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A Literature Review Of Electric Vehicle To Grid Technology

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Abstract-
Increasing greenhouse gas emissions, depletion of fossil resources, the oil crisis and rising petroleum prices necessitate a switch from internal combustion engines to electric vehicles. Commercial EV deployment need a big charging infrastructure. Vehicle to Grid is a new developing technology since many EVs may be utilised as load and energy storage to assist the grid. However, uncoordinated EV charging illustrates the system's critical significance. So optimal V2G coordination is required. Thus, this study covers a full V2G system investigation. The paper discusses the V2G power flow approach. It also highlights the main business challenges to V2G adoption. A comparison of the state of the art for V2G, V2H, and V2V is also provided (V2V). In a coordinated V2G system, several optimization strategies assist the optimal energy management system.

Keyword: Electric Vehicle, Vehicle to Grid, Unidirectional, Bidirectional, Genetic Algorithm

1. Introduction

V2G stands for “vehicle to grid” and is a technology that allows an electric car's battery to send energy back to the grid. With electric vehicle-to-grid technology, a car's battery may be charged or emptied dependent on surrounding energy output or consumption.

Vehicle-to-everything. It contains V2H, V2B, and V2G services. Using an EV battery to power your house or building requires various acronyms. Your car can function for you even if you don't feed back to the grid.

In a nutshell, vehicle-to-grid charging is comparable to smart charging. Smart charging, also known as V1G charging, allows us to regulate the charging of electric automobiles by increasing and decreasing the charging power as needed. Vehicle-to-grid allows charged electricity from automobile batteries to be temporarily transferred back to the grid to balance fluctuations in energy output and consumption.

EVs initially appeared in the mid-1800s. Because of these advances, EVs became very popular in the twenty-first century. Internal combustion engines pollute the air by emitting enormous amounts of greenhouse gases, especially CO2. One of the world's greatest challenges right now is global warming. Many governments, particularly the US and EU, have introduced numerous incentives to promote EV adoption.

Choosing EVs over internal combustion engines has a big environmental impact. EVs have improved air quality, reduced noise pollution, and helped reduce greenhouse gas emissions. In 2017, 1 million electric automobiles were sold, bringing the total to over 3 million. International energy predictions predict a 3 million to 125 million EV rise by 2030. Figure 1 illustrates 2017 EV sales by region. A new market for electric vehicles is forming.

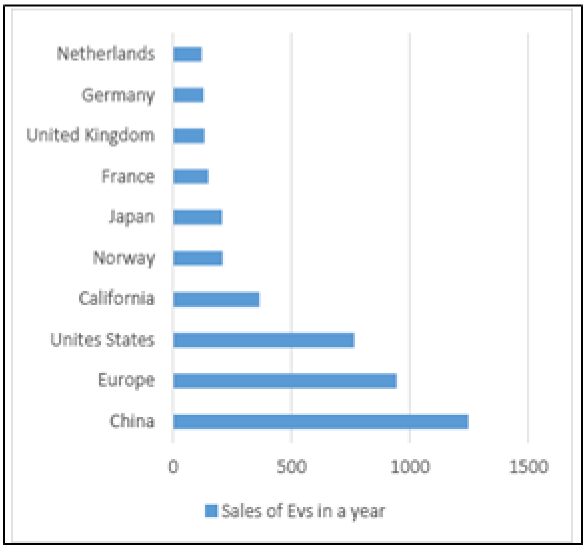


Figure 1 Sales of EVS During 2017

India has 10 of the twenty most polluted cities in the world. Transportation sources contribute one-third of all pollution (PM). Thus, India should be a perfect market for EVs. A source estimates 4.7 GW of EV storage in 2022. Delhi, Jaipur, and Chandigarh will get 200 charging stations. Smart Charging Company of India announced a billion-rupee investment in charging infrastructure.

Figure 2 depicts "V2G" and "G2V" energy transfers between a vehicle and the grid. Figure 3 depicts the survey of an Odhpura 132 kV substation in Uttar Pradesh's Hathras district. The table shows the daily fluctuations in demand for a substation. The substation's minimum demand is 18.86 MW at 5 a.m., while its highest demand is 48.99 MW at 1 p.m. Demand varies greatly between peak teams and off-peak times. So, the EVs would be completely charged during off-peak hours and feed power back to the grid during peak hours. The V2G technology is designed to overcome the problem of EVs acting as energy storage units. During off–peak demand, the EV user can buy electricity from the grid at a cheaper cost, and sell electricity to the grid at a higher cost. Thus, EVs are mobile energy storage devices.

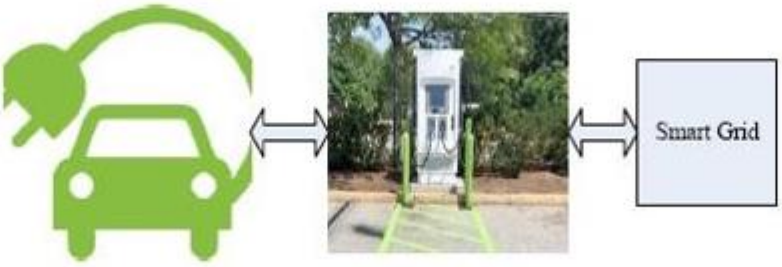


Figure 2 V2g And G2v

Figure 4 summarises credible journal work. Articles published at IEEE conferences are shown in series 1, whereas papers published in Elsevier and IEEE journals are shown in series 2 and 3.

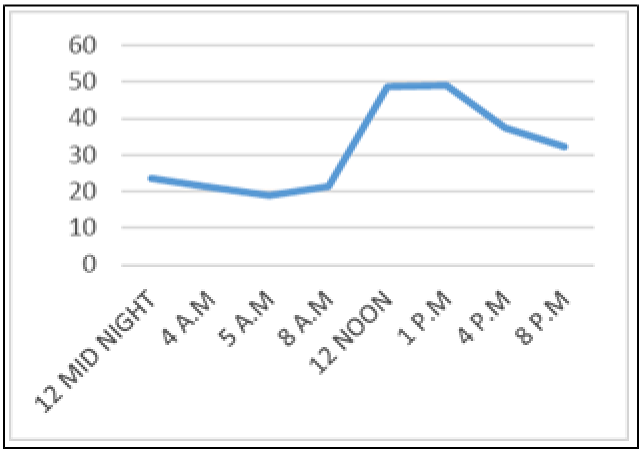


Figure 3 Variations in Demand

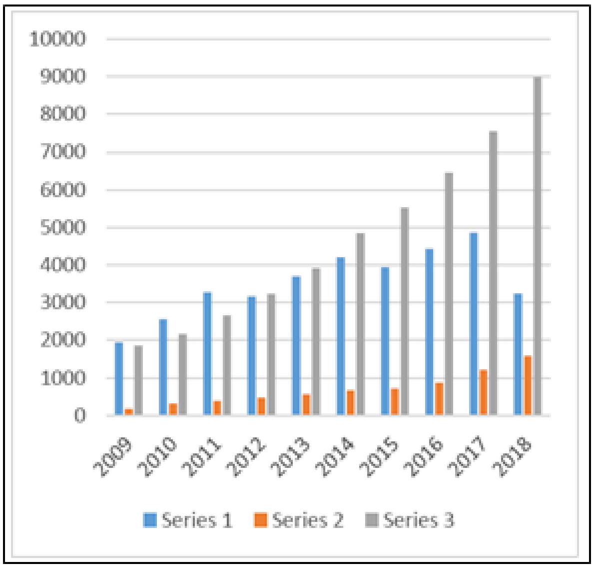


Figure 4 Number of Research Papers Published

Sections of the papers are included below. In Section 1, we give a brief introduction. Using a power flow diagram, Section 2 explains how to implement this strategy. The V2G system administration is covered in Section 3. Among the advantages of the V2G system are those outlined in Section 4. Comparisons of V2G, H, V2V are made in Section 5. The V2G system's roadblocks are discussed in detail in Section 6. The V2G system optimization methodologies are discussed in detail in the next section. Optimising goals is the focus of Section 8. Section 9 wraps up and sets the stage for future projects. Citations can be found in Section 10.

2. Vehicle-to-grid (V2G) power flow methods

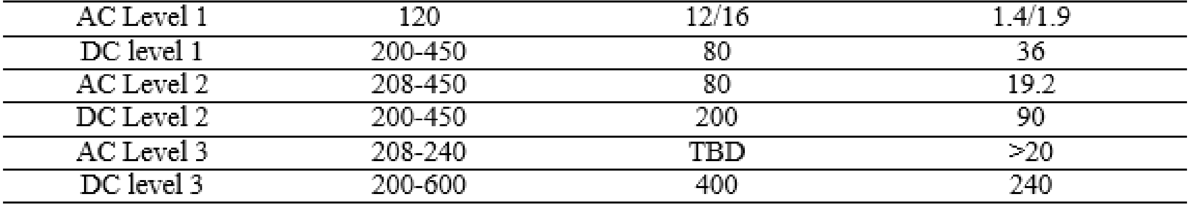
V2G allows three different types of EV. The success of the V2G system is dependent on excellent communication. Maintaining effective communication between the electrical grid and the electric vehicle battery is essential for power flow control.

The electricity company is interested in the benefits of the communication facility. Among the most important issues are profit maximisation, reduction of greenhouse gas emissions, and improvement of grid power quality.

2.1 Unidirectional V2G

Unidirectional V2G is a system that only allows one-way power transmission between EVs and the grid. Its infrastructure is appealing. The controller makes these methods uneconomical. The unidirectional technique improves grid control and spinning reserve. Smart trading promotes V2G.

Table 1 Charging Configurations and Ratings



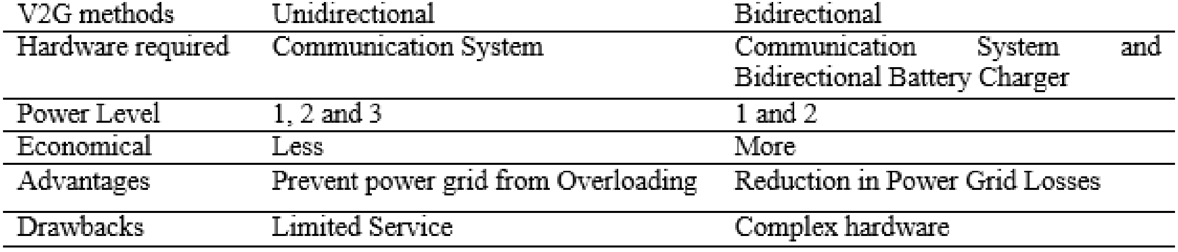
Methods of Charging	Supply Voltage (V)	Maximum Current (A)	Maximum Power (kW)
AC Level 1	120	12/16	1.4/1.9
DC level 1	200-450	80	36
AC Level 2	208-450	80	19.2
DC Level 2	200-450	200	90
AC Level 3	208-240	TBD	>20
DC level 3	200-600	400	240

Optimizing profit while reducing emissions is V2G. Table 1 displays the charging voltage, current, and power.

2.2 Bidirectional V2G

Electricity may flow in both directions between EVs and the grid. It beats V2G in certain ways. It contains AC/DC converters in both directions. Bidirectionally applied EV energy management solutions Table 2 compares one-way and two-way V2G.

Table 2 Comparison between V2G, V2H, and V2V



V2G methods	Unidirectional	Bidirectional
Hardware required	Communication System	Communication System and Bidirectional Battery Charger
Power Level	1, 2 and 3	1 and 2
Economical	Less	More
Advantages	Prevent power grid from Overloading	Reduction in Power Grid Losses
Drawbacks	Limited Service	Complex hardware

3. Management of V2G system

In addition to Optimal Energy Management, academics have recommended IEM and Battery Management Systems. Several charging strategies are envisaged for EV adoption. Concerning the V2G system, optimal placement of EV charging stations is required to avoid normal peak-load periods, thus lowering the impact on the power grid. Because V2G is a novel technology, V2G research is in its infancy. The V2G study focuses on each component's structure, practicality, and operation. EVs may help reduce grid load. EVs have two charging modes: mobile and parked. The study presents the energy management tactics and supervisory control algorithms utilised in EVs.

3.1 Centralized V2G management

Centralized V2G is a system that uses a timetable to collect EV energy in certain regions while managing charging and discharging tactics. Grids and charging stations work together to control peak-load for EV charging. The study discusses control strategies for various EVs.

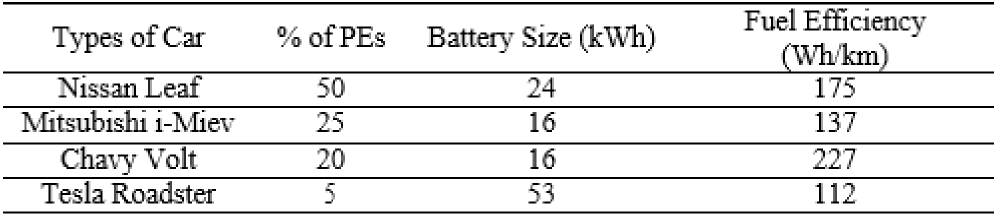
3.2 Independent V2G management

Centralised administration is difficult because of EV dispersion. Its smart charger responds to cost, reactive power consumption, and voltage changes. The study recommends G2V and V2G charging topologies for EVs. It varies by area and EV count. Since the EVs are scattered, there should be no central scheduling. The EV control centre, distribution system scheduling, and transmission system scheduling are all based on the hierarchy of control. The article proposed employing synchro converter technology to model and regulate a V2G charging station for EVs. The report offered a method for making a programmable EV charger. This EV charger can interface with a smart energy management system. It is intended for home use.

Management of battery pack replacements

The report proposed ways to improve the battery's energy storage capacity, safeguard it against over- and under-voltage, and make it easier to recharge. V2G analysis requires a new battery pack. This method resembles centralized V2G. The management strategy is different. Insufficient mileage is reduced by combining the benefits of both sat and conventional charging. The charging station must house a huge number of batteries. The V2G technique simply meets the grid's scheduled demand plan by replacing batteries. We now use centralised charging and battery replacement. The research presents and validates three clever unidirectional and bidirectional methods, including V2G and V2H.

Table 3. PEV Attributes [6]



Types of Car	% of PEs	Battery Size (kWh)	Fuel Efficiency (Wh/km)
Nissan Leaf	50	24	175
Mitsubishi i-Miev	25	16	137
Chavy Volt	20	16	227
Tesla Roadster	5	53	112

4. V2G services and advantages

This study discusses the benefits of V2G technology for PHEVs. Using V2G technology has several benefits in many nations. EVs, charging stations, the grid, and utilities all benefit. Here are a few:

4.1Ancillary Services

The paper provides extras. Ancillary services include spinning reserve and grid regulation. Auxiliary services are delivered to load using unidirectional V2G. So the aggregator can communicate with a large fleet of EVs. The electrical grid regulates the frequency to meet generation and load requirements. The spinning reserve compensates for the generation failure in 10 minutes.

4.2Active Power Support

The power grid uses EVs' extra energy in the V2G service. Only bidirectional V2G achieves this. This service's major goals are "peak load shaving" & "load levelling." The demand is frequently daily. EV supply is economical during peak load. Less load on power system components. EV owners will also enjoy a better energy tariff. The HPSA is used in households with PHEVs.

Backup energy for home

The study proposes a solution to RES by storing energy in an EV fleet. The V2G technology provides backup production for RES like solar and wind. In the case of large RES output, centralised power plants should reduce output. Charging and draining EV batteries attempts to match generation and consumption. Unused RES energy is stored in EVs and utilised when demand is high.

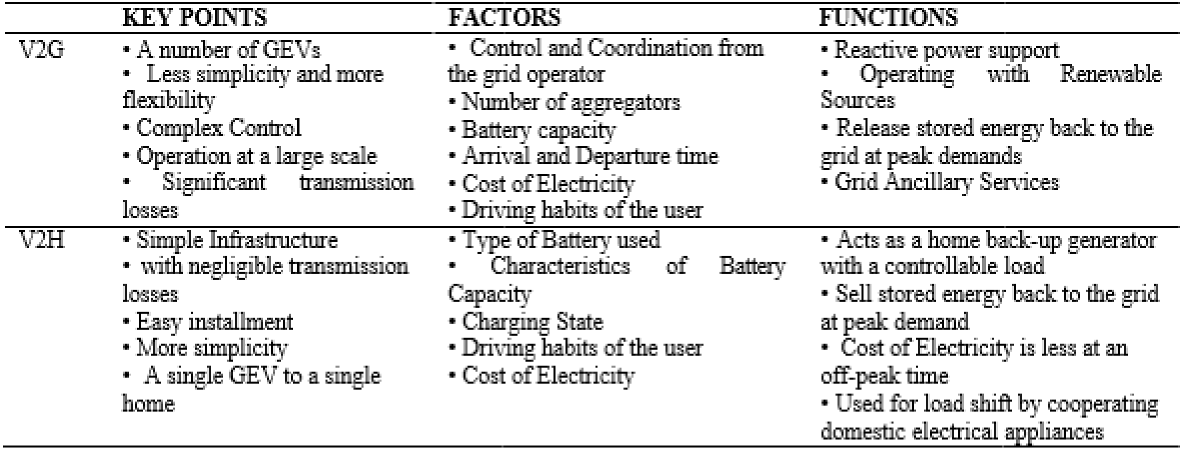
Reactive power compensation

The report covers V2reactive G's power adjustment as a crucial feature. Voltage regulation is critical to the V2G system's operation. Reactive power compensation regulates grid voltage. The power factor improves with reactive power. A reactive power compensator usually consumes reactive power. Capacitive reactive power is recommended in most circumstances.

5. Comparison between V2G, V2H, and V2V

Figure 5 depicts the technology used. Table 4 compares V2G, V2H, and V2V on major points, main factors, and functionalities. In some cases, V2G is better than V2H and V2V, whereas in others, V2H is preferable. Some localities favour V2V.

Table 4 Comparison between V2V, V2H, and V2V



	KEY POINTS	FACTORS	FUNCTIONS
V2G	• A number of GEVs • Less simplicity and more flexibility • Complex Control • Operation at a large scale • Significant transmission losses	• Control and Coordination from the grid operator • Number of aggregators • Battery capacity • Arrival and Departure time • Cost of Electricity • Driving habits of the user	• Reactive power support • Operating with Renewable Sources • Release stored energy back to the grid at peak demands • Grid Ancillary Services
V2H	• Simple Infrastructure • with negligible transmission losses • Easy installment • More simplicity • A single GEV to a single home	• Type of Battery used • Characteristics of Battery Capacity • Charging State • Driving habits of the user • Cost of Electricity	• Acts as a home back-up generator with a controllable load • Sell stored energy back to the grid at peak demand • Cost of Electricity is less at an off-peak time • Used for load shift by cooperating domestic electrical appliances

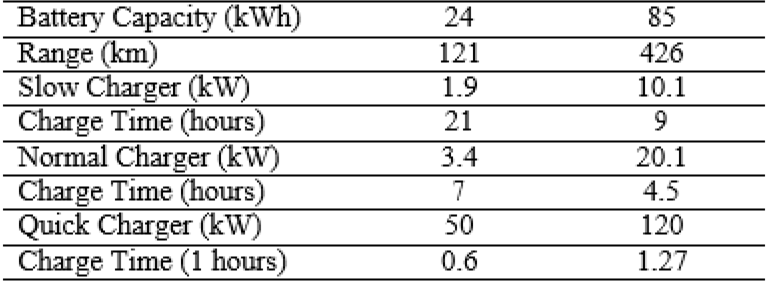
6. The Difficulties with V2G Technologies

An overview of EV infrastructure, charging systems, charging codes, and international standards is provided. While V2G has many benefits and services for the electricity grid, it also has significant drawbacks. V2G is still in beta. We face various obstacles in adopting V2G technology, including economic, social, and technical issues. On the distribution grid, the V2G system is vast.

6.1 Degradation of the battery

Battery deterioration is a big issue. 13% of the overall EV cost is battery. a battery-powered electric scooter prototype It's Li-on. It's a good scooter. A battery's charge/discharge cycles are limited. After then, the battery's performance degrades. Chemical reaction reduces battery capacity. Charge and discharge rates affect this impact. Heat and voltage are issues. The V2G technology requires a high cycle battery. An EV battery modelled in this article. Data for Nissan Leaf and Tesla are shown in Table 5.

Table 5. Battery Charging Times for Nissan Leaf and Tesla Models [30]



Specification	Nissan Leaf	Tesla Model
Battery Capacity (kWh)	24	85
Range (km)	121	426
Slow Charger (kW)	1.9	10.1
Charge Time (hours)	21	9
Normal Charger (kW)	3.4	20.1
Charge Time (hours)	7	4.5
Quick Charger (kW)	50	120
Charge Time (1 hours)	0.6	1.27

6.2 Investment Cost

The high cost of V2G installation is a deterrent. V2G needs new electricity. The V2G hardware and software should be improved. A bidirectional battery charger is required for each V2G EV. Simple controller and cord. These cables must be safe. The charging and discharging cycles cause system losses. This report looks the US EV investment.

Social Barriers

The public's adoption of V2G is another major issue. EV owners will conserve energy for emergencies and unplanned trips. The grid system produces range anxiety. Worse, there is no charging station.

7. Optimization methods

As EVs interact with the grid, complicated V2G technologies emerge incorporating numerous nonlinear factors. Engineers employ several ways to solve optimization challenges. These are metaheuristic, analytical, and hybrid approaches. Solutions are found utilising Particle Swarm Optimization, Monarch Butterfly Optimization, and Genetic Algorithms. The research provides an optimization technique for EVs in microgrids that considers time, space, and energy transfer. The study gives PSO optimization restrictions. PSO is a computer algorithm that solves problems repeatedly. Kennedy, Eberhart, and Shi designed the PSO after bird or fish school social behaviour.

The study illustrates the GA approach for hybrid EV control. The GA approach is also popular. GA is a method that uses the biological organism's evolutionary process. It is a powerful tool for many optimization tasks. The genetic algorithm must give a plausible solution. Chromosomes are a string of actual integers. After the evaluation, the GA principle will repeat for the next generation of chromosomes.

8. Objectives of the Optimization

8.1 Commercial aspects

The cost of this technology includes fuel, startup, and V2G. The goal is to lower the cost of the electricity system. Fuel prices can be stated in kW. Restarting a plant costs a lot of money. The boiler's temperature affects the gas turbine's start-up time. A quick shutdown saves fuel. If the power plant is shut down for a lengthy time, it will require more fuel to reheat the boiler. Researchers are working to reduce the overall cost of V2G.

8.2 Emission of the Carbon dioxide

Minimizing CO2 emissions is also critical for the V2G system. The EU has developed an ETS trading system. The ETS sets a cap on each industry's emissions. If a plant exceeds the limit, it must buy extra allowance from the market or pay a penalty.

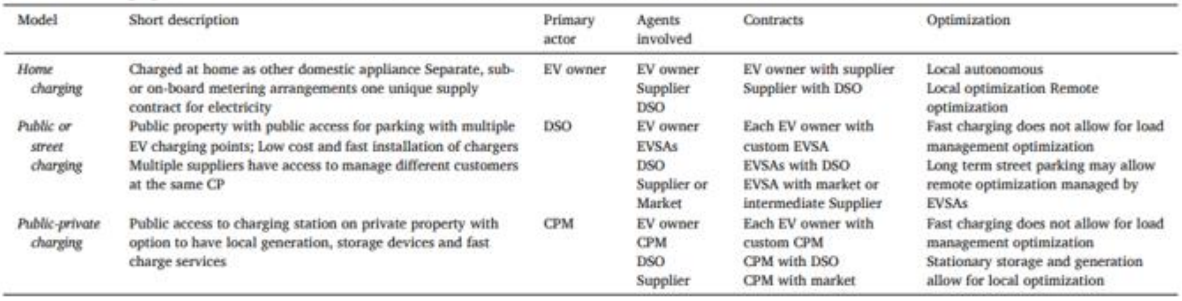
Generation of Renewable Energy

As a backup battery for when renewable energy sources are insufficient, electric vehicle fleets will be deployed. A battery-powered electric vehicle will store excess electricity generated by a renewable energy source. It is possible to have a sustainable energy network while also lowering generation costs.

Power Losses and Load Curve

The EV battery's extra power is employed as an active power grid. Many research publications attempt to flatten the load curve by reducing peak load.

Table 6: EV and V2G Charging markets and business models



Model	Short description	Primary actor	Agents involved	Contracts	Optimization
Home charging	Charged at home as other domestic appliance Separate, sub- or on-board metering arrangements one unique supply contract for electricity	EV owner	EV owner Supplier DSO	EV owner with supplier Supplier with DSO	Local autonomous Local optimization Remote optimization
Public or street charging	Public property with public access for parking with multiple EV charging points; Low cost and fast installation of chargers Multiple suppliers have access to manage different customers at the same CP	DSO	EV owner EVSAs DSO Supplier or Market	Each EV owner with custom EVSA EVSAs with DSO EVSA with market or intermediate Supplier	Fast charging does not allow for load management optimization Long term street parking may allow remote optimization managed by EVSAs
Public-private charging	Public access to charging station on private property with option to have local generation, storage devices and fast charge services	CPM	EV owner CPM DSO Supplier	Each EV owner with custom CPM CPM with DSO CPM with market	Fast charging does not allow for load management optimization Stationary storage and generation allow for local optimization

Table 6 summarises three types of charging marketplaces proposed by Roma et al. Different types of third-party pricing might only enhance (or destroy) these business models. DSO-led operations and initiatives are substantially hampered by the newly adopted energy sector directive. They only let DSOs participate when there are no commercial participants, a need for market development, and regulator permission.

R73 confirmed the variety of business models, but also doubting some of their viability. It works for apartment complexes with residents who demand it and are ready to pay for it. In other cases, such as shopping malls, public parking and charging stations are seen as a strategy to attract people rather than directly generate income. I don't see dedicated charging stations at gas stations as a viable business strategy. The finest model has been Tesla, which made us all feel that it is free, although it is not, we merely paid it in advance when we bought the car.

9. Conclusion and Future Work

Electric and plug-in hybrid vehicles (PHEV) are quieter, cleaner, and more efficient than gasoline-powered vehicles (ICEV). So the work provided here is exhaustive for V2G, V2H, and V2V. The EVSE charging process communication, signalling, and control components have been examined in detail. Because PEV/PHEVs have a higher voltage battery than HEVs (hybrid EVs), they must be charged from an external source.

Moreover, challenges connected to battery deterioration are current subjects that can be explored for EV charging and discharging coordination optimization strategies.

EV market research and product design opportunities abound. Active or reactive EV integrated power systems have studied new market techniques like as peak shaving, load shifting, valley filling, and reactive power regulation.

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