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TECHNIQUES IN ENVIRONMENTAL MONITORING: ANALYTICAL METHODS FOR ASSESSING ENVIRONMENTAL POLLUTANTS

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Abstract

Electric vehicles are an important option for reducing emissions of greenhouse gases. Electric vehicles not only reduce the dependency on fossil fuel but also diminish the impact of ozone depleting substances and promote large scale renewable deployment. Despite comprehensive research on the attributes and characteristics of electric vehicles and the nature of their charging infrastructure, electric vehicle production and network modelling continues to evolve and be constrained. The paper provides an overview of the studies of Electric Vehicle, Hybrid

Electric Vehicle, Plug-in-Hybrid Electric Vehicle and Battery Electric Vehicle penetration rate into the market and discusses their different modelling approach and optimisation techniques. The research on the essential barriers and insufficient charging facilities are addressed for a developing country like India that makes the study unique. The development of new concept of Vehicle-to-Grid has created an extra power source when renewable energy sources are not available. We conclude that taking into account, the special characteristics of electric vehicles areso important in their mobility

Keywords : Electric vehicles, Vehicle to grid, Optimisation technique, CO2reduction

Introduction:

With the rapid increase in the Indian Automobile market, Electric vehicles (EVs) are turning into a promising channel towards improving air quality, energy security and economic opportunity. The government of India recognises the urgency to look at sustainable mobility solutions to reduce dependency on imported energy sources, reduced greenhouse gas emissions and mitigate adverse impacts of transportation including global warming. The carbon dioxide emission can be reduced by taking precautionary measures to reduce the catastrophic climate change that threatens the species of this planet. Major endeavours have been taken for minimal use of fossil fuels for power generation, transport propulsion, reduction of energy consumption and protection of carbon sequestration. EVs could be the alternative to decrease the carbon dioxide gas emission. Though the use of EVs has begun, people are still depending upon fossil fuel powered vehicles. However, the EVs are facing challenges onlife cycle assessment (LCA), charging, and driving range compared to the conventional fossil fueledvehicles. The CO2 emitted from Electric vehicle production is (59%) more than that of the ICEV. The ICEV generates 120 g/km of CO2 emission on a tank to wheel basis, but from the point of view of the LCA, this increases to 170–180 g/km. While EV

ISSN No: 2321-8681
Review article
PP: 17-26
Peer Reviewed Refereed Journal

has zero emissions of CO2 on a tank to wheel basis, we estimate that the average CO2 is measured over the life cycle of a vehicle rather than over a vehicle. The vehicle The total CO2 emission over its full life time varies significantly depending on the power source where the vehicle is manufactured and driven. Harmful emission from the transport sector, and investment by different OEMs, there arises a concern for growing more and low cost EVs in the forthcoming years.Several factors such as technological advancement, reduction in the cost of a vehicle, Govt policy support, vehicle purchasing incentives, parking benefit, and good public charging infrastructure facility could result in the uptake of EVs in India. As the production of EVs is very low, the overall share of EVs in the Indian marketis negligible. EVs can be i) electric two wheelers (E2Ws) like electric bicycles and electric scooters, ii) three wheelers like E- rickshaws and iii) four wheeler consists of electric cars. India's first electric car company "The Reva Electric car" which launched its car in the early 2000s focuses to produce affordable cars through advanced technology. The only BEV manufacturer,Mahindra Electric mobility Ltd is leading in the Indian market. Other major HEVmanufacturer companies operating in Indian markets are Toyota Kirloskar Motor Pvt. Limited, BMW AG, Volvo Car Corporation and Honda Motors Co. Ltd. Some of the other models were Mahindra e2oPlus, Mahindra e-Verito, Mahindra e-KUV 100, Eddy Current Controls Love Bird, Atom Motors Stellar, and Tata Tiago Electric In 2014, India's overall greenhouse gas emission amounted to 3202 million metric tonnes of carbon dioxide equivalent, which accounted for 6.55% of global greenhouse gas emissions. In India, 68% of greenhousegas emission come from the energy sector, followed by agriculture, manufacturing processes, improvements in land use and forestry, and waste adding 19.6%, 6.0%, 3.8% and 1.9% relative to greenhouse gas emission An electric vehicle can be used as a flexible load for standardizing the grid with a substantial share of fluctuating renewable energy generation The ownersof the Electric vehicle do not have a transaction in the electricity market due to the low power of a single transaction Some authors considered a current practice for the estimation of current smart policies, which were established in advance for changing scenarios and are exogenous. To exploit the full potential ofan EV, flexible load, and smart charging strategies should be executed. In another study by revealed that, the EV users organized themselves to impart to the aggregator as far as timing and energy necessity.The timing requirement defines the time by which a charging operation must be completed, whereas the battery level supports the energy requirement. In a similar study conducted by indicated that a decentralised framework and a central entity should provide the pricing signal to owners of electric vehicles expecting the centralised and decentralised frameworks to overlap.Brady and Mahony, 2016 studied the stochastic simulationmethodology of an electric vehicle for generating a dynamic travel schedule and charging profile for the propulsion of the EVs in this real world. They concluded that when the conditions of parking time distribution are increased, the parking time distribution accuracy, as well as the overall accuracy of the model, would be improved. Morrissey et al., 2016 studied some electric vehicle consumers and revealed that they prefer charging their vehicles at their home during peak electricity demand in the evening. Foley et al., 2013 studied the impact of EV charging under peak and off-peak charging scenarios in a single extensive electricity market in Ireland and found that the peak charging is detrimental compared to off-peak charging. Doucette and Mc Culloch, 2011 conducted a study on the BEV and the PHEV to determine their carbon dioxide emission level and compared their results with CO2 emission from Ford Focus. Steinhilber et al., 2013 studied the essential tools and strategies for introducing new technology and innovation by exploring key barriers to an EV in two countries. Yu et al.,

ISSN No: 2321-8681
Review article
PP: 17-26
Peer Reviewed Refereed Journal

2012 introduced a driving pattern recognition technique for evaluating the driving range of the EVs based on the trip segment partitioning algorithm. 2011investigated for different driving conditions and topographies by building up a vehicle model. Salah et al., 2015 studied the EVs charging impact on Swiss distribution substation and found that higher penetration level and dynamic tariff increases the risk of overloads at some locations. These parameters are then compared with each other by their range type. The impact of various classifications of charging methodology of electric vehicles on the national grid and the storage utilization has been presented by studied the model-based non-linear observers for estimating the torque of permanent magnet synchronous motor for hybrid electric vehicles. The maximum transmissible torque method is determined by for increasing the antiskid execution of the torque control framework and to improve the stability of the Electric vehicles. Lu et al., 2013 made a review of key issues for Li-ion battery management in an Electric vehicle. The issue such as voltage of the battery cell, battery state estimation (battery SOC, SOH, DOD and SOF), battery equalization and uniformity and fault analysis of the battery can provide motivation for the research and design of the battery management system. Reviews on optimal management strategies, energy management system and the modelling approach for electric vehicles were studied by EVs can also interact with the grid via charging and discharging.Different modes of interfacing with the grid, are Grid-to-Vehicle (G2V), Vehicle to Grid (V2G), and Vehicle to Building (V2B).In G2V, the EV is charged from the grid while in V2G, the vehicle discharges power to the grid. In V2G, there is a capability to control the bi-directional flow of electrical energy between a vehicle and electric grid at regular intervals. The integration of electric vehicles into the power grid is called the vehicle to grid system. Here the energy flows both to and from the vehicle, making it into a portable battery store. In V2B, the energy transfers from the battery to a building. This paper presents an overview of the barriers and challenges of an Electric vehicle in the Indian context and is the main novelty of this paper. As the EV market expands, the focus should be on the actual adoption action of EV and not just on the intervention. Furthermore, the gap between intention and actual behaviour is important to consider. Consumer knowledge and skills for estimating and comparing the financial benefit and cost of EV are the major research gap of the current research. Future studies on how to inform customers may have implications for knowing the financial benefit and cost of EV's by policy makers and marketing specialists.The objective of this study is To identify the essential methods, barriers, and challenges of using a battery-operated vehicle in a developing country like India.To identify the reasons why electric vehicle could not get much attention in India.

To create awareness about the added advantages of battery operated vehicles over conventional fossil fueled vehicles in India.To study different Government initiatives taken in promoting Electric/Hybrid Vehicles.

Electric vehicle overview :

The grail behind the electric vehicle is to replace an internal combustion engine with an electric motor which is powered by the energy stored in the batteries through power electronic traction inverter. The Electric motor uses 90–95% of input energy to power the vehicle, which makes it a very efficient one. The key components of an Electric car are battery, charging port, charger, DC/DC converter, power electronics controller, regenerative braking, and drive system. The purpose of the electric motor is that it utilizes the electrical energy stored in batteries for powering the Electric vehicle. The EVs be- come environment-friendly as they are recharged with lower emission power sources. The cells are charged from the electric grid. The primary function of the battery is to provide power to the Electric car for making it in running condition. Generally, EVs use lithium-ion batteriesbecause

ISSN No: 2321-8681
Review article
PP: 17-26
Peer Reviewed Refereed Journal

they are more efficient than other cells due to their lightweight and negligible maintenance. The manufacturing of these Li-ion batteries is bit expensive as compared to the nickel-metal hydride and lead-acid batteries. Depending upon the climatic location and maintenance schedule, the Li-ion batteries last up to 8 to 12 years. The charging port is the point that permits the vehicle to connect with an external power supply system through a charger to charge the battery.

Types of electric vehicles :

Several countries have developed the EVs, but the broader market of EVs comes from China, UK, USA, and Germany. The EV market is growing remarkably across the world. The vehicles can be arranged into three groups: Hybrid Electric Vehicles (HEV), Plug-in-Hybrid Electric Vehicle (PHEV) and Battery Electric Vehicle(BEV).

1.1. Hybrid electric vehicle :

A hybrid electric vehicle consist of IC engine and electric motor. Here the batteries get charged by the engine and by the energy generated when decelerating and braking. In the current scenario, they are referred to as hybrid vehicles because they combine a combustion engine and an electric motor as a power converter. Hybrid electric vehicle technology is deployed worldwide as they have many advantages of offering contemporary performance with no worry about the charging infrastructure dependency. They can also reduce fuel consumption to a great extent through electrification of powertrain. The HEV can be connected in many topologies depending upon the type of hybrid system. These are series hybrid, parallel hybrid, and power-split hybrid. In a series hybrid, the electric motor is the only means to provide power to the wheel. The motor gets the power either from the battery or from the generator. Here the batteries are being charged through an IC engine to provide power for driving electric motor. In Power-split hybrid system, motor, generator, and the engine, all are attached to a transmission with a planetary gearbox. They can be arranged in both series and parallel configurations in a single frame. Here the battery and the engine alone or together can power the vehicle, and the battery can be charged simultaneously through the engine. Different speed and torque of every component are employed to decide the power delivered to the wheel. The speed and load can be varied to get maximum engine efficiency.

1.2. Plug-in hybrid electric vehicle :

Plug-in hybrid electric vehicle (PHEV) comprises of an internal combustion engine and an electric motor. These vehicles are powered by gasoline and have a large rechargeable battery, which is charged up with electricity. The benefits of Plug in Hybrid Electric Vehicles are:

Less petroleum use PHEV use about 30–60% less oil than conventional vehicle. Since electricity is mostly produced from domestic sources, plug in hybridreduces the dependency of the oil. Greenhouse gas emission Usually PHEV emit less greenhouse gas than conventional vehicle. Nuclear and hydropower plants for example are cleaner than coal fired power plant.Recharging take time Recharging with a 120 V household outlet may take several hours whereas with a 240 V, home or public charger it take 1 to 4 h. The fast charge of upto 80% of the capacity take as little as 30 min. However these vehicle do not need to be plugged in. They can only be fueled with gasoline, but without charging, they will not achieve maximum range or fuel economy.

1.3. Battery electric vehicle :

The battery electric vehicle also termed as BEV is fully electric vehicle. It has no gasoline engine, but consists of high capacity rechargeable battery packs that can be charged from an external source. The battery electric vehicle utilizes the chemical energy stored in rechargeable batteries to run the electric motor and all electronics involved internally. The BEV could not only reduce the carbon dioxide emission from the

ISSN No: 2321-8681
Review article
PP: 17-26
Peer Reviewed Refereed Journal

light-duty vehicle fleet but also reduce the dependency on fossil-fueled vehicles (Andwari et al., 2017) [63].The BEVs are said to hold the largestshare in the Indian market, contributing more than 70% trade-in 2017, which is expected to grow in the coming years. Though the BEVs dominated the sale over PHEV in many countries until 2014, there is a rapid growth of PHEV in the last two years, and the sale has gone almost equal with the BEV. In view of sorts of batteries utilized in the Indian market, it can be classified as Lead-acid batteries, Nickel-metal hydride batteries, and Lithium-ion batteries. In India, the state of Maharashtra has the highest selling volume of Electric cars in 2017. There are similar kinds of literature that study the comparative strategy for estimating the SOC and SOH of hybrid and battery electric vehicles .The Hinf observer-based fault estimation of battery in HEV application have been presented by and the algorithm for determining the temperature and thermal life of traction motor in commercial HEV has been discussed by.Andy et al., 2010 proposed two steps model that first segments the road traffic and their respective demands into a hierarchy of clusters,in a natural and automatic manner, followed by optimization by using linear programming for assigning the stations to the demand cluster. This work is believed to be useful for city planning, and for designing a refuelling infrastructure in an urbanized area for BEVs. Cuma & Koroglu, 2015 did a comparative review in the estimation strategy and different methodologies used in hybrid and battery electric vehicles. Battery Electric Vehicles (BEVs) satisfy two conditions i.e. an electric motor is powered by a battery that replaces the ICEV and the tank, and when not in use, the vehicle is plugged into the charging port.

2.2. Battery thermal management system :

The use of EV will increase in near future and so priority is given to the need of developing effective batteries. The thermal degradation of the batteries is a big challenge for better BTMS which affect the range of the EV. The main objective of the BTMS is to control the temperature of the battery cell and thus improve the battery life. Li ion batteries are usually preferred for their energy storage in electric vehicle. There are many challenges such as low efficiency at high and low temperature, decrease life of electrodes at high temperature and the direct effect on the performance, reliability, cost and protection of the vehicle and the safety issues related to thermal runaway in lithium ion batteries. So an effective thermal battery management system is therefore one of the most crucial technology for long term success of an electric vehicle. Normally the temperature ranges from 25 °C to 40 °C is the optimal working conditions for the Li-ion batteries. When the temperature of these batteries is higher than 50 °C, it degrades the life of the battery.

Electric vehicle scenario in India :

Currently, the EV market is extremely small in India. The sale of electric cars has become dormant at 2000 units per year for the last two years . But there is a vision for 100% electric vehicle sale by 2030 and since we are in 2020, the compound annual growth rate is 28.12%. India's first electric car Reva (Mahindra), was introduced in 2001, and since its launch, it could able to sell a few units. In 2010, Toyota began Prius hybrid model, followed by Camry hybrid in 2013. Electric buses and hybrid vehicles have been commenced as a pilot proposal in a few cities.

Scheme for purchasing electric vehicle in India :

Central Govt and state Govt have launched various schemes and incentives to promote electric mobility in India .Some of the schemes are mentioned below. National Electric Mobility Mission Plan (NEMMP) 2020 was declared by the Government of India to enhance the national energy security, mitigating the harmful effect of fossil fuel power vehicles on the environment and development of domestic manufacturing capabilities (GoI, 2012). The NEMMP 2020

ISSN No: 2321-8681
Review article
PP: 17-26
Peer Reviewed Refereed Journal

could help with the sale of 6–7 million units of electric vehicles, which in turn could be able to save 2.2–2.5 million tonnes of fossil fuel. The vehicular emission and CO2 emission could be lowered to 1.3–1.5% in 2020 as a result of this new plan. According to this plan, 5–7 million electric vehicles can be deployed by the end of 2020. It also emphasizes the importance of Government incentives and coordination between industry and academia. The Government of India is also making arrangement for 100 GW of solar based power generation by 2022, which could improve the reliability and use of renewable energy that will be helpful for charging stations of EVs. Barriers for EVs in the Indian market:

Barriers for EVs in the Indian market can be addressed from various prospective such as Technical barriers, policy barriers, and lack of infrastructure.

Market

Vehicle servicing

In order to take proper care of the electric car, a trained technician should be available to repair, maintain, and find troubleshoot of the electric vehicle. They must be able to apply their skills to rectify the problem as quickly as possible

High capital cost :

The battery packs of an electric vehicle are expensive, and also it needs replacement more than once in its lifetime. The gas-powered cars are cheap when compared with electric vehicles.

Consumer perception :

Consumer perception plays a vital role in attracting new customer and retains an existing customer. Despite the growing range in the auto market with a broader range of electric vehicles, the choice of buying an electric car is limited and is expected to continue over time. So there should be aware of the company offerings to the customer by means of advertising, social media, or another channel. Studies show that the lack of knowledge associated with the Government scheme, economic benefit, and awareness of the vehicular technology can have a direct impact on the electric vehicle adoption.

Raw materials for batteries :

The raw materials for EVs batteries include lithium, nickel, phosphate and manganese, graphite, and cobalt, which are rare earth material. For an internal combustion engine, aluminium copper and steel are required. The catalysers for combustion automobiles need platinum, rhodium, and palladium to filter the toxic gases. These all are scare material, and the availability of this material may not be available enough for battery production. The lithium-ion batteries alone consume 5million tons/yr of nickel, which could lead to 10–20 times more consumption of lithium and cobalt in future.

Technical

Battery lifespan/efficiency :

The electric cars are usually created by using electric motors, batteries, chargers and controllers by replacing fuel tank and gasoline engine of a conventional vehicle. As the EVs batteries are designed for a long life, it wears out in due course of time. Currently, most manufacturers are offering eight years/100,000 mile warranty for their batteries.

Driving range of electric vehicle :

A driving range is recognized as the main barrier of Electric vehicle typically because EVs has a smaller range as compared with the equivalent ICE vehicle. The distance an electric vehicle can travel on a full charge or full tank is considered as a significant drawback to uptake the. EV in the global market. Most of the BEV provides a driving range of less than 250 km per recharge. However, some of the latest models can offer up to 400 km [91]. By now, PHEV is offering a range of 500 km or more due to the availability of liquid fuel internal combustion engines. The driver must plan their trip carefully and may not have the option for a long-distance trip. This

ISSN No: 2321-8681
Review article
PP: 17-26
Peer Reviewed Refereed Journal

makes the magnitude of driving range as a barrier.

Charging time

Charging time is closely related to the issue of driving range. With a slow charger, the EV can take up to 8 h for a full charge from the empty state using a 7 kW charging point. The charging time mainly depends upon the size of the battery. Bigger the size of car batteries, longer the time it takes to recharge the battery from empty to full state. Also, the charging time of the battery directly depends on the charging rate of the charge point. Higher the charging price of the charge point, lower will be the time taken by the battery to get fully charged. In the current scenario, rapid chargers are used to charge the vehicle in a faster way reducing the time required. The commercially available electric cars are compatibles with charge points having a higher maximum charge rate than they can handle. This indicates that the battery can be charged at a maximum rate that they can handle without any fault. However, the charging rate of the battery with rapid charger reduces with a decrease in temperature or at cold temperature. The EV chargers are categorized in accordance with their charging speed at which their battery gets recharged.

Safety requirements of electric vehicle :

The Electric vehicle must meet the safety standard as specified by state or local regulation. The batteries should also meet the testing standards that are subject to conditions like overcharge, temperature, short circuit, fire collision, vibration, humidity, and water immersion. The design of these vehicles should be such that they should have safety features like detecting a collision, short circuit, and should be insulated from high voltage lines.

Environmental impact :

Generally, the electric vehicles do not pollute the environment, but the elements of the batteries are extracted from mines or brine in the desert. This extraction has a low environmental impact on mining.

Policy :

To speed up the Indian electric vehicle revolution, the Government of India is planning to subsidize EVs charging infrastructure in the country. The ministry of power has also recently clarified that the EV charging station requires no license to operate in India, which can boost nationwide EV charging station infrastructure. The Govt. should not only slash applicable rate for Goods and Service Tax (GST) on Li-ion batteries, provide incentives and concessions to EV buyers, but also should provide incentives for shifting the public transport sector to Electric vehicle

Infrastructure :

Charging infrastructure :

More charging infrastructure is required for a larger number of electric vehicles and hence, higher demands for electrical energy. Due to the lack of existing charging infrastructure in India, the sale of the electric vehicle is low. The chargeable batteries ought to be appreciated by EV manufacturers from a design point of view so that discharge batteries might be replaced by completely energized batteries. During the off-peak time, at reduced electricity tariff, the charging station can plan to charge their batteries. There should also be an option for setting up a charging point at home for this vehicle as people would have to start their day by charging their electric vehicle in their residence. In the absence of charging infrastructure at residence, people would rather prefer to charge their vehicle at their workplace or in a suitable charging station where they have to stop over two to three hours or more. Such a location, like home and workplace, is ideal for slow charging and places like highways and commercial complexes where vehicle halt for a shorter duration, fast charging would be the best option. It may also be noted that fast charging of 30 min or less, the EV must be capable of taking high

ISSN No: 2321-8681
Review article
PP: 17-26
Peer Reviewed Refereed Journal

current andvoltage or both. This will not only increase the cost of the EV but also have a negative impact on the life of the battery. So, a combination of slow and fast chargers could be the best option for the EVs.

Battery recycling

The batteries used in Electric vehicles are generally planned to last for a limited lifetime of the vehicle but will wear out eventually. The pricing for battery replacement is not properly informed by the manufacturers, but if there is a need for battery replacement outside its warranty period, then it adds the expenses by dumping the old battery with a new one. The chemical elements of the batteries like Lithium, Nickel, Cobalt, Manganese, Titanium not only increases the cost-effectiveness of the supply chain but also have environment concern during scraping of the battery elements.

Optimisation technique :

Application of optimisation technique for EVs :

In this paper, the charging demand of EV is characterized by various frameworks in different geographical locations. The framework consists of Random utility model, Activity-based equilibrium scheduling, Driving pattern recognition, Stochastic model, Trip prediction model, Probabilistic model, Fuzzy based model and Data mining model, Forecasting model, Distributed Optimization, Hybrid particle swarm optimization, Ant colony optimization and Household Activity Pattern,Particle swarm optimisation,linear programming, multi-objective and adaptive model which are summarised below. The scope of this study was to investigate the potential benefit of charging characteristics of all EVs. Various studies conducted worldwide by different authors for finding the optimisation technique of Electric Vehicles.

Vehicle to grid technology :

The V2G concept was first introduced by. Under this concept, the parked EV can supply electrical power to the grid and have a bidirectional charger, i.e., it can either deliver power to the grid or can be used to charge the battery. In V2G and Grid to Vehicle, the impact of bidirectional charging of Li-ion cells has been proposed to find its cell performance. Overview of employing energy storage technology in the planning and operation of a distribution system is presented by. They studied the battery technology and policy of V2G technology. They provided a methodology to manage battery degradation, which can be used for extending the life of the battery usedin the electric vehicle.

Application of optimisation technique for V2G :

Various control strategies are proposed for optimal performance of V2G. Many authors across the globe have investigated challenges to V2G using smart charging method. The Batteries used in EVs do not have any significant impact on the grid due to their small size, as revealed by However, V2G faces many socio-technical barriers due to their large scale deployment . For evaluating V2G economics, Kempton and Tomic, 2005 expressed the lifetime of the battery energy as a function of battery capacity, battery cycle lifetime, and it's DOD. The energy transfer of V2G has already been carried out in different countries to regulate varying, unpredicted energy demand or variation in supply availability. Ekman, 2011 studied the cooperation between large EV fleets and high wind energy penetration in Denmark.V2G concept for Electric vehicle can either be hybrid, fuel cell, or pure battery vehicle. These hybrid vehicle drive train, fuel cell, and battery EVs have been analyzed for various energy markets peak load, base load, spinning reserve, and regulation services . Several elements must be met to enable V2G; these are i) the vehicle must have a connection with the grid for transfer of electrical power ii) communication either control or logical connection concerning grid operation and iii) onboard metering device of the vehicle.

ISSN No: 2321-8681
Review article
PP: 17-26
Peer Reviewed Refereed Journal

Conclusion :

Hybrid, Plug in Hybrid and Electric Vehicles are capable of increasing the fuel economy of vehicles but with an increase in the cost of buying compared to traditional vehicles. In general their decreased consumption of petroleum and increased productivity offers economic benefit to buyers, society, automakers and policymakers over the lifetime.This paper provides a detailed overview of the literature, overview, and guidelines for HEV, PHEV and BEV penetration rate studies into the Indian Market. The recent initiatives and various subsidies by the Indian Government will help push the e-mobility drive in India. The development of a new concept of Vehicle-to-Grid can either deliver power to the grid or can be used to charge the battery when non-conventional energy sources are not available. This technology is an important aspect of energy security, renewable energy, and giving a great scope to deal with global warming issues. This paper provides a summary of an electric vehicle's barriers and problems in the Indian context and is the main novelty of the paper.

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