ChargePanel

V2G - An Overview

Vehicle-to-Grid (V2G)

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The industry for Electric Vehicle charging is developing at a fast pace and so are the solutions we provide. This document is a living document and may be updated with revisions and changes over time.

Introduction

With the increasing presence of electric vehicles in the electricity system, there is a concern about potential strain on the grid if many vehicles charge simultaneously. However, through the implementation of smart charging and Vehicle-to-Grid (V2G) technologies, electric vehicles have the potential to offer solutions rather than exacerbate the issue.

This integration of the transportation sector with the electricity system is crucial for the future, where the demand for storage and flexibility is expected to rise significantly.

V2G technology

Vehicle-to-Grid (V2G) technology operates by continuously analysing various factors such as real-time vehicle data, electricity market conditions, and user preferences to determine optimal charging and discharging times for electric vehicles (EVs). When an EV is connected for charging, the V2G system monitors grid status and adjusts the charging levels based on real-time grid conditions. During periods of surplus electricity, the EV can charge fully, while in high-demand situations where additional power is needed, the EV can discharge stored energy as required. These adjustments can occur automatically without any manual intervention from the EV drivers.

Participation in V2G programs requires customer consent, with participants receiving compensation for the energy their EV contributes back to the grid. Energy retailers or V2G service providers may calculate the exchanged energy and determine compensation based on agreed-upon rates. Compensation may come in the form of credits, reduced energy bills, or direct payments, depending on the program's structure.

Ongoing advancements in technology are driving the progress of solutions such as:

- Vehicle-to-Grid (V2G)
- Vehicle-to-Home (V2H)
- Vehicle-to-Everything (V2X)

While V2G allows cars to feed electricity back into the grid, V2X encompasses broader interactions between vehicles and surrounding systems.

Electric vehicle batteries can serve as **valuable resources** enabling EVs to function as:

- energy storage units
- emergency backup power sources for buildings

- chargers for other vehicles during emergencies
- contributors to grid stability and support services

Vehicle-to-Grid (V2G) technology holds significant promise for **enhancing the electricity system** in various ways, including:

- enhanced control and efficiency for vehicle owners during charging
- economic opportunities through selling electricity back to the grid

V2G can also address:

- local network constraints,
- provide flexibility for grid balancing
- deliver essential services like frequency regulation to support the overall electricity system.

The successful integration of electric vehicles into the grid necessitates **innovation across various fronts**, including:

- tailored customer offerings
- novel business models
- digitalization processes

Integration **may require updates** to:

- hardware in vehicles
- charging stations
- grid infrastructure, (such as meters and control systems)

As the landscape evolves, various market actors may assume new roles as service providers to facilitate this transition.

Potential (Sweden)

- Bidirectional charging provides significant flexibility for the electricity system.
- Approximately 90% of the installed battery volume could be in various types of vehicles in the future according to Svenska kraftnät.
- On average, cars are parked 96% of the time.
- A NEPP2 report estimated that 3.8 million chargeable cars could have a combined battery capacity of 114 GWh, potentially supplying all of Sweden with electricity for several hours.
- The Swedish Energy Agency predicts that by 2025, 2% of Sweden's vehicle fleet will have V2G technology, increasing to 10% by 2030 and reaching 100% by 2050.

Adaptions

- V2G technology requires new hardware such as additional power electronics in vehicles or charging stations to enable bidirectional current flow back to the grid. Upgraded hardware is necessary to support the advanced software required for V2G.
- The software for V2G must facilitate data exchange between vehicles, chargers, and the electricity system or property, involving information on contracts, tariffs, billing, energy needs, network codes, schedules, State of Charge (SOC), and technical variables.
- Data exchange requirements vary based on the service the vehicle's battery is providing, with different response time expectations depending on the targeted markets like national support services, energy arbitrage, flexibility markets, or self-consumption of solar power.
- Charging strategies need to be tailored considering factors like planned car usage and battery health impact.

AC and DC

- The choice between AC and DC charging impacts V2G equipment design for electric vehicles.

- Electric vehicle batteries require DC charging for V2G operations, while the electricity grid primarily uses AC transmission.

- Conversion from AC to DC for V2G can occur in the vehicle through an onboard charger or at the V2G-enabled charging station.

- Most electric cars designed for V2G have onboard chargers, necessitating additional power electronics for bidirectional charging capabilities.

- The location of power electronics and control systems in V2G setups influences communication handling and regulations compliance for feeding electricity into the grid.

- Ongoing development focuses on V2G solutions where costs for technology may be integrated into the vehicle or the V2G charging infrastructure.

- Combined inverters are technically feasible for V2G applications, such as integrating household solar panels with V2G-compatible charging stations.

Standards and Protocols

Standards and protocols play a crucial role in establishing interoperability among diverse products, systems, within the electric vehicle (EV) ecosystem and the grid, with further development needed for mainstream adoption of V2G technology. With a multitude of actors, standards, and protocols governing hardware and software from EVs to the grid, a comprehensive approach is essential for Vehicle-to-Grid (V2G) operations to succeed both in regulatory compliance, technical functionality, and unlocking the business potential to offer diverse services to the electricity system.

Industry standards play a crucial role.

OCPP (Open Charge Point Protocol): Developed since 2009, OCPP facilitates communication between charging stations and the Charging Station Management System (CSMS). It ensures interoperability in EV charging networks.

ISO 15118: provides for bidirectional energy transfer,allowing EVs to feed energy back to the grid This standard also provides a Plug & Charge mechanism, allowing EV drivers to connect to public chargers without using a mobile app or credit card. The vehicle directly communicates with the charger.

IEC 63110: Still in development, IEC 63110 aims to contribute to the interoperability of EV charging systems.

IEC 63119 IEC 63119 is still in a relatively early phase. At the moment, charging is often organized through the Open Charge Point Interface (OCPI), an open-source protocol that allows eMSPs to communicate with CSOs.

Effective communication is vital at various stages involving EVs, chargers and the electricity system.

The following four main communication flows have been identified:

- Communication between electric vehicle (EV) and charging stations (EVSE/CP)
- Communication between EVSE and the central control system (CPO) (Back-end)
- Communication between CPO and EMSPs/E-Roaming platforms
- Communication between the CPO and the energy system (integration with the power grid)

International and European standardization organizations are currently working on developing standards that are interoperable with each other.

For communication between EV-EVSE it’s suggested ISO 15118–20 be used.
For communication between EVSE-CPO, IEC 63110 is proposed.
Between CPO and EMSPs/E-Roaming platforms IEC 63119 is under development.

Business Models and Incentives

- EVs offer larger storage potential for households compared to home batteries, with capacities ranging from 60 to 80 kWh in Sweden's common electric cars, surpassing the typical 10 kWh capacity of home batteries.

- Higher storage capacity enables households to maximize self-produced solar power utilization, optimize consumption against spot prices, and provide support services on multiple markets.

- Incentives for flexibility and storage must be enhanced to boost interest in Vehicle-to-Grid (V2G) technology.

- Energy tax structures currently hinder V2G adoption by discouraging storage and favouring direct electricity use.

- Bidirectional charging applications, focusing on using stored electricity locally, have been particularly appealing in Sweden.

- V2G revenue opportunities include offering support services to the electricity system and participating in frequency regulation markets.

- Aggregators play a crucial role in enabling small-scale resources like home batteries and electric cars to participate effectively in energy markets.

- The aggregation of flexibility needs further improvement to incentivize electric vehicles to contribute to support service markets managed by Svenska kraftnät.

Batteries

- Battery degradation in Vehicle-to-Grid (V2G) systems can impact the profitability of V2G operations and is influenced by cyclic aging and calendar aging.

- Cyclic aging, affected by factors like charging cycles, speed, energy per cycle, etc., results from charging and discharging cycles.

- Calendar aging, dependent on the battery's physical age and State of Charge (SOC) at rest, can be accelerated if the electric car is frequently parked with a high SOC.

- The impact of V2G on battery degradation compared to other charging methods is uncertain, with studies suggesting V2G may accelerate cyclic aging.

- Charging without smart technology considering the SOC can intensify calendar aging effects.

- Research challenges exist due to the time-consuming nature of low-power charging cycles for studying battery degradation.

- Electric car manufacturers are keen on research collaborations to assess battery warranty designs concerning bidirectional charging practices.

Regulations

- Legislation, regulations, and policy alignment needed for V2G implementation.
- Challenges requiring further investigation for V2G implementation.
- No direct legal obstacles to feeding electricity from a car into the grid.
- Requirements for implementing V2G: meter for measuring fed-in and fed-out electricity, feed-in subscription, and electricity buyer.
- Lack of specific regulations for V2G classification when connected to the grid.
- Proposal to treat bidirectional charging like a fixed electric production installation.
- Uncertainty about grid feed-in subscription design for V2G and need for updates.
- Consideration of the car itself as a grid feed-in point for V2G services.
- Challenges with grid regulations (grid codes) not adapted for mobile flexible resources.
- Need for vehicles to adapt to grid codes in their current location.
- Uncertainty around responsibility for following grid codes in AC-based V2G under ISO 15118 standard.
- Taxation issues: electricity taxed multiple times when stored and fed back onto the grid.
- Swedish Tax Agency's refund possibility for electricity fed back onto the same grid.
- Limitations for V2G users living and working in different electrical grid areas.

Summary

Interest in Vehicle-to-Grid (V2G) technology has surged recently, with numerous pilot projects, academic studies, and industry initiatives underway. The potential for large-scale commercialization within five years is recognized by many industry players.

However, before widespread adoption can occur, several key issues must be addressed:

- Strengthening incentives, resolving storage, flexibility, and aggregation challenges, updating standards, regulations, and industry practices for V2G support are crucial.

- Reviewing tax and VAT rules, adapting business models and markets, and enhancing awareness among industry stakeholders and users are essential steps.

- Digitalization and optimizing control signals from the grid are critical considerations.

- Increasing the availability of bidirectional charging-capable car models and chargers, reducing technology costs, and deciding on control location (car or charging station) are important decisions to make.

As barriers are overcome, V2G holds significant potential to reduce system costs, enhance resource efficiency, enable car owners to generate income through market participation or increased self-use of solar power. The effective utilization of car batteries' capacity in the future can bring substantial benefits to both car owners and the electricity system.

References and Further Reading

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ECOS, Environmental Coalition on Standards - Standards for EV smart charging: A guide for local authorities

Do you have questions?

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