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A study the review of electric vehicle aggregator scheduling in electricity markets

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Abstract- The rapid expansion of electric vehicles (EVs) presents a transformative opportunity to integrate sustainable transportation with the energy sector. EV aggregators, which consolidate the charging demands of multiple EVs, play a pivotal role in balancing electricity markets by scheduling EV charging in response to grid conditions. This study comprehensively reviews the strategies and mechanisms employed by EV aggregators in scheduling EV fleets to optimize their participation in electricity markets. The EVA pools the power output of numerous EVs and puts out bids for the combined power output in power markets. EVA acts as a go-between for SO & EV owners, doing optimisation and aggregation while also pragmatically overseeing and managing the EV asset portfolio. G2V technology allows for the efficient integration of electric vehicles with the power grid.

Keywords- Electric Vehicles, Aggregators, G2V Technology, Electricity Markets

INTRODUCTION

Electric vehicles (EVs) reduce fossil fuel use & greenhouse gas emissions [S. Goel 2021]. Transportation accounts for around 25% of all emissions of greenhouse gases (GHGs) due to energy use. The figure is expected to treble by 2050 if this issue is not addressed [Climate Change2011]. Governments throughout the world are contemplating drastic measures to limit emissions of greenhouse gases in order to avert this situation. Authorities are worried about the rising air pollution levels in numerous cities. Consequently, for several economic and environmental reasons, the global penetration of EVs is on the rise. A goal of 80% carbon reduction by 2050 has already been set by the British government [S.Huang 2010]. In the United States, 62% of all automobiles could be electric by the year 2050, according to the Electric Power Research Institute (EPRI) (W. Su 2012). According to EPRI's moderate evolution scenario, 62% of all vehicles will be electric by 2040 [L. Pieltain Fernandez 211]. As a result of electric vehicle integration, total electricity consumption in Belgium climbs to 5% [K. Clement-2009] and in Sweden to 6% when 80% of all vehicles in the country are EVs.

IMPACT OF ELECTRIC VEHICLES ADOPTION IN DISTRIBUTION SYSTEM

Electric vehicles (EVs) affect more than just transportation. So, the shift in the car industry brought about by EVs affects economies, power in large portions of electrical networks, and the environment significantly [Hussain Shareef 2016]. Electric vehicles' impacts on the power system, weather, and GDP growth are illustrated in Fig. 1. Overloading the system, damaging network equipment, removing protective relays, and increasing installation costs are all consequences of charging during peak hours, which is a very worrying situation [Francis Mwasilu 2014]. The location, penetration level, and EV charging time of electric vehicles impact the voltage stability of the grid. The unpredictability of EV connection sites, penetration levels, and charging connection & disconnection periods adds to the load demand.

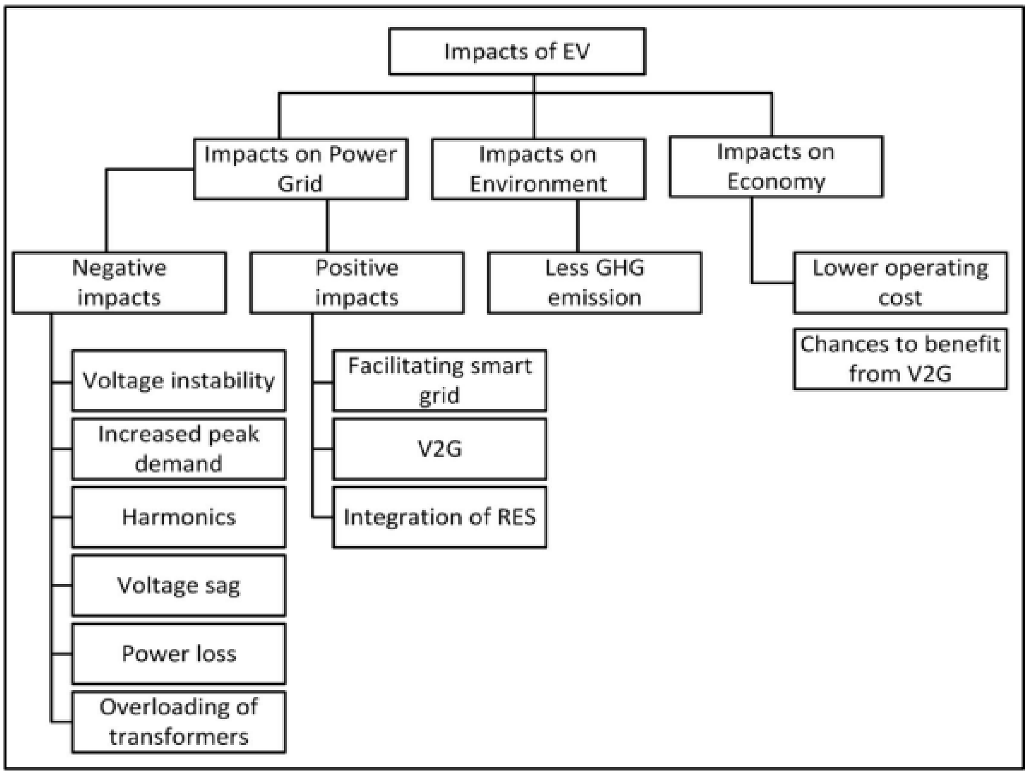

Figure 1. Impact of EVs on Power Grid, Environment and Economy

The extensive use of EVs affects distribution network quality. Inadequate network capacity, imbalanced three-phase voltage, & issues with off-nominal frequencies are all examples of such challenges. Electric vehicles can be seamlessly integrated into distribution networks using any of the three phases due to their status as portable single-phase loads. This causes the power cables to be overloaded at the expense of the other two phases' electrical connections. A number of power quality issues, including transformer failure, equipment malfunction, & faulty relays, can result from unbalanced three-phase loads. Furthermore, the grid's stability and security are compromised due to the significant spatial and temporal unpredictability of electric vehicles, making it difficult to manage them as excess loads. Residential demand peaks at the same time that electric vehicle home charging peaks, leading to extra system peaks at that time. Furthermore, poor power quality can be caused by a considerable increase in harmonics when there are more EVCSs in the same area [V. Monteiro 2011]. This is why the majority of the research and engineering community is worried about how to integrate a large number of EVs into distribution networks. Specifically, the community is looking for solutions to make electric vehicle charging more efficient and productive so that the issues can be mitigated. The overall efficiency of the distribution system will be reduced as a consequence of the increased power reduction in the feeders caused by the increased demand for energy transmission caused by increased EV usage.

CLASSIFICATION OF ELECTRIC VEHICLES

There are four varieties of electric vehicles [J. Erjavec 2012]

i) Battery Electric Vehicle (BEV) One or more Electric motors alone can run the vehicle, the power required to drive the wheels is obtained from the electricity stored inside the batteries and these batteries are charged from an outside source No Internal Combustion Engine (ICE) is required. BEVs are more efficient compared to other types of EVs.

ii) Hybrid Electric Vehicle (HEV) Both ICE and electric motor can power these vehicles. Energy saved in batteries drives the motor and regenerative braking can be used to recharge the batteries through an ICE but should not be plugged in to the grid. HEVs are also called Hybrids. These vehicles cannot be recharged from the grid and the ICE (gasoline or petrol engine) will complete most of the driving tasks.

iii) Plug-in Hybrid Electric Vehicle (PHEV) PHEV is powered by both electric motor gets its power from batteries and ICE. The batteries, unlike HEVs, can be charged by plugging them into an electrical socket. PHEV can run either in pure electric mode or hybrid mode. In electric mode, batteries will provide the necessary energy and in hybrid mode both ICE and motor are used to drive the car. These vehicles generally start in electric mode and continue to drive in the same mode until the battery pack gets discharged.

iv) Fuel-Cell Electric Vehicle (FCEV) FCEV uses the fuel cell produced electricity to power motors that drive the wheels of the vehicle. Here, chemical energy produces the required electrical energy. FCEV is powered by hydrogen fuel cells.

EV AGGREGATOR

When it comes to trading electricity, most small and medium-sized consumers just do not have the financial wherewithal. An aggregator agent would be necessary for them to trade their flexibility since it would collect it from multiple consumers and combine it with their active demand capacity to form a single resource. Electric cooling & heating, fans, electric boilers, refrigerators, and so on are all examples of loads that could be aggregated. In addition, the aggregator might facilitate agreements between customers to instantly modify their energy consumption. The "EV aggregator" is a broker that specializes in the unique trading opportunities presented by electric vehicles. The roles of EV aggregators are comparable to those of electricity retailers within the framework of electrical energy markets. Therefore, Figure 2 might be used to describe its interaction with other market participants.

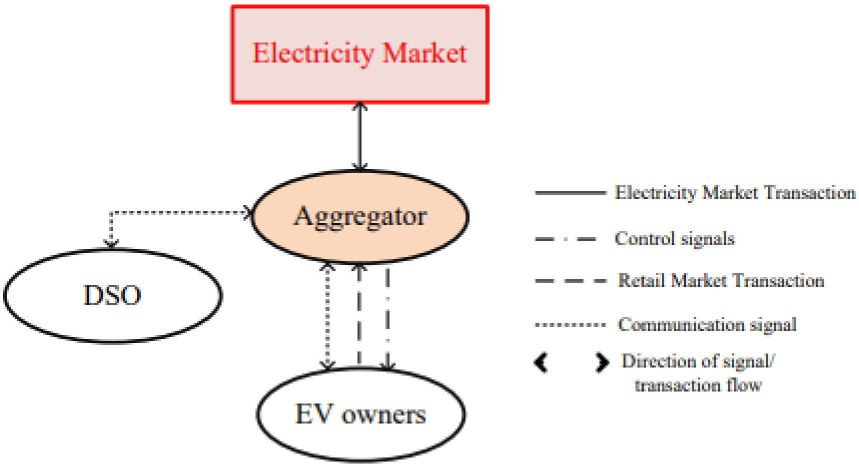

Figure 2: Summary of aggregator and physical market interaction

While the idea of an aggregator could be useful in the power market, there may be other requirements that must be satisfied before it can be fully implemented [J. Lopes 2010]. The following are examples of some of these:

i) Aggregators should have the communication infrastructure needed to get measurements of power use, the status of car batteries, and the consumption needs of electric vehicle owners in near real-time [C. Hay 2014].

ii) A system should be established to regulate the batteries owned by electric vehicle owners. Following the establishment of the required automated control infrastructure & approval of the relevant market and power system operational regulations, the aggregator may take direct management of the batteries, with the DSO validating the energy schedule. According to J. Lopes (2010), if the rules require aggregators to keep their operations and businesses separate, the DSO may be able to assume management of EV batteries using the energy scheduling plan that the aggregator has communicated with them.

iii) To cut down on aggregator forecasting mistakes, it may be required to shorten the gaps between market closure & operating hours to 30 minutes or fewer [S. L. Andersson 2014].

iv) It may become necessary to lower the market minimum bid size to values below 1 MW in order to increase participation from small users [S. L. Andersson 2014].

ELECTRIC VEHICLE CHARGING STATION INFRASTRUCTURE

Electric vehicles present distribution firms with an increasing opportunity to tap into flexible demand sources and earn revenue from a set of customers that will grow substantially over the next decade. There has to be strategic planning to reduce prices and boost advantages for users and distribution businesses because the demand for grid electricity would increase by terawatt-hours when the current vehicle fleet in India converts to electric vehicles. The large FAME II subsidy is also accessible to many other types of cars, which should hasten the transition to electric vehicles in those industries. Direct support of charging infrastructure is necessary for FAME II to promote the electric vehicle sector, though. If properly managed and organised, this new large and unpredictable load will improve the distribution company's operating efficiency and contribute to economic development. However, distribution firms may encounter difficulties such as an overwhelming amount of connection requests and an inability to manage the increased load if the extra demand is not addressed in a proactive manner. This will lead to a failure in supply-side demand management and a slowdown in demand growth [RMI India. 2019]. Commercial vehicle fleet owners and operators, bus companies, and providers of industrial electric vehicle charging networks are expected to make the most interconnection requests in the early phases of EV expansion, catering to both corporate and personal automotive sectors. Depending on the number and kind of cars, these extra loads could be quite significant, using hundreds to thousands of megawatts of power. Efficiency and simplification in handling connections and authorization requests are of the utmost importance in promoting the use of electric vehicles and generating new, long-term revenue for the utility company.

EV CHARGING DEPLOYMENT INITIATIVES IN INDIA

Different government agencies have been allocated specific EVSE implementation elements including standards, incentives, deployment and execution as part of the broader electric vehicle adoption campaign. The entities, as well as their functions and responsibilities, are listed in the table below.

Table. 1. Government entities' roles and responsibilities

Organization	**Roles and Responsibilities**
Department of Heavy Industries(DHI)	➢ Ensuring that FAME II, India's program to speed up the adoption and production of electric and hybrid vehicles, gets off to a good start. ➢ Invited ideas for using incentivesunder FAME II for the implementation of EV charging infrastructure.
Ministry of Power (MoP)	➢ Issued a set of guidelines and standards for charging infrastructurefor electric vehicles. ➢ The process of recharging electric vehicles should be seen as a utility, not a commodity.
Department of Science and Technology (DST) & Bureau of Indian Standards (BIS)	➢ There is a joint effort between BIS and DST to develop indigenous charging standards. ➢ Industry-academia cooperation to produce low-cost, locally manufactured chargers is being supported by DST.
Central Electricity Authority (CEA)	➢ To keep track of all public charging stations around the country, the CEA has been given the responsibility of creating a national database.
Bureau of Energy Efficiency (BEE)	➢ Under MoP's standards, BEE serves as the key nodal agency for the deployment of EV public charging infrastructure.
State discoms	➢ Unless a state government prefers alternative metropolitan localities or public sector entities, state discoms are the state's default nodal agency.

GST Council	➢ Reduction in the tax rate from 18 percent down to 5 percent for electric vehicle chargers and charging stations. (Effective as of the first of August in 2019)

A budget of Rs. 10,000 crores have been allocated by the government to support the expansion of India's electric car market via the FAME 2 program. India has committed up to $1 billion for the construction of electric car charging infrastructure throughout the country. Interconnecting renewable energy sources with charging facilities will also be encouraged under FAME 2.

The government may provide financial incentives to encourage the purchase of 7,090 electric buses, 20,000 hybrid vehicles, 35,000 four-wheelers, and 500,000 three wheelers, all of which would cost $3,545 crore. The GST rate for chargers and charging stations has been reduced from 18 percent to 5 percent. In addition, loans for the purchase of an electric vehicle would be tax-exempt for up to Rs 1.5 million. Additionally, there will be an "upfront bonus" on the purchase of an EV. Investing in start-ups will also be tax-exempt as a result of this new policy.

EV ACTING AS LOAD (G2V) AND SOURCE (V2G) IN THE DISTRIBUTION SYSTEM

RES and PEV penetration are expected to be at a greater extent in the Smart Distribution System, which is the primary focus of Ramakrishna Reddy et al., [2018] the stability of the distribution network is explored about the effects of intermittent RES and uncoordinated PEVs. Solar and wind power production variations might be minimized by using PEVs as storage units with bidirectional power flow. A case study based on real-time data from the Danish distribution network is employed to portray how PEVs may be used to provide grid ancillary support.

The optimal position and size of numerous DGs and EVCS operating in G2V and V2G modes are used as a strategy to reduce losses. Chippada et al., [2022] propose the sizing and positioning of several kinds of DG units, both renewable and non-renewable, as well as an EV charging station. Overall, this strategy decreases power losses while simultaneously increasing network voltages. For the IEEE 15, 33, 69, and 85 bus systems, the PSO algorithm is used to test the performance of the system. The findings suggest that by improving the planning and operation of both DGs and EVs, the proposed optimization approach increases the system's

Table.2. Number of state-authorized EV chargers

State	No. of EV Chargers Sanctioned
Maharashtra	317
Andhra Pradesh	266
Tamil Nadu	256
Gujarat	228
Uttar Pradesh	207
Rajasthan	205
Karnataka	172
Madhya Pradesh	159
West Bengal	141
Telangana	138
Kerala	131
Delhi	72
Chandigarh	70
Haryana	50
Meghalaya	40
Bihar	37
Sikkim	29
Jammu & Kashmir	25
Chhattisgarh	25
Assam	20
Odisha	18
Uttarakhand	10
Puducherry	10
Himachal Pradesh	10

The V2G function of EVs is incorporated by LuoLizi et al., [2020] with the optimization model for the deployment of EVCS and distributed generating resources. Linearized Distflow equations and an exact second-order conic relaxation are used to make the optimization model optimally convex. It is thus possible to solve the proposed model using commercial solvers off the shelf in polynomial time while still obtaining effective allocation methods with low annualized societal costs. Finally, a real-world metropolitan region in China with a 31-bus distribution system is chosen as a test system for the suggested technique, and numerical data are studied to validate its efficacy.

Zheng et al., [2021] proposed two charging and discharging load modes for EVs which were developed in consideration of V2G. There were two modes of charging and discharging, one based on travel patterns and the other on TOU pricing; the Monte Carlo approach proved the case. It was hypothesized that the solar charging station's capacity might be maximized under two separate charging and discharging modes using V2G. The developed mathematical models have the objective function of charging system's energy efficiency maximization, reduction of investment and minimizing operating cost. The range of choice factors, the restrictions of the power balancing need, and the approach for exchanging energy were provide]. Verification of the instances was carried out using either the NSGA-II or the NSGA-SA algorithms. In terms of reducing strain on the power grid, the disorderly charging and discharging method are inferior to the ordered charging and discharging mode that employs V2G, decreasing system investment and increasing energy efficiency in both algorithms by comparing simulation results for the two distinct modes.

A rigorous and efficient technique is used to examine the effects of EVs and V2G on the reliability, cost and emissions of the electricity grid. The contribution of this approach is that it can be used in a wide range of power grids with varying patterns and characteristics in terms of the proportion of RESs electricity production by explicitly addressing the stochastic factors affecting the daily demand/supply curves. Bijan et al., [2021] presents two new indices for measuring power grid performance based on the availability of RESs under different: stochastic and constant power supply system's. To cover all the possibilities, a Monte Carlo simulation is used to analyze the influence of the investigated situations on reliability, emission, and cost of power grid reliability, as well as the impact of alternative charging types, locations, and schedules. The findings of the quantitative study revealed that the integration of EVs and V2G systems in stochastic power supply enhances the performance of the power grid in terms of reducing overall costs and emission rates.

Sami et al., [2019]illustrate the interaction of Smart Buildings (SB) with energy storage devices, Power EVs, to shift grid load, trim peaks and reduce yearly energy consumption. The key issues that are addressed and studied include, interface with the V2G, charging and discharging speeds, battery backup and reliability. Models of simulations using V2G and G2V are presented to examine the effects of different gridinterface network settings. Grid stabilization and control, as well as V2G and G2V gridinterconnected systems, were examined in this case study.

Chen et al., [2015] provide an authentication strategy for V2G networks that is both safe and efficient while also protecting user privacy. With this system, the charging/discharging station can anonymously identify and dynamically manage PEVs. Additionally, the monitoring data acquired by the charging/discharging station may be forwarded to a local aggregator in the batch process. There is no need to refresh the membership certificate and key pair before a PEV logs out since the verification time is independent of the number of PEVs engaged.

Chtioui et al., [2021] explore the simulation environment modeling of a micro-grid that is connected to a fleet of EVs and has a restricted vehicle-to-grid application. The discharging mode is only used if peak demand occurs alongside an extremely slow response time. In this presentation, the fundamental components of this microgrid are modeled and analyzed. This article analyses the charging and discharging situations and goes further into the management strategies that were used in this simulation to control the power.

Since EVs produce both active and reactive power, J. Singh et al., [2020] examine the effects of both on schedule. By exploiting V2G operations of EVs, both solutions aim to reduce system losses. Optimized charging and discharging of the EVs is achieved by using an Active Power dispatch (APD) based method. The reactive Power dispatch (RPD) technique, on the other hand, reduces losses by optimizing charging and reactive power injection from the EVs. Distribution system reconfiguration (DSR) is studied in system operation and planning using two alternative scheduling methodologies before its positive impact is assessed. A 33-bus distribution system is used to simulate the efficacy and viability of the suggested strategy and the results are encouraging.

CONCLUSION

EVs represent a paradigm shift for both the transport and power sectors, with the potential to advance the decarbonisation of both sectors by coupling them. Although the transport sector currently has a very low share of renewable energy, it is undergoing a fundamental change, particularly in the passenger road vehicle segment where EVs are emerging. The intermittent nature of renewable generation, as well as the charging behaviour of EV owners, may impact the distribution system adversely. This intermittency may pose operational challenges to SO and might threaten system security and reliability. Synergetic integration of these two technologies might overcome the intermittency issue of renewables. Intermittent charging could be reduced by controlling the driving behaviour of EV owners and performing their G2V operational scheduling. Therefore, it necessitates a scheduling coordinator as an intermediary between SO & EV owners, known as EVA for G2V scheduling. They can act as flexible loads and as decentralised storage resources, capable of providing additional flexibility to support power system operations.

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