Electric Vehicles - A Window of Technological Opportunities

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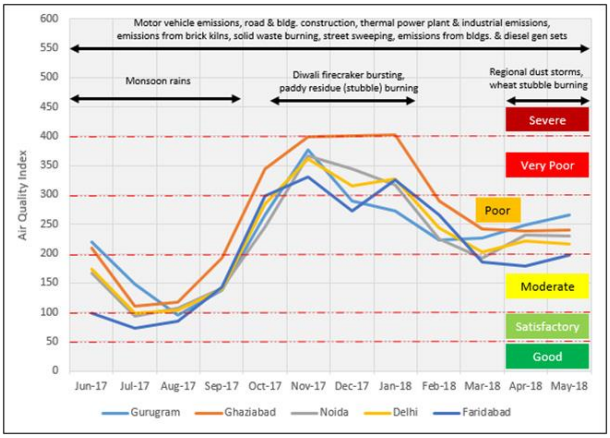
Abstract- *As of 2020,Twenty-two of the Top Thirty most polluted cities in the world are in India. Due to increasing pollution and rising gas prices (which have reached a record 100 Rs. Per litre) the increasing trend is to electrify India. This review paper helps identifying problems, mass production of electric vehicles, the grid of electric charging station across India, it also glares on improvements to be made to the infrastructure as a whole. Furthermore we will be looking at the environmental problems due to ICE vehicles, availability of raw resources and battery charging methods.We conclude with details about the ongoing programs (both private and goverment initiatives) regarding making EVs more affordable.*

I. INTRODUCTION

Vehicles have been a huge part of our lives since their invention, making travelling easier and cutting down travel times .The first electric car was invented in the early 1800s decades before the First Gas Car , due to its subpar performance and lacking battery tech it wasn't implemented. But with advancements in technology in modern not only has automobile performance improved so has technology supplementing it.According to a report by the European Union, The CO2 Pollution due to the transport sector is nearly 28%, out of which road transport is responsible for 70%. All the developed countries are hence pushing for the green initiative with the introduction of EVs on a large scale. EVs can help reduce the amount of CO2 and other greenhouse gases . The EV penetration will be lead via various Government initiatives like tax breaks ,reduced prices, incentive on refills ,free public parking etc.



Climatic Conditions, Sources of Air Pollution, and Air Quality Index (AQI) in NCR Cities (June 2017 to May 2018)

Advantages of an EV over conventional vehicles-

A. Increase in vehicle longetivity- As electric vehicles have no combustion Engine the wear and tear of these automobiles is significantly reduced thus increasing the overall life.

B. Reduced Pricing- Lack of combustion engine also means the the motor structure is simpler and compact, they do not need a cooling circuit, gearshift, clutch, or elements that reduce the engine noise.

C. Convenience- EVs are a lot for comfortable compared to traditional vehicles due to lack of noise and vibrations.

D. Efficiency- The pickup and acceleration for these vehicles is better compared to ICE thus increasing overall mileage and efficiency.

E. Pollution control- As opposed to traditional ICEs that use Disc Brakes EVs use regenerative brakes that restore the braking energy back to the vehicle hence powering the battery back again which also reduces particle pollution which we see in normal cars.

F. Range-The current EVs give upto 200-300 Km but future vehicles will improve on this range we have been seeing positive trends. The ORA1 by great wall motors has a range of upto 350kms, Tesla model S performance has a range of 525 kms and

the Roadster is rumoured to have an on road range of 600 miles

G. Charging technology- Although tesla's supercharge is unbeatable which reaches 80% in a minimum 30 mins, Other manufacturers have also started to develop their own version of fast charge which are just as good.

In the coming years the EV movement will gain even more traction. With growing pollution and increasing petroleum prices the Indian government in subordination with other world goverments has decided to go all electric . By the year 2030 india is expected to have 30% of all on road vehicles to be electric under a joint venture with Society of automobile manufacturers(SIAM).In this paper, we try to attain that goal with the help of (i)surveys on current Ev trends, (ii)availability of Raw materials,(iii)Charging technology and charging infrastructure.

II. EXISTING EV SURVEYS IN INDIA

In the last decade, there has been a significant progress in several aspects that are related to the production of electric vehicles, and the use of new technologies as well as their sales. Similarly, the research efforts have also increased, which has caused a significant increase of new jobs and proposals that are related to electric vehicles. Within this section, a short compilation of the most relevant topics related to EVs, which have been addressed by previously available works in the literature, are introduced. In addition, the more notable differences with this survey are highlighted.With global electric vehicles (EVs) sales expected to boom in the next 12 months, nearly 90 per cent of consumers in India are willing to pay a premium for buying an EV, according to a survey by consultancy firm EY.The EY Mobility Consumer Index (MCI), a survey of more than 9,000 respondents from 13 countries, including 1,000 respondents from India, also found that 40 per cent of the respondents were ready to pay a premium of up to 20 per cent. The survey concluded in the second half of July."Among the car buyers in India, 3 in 10 respondents would prefer to buy an electric/hydrogen vehicle," the survey said.A majority of the respondents surveyed in India consider a driving range of 100 to 200 miles from a fully charged EV, EY said.It further said, "Nearly 90 per cent of consumers in India are willing to pay a premium for buying an EV and over 40 per cent of respondents are ready to pay a premium of up to 20%."Existing and future EV owners, who intend to buy a car, have a relatively higher preference for digital channels compared to the existing and future ICE owners.Commenting on the findings, EY India Partner and Automotive Sector Leader Vinay Raghunath said, "The reducing gap in cost of ownership between electric and other technology platforms and the increasing segment of consumers vocal about environmental impact will drive a fundamental change in consumer buying behaviour for electric vehicles. "He further said, "Consumers are willing to pay extra for an added value being environmentally responsible." According to the survey, the top reason for buying an EV is environmental concern, with 97 per cent also stating that the COVID-19 pandemic has heightened awareness and concerns about environmental issues.About 67per cent of those looking to buy an EV feel it is their responsibility to reduce their personal environmental impact, and 69 per cent feel buying an EV is one way to achieve this goal.When it comes to charging, the survey found that "nearly a third of the existing EV owners expect vehicle charging to take less than an hour compared to 45 per cent of the respondents who are planning to buy an EV".

III. ELECTRIC VEHICLES

Here there is a classification of the different types of electric vehicles, mainly commenting on the characteristics of different vehicles. The current market situation is discussed and analyzing the sales data of the different kinds of vehicles in the world.

Now, here are some different types of EV's according to their engine technology. There are five types given here:

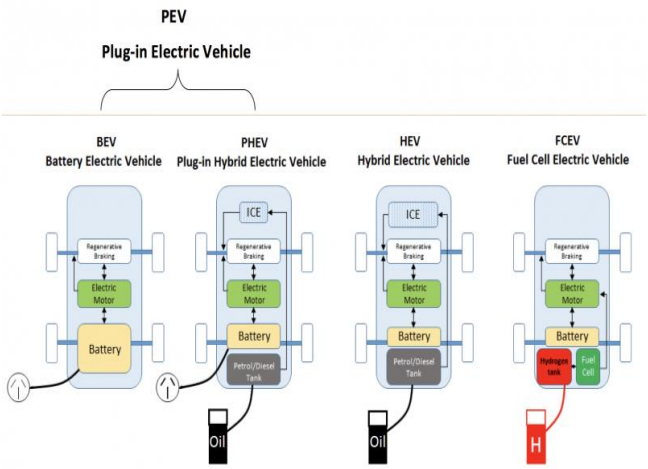
a) Battery Electric Vehicles (BEVs): Vehicles 100% are propelled by electric power. A battery electric vehicle (BEV), pure electric vehicle, only-electric vehicle or all-electric vehicle is a type of electric vehicle (EV) that exclusively uses chemical energy stored in rechargeable battery packs, with no secondary source of propulsion (e.g. hydrogen fuel cell, internal combustion engine, etc.). A BEV has capacity to reach from 160-250km, and many of them can also travel 500 km max in a single charge. Example for this type of Battery Electric Vehicle is Nissan Leaf, this vehicle is 100% electric and it also provides a 62 kWh battery and can travel upto 360 km max.

b) Plug-In Hybrid Electric Vehicles (PHEVs): The plug-in hybrid electric vehicle (PHEV) is a hybrid electric vehicle whose battery can be recharged by plugging a charging cable into an external electric power source, in addition to internally by its on-board internal combustion engine-powered generator. Here the example for Plug-in Electric Vehicle is Mitsubishi Outlander which is providing us a 12 kWh battery, and allows us just to drive around 50 km only with the electric engine. It also states that the fuel consumption of the PEV is very high than that of the other manufacturers of car.

c)Hybrid Electric Vehicles (HEVs): A hybrid electric vehicle is a type of hybrid vehicle that combines a conventional internal combustion engine system with an electric propulsion system. The presence of the electric powertrain is intended to achieve either better fuel economy than a conventional vehicle or better performance. The very main difference was that the PEV and the HEV cannot be plugged in accordingly. The first hybrid car was built in the year 1899 by engineer Ferdinand Porsche. Called the System Lohner-Porsche Mixte, it used a gasoline engine to supply power to an electric motor that drove the car's front wheels. The car was very well-received and after that over 300 very more produced.

d) Fuel Cell Electric Vehicles (FCEVs): The fuel cell electric vehicles (FCEVs) use electricity to power an electric motor. In contrast to other electric vehicles, FCEVs produce electricity using a fuel cell powered by hydrogen, rather than drawing electricity from only a battery. Although the FCEV's are considered as "zero emissions", compared with internal combustion vehicles, hydrogen vehicles centralize pollutants at the site of the hydrogen production, where hydrogen is typically derived from reformed natural gas. At very first the hydrogen fuel cell automobile produced was the Hyundai in 2013, then Toyota in 2015 and then Honda was introduced in the market.

e) Extended-range EVs (ER-EVs): A range extender is a fuel-based auxiliary power unit that extends the range of a battery electric vehicle by driving an electric generator that charges the vehicle's battery. This arrangement is known as a series hybrid drivetrain. The ER-EV's are very very similar to that of the BEV category. The engine of the vehicle provides supplementary combustion in which the battery is charged whenever needed. The engine provided by the PHEV and the HEV are only used for charging the so that the wheels of the vehicles are not connected to the batteries. The example of this type of vehicle is the BMW i3, that has a 42.2 kWh battery and which covers a maximum distance of 260 km in the electric mode and the customers can be benefited by an additional 130 km from that extended mode of range that is provided.



Four main types of electric vehicle available. These are summarised in figure 2.

IV. BATTERIES AND CHARGING FACILITIES

The battery capacity represents the maximum amount of energy that can be extracted from the battery under certain specified conditions. Obtaining the highest energy density possible is another important aspect in the development of batteries, in other words, that with equal size and weight a battery is able to accumulate a higher energy quantity. batteries are a key component in EVs and therefore, there are increasing manufacturers (e.g., LG, Panasonic, Samsung, Sony, and Bosch) that invest to develop improved and cheaper batteries. batteries are a key component in EVs and therefore, there are increasing. Therefore, it is highly important that batteries can support quick charging and higher temperatures induced due to the internal resistance. In addition, the decrease of this resistance can reduce the charging time that is required, which is one of the most important drawbacks of this type of vehicles today. However, the increase of the number of EV models, as well as the different types of batteries and the lack of standardization, are not making the use of BESs a feasible process, since all of the vehicles served by BES should use identical batteries

Types of batteries

1)Sodium sulfur batteries (Na-S), which contain sodium liquid (Na) and sulfur (S).This type of battery has a high energy density, high loading and unloading efficiency(89–92%), and a long life cycle. In addition, their advantage is that these materials have a very low cost. However, they can reach functioning temperatures of between300 and 350 _C .This type of batteries is used in the Ford Ecostar, the model that was launched in 1992–1993.

2) Lithium-ion batteries (Li-Ion). These batteries employ, as electrolyte, a lithium salt that provides the necessary ions for the reversible electrochemical reaction that takes place between the cathode and anode. Lithium-ion batteries have the advantages of the lightness of their components, their high loading capacity, their internal resistance, as well as their high loading and unloading cycles. In addition, they present a reduced memory effect.

Charging of Electric Vehicles

When charging electric vehicles, we can find different standards, which are determined, mainly, by the region in which they are being used or applied Electric vehicles have an AC/DC converter that allows charging their batteries at home through the use of traditional outlets

They present the following advantages:

a) They are sealed solutions (not affected by water or humidity).
b) They carry a mechanic or electronic blockage.
c) They enable communication with the vehicle.
d) Electricity is not supplied until the blockage system is not activated.
e) While the blockage system is activated, the vehicle cannot be set in motion, so that a vehicle cannot leave while plugged.
f) Some connectors are able to charge in three-phase mode.

Modes of charging-

I. Mode 1 (Slow charging). It is defined as a domestic charging mode, with a maximum intensity of 16 A, and it uses a standard single-phase or three-phase power outlet with phase(s), neutral, and protective earth conductors. This mode is the most used in our homes.

II. Mode 2 (Semi-fast charging). This mode can be used at home or in public areas, its defined maximum intensity is of 32 A, and, similar to the previous mode, it uses standardized power outlets with phase(s), neutral, and protective earth conductors.

III. Mode 3 (Fast charging). It provides an intensity between 32 and 250 A. This charging mode requires the use of an EV Supply Equipment (EVSE), a specific power supply for charging electric vehicles. This device (i.e., the EVSE) provides communication with the vehicles, monitors the charging process, incorporates protection systems, and stops the energy flow when the connection to the vehicle is not detected.

V. AVAILABILITY OF RAW MATERIALS

Use of critical metals in the EVs

In the production of the electric vehicles there are high-tech applications which uses critical metals, and they are called as rare-earth elements. The EV's batteries are mostly made up of Lithium-ion, which uses Lithium, Cobalt, Nickel and Graphite. Here in the given figure, there is a composition of the Lithium-ion cells:

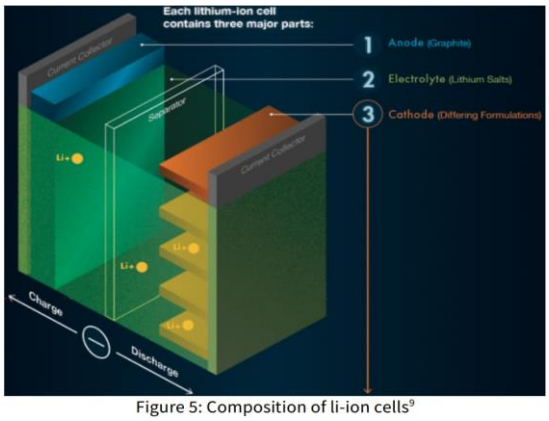


Figure 5: Composition of li-ion cells[9]

The Li-ion cell uses a cathode (positive electrode), and an anode (negative electrode) and the electrode as a conductor. Cathode consists of the metals like Lithium(11%), cobalt(14%), nickel(73%) and aluminium(2%). The anode is completely made up of graphite and the electrolyte uses Lithium salts which are organic solvents. The batteries of the electric motors include a number of rare earth elements(REE), which are a group of 17 elements the metals are not scarce but are available in only small amounts which are only found on the Earth's crust. Many of the electric vehicles use Neodymium Iron Boron which are permanent magnets and are very essential for the production of high-performance in the vehicles. Those magnets mainly contain Neodymium, Praseodymium, Dysprosium which are considered as rare-earth elements.

Rare Earth Elements:

Many of the electric vehicles motors in the Hybrids(HEV's), Plug-in Hybrids(PEV's), the Battery Electric Vehicles((BEV's), and the Fuel Electric Vehicles(FCEV) are the very permanent magnet synchronous motors which contains the neodymium iron boron magnets. Those motors are preferred because they are light-weight, compactness and

their energy efficiency. The rare earth elements like neodymium, praseodymium, dysprosium and terbium are present in the Neodymium Iron Boron magnets.

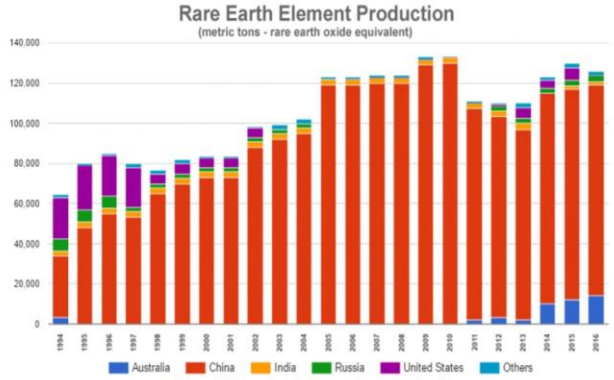


Figure 7: Rare Earth Element production[31]

VI. ENVIRONMENTAL IMPACT OF EV

Over the last decade, there's been an increase in the purchasing of electric vehicles (EV). There are many reasons why one might consider making the switch to an EV – electric cars are higher efficiency than gas-powered cars, can reduce your dependence on fossil fuels and require less maintenance than most cars, to name three popular reasons.One draw for many people who decide to buy an electric car is that EVs are often considered to be one of the most sustainable forms of transportation. Unlike hybrid vehicles or gas-powered cars, EVs run solely on electric power – depending on how that electric power is produced, your EV can be run 100% on sustainable, renewable resources. There are four factors to consider when evaluating the impact of electric cars on the environment: tailpipe emissions, well-to-wheel emissions, the energy source that charges the battery, and the car's efficiency.

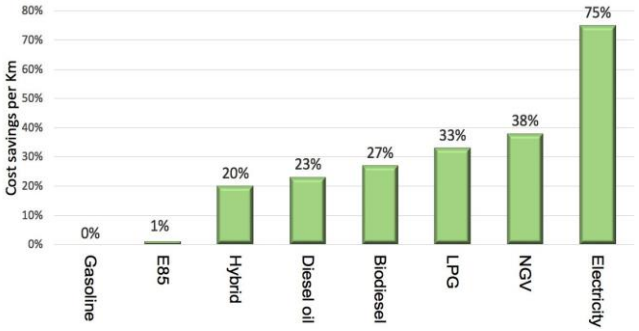
Electric car emissions: tailpipe and well-to-wheel

When an electric vehicles is running on electricity, it emits no tailpipe emissions. When evaluated on that factor alone, EVs are a lot more eco-friendly than conventional gasoline-powered vehicles on the market today.However, when evaluating the eco-friendliness of an electric vehicle, you also need to take the "well-to-wheel" emissions into account. This is an overarching term that includes greenhouse gas and air pollutants that are emitted to produce and distribute the energy being used to power the car. Electricity production results in a varying amount of emissions depending on the resource. While "being green" in the act of driving your electric vehicle is a start, if your primary goal in purchasing an electric vehicle is to reduce your greenhouse gas and pollutants emissions, you should also prioritize using zero-emissions electricity wherever possible. When taking well-to-wheel emissions into account, all-electric vehicles emit an average of around 4,450 pounds of CO_2 equivalent each year. By comparison, conventional gasoline cars will emit over twice as much annually. The amount of well-to-wheel emissions your EV is responsible for is largely dependent on your geographic area and the energy sources most commonly used for electricity. For example, if you live in California, your electricity likely comes from natural gas. This doesn't hold true if your electric vehicle is being used and charged in New Hampshire, as the state sources most of it's electricity from nuclear power plants. Natural gas provides the majority of electricity in the United States, followed closely by coal. It is often considered to be the "cleanest" fossil fuel, because it emits 50 to 60 percent less carbon dioxide than coal. Coal is responsible for around 65 percent of carbon dioxide emissions by the electric power sector in the U.S. That being said, even if your electricity is primarily from a coal plant, driving an EV will likely still overall have lower or similar well-to-wheel emissions when compared to a conventional car. In most places in the United States today, the mix of resources used to generate your electricity mean that driving an electric vehicle will produce lower well-to-wheel emissions than a traditional car.

How to maximize the environmental benefits of your electric car

An electric vehicle will produce fewer emissions than a comparable gasoline-powered car. However, if you are looking to generate as close to zero well-to-wheel emissions as possible, not all electricity sources are created equal. If your primary motive in purchasing an electric vehicle is to be green, you should consider powering your car with a renewable energy source that you can generate at your home (such as solar, wind, or geothermal energy).When purchasing an electric vehicle, homeowners often consider pairing it with a solar panel system on their roof to charge their car. An average home with a 5 kW installation pays around $10,465 for their solar panel system. Payback period varies depending on your location, but most homes throughout the country break even on the investment of solar panels by year seven.Your solar savings can be even larger and payback even quicker when pairing an installation with an electric vehicle. Why? Installing solar means you eliminate what you typically pay for gasoline, and power your vehicle with free electricity produced by your panels. You may even want to consider oversizing your solar panel system in order to build the capacity to charge your electric vehicle. The number of additional panels you'd need to power your EV is going to depend on the efficiency of the car, how often you drive it, and the solar potential of the area you're looking to install

on.Even if you can't generate your own renewable energy at your property for your EV to use, you can look into subscribing to a community solar share or changing your electricity supplier to a "green power" option that uses renewable energy sources. Community solar is rapidly expanding across the country, and the majority of utility companies today also have options to specifically purchase electricity from renewable resources.



Efficiency of electric cars

Outside of the resource used to produce your power, another reason why electric vehicles are considered more sustainable than traditional vehicles is because electric car efficiency is higher. When the gasoline in conventional vehicles combusts to power the car, approximately 17 to 21 percent of the energy is converted into power for the car. EVs, on the other hand, are able to convert 59 to 62 percent of the electric energy to power for the vehicle.When comparing an EV option to a conventional gasoline vehicle (or even a hybrid option), car shoppers also often evaluate MPGe, otherwise known as miles per gallon equivalent (of gasoline). The EPA calculates MPGe by representing the number of miles a vehicle can go given the same (or equivalent) amount of energy that would be contained in one gallon of gasoline. The average MPG of a typical gasoline-powered car is around 24.7 miles per gallon. While that's much more efficient than in the past, it's not much when compared to the MPGe of electric vehicles on the market today. Electric vehicles available now can have a comparable "fuel economy" of as high as 100 MPGe – more than quadruple the efficiency of conventional vehicles.

Government and Private aid-

The government has started an initiative to electrify india under the name FAME (Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India) Scheme is launched under National Mission on Electric Mobility in 2011/ National Electric Mobility Mission Plan 2020, unveiled in 2013. The scheme aims to encourage progressive induction of reliable, affordable and efficient electric and hybrid vehicles (xEV). The First Phase of the scheme was initially approved for a period of 2 years, commencing from 1st April, 2015 ,under the second phase of this project government has approved Scheme with an outlay of Rs. 10,000 Crore for a period of 3 years commencing from 1st April 2019. Out of total budgetary support, about 86 percent of fund has been allocated for Demand Incentive so as to create demand for xEVs in the country. This phase aims to generate demand by way of supporting 7000 e-Buses, 5 lakh e-3 Wheelers, 55000 e-4 Wheeler Passenger Cars (including Strong Hybrid) and 10 lakh e-2 Wheelers. However, depending upon off-take of different category of xEVs, these numbers may vary as the provision has been made for inter as well as intra segment wise fungibility.Only advanced battery and registered vehicles will be incentivized under the scheme. With greater emphasis on providing affordable & environment friendly public transportation options for the masses, scheme will be applicable mainly to vehicles used for public transport or those registered for commercial purposes in e-3W, e-4W and e-bus segments. However, privately owned registered e-2Ws are also covered under the scheme as a mass segment.
The list of approved vehicals can be seen here:
https://fame2.heavyindustry.gov.in/ModelUnderFame.aspx
In addition to that government has tie ups with certified OEMs and dealers to give bonus credits to buyers
List of which can be found here: https://fame2.heavyindustry.gov.in/content/english/20_1_OEM.aspx

Private ventures-

As majority of India still uses two wheelers as their main vehicle many private ventures have focused on this part of the program where Bajaj and Honda have been the leaders. In recent time OLA has set- up plants across Krishnagri and Pochipalliof Tamil-Nadu. This plant has a investment of Rs 2400 crore ,Once up and running the in house battery manufacturing could produce 25,000 motors per day . Initial annual capacity is pegged at 20 lakh unit while the company is also working on setting up a Hypercharger Network that will include 1 lakh high speed charging points across 400 cities. Phase 1 of Ola e-scooter factory is nearing completion and as Ola Group Chairman and CEO Bhavish Aggarwal has announced, the first lot of vehicles will start rolling out soon.

VII. CONCLUSION

In this paper, we help educate people on various types of electric vehicles from pure EVs to PHEVs and FCEVs with the help of a general survey.

Batteries are the heart of an Electric vehicle so in this review we also emphasize on battery technology ,charging speeds methods and networks across the country. We look at the availability of raw materials and other rare minerals.

Furthermore without forgetting our main goal that is to have a better environment for the future we also look at the environmental impact of these vehicles as compared to traditional combustion engine automobiles. We highlight ways to increase efficiency of these vehicles and maximize their environmental benefit.

Additionally we look at Government and openly funded programs that will help us in this EV penetration movement.