A review of the perception of electric vehicles till date, its reason, and some suggestions to implement it on a large scale in India.

A major project submitted to fulfill the requirements for completing the

HEV Course in **InMovidu Tech**

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Table of Contents

Abstract

The electric vehicle is a concept which fascinated many people around the world and continues to do so. They offer an excellent alternative to the traditional Internal Combustion (IC) engine vehicles, which cause a lot of emissions and increase the carbon footprint. They also reduce the dependency on fossil fuels which could save a lot of money for the country. However, they are not implemented and utilized properly. Although comprehensive research on the characteristics of electric vehicles and the nature of their charging infrastructure is being carried out around the world, electric vehicle production and network modelling continues to evolve and be constrained. This paper contains some extensive data about the EV's, its perception globally, the challenges it faces for full-scale implementation in countries like India. This compilation on the essential barriers and insufficient charging facilities are addressed for a developing country like India that makes the study unique and worthy.

List of Figures

List of Tables

1. Introduction:

Table 1 Abbreviations of the terms used.

Nomenclature	
IC – Internal Combustion	EV - Electric Vehicle
U.S – United States	BEV – Battery Electric Vehicles
BMS – Battery Management System	HEV – Hybrid Electric Vehicles
PEC – Power Electronics Controller	PHEV – Plug-in Hybrid Electric Vehicles
PV – Photo-Voltaic	FCEV – Fuel Cell Electric Vehicle
DC – Direct Current	SEV – Solar Electric Vehicles
AC – Alternating Current	Kw – Kilo watt
FAME – Faster Adoption and Manufacturing	CNG – Compressed Natural Gas
of Hybrid and Electric vehicles	AVTS – Automatic Vehicle Tracking System
CCTV – Closed Circuit Tele-Vision	G2V – Grid-to-Vehicle
V2B – Vehicle-to-Building	V2G – Vehicle-to-Grid
GST – Goods and Service Tax	Li-ion – Lithium-ion

We are living in a progressing world. The first industrial revolution brought a lot of changes in the lifestyles of people. They could experience products imported from other countries as well as export their goods by means of mass production. It is not a mistake to say that we are headed towards another industrial revolution. We see massive developments in shifting towards electrification of all mechanical machines and human labours.

With the rapid increase in competition in the Indian automobile market, Electric Vehicles (EV's) are turning into a promising channel towards improving air quality, energy utilization, and economic opportunities. There is an immediate need to reduce greenhouse gas emissions, which cause a threat to the ozone layer by free radical chain reaction.

India imports a majority amount of fossil fuel like petroleum from gulf countries like Saudi Arabia to produce various products like refined bitumen, naphthalene, paraffin wax, gasoline, etc. Due to the extensive mining of fossil fuels, there will be a day where they are no more. It will be followed by a rapid increase in fuel prices and will affect the whole country economically. Steps have been taken for minimal use of fossil fuels for power generation, transport propulsion, reduction of energy consumption, and protection of carbon sequestration. However, EV's could be the best alternative to decrease carbon dioxide gas emission [1] as well as develop the transportation sector.

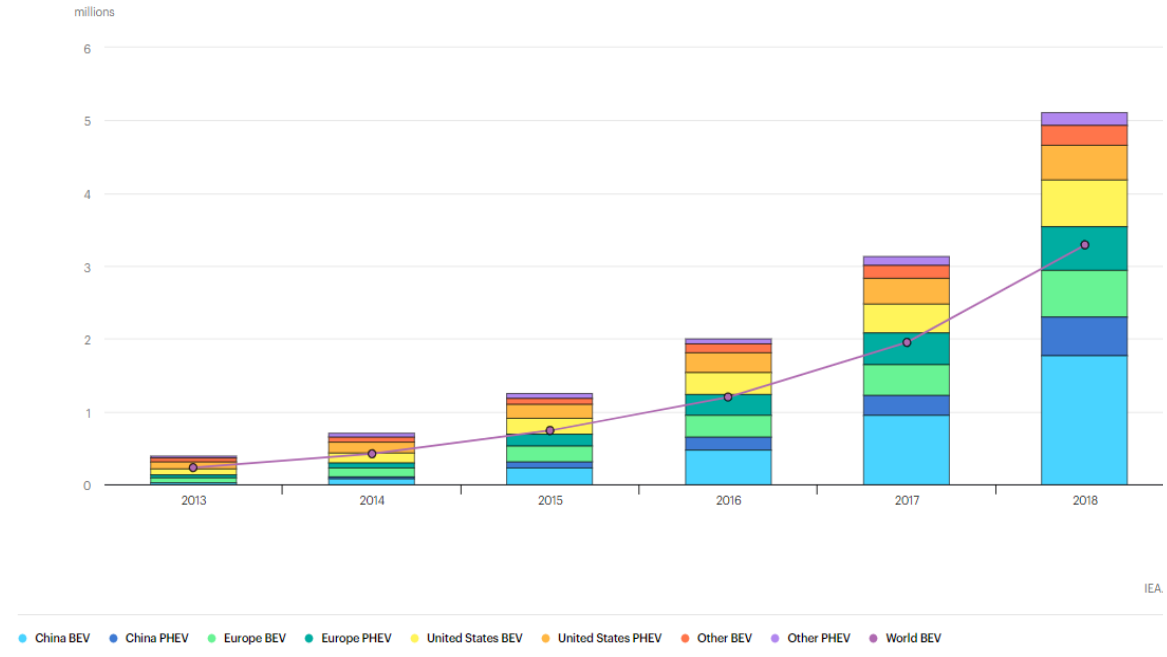

Fig. 1. Electric car deployment in selected countries from 2013- 2018

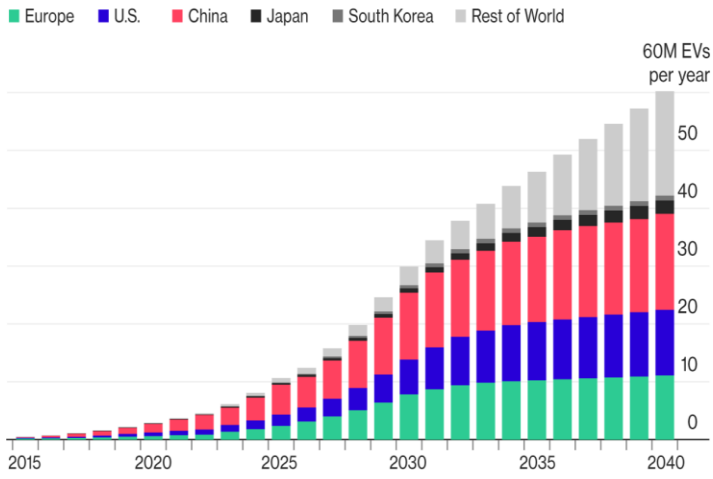

Fig. 2. Estimated productions of EV's

On a global level, it is clearly observable that China is leading the revolution in using EV's followed by the U.S and European countries. According to an analysis, in 2020, EVs make up just 7 percent of the total (1.6 million vehicles). By 2025, that share is expected to be around 21 percent (5.4 million). And by

2030, it will be about 37 percent (11.2 million). Altogether, 66 million EVs are expected to be sold between 2020 and 2030.

A Foley et al., 2013 [2] studied the impact of EV charging under peak and off-peak charging scenarios in a single extensive electricity market in Ireland and found that peak charging is detrimental compared to off-peak charging. Salah et al., 2015 [3] 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. V Nimesh et al, 2021 [4] has assessed the viability of implementing electric vehicles in nations with a high vehicle population. W Wu and B Lin, 2021 [5] have written extensively about how integrating EVs with the grid can smoothen the load curve and cut electricity costs. S Goel et al, 2021 [6] has explained the objectives of this paper similarly, putting forward their views on the current scenario of electrification of vehicles.

It is an excellent thing that EV's are becoming popular everywhere these days due to various technological developments, but still, many people in our country depend on fossil fuels. It is not entirely correct to criticize them as EV's are still encountering challenges in charging, capital recovery period, and driving range compared to conventional fossil fuel vehicles. Several factors such as technological advancement, reduction in the cost of a vehicle, government policy support, vehicle purchasing incentives, parking benefit, and good public charging infrastructure facility could result in the uptake of EVs in India.

2. Methodology:

This paper begins with the introduction of why electric vehicles need to replace IC engine vehicles and shows the trends of the rise of the former in other countries over the recent years. Various challenges in the ownership of EV's are mentioned here, which need to be dealt with. Some policies and subsidies passed by the central government and various state governments are depicted, and further suggestions are given which may help immensely in making EV's prevalent in our country.

3. A brief overview of electric vehicles:

An Electric Vehicle (EV) is simply an automobile that uses one or more electric motors for the propulsion of the vehicle. An electric vehicle may be powered through a collector system by electricity from off-vehicle sources or self-contained with a battery, fuel cells, solar panels, or

an electric generator to convert fuel to electricity. EVs include, but are not limited to, rail and road vehicles, surface and underwater vessels, electric air crafts, and electric spacecraft.

EVs first came into existence in the mid-19th century, when electricity was among the preferred methods for motor vehicle propulsion, providing a comfort and ease of operation that could not be achieved by the gasoline cars of the time. However, modern internal combustion engines have been the dominant propulsion method for motor vehicles for almost 100 years. Still, electric power has remained commonplace in other vehicle types, such as trains and smaller vehicles of all kinds.

There are generally five types of electric vehicles/cars used commercially by people and run on the road.

3.1 Battery Electric Vehicles:

The Battery Electric Vehicles (BEV's) run purely on electricity recharged from charging stations and outlets. This is produced from various other resources of energy and is stored in the vehicle with a rechargeable lithium-ion battery. The powertrain of BEV's mainly consists of a traction battery, auxiliary batteries, motor drive, charger, Power Electronics Controller (PEC), Battery Management System (BMS), and transmission.

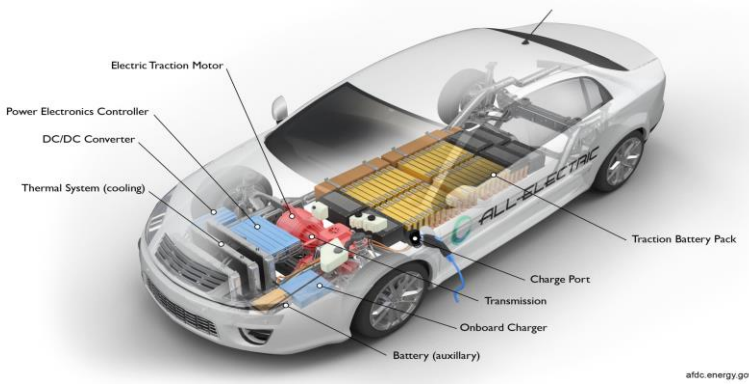

Fig. 3. Battery Electric Vehicle

3.2 Hybrid Electric Vehicles:

These Hybrid Electric Vehicles utilize either petrol or diesel as the fuel source. However, as the name suggests, they are a combination of traditional IC engine vehicles and BEV's. Here the electric motor is not only used to start the engine but also supports it during the run. Depending upon the configuration of the power train, there are three more types of HEV's [7].

3.2.1 Series Hybrid Electric Vehicles:

The series HEV's use the combustion of the fuel to rotate the shaft by which the generator produces electricity. This is stored in the batteries and used appropriately to run the motor and

propel the vehicle. Note that regenerative braking also recharges the battery pack along with the engine. Since the work of the IC engine is just to rotate the shaft, they are smaller in size relatively and have bigger battery packs than parallel HEV's. Hence, they are expensive relatively. An important point to note is that the series HEV's are very efficient at low speeds, unlike petrol and diesel engines, and are ideal for driving in metropolitan areas.

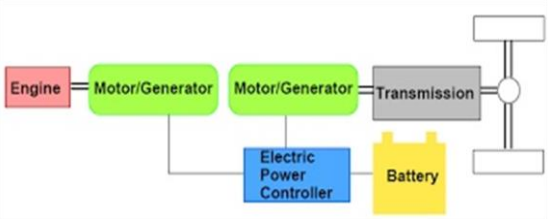

Fig. 4. Series configured HEV

3.2.2 Parallel Hybrid Electric Vehicles:

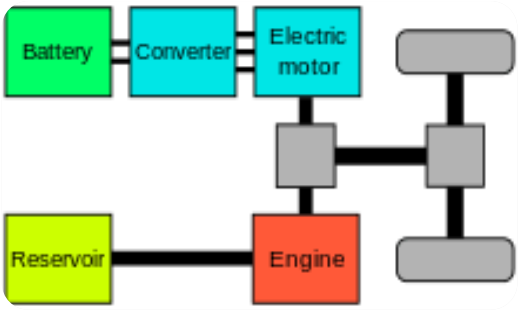

Fig. 5. Parallel configured HEV

In parallel HEV's both the IC engine and electric motor work in harmony. Together they can propel the wheels at the same time. Here it utilizes a full-sized IC engine but a relatively small-sized battery pack and electric motor. These vehicles rely on regenerative braking to keep the battery pack recharged, and when the power demands are low, parallel hybrids also utilize the motor as a generator for supplemental recharging. As expected, they are more efficient at higher speeds, unlike the series HEV's. Since the engine is connected directly to the wheels in parallel drivetrains, the process of converting mechanical power to electricity and back is eliminated, increasing the efficiency of these hybrids on the highways at high speeds. This reduces but does not eliminate the efficiency benefits of having an electric motor and battery in stop-and-go traffic.

3.2.3 Series-Parallel Hybrid Electric Vehicles:

The series-parallel HEV's have the flexibility to change to any configurations according to the requirement. Here it merges the advantages of both series and parallel configurations and operates at near optimum efficiency more often. At lower speeds, it serves more as a series vehicle, while at high speeds, where the series drivetrain is less efficient, the engine takes over, and energy loss is reduced by adopting parallel arrangement.

This system incurs higher costs than a pure parallel hybrid since it requires a generator, a larger battery pack, and more computing power to control the dual system. Yet its efficiency statistics show that the series-parallel drivetrain can perform better and use less fuel than either the series or parallel systems alone.

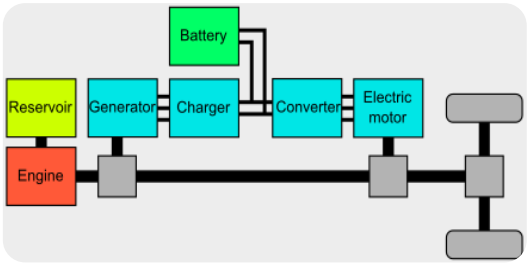

Fig. 6. Series-Parallel configured HEV

3.3 Plug-in Hybrid Electric Vehicles:

The PHEV's are similar to HEV's except for the fact that, additionally, the batteries can be recharged by using an onboard charger. The amount of electricity a PHEV can store in its battery can significantly reduce the vehicle's petroleum consumption under typical driving conditions. Hence, the size of the battery is relatively larger.

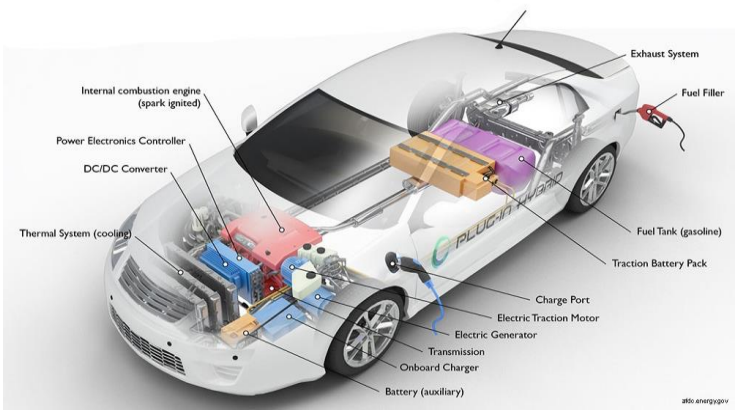

Fig. 7. Plug-in Hybrid Electric Vehicle

The PHEV's generally cost more than the other non-plug-in types, but they use about 40 to 60 percent less petroleum than conventional vehicles. As electricity is produced primarily from domestic resources, PHEVs reduce petroleum dependence. Charging the battery typically takes several hours, but a quick charge to 80% capacity may take as little as 30 minutes. However, PHEVs can be driven without being plugged in. They can be fuelled solely with gasoline but will not achieve maximum range or fuel economy without charging.

3.4 Fuel Cell Electric Vehicles:

Fuel Cell Electric Vehicles (FCEV's) are powered mainly by hydrogen. They are more efficient than conventional IC engine vehicles and produce no harmful tailpipe emissions [8]. When a fuel like hydrogen is fed into the vehicle, it is stored in a chamber very carefully. In the fuel cell, due to the chemical reaction between hydrogen and oxygen, a potential difference is created, which drives a current.

This power is stored in batteries and is used to drive the electric motor and propel the vehicle. The striking features of FCEV are that the by-products of the chemical reaction are just water and warm air. These vehicles also provide a long range when compared to BEV's and are still in research and development. FCEVs are equipped with other advanced technologies to increase efficiency, such as regenerative braking systems, which capture the energy lost during braking and store it in a battery.

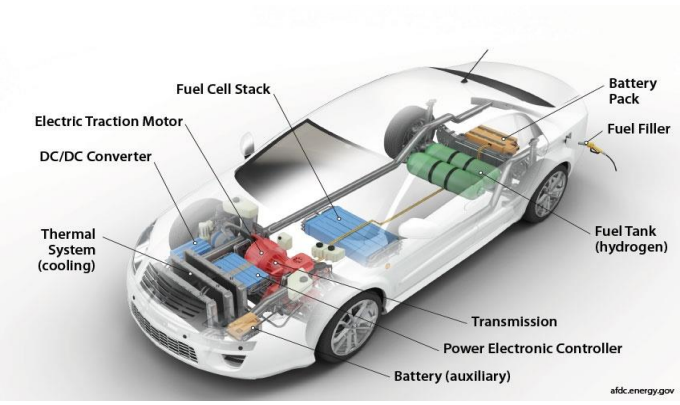

Fig. 8. Fuel Cell Electric Vehicle

3.5 Solar Electric Vehicles:

A solar vehicle or Solar Electric Vehicle is an electric vehicle powered completely or significantly by direct solar energy. Usually, Photo-Voltaic (PV) cells in solar panels convert the sun's energy directly into electric energy and produce direct current. This is directed to a DC-to-DC power converter and taken to a DC-AC inverter, after which the alternating current is used for charging the EV. However, a more efficient way would be introducing an isolated DC-to-DC converter that charges the EV directly from PV cells by DC charging. Solar vehicles are not sold as practical day-to-day transportation devices at present but are primarily demonstration vehicles and engineering exercises, often sponsored by government agencies. Questions over their low power output and inability to operate at maximum efficiency due to weather conditions make them less popular and hence, still in the development phase.

Table 2 Types of EV's, their primary energy source, and method of propulsion

Type of EV	Primary Energy Source	Propulsion
Series HEV	Petrol/Diesel	Electric motor
Parallel HEV		Electric motor + IC engine
Series-Parallel HEV		Electric motor + IC engine

Series PHEV	Petrol/Diesel + Recharged battery	Electric motor
Parallel PHEV		Electric motor + IC engine
BEV	Recharged battery	Electric motor
FCEV	Hydrogen in fuel cell	Electric motor
SEV	Solar panels	Electric motor

4. Challenges faced in the full-scale implementation of EV's:

4.1 Technical barriers:

Electric cars are usually created using electric motors, batteries, chargers, and controllers by replacing the fuel tank and gasoline engine of a conventional vehicle. As the EVs batteries are designed for long life, it wears out in due time and needs to be carefully replaced [9].

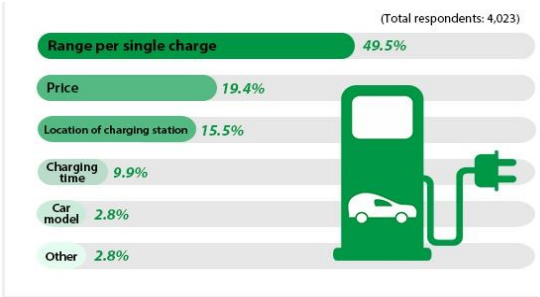

Fig. 9. A study conducted revealing which factors people consider the most before buying an EV.

A driving range is recognized as the main barrier of an electric vehicle, typically because EVs have a smaller range when compared with their equivalent IC engine vehicles. Fig 9 shows the primary concern people have in their minds before buying an EV. The distance an electric vehicle can travel on a full charge or full tank is considered a significant drawback to uptake the EV in the global market. The driver must plan their trip carefully and may not have the option for a long-distance journey. This makes the magnitude of the driving range a barrier.

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, the longer 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, the 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 a rapid charger reduces with a decrease in temperature or in cold weather. The EV chargers are categorized in accordance with their charging speed at which their battery gets recharged.

There are three fundamental kinds of EV charging, for example, Level 1, Level 2, and DC fast. Level 1 charging utilizes a standard 120 V outlet by converting AC to DC using an onboard converter. It takes 8 hours to charge the EV with 120 V outlets for a range of approximately 120– 130 km. Level 1 charging is basically done at home or in the working environment. Level 2 chargers are typically set up at a public place or workplace that can be charged with a 240 V outlet. It takes 4 hours to charge the battery for a range of 120–130 km.

With DC fast charging, the change from AC to DC occurs in the charging station with the appropriate arrangements. This permits stations to supply more power, charging vehicles more quickly. It can charge the battery in 30 min for a range of 145 km. However, DC charging too, has its own share of disadvantages. Supplying high current continuously will generate a lot of heat, resulting in the reduction of the overall capacity of the battery. The communication will be tougher between the BMS and charger since DC chargers are usually located outside the vehicle. The wires need to be thick to supply high power to the EV, which decreases its flexibility.

4.2 Economic barriers:

The battery packs of an electric vehicle are costly, and they need to be replaced more than once in their lifetime. Gas-powered cars are cheap when compared with electric cars in this aspect.

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

The initial cost of an EV is very high currently when compared to an average IC engine vehicle. Even though the seller promises its benefit over the petrol/diesel vehicles in the future, in most cases, the payback period is very long. Again, this is due to the inefficiencies of the car and the price of the raw materials.

4.3 Environmental barriers:

While it's not a mistake to say that EV's produce less emissions overall than IC engine vehicles, pollution is not entirely prevented. The energy required to power an electric vehicle is obtained from various sources, resulting from the burning up of coal in the current scenario. To completely establish a pollution-free vehicle, we have to reduce our dependence on non-renewable sources of energy and harvest from solar energy, hydroelectric power, etc.

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, it adds the expenses by dumping the old battery with a new one. The chemical elements of the batteries like lithium, nickel, cobalt, manganese, and titanium increase the cost-effectiveness of the supply chain and have an environmental impact during the scraping of the battery elements.

4.4 Other reasons:

Consumer perception plays a vital role in attracting new customers and retains existing customers. 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. Hence, there should be a proper awareness of the company's 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 vehicular technology can have a direct impact on electric vehicle adoption.

The electric vehicle must meet the safety standard as specified by state or local regulation. The batteries should also meet the testing standards subjected 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-circuiting, and should be insulated from high voltage lines.

5. Government policies supporting EV's launched till now:

The central and state governments have launched incentives and schemes to promote widespread electric mobility in the country, and some regulations and standards are also implemented. While the country stands to benefit significantly by switching its transportation from traditional IC engines to electric motor-powered, there are many challenges, as discussed above. Still, e-commerce companies, car manufacturers, mobility solution providers, and app-based transportation network companies have entered the sector and are slowly developing up electric car's capacity and efficiency [10].

5.1 Central Government policies:

The union government has expressed its vision to make the country an all-electric vehicle market by the year 2031 to stop depending on fossil fuels and reduce the country's carbon footprint. Hence, it released a two-pronged strategy that aims at both buyers and manufacturers. It offers $1.4 billion in subsidies to buyers while imposing a hike on import tariffs to increase the manufacturing of these vehicles by local companies. The government is mainly focusing to completely electrify public transportation as the subsidies are primarily available for three-wheelers, two-wheelers, and buses. This policy also assigns $140 million to develop charging infrastructure, which should further help in strengthening the EV industry in India. On 14 December 2018, the government released a document that outlines the standard and guidelines for EV charging infrastructure. Beyond the specifications of the charging infrastructure, the guidelines also insist a charging station be present every 25 km along a road/highway.

The government also initiated the Faster Adoption and Manufacturing of Hybrid and Electric vehicles (FAME) scheme [11], which provides incentives for purchasing electric vehicles. Phase I of the scheme lasted from 2015 to 2019, while Phase II began in 2019 and is planned to be completed in 2022. 'The Go Electric Campaign' was started at the beginning of 2021 to encourage the adoption of electric mobility vehicles and electric cooking appliances and to ensure energy security in the country. Road transport and highways minister Mr. Nitin Gadkari launched the campaign, saying 'Go Electric Campaign' is a future for India that will promote low-cost, environmentally friendly, and indigenous electrical products. He expressed concern about the huge cost of importing fossil fuels and said CO2 emissions from vehicles are a major challenge that needs to be eradicated and insisted the public must encourage the use of vehicles that run on alternative fuels such as electric batteries, CNG, and biofuels [12].

5.2 State Government policies:

The Delhi government recently approved the usage of 1,000 low-floor AC Electric buses in Delhi's public transport system. These buses have CCTV, Automatic Vehicle Tracking System (AVTS), panic buttons, and panic alarms; hence, they are very secure for passengers. Subsidies are also given by this government which is up to Rs 75 lakh or 60% of the cost of the bus, whichever is lesser.

Tamil Nadu chief minister Mr. Edappadi K Palaniswami launched Mauto Electric Mobility's electric autorickshaws. It is said to be India's first retrofit electric autos in 2019. Dubai-based KMC group and Mauto Electric Mobility will convert petrol-run traditional autorickshaws into electric vehicles with an investment of Rs 100 crore and offer job opportunities to 5,000 people. The driving range after a full charge will be around 100 km. The goal is to introduce 4,000 electric rickshaws in the city, 100 by a month, to reduce air pollution rapidly. The autos are fitted with CCTV surveillance and panic button; hence it is highly safe for children going to school and women. The conventional petrol-driven autorickshaws would incur an expenditure of Rs 350 - Rs 400 for every 100 km, while it is Rs 40, significantly less, for electric autorickshaws. The company is aiming to set up charging stations in each of the ten zones of Chennai city. Charging on the go would be possible with the help of a mobile app [13].

Karnataka government approved 'Electric Vehicle and Energy Storage Policy 2017' [14]. It aims to attract an investment of Rs 31,000 crore and create around 55,000 employment opportunities.

The Maharashtra Government started focusing on increasing EV use in its state by proposing to exempt EV's owners from road tax and providing a 15% subsidy to the first one lakh EV's registered in the state. To develop a suitable infrastructure, the government has proposed to provide a maximum subsidy of Rs 1 million per charging station up to the first 250 charging stations that are set up in Maharashtra [15].

In 2018, the Uttrakhand Government introduced a new scheme to help the manufacturing and promote electric vehicles as well [16]. This scheme would permit companies to receive loans between Rs 10 crore and Rs 50 crore to build EV's and charging infrastructure. Under this scheme, the first one lakh registered customers need not pay their motor tax for their EV's for the next five years.

6. Additional Steps to implement EV's on a larger scale:

Wide-scale implementation of EV creates an adverse impact on the grid. Everyone would charge their vehicle, which results in power inflation and sometimes may develop a shortage elsewhere. An electric vehicle can be used as a flexible load for standardizing the grid with a substantial share of fluctuating renewable energy generation [17]. Hence good infrastructures for charging (both AC and DC) needs to be made which do not strain the grid and utilize power balancing techniques like 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 the 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.

The ministry of power has conveyed 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 the applicable rate for Goods and Service Tax (GST) on li-ion batteries, provide further incentives and concessions to EV buyers, but also should provide incentives for shifting the public transport sector to Electric vehicle.

To take proper care of the electric car, a trained technician should be made available at request to repair, maintain, and troubleshoot the electric vehicle. They must be able to implement their skills to rectify the problem as quickly as possible. In this way, the livelihood of people currently working in IC engine car factories will not be taken away. There is a huge scope for increasing job opportunities as technology advances every day; hence it advantageous for all.

7. Result and Analysis:

There are around 1.38 billion people residing in India, and we are the most populous country after China. Such a vast population has its own share of advantages and disadvantages.

Except for China, all other countries shown in Fig 10 consist of a small population compared to India. China is again, a superpower globally and a highly developed country.

Our country spends a lot on importing fossil fuels from gulf countries like Saudi Arabia. We are so dependent on petroleum by-products that a sudden shortage across the country would create major havoc. The prices are also increasing due to extensive mining, and the governments are also imposing various taxes, which ultimately affects the citizens. We as a country must learn to adapt, and it is the responsibility of each and everyone to protect the future for the sake of subsequent generations. We have to switch to a non-polluting mode of transportations like EV's which don't harm nature and degrade the surroundings. The government must also actively participate in switching over from fossil fuels and realize the potential of EV's. More policies must be passed favouring EV ownership, and steps must be taken to electrify all public modes of transportation extensively. Infrastructures must be developed in accordance by increasing the start-up culture among students and engaging in various foreign policies.

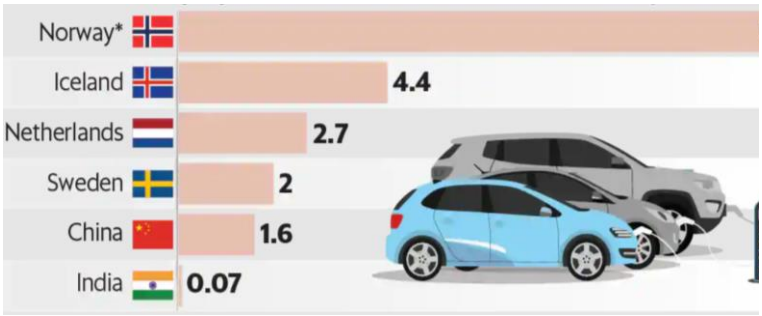

Fig. 10. Electric cars as a proportion of the number of cars in a country (in %)

8. Conclusion:

Hybrid, Plug-in Hybrid, and Electric Vehicles are very 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 benefits to buyers, society, automakers, and policymakers over the lifetime. The recent initiatives and various subsidies by the Indian government will help in enabling the e-mobility drive in India. This technology is an important aspect of energy security, renewable energy, and great scope to deal with global warming issues. This paper summarizes the main challenges faced in the rise of electric vehicles and some steps to overcome them.

Acknowledgment

I want to thank my mentor, Mr. Rahul Batter, for guiding me very patiently to complete this major project successfully.

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