ANALYSIS OF THE CHALLENGES IN CHARGING OF E-VEHICLE

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Abstract – One significant way to cut greenhouse gas emissions is by using electric cars. In addition to lowering reliance on fossil fuels, electric cars help lessen the effects of compounds that deplete the ozone layer and encourage the widespread use of renewable energy sources. Electric car manufacturing and network models are still limited and evolving despite extensive study on the features and properties of electric vehicles as well as the nature of their charging infrastructure. The study addresses the various modelling approaches and optimisation methods used in the studies of the market penetration rates of electric vehicles, hybrid electric vehicles, plug-in hybrid electric vehicles, and battery electric vehicles. The report is distinctive in that it addresses the fundamental obstacles and inadequate charging infrastructure for a developing nation like India. When renewable energy sources are unavailable, there is now an additional power source thanks to the development of the innovative Vehicle-to-Grid concept. We come to the conclusion that considering the unique qualities of electric cars is crucial to their mobility.

Keywords: Optimisation methods, E-Vehicle, Charging, Hybrid vehicle etc.

1. INTRODUCTION

Electric vehicles (EVs) are emerging as a possible avenue for enhancing air quality, energy security, and economic opportunity due to the fast growth of the Indian automobile sector. The Indian government understands how important it is to investigate sustainable mobility options in order to lessen reliance on foreign energy sources, cut greenhouse gas emissions, and lessen the negative effects of transport, such as global warming. By adopting preventative steps to lessen the catastrophic climate change that threatens the planet's biodiversity, carbon dioxide emissions may be decreased. Significant efforts have been made to reduce the amount of fossil fuels used for energy production, transportation propulsion, energy consumption, and carbon sequestration protection. An approach to reduce carbon dioxide petrol emissions might be electric vehicles [1]. Even if EV adoption has started, people still rely on cars that run on fossil fuels. In contrast to traditional fossil fuel-powered cars, electric vehicles (EVs) have difficulties with life cycle assessment (LCA), charging, and driving range. The manufacture of electric vehicles emits 59% more CO2 than that of internal combustion engines. From a tank to wheel perspective, the ICEV emits 120 g/km of CO2, but from an LCA perspective, this rises to 170–180 g/km. Although CO2 emissions from EVs are zero from tank to wheel, we estimate that average CO2 emissions are assessed across the car's life cycle rather than just one vehicle. Depending on the power source used when the car is made and operated, the overall CO2 output during its lifetime varies greatly [2]. Due to the transportation sector's harmful emissions and various OEM investments, there is a rising worry about the need for more affordable and efficient electric vehicles in the years to come. The adoption of EVs in India may be influenced by a number of variables, including improvements in technology, falling car prices, government policy support, incentives for buying new cars, parking benefits, and well-developed public charging infrastructure. Since there is relatively little manufacturing of EVs, their entire market share in India is quite small. Electric vehicles (EVs) may be classified into three categories: i) three-wheelers, such as e-rickshaws; ii) four-wheelers, which include electric automobiles. The Reva Electric Car, the country's first electric vehicle manufacturer, was founded in the early 2000s with the goal of producing automobiles at a reasonable price point using cutting-edge technology. Mahindra Electric Mobility Ltd., the only producer of BEVs, is at the top of the Indian market. Honda Motors Co. Ltd., BMW AG, Volvo Car Corporation, Toyota Kirloskar Motor Pvt. Limited, and other significant HEV manufacturers are also present in the Indian market. The Mahindra e2oPlus, Mahindra e-Verito, Mahindra e-KUV 100, Eddy Controls Love Bird, Atom Motors Stellar, and Tata Tiago Electric were a few of the other models [3]. 3202 million metric tonnes of carbon dioxide equivalent were India's total greenhouse gas emissions in 2014, making up 6.55% of the world's total emissions. The energy sector accounts for 68% of greenhouse gas emissions in India. Then come improvements in land use and forestry, waste, manufacturing, agriculture, and 6.0%, 3.8%, and 1.9% of emissions, respectively [4]. For the purpose of standardising the grid with a significant portion of variable renewable energy output, an electric car may be used as a flexible load [5]. Because a single transaction has little influence, the owners of electric vehicles do not engage in the energy market [6]. A contemporary approach for estimating exogenous smart policies—which were predetermined in anticipation of changing scenarios—was examined by certain writers [7–12]. It is important to have variable load and intelligent charging procedures in order to fully use an electric vehicle. According to a different research by [13], EV users banded together to inform the aggregator about time and energy requirements. While the battery level satisfies the energy need, the timeliness requirement establishes the deadline for finishing a charging procedure. According to a related research by [14], owners of electric cars should get price signals from both a central and a decentralised framework, with the expectation that the two would overlap. The stochastic simulation approach of an electric vehicle was examined by Brady and Mahony, 2016 [15] in order to create a dynamic trip itinerary and charging profile for the purpose of EV propulsion in the actual world. They came to the conclusion that both the accuracy of the parking time distribution and the model as a whole would rise with greater parking time distribution circumstances. According to a study conducted by Morrissey et al., 2016 [16], a number of electric vehicle owners choose to charge their cars at home in the evening, when demand for power is at its highest. Peak charging is more harmful than off-peak charging, according to research by Foley et al., 2013 [17] on the effects of EV charging in a single, large Irish energy market under peak and off-peak charging conditions. In order to determine the carbon dioxide emission levels of BEVs and PHEVs, Doucette and Mc Culloch, 2011 [1] compared their findings with the CO_2 emissions of Ford Focus vehicles. Steinhilber et al., 2013 [18] examined the main obstacles to an EV in two nations in order to study the necessary instruments and approaches for bringing new technology and innovation. A driving pattern recognition method was presented by Yu et al., 2012 [19] to assess the EVs' driving range using the trip segment partitioning algorithm. By developing a vehicle model, Hayes et al., 2011 [20] looked into various driving situations and topographies.

2. METHODOLOGY

We have researched the several kinds of electric cars that are now on the road worldwide. In addition, we have identified the obstacles facing EVs in the Indian market. Additionally covered are several optimising strategies. Fig. 1 presents the comprehensive overview of electric vehicles that was examined. This essay is divided into many sections, including: The process is explained in Section 2. A summary of all the different configurations for electric vehicles is provided in Section 3, and then in Sections 4 and 5, the charging scenario and the electric car barrier are discussed. In Section 6, the EV and V2G optimisation approach is given, and in Section 7, it is concluded.

3. Overview of electric vehicles

The holy grail of electric vehicles is to swap out their internal combustion engine with an electric motor that runs on battery energy via a power electronic traction inverter. The electric motor is very efficient since it only utilises 90–95% of the input energy to power the vehicle. The battery, charging port, charger, DC/DC converter, power electronics controller, regenerative braking, and drive system are the essential parts of an electric vehicle. The electric motor's function is to use the electrical energy that is kept in batteries to power the electric vehicle. Since they are recharged using power sources with less emissions, EVs become more environmentally beneficial. The electrical grid provides the cells with power. The main purpose of the battery is to provide the electric automobile with enough electricity to start it. Since lithium-ion batteries are lightweight and need very little maintenance, they are often used in electric vehicles (EVs). Comparing the production cost of Li-ion batteries to lead-acid and nickel-metal hydride batteries, they are a little more. Li-ion batteries have a lifespan of eight to twelve years, depending on the climate and maintenance regimen.

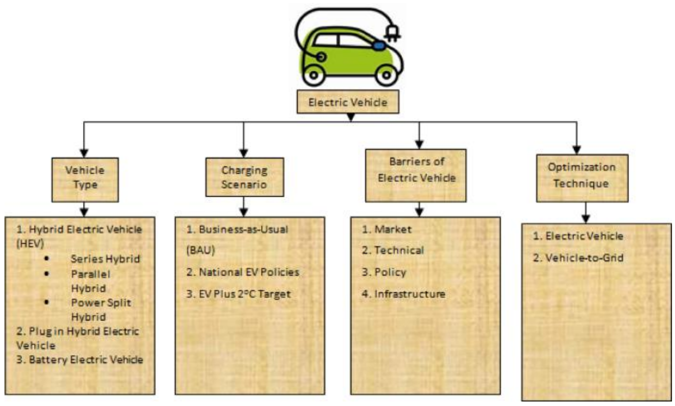

Fig. 1. Overview of the Electric Vehicle

The charging port is the location where the car may connect to an external power source so that the battery can be charged using a charger. Using a charge port, the charger's job is to accept the AC power from the power source and transform it into DC power so that the battery may be charged. While the battery is being charged, it also keeps an eye on its voltage, current, temperature, and level of charge. To power the car accessories, the DC/DC converter transforms high voltage DC power from the battery into low voltage DC power. By regulating the flow of electrical energy from the traction battery, the power electronics controller regulates the torque and speed of the traction motor. Regenerative braking is crucial for preserving the strength of the vehicle and producing more energy. Using the motor's mechanical energy, this braking technique transforms kinetic energy into electrical energy to replenish the battery. Regenerative braking is often used in all hybrid and battery electric vehicle (BEV) types since it extends the EV's range. Here, the automobile travels ahead thanks to the electric motor's forward motion, and when the brake is applied—a process known as regenerative braking—the motor may be utilised to charge the batteries. 15% of the energy consumed for acceleration may be recovered. Despite being a useful part, it cannot completely recharge the electric car. By delivering mechanical energy into the traction wheel, the drive system's job is to create motion. The electric car has several internal layouts depending on how the components are used, and it doesn't need a traditional gearbox. Certain designs, for instance, make use of many tiny motors that are meant to power each wheel separately.

3.1. Types of Electric vehicle

Although EVs have been created in many nations, China, the UK, the USA, and Germany account for the majority of the global EV market. Globally, the EV market is expanding quite quickly. Hybrid Electric cars (HEV), Plug-in Hybrid Electric Vehicles (PHEV), and Battery Electric Vehicles (BEV) are the three categories into which the cars may be divided.

3.1.1. Electric hybrid Vehicles

An electric motor and an internal combustion engine make up a hybrid electric car. Here, the engine and the energy produced during braking and deceleration are used to charge the batteries. Because they combine an electric motor as a power converter with a combustion engine, they are known as hybrid cars in the modern context. The technology of hybrid electric vehicles is being used all over the globe because of its numerous benefits, which include providing modern performance without requiring a charging infrastructure. They can also significantly reduce fuel usage by electrifying the power train. Depending on the kind of hybrid system, there are several topologies in which the HEV may be linked. These three types of hybrids are power-split, parallel, and series. The electric motor in a series hybrid is the sole source of power for the wheel. Either the generator or the battery provides the motor with power. Here, an IC engine is used to charge the batteries so that an electric motor can run. The computer determines how much power comes from the engine/generator or the battery. The battery pack is energised by both the engine/generator and the use of regenerative braking. Larger battery packs and massive motors paired with tiny internal combustion engines are typical features of the HEV series. They are supported by ultra-caps, which work to increase the battery's efficiency and reduce loss. They absorb regenerative energy during stopping and release their maximum energy when accelerating.

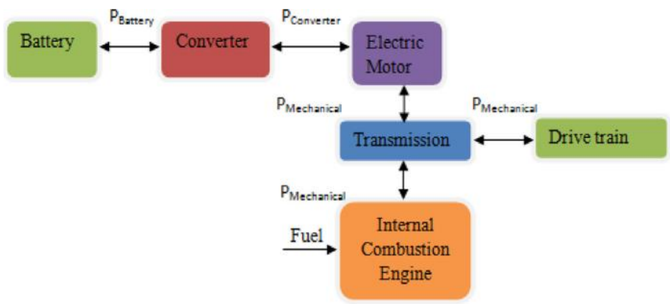

Fig. 2. The power flow of parallel Hybrid Electric Vehicle.

3.1.2. Plug-in hybrid electric vehicle

An electric motor and an internal combustion engine make up a plug-in hybrid electric vehicle (PHEV). These cars run on petrol and feature a large rechargeable battery that is fed energy to charge it. Plug-in hybrid electric vehicles provide the following advantages: Reduced use of petroleum About 30–60% less oil is used by PHEVs than by conventional cars. Plug-in hybrids lessen reliance on foreign oil since the majority of power is generated domestically. greenhouse gas emissions PHEVs often produce less greenhouse gas emissions than regular cars. However, the method used to generate power affects how much gas is released. For instance, power plants using hydropower and nuclear energy are cleaner than those using coal. It takes time to recharge. A 240 V home or public charger may recharge a device in one to four hours, but a 120 V domestic outlet may take many hours. In as little as 30 minutes, the battery may be quickly charged to 80% of its capacity. But these cars don't need a plug to operate. They can only run on petrol, and they won't get the most range or fuel efficiency if they aren't charged. Calculating fuel efficiency Since a plug-in may operate on electricity, petrol, or a mix of the two, the Environmental Protection Agency gives a fuel efficiency estimate for combined city highway travel for petrol solely, electric only, and gas and electric operation.

3.1.3. Battery electric vehicle

A completely electric car is a battery electric vehicle, or BEV. It is powered by large capacity rechargeable battery packs that may be charged externally instead of a petrol engine. The internal electronics and electric motor of a battery-electric vehicle are powered by chemical energy that is stored in rechargeable batteries. According to Andwari et al. (2017), the BEV has the potential to decrease carbon dioxide emissions from light-duty vehicle fleets while simultaneously decreasing reliance on fossil fuel-powered cars.According to reports, BEVs contributed over 70% of commerce in 2017 and are predicted to continue growing in the next years, giving them the greatest share of the Indian market. Even though BEVs outsold PHEVs in several countries until 2014, PHEV sales have increased significantly over the previous two years to almost match BEV sales. The types of batteries used in the Indian market may be divided into three categories: lithium-ion, lead-acid, and nickel-metal hydride. Maharashtra is the state in India where the most electric vehicles were sold in 2017. Similar types of publications compare the methods used to estimate the SOC and SOH of battery-electric and hybrid cars.

3.2. Battery thermal management system

The development of efficient batteries is prioritised since the usage of electric vehicles (EVs) is expected to rise in the near future. Better BTMSs have significant challenges because to battery thermal deterioration, which reduces EV range. Controlling the battery cell's temperature in order to prolong its life is the primary goal of the BTMS. In electric vehicles, Li-ion batteries are often used for their energy storage capabilities. Numerous difficulties exist, including poor efficiency at high and low temperatures, a reduction in electrode life at high temperatures, and a direct impact on the vehicle's protection, cost, performance, and dependability. There are also safety concerns with thermal runaway in lithium ion batteries. For an electric car to succeed in the long run, one of the most important technologies is an efficient thermal battery management system. The ideal operating temperature range for Li-ion batteries is typically between 25 and 40 degrees Celsius. The life of these batteries is shortened when their temperature rises over 50 °C.

4. Electric vehicle scenario in India

In India for now, the EV market is minuscule. For the last two years, sales of electric automobiles have plateaued at 2000 units annually. However, the goal is for all electric vehicle sales to reach 100% by 2030; as of 2020, the compound annual growth rate is at 28.12%. Since its 2001 introduction, India's first electric vehicle, the Mahindra Reva, has managed to sell a small number of vehicles. Toyota debuted the Prius hybrid in 2010 and the Camry hybrid in 2013. In several places, the usage of hybrid and electric buses as a test project has begun. Recently, electric transit was made available on a busy city corridor by the Bangalore Municipal transit Corporation. A poll conducted in the city of Ludhiana revealed that 36 percent of those who now own cars and two-wheelers were eager to switch to electric vehicles. The state government of Telengana is also promoting the usage of EVs and has declared that owners of EVs would not be required to pay road taxes. The Telengana State Electricity Regulatory Commission (TSERC) authorised an INR 6 charge rate for electric vehicles in 2018. Additionally, the TSERC set the state-wide cost of service at INR 6.04/kWh. Additionally, Power Grid Corporation of India Ltd. and Hyderabad Metro Rail have partnered to provide EV charging stations. The Hyderabad metro rail is set to become the first in the nation to have electric vehicle (EV) charging stations that are controlled and monitored by the power grid. The government of Hyderabad is also considering switching to electric public transport vehicles from diesel ones. The government of New Delhi was granted permission this year to install 131 public charging stations across the nation's capital. The Delhi government unveiled a draft strategy in November 2018 with the goal of converting 25% of its cars to electric vehicles (EVs) via a variety of incentives and the installation of charging infrastructure in both residential and non-residential locations. By providing a 100% subsidy (up to INR 30,000) and waiving the road tax, parking fees, and registration cost for electric vehicles, this programme aims to provide a charging station every three km by 2023. A private company called Magenta Power is also planning to provide EV charging infrastructure along the Mumbai-Pune motorway.

4.1. Scheme for purchasing electric vehicle in India

India's state and federal governments have introduced a number of programmes and incentives to encourage the use of electric vehicles.The following list includes a few of the schemes. The Government of India announced the National Electric Mobility Mission Plan (NEMMP) 2020 with the aim of improving the country's energy security, reducing the negative environmental impact of fossil fuel-powered cars, and fostering the growth of indigenous manufacturing skills (GoI, 2012). The NEMMP 2020 may contribute to the sale of 6–7 million electric cars, which might result in the conservation of 2.2–2.5 million tonnes of fossil fuel. According to this new proposal, vehicle emissions and CO2 emissions may be reduced to 1.3-2.5% in 2020. This strategy calls for the deployment of 5-7 million electric cars by the end of 2020. It also highlights how crucial government incentives are, as well as how business and academics should work together. Additionally, the Indian government is planning to generate 100 GW of electricity from solar power by 2022. This might increase the dependability and efficiency of renewable energy, which would be beneficial for EV charging stations. To facilitate the faster adoption of electric and hybrid vehicles, the Indian government has introduced the Faster Adoption and Manufacturing of Electric Vehicles (FAME II) strategy. This programme also promotes the purchase of electric vehicles by offering a number of incentives and putting up infrastructure for charging them. Cabinet approved 10,000 crore for FAME II in February 2019 with the intention of implementing it on April 1st, 2019 for a three-year term [88]. The implementation of this unified regulatory scheme, together with manufacturing incentives and charging infrastructure, is highly anticipated by EV manufacturers since it will provide a roadmap for the EV ecosystem.

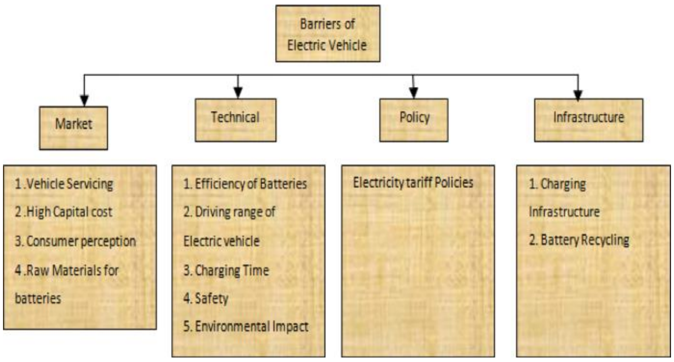

Fig. 3. Different types of barrier for EV

5. Barriers for EVs in the Indian market

There are a number of ways to solve obstacles for electric vehicles in the Indian market, including lack of infrastructure, legislative obstacles, and technical obstacles. These are seen in Figure 3.

5.1. Market

5.1.1. Vehicle Service

An experienced technician should be on hand to fix, maintain, and troubleshoot the electric car in order to ensure that it is properly cared for. They need to be able to use their abilities to solve the issue as soon as feasible.

5.1.2. Exorbitant initial investment

An electric vehicle's battery packs are costly and need replacement many times over the course of its lifespan. When compared to electric automobiles, gas-powered cars are less expensive.

5.1.3. Perception among consumers

Customer impression is essential for drawing in new business and keeping hold of current clientele. Even if the selection of electric cars on the market is expanding and is predicted to do so for some time, purchasing an electric car is still not as easy as it once was. Therefore, they have to be aware of what the business offers to customers via social media, advertising, or other channels. Research indicates that the adoption of electric vehicles may be directly impacted by one's ignorance of the government programme, the financial advantages, and the state of car technology.

5.1.4. Battery-related raw materials

The rare earth elements manganese, graphite, cobalt, nickel, phosphate, and lithium are used as basic materials in EV batteries. An internal combustion engine needs steel, copper, and aluminium. Palladium, rhodium, and platinum are needed by combustion car catalysers in order to filter harmful gases. These are all scarce materials, and there may not be enough of them to be able to produce enough batteries. The lithium-ion batteries alone use five million tonnes of nickel annually, which might result in a future when lithium and cobalt are used ten to twenty times more often.

5.2. Technical

5.2.1. Battery efficiency and longevity

The fuel tank and gasoline engine of a normal vehicle are often replaced with electric motors, batteries, chargers, and controls to make electric automobiles. Since EV batteries are intended to last a long period, wear and tear occurs eventually. For their batteries, the majority of manufacturers now provide warranties of eight years or 100,000 miles.

5.2.2. Electric vehicle driving range

The primary obstacle to electric vehicles is often their driving range, since EVs have a lower range than their equivalent internal combustion engine (ICE) vehicles. One major barrier to the widespread adoption of electric vehicles (EVs) in the worldwide market is the limited range that they can cover when fully charged or when their tank is empty. Less than 250 km may be driven between recharges for the majority of BEVs. Some of the newest versions, nevertheless, may provide up to 400 km. Because internal combustion engines that run on liquid gasoline are now available, plug-in hybrid electric vehicles (PHEVs) may go 500 km or more. The choice to take a long-distance journey may not be available to the driver, therefore they must carefully plan their route. As a result, the driving range's size becomes a barrier.

5.2.3. Duration of charging

Driving range is a closely connected problem to charging time. The EV may take up to 8 hours to fully charge from an empty state when utilising a 7 kW slow charger. The size of the battery is the primary factor influencing the charging time. The time it takes to recharge an automobile battery from empty to full capacity increases with battery size. Additionally, the battery's charging time is closely correlated with the charge point's rate of charging. The longer it takes the battery to charge completely, the more expensive the charging station is. In the present situation, the car is charged more quickly thanks to rapid chargers, which cut down on the amount of time needed. The maximum charge rate that the commercially available electric vehicles can withstand may be reached by them at charging stations. This suggests that the battery may be charged to its full capacity without experiencing any issues. Nevertheless, as the temperature drops or when the battery is cold, the quick charger's charging rate decreases as well. The EV chargers are divided into several categories based on how quickly their batteries can be charged. Three basic methods of charging electric vehicles exist: DC fast, Level 1, and Level 2.

Through the use of an on-board converter, Level 1 charging makes use of a conventional 120 V output. The EV can be charged in 8 hours using 120 V outlets, giving it a range of around 120–130 kilometres. Generally, level 1 charging takes place at home or at the office. Usually, 240 V outlets are available for charging in public spaces or workplaces, where level 2 chargers are installed. The battery may be charged in 4 hours for a 120–130 km range. When using DC fast charging, the charging station with the fastest fast charging setup is where the AC to DC conversion takes place. This enables stations to provide more power, enabling faster car charging. With a 145 km range, the battery can be charged in 30 minutes.

5.2.4. Electric vehicle safety regulations

The state or municipal regulation's safety criteria must be met by the electric vehicle. In addition, the batteries must pass the testing criteria that include exposure to various environmental factors such as vibration, humidity, water immersion, temperature, short circuit, overcharge, and fire impact. These cars have to be built with safety features including collision detection, short circuit protection, and insulation against high-voltage power lines. 5.2.5. The effect on the environment Although the components of electric cars don't usually harm the environment, they are taken from brine or mines in the desert. The mining industry is not significantly impacted by this extraction.

5.3. Guidelines

The Government of India intends to subsidise the nation's EV charging infrastructure in an effort to hasten the electric car revolution in that nation. Recently, the ministry of electricity made it clear that an EV charging station does not need a licence to operate in India, which might improve the infrastructure of EV charging stations around the country. In addition to offering incentives and exemptions to EV consumers and reducing the relevant rate of Goods and Services Tax (GST) on Li-ion batteries, the government need also provide incentives to encourage the transition of public transport to electric vehicles.

5.4. Facilities

5.4.1. Infrastructure for charging

More infrastructure for charging is needed as the number of electric cars rises, increasing the need for electricity. The poor sales of electric vehicles may be attributed to India's lack of current infrastructure for charging them. From an engineering perspective, EV makers should recognise the value of charging batteries so that discharge batteries may be swapped out for fully charged ones. The charging station may schedule the battery charging to occur during off-peak hours at a discounted power rate. Since owners would need to charge their electric vehicle at home before leaving for the day, there need to be a way to set up a charging station for this car. People would prefer to charge their cars at work or at a dedicated charging station, where they have to stop for two to three hours or more, if they don't have access to charging infrastructure at home. Places like homes and workplaces are perfect for slow charging, whereas rapid charging is great in areas like highways and business complexes where vehicles stop for brief periods of time. It should be mentioned that in order for an EV to charge quickly—in less than 30 minutes—it must be able to handle high voltage and/or high current. This will not only make the EV more expensive, but it will also shorten the battery's lifespan. Thus, the ideal choice for EVs may be a mix of slow and rapid charges.

5.4.2. Reusing batteries

Although they are typically designed to last just as long as the vehicle, electric car batteries ultimately run out of power. When a battery has to be replaced after its warranty has expired, replacing the old battery with a new one increases costs. However, manufacturers do not provide accurate information on replacement battery price. Batteries' chemical components, such as lithium, nickel, cobalt, manganese, and titanium, not only make the supply chain more economical but also pose environmental risks when the battery pieces are scrapped.

6. Technique for optimisation

6.1. Using an optimisation approach for electric vehicles

In this article, multiple frameworks in different geographical regions are used to characterise the charging needs of electric vehicles. The framework comprises the following: forecasting model; distributed optimisation; hybrid particle swarm optimisation; ant colony optimisation and household activity pattern; driving pattern recognition; stochastic model; trip prediction model; probabilistic model; fuzzy based model and data mining model; Particle swarm optimisation; linear programming; multi-objective and adaptive model. The purpose of this research was to look at the possible advantages of all EVs' charging features. Many investigations carried out globally by many authors in an effort to determine the best method for optimising electric vehicles.

6.2. Technology from vehicles to grid

When the V2G idea was originally presented, According to this idea, an electric vehicle that is parked may both send electricity to the grid and act as a bidirectional charger, meaning it can be used to charge the battery or deliver power to the grid. It has been suggested that bidirectional charging of Li-ion cells in V2G and Grid to Vehicle may be used to determine cell performance. An overview of the use of energy storage technologies in distribution system design and operation is provided. Fig. 4 depicts the Vehicle to Grid charging mechanism.

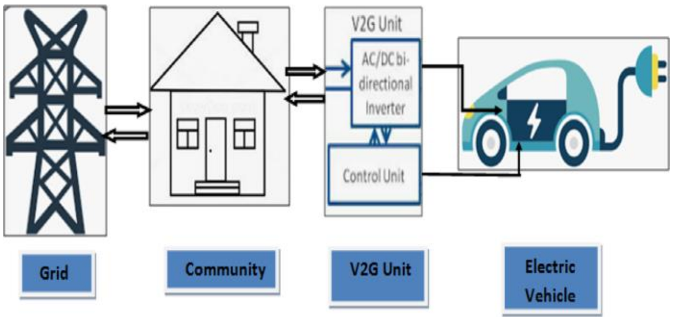

Fig. 4. Vehicle to Grid charging

6.2.1. Application of optimization technique for V2G

A range of control approaches are suggested to provide the best possible V2G performance. Numerous writers from all around the world have looked at V2G difficulties and various optimisation strategies. The approach that has been published by several writers worldwide is examined. In terms of carbon dioxide emissions and associated costs, Tulpule et al. (2013) demonstrated the feasibility study in a parking lot at a workplace in the USA, OH, Columbus, Los Angeles, and CA, and contrasted it with the home charging system. In a related research, parking lots in the USA, NJ, and NJ were taken into account. A simple method was used to determine which driving demands might be satisfied by solar power in the summer but not in the winter. Numerous writers have examined the EV fleets on a local or regional scale. In one such study,[125] in the Kansai Area of Japan paired one million electric vehicles (EVs) with one million heat pumps in order to reduce surplus solar power by three TWh via the use of smart charging techniques. Due to their modest size, the batteries used in EVs have no discernible effect on the grid. Fig. 5 depicts the aggregator of a V2G system.

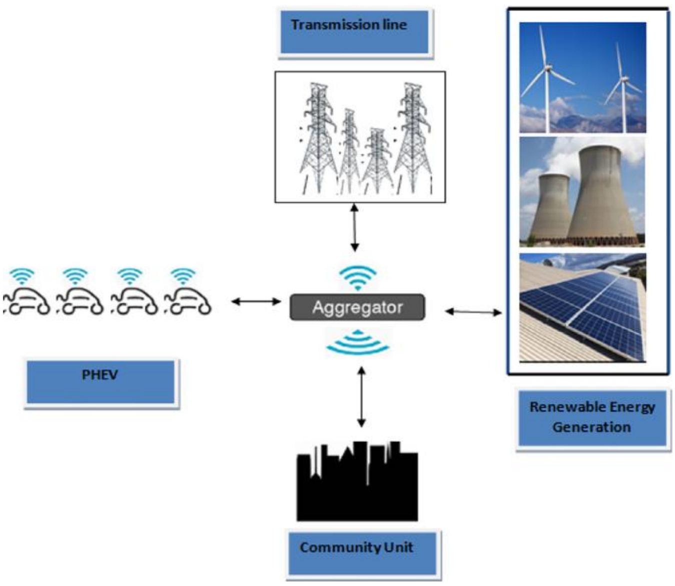

Fig. 5. Aggregator of a V2G system.

7. Conclusion

When compared to conventional cars, hybrid, plug-in hybrid, and electric vehicles may boost a vehicle's fuel efficiency, but the cost of ownership will go up. Generally speaking, over time, consumers, society, automakers, and legislators will all profit economically from their lower petroleum use and higher production.

This document offers recommendations, a comprehensive review of the literature, and penetration rate studies for BEV, PHEV, and HEV in the Indian market. The Indian government's latest efforts and different incentives will accelerate the country's e-mobility push. When non-conventional energy sources are unavailable, the creation of a new vehicle-to-grid idea may be employed to either provide electricity to the grid or charge the battery. This technology has a significant lot of potential for addressing global warming challenges and is a crucial component of renewable energy and energy security. The primary originality of this research is an overview of the obstacles and issues related to electric vehicles in the Indian setting.

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