care of. As per the analysis by National Grid Electricity System Operator's report, published in July 2020, it is expected that by 2050, up to 45% of households will actively provide V2G services[9].

[7] Vehicle to Grid Networks: Issues and Challenges; Christos Tsoleridis, Periklis Chatzimisios and Panayotis Fouliras; https://www.researchgate.net/publication/299982526_Vehicle-to-Grid_Networks_Issues_and_Challenges

[8] https://www.greentechmedia.com/articles/read/why-is-vehicle-to-grid-taking-so-long-to-happen

[9] https://cleantechnica.com/2020/09/05/the-present-future-of-vehicle-to-grid-technology/