

Analysis of the widespread implementation of Vehicle to grid to mitigate the effects of peak energy demands.

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Introduction

In this report the electric vehicle charging system Vehicle to Grid will be critically analysed. Vehicle to Grid is a charging system developed from the impending climate crisis with promise to reduce the connected carbon emissions of owning an electric vehicle. This report will analyse Vehicle to grids suitability for domestic use as well as commensal and industrial applications.

What is V2G

Vehicle to grid is a proposed system that connects Electric vehicles to the grid to utilize their batteries to help level out the energy supply to the demands of the grid. By connecting an electric vehicle to the grid, the proposed systems can charge up the batteries at low demand when there is a surplus of energy. The electric vehicles can then be discharged back in to the grid at high demand as an instant response for the required energy.

The goal of vehicle to grid is to reduce the amount of fossil fuels burnt generating energy at high demand. Fossil fuels are considered as a form of energy storage as gas and coal power stations can be turned on to fill in at peak demand. In the UK a large proportion of energy production comes from gas with coal only being fired up in emergency situations. This comes at a cost as this energy has to be bought from the reserve power stations. This drives up the prices at peak times if there is no control. By storing energy in stationary electric vehicles, V2G aims to reduce this dependency and in turn reduce the carbon footprint of the vehicle. This also gives some control over the extra energy usage and thus the increased prices.

Renewable energy generation cannot be switched on and off with demand like fossil fuels can. Wind, solar and tidal energy are very dependent on weather which makes the

levels of renewable energy produced very volatile. Solar especially is dependent on sunlight hours in the day. Throughout the winter months solar doesn't contribute to the peak energy consumption seen from 6pm to 7pm as this is after dark. By implementing a vehicle to grid system locally with solar generation this energy can be stored and used at peak time.

The demand of the grid

Estimates of peak demands during 2021 is 32GW during summer months and 50GW during winter months. The National Grid predicts that there will be up to 11 million electric vehicles on English roads by 2030 and as many as 36 million by 2040. With just a take up of V2G of 220,000 cars they could supply up to 2GW collectively. This is a large amount of energy but with a larger take up this could drastically reduce the dependency on fossil fuels for energy generation.

Vehicle to grid for buildings, work places and factory's

Vehicle to grid can be used to level out the energy demands of a building or factory. Vehicle to building can react quickly to energy spikes to avoid any unnecessary energy costs for the building. This means no extra energy needs to be consumed from the grid reducing the buildings energy costs and carbon footprint.

When applied to a work place with a large take up there could be some practicality issues. For example, with a large take up, the electric vehicles would then create their own spike in electricity just before the owners leave for rush hour. With the transport industry pitching towards electric vehicles the demand for vehicle charging is going to increase. This is where the management of vehicle to grid will make or break the system.

One suggestion that could work for this application is the use of an algorithm. This could monitor the number of cars connected to the building, their battery capacity and the distance the vehicle has to travel post working day. The algorithm can insure only the power needed to level the buildings needs is used and then replaced when there is low demand to insure all the vehicles are charged with out creating a spike in energy demand. This algorithm would have to know when each person leaves work and if there are any deviant from normal behaviour.

Courier V2G

Courier companies were actually some of the first adopters of vehicle to grid. V2G makes a lot of sense for couriers as they can charge their vans up over night when electricity is cheap with a predetermined route for deliveries. The vans go out in the morning and return in the late afternoon. Connected back in to the grid ready to export energy for peak energy hour. With the delivery routes set the system can pricelessly allocate energy to the vans and then export it when the demand is high. A system like this drastically reduces the running costs of the fleet which was one of the largest expenses of a courier service.

Nuvve is a company aiming to increase the use of V2G in the courier world with their E-Flex project. They work with companies like Gnewt which is the UK's largest 100% electric vehicle-based delivery service. Nuvve plans vastly increase the use of V2G in this sector.

Vehicle to grid compared to conventional charging

Even in vehicle to grids simplest form it is still beneficial over conventional charging as it can discharge to remaining battery of the vehicle back in to the grid to supplement demand. With conventional charging the vehicle will charge from when it is connected until it is full. This often means that the owner will return from work at peak times and plug the car in adding to the demand on the grid. This increases the fossil foot print of the electric

vehicle as its increases the need for fossil fuels at peak times. This starts to defeat the message of running an electric vehicle by increasing the demand on fossil fuels.

However, Vehicle to grid will have to be dictated by the user's schedule to ensure that the vehicle has enough energy for the operator's needs. This would require an app of system of the user logging when they plan on using their car and how far they plan on driving. Such foresight in to planning your own movements would force a behavioral change in society as this has the potential to limit spontaneity if the car is drained when the owner comes to uses it. Such restrictions could limit take up with people who only have an electric vehicle as their mode of transport. This could leave a small dependency on a second ICE or hybrid vehicle for spontaneous or emergency trips.

Vehicle to home.

Quasar Wall box.

Quasar is the first domestic vehicle to grid charger designed to replace or work alongside a home battery. A home battery is used with domestic solar to store the energy and supply it to the house when its required. Quasar allows the operator to schedule when the car charges and discharges meaning it is not a constantly active operation. This still relies on the user to be smart about when they charge and discharge. For instance, charging when there is high solar generation and discharging when there is high demand and price for energy. This system doesn't require domestic solar but it is at its most efficient when it is paired together.

Quasar is a DC bidirectional wall box. This means it converts the alternating current from the grid in to direct current in the wall box. All electric vehicles have this capability on board but in the case of vehicle to grid this module is by passed. One downfall of this is that the wall box gets very hot and requires a cooling fan and large heat sink. In the case of some reviews the fan gets very loud and has meant that the operators refrain from charge

at night in an effort to keep friendly with the neighbours. This becomes a practicality issue when night charging is required to fit the users schedule.

Quasar is 7.4kW (1 phase) system meaning it won't be doing any fast charging. This is the same as many of the 1 phase single direction wall boxes however many of these wall boxes offer a 3 phase 22kW option. For some electric vehicle buyers, the option of a 22kW charger would be more attractive due to the desire for faster charging caused by range anxiety.

Ovo Energy Charging Trail

Ovo Energy started a trial of vehicle to grid in 2019 with the goal of creating the largest V2G fleet in the world. This trial involved 1000 Nissan Leaf and e-NV200 Vans using Ovo's V2G chargers and an app which allowed the owners to state when they required their car to be charged. The app then controlled when the cars are charged and discharged. Ovo claims that if owners regularly leave their cars plugged in they shouldn't have to pay for their energy. This implies that the returns from exporting energy to the grid cover the costs of charging the vehicle.

This is a far superior system to the Quasar one as it is not reliant on the owner to decide when to export and when to charge. With a reactive app that can export and charge based on demand there is potential to not just reduce or eliminate running costs of the vehicle but also substantially reduce the carbon footprint of the household.

However, this is still just a trial. This system is yet to reach the market but has serious potential of success. With a big push among vehicle buyers for lower running cost the idea of a vehicle being free to run would be irresistible for many.

Coupling V2G With domestic solar.

The ultimate goal of domestic V2G is to optimize it along side domestic solar generation fitted to the roof of a home. V2G

can control when the solar energy charges the car or exports to the grid and then when the car exports to the grid. Coupled with an app like the one described in the Ovo trial this could be very effective at not only leveling the grid but using more renewable energy and increasing the value of the solar energy generated. Generally solar does not generate large amounts of energy at the peak time of 6pm meaning this energy is exported at lower exchange rates. By storing this energy and exporting the energy at peak time it drives up the value of the solar Energy. This is especially effective for solar in the winter months when it can get dark as early as 4pm. According to the solar trade association around 900,000 British homes have solar panels giving the UK the combined power of 13.26GW of power. An estimate by the Energy Saving Trust states that a UK home with solar PV could reduce their carbon emissions by 1.2 to 1.7 tones per year. This is huge when multiplied by the thousands of homes that are already using solar. But this carbon reduction has the potential to be reduced further when solar PV is paired with V2G to use more solar at peak rather than requiring gas to fill the demand.

Vehicles compatible with V2G

One vehicle that keeps popping up when V2G is discussed is the Nissan Leaf. This is no surprise as this was one of the first vehicles to be compatible with V2G and to this day there are only a handful of others. Other manufactures offering V2G compatible cars are Toyota and Mitsubishi. This means if you opt for V2G you are currently quite limited on your choice. This will deter many not only because of the limited choice but because these brands aren't the market leaders for battery range or motor performance.

However, there is hope as other manufactures and market leaders such as Tesla and BMW are starting to implement this technology in future models. "Vehicle to grid benefits can be recognized much more efficiently when EV deployment is at scale rather than in early adopter phase" - Tesla-2020. Although this doesn't sound promising Tesla has actually been implementing the capabilities in their

recent vehicles ready for the day, they see it fit to use V2G.

Audi have announced that they are developing a vehicle to grid system for their E-Tron SUV. “Electric mobility is bringing the automotive industry and the energy sector closer together. The batter of an Audi e-tron could supply a single-family home with energy for around one week independently”-Martin Dehm, Technical project manager for bidirectional charging at Audi. The Audi e-tron SUV is the global leader for electric SUV’s meaning it is incredibly promising for V2G that Audi are developing these capabilities. Audi is a widely respected automotive manufacturer among the general public with their electric vehicles receiving higher approval rates than those that predated them from Nissan and Toyota. This would expose vehicle to grid to the masses rather than just the cult environmentally focused V2G activists that currently advocate the technology. This could be key to rolling V2G out on scale and achieving the benefits recognised by Tesla.

problems with V2G

The main worry with V2G is its potential to prematurely wear and degrade the battery of a vehicle. This is why Tesla (a market leader in the electric vehicle segment) was reluctant to join in on V2G. the accelerated degrading of the vehicles is a big problem as the majority of new electric vehicles use their battery unit as a structural part of the chassis. Some even are completely unremovable meaning once the life of the battery is depleted the chassis becomes redundant. This makes the end-of-life processes very difficult which is why it is understandable for manufacturers to be reluctant to accelerate this process. Even the chassis that the batteries can be removed and replaced this is a massive job that becomes quite costly. This would detour many owners with out an incentive like the one given to electric vehicle buyers. By creating such an end-of-life problem with the electric vehicles

would be counter productive with the climate crisis as producing new vehicles to replace the dead ones produces huge amounts of green house gasses. Does this mean V2G is only suitable for vehicles with removable batteries? Its hard to know for sure but would be ultimately decided by the carbon saved by V2G compared with the Carbon emitted by manufacturing replacement Vehicles and batteries.

Another problem with V2G is one stated earlier in the report of foresight of the user. Through all the trials and current available V2G solutions the system is reliant on the user pre-stating when they plan on using the vehicle to ensure that it has sufficient charge for the journey. In an ideal world with perfect foresight; this is not a problem. However, this is not a perfect world and people forget to do things especially communicating their planned movements. This would cause much frustration and require behaviour changes on the user to plan their movements days if not a week in advanced. Another problem with this is the unexpected and unplanned journeys. This would be impossible if a spontaneous plan is made but the car is drained. Current V2G chargers are not fast charging capable nor are the current compatible cars so you can’t even delay said plans by 30 minutes or an hour. For a long distance plan an hour plus would be needed to charge the vehicle sufficiently from empty.

Conclusion

To conclude, vehicle to grid is very promising technology with a bright future although it currently come with its own issue and challenges. Issues such as accelerated battery degradation with inevitable refinement and a large scale roll out V2G could have a major impact on stabilizing the grid and increasing the amount of renewable energy contributed to the grid. The reduction of fossil fuel dependency will be the ultimate sign of success of V2G.

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