



A Comprehensive Study of Electric Vehicles and their Impact in India

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Abstract: The market share of electric vehicles has been growing exponentially and will continue to do so. In the wake of the immense worries caused by air pollution, we must study more about electric vehicles and how we can make sure that they are available to the general public at competent prices. There are 4 main types of electric vehicles: Battery Electric Vehicle (BEV), Plug-in Hybrid Electric Vehicles (PHEV), Hybrid Electric Vehicle (HEV), and Fuel-cell Electric Vehicle (FCEV). This paper deals with the comprehensive study of electric vehicles, the various kinds of electric vehicles available right now, and being currently researched on, the recent trends and emerging technologies that could shape the future of the electric vehicle industry and the impact electric vehicles will have on the automobile market of India.

Index Terms - Electric vehicle, trends, emissions, battery, impact.

I. INTRODUCTION

For Electric vehicles are being regarded as the future of the society. The global electric vehicle market has already taken a huge leap in the past decade and this growth is only going to increase exponentially. In fact, Wikipedia claims that the electric vehicles are expected to increase from approximately 2% of the total global share in 2016 to around 22% in the year 2030. This number may not seem significant at face value, but considering the number of vehicles that are in use globally, it accounts for a lot. When we have a look at the historical data of the growth of the EV market globally, in the past 10 years we see a growth of around 46-69% year over year growth in the number of light electric vehicles globally. As of 2018, the total number of vehicles that run on electricity stands at around 2.2%. Global EV Outlook 2019 states that the global electric car fleet exceeded approximately 5.1 million in 2018. That actually means that there has been an increase of around 2 million from the year 2017, nearly doubling the sales in just a single year. China, UK and the United States remain the biggest consumers of electric vehicles with China having around 2.3 million electric vehicles in use as of 2018. But when we look at the total percentage of electric vehicles being used in a country. Norway is way ahead of other countries with electric vehicles taking up around 46% of the new cars in the country being electric vehicles. This is a promising sign and will hopefully serve as an impediment for other countries to adopt electric vehicles into their system as well. A survey conducted by the World Health Organization (WHO) has shown that around 4.2 million people die every year due to air pollution related diseases.

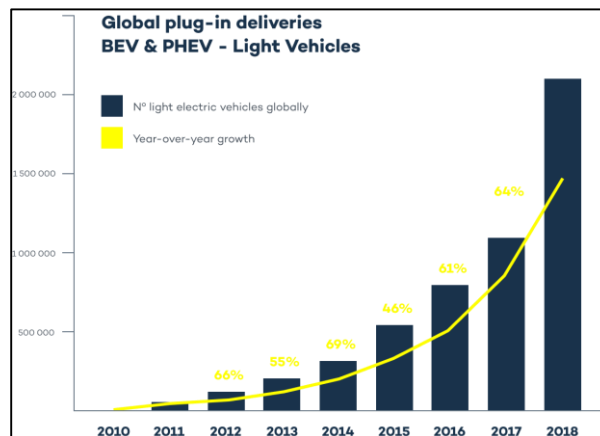


Fig-1: Global plug-in deliveries (BEV & PHEV)

The Indian electric vehicle market also seems to be increasing at an exponential rate and this has been confirmed by the fact that the total electric vehicle sales, excluding e-rickshaw grew by a promising 20% at 1.56 lakh units in the year 2019-2020, as stated by Society of Manufacturers of Electric Vehicles (SMEV). In a country such as India where pollution is a serious bane that needs to be curbed, electric vehicles can help out a lot. Transportation contributes to around 27% of the total air pollution in India and this major percentage of the air pollution can be drastically reduced. The lockdown that has been enforced all around the world due to the spread of Covid-19 and this has had some positive effects on the environment. A recent article from Insider displays a series of images comparing various polluted cities from

India from 2018 to 2020, during the lockdown and the results speak for themselves. Some news sources also claim that the pollution in some cities around the world had reduced by around 50%. All of these reasons point to the fact that we need to spend a lot of time and effort in the research of electric vehicles and to make sure that they can be made available to the general public for competent prices.

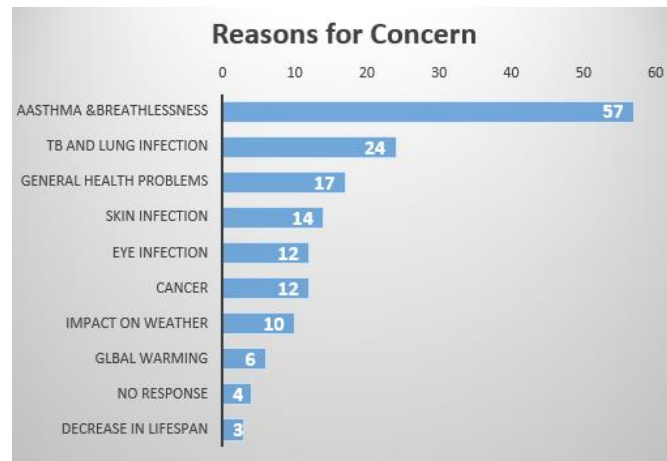


Fig-2: Various outcomes of air pollution

This paper will deal with the comparative study of the different types of electric vehicles currently available to use by the public or under development and try to study the impact each of these vehicles will have on the overall reduction of the air pollution and the increase in the global market share of electric vehicles.

II. DIFFERENT TYPES OF ELECTRIC VEHICLES

There are primarily 4 main classifications of electric vehicles. They are:

- Battery Electric Vehicle (BEV)
- Plug-in Hybrid Electric Vehicle (PHEV)
- Hybrid Electric Vehicle (HEV)
- Fuel-cell Electric Vehicle (FCEV)

Battery Electric Vehicles (BEV's) are purely electric vehicles, which use rechargeable batteries and do not use gasoline. They usually store the electricity using inbuilt battery packs and this battery power is used to power the motor which in turn helps in the propulsion of the electric vehicle. As a result of not using a gasoline engine, BEV's do not emit any harmful radiations or pollutants, thereby reducing the effective air pollution caused due to transportation.

The key components of a battery electric vehicle are:

- Electric motor.
- Inverter
- Battery
- Battery charger
- Controller
- Charging cable

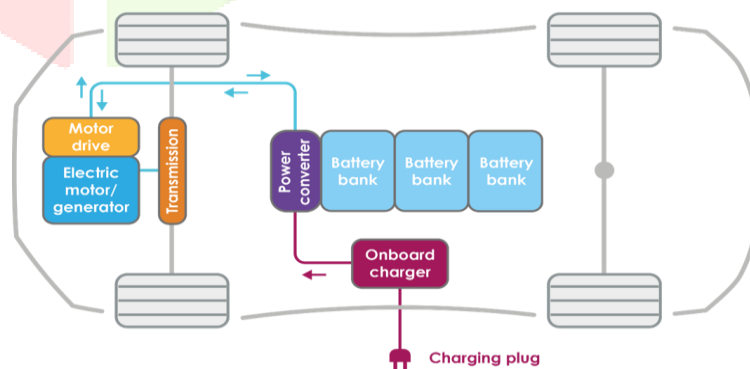


Fig-3: Simple block diagram of an electric vehicle

Electric vehicles are usually classified according to the speed at which they recharge the battery of an EV. The classifications are:

- Level 1: This type of charging uses the normal household outlet in order to charge the electric vehicle. This will typically take a few hours to charge a vehicle fully. The advantage of this kind of charging is its compatibility. It can be used to charge a majority of the electric vehicles that are available in the market.
- Level 2: This type of charging requires a specialized hub or station in order to perform the charging. These can charge a battery of a higher capacity in a couple of hours.
- Level 3/ DC fast charging: This is the fastest charging solution available in the market as of now.

A few examples of battery electric vehicles are most of Tesla's products, like the Model S or the Model X. These are a bit on the expensive side. Other affordable models such as the Chevrolet Bolt and the Hyundai Ioniq are viable options.

Plug-in Hybrid Electric Vehicles (PHEV's) can be recharged through an external source of electricity, such as wall sockets as well as the electricity stored in the inbuilt battery packs. These vehicles are also called New Energy Vehicles (NEV's) in China. The advent of PHEV's actually began back in late December 2010, with the introduction of the Nissan Leaf and the Chevrolet Volt. The major difference between the PHEV and the HEV is that the PHEV is capable of charging via the power grid, whereas the HEV cannot be charged using the power grid. For this reason, the vehicle is also fitted with significantly bigger batteries and can thereby provide a purely electric drive for long ranges. In case the battery is depleted, the PHEV switches to the gasoline engines present in the vehicle as well. This makes PHEV's extremely viable for long distance travels. The addition of the combustion engine and the electric engine means that the vehicle construction is pretty complex and will require a lot of deliberation. This can also bring a lot of maintenance costs at times. A few examples of these vehicles are the Chevy Volt, Ford C-Max Energi, and the Hyundai Sonata Plug-in.



Fig-4: Chevy volt, an affordable PHEV

Hybrid Electric Vehicles (HEV's) are powered by both gasoline and electricity. These cars use electricity during the start-off and switch to gasoline when the load or the speed of the vehicle increases. This is done effectively using an on-board computer present in the car. The main differentiating aspect of a hybrid electric vehicle is that it cannot be charged using the power grid. Thus, the entire charging of the battery packs is done using regenerative braking. Therefore, most of the commute is actually handled by the gasoline engine system. The main differences between the PHEVs and HEVs are the fact that the HEV cannot be recharged using a power grid and also that the internal combustion engine is more dominant in the HEV whereas the electric motor is more dominant in the PHEVs. The HEV aims at bettering the fuel economy of the vehicles coupled with a better car efficiency. The addition of the combustion engine means that the effective range of the vehicle is more compared to an all-electric vehicle. There are 3 main classifications of HEVs:

- Parallel hybrid.
- Series hybrid.
- Twin drain vehicle.

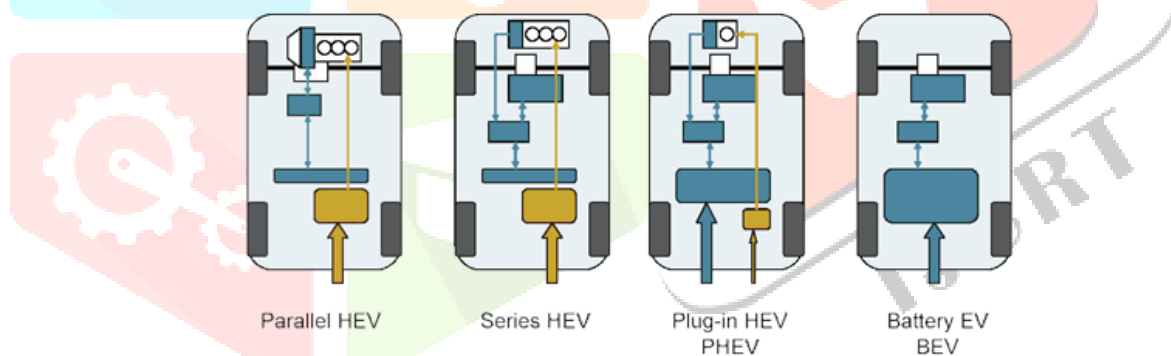


Fig-5: The different types of hybrid electric vehicles

Fuel-cell Electric Vehicles (FCEV's) use a propulsion system where the energy is stored as hydrogen in the vehicle. This energy is converted into electrical energy by the fuel cell. The hydrogen is stored in a tank built into the vehicle. Due to the usage of fuel-cells in order to produce the energy required for the propulsion of the vehicle and the incredibly high efficiency of operation, this type of vehicle is even considered by some experts to be the best type of electric vehicles. These vehicles are however in their development phase and it will be a while before these vehicles are available to the general consumer.

III. COMPARATIVE STUDY OF ELECTRIC VEHICLES AND THEIR IMPACT ON INDIA

3.1 Different types of emissions:

There are mainly two types of vehicle emissions, namely direct emissions, and life-cycle emissions.

Direct emissions are the emissions that are emitted through the tailpipe, through the evaporation from the fuel systems and also during the fueling process. These include smog-forming pollutants such as nitrogen oxides and greenhouse gases, primarily carbon dioxide. All-electric vehicles, that do not use a gasoline engine at all, produce direct zero-emissions whereas plug-in hybrid electric vehicles, which use a gasoline engine along with an electric motor does produce a few direct emissions. But considering that it regulates the operation of the electric and gasoline motors, it is far more economical and environmentally friendly compared to conventional internal combustion engine vehicles.

Life-cycle emissions are emissions related to fuel and vehicle production, processing, distribution, use, and recycling. Life-cycle emissions also give rise to harmful pollutants and greenhouse gases. The life-cycle emissions that are produced by the electric vehicles are comparatively much lesser than the life-cycle emissions emitted by conventional vehicles. The life-cycle emissions can technically be reduced further if the electricity is generated using a renewable source of energy such as solar energy or wind energy.

3.2 Comparison between normal IC engine vehicles and electric vehicles:

PARAMETERS	IC ENGINE VEHICLE	ELECTRIC VEHICLE
Emissions	A lot of harmful pollutants such as nitrogen oxides and greenhouse gases such as carbon dioxide are liberated.	They do not produce any tailpipe emissions (except in PHEVs).
Range	Around 500-600 KM with a full tank.	Around 300-400 KM on a single complete charge.
Acceleration	Accelerative capability less compared to electric vehicles.	Instant acceleration.
Fueling	High maintenance thereby leading to excess cost.	Low maintenance.
Maintenance	Lot of petroleum bunks available all throughout the country.	Limited charging stations available.
Availability	Oil sources are being depleted rapidly thereby the supply is limited but the demand increases day by day.	Numerous ways to generate electricity even by using renewable sources of energy.

Table-1: Comparison between IC engine vehicles and electric vehicles

3.3 Recent trends and emerging technologies:

As discussed earlier, there are a lot of benefits of using electric vehicles. The savings in the cost, the maintenance issues, the massive reduction in the air pollution and the tailpipe emissions are all some of the many benefits of electrification going into the future.

A few trends that have started to emerge in the landscape due to the advent of electric vehicles. The cost of EVs will continue to drop as the years go by. This is owing to the ongoing vigorous research on new and improved battery technologies. This is imperative because even though the emission reducing capabilities of electric vehicles are embraced, there is a lot of doubt regarding the battery technologies being used in the electric vehicles, mainly the use of rare-earth metals. There is a lot of research being conducted right now on various battery technologies that not only enable faster charging technologies but also help in the increase of the effective range that can be travelled by the electric vehicle. A few emerging technologies that have garnered a lot of interest are:

- Lithium-Sulphur batteries that have a lesser environmental impact. This battery technology is also said to have the power required to propel a vehicle for around 1000 kilometers.
- XFC, a new extreme fast charging mechanism which aims to deliver around 200 kilometers in just around 10 minutes with 400 kW charging. This method also claims to reduce the usual battery degradation that occurs due to fast charging, while also sustaining the extremely high speeds of charging.
- Graphene batteries are garnering a lot of attention from the media and tech enthusiasts worldwide. The batteries are touted to be able to charge completely in just a few minutes and can offer a range of around 500 miles just on a single charge.
- Aluminium-air batteries that make use of the oxygen from the air to fill its cathode, which in turn makes the overall weight of the vehicle extremely light. This in turn gives the vehicle a greater range. Using this technology, an electric car has actually been tested and it was able to complete around 1100 miles on a single charge which is way more than the industry standard of around 300 miles offered by Tesla.

Another main trend that has been noted in the electric vehicle industry is the adoption of heavier vehicles such as trucks and trying to create environmentally friendly versions of the heavier vehicles. Many OEM's such as Tesla and Thor Trucks have come out with heavy-duty electric trucks which not only have the power required to perform heavy duty tasks but also all the benefits of electrification as well. Combining the push by OEM's to venture out and further the electrification of the automobile industry with the various updates to the policies done by the government, this only means that the growth of electrification all around the world is inevitable. This will lead to the increase of the adoption of electric vehicles which also means that there will be an increase in the number of charging stations available for the consumers to use. This in turn reduces the price of the vehicle and the maintenance and refuel charges significantly.



Fig-6: The Tesla Semi, a heavy-duty electric truck

3.3 Impact of electric vehicles in India:

The advent of electrical vehicles has impacted India in a huge way. The Indian government has been enforcing strict laws and policies governing electric vehicles in India. This is imperative in order to set up a uniform system of governance that can be referred to in case of any discrepancies. A lot of things are being discussed about even now regarding how the electric vehicle market will grow in India. A few observations that can be made are the follows:

- Elon Musk has said that the import duty that is levied by the Indian Government will increase the prices of the cars to such an extent that they will become unaffordable for the Indian consumers. Musk had also stated that this could change in the future depending on the tax rates. This is also not to say that India is not capable of manufacturing its own electric vehicles. The advent

of Tesla in India will only serve as an impediment in increasing the acceptance of electric vehicles in India and will push us closer towards our goal to completely transform India into an all-electric country.

- Cooperative efforts with other countries in order to further the electrification of India might become a reality in the near future. India is a rapidly growing market and is one of the biggest automobile markets in the entire world. Capturing such a booming market such as India does not only serve as a profitable venture for various OEMs but also for India as a country suffering due to air pollution.
- The Indian government has been taking various steps in order to further the adoption rate of electric vehicles not only by the general public but for commercial and industrial use as well. A lot of policies and laws have been enforced in order to promote the acceptance of electric vehicles in India.
- Indian central government policy introduced a policy called the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) for a two-year period at an approved outlay of 795 crores in the year 2015. This was extended till September 2018.
- Most of the Indian states have enforced their own electric vehicle policy in order to lead to the faster adoption of electric vehicles in that particular state. This is also needed in order to ensure that there is a uniformity in the enforcement of the law.

Prerana Chaturvedi, CEO and spokesperson of Evolet said, "India is well placed to start the EV revolution. All that is required is the will to do it and the governments with their various steps have clearly indicated that it is in favor of the EVs" and this could not have been truer in our current scenario. A lot of scope is available for the growth of the electric vehicle market in India and the policies enforced by the government is just a small stepping stone which will usher in a lot of opportunities for OEMs to produce in-house electric vehicles, not only reducing the air pollution but also helping in the electrification of India.

IV. RESULTS AND DISCUSSION

Electric vehicles are the future of the automobile industry going forward and it is imperative that everyone has a basic knowledge about the capabilities and the advantages that the electric vehicles bring to the table. It is also important to understand more about the different types of electric vehicles available for use and how the adoption of electrification will impact the Indian automobile market. This paper has given a comprehensive description of electric vehicles, their types, the new emerging technologies and the recent trends in the field of electric vehicles as well as the impact that electric vehicles will have on the automobile market of India and the world as a whole.

REFERENCES

- [1] K.W.E Cheng, "Recent Development on Electric Vehicles", 2009 3rd International Conference on Power Electronics Systems and Applications.
- [2] The global electric vehicle market in 2020: statistics & forecasts. Source: <https://www.virta.global/global-electric-vehicle-market#:~:text=Global%20electric%20car%20market%20size,sales%20in%20just%20one%20year>
- [3] Reducing pollution: <https://www.energy.gov/eere/electricvehicles/reducing-pollution-electric-vehicles>
- [4] Elon Musk explains why Tesla is not yet available in India. Source: <https://www.digit.in/news/car-tech/elon-musk-explains-why-tesla-is-still-not-in-india-49490.html>
- [5] Upcoming battery technologies. Source: <https://www.pocket-lint.com/gadgets/news/130380-future-batteries-coming-soon-charge-in-seconds-last-months-and-power-over-the-air>
- [6] Government policies enforced in favour of electric vehicles in India. Source: <https://inc42.com/features/paving-the-way-for-employment-state-and-central-government-ev-policies-in-india/#:~:text=With%20this%20the%20government%20aims,encourage%20people%20to%20use%20them>
- [7] A comparison of Electric Vehicles and Conventional Automobiles: Costs and Quality Perspective by Marek Palinski Source: <https://www.theseus.fi/bitstream/handle/10024/133032/BA.pdf?sequence=1&isAllowed=y>
- [8] Rajeev Kumar Upadhyay, "Can Electric Vehicles be a Viable and Sustainable Mode of Transportation in India", Pacific Business Review International, Volume 12 issue 5, November 2019
- [9] Aniket Magar, Atharva Hasabnis, "Why Electric Vehicle? A Big Question in the 21st Century", Volume 8, Issue 1, International Journal for Research in Applied Science & Engineering Technology (IJRASET)
- [10] Types of electric vehicles. Source: <https://www.evgo.com/why-evs/types-of-electric-vehicles/#:~:text=Battery%20Electric%20Vehicles%2C%20also%20called,with%20high%2Dcapacity%20battery%20packs.&text=BEVs%20are%20charged%20by%20electricity%20from%20an%20external%20source>