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Vehicle to grid Technology

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Abstract

To examine the contemporary environmental issues raised by the automotive and motorsport industry and to investigate the technical and legislative response available to the governing bodies, teams and manufactures

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1.Introduction

There is currently a global dependency of the use of motorised vehicles and these vehicles thirst for fossil fuels. This dependency has created a huge number of impacts not only to the planet and environment around us but also has created a huge number of social impacts that also surround it. The report will investigate the concept of vehicle to grid (V2G) technology for use in domestic/company/factory based automotive applications, the report will also investigate if there are any long term or immediate issues and problems that surround the implementation of the roll out of V2G along with understanding the ethical issues and legalities that will surround the technology. V2G technology allows for vehicles that are either fully electric or hybrid to not only just be vehicles when they are driving around but can also become “self-contained resources that can manage power flow and displace the need for electric utility infrastructure” (Sovacool & , 2018), allowing for power to be used from the batteries when the grid is experiencing peak power supply times. The vehicles will then recharge when there is less of a demand for power such as in the night-time. Throughout the report issues regarding electricity demands, ethical issues, practicalities of the technology and the current charging technologies. The report will also analyse whether a V2G roll out would be feasible in either just an industry and company level or have the possibilities of working for a nationwide domestic level as well. To do this I will look at the costing of having a V2G system installed in a domestic setting and looking into current trials and schemes that are available to reach a wider domestic/industry market

2.0. Literature Review

2.1. Domestic and Company

The use of Vehicle to grid technology at a domestic level does have the potential to work as this is one of the main areas it is targeted due to most electric vehicles being parked up overnight on charge allowing them to have power when the grid is a low demand. The traditional peak in power in the UK is usually from 6pm to 8pm in the evening (national grid, 2020) this is mainly due to people getting home from work and charging cars and powering their homes. According to the national grid the peak power supply in the UK is around 52GW during peak times and if the whole of the UK were to switch to electric vehicles tomorrow the national grid quote that “demand would only increase by around 10 per cent” (national grid, 2020). This would still be under what the maximum output for the grid, but if there was an option to be able to put power back into the grid via the left over electricity this would go towards reducing the need to burn more fossil fuels during peak times and allow for the vehicles to be charged over night when more renewable energy sources can be utilised throughout the night such as wind and hydro energy or if the vehicle is not needed until the previous evening solar power could then also be used instead of fossil fuels.

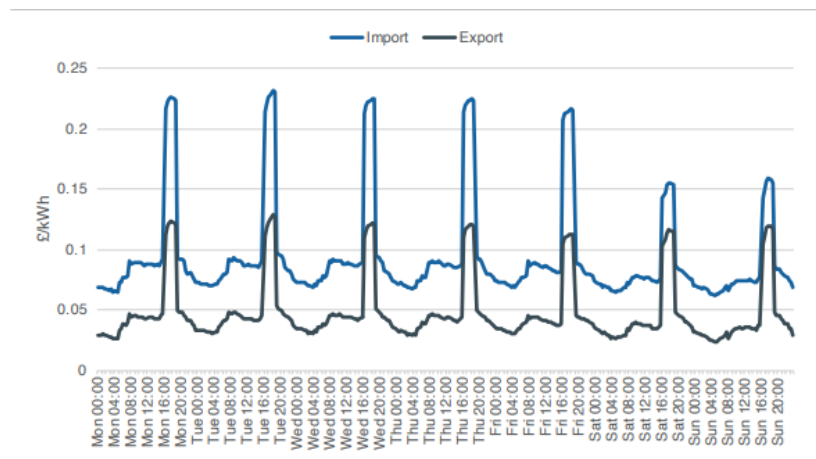


Figure 1 mean tariff prices throughout week UK

When investigating at the drawbacks of the vehicle to grid technology the first issue is the upfront starting cost to get all the equipment needed to start sharing power between the grid and the vehicles that we drive. The average cost of a V2G smart charger based off smart home charge website which sells 7 of the latest smart chargers is £761.91 and with a study recently completed in 2020 of 300 vehicle to grid units found that the “installation costs: By the end of the trial, the V2G hardware and installation cost was around £3,700 higher than that of a smart ChargePoint” (worlds largest vehicle to grid trial, 2021). The average cost of installing a smart vehicle to grid charger could be up to an additional £4500 or more on top of the cost of the electric vehicle which due to current technology are still fetching higher prices than their conventional ICE counterparts. This additional cost is enough to turn potential uses of the technology due to its expense and seemingly low returns, however there are currently grants available (OZEV grant) to help bring the overall cost down by giving up to an addition £350 off the chargers. Looking into one of the biggest roll outs of vehicle to grid technology in the UK where a company called Kaluza is pioneering the UK development of the technology with their estimated return s off vehicle to grid technology is 13/14p/kWh more than what the average cost was in the UK in 2020 at 17.2p/kWh (smith, 2019), yet “V2G owners get paid for the energy sold back to the grid from their vehicle at a rate of 30p per kWh and use Kaluza’s mobile app to tell the platform when they would like their car ready to drive. This data feeds into Kaluza’s real-time automation engine so that the platform enables the V2G-connected cars to charge using the cheapest energy.” (ofgem, 2021) and according to the trial run done through Kaluza “Customers in the trial have been able to earn as much as £725 a year without needing to do anything except keep their cars plugged in when they are not in use.” (ofgem, 2021),. Other sources have stated that “Ovo Energy estimates people could save up to £305 on energy bills” (porter, 2021).

One big issue that surrounds the electric car movement and will have a big effect on the V2G systems is access to chargers. “The majority (roughly 60:40) of UK dwellings have off street parking.” (roseanne, 2021), this still leaves at least 40% of the UK without off road parking to be able to charge safely and this does not include houses with only one drive way spot as the majority of UK homes were not designed to have more than one vehicle making other cars in the household park on the streets. It would not be feasible to have cables running over the streets as shown in figure 2, this would end up being a trip hazard and the vehicles owner could face legal problems if there was an injury due to their negligence. “If you can and did run a cable, then any issues (such as pedestrians tripping and hurting themselves or wheelchair users / prams not being able to get by) would be your direct legal responsibility – so the risk may not be worth the reward.” (woodhouse, 2021)



Figure 2 BMW i3 charger running over the pavement

This system would also struggle to work in places where flats are a common sight. It would then involve rewiring the car chargers to peoples flats as this would prove even more costly than setting a vehicle to grid system up in a house and currently the technology isn't cheap enough to justify its use nationwide.

2.2 Factory

The use of vehicle to grid technology could be very beneficial to a company's and factories if the business has a fleet of electric vehicles at its disposal there could be used to supplement the companies electrical use when the vehicles aren't in use on weekends for example. The use of the Vehicle to grid technology could be implemented in larger service vehicles such as buses and coaches as a lot of these vehicles can spend hours parked up in the evenings as school runs and bus routes would tend to be done by the evening this could allow for companies to let the rest of the power that are in the vehicles to go the grid at the peak times and then recharge the vehicles overnight when demand on the grid is lower. This could result in lower tariff for buses as the price of fuel (electricity in this case) will be a fraction of what it was if the vehicle ran off diesel and "can help reduce the annual cost of electric fuel (equivalent to an average 9,000 miles per year per V2G charger, enough to run your vehicles for free." (edf energy, 2021) . Having lower running costs for businesses vehicles could see the savings passed on the customers in the long run no matter what type of business.

3. Discussion

The Battery's that are found in electric vehicles only have a finite number of cycles, this can effect the life span of the vehicles battery's if not carefully and properly looked after, this may also hinder the regular user from using a V2G system as if there is a potential to damage and reduce the lifespan of your electric car battery is it really a feasible option or will potential user be put off by this and just charge the vehicles up as normal . "As lithium-ion batteries age and undergo charge cycles they lose both charge capacity and power capability, which in turn causes a battery-powered vehicle to become less efficient and able to travel shorter distances between charges." (Uddin, Dubarry, M, & Glick, M, 2019). While this could be the case that battery performance has the potential to be effected by the technology, there is also studies that have shown results that may increase the overall lifespan of the battery but "using a battery in a V2G scenario does not necessarily degrade its

performance – in fact, it might conceivably improve it.” (morris, 2017),. While this could be the case no real-world long-term test has currently been implemented as the technology is so new and the only data available to discuss are either simulations or short-term testing.

V2G technology has a main drawback that when the car is plugged back into the grid, the vehicle has then lost its range and usability due to the charge in the battery pack being used by the grid. This would mean that to use the technology you would need to not use the car for a long period after it was plugged in as it would then need to recharge when the grid was not at peak power therefore the vehicle will not be in a ready to go state.

The vehicle to grid charging system uses an intelligent charger “The EV driver must be able to communicate when they want to unplug the car and how full the battery should be at that time.” (Virta, 2021). This allows for the batteries to be charged “to 70-90% when the driver needs to go.” (Virta, 2021)making sure the driver has enough to charge to get where they are going.

There is also a main issue that surround the vehicle to grid technology and that is the AI technology and algorithms that will have to be included into the smart chargers, so they are able to have your vehicle ready for you at the point of use. There is a potential for ethical issues to arise from this as the smart chargers will need to be able to understand how and when you use your vehicle as the intelligent chargers already need to know “ real-time market signals - such as wholesale electricity price feeds, weather and grid data - to automatically charge V2G-connected cars when prices and carbon levels are low, and instruct cars to export energy to the grid when the local grid needs support.” (ofgem, 2021) along with If the vehicle is not used overnight and say for example is used 5 times a week to do a 20 miles journey to work and back and the car is set up on a Vehicle to grid charger will the charger will need to know what times you need the vehicle for and also how much power to put into the battery so you use to get to work, school run etc, so that the vehicle can be charged enough to get back and forth without worrying if the vehicle will have enough charge before leaving the house and giving the user range anxiety even though “With 98% of car journeys being under 50 miles in distance” (joju solar, 2020)

Issues may arise if the vehicle is needed in an emergency as the batteries could be nearly empty even though it may be plugged in for several hours but would have been used to power the grid leaving the user with not enough charge to use the vehicle. There’s also benefits to the technology in emergencies as the car can be used to power your home. “A typical electric car has a battery that can hold about 60 kilowatt hours (kWh) of energy, enough to provide back-up power to an average U.S. household for two days” (Gorguinpour & lashof, 2019)and with the current situation in states like California where global warming is causing huge wild fires cutting people’s homes off for days if not weeks this system could be lifesaving.

The technology does have the potential to be successful and produce returns but seeing as the upfront cost is still very high due to it being a new technology it would take over 6 years to recoup the initial investment and by that time the technology will be outdated and something new will have come onto the market by then. Currently in the UK there are only “330 V2G devices” (ofgem, 2021) installed in the UK giving consumers back many free miles of travel which indicates that the technology is still in its infancy stage and not yet designed for the mass market.

Current vehicles that are compatible with the V2G technology are the ones that include CHAdeMO fast charging system “Currently, only the ‘CHAdeMO’ DC connector is compatible with V2G, and so only car models that support this connector are V2G compatible. As of May 2021, the models that accept a ‘CHAdeMO’ connection are: Nissan Leaf 40kWh, Mitsubishi Outlander PHEV, Toyota Prius

Plug-In, Tesla Model S (when fitted with an adapter), Nissan e-NV200 (van), Kia Soul EV, Citroen Berlingo Electric, Citroen C-Zero, LEVC London Taxi ." (what is vehicle to grid , 2021). Slowly more and more vehicles are coming out with vehicle to grid capabilities, as in 2019 there was only two vehicles that has this capability and that was the Nissan leaf and the Nissan e-Nv200 as Nissan was the first to bring out CHAdeMO in its electric cars.

3.1. Ethics of vehicle to grid technology

Whilst researching vehicle to grid technologies it is hard to skim over the fact that at the heart of the eco-friendly technology lies big battery. Even though on the surface a battery technology seems to be the answer for the future of the automobile there are a seemingly huger number of problems that go with it. Looking into the ethics of electric vehicles and V2G charging, there are a lot of issues that will face the technology and potentially hinder its roll out for the mass domestic market. Firstly, is the big issue that looms over the electric car market and that is the processes and technology used in the manufacturing of the "eco-friendly" batteries is far from the ideal situation with batteries replacing the natural resource that is crude oil which is heavily used in the ICE vehicles but instead using precious metals such as Lithium, Cobalt and Nickel.

Lithium is the popular choice for battery technology as it has a very low density so can store a lot of energy. Lithium has also been called the new "white gold" as it is a natural resource like oil. The problems with lithium mining won't be seen in most first world countries with "The majority (58 per cent) of lithium comes from Chile" (griffiths, 2021) and another source stating that "Around one-third of the world's lithium — the major component of the batteries — comes from salt flats in Argentina and Chile, where the material is mined using huge quantities of water in an otherwise arid area" (nature, 2021). The mining problem for lithium not only strips the country of a raw material but the effects are felt by the population who currently live there, as "in some areas 65 per cent of the water supply is used in lithium and other mining activities. This leads to the forced migration of populations from villages and the abandonment of ancestral settlements thanks to water scarcity and an increasingly erratic water supply, the report warns." (griffiths, 2021). This level of mining is not sustainable for any country involved as it is ruining natural resources and the only people to really gain for the mining aren't the locals working there but the foreign investors who have set up the mines in the first place.

Another raw material used in battery production is cobalt, cobalt is commonly found in the Democratic Republic of the Congo where "Nearly 50% of world cobalt reserves are" (UNCTAD, 2020). The Artisanal mines (posh way of saying slave mine) are responsible for "About 20% of cobalt sourced from the central African nation comes from artisanal mines, where some 40,000 children work in extremely dangerous conditions, according to UNICEF, the UN's children's agency." (UNCTAD, 2020). The conditions of these mines are terrible with their long working hours for little to no pay, "Pay is based on what they find. No minerals, no money. And the money is meagre — the equivalent of \$2 to \$3 on a good day" (C.Frankel, 2016). The conditions that these people have to work in usually are very toxic and where "For years, human rights groups have documented severe human rights issues in mining operations. These human rights risks are particularly high in artisanal mines in the DRC, a country weakened by violent ethnic conflict, Ebola, and high levels of corruption. Child labour, fatal accidents, and violent clashes between artisanal miners and security personnel of large mining firms are recurrent." (Campbell, 2020)

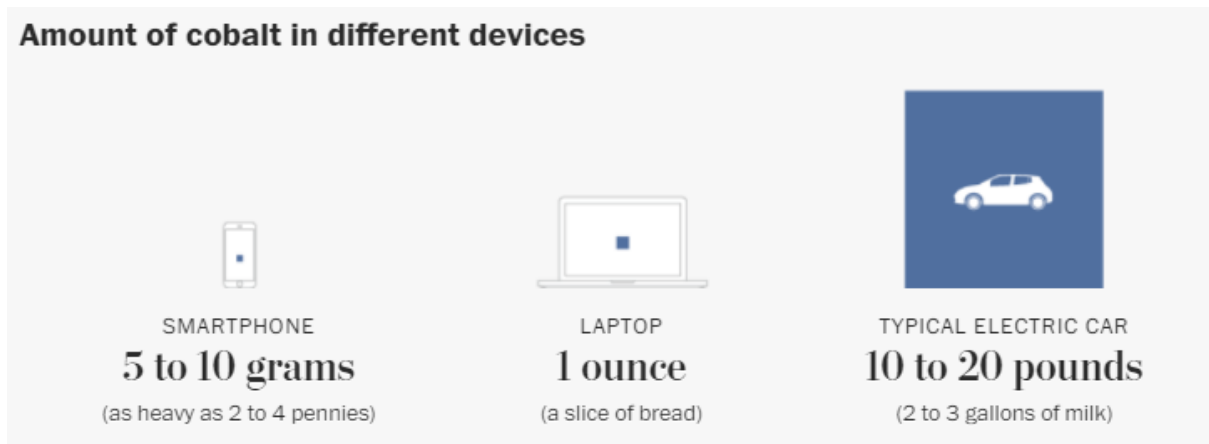


Figure 3 cobalt needed in different batteries

Conclusion

Vehicle to grid technology is not something that should be overlooked when considering options for a more sustainable replacement way of charging electric vehicles. Even though the compounds found battery technology isn't the cleanest way and most eco-friendly way to replace the ICE systems, they are currently and will keep being manufactured regardless and is better to utilise electric vehicles and their technology whilst they are being produced. With various sources stating different returns from the vehicle to grid systems it is hard to say whether the technology is currently viable for the domestic user as monthly returns are being seen each month, but the downfall is mainly the huge upfront costs of up to £5,500 for a charger (worlds largest vehicle to grid trial, 2021). If a charging system can be acquired through a trial scheme or grant which there are programmes running it will then be viable. The technology is currently only available for a limited number of vehicles which are mainly manufactured by Nissan so would be more widespread if other manufacturers such as Tesla would be on board with the technology. Due to the technology being relatively new unless your vehicle is on a trial there isn't much chance of using the technology domestically as "vehicle to grid offer is currently only available to business customers" (edf energy, 2021). This technology is more than likely to be included into our lives in the future even more so now as reducing bills during the current UK energy crisis any help towards reducing cost and lowering the amount that grid is relied as currently "Around half of the UK's electricity is generated by burning fossil fuel in gas-fired power plants" (Ambrose, 2021). This technology could benefit everyone in the future and has the potential to work with all types of electric and hybrid vehicles such as hydrogen electric and plug in electric hybrids as because of precious metal mining required for batteries could see a shift towards smaller batteries and a larger investment into hydrogen technology as the extraction processes being a lot more environmentally friendly.

Vehicle to grid technology will reduce the country's levels of CO₂ as it will allow for more renewable energy to be used whilst charging electric vehicles be that Domestically or Company/Factory based. The renewable energy that is used will help be part of the solution to get to Net zero by 2050 which is a target set by the UK government and as well as going towards the Paris agreement target of a reduction in CO₂ emissions of 55% by 2030, and vehicle to grid technology when used with other technology will have an impact in reducing motor vehicle tailpipe emissions and drive a more sustainable future in the automotive industry.

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