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THE IMPACT OF VECHICLE-TO-GRID TECHNOLOGY ON ELECTRICITY QUALITY

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ABSTRACT- Adverse effects of fossil fuel burning and internal combustion engine vehicles have alarmed nations worldwide. Governments are taking steps to promote the use of Electric Vehicles due to less carbon emissions and to pacify the environmental issues. The added load of Electric Vehicles poses a threat to the existing grid which leads to instability of the grid. The problem of demand supply mismatching can be solved by integrating the renewable energy sources with Electric vehicle charging station resulting in bi-directional flow of power. Vehicle to Grid technology helps the utility with active and reactive power support by feeding power from battery pack to grid and vice versa. Vehicle to Grid describes a system in which electric vehicles, plug-in hybrid, fuel cells electric vehicles are connected to the power grid to provide high power, spinning reserves, regulation services etc. The perspective of this study is to evolve a smart charging schedule based on the load on grid, time of use of the EV and other factors in order to minimize cost of charging for electric utilities and EVs as well as promote profits to EV owners.

KEYWORDS - Electric Vehicle (EV), Smart Charging Schedule, Vehicle to Grid (V2G).

INTRODUCTION :- Nowadays, the demand of electricity is increasing which requires the enhancement in power generation. The diminution of fossil fuels has also become a matter of concern to the world. The prolonged use of fossil fuels also leads to environmental hazards such as GHG and CO2 emissions. To promote sustainable, low emission development, many countries are adapting renewable energy sources to meet the load demand. Integration of renewable energy sources such as solar and wind has become possible but they are more variable and uncertain than conventional sources; also, it requires changes in the power system planning and operation. Therefore, it is necessary to build an energy storage system which will improve the power quality of the grid which leads to increase in the capital cost of the system. Electrification of Transportation sector assures a reduction in the environmental issues. It is an effective solution to reduce GHG emission caused by combustion engines. Additionally, electric companies can improve power quality by employing EV integration. Electric vehicles have become very popular in recent years and a continuation of this trend can be predicted in the near future until the day most of the transportation sector will comprise of EV. A big portion of vehicles are expected to be parked during a major part of the day. This idea can be used to facilitate V2G technology. During these idle times, plugged-in EVs can be used to support bidirectional power flow between utilities and EV batteries.V2G is the latest attraction in the field of EVs and their integration with electric grid. According to this concept, bidirectional flow of electric power is

taken into consideration, that is power can be taken from grid to charge EV batteries during off-peak hours and power can be provided to grid during peak hours from EV batteries to reduce utility load. This paper reviews and analyses the app.

METHODOLOGY:

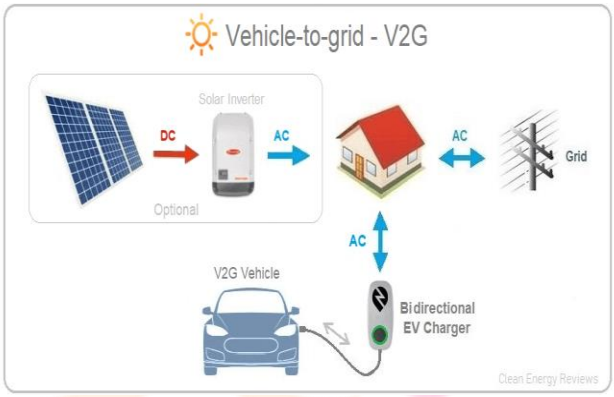
VEHICLE TO GRID (V2G)

Vehicle-to-grid (V2G) technology allows an electric vehicle (EV) to send power into the electricity grid using a bidirectional (two-way) charger controlled via a remote management system. Some vehicles with V2G can also be used to supply backup power. However, V2G should not be confused with Vehicle-to-home (V2H) or Vehicle-to-load (V2L), where the vehicle is used to power a home or loads rather than send power to the grid.

V2G technology allows an electric vehicle to synchronize with the electricity grid and inject power back into the grid using a specialized bidirectional charger. These advanced devices contain sophisticated power converters which can either charge the EVs battery or send power back to the grid when instructed, such as in times of high-power demand to help stabilize the grid. However, for it to function, the following three prerequisites are required:

1. *An electric vehicle with V2G capability.*
2. *A compatible bidirectional charger.*
3. *The owner must participate in a V2G program such as a VPP.*

V2G technology can help stabilize the electricity grid by paying individuals to allow the local grid operator to use some of their EV battery capacity for grid support services. However, you cannot simply connect a bidirectional charger to an EV and start feeding power into the grid without having approval from the grid operator. For it to work, the grid operator must be able to manage the bidirectional charger remotely and control the amount of energy injected into the grid. This remote management is typically done via a Virtual Power Plant program (VPP), which we explain later.



WHAT IS A BIDIRECTIONAL CHARGER?

Wall box Quasar bidirectional charger

Put simply, a bidirectional charger is an advanced two-way charger that can charge and discharge an EV battery. Compared to regular EV chargers that charge using AC (alternating current), bidirectional chargers can convert AC to DC (direct current) when charging, and convert DC battery power back to AC which is sent back into the grid. However, this advanced

power conversion comes at a price, and bidirectional chargers are still expensive due to the sophisticated power electronics needed.

There are a limited number of bidirectional V2G chargers on the market, but several companies have announced V2G chargers with more advanced features, such as backup power, which also enables vehicle-to-home V2H capability. V2H can power a home and allows an EV to store excess solar energy like a home battery system. These multipurpose chargers are often called V2X chargers.

EV BATTERY CAPACITY (KWH)

Before we explain the benefits of using V2G, it helps to understand the massive energy potential of EVs. Regular passenger vehicles spend most of their time parked at home or work. Unlike regular ICE (petrol/diesel) vehicles, EVs have large, powerful battery systems that can be utilised when parked, thus providing an alternative use for these untapped energy sources. For instance, an average EV has a battery capacity of 60kWh, which is six times larger than a typical 10kWh home battery and around three times more energy than an average household uses per day, which is closer to 20kWh. So just one EV could potentially power a home for several days.

DIFFICULTIES WITH BIDIRECTIONAL CHARGER STANDARDS

One of the reasons why Vehicle-to-grid has been very slow to roll out is because the standards around V2G are difficult and complex as they involve regulating the power, safety and electrical requirements **WHEN** discharging energy into the grid. These standards are still under development and are similar to solar inverter standards and requirements. UL9741 is a new proposed safety standard for bidirectional EV charging system equipment. This standard is built around the UL1741 (safety standard) and the IEEE1547 standard for interconnecting distributed energy resources (DER) with electrical power systems. While V2G trials are taking place, industry and governments are working hard on developing and finalizing standards to ensure V2G technology can safely integrate with grid networks worldwide.

BENEFITS OF V2G

V2G technology can enable thousands of EVs to work in unison and act as a large distributed energy system, providing valuable services to the power grid. One way it can do this is by supplying energy during periods of peak demand, and charging up during periods of low demand, effectively balancing the grid. This orchestra of EVs or fixed battery systems is referred to as a Virtual power plant (VPP), explained below. For instance, when an EV is plugged in, excess energy can be sent back during a heat wave when the grid needs more capacity to meet the extra demand from air-conditioning. In contrast, EVs can also charge during times of excess supply, such as when the wind is blowing on a sunny day, or when electricity costs are down due to low demand.

- Virtual power plants - VPPs

V2G technology enables EV owners to earn money or credit by participating in Virtual Power Plants, also known as demand response programs. People participating in VPPs are paid for letting either the grid operator or an energy retailer use some of the EVs battery, or a home battery, to help meet grid demand. VPPs typically use cloud-based software to control thousands of battery systems to create a virtual large-scale generator or storage system. However, not all participants may be available or allow their vehicles to be used. The EV owner may set preferences for when they want their EV to charge or discharge. For instance, they may enable the vehicle to discharge during the peak evening hours when electricity rates are higher, thus earning revenue, and charge during the cheaper off-peak hours or when there is excess renewable generation. The participant or VPP program may also limit use to only emergency situations where the grid may suddenly experience a surge in demand or a sudden lack of supply.

The South Australian grid currently has the highest penetration of wind and solar in the world, and the local grid network operator (SAPN) is now the first in Australia to allow network connection of V2G bidirectional chargers. See the full SAPN V2G media release.

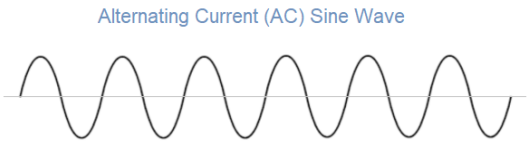
Additionally, Australian energy retailer AGL recently concluded the first internationally recognized VPP trial in South Australia, using 1000 home battery systems to help balance grid demand.

- Balancing the grid

One of the key benefits of V2G technology is that it can help reduce the need for expensive gas "Peaker" power plants commonly used to supply excess power during times of high demand. In many countries with unregulated (market-based) power grids, such as Australia, gas-peaking plants generally set the wholesale electricity price. This has become problematic as gas prices skyrocketed in 2022 due to supply shortages, and in turn, electricity prices have also surged by a similar margin. In comparison, decentralized energy sources such as wind, solar and battery systems, including EVs, have very low fixed operating costs and thus can reduce the cost of electricity. However, due to the intermittent nature of wind and solar, firming or battery storage is sometimes required to buffer the variation in output. This is where V2G technology can assist, as it acts as a buffer to enable the integration of more renewable energy sources, like wind and solar, into the grid.

- Frequency regulation

Electricity grids use alternating current (AC) and operate at a frequency of either 50Hz or 60Hz. For electricity generators, including nuclear, gas, solar and wind, to work in unison, the grid frequency must be very stable, and this is where frequency regulation is essential.



V2G can also be used for frequency regulation, which helps stabilize the grid by quickly

responding to sudden changes in supply or demand. For example, if a large GW (Gigawatt) scale thermal coal or nuclear generator suddenly trips due to a fault, the frequency can rapidly fall to the lower operational limit; this can have serious flow-on effects and even cause other generators to trip off. Currently, gas-peaking plants and large-scale grid batteries combined with grid-forming inverters are being used in many countries to help maintain grid frequency, and EVs participating in VPPs programs can work in much the same way. The combined energy of thousands of EVs can easily reach a gigawatt scale and be deployed rapidly when vehicles are parked in homes and garages during the evening peak electricity demand period. However, one of the biggest challenges of using V2G for frequency regulation is synchronizing all the V2G enabled vehicles with precision timing using a reliable cloud-based control system.

- Backup power

Bidirectional inverters used to enable V2G are not only used to provide grid support. These powerful devices contain power inverters, and most new bidirectional chargers can also enable backup power in the event of a blackout or emergency. However, for a bidirectional inverter to power a house independently of the grid, it must first isolate from the grid network, known as islanding. This capability is the same as vehicle-to-home (V2H) but should not be confused with vehicle-to-load (V2L), where the inverter is inside the vehicle. .

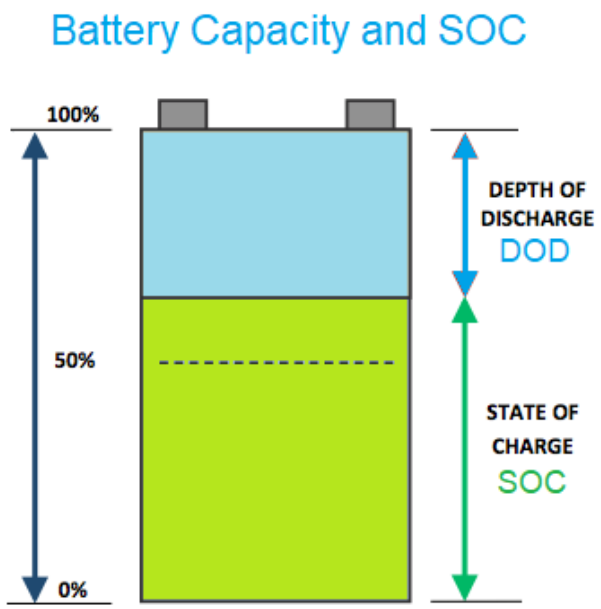
ISSUES AND CHALLENGES

While V2G technology has the potential to revolutionize the way we generate and use energy, many technical challenges still need to be overcome. Currently, several trials are being conducted around the world to help understand how V2G technology can be used and regulated. At this stage, the primary issues preventing the widespread adoption of Vehicle-to-Grid technology include the following:

- **Lack of standardization:** There is currently no standard protocol for V2G communication and interaction with the grid, which makes it difficult for different V2G systems to interoperate.
- **High costs:** The cost of bidirectional chargers is currently high, which makes it difficult for individuals to justify the investment.
- **Regulation:** The regulatory environment surrounding V2G technology is still uncertain, and different countries, regions and grid operators have different regulations and incentives.
- **Safety:** There are concerns about the safety of V2G systems, particularly in the event of power grid failure where the bidirectional inverter must disconnect from the grid while it is being repaired.
- **Limited EVs available:** There are very few EVs available that are compatible with bidirectional charging.

Despite these challenges, V2G technology has enormous potential in an increasingly decentralized energy system and may even hold the key to creating 100% renewable power grids.

WILL V2G REDUCE EV BATTERY LIFE?



There is a common misconception that using an EV for V2G services will dramatically reduce the life of the battery by discharging the battery more often. There is some level of truth in this, but the reality is the rate of discharge, and amount of energy used, are extremely low compared to driving an EV. For example, most V2G chargers are rated at 10kW; in comparison, when driving an EV, the power consumption will generally be closer to 20kW while cruising and often well over 100kW when accelerating. Thus, when an EV is used for V2G, the battery will be under very little stress and will not heat up or drain quickly. Additionally, V2G services will often only last for no more than 1 or 2 hours, so the amount of energy discharged will be relatively low. For instance, an average EV battery is 60kWh, and at full power, only 10kWh or 16% of the battery capacity will be used if the V2G service lasts 1 hour. Unless the vehicle is used for V2G services every day for a prolonged amount of time, which is presently not the case, there will be minimal effect on the battery life. Additionally, as the percentage of electric vehicles increases and thousands more EVs can participate in grid services, the demand per EV will reduce.

The latest generation EV batteries are engineered to have a 300,000 to 500,000km lifespan, so rough calculations suggest regular V2G use may reduce the lifespan by 50,000km, or approximately 10 to 12%. However, the real-world use of V2G services will evolve as the grid becomes more decentralized and increasingly renewable-powered. That being said, EV battery technology is also continuously improving. Next-generation solid-state batteries are expected to have a one-million-mile lifespan, so the detrimental effects of V2G will likely be reduced further.

CONCLUSION: - Vehicle-to-grid capabilities provides important services to grid operator, which includes the balancing of renewable peaks and valleys, providing spinning reserves, and balancing frequencies. In further studies it will be shown that V2G improves the technical performance of the grid in areas such as power quality, efficiency, stability and reliability. V2G technology also encourages the use of renewable energy sources like solar and wind energy which is beneficial in account of environmental conditions. The challenges to the V2G technology include battery deterioration, reduced life of PEV, need for comprehensive communication between vehicles and the grid, effects on distribution equipment, infrastructure changes, social, cultural and technical problems and increased cost of generation. These challenges can be mitigated by certain specific measures as mentioned in the paper. In addition to the points mentioned before, the benefits of V2G also include economy of operation for both EV owners and grid operators as well as environmental benefits. These benefits far outweigh the drawbacks and challenges as pointed out in the paper.