Electric Vehicles: Present Trends and Future Scope in India

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Abstract- The problem of Greenhouse gases has been on our plates for a couple of decades now. While collective efforts are made everywhere, ICE technology hasn't changed much. Vehicles are one of the main culprits for this persisting problem. Hence, a huge amount of expectations rest on the shoulders of the newly emerged electric vehicle which has the potential to change the face of the pollution on our planet. As promising as the new electric drive train is, there are some hurdles that we need to overcome before they become a reality. Especially in a country like India, where geography, climate and people affect the emergence of EVs along with cost and maintenance. In this work, these factors have been discussed in detail and an attempt is made to provide a perspective. This paper is a review of the existing works that discuss the adoption of EVs into the Indian lifestyle in near future from multiple standpoints. It further intends to throw light upon the blocking problems we face in order to normalize EVs in India in the sense of costs, distribution and maintenance.

Keywords: Electric Vehicles, Vehicle to the grid, Developing economy, India, Battery Electrical Vehicle (BEV).

1.INTRODUCTION

India is steadily moving up on the path of development. However, this development has some apparent side effects. One of the major concerns of the country at this hour is the ever-increasing emissions from the millions of vehicles that run on the country's roads each day.

The major pollutants emitted by ICE vehicles are gases like carbon dioxide, carbon monoxide, photochemical oxidants which are also called air toxins and include substances like benzene (C_6H_6), 1,3 butadiene (C_4H_6), lead (Pb), particulate matter (PM), hydrocarbon (HC) compounds like aldehydes, polycyclic aromatic hydrocarbons (PAHs) oxides of sulphur (SO_2) and nitrogen (NO_x)[8].

In India, almost 27% of the total pollution is caused by vehicles. Air pollution is highest due to vehicles. ICEs release particulate matter which is a serious challenge in India.

The major reasons for increased pollution due to vehicles in urban regions of India are as below;

- Increased vehicle density in Indian urban centres.
- Older models of vehicles dominate the roads.
- Private vehicles are in large numbers, especially cars and two-wheelers. This is due to the unsatisfactory public transport system. This results in higher idling emissions and traffic congestion. Traffic intersections have high levels of pollution.
- Improper land use planning in the development of urban areas has led to more vehicle travel and fuel consumption.
- Adulteration of fuel & fuel products on a large scale.
- Improper traffic management system.
- Bad road conditions.
- No mass rapid transport system & intra-city railway networks
- High population exodus to the urban centres.

A study for CO_2 emission carried out by a Delhi based organization Centre for Science and Environment has stated that by 2035, the emission of CO_2 on Indian roads can reach a value of 1212 million tonnes from a value of 208 million tonnes back in 2005[8].

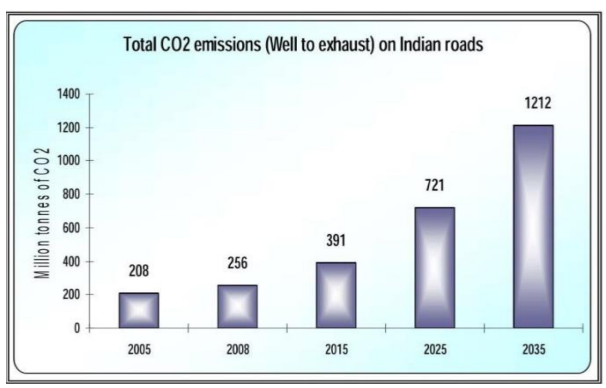

Fig 1: Total CO_2 emissions (Well to Exhaust) on Indian Roads [8]

Another major side-effect of ICEs is the heavy use of oil, petrol and diesel which is imported in India. India's energy import bill is expected to double from around 150 billion dollars to $ 300 billion by 2030.

As a mitigation to these alarming figures, Electric Vehicles hold a good probability of success. Tesla has been the leading manufacturer of EVs in the world. However, the technology is very costly and hence it is deemed unfit for India. While the concept of EVs is a big plus, the major problem we face is adapting it in India.

1.1 Overview of EVs in India

India's first electric car was Reva by Mahindra. It was introduced in 2001 but it could sell a few units after its launch. In 2010, Toyota began the Prius hybrid model, followed by the Camry hybrid in 2013. Electric buses and hybrid vehicles have been commenced as a pilot proposal in a few cities like Mumbai, Bangalore and Delhi.

There is a vision for 100% EVs by 2030.

1.2 Advantages of EVs over ICE

- Low operational costs: Petrol rates are Rs. 100 per litre while using 5 to 8 Rs. per kWh
- No Carbon Emissions.
- Three motors can give 30 power configurations in 3-Wheelers to support everyone’s needs.
- Less moving parts means no vibrations.
- No maintenance costs and saving on lubricants and oils.
- Reduced friction losses.
- EVs are more energy efficient. In ICEs, 16/100 units of fuel consumed result in propulsion. In the case of EVs, 85/100 units of electricity are used for driving.
- An electric vehicle is very quiet and smooth. The motor RPM can be changed easily so no need for a gearbox or clutch system. No bump or jolt in transmission.
- Electric vehicles are much lighter than ICE. This decrease brake wear and increases pick-up especially on an uphill drive. This is a benefit for goods vehicles.

2.RESEARCH METHODOLOGY

This is a descriptive design paper and all the data and inferences are based on secondary data sources. Along with the literature study, a good portion of the concepts come from NPTEL lectures on Electric Vehicles and Renewable Energy taught by IIT-M.

2.1 Objectives

- To understand the working of an EV and its difference from the conventional vehicles.
- To understand the concept of EVs in the background of a densely populated and developing country like India.
- To pinpoint, the barriers faced in the normalisation of EVs in India.
- To suggest probable solutions to overcome the problems.
- To understand the impact of EVs in reducing pollution and creating new opportunities.

2.2Limitations of the Study

This study gives a bird-eye view of the EV sector of India and may be missing some grassroots level problems. Although an attempt is made to provide the most feasible solutions their efficiency is not tested.

This paper does not contain the mathematical operations used to arrive at certain data sets.

2.3 How do EVs work? How is it different from ICE?

In most simple terms, the drivetrain of an EV uses an electric motor as the source of power instead of the IC Engine. This decreases the size of the engine and removes the need for a gearbox as the amount of speed and torque can be adjusted by adjustments in the supply current. The aux system is more or less the same in both drive trains except for the fact that an ICE uses a generator and a battery to run the aux system while an EV uses AC-AC, AC-DC, DC-AC converters to adjust the current and voltage.

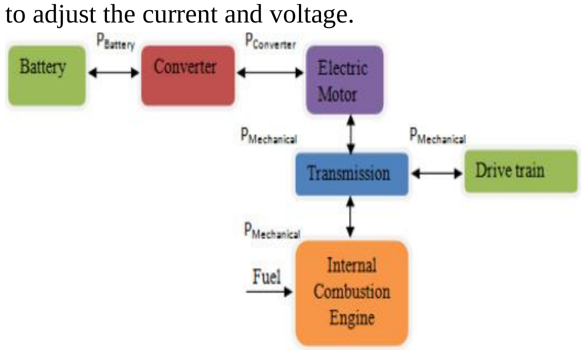

Fig 2: Difference between ICE and EV Drive Train [4]

2.4 Different Types of EVs

There are three main types of EVs: Hybrid Electric Vehicles (HEV), Plug-in-Hybrid Electric Vehicle (PHEV) and Battery Electric Vehicle (BEV).

1. Hybrid Electric Vehicles (HEV) is made up of both, an IC engine and an electric motor. The engine is responsible for charging the battery. Due to the electrification of the powertrain, fuel consumption is reduced to a great extent.
2. Plug-in-Hybrid Electric Vehicle (PHEV) also consists of a battery and an engine. However, it does not utilise the engine power unless the battery is completely discharged.
3. Battery Electric Vehicle (BEV) completely runs on battery and are most efficient in controlling the emissions.

3.VEHICLE REQUIREMENTS

Vehicles need power is used to overcome: a. Aerodynamic Drag b. Rolling Resistance c. Gradient Resistance and is also used for a. Acceleration.
As the velocity increases power required increases.

$$\text{Aerodynamic Drag} = \frac{1}{2} \times \rho \times C.D. \times A \times v^2 \quad \textbf{(1)}$$

$$\text{Rolling resistance} = F_{rr} = \mu \times m \times g \quad \textbf{(2)}$$

$$\text{Gradient Resistance} = F_g = mgsin\theta \quad \textbf{(3)}$$

$$\text{Acceleration Force} = m \times a \quad \textbf{(4)}$$

Consider the following data for a drive without gradient:

Table 1 Vehicle Requirements

Vehicle	GVW (kg)	Cd	Area (m2)	µ	V1 (km/h)	V2 (km/h)	Tyre Radius (m)
2-wheeler	200	0.9	0.6	0.015	30	80	0.28
3-wheeler	600	0.45	1.6	0.015	30	80	0.2
4-wheeler	1500	0.3	2.5	0.015	30	80	0.3

Table 2 Forces Acting on the Vehicles

Vehicle	AV1	AV2	RV1	RV2	GF
2-wheeler	22.5	160	29.4	29.4	273
3-wheeler	30	213.33	87.43	87.43	819.17
4-wheeler	31.25	222.22	2047.93	218.57	2047.93

AV1= Aerodynamic drag at V1 in newtons, AV2= Aerodynamic drag at V2 in newtons, RV1= rolling resistance at V1 in newtons, RV2= rolling resistance at V2 in newtons, GF = gradient force in newtons (Data utilised from NPTEL)
On basis of this, we can calculate the traction force, the power required and torque as follows:

$$F_{trac} = F_d + F_{rr} + F_a \quad (5)$$

$$Power = F_{trac} \times v \quad (6)$$

$$Torque = r \times F_{trac} \quad (7)$$

Table 3 Traction and Power Requirement of the Vehicles

Vehicle	Traction Force (N)		Power Required (kW)		Torque(Nm)	
	V1	V2	V1	V2	V1	V2
2-wheeler	190.66	328.17	1.587	7.291	53.38	91.88
3-wheeler	533.69	717.01	4.445	15.931	106.74	143.40
4-wheeler	1290.51	1481.47	10.75	32.918	387.15	444.44

The above data gives us an idea of how the power requirements of the vehicle vary with speed. We also get a gist of how the three defined parameters, Power, Force and Torque are related to one another.

3.1 Consumer Perspective on EVs

Consumers like the idea of Electric Vehicles as that reduces fuel costs. However, due to a series of drawbacks of using EVs, they are more inclined towards a hybrid car.

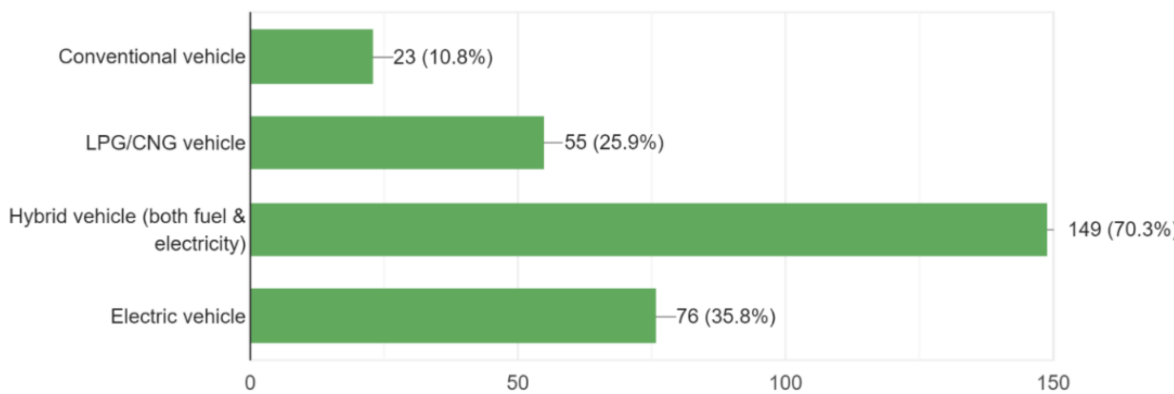

Fig 3 Consumer Preference for different types of vehicles [3]

4.CHALLENGES IN THE USE OF EVS

Listed below are the most prominent challenges faced by the use of EVs today based on the above data.

4.1 High Capital Cost

The heart of EVs is the battery and it does not come cheap. It accounts for 30% to 40% of the cost of the vehicle. Although the costs are going down each year, still the amount is significant. From the above data, one can infer that the battery capacity of vehicles. Typically electric scooters/rickshaws run on 48V to 60V lithium-ion battery packs with an average capacity between 1.2 to 2.5 kWh. They give a range of 50 to 80 km in a single charge. On the other hand, a 4 wheeler requires a battery of 30 kWh to 35 KWh to give a range of 300 to 400 km. Thus, we can say that long-distance road trips are difficult with these batteries. The Tesla Model S and Model X uses a minimum 100 kWh battery. They easily give a range up to 500 to 600 km. At the moment the average cost of a lithium-ion battery pack is about $140 per kilowatt-hour.

4.2 Battery Charging Constraints

The Life of the battery is measured in several charging and discharging cycles. In addition, the battery charge should lie between 5% to 80%. If the charge falls down 5% value, the life of electrodes depletes. If the charge exceeds 80%, there will be a spill. Moreover, fast charging reduces battery life. The battery needs to be charged at a slow rate at temperature conditions of $25\ °C\ to\ 40\ °C$. The temperatures in India easily go to above 40°C. Hence, an efficient Battery Thermal Management System is required.

4.3 Indirect Pollution by Batteries

A Li-ion battery is used in an EV because Li-ion batteries power density is much high than any type of other conventional battery. Also, their weight/ power ratio is high and they are safer than other batteries. India isn't a leading producer of Lithium hence, the raw material has to be imported. In addition, lithium mining leads to a huge amount of pollution.

4.4 Lack of Infrastructure

ICE requires petrol or diesel. There are over 80,000 petrol pumps in India. These infrastructures were built over a long time. Switching to electric vehicles will require a similar infrastructure for battery charging. The catch is battery charging can take hours. Fast charging still requires an hour while super-fast charging will take 15 minutes. As compared to refuelling this is a lot of time. Hence, a small space like a petrol station can never tend to the needs of everyone.

4.5 Heat Dissipation and Insulation

Batteries have two types of power: Peak Power and Average Power. Average power is always less than peak power. In any case, we cannot run the battery at peak power for more than a few minutes. Running the battery at peak power causes a huge amount of heat generation which can be lethal. Hence, the battery always has to run on average power. Having a huge battery also requires good insulation which isolates the electric system to avoid shocks. This further constraint the size of the battery that can be used.

4.6 Limited Battery Life

A fuel tank once installed rarely needs any changing during the entire lifetime of the vehicle. However, depending upon the climatic location and maintenance schedule, the Li-ion batteries last up to 8 to 12 years. So this is an additional operational cost in the case of EVs.

4.7 Energy Requirements

Electricity is required to run the electric vehicles and hence, higher demands for electrical energy. As for now in India, most of the electricity comes from coal. So to meet the needs of all the population huge amounts of coal will be burned until the alternate renewable energy generation is put into use.

Here are the major sources of electricity production in India.

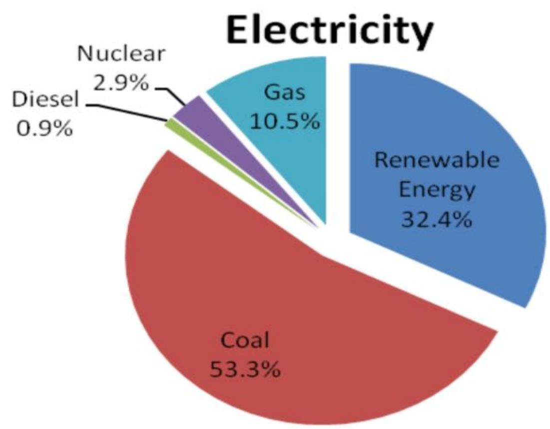

Fig 5 Major sources of electricity production in India [4]

4.8 Energy Density

Batteries have a very less energy density in comparison to petrol. Here's an overview of how the energy density of different fuels vary

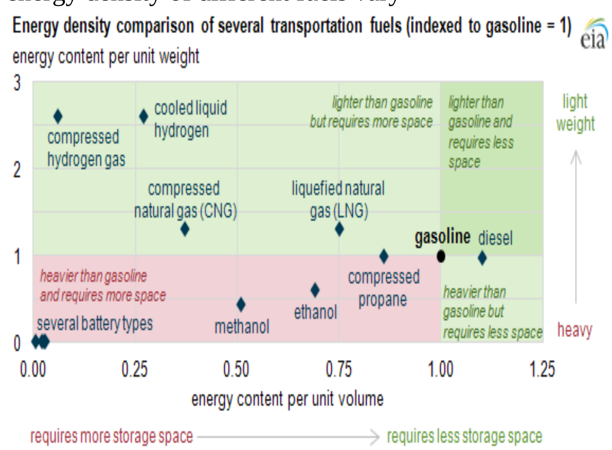

Fig 6 Energy Density Comparison of different fuels [10]

However, in the case of EVs, this can be easily compensated by low rates of charging. In addition, the volumetric energy density for Lithium-ion battery cells is constantly improving. It was190 Wh/l in 1991, 580 Wh/l in 2005. Current production lithium-ion cells have 676 Wh/l. All these while the cost decreases.

5.DISCUSSION

In India, the general perspective of any customer is usability at less cost. This is true even for vehicles. So sheer logic suggests that the consumers will only switch to EVs if their price is lower than or equal to ICEs. However, currently, the battery alone is the single most costly component with many restrictions as mentioned in the above section. In this section, an attempt is made to provide viable solutions to these issues.

5.1 Battery Swapping instead of Battery Charging.

EV batteries can take 5-6 hours to charge at the normal rate. Fast and Superfast charging though possible is not recommended daily. The longer the range of the battery longer the time is taken to charge. Plus, we need to maintain the ambient conditions while charging to protect the life of the battery.

Building Battery Charging stations will require lots of space and frequent overcrowding will lead to mismanagement. A better idea would be to build battery swapping stations. Battery swapping stations will do nothing but swap the discharged batteries with a new one.

5.1.1 Benefits of Battery Swapping over Battery Charging

- Battery swapping hardly takes more than a few minutes as compared to battery charging.
- Battery swapping can function in the existing petrol pumps within minimum space. So there is no need to build additional infrastructure.
- The discharged batteries when collected at the swapping station can be charged at a slow rate and the required conditions.
- Having a good network of battery swapping stations means long-distance travelling is possible even when the EV has a low range battery. It can be easily swapped at the nearest station. So the capital costs of EVs can be kept to a bare minimum. A smaller battery also means fewer risks of accidents.
- Dead batteries can be discarded properly. Since the swapping stations will be responsible for handling the batteries it is possible to keep a check on the E-waste.
- Standards can be maintained for battery charging time, plugs and other accessories used for charging. A centralised system for management and rules can be maintained.
- A battery-swapping station will require a series of technicians, ground staff, inventory and a proper SCM network creating more employment opportunities.

Having a battery swapping station is best suited for Indian needs. It is analogous to the distribution system of LPG gas that is used for cooking. While many countries have gas pipelines, India has an indigenously developed distribution and management system unique and limited to our country itself.

On the downside of having a battery swapping station instead of a battery charging station, there will be a need for huge amounts of batteries. Buying these surplus batteries will require a lot of money and a huge amount of inventory space. In addition, the inventory operators will require to work very vigilantly to avoid accidents which can easily increase in magnitude due to huge amounts of batteries stored together.

5.2 Regenerative Drive Train

The battery supplies electricity for the EV wheels to move. However, during braking, deceleration or while driving the mechanical energy can be converted back into electrical energy instead of losing it as heat. It can be easily done with the help of a simple generator. It is not highly efficient but about 30% of the energy can be generated. This type of regeneration is not possible in petrol vehicles. In short, an EV drivetrain can be designed to be efficient with multiple regeneration arrangements to recharge the battery while driving.

5.3 Use of Renewable Energy to Charge Battery

Just like the regeneration of mechanical energy, it is possible to convert solar energy (on a clear day) and wind energy into electrical energy to charge the battery. This is a hypothesis and work needs to be done on it.

In addition, renewable energy can be used to charge the batteries at swapping or charging stations. China houses the largest solar-powered charging station in the world. It can serve up to 80 EVs at a time. A pilot project is also launched in Shanghai for testing the ability of the electric vehicle to incorporate sustainable power sources with the electric grid.

5.4 Urban Mining

India imports 100 per cent lithium-ion batteries from China, Europe, the US and Japan or some companies import the parts and assemble them here. Lithium-ion batteries are not just used in EVs but also in laptop and mobile phone batteries. These batteries can be recycled to extract the raw materials to make new batteries. Tata Chemicals Ltd commissioned a li-ion battery recycling plant in Maharashtra in 201. However, India lacks clear scientific guidelines and regulations. With the guidelines in place, India can cut down the import cost in turn cutting down the manufacturing cost of EVs.

5.5 Vehicle to Grid Technology

The Vehicle to Grid Technology or V2G concept simply put is nothing but the idea that the parked EV can supply electrical power to the grid. This can be done by using a bidirectional charger allowing the vehicle to supply power to the grid as well as charge up. This is an efficient methodology to manage battery degradation and is used in many Nordic countries. It is useful to avoid quick degradation of the battery life. Bi-directional charging also maximizes the profit of EV users.

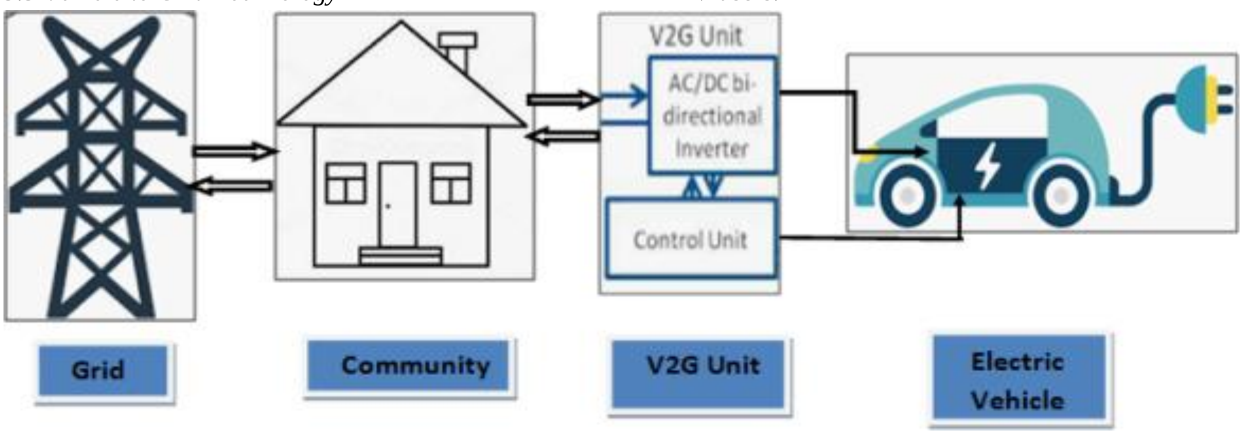

Fig 7 Block Diagram of V2G Grid Technology [4]

6.GOVERNMENT INITIATIVES

The Government is taking measures to promote the use of EVs. Some of the states have started using electric buses and 3-Wheelers for public transport. A series of schemes are being funded to make EV a reality

- The FAME India Scheme is an incentive scheme for the promotion of electric and hybrid vehicles. It promotes electric vehicles in the country and gives financial incentives for enhancing EV production/ It also helps in the creation of electric transportation infrastructure.
- The National Electric Mobility Mission Plan (NEMMP) 2020 is a National Mission document. It provides the vision and the roadmap for the faster adoption of EVs and their manufacturing.
- The Telangana State government has encouraged the use of EVs and announced that the EV owners would not pay any road tax.
- Hyderabad metro rail has also signed a partnership with Power Grid Corporation of India Ltd to provide EV charging facilities at metro stations.
- NITI Aayog's published a report on transformative mobility report in 2017. It has set a roadmap for the use of pure electric vehicles following the development of the EVs technology and the necessity to reduce energy demand in the automobile sector. It is said that if India adopt the transformative solution of shared connected electric mobility, 100% public transport vehicle and 40% private vehicles, then it can become completely electric by 2030.

7.CONCLUSION

Indian automotive industry has become a favourable investment destination by global auto industry major manufacturers. Currently. India is the second main manufacturer of two-wheelers, fifth major commercial vehicle manufacturer in the world. It is the fourth chief passenger car market in Asia and the largest motorcycle manufacture hence the opportunities for electric vehicles are very large.

By studying the facts one can conclude that it's obvious that internal combustion engine vehicles will lose the battle against electric vehicles. In recent times, demographic factors like increasing purchasing power, new environmentally friendly vehicle launches, flourishing exports and easy finance accessibility have resulted in increased automobile sale volumes. If people are provided with better options than ICEs then the sales of EVs will boom.

Besides changing the perception of the end-user customer, other key stakeholders who play an important role in India's transition towards EVs like government, incentives and subsidies and the automotive value chain industry also need to work to make EVs better.

The government can help by defining the regulations relating to emission norms, fuel efficiency, strategic intent and direction, exploring incentives and subsidies, and developing a supportive ecosystem.

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