BHARTIYA VIDHYA BHAVAN'S

SARDAR PATEL COLLEGE OF ENGINEERING

(GOVERNMENT AIDED AUTONOMOUS INSTITUTE)
MUNSHINAGAR, ANDHERI (W), MUMBAI - 400 058, INDIA

IS INDIA READY FOR ELECTRIC VEHICLES?

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FACULTY - DR. SHYAMLEE SOLANKI

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Abstract

Most of the urban Indian cities face challenges of traffic congestion and severe air pollution due to rapid urbanization and growth in automobiles. With the current depletion of fossil fuels and its price hike. As a result, there is a potential need for adopting alternative technologies in automobiles such as electric vehicles (EV).

The focus of this study is to explore various influencers of purchase intention of EVs in India by proposing a framework based on utility theory that integrates economic and psychological perspectives. Data for this study was collected from a sample of 95 respondents using the online questionnaire survey method. This study used to examine the role of performance features, financial benefits, environmental concerns, social influence, cost of ownership and infrastructure support on purchase intention of Indian consumers towards EVs by the various kind of open-ended questions in the survey. The study revealed environmental concern and performance features as most important factors influencing Indian consumers' consumption behaviour towards EVs. Presently, two factors-cost of ownership and infrastructure support were not imperative for the adoption of Evs to Indians. As environmental concern was the most important factor for Indian consumers, therefore, it is pertinent for car manufacturers and policymaker to highlight the environmental benefits of e-Mobility.

The automobile sector is considering Electric Vehicle as a solution to the industry and environment in India. However, the current market penetration of EV is relatively low in spite of governments implementing EV policies. Through this report potential scope of Electric vehicle in India will be studied and Consumer perception for same will be analysed.

1.Introduction

The Indian Automobile Industry is currently ranked 4 th largest in the world and is set to be the 3rd largest by 2030. The requirement of mobility in India is set to change dramatically in the near future to cater to the requirement of 1.30 billion+ population. The past modes of transport and infrastructure will not suffice in coming years. Recognising this aspect, the Government of India, is working towards developing a mobility option which is 'Shared, Connected and Electric'. There is an increased need to prepare for a green future for Indian mobility and reduce dependence on imported crude oil.

India is a country with the third-largest road network in the world. Road travel seemed to be a preferred choice in India with over 60 % of the population used personal or shared vehicles to commute. Conventional vehicles are a major cause of global warming and environmental air pollution. All types of vehicles produce dust from brakes, tires, and road wear. The average diesel vehicle has worse effect on air quality than the average gasoline vehicle. But both gasoline and diesel vehicle pollute more than the electric vehicle.

Governments started using fiscal policies, such as road tax, to discourage the purchase and use of more polluting cars. Green tax is imposed while re-registering the vehicle after 15 years of use to make people discontinue the use of polluting vehicles and encourage them for fuel-efficient and less polluting vehicles. Fuel taxes may act as an incentive for the production of more efficient, less polluting, vehicle and the development of alternative fuels. High fuel taxes or cultural change may provide a powerful incentive for consumers to buy lighter, smaller, fuel-efficient cars, or to not drive.

India endeavours to be on a path of energy transition in the road transport sector. The National Electric Mobility Mission Plan (NEMMP) 2020, launched in 2013, aimed at paving the way for a shift from fossil fuel-based mobility to an electric powered one. The mission set an ambitious target of 6–7 million electric vehicles in the country by 2020. The impact of subsequent schemes and initiatives by the Government of India, mostly channelled through the FAME schemes, has been limited in achieving the targets of NEMMP. As of June, 2020, just about 4.7 lakh electric vehicles have been sold under the FAME scheme since its implementation in April, 2015 including about 1.7 lakh electric two-wheelers.

The government has announced that the country would shift to an entirely electric public transport along with 30% electric private vehicles by 2030, lending a further push towards the goal of electrification.

India has certainly shown a progress towards electric vehicle adoption, but a slow one (SMEV, 2017). The sluggish growth as compared to the visioned numbers clearly indicates the presence of unforeseen challenges impeding the targeted electrification.

There is a need to acknowledge that a quick transition, howsoever well-desired, might be challenging to achieve in the absence of a clear policy, limited understanding about technological challenges, infrastructural deficiencies, and lack of consumer acceptance and awareness in the Indian market. Quick technological transitions may also have negative externalities on the job markets. To enable faster adoption of electric vehicles, it is imperative to develop an understanding of these challenge.

Against this background, we tried undertaking a survey and research study by reviewing the various statistics and the new age buzz word EV, to bridge the vital gap between the expectations of the consumers and the industry, government policies, initiatives, and actions. To find out, **Is India ready for E-vehicles?**

1.1 Objectives of the report-

The report aims to develop an understanding of the challenges that are limiting the adoption of electric vehicles in the country and suggest measures to address them. The study will focus on bringing forth the perspective of the consumers in terms of their preference and willingness to pay, perspective of the industry focusing on challenges faced in terms of their manufacturing capabilities, and resource availability.

1. To understand the mobility scenario in India

In this section, the report will investigate the current mobility pattern in India. The aim will be to understand the share of different modes in passenger transport and their preferences and roles. This section will also assess the negative externalities of rising travel demand in terms of energy consumption, carbon emissions, and local air pollution.

2. To understand the role of electric vehicles in India's mobility scenario-

Under this component, the study will investigate the role of electric vehicles as a potential solution for sustainable mobility in India. The section will aim to understand the Indian automobile industry regarding the segment wise production and sales of vehicle. This section aims to understand the current state of electric mobility in India in terms of technology, sales, usage, and policy intervention at the local, state, and national levels.

3. To estimate emission and energy impact of electrification of two-wheelers in India

Under this section, the study will estimate the potential emission, energy, and cost impact of different scales electric vehicle adoption developed as scenarios. Using bottom-up approach, this section projects the growth in two-wheelers by 2025 and 2030 across different segments. Based on alternative growth projections, the emissions and energy savings are estimated.

4. To understand the EV working infrastructure

This section will focus on understanding the ecosystem required for faster adoption of electric vehicles. The section will estimate the charging requirements for the predicted increase in electric two-wheelers in India.

5. To understand consumers perspective in electrification of two-wheelers

The study will investigate current consumer preference, focusing specifically on the two-wheelers segment. The aim will be to gain insight on their product, technology, infrastructure, financial, and policy preference. Based on the literature and secondary data, consumer's willingness to pay will also be estimated.

The facts and figures in this section will be based on the survey conducted.

6. To understand industry perspective in electrification of two-wheelers

This section will focus on understanding the perspective of the automobile Industry and its ancillary industries regarding the paradigm shift into electric. The objective of this section is to understand the change in the supply and value chain of automobiles in India on phased adoption into electric. The section aims to briefly scope the effect on employment and domestic value added from the EV transition.

1.2 Overview of the report-

With the depletion of fossil fuels and constant hike in fuel prices, there is a need for energy transition in vehicles in India. Govt has taken initiative to fight pollution levels by promoting EVs and giving subsidies on purchase. To boost its production, Govt has eased the FDI norms. Various emerging brands are launching EVs in India. The Government and manufacturers should join their hands to build the infrastructure and create positive environment for EVs. The respondents are aware of global climate conditions and are ready to change their preference from conventional to eco-friendly vehicles. Cost is an important factor while considering the purchase of EV.

The report study is conducted to explore various factors that influence Indian consumers to intend to buy electric vehicles (EVs). So far, no study has been carried out to understand consumption behaviours of Indian consumers towards e-mobility. The study applied utility theory through the integration of economic and psychological perspectives by proposing a valuable framework to understand the key influencers of consumer behaviour in the context of EVs.

Based on survey, the current study identified six key factors that may influence consumer behaviour for EVs: a) Performance features, b) Financial advantages, c) Environmental concerns, d) Social influence, e) Cost of ownership, and f) Infrastructure support.

Fig 1.1- Electric vehicle

2.Electric vehicle as potential solution

2.1- Indian automobile industry an overview-

The automotive industry has been rightly called as the 'industry of industries' since it utilizes the outputs of nearly all the manufacturing industries and also supports the upstream industries like steel and downstream industries like insurance. Undoubtedly, it is widely considered as the driver of the nation's economy and is as a significant contributor to the global economy. According to the Society of Indian Automobile Manufacturers (SIAM), the industry has grown by 14.4% in the past decade. The industry contributes 7.2% of India's total GDP and about 22% of the manufacturing GDP. In 2017, with total vehicular production over 25 Million in numbers, India's auto industry was the fourth largest producer of cars and seventh largest producer of commercial vehicles in the world.

Indian automobile industry is currently the fourth largest in the world and is set to take over as the third largest automobile industry by 2030 there are a range of players operating in India as shown below:

Passenger Vehicles	2 Wheelers	3 wheelers	Commercial Vehicles	Tractors
Number of OEMs				
15	13	7	12	17
No. of Manufacturing units				
29	22	7	34	20
Maruti Suzuki	Hero Moto Corp	TVS	Tata Motors	Mahindra
Hyundai	Honda Motors	Bajaj	Ashok Leyland	Escorts
Tata Motors	Bajaj	Piaggio	Force Motors	TAFE
Fiat	TVS	Atul Auto	Hindustan Motors	John Deere
Ford	Suzuki Motorcycles	Scooters India	Isuzu Motors	New Holland Tractors
Honda	Yamaha	Mahindra	Mahindra	International Tractors
General Motors	Mahindra	Force Motors	AMW Motors	Force Motors
Mahindra	Royal-Enfield		Piaggio Vehicles	Indofarm Tractors
Nissan	Piaggio Vehicles		SML Isuzu Ltd	SAS Motors
Toyota	LML		Eicher	HMT Tractors
Volkswagen Group	Harley Davidson		Volvo	CNH Industrial
Renault	Triumph		Man Force	ACE
Premier Auto	Kawasaki			Preet Tractors
Mercedes Benz				SAME DEUTZ – FAHR INDIA
BMW				Standard Tractors
				Captain Tractors
				Trishul Tractors

Fig 2.1- Automotive industry overview

The pace that is witnessed by India is experienced by no other country before. between 2001 and 2011 the Urban population in the country e grew by hundred million. In India out of the total population of 1366 million as on 1st august, 2021 about 377.1 million are in urban areas. The net addition of population in urban areas over the last decade is 91 million. The percentage of Urban population to the total population of the country stands at 31.6 percent. Due to this urbanization cities are also experiencing the demand for travel. While the transport is well aware, mobility also remains critical to ensure the comfort of citizens by facilitating their access to the social economic opportunities.

As per the energy and resources Institute transport projections the on-road stock of vehicles will be more than double that is from 180 million to about 373 million from 2016 to 2030 respectively.

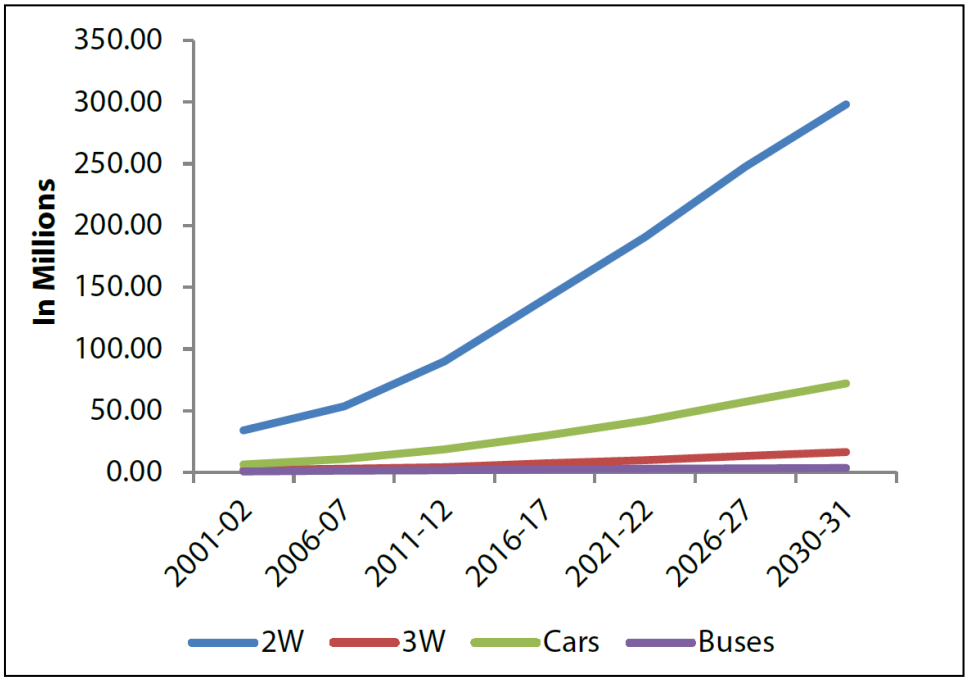


Fig 2.2- on road vehicles per million in future

Report says the road transport has contributed to approximately 213 million tonnes of carbon dioxide Where in two-wheeler and car segment contributed to about 40%, and maximum contribution is by buses that is 48%. The road transports segment has consumed about 2.9 million Tera joules of energy in 2019-20 whereas two-wheeler segment contributed 21% of the energy consumption.

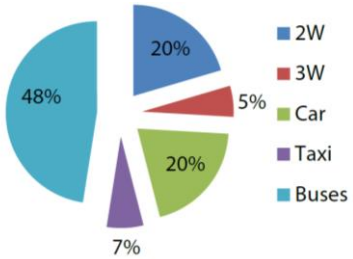


Fig2.3 Co2 Emission

2.2- Vehicle production in India-

The automotive industry produced a total of 29.86 million vehicles including commercial vehicles, passenger vehicles, tractors, three-wheelers, two-wheelers and quadricycle in the FY 17–18. The two wheelers are the dominant automobile manufactured in India, accounting for 79.7% of the total vehicles manufactured in the FY 2017-18, followed by passenger vehicles (13.7%), three-wheelers (3.5%), and commercial vehicles (3.1%).

a) A Within the two-wheeler segment, motorcycles accounted for 66% of the production followed by scooters (30%) and mopeds (4%).
b) A 71% of passenger vehicles produced in the FY 2017 – 18 were cars, followed by utility vehicles (24%) and vans (5%).
c) A Passenger carrier dominate the three-wheeler segment by constituting 86% of the production. The rest (14%) are goods carriers.
d) A 57% of the commercial vehicles produced in India during the FY 2017–18 were LCVs and 43% were M&HCVs. However, only 12% of these commercial vehicles produced were passenger carriers and 88% were goods carriers.

According to data released by the Society of Indian Automobile Manufacturers (SIAM), In April-March 2018, overall exports in automobiles increased by 16.12%.

Automobile Exports Trends (Number of Vehicles)

Category	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018
Passenger Vehicle	5,96,142	6,21,341	6,53,053	7,58,727	7,47,287
Commercial Vehicle	77,050	86,939	1,03,124	1,08,271	96,867
Three-wheeler	3,53,392	4,07,600	4,04,441	2,71,894	3,81,002
Two-wheeler	20,84,000	24,57,466	24,82,876	23,40,277	28.15,016
Grand total	**31,10,584**	**35,73,346**	**36,43.494**	**34,79,169**	**40,40,172**

Fig 2.4- Automobile export trends

In the past 10 years (2008-09 to 2017-18), vehicle production in India increased by 126%. The increase in the manufacturing volume was led by the two-wheeler segment which increased by 139% in 10 years, followed by commercial vehicles (92%), passenger vehicles (83%) and three wheelers (83%).

a) A The commercial vehicles segment saw a production increase by 10.4% in FY 17–18 over the FY 16–17 which was mainly due to the 19.9% and 17.8% growth in goods carriers and tractors respectively.
b) A The passenger carriers in the medium and heavy commercial vehicles in this segment, which includes mainly buses, witnessed a reduction in production by 24.1% during the FY 2017–18.
c) A Passenger vehicles segment witnessed an increase of 5.5% in FY 17–18 over the FY 16–17 mainly due to the 19.9% increase in production of utility vehicles.

Two-wheeler segment constitutes as a major part of the production volume of vehicles in India. Two wheelers increased from 76% of the total automobile production in 2008–09 to 80% in 2017–18.

Similar to the production in India, two-wheelers dominate the sales too. In the FY 2017–18, 82% of the market share belonged to the two-wheeler segment of the automobile industry.

2.3- E-Vehicle as a potential solution-

More importantly, self-driving cars would likely increase car congestion sharply if simply placed in the extant policy environment. A clever experiment to measure how people would behave with access to a self-driving car (simulated by giving them a chauffeur at their beck and call) found they increased their miles driven by an average of 83 percent, as they sent the car hither and yon to pick up children, run to the store, and so on. Having a chauffeur is indeed very convenient, but if everyone gets one, the roads are going to be even more clogged than they already are.

Furthermore, even a small car still takes a tremendous amount of energy and raw materials to manufacture. Smelting and casting steel and aluminium takes tons of energy — and with steel there is as yet no workable carbon-free method of making it (though some are under development). The huge batteries in electric cars require gobs of rare earth elements, often sourced in brutal conditions in poverty-stricken African countries. Replacing the hundreds of millions of gas-powered American cars with electric ones will eat up vast investment that could otherwise go to far more useful projects, like upgrading the power grid or high-speed rail.

many of the electric cars being marketed to Americans today are not small. On the contrary, they are largely heavy and high-performance machines aimed at the luxury market. Tesla is developing a gigantic ‘Cybertruck’ with a 7,500-pound towing capacity that will probably weigh at least 4 tons. Nikola Motors is competing with a giant pickup

of its own. And the elephantine new e-Hummer will reportedly have an eye-popping 1,000 horsepower and 11,000 pound-feet of torque.

An e-bike of course takes more raw materials to manufacture than a regular bike, but it is orders of magnitude smaller than a car. Instead of tons, we're talking 20 to perhaps a few hundred pounds of metal for the biggest delivery trikes. The Tesla Model S has a battery with 100 kilowatt-hours of energy — something like 200 times larger than a typical e-bike model. E-bikes are correspondingly cheaper to buy and operate; even the fanciest are seldom more than $10,000, while one can pick up a decent cheap model for a few hundred dollars. Neither do you need a 480-volt "Supercharger" (expensive both to install and to use) to fill up a bike battery, normal wall power will do just fine. And while people do crash on bikes, given the lower speeds involved and the far lower weight of the bicycle, severe injuries to either the rider or an unlucky pedestrian are much rarer. (By far the greatest risk to cyclists is getting hit by a car.)

The promising e-bike future is going to take a revolution in city politics and planning, however. As I have previously written, for decades the needs of drivers and their polluting, dangerous machines has gotten first, second, and third priority in city policy. Car supremacy is why the United States has lousy public transit in its cities and is a century behind the curve in intercity rail — where we used to lead the world in both categories.

2.4- Emission and energy impact of electrification of two-wheeler segment-

Fuel demand in India's transport sector is largely met by imports, which accounts for more than 85% of the total oil demand. India's future energy security is likely to face a serious challenge due to increasing oil prices and high import dependence. A high share of this demand largely comes from the transport sector. It is one of the most energy-intensive sectors in the country and accounts for 24% of the total energy consumption in the country, 98.5% of which is met by petroleum products (TERI, 2016). India's transport sector accounts for 99.6% of the total petrol and 70% of the total diesel consumption in the country (Nielsen, 2013). Transport sector in India accounts for 13.2% of the total CO2 emissions from fuel combustion across sectors in the country (UIC / IEA, 2016). Within the transport sector, road transport with a share of 87% accounted for the highest share of the CO2 emissions. The unprecedented growth in road transport sector has huge implications on the overall energy demand of the sector and the concomitant emissions. Considering the high reliance of the sector on fuel consumption coupled with India's high import dependence of crude oil, it is imperative to plan for sectoral policies that can manage fuel and energy demand from the sector in the coming decades and can influence the future carbon emissions.

To this end, faster adoption of EVs is one of the key policy interventions that the Government of India has taken to increase the efficiency of transport sector and to mitigate the adverse economic and environmental impact from the sector. As India's road transportation sector is experiencing high rate of motorization, most of which is

attributed to growth in demand for two-wheelers which account for 75% of the total registered vehicles (MoRTH, 2016); electrification of this segment of vehicle can significantly reduce India's dependency on fossil fuels in the long run. This section provides results of the analysis undertaken to estimate the CO2 emissions and energy savings that can be realized by electrification of two-wheelers. Considering future growth of India's transport sector and specifically the growth of two-wheelers, our analysis focuses on the potential of electric two-wheelers in decarbonizing this sector.

2.4.1 Analysis Framework -

The analysis follows a Bottom-up approach and projects the growth in two-wheelers by 2025 and 2030 across different segments. This is followed by estimation of energy consumption and CO2emissions. For arriving at the total two-wheeler passenger demand a multi-step approach is followed. Firstly, the vehicle ownership is projected based on socio-economic variables such as GDP and population. The vehicle ownership is then disaggregated at urban and rural level. Further, based on the assumptions of fuel type, fleet utilization and vehicle occupancy for different two-wheeler segments (scooters, motorcycles, mopeds, electric-two wheelers) the annual BPKM is calculated for both urban and rural areas separately. Lastly, the total annual BPKM at pan India level is arrived at by summation of urban and rural BPKM. Post the estimation of the total BPKM; dynamic fuel efficiency coefficients are applied to BPKM to arrive at the fuel consumption by two wheelers. The total fuel consumption is then converted to equivalent energy consumption and the concomitant CO2 emissions.

2.4.2 Travel demand and vehicle segmentation-

As per the model two-wheelers are expected to witness a CAGR of 9% between 2014-15 and 2029-30. The demand for two-wheelers is expected to saturate as a greater share of people choosing personal mobility would shift to cars over two-wheelers. Growth in income levels is expected to support this trend, primarily in urban areas. Travel demand by two-wheelers is expected to experience a CAGR of 9% between 2030 from 2015, as compared to 15% between 2001 and 2015 in two-wheeler sector. Currently, 52% of the share of this demand arises from urban areas and the rest by rural and intercity travel, which is expected to reverse by 2030, i.e., 48% by urban areas and 52% by rural areas. This reversal in trend is primarily associated with better connectivity, improved road infrastructure and availability of easy finance in rural areas. The market of two-wheeler segment is also expected to slow down in urban areas as compared to rural areas because it is assumed cities and towns would have improved public transport and shared mobility services, which would remain lacking in case of rural areas (ET Bureau, 2018). Further, considering the market share of different segments in two wheelers4, the projections have been made with regard to the growth of different categories of two-wheelers by 2030.

2.4.3 Assumptions for electric 2-wheeler share-

One of the key assumptions for estimating the impact of electric two-wheelers is the demand number and the market share that this segment will have in the horizon period. Typically, past trends are relied upon to make market projections; however, in the case of electric vehicles the past trends will certainly not provide a comprehensive foresight into the future. This is because a strict empirical analysis will not be able to accommodate for the fact that EV technology is a disruptive technology and once it reaches a cost parity with the ICE technology, its growth is expected to witness a widespread adoption. The following sections provide a discussion on likely factors that will determine the market share of electric two-wheelers in the country is a disruptive technology and once it reach a cost parity with the ICE technology, its growth is expected to witness a widespread adoption. The following sections provide a discussion on likely factors that will determine the market share of electric two-wheelers in the country.

2.5- Alternate electric two-wheeler uptake scenarios

In order to estimate the decarbonization impacts of electrification of two-wheelers, three scenarios have been developed, namely, the Business-As-Usual Scenario, technology upgradation scenario, and high ambition scenario.

2.5.1 Business-As-Usual (BAU) Scenario (or Reference Scenario)

It is assumed that in the BAU Scenario, the penetration of electric-two-wheelers in the market will remain negligible due to limited policy push and lack of technological improvements. Under the BAU scenario, scooters and motorcycles dominate the total demand with their share in on-road stock being 46% and 52% respectively, by 2030. It is also estimated that the market share of electric two-wheelers will reach up to 1.71% by2025 and then increase up to 7% by 2030. Subsequently, the CO2 emissions from two-wheelers are estimated to increase from 38.59 million tonnes in 2015 to 76.92 million tonnes in 2030.

2.5.2 Upgraded Technology Scenario

It is assumed that post-2025, the cost parity between electric and ICE two-wheelers would have been reached. Hence post-2025, an exponential growth in the electric two-wheelers segment is assumed. With this scenario, the share of electric two-wheelers of the new two-wheeler registrations is expected to become 5% in 2025 and 15% in 2030, respectively. This increase in the market share will reduce emissions by 1.3% and 2.7% by 2025 and 2030, respectively.

2.5.3 High Ambition Scenario

In the High Ambition Scenario, it has been assumed that along with strong focus of the central government the role played by various state-level policies will play a crucial role in increasing the uptake of electric two-wheelers in India. It is assumed that, the benefits offered in FAME-II, benefits from the State governments along with a reduction

in battery prices can lead to increased penetration after 2025. Considering all the factors fall in favour of EVs along with the preferences of consumers, this could imply a 5% penetration in 2025 followed by 30% in 2030.

It is assumed that in the high ambition scenario, cities and states will aggressively pursue the FAME-II targets. Efforts by various states and cities already point towards this direction. Several states are boosting the uptake of electric two-wheelers by providing incentives at various levels, such as Gujarat is providing subsidies to students for purchasing electric two-wheelers, Kerala has proposed a pilot fleet of 200,000 e-2W, Telangana has provided a designated EV cluster for component manufacturing of e-2W. This scenario assumes the policy targets as announced by Government of India will be exceeded/over-achieved. A greater push will be given to electric services with increased support in terms of financial and non-financial incentives.

It is expected that post-2025, when the cost parity would have been achieved between the ICE and electric two-wheelers, with the continued policy push, electric two-wheelers would grow exponentially and a share of 30% in new two-wheeler vehicle registrations is assumed to be achieved by 2030. As a result, the emissions are expected to reduce by 1.3% and 6% by 2025 and 2030 respectively, as compared to the BAU scenario.

3.E-Vehicles Overview

3.1 Classification of Hybrid Cars

3.1.1-Hybrid Cars

A **hybrid vehicle** uses two or more distinct types of power, such as internal combustion engine to drive an electric generator that powers an electric motor, e.g. in diesel-electric trains using diesel engines to drive an electric generator that powers an electric motor, and submarines that use diesels when surfaced and batteries when submerged. Other means to store energy include pressurized fluid in hydraulic hybrids.

The basic principle with hybrid vehicles is that the different motors work better at different speeds; the electric motor is more efficient at producing torque, or turning power, and the combustion engine is better for maintaining high speed (better than typical electric motor). Switching from one to the other at the proper time while speeding up yields a win-win in terms of energy efficiency, as such that translates into greater fuel efficiency.

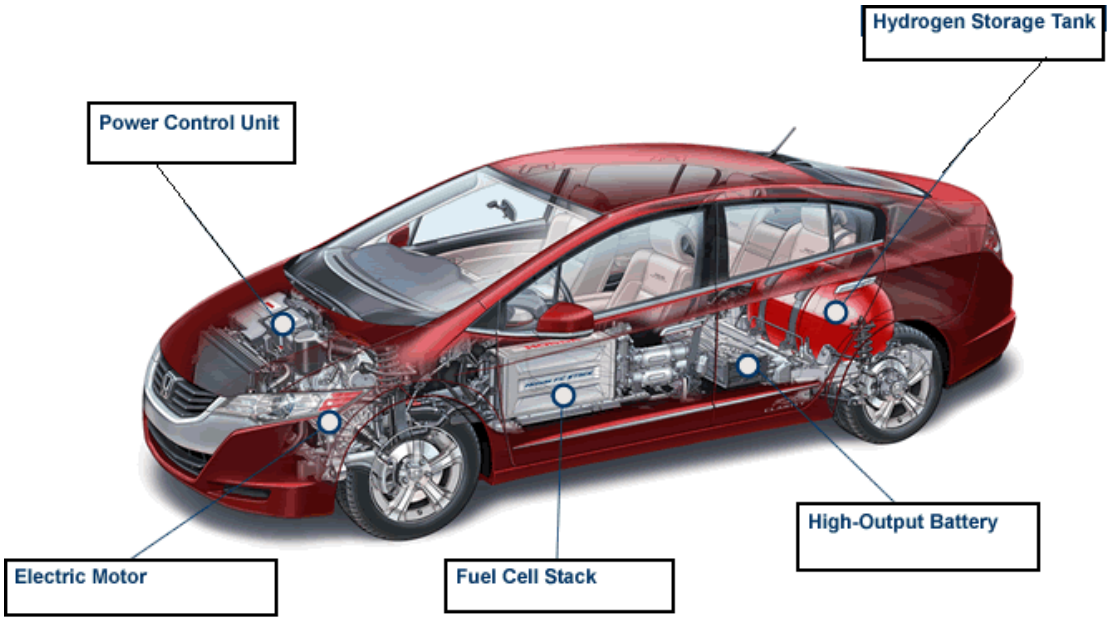


Fig 3.1 – Electric vehicle construction

3.1.2 Hybrid Car Manufacturers:

While the Honda Insight, released in 1999, was the first hybrid car available, the Toyota Prius (introduced in the United States in 2000) has become the best-selling hybrid on the market. The Prius continues to earn favourable reviews as one of the better hybrid cars available, and a number of car companies have been aggressively targeting environmentally conscious consumers with their hybrid offerings.

3.1.2.1 Cars

Hybrid cars still offer the best gas mileage available, some boasting mileage as high as 60 miles per gallon on the highway. If you're looking for a hybrid car, you can find options at the following manufacturers:

- Honda: Accord, Civic, Insight, CR-Z, Fit
- Toyota: Prius, Camry
- Nissan: Altima
- Lexus: LS 600h L, GS 450h, HS 250h, CT200h
- Mercedes: S400 BlueHybrid
- Hyundai: Sonata
- Ford: Fusion
- Infiniti: M35h
- Lincoln: MKZ
- BMW: Active Hybrid 7
- Kia: Optima Hybrid
- Buick: Lacrosse eAssist
- Fisker: Karma
- Volkswagon: Jetta

Fig 3.2 – Various examples of EV-Cars

3.1.2.2 SUVs and Vans

Most hybrid SUVs and vans offer between 20 to 30 miles per gallon of gasoline. That isn't nearly as good as the gas mileage for cars, but if you have a large family and need the extra space afforded by a SUV, then every little bit you can save on gasoline will help your bottom line. Look for these makes and models of hybrid SUVs:

- BMW: X6 Hybrid
- Cadillac: Escalade
- Ford: Escape, C-Max
- Toyota: Highlander, Prius V, Sienna
- Chevrolet: Tahoe
- Porsche: Cayenne S
- Mercedes: ML 450
- GMC: Yukon
- Lexus: RX 450h
- Volkswagon: Touareg

Fig 3.3 – Various examples of EV-SUVs

3.1.2.3 Trucks

Trucks haven't come onto the scene yet as a major hybrid market, but there are a few options available that will enable you to get roughly 20 to 25 miles per gallon:

- Chevrolet: Silverado
- GMC: Sierra

3.1.3 Types of Hybrid Cars:

The following are the types of the hybrid cars:

1. Micro Hybrid
2. Mild Hybrid
3. Full Hybrid
4. Series Hybrid
5. Parallel Hybrid
6. Plug-in Hybrid Electric Vehicle (PHEV)

1. Micro Hybrid:

It not hybrid but it has only one feature of hybrid the start-stop engine system which automatically stops the car engine when we are stop at signals and automatically starts car engine when we press gas pedal.

Example- Mahindra Scorpio 2014

2. Mild Hybrid:

Unlike full hybrid mild hybrid did not stop the engine and cannot run fully on electric motors but it gives extra power to the engines output by a motor it is light weight, low cost and use smaller battery than full hybrid vehicle.

Example -Ferrari laferrari

Ferrari LaFerrari it is a ferrari's most powerful road legal hyper car and it is mild hybrid it has a naturally aspirated v12 engine that produces 800 HP and has 163 kw electric motor the engine and motor both coupled with 7 speed dual clutch transmission it is rear wheel drive car .when we put key in the ignition and turn it on it stars both motor and v12 engine when we accelerate the car the both motor and engine powers the car gives the acceleration like Koenigsegg agera and a Bugatti Chiron the hybrid system of Ferrari is Leona as HY KERS or hybrid kinetic energy recount system when the car deaccelerate the motor works as regenerative braking system .The HY KERS reduces the engine weight by replacing the starter motor and alternator in car by a single 163 me electric motor.

3. **Full Hybrid:**

In full hybrid vehicles we can use either engine or electric motor and the combination of both to drive the car.

Example-Toyota Camry

Toyota Camry is a full hybrid vehicle when we start ignition in this car the gasoline engine did not start it starts an electric motor it has an electronic coupling clutch which couples and decouples the engine from the transmission when we smoothly accelerate the car the engine is stop and car runs only on motor that took powers from lithium ion battery when we quickly accelerate the car a smart starter motor system starts the car engine and electronic clutch couples the engine from transmission and then for more speed engine and motor both run together when we de-accelerate the car the electronic clutch decouples the engine from transmission and regenerative braking activate which convert kinetic energy into electrical energy by a small motor/generator and store it in a battery.

4. **Parallel Hybrid:**

In a parallel hybrid vehicle, an electric motor and an internal combustion engine are coupled such that they can power the vehicle either individually or together. Most commonly the internal combustion engine, the electric motor and gear box are coupled by automatically controlled clutches. For electric driving the clutch between the internal combustion engine is open while the clutch to the gear box is engaged. While in combustion mode the engine and motor run at the same speed.

The first mass production parallel hybrid sold outside Japan was the 1st generation Honda Insight.

5. **Plug-in Hybrid Electric Vehicle (PHEV)**

A **Plug-in hybrid electric vehicle (PHEV)** is a hybrid electric vehicle whose battery can be recharged by plugging it into an external source of electric power, as well as by its on-board engine and generator. Most PHEVs are passenger cars, but there are also PHEV versions of commercial vehicles and vans, utility trucks, buses, trains, motorcycles, scooters, and military vehicles.

Similarly, to all-electric vehicles, plug-in hybrids displace emissions from the car tailpipe to the generators powering the electricity grid. These generators may be renewable, or may have lower emission than an internal combustion engine. Charging the battery from the grid can cost less than using the on-board engine, helping to reduce operating cost.

Mass-produced plug-in hybrids were available to the public in China and the United States in 2010. By the end of 2017, there were over 40 models of series-production highway legal plug-in hybrids for retail sales. Plug-in hybrid cars are available mainly in the United States, Canada, Western Europe, Japan, and China. The top-selling models are the Mitsubishi Outlander P-HEV, the Chevrolet Volt family, and the Toyota Prius PHV.

Fig 3.4 – Plug-in Hybrid Electric Vehicle (PHEV)

3.2 Electric Vehicles

3.2.1 Definition of E-Vehicle:

An **electric vehicle**, also called an EV, uses one or more electric motors or traction motors for propulsion. An electric vehicle may be powered through a collector system by electricity from off-vehicle sources, or may be self-contained with a battery, solar panels or an electric generator to convert fuel to electricity. EVs include, but are not limited to, road and rail vehicles, surface and underwater vessels, electric aircraft 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 level of comfort and ease of operation that could not be achieved by the gasoline cars of the time. Modern internal combustion engines have been the dominant propulsion method for motor vehicles for almost 100 years, but electric power has remained commonplace in other vehicle types, such as trains and smaller vehicles of all types.

3.2.2 History:

Electric motive power started in 1827, when Hungarian priest Ányos Jedlik built the first crude but viable electric motor, provided with stator, rotor and commutator, and the year after he used it to power a tiny car. A few years later, in 1835, professor Sibrandus Stratingh of the University of Groningen, the Netherlands, built a small-scale electric car, and between 1832 and 1839 (the exact year is uncertain), Robert Anderson of Scotland invented the first crude electric carriage, powered by non-rechargeable primary cells. Around the same period, early experimental electrical cars were moving on rails, too. American blacksmith and inventor Thomas Davenport built a toy electric locomotive, powered by a primitive electric motor, in 1835. In 1838, a Scotsman named Robert Davidson built an electric locomotive that attained a speed of four miles per hour (6 km/h). In England a patent was granted in 1840 for the use of rails as conductors of electric current, and similar American patents were issued to Lilley and Colten in 1847.

The first mass-produced electric vehicles appeared in America in the early 1900s. In 1902, "Studebaker Automobile Company" entered the automotive business with electric vehicles, though it also entered the gasoline vehicles market in 1904. However, with the advent of cheap assembly line cars by Ford, electric cars fell to the wayside

Due to the limitations of storage batteries at that time, electric cars did not gain much popularity, however electric trains gained immense popularity due to their economies and fast speeds achievable. By the 20th century, electric rail transport became commonplace due to advances in the development of electric locomotives. Over time their general-purpose commercial use reduced to specialist roles, as platform trucks, forklift trucks, ambulances, tow tractors and urban delivery vehicles, such as the

iconic British milk float; for most of the 20th century, the UK was the world's largest user of electric road vehicles.

Electrified trains were used for coal transport, as the motors did not use precious oxygen in the mines. Switzerland's lack of natural fossil resources forced the rapid electrification of their rail network. One of the earliest rechargeable batteries – the nickel-iron battery – was favoured by Edison for use in electric cars.

EVs were among the earliest automobiles, and before the pre-eminence of light, powerful internal combustion engines, electric automobiles held many vehicles land speed and distance records in the early 1900s. They were produced by Baker Electric, Columbia Electric, Detroit Electric, and others, and at one point in history out-sold gasoline-powered vehicles. In fact, in 1900, 28 percent of the cars on the road in the USA were electric. EVs were so popular that even President Woodrow Wilson and his secret service agents toured Washington, DC, in their Milburn Electrics, which covered 60–70 mi (100–110 km) per charge.

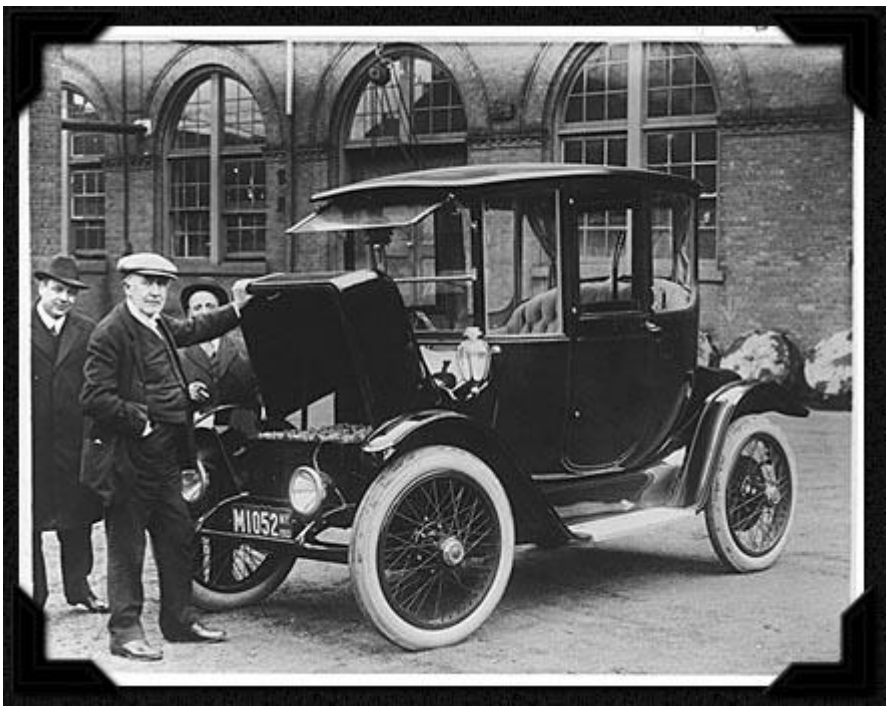


Fig 3.5– Ancient EV

A number of developments contributed to decline of electric cars. Improved road infrastructure required a greater range than that offered by electric cars, and the discovery of large reserves of petroleum in Texas, Oklahoma, and California led to the wide availability of affordable gasoline/petrol, making internal combustion powered cars cheaper to operate over long distances. Also internal combustion powered cars became ever easier to operate thanks to the invention of the electric starter by Charles

Kettering in 1912, which eliminated the need of a hand crank for starting a gasoline engine, and the noise emitted by ICE cars became more bearable thanks to the use of the muffler, which Hiram Percy Maxim had invented in 1897. As roads were improved outside urban areas electric vehicle range could not compete with the ICE. Finally, the initiation of mass production of gasoline-powered vehicles by Henry Ford in 1913 reduced significantly the cost of gasoline cars as compared to electric cars.

In the 1930s, National City Lines, which was a partnership of General Motors, Firestone, and Standard Oil of California purchased many electric tram networks across the country to dismantle them and replace them with GM buses. The partnership was convicted of conspiring to monopolize the sale of equipment and supplies to their subsidiary companies, but were acquitted of conspiring to monopolize the provision of transportation services.

3.2.3 Manufacturers:

- Honda
- Toyota
- Hyundai
- Mazda
- NISSAN
- Mercedes-Benz
- Kia Motors
- BMW Motorrad
- Audi
- 10. Ford Motor Company

3.2.4 Specification:

Car Name:	Nissan Acenta
Manufacturer:	NISSAN
Price:	£26,345 (Dt. 31/12/2019)
	Engine
Fuel type:	Electricity
Max. Torque, Nm/rpm:	320
Drivetrain:	2WD
Maximum Engine Power, PS:	150
Acceleration 0-62mph:	7.9 seconds
Max. Speed:	90 mph
Transmission type:	Automatic
Electric Motor Type:	AC synchronous
Max RPM:	9,795 rpm
Driven Wheels:	Front Wheel Drive
	Weights & dimensions
Maximum payload:	450 Kg
Gross Vehicle Weight:	1,995 Kg
Overall width with mirrors:	2,030mm
Luggage space - max length:	790.0 mm
Luggage space - max width:	1,103 mm
Wheelbase:	2,700 mm
Track front:	1,540 / 1,530 mm
Track rear:	1,555 / 1,545 mm
	Body
Number of Doors:	5
Body Type:	Hatchback
Number of Seats:	5
	Efficiency
CO2 Emissions while driving:	0 g/km

Range (WLTP Combined Cycle):	Up to 168 miles
Range (WLTP City Driving Cycle): Up to 242 mile	
Chassis	
Suspension:	Front Mac Pherson strut
Suspension Rear:	Twist beam axle
Steering:	Electric power assisted
Braking system:	Electrically Driven Intelligent Brake
Front Brake:	Vented discs
Rear Brake:	Vented discs
Wheel size:	16" Alloy
Tyre size:	205/55 R1
Charging	
On-board charger:	6.6 kW
Port for Rapid Charging type:	50 kW
Battery	
Type:	Laminated Lithium Ion
Voltage:	350V
Capacity:	40 kwh
Battery Charging:	7.5 hr
Battery Charging (50kW Rapid Charger) from 20% to 80%, min	

Around 60 min, time is dependent on charging conditions, including charger type and condition, battery temperature as well as ambient temperature at point of use.

4.E-Vehicles Infrastructure

4.1 E Vehicle Charging Infrastructure Requirement-

To address the range anxiety among potential EV customers, adequate charging infrastructure is required. An in-depth analysis of various possibilities of EV charging and associated business models are addressed in this chapter.

Almost all electric two-wheeler owners charged their vehicles at home. Home charging is a complex problem in India as most urban citizens live in MURB (Multi Unit Residential Blocks) and many lack parking facilities within their buildings. Private charging facility at home is a primary consideration for boosting the initial uptake of electric vehicles.

As adequate public charging infrastructure is essential for increasing the adoption of electric vehicles. This report assessed the business feasibility of public charging stations (PCS). Through analysis it was found that break even occurs at tariffs significantly higher than home charging rates. On the other hand, it was found that existing or potential electric two-wheeler owners require public charging tariff to be competitive with the home charging rates, for regular charging and not charging only in the case of emergency. The main driver of longer breakeven are the real-estate rental costs in cities for PCS.

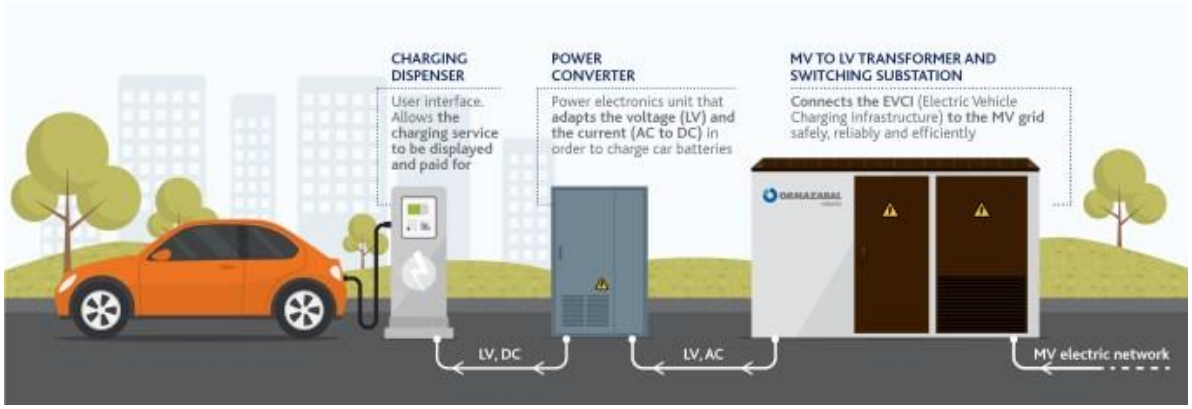


Fig 4.1– EV Charging Infrastructure

To make charging infrastructure viable for initial low demand scenario, measures such as enabling real estate procurement at key locations at lower costs, capital subsidy, or interest subvention on capital expenditure should be considered. The minimum charging station requirements to be eligible for incentives as per ministry of power guidelines should also be brought down. Support from state authorities and local DISCOMs for single window approvals and providing power infrastructure to bear

additional electricity load is also needed. Finalization of charging standards for all vehicle categories will be helpful in reducing demand uncertainty for type of charging equipment and yielding higher utilization of charging infra.

Business analysis of battery swapping stations was also undertaken. The analysis shows that BSS would even be more expensive than PCS and home charging, and presenting host of other customer satisfaction, operational and technical challenges.

This report also attempted to understand how much energy be required to be set up to cater to the electric two-wheeler demand projected in the technology upgradation scenario and what will be the costs for the same. To make a successful adoption of electric vehicles there has to be planned coordination in research, policy, and implementation of both energy and transport sectors.

4.2 AN ECOSYSTEM FOR ELECTRIC TWO-WHEELERS (FEASIBILITY STUDY)

4.2.1 Introduction –

Charging infrastructure will remain a critical driver for the success of EV adoption. Electrical two-wheelers can typically be charged at home, at a PCS or at a battery swapping station (BSS). This section attempts to assess the costs of setting up of each of these charging solutions in order to derive which of these mechanisms would likely become popular due to favourable economics.

4.2.2 Private charging-

At present, there are two primary modes of private charging: charging at home and charging at office. This section discusses the private charging scenario for individual electric two-wheeler owners. Although (Original Equipment Manufacturers) OEMs are offering solutions for home charging along with the EV purchases, taxation, theft and accounting remain major challenges for private charging.

It is well acknowledged that convenient home charging will increase the EV adoption. Home charging is also supposed to result in longer battery life and grid balancing. It leads to effective utilisation of electricity as the electric vehicles are usually charged at night in off-peak hours. Appropriate and convenient home charging is an essential catalyst for the transition of vehicle stocks into electric.

4.2.2.1 Key Assumptions

1. All electric two-wheelers are charged at home.
2. The cost of home charging is Rs. 5 per kWh.
3. Each two-wheeler covers 30 km per day for 300 days in a year
4. Each two-wheeler has a 1.5 kWh battery with a capacity to cover 60 km on full charge.

Review of various sources and analytics have helped discover that load of extra 231 crore kWh from 1.03 crore electric two-wheelers by 2030 can be absorbed by the existing

infrastructure, with no extra cost, if the demand is well managed and distributed across off-peak hours. Considering a nominal cost of electricity, the annual cost of charging an e-2w comes out to be Rs. 1125 only.

The home charging solution for individual housing units is not challenging. Individual households can charge the electric two-wheeler as they charge any other electronic commodity in the household. The level 1 chargers in households are adequate for charging electric two-wheelers. However, the challenge arises in multiple dwelling units or multi-unit residential blocks (MURBs) defined as residences with three or more dwelling units and common interior and exterior areas. A significant population of Indian metropolitan cities live in such units. Tier II and tier III cities in India mostly have individual homes, but tier I cities such as Delhi, Mumbai and Bangalore have more of multi-unit residential blocks.

For destination charging, a key challenge is to ensure that the parking spaces in residential, commercial and institutional places are EV ready. Government has already recognised the challenges and Ministry of Housing and Urban Affairs has issued specified guidelines in Model Building By-Laws.

The state or city level building codes should be modified without setting high standards and creating unnecessary costs to the building in establishing EV infrastructure. A typical building's power distribution system, which is composed of a series of electrical energy carrying components to carry electricity in a safe and efficient manner, is not usually designed to cope with additional EV loads. However, electric two-wheelers with average 1.5–2 kWh batteries are not expected to challenge the load capacity of most compliant buildings. But the experts recommend assessment of building's wiring and metering configuration on a case by-case basis. Individual meters might be required in parking lots to calculate electricity consumption of each end user. For the existing buildings to retrofit the EV charging infrastructure, adequate incentive schemes may be designed by the state of local governments. The installation of charging infrastructure by the existing building is dependent on the proportion of EV owners among the households as non-EV owners may be against installation of the same as the costs are variable and rewiring disturbing.

Private charging is a crucial component for boosting the initial uptake of electric vehicles, State and local governments must critically assess the plan for the same in terms of regulation, incentives, standards, metering and billing.

4.2.3 Public Charging Station

Although private charging might remain the most convenient method of charging e-2w, the availability of PCS will also remain critical to tackle the level of anxiety, support unplanned trips by EV and also support EV charging in areas where

private/home/destination charging might not be feasible due to lack of EV parking spaces.

In order to assess the financial feasibility of PCS, it is assumed that 3.3 kW chargers for normal charging and 22 kW Type 2 AC charger for fast charging should be sufficient as recommended by Ministry of Power (MoP). Higher configuration chargers have not been considered for the PCS assessment here.

The feasibility of public charging stations is assessed under two main cases: including land cost and excluding land cost. The rental cost of the land in which the public charging station has to operate is a significant variable cost for operations of any public charging station. Public charging stations have to be situated centrally in the urban areas in order to effectively cater to EV charging demand. However, the land rental and purchase rates are enormous in such prime locations in the Indian cities. This land cost significantly affects the business feasibility of vehicles. Hence, we have assessed the business feasibility of PCS in both scenarios, that is, where land costs are incurred and where they are not.

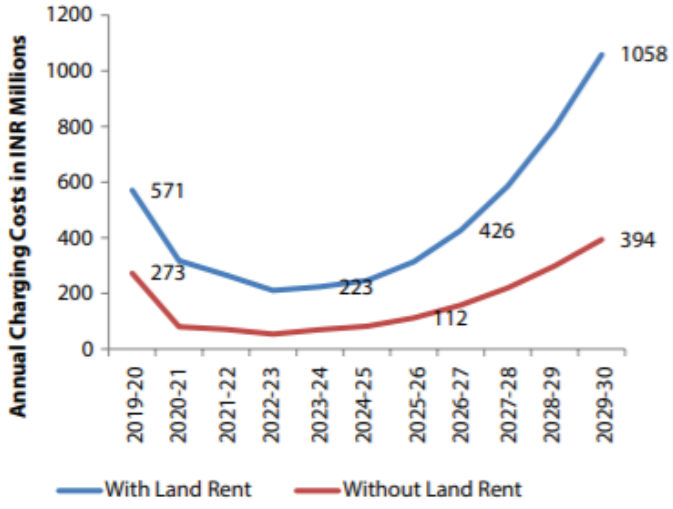


Fig 4.2 Annual charging costs to ecosystem, including all annual capital and variable costs

4.2.4Key takeaway from the study -

An expenditure of Rs. 1600 crore must be made to facilitate setting up of public charging stations and their operations till 2025. In the case where PCS businesses do not have to spend on land rents, an expenditure of Rs. 570 crores must be made to facilitate setting up of public charging stations and their operations till 2025.

The annual cost per e-2w is the annual charging cost divided by the total e-2w stock in that year. These values were estimated to determine the hypothetical financial burden on the electric two-wheeler owners from the costs of charging ecosystem.

The annual cost per electric two-wheeler for the PCS ecosystem stabilises only after higher utilisation levels achieved in 6–7 years of operations of PCS.

The annual cost per electric two-wheeler does not include the cost to be incurred in charging the electric vehicle.

From 2019–20 to 2029–30, costs per electric two-wheeler fall from Rs. 823 to Rs. 103 in the case of businesses incurring land rents in contrast to the fall from Rs. 393 to Rs. 38 per electric two-wheeler in the absence of land rents

4.3 The NITI Ayog plan

Based on the NITI Ayog plan, the Ministry of Power has already undertaken several leads in pushing the EV Infrastructure initiatives through its various PSU companies, such as,

1. National Thermal Power Corporation (NTPC) – plans for setting up 100,000 EV charging stations in India
2. Bharat Heavy Electricals Ltd (power equipment PSU) plans to make batteries in India using the Lithium technology developed by ISRO
3. Energy Efficiency Services Ltd (EESL – a national ESCO company, experienced in large tendering process) has already issued tenders to source 10,000 EV and about 4,000 EV chargers in India
4. Rajasthan Electronics (I) Ltd, (REIL) – plans to set up 200 charging stations in Delhi, Jaipur and Chandigarh

Each of these initiatives will help set the basic infrastructure and bring in interest from the private firms as well, already many announcements have been made by various private organizations.

1. Tata Power has a set up a pilot project of EV charging and is likely to install more in future
2. Mahindra along with Ola has been setting up EV charging stations so far and will continue to be aggressive about this
3. Fortum India, Finland's Utility firm, plans to enter and set up nationwide EV Charging stations
4. Lithium Urban, an EV feet firm has plans to set up 60 charging stations

NTPC will be a key player in setting up EV chargers' infrastructure in India

4.3.1Present Status of EV Charging Stations

National Thermal Power Corporation (NTPC) ventured into EV-Charging business and has installed first charging stations at its offices in Delhi and Noida. At present, they are

looking for a country-wide licensing. If that happens than they will be able to set up the charging stations very quickly. the main objective in setting up EV charging points is to be part of promoting clean energy transportation. In NTPC, the charging station installed as of now is specific to Mahindra vehicles. NTPC has applied for National Distribution License to roll out this at a national level.

Fig 4.3– NTPC EV Charging Station

4.3.2 Bharat Heavy Electricals Ltd (BHEL)

Memorandum of Understanding (MOU) has been signed between BHEL and ISRO for making Electric Vehicles battery. ISRO is providing R&D technology to BHEL for making efficient and low-cost lithium - ion battery. For batteries, BHEL is in conversation with ISRO. A foreign agency is also involved with the company for technology tie-up. BHEL has started manufacturing electric motors for Ashok Leyland and Tata Motors for their electric vehicles. BHEL has formed an internal committee to understand the market and demand for batteries. According to BHEL there should be a generic standard for batteries in India. Presently, Mahindra Reva is using Chinese battery for its EVs.

The Ministry of Power has called for sourcing 4,000 EV chargers through an open tender from one of its PSU's – EESL (Energy Efficiency Services Limited)

4.3.2.1 Objective of this tender

1. Ministry of Power has initiated a program to source 10,000 electric cars in India, through EESL.
2. The goal of this initiative is to provide an impetus for Indian Vehicle manufacturers, charging infra firms, fleet operators, services providers etc to gain efficiencies of scale and drive down costs
3. Create local manufacturing facilities
4. Grow technical competence for the long-term growth of EV industry in India
5. To enable Indian EV manufacturers to emerge as major global players
6. EESL shall be supporting the new Electric Mobility Mission to scale EVs in India through bulk aggregating of demands of EV charging infrastructure, procuring best quality products & services at lowest prices

4.3.2.2 Structure of the order

a. EESL plans to procure 1,000 EVs immediately in the Phase 1 of the exercise and 9,000 EVs later in the Phase 2 of this tender

b. The Phase 1 for 1000 EVs are being procured for use in various Central Government Ministries in India

c. Phase 2 exercise for sourcing 9,000 EVs is aimed at leasing the vehicles to various fleet operators

4.3.2.3 Some key points on the EV Chargers

1. The charging equipment must be CE Certified
2. The charging equipment must come with a comprehensive extended on-site warranty and AMC package for 5 years from the date of commissioning and must have a design life of 10 years
3. The charging equipment before delivery, should be type tested as per AIS 138 at ARAI (Automotive Research Association of India) and IIT Madras

4.3.3 Tata Power

Tata Power is a private power distribution company that plans to invest in EV charging infrastructure

1. Tata Power recently has installed its first electric vehicle charging facility at Vikhroli in Mumbai. It has set up 2 more stations in North & Central Mumbai.
2. Tata Power plans to roll out nearly 50 EV charging stations in Mumbai and New Delhi
3. The chargers can also monitor the car battery charging status and units consumed while charging a car.

4.3.4 Ola

Ola has gone one step ahead in implementing Charging stations

4.3.4.1 Electric Vehicles

1. Launched 200+ Ola cars that are charged by the company as of now in Nagpur pilot project
2. Has 50+ charging stations at 4 strategic locations in Nagpur
3. Ola electric vehicles are from Mahindra Electric (E20 model)
4. The payment system is provided to third party vendor and can be paid via electronic or cash mode
5. These cabs run around 200Kms per day

4.3.4.2 Limitations/ hurdles

1. Setting up charging stations in Tier I city is operationally not feasible
2. Drivers come back to charging station to charge, covering 7-8 trips
3. Navigation and other apps are draining the battery, and in some instances, they have covered only 75-80 km over an anticipated mileage of 100km

4.3.4.3 Charging Stations

1. DC fast charging that takes around 75 min to charge
2. The ACME group has supplied the charging station
3. Company has invested INR 50 Cr in the entire EV project
4. The Ola cars are charged by the company under a subsidy

4.3.4.4 Future Plans

1. Planning to launch the same in 2 Tier-I and 3 Tier-III cities in coming years
2. Looking at Hyderabad, Lucknow and Kochi in the pilot phase
3. Plans to invest $2 billion in EVs in all cities of India and run one million electricity powered vehicles on the Ola platform by 2020
4. Looking to tie up with OEM's like TATA and Bajaj in future
5. Ola is in talks with Government for PPP for pilot projects on EV segment.

EV Charging business currently falls under the regulated environment (needing a License) but may be amended to allow more private sector participation

For the EV charging business, there are no specific rules as such which is set out – due to the lack of the EV Policy overall. Under the existing rules, EV charging business is classified as Electricity Sales and falls under the Electricity Act 2003 (EA 2003) and under the domain of the regulated sectors, needing a distribution license. However, the EV chargers/charging stations used for maintaining own vehicles does not fall under the regulated environment and is allowed - considered as captive consumption. There are

now talks of getting this rule amended in the Electricity Act 2003 and allowing EV charging business to kept out of the regulated environment. discussions with various states like Karnataka, Telangana and Andhra Pradesh has also indicated that they could use some provisions for private sector participation in the EV charging business and need not be under the regulated domain.

4.4 Indian Government has recently notified the standards for EV Chargers to be adapted in India

The Government of India has recently notified the Protocol for Adaption of standards for Bharat Chargers (AC-001 & DC-001).

The process of adapting these standards included the following steps:

1. Under the FAME Policy in 2015, the Department of Heavy Industries (DHI) had authorized the Automotive Research Association of India (ARAI) to come up with Draft Standards for EV Chargers in India.
2. ARAI had published these standards in 2016 and the DHI invited Industry response to the same.
3. DHI along with Niti-Ayog has proposed standards for EV Chargers in India.

4.5 Likely future market for EV Chargers in India

	2017-18	2018-19	2019-21	2021-25	Cumulative potential upto 2026
No of EV Charging stations likely to be set up	1,000	5,000	50,000	350,000	**406,000**
Norms of EV Chargers likely to be installed	4	4	6	6	
Total EV Chargers likely to be installed	4,000	20,000	300,000	2,100,000	**2,424,000**
% of AC Slow chargers likely	90%	80%	80%	70%	
% of DC Fast Chargers likely	10%	20%	20%	30%	
No of AC Slow chargers likely to be installed	3,600	16,000	240,000	1,470,000	**1,729,600**
No of DC Fast Chargers likely to be installed	400	4,000	60,000	630,000	**694,400**

Fig 4.4– Future Market trends of EV chargers

4.6 Battery Market in India

The battery market is characterized by the unorganized sector which accounts for 40% of the market in volume terms. This market is currently ruled only by the Lead Acid batteries in India. Most Lithium Battery requirements are imported and now we see some lithium battery packaging happening in India since the last 1 year.

There are close to 2,500 odd players making Batteries in India in the Lead Acid market. There could be close to another 10,000 odd small and unorganized players in the battery market. The market is dominated by 2 key large players – **Exide Industries and Amara Raja Industries.** The battery market is a INR 177 billion industry and around 80.5 million units.

Automotive is a key large market dominating the end use application segments accounting for 60% of the market in India and the rest industrial and commercial applications accounting for the balance. In terms of the types of batteries, Enhanced Maintenance Free (EMF) batteries account for 67% of the market, VRLA are now gaining in prominence and is about 31% of the market. Low maintenance batteries account for 2% of the market

Automotive sector accounts for 60% of the 80.5 mn battery unit market

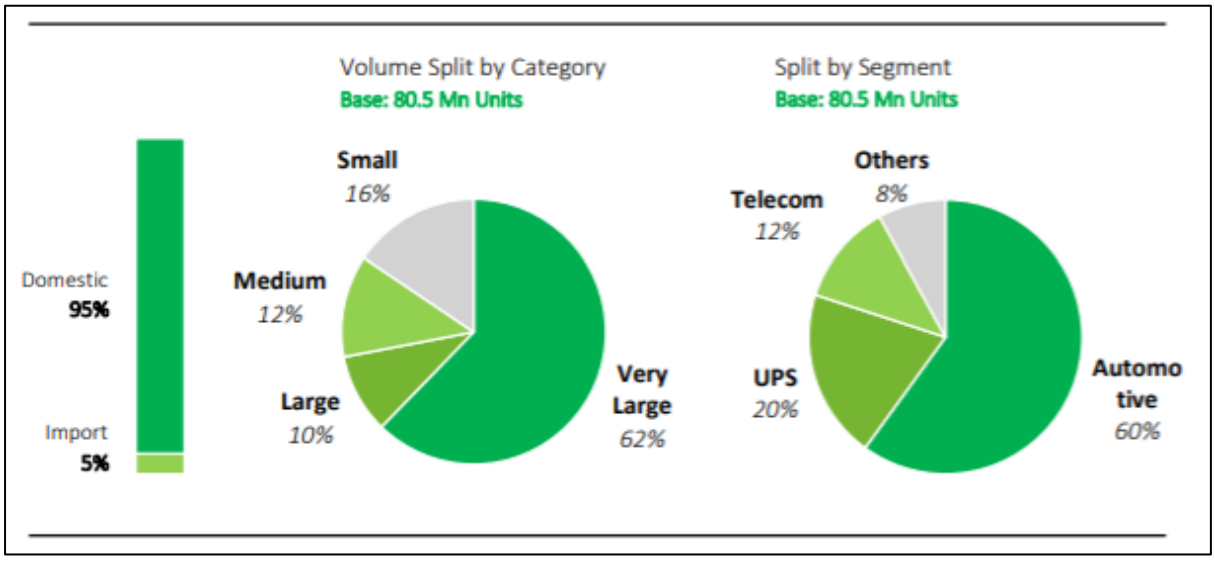


Fig 4.5– Indian Battery market overview

India is a virgin market for Lithium Ion or other advanced batteries market

A mature market of Lead acid battery manufacturing eco-system established in the country. Lithium-Ion Battery manufacturing is just starting out and is currently almost non-existent.

As of last year, most Lithium batteries were being imported from China, South Korea Vietnam, Singapore and Japan predominantly. Last one year saw some major activities in Lithium-Ion Batteries packaging in India o India may reach a capacity of 1GWH of Battery packaging by 2018. Major announcements are being made by global private and public sector units to look at Lithium-Ion Battery production in India.

5. EV-Policy structure

5.1 Overview of political structure in EV policy development –

The Government of India's think tank, Niti Aayog, and Rocky Mountain Institute have jointly prepared a report that quantifies the energy and carbon savings that the vehicles eligible for FAME II will deliver over their lifetimes. Assuming all vehicles eligible for FAME II incentives are deployed, the net savings would be 5 million tons of oil equivalent (Mtoe) and 7 million tons of CO2.

FAME II is a beginning, not an end. Therefore, the report also quantifies the catalytic effect that FAME II could have on the overall EV market. If FAME II and other measures are successful, India could realize EV sales penetration of 30% for private cars, 70% for commercial cars, 40% for buses, and 80% for two- and three-wheelers by 2030. In addition, the lifetime cumulative oil and carbon savings of all electric vehicles deployed through 2030 could be manyfold larger than the direct savings from FAME II. For example, achieving these levels of market share by 2030 could generate cumulative savings of 846 million tons of CO2 over the deployed vehicles' lifetimes.

India's efforts in implementing several policies, including FAME II, signal the country's vision for a shared, clean, and connected mobility system. Participation of multiple stakeholders will help capture the benefits of FAME II and its intended effect on the electric mobility ecosystem.

5.2 Objectives

1. Provide a summary of key policy and industry initiatives to support rapid adoption of electric mobility
2. Analyse the impacts of FAME II with respect to emissions, oil consumption, and overall EV adoption trends
3. Propose possible actions that industry and government can take in continued support of the faster deployment of electric vehicles

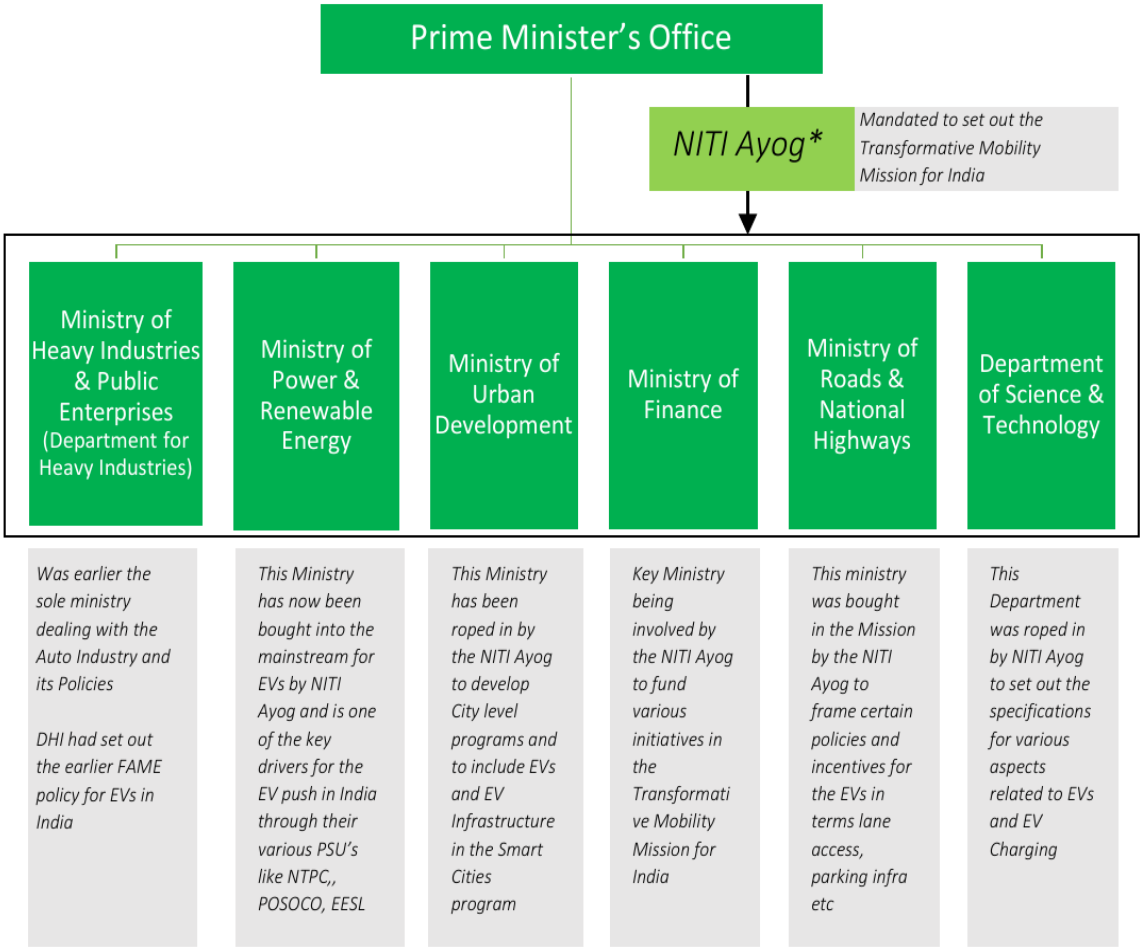


Fig 5.1 – EV- Policy structure in a nutshell

5.3 Key milestones in EV-policy

5.3.1 Alternate Fuel for Surface Transportation Program (2010 – 2012)

Back in 2010, the Ministry of New and Renewable Energy (MNRE) implemented a 20 per cent subsidy for EVs through this scheme, which ranged from Rs 5,000 for two-wheelers, Rs 60,000 for seven-seater three-wheelers, Rs1 lakh for four-seater passenger cars, to nearly Rs4 lakh for buses. The program had a total outlay of Rs 95 crore. Post its implementation, there was a big leap in sales of electric vehicles, particularly the e-bikes segment. However, the initial spurt in sales was soon followed by a slump as the scheme had limited scope and did not cover any major vehicle or component development activity by the industry.

5.3.2 National Electric Mobility Mission Plan 2020 (NEMMP)

In 2013, the Department of Heavy Industry introduced the National Electric Mobility Mission Plan 2020 (NEMMP) with an outlay of Rs 14,000 crore towards the creation of infrastructure and promoting the use of EVs in India. The mission envisaged Electric and Hybrid vehicle sales in India to reach 6-7 million units by 2020, spearheading India towards a global leadership position in EV manufacturing. The Faster Adoption and Manufacturing of Electric Vehicles in India (FAME) Scheme was launched under this mission.

5.3.3 FAME-I Scheme

On 1 April, 2015 the Department of Heavy Industry launched the FAME India scheme (Faster Adoption and Manufacturing of Electric Vehicles) with an outlay of Rs 795 crore. The programme was aimed at promoting hybrid as well as electric vehicles, along with technology industries that have been planning to enter it. The key areas of focus included demand creation through upfront subsidy, research and development of pilot projects, and charging infrastructure. Additionally, subsidies were also provided for two-wheelers, three-wheelers, passenger vehicles, light commercial vehicles, and busses.

5.3.4 FAME-II Scheme

Effective from 1 April 2019, the Department of Heavy Industry introduced the second phase of FAME (Faster Adoption and Manufacturing of Electric vehicles) with a budget of Rs 10,000 crore. The subsidy on EVs became applicable to commercial vehicles, public transport vehicles, and two-wheelers. The FAME-II scheme is applicable for a period of three years from 2019 to 2022. Under this scheme, only vehicles that are powered by lithium-ion batteries or a more advanced power source can avail the government benefits. As a part of EV charging infrastructure plans, around 2,700 charging stations were planned to be set up across different locations in tier-1 cities. The plan is to ensure the availability of at least one charging station in a grid of 3km x 3km.

Back then, charging station establishments were proposed on major highways connecting major city clusters. On such highways, charging stations were planned to be established on both sides of the road at an interval of 25km. Under the scheme, buses have to be priced under Rs 2 crore, plug-in hybrids under Rs 15 lakh, three-wheelers under Rs 5 lakh, and two-wheelers under Rs 1.5 lakh to be eligible for incentives. As per the notification, the FAME-II eligibility certificates which were issued by the testing agencies and approved models of electric vehicles were valid only up to March 31, 2021. Under the scheme, the approved models were required to submit re-validation certificates for availing of demand incentives under the FAME-II scheme. However, last month the Department of Heavy Industry extended the validity of FAME-II certification to help OEMs who are stuck with their unsold inventory due to the ongoing pandemic in the country.

Apart from working on a roadmap for EVs in the country, the central government has also undertaken other noteworthy initiatives, such as – Smart Cities Mission (launched in 2015), National Mission on Transformative Mobility and battery storage (approved in 2019), and Production-linked Incentive Scheme (launched in 2020).

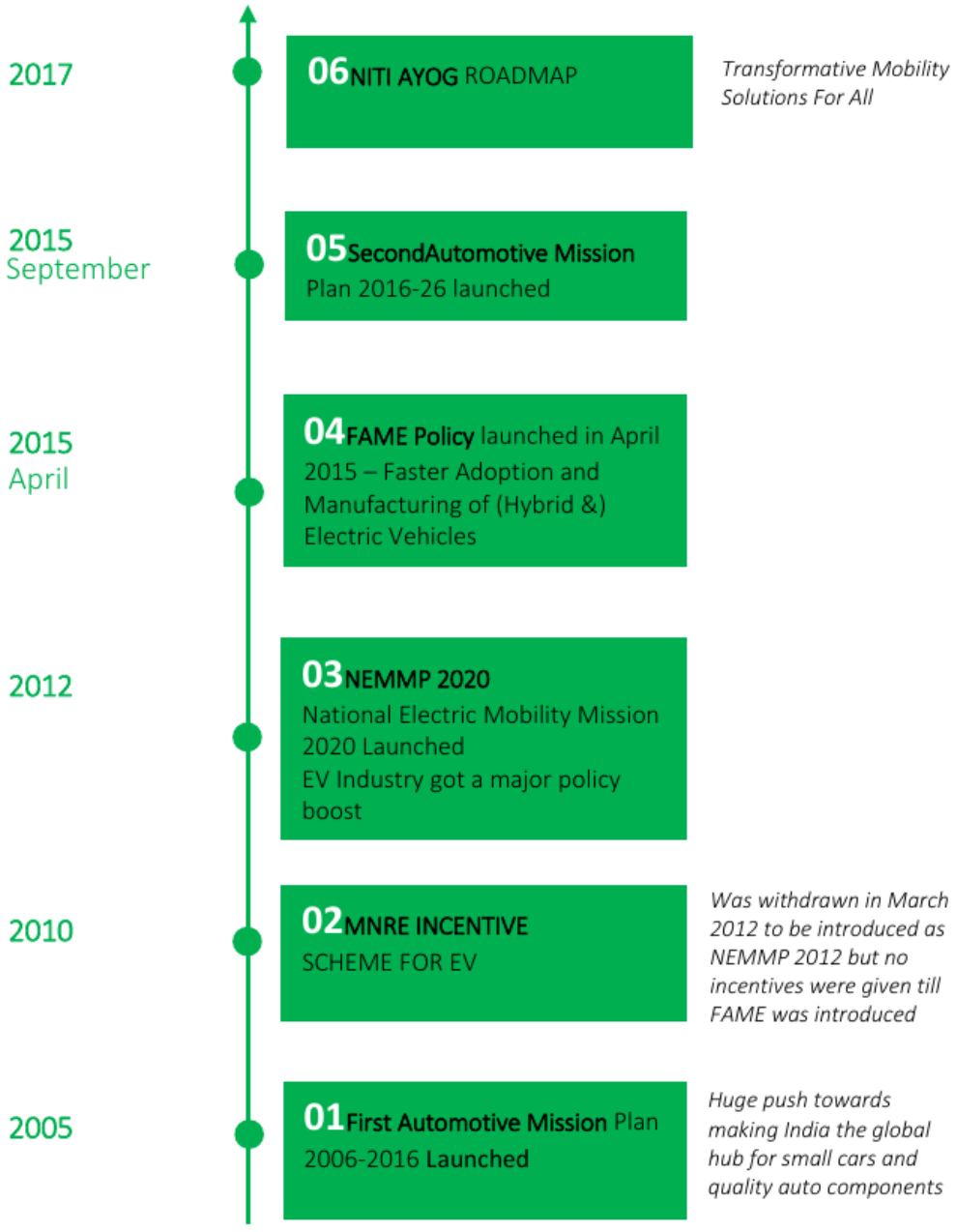


Fig 5.2 – National Electric Mobility Mission Plan 2020 (NEMMP)

5.4- National Electric Mobility Mission Plan 2020

Under this mission, the Government would use the following mechanisms/ policies to increase the usage of electric vehicles in India. National Electric Mobility Plan (NEMMP) 2020 targets to deploy 5 to 7 million electric vehicles in the country by 2020.

NEMMP also targets 400,000 passenger battery electric cars (BEVs) by 2020 avoiding 120 million barrels of oil and 4 million tons of CO2. Total investment required for this will be Rs. 20,000 – 23,000 Crores (approx. 3 billion USD).

1. Permissive legislations: Legislations to allow usage of electric vehicles in various areas, if not already allowed.
2. Operational regulations: Use of legislation framework and regulations aimed at setting safety regulations, emission regulations, vehicle performance standards, charging infrastructure standards, etc.
3. Fiscal policy measures: Trade related policies for shaping the market, imports and exports. Manufacturing policies aimed at encouraging investments Specific policies aimed at incentivizing manufacturing and early adoption of electric vehicles through demand creation initiatives. Schemes and pilot projects for facilitating infrastructure creation. Policy for facilitating research & development.

Apart from launching this plan and conducting few pilot projects, nothing much was done on ground in terms of implementation of this policy till 2015 when the new government launched the FAME program.

5.5 FAME plan

Faster Adoption and Manufacturing of Hybrid and Electric vehicles was launched in April 2015 to fast track the goals of NEMMP 2020 plan

In order to promote the sale of electric vehicles in the Indian market, the government launched FAME scheme (Faster Adoption and Manufacturing of Hybrid and Electric vehicles) in India, as a part of the National Electric Mobility Mission Plan 2020, under which, the government would provide certain incentives to lower the purchasing cost of electric vehicles.

The scheme has 4 focus areas i.e. Technology Development, Demand Creation, Pilot,Projects and Charging Infrastructure.

Overall, the government is expected to spend around Rs. 14,000 Crores for this scheme, which includes incentives to the customers for purchasing electric vehicles, incentives to the manufacturers for research and development besides developing the charging infrastructure.

During the financial Year 2015-16, an amount of Rs. 75 Crores was allocated for this scheme, which was almost fully utilised. In the last financial year (2016-17), Rs. 91 Crores(approx.) has been utilised out of the budget allocation of Rs. 122.90 Crores

Under phase 1 of this scheme, support was extended to buyers during the fiscal years 2015-16 (Rs. 260 Crores) and 2016-17 (Rs. Rs 535 Crores). Further incentives would be provided depending upon the success of phase 1 Incentives of about Rs. 33 to 66 Lakhs are planned for each electric bus which typically costs around Rs. 1-2 Crores (imported buses) and around Rs. 50-80 Lakhs (domestically manufactured) Under the JNNURM (Jawaharlal Nehru National Urban Renewal Mission), NEMMP (National Electric Mobility Mission Plan) and Smart city plans launched by the government, various state and local transport bodies are expected to purchase electric buses over the next 5 years.

In 2017, the Government of India through extensive ministerial discussions came out with a major policy document in terms of “Transformative Mobility For All”

The NEMMP 2020 was extensively handled by Department of Heavy Industries till 2016.

In 2017, a major inter-ministerial discussion on this took place which included the Prime Minister's Office, NitiAyog (Planning Body), Department of Heavy Industries, Power Ministry, Ministry of Surface Transport & Roads, Urban Development Ministry, Petroleum and the Finance Ministry. From this emerged, a need to look at transforming the mobility in the country and reduce the dependence on fossil fuels and reduce imports obligations. One of the key pillars of this transformative mobility is the emergence of EVs and the EV infrastructure that is likely to be needed. Post this discussion, the NitiAyog has come out with a report on the plans for the Government on Transformative Mobility Solutions for All.

Under the GST regime, EVs were kept at the 12% tax levels, while hybrids fell at the 43% levels (luxury products) - this has led to a lot of heartburn in the auto industry as major players have been focusing on hybrids. There are now representations to give more weightage to Hybrids as well and reduce GST on Hybrids.

5.6 The NITI Aayog plan-

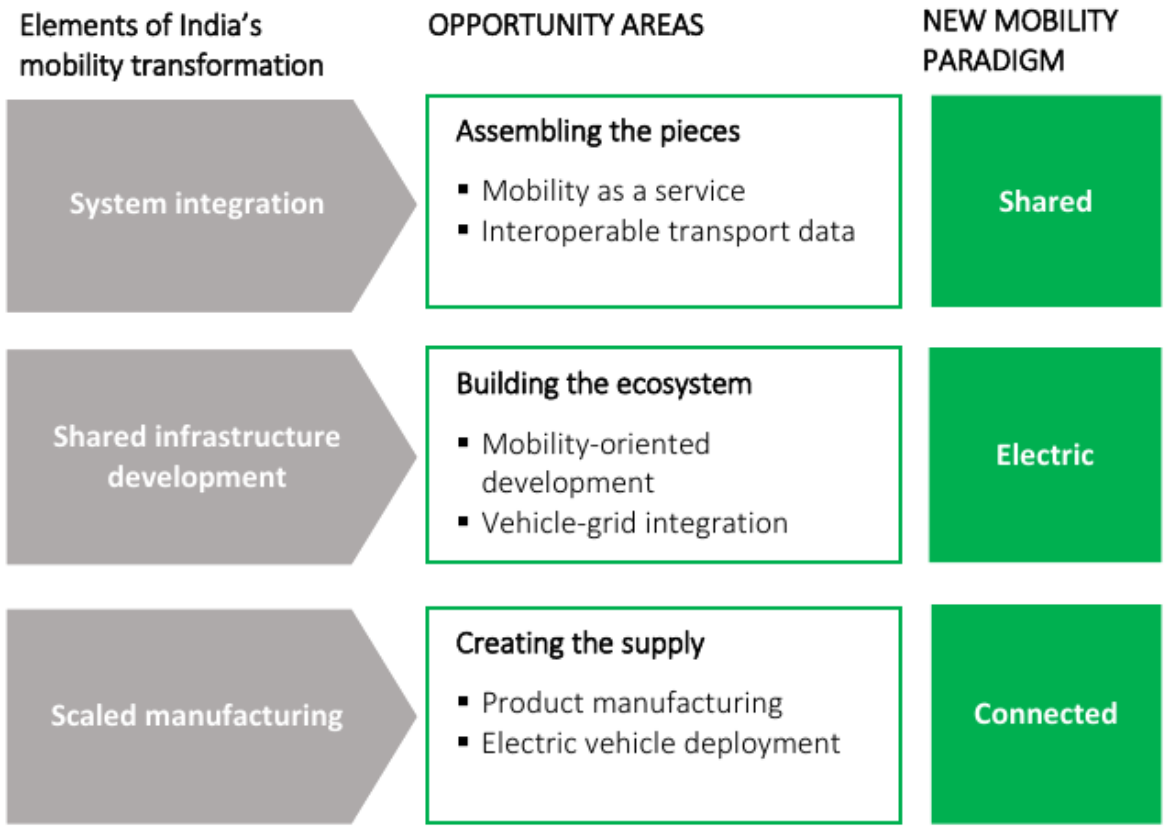


Fig 5.3 – EV- NITI AAYOG Plan

1. Systems integration: Enabling wide-scale adoption of mobility solutions through ubiquitous availability and sharing of interoperable transport data (ITD).

2. Scaled manufacturing: Facilitating market creation through policies and mechanisms that enable manufacturing of electric vehicles (EVs) and necessary components in successive segments based on their market readiness.

3. Shared infrastructure development: Better urban design, where a larger fraction of mobility demand is met by nonmotorized transit and public transit, and access to vehicle-charging infrastructure enables higher penetration of EVs.

The current Government in India is firmly disposed towards bringing in a low / reduced carbon footprint in India's mobility scenario by 2030 – and EVs seem to be pivotal to these plans.

Even though there are multiple voices within the Government stakeholders towards the route of implementing this Various Government bodies / Ministers are discussing the push towards EV, Alternate Fuels and a move towards a 'Shared Mobility' era.

As of now, there is no formal Policy announcement / notification on EVs but the NitiAyog is mandated to come out with an EV policy now and it will be implemented by multiple Ministries

5.7 Government subsidies -

Lack of awareness about running cost, battery life cycle and just over 2400 charging stations across India are a few things making prospective buyers think twice.

However, the situation appears to be improving with state governments unveiling a raft for incentives for EV makers as well as buyers. Today more than 13 states have notified electric vehicle policies.

It is important to note that the central government recently raised the financial incentive on electric two wheelers from Rs 10000 to Rs 15000/kWh, subject to a limit of 40 percent of the vehicle cost. This incentive is available to EV buyers across the country and some states like Maharashtra, Gujarat and Delhi are offering subsidies in addition to the Rs 15000/kWh subsidy available under the union government's Faster Adoption and Manufacturing of Electric Vehicles scheme. 3 states which have notified EV policies, Delhi, Maharashtra and Gujarat are providing strong purchase incentives. What is important to note is that with the states topping up FAME II incentives of Government of India, upfront cost of EVs in these states in coming down by 50 to 65% and bringing them at par with internal combustion engine vehicles", said Akshima T Ghate, Principal, RMI India

Let's take a close look at some state government electric vehicle policies and how they impact the consumer and seller.

5.7.1 Maharashtra -

Maharashtra's electric vehicle policy is the most recent and extremely friendly for both consumers and manufacturers. Buying an EV could be cheaper in Maharashtra than any other state this year, compared to other states. Why? Because the state is providing an incentive of Rs 5000/kWh for all vehicle categories, along with an early bird discount of Rs 5000/kWh. The maximum subsidy on electric two wheelers is Rs 10000, Rs 30000

on electric three wheelers, Rs 150000 on electric four wheelers and Rs 20 lakh on electric buses.

So if you are buying an electric two wheeler which has a 3 kWh battery pack, then the maximum subsidy would be Rs 10000. But, if you buy it before December 31 this year then you get an early bird discount of Rs 5000/kWh. So along with a regular subsidy of Rs 10000 you could get an early bird discount of Rs 15000. That's not all: the state is also offering a subsidy of up to Rs 7000 on the purchase of your new electric two-wheeler if you scrap your old petrol two wheeler.

On top of the above financial incentives, Maharashtra is the first state to provide incentives to automobile companies to give a 5-year battery warranty to customers.

5.7.2-Gujrat-

In terms of subsidies, Gujarat is offering the highest subsidy of Rs 10000/kWh. The maximum subsidy on electric two wheelers is Rs 20000, Rs 50000 for electric three wheelers and Rs 1.5 lakh on electric cars. The state has also announced a waiver of registration charges which is barely a few hundred rupees but unlike the Maharashtra government it has not waived off the road tax which could be 6 percent of the vehicle cost.

On the charging front, while Maharashtra is offering a maximum subsidy of Rs 5 lakh, the Gujarat government is offering a maximum subsidy of Rs 10 lakh. Maharashtra is looking to setup over 2400 charging stations in just 7 cities in the coming years, Gujarat is looking at about 528 charging stations.

5.7.3 Delhi

Delhi government is in the process of making minor tweaks to its EV policy which was launched in 2020. One of the additions could include guidelines for an electric bike taxi scheme similar to the one launched by the Karnataka government.

Launched in August 2020 with a three-year roadmap, the Delhi government's EV policy is one of the most comprehensive in the country. The policy offers Rs 5000/kWh subsidy on electric two wheeler, subject to a maximum limit of Rs 30000. Currently all electric scooters in India have a battery capacity of 2-3 kWh, which means the maximum subsidy you could get would be Rs 15000. The state also offers a subsidy of up to Rs 30000 on electric three wheelers, Rs 1.5 lakh on electric cars.

Just like Maharashtra, the Delhi government also provides you scrapping incentives in the range of Rs 5000-7000, waiver of road tax and registration charges on electric vehicles.

"Most of the states that are aiming for charging infrastructure deployment are targeting at least 1 public charging station in a grid of 3X3 km in cities. If successfully

achieved, this should translate into adequate charging stations in populated cities of different states. Maharashtra and Delhi in particular are giving a lot of emphasis to slow chargers and providing significant capex subsidy on slow chargers. The expectation would be that these states would be able to have a high density of slow chargers in the next 2-3 years", said Akshima T Ghate, Principal, RMI India.

5.7.4 Karnataka

If you buy an EV in Karnataka, you would be eligible for a subsidy under the union government's FAME scheme, which could be 15000/kWh but the state does not offer the kind of subsidies offered by Gujarat, Maharashtra or Delhi.

Karnataka government has recently launched the electric bike taxi scheme, allowing aggregators like Rapido, Ola, Uber to register as e-bike taxi operators. These taxis would be allowed to ply for ten kilometers and could give a boost to electric vehicles in the last mile mobility segment. Karnataka was the first state to launch an electric vehicle policy back in 2017. The state recently tweaked its policy to give a 15% capital subsidy to investors in the electric vehicle sector. It has also decided to replace 50% of state government vehicles to electric in the next 2-3 years.

5.7.5 Telangana-

Telangana had rolled out its electric vehicle policy in 2020. The state offers 100% exemption from road tax and registration on all categories of electric vehicles but currently does not offer the kind of subsidies offered by Maharashtra, Delhi and Gujarat.

However, the state does offer some strong supply side incentives such as capital investment subsidy of up to Rs 30 crore, SGST reimbursement up to 5 crore per year, power tariff discount up to 5 crore and interest subvention of up to 5 crore. The state also offers tailor made benefits to mega and strategic projects on a case by case basis. Recently, US based EV manufacturer Triton EV signed a MoU with the government of Telangana to invest over 2100 crore in an electric vehicle manufacturing plant.

Telangana government officials are currently studying the restructured FAME scheme and other state government policies and may announce some changes to their policy launched in 2020.

"Beyond the fiscal incentives that are bringing down the upfront cost and total cost of ownership of EVs, most of the states are making significant regulatory reforms and tax exemptions for EVs, such as open permit system for e-autorickshaws, waiver of road tax and registration charges, provision for reserved parking for EVs, all of which would go a long way in making EVs competitive with their ICE counterparts", said Akshima T Ghate, Principal, RMI India

Currently, Delhi, Maharashtra, Karnataka, Kerala, Bihar, Uttarakhand, Tamil Nadu, Andhra Pradesh, Telangana and Punjab offer 100 percent road tax exemption for newly-purchased electric vehicles.

5.8- Foreign investment

"Tesla's plans to launch the Model 3 in India and Ola Electric's debut has created a lot of excitement. While Ola is set to launch its electric scooter in less than 20 days and hopes to sell over a million vehicles this year itself, Tesla will soon begin India sales and is exploring the possibility of manufacturing Tesla cars in India in future. At least six states are in talks with Tesla and have offered them land and other concessions. Clearly, competition among states may not just bring down prices for the EV buyer but may also give some very lucrative deals to electric vehicle manufacturers."

6. Consumer perspective

6.1 Introduction-

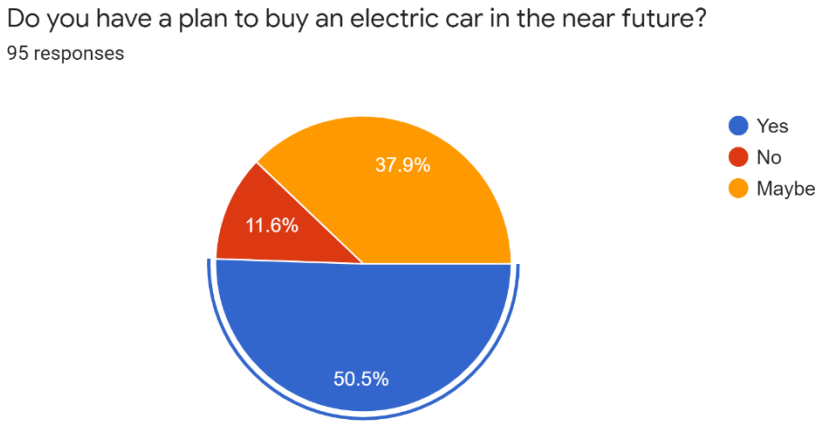
Electric Vehicles (EVs) have the potential to contribute to reduction of air pollution, carbon emissions, and oil dependency in India. No wonder then, that in recent years policy makers and environmentally conscious citizens have been increasingly looking into wider EV adoption. The government's policies and targets for EV sales have also encouraged their production and adoption in India.

According to the Society of Manufacturers of Electric Vehicles (SMEV), 3,400 electric cars and 1.52 lakh electric two-wheelers were sold in India in financial year (FY) 19-20. The total sales grew by 20% compared to the previous financial year. However, current EV penetration in India is low despite the government's measures.

In order to understand consumer perception of EVs in India, we conducted an online survey considering various factors that affect vehicle purchase decisions. According to the survey findings, there exists a significant difference in the expectations of those who own an EV and those who do not. EV owners do not assign much importance to availability of a used-car market and the vehicle's resale value, which were among the issues the survey sought to find responses on. The difference in consumer perception of the two groups is directly related to the knowledge and experience of EVs. The survey findings also reveal that household income is statistically insignificant and does not affect EV purchase decisions.

6.2 Survey outcomes-

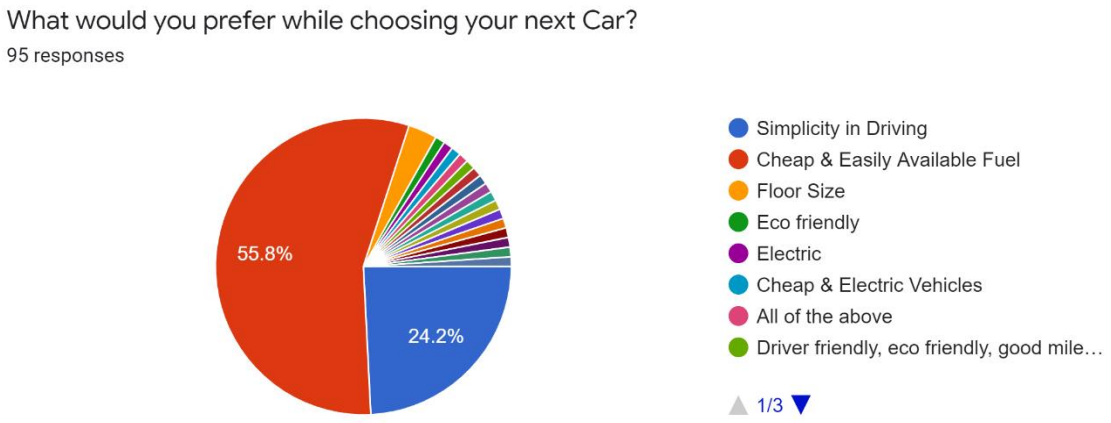
In the survey when it was asked **'Do People have a plan to buy an electric car in the near future?'**



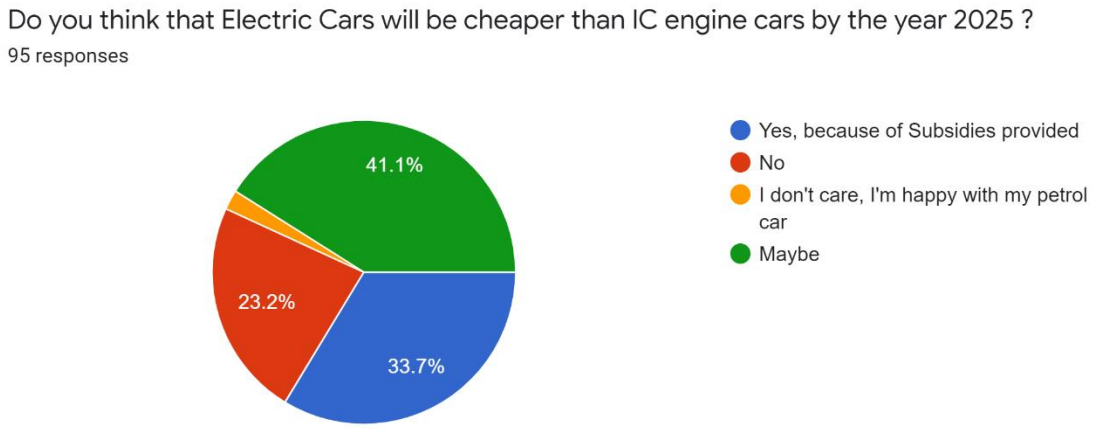
about 51% people showed positive response and 40% respondents were still unsure about the decision. This results basically shows the lack of understanding of the e vehicles and business model, also all the respondents seem positive about the EVs in general.

Consumer expectations from EVs were found to vary based on certain factors, one of which was age group of the respondent. In the survey, 41% and 71% of respondents under the age of 25 found the existence of an EV used-car market and the vehicle resale value, respectively, important. These consumers are more likely to procure a vehicle from the used-car market and hence the upfront cost of the first-hand EV is not a major concern for them. This is due to the income level and the desire to replace existing vehicles periodically.

When talk about Indians in general sense, we are very much concerned about the certainty of the situation and we hesitate to adopt changes easily. E.g., when in the survey it was asked about **"What would you prefer while choosing your next Car?"**

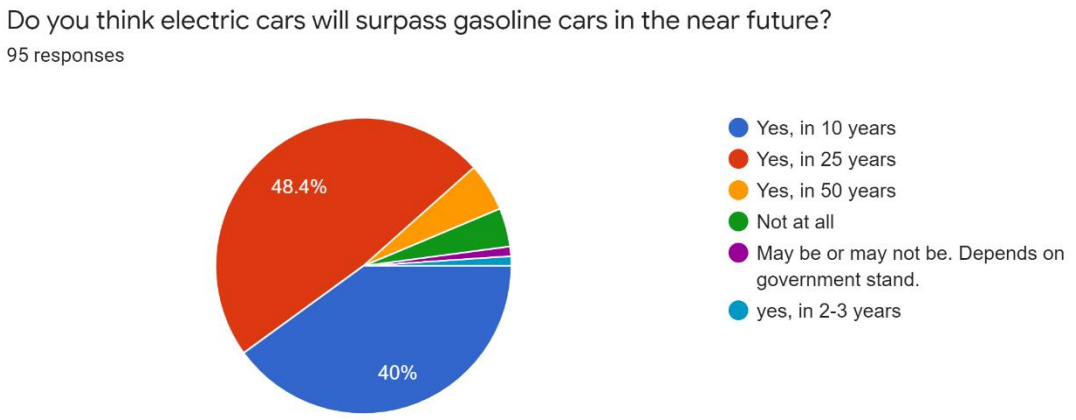


About 56% respondents choose cheap and easy availability of fuel followed by 24% choosing comfort and simplicity in driving. Results basically marks a trait of Indian thinking and manufacturers has to consider these factors while thinking about India as EV market.

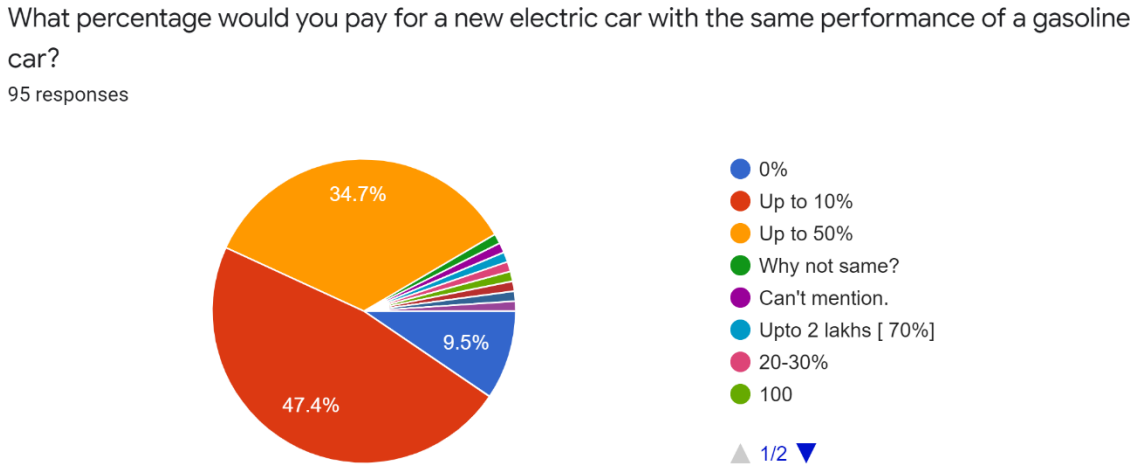


The survey also revealed that on an average, all respondents wish to make a short distance trip (less than 10 km) at least five days a week but medium (up to 100 km) and long distance (up to 160 km) trips are rare. The ability of EVs to cover a limited distance in comparison to Internal Combustion Engine (ICE) vehicles has an impact on consumers' perception and highlights the important issue of range anxiety. However, the EVs currently available in the market are capable of completing short and medium distance trips conveniently. Over 70% of the respondents are aware of this, and 75% are aware of how much EVs cost.

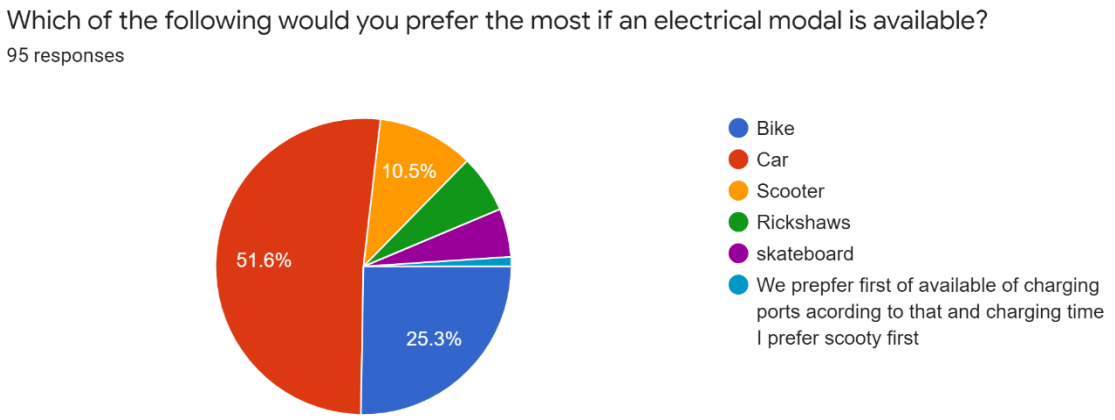
When it was asked to compare the existing gasoline and EV, over 96% respondents believes that electric cars will surpass gasoline cars in the near future but the tenure is what differs here, over 40% respondents thinks the surpass will happen in the next 10 years while 49% thinks it will take more 25 years to this happen.



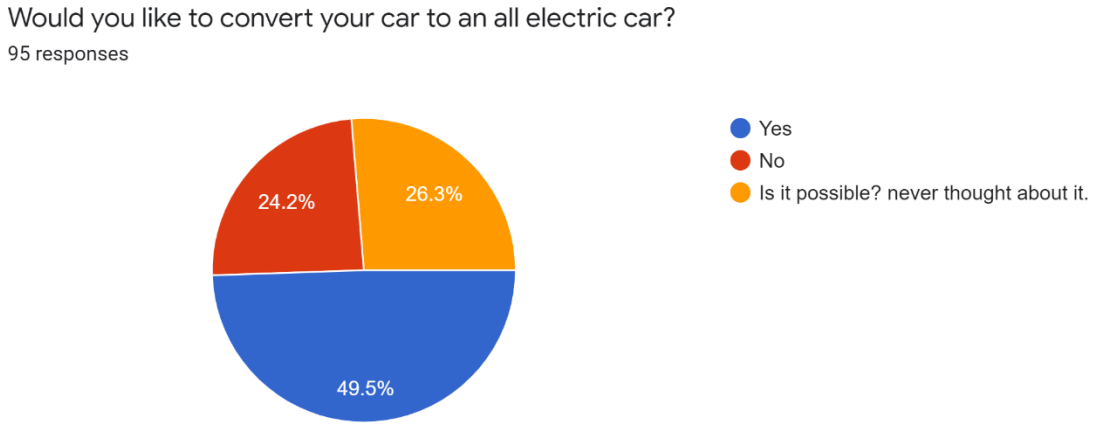
In the similar manner, when they had given a choice to replace their existing vehicle with EV, and what extra amount are they ready to pay? Over 47% respondents agreed to over 10% of the amount and accept the EV.



While choosing an electrical vehicle, there are also clash of opinions seen, over 52% respondents wish to buy there EV as Car but remaining 50% has some different choice 25% out of which prefers a Bike.



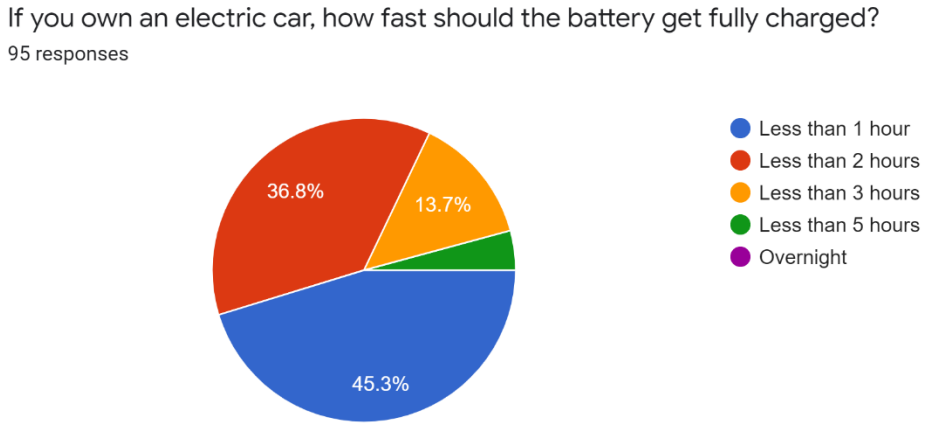
In the previous chapter of this report, we had discussed about the hybrid vehicles, so when respondents were asked, **'Would you like to convert your car to an all-electric car?'** we got the mix set of responses as follows.



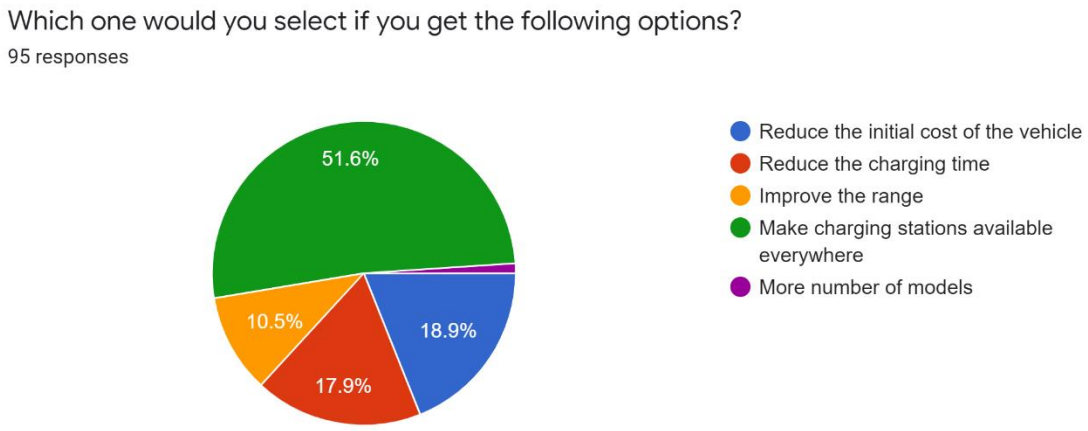
6.3 Expectations with the future and electric vehicles.

Till now in the survey, it is evident to conclude that generation-z is interested and has a positive outlook towards EV, when it was asked about choosing EV 87% respondents are ready to opt for EV instead of settling for fossil fuel vehicle and polluting the environment

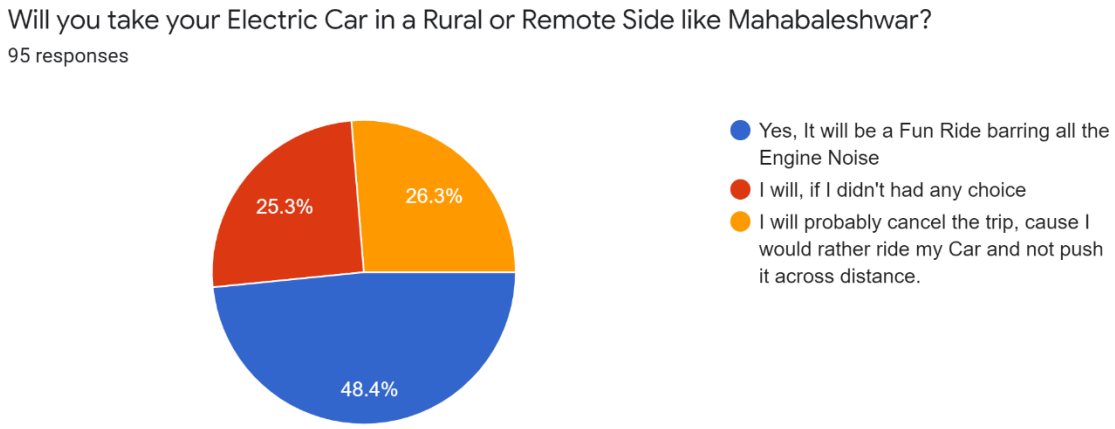
'Practical thinking is right way of living, but there is nothing bad in having expectations' to back this quote about 45% and 37% respondents wished their EVs to get full charged in 1 and 2 hours respectively.

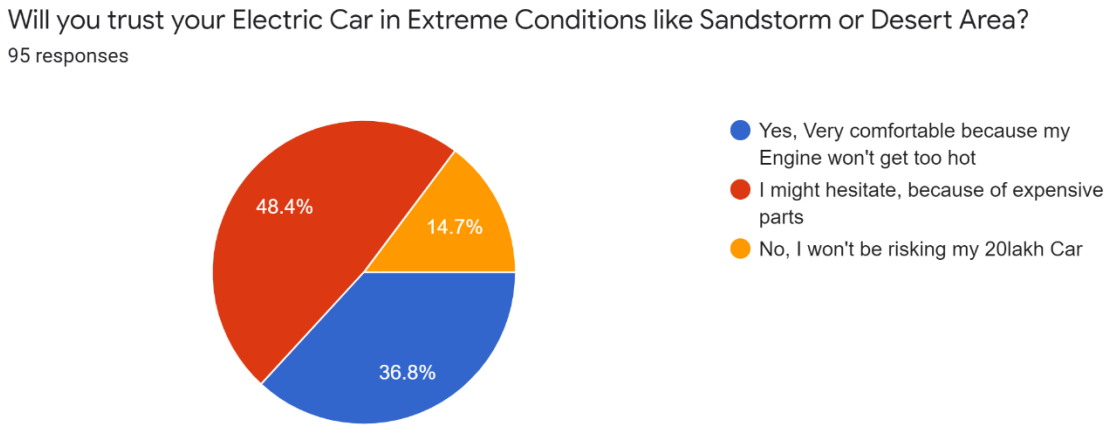


Similarly, respondents give more preference to the availability of charging stations and reduction in the initial cost of vehicle instead of having a greater number of models and choices to buy an EV.



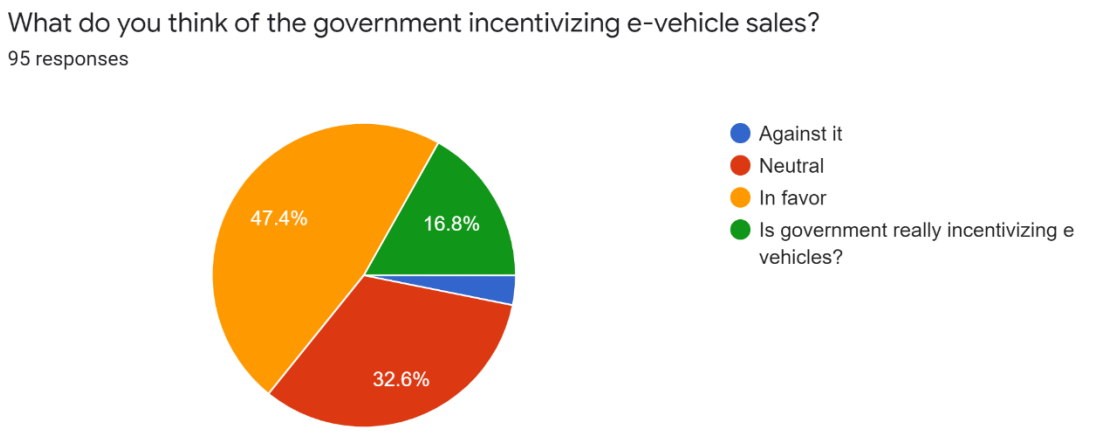
To make the survey more interactive, when it was asked about some real-life scenarios such as,





People seem positive in enjoying their noise less vehicle and taking it for a long ride, but at the same time hesitating to use it in the extreme conditions to save it from damage, basically the over possessive materialistic trait of Indian families in general.

For the success of EV in India there is going to be the major role of government for creating awareness and also take suitable decisions to promote the e vehicles in general. About 48% respondents were in favor of government incentivizing the e-vehicles which shows is the positive results for success rate of EVs.



6.4 Some of the comments by survey respondents.

Q-What according to you is major flaw of E-vehicles?

Responses

"The cost and the lack of charging station across cities and highways will make more people reluctant to buy it"

"The biggest problem with EVs is range. While a plug-in hybrid can count on gasoline as a backup, EVs can't. An EV like the Tesla Model S can travel nearly 400 miles on a single charge, but not all EVs can make it quite that far. EVs like the Model S tend to be pretty expensive too"

"Non-existence in a country like ours. 🙃"

"the major flow is charging time it requires so much charging time and charging station need to be installed more so we don't need to wait for other people to charge vehicle"

"They tend to be on the Expensive and heavier side. Another flaw which is not in the vehicle itself, is the charging stations"

"EVs in India are expensive thanks to 100% import tax, and EVs produced here cost ₹20 lakh or more and have less range e.g., 100-150km. Also, no infrastructure of charging stations. People will always buy an IC engine car until EVs reduce the price and there are enough charging stations"

"Maintenance cost is low as well as it is easy to fit in everyone's budget"

"In the E vehicle the major problem are the low torque are present due to this type of vehicle are not use for transportation & other related to heavy works..."

"Lack of coordination between government and EV manufacturers"

"PowerStation's, Charging Stations"

"Pollution problem, It's maintenance cost. It can't be used for longer rides. Battery is bit expensive."

Q- Comment on the E-vehicle working infrastructure.

"The charging stations were installed by an American-based company EVGo and enable EV users to recharge rapidly when away from home. Most electric vehicle drivers will charge at home and work."

"Needs a lot of development and attention"

"Charging stations instead of petrol station"

"charging station should available everywhere and the major thing in India is cost if the cost of e vehicle is low then people can defidetly buy it so the cost of e vehicle should minimum as possible so maximum no of Indian people can buy e vehicle. e vehicle should availably form low cost to high cost, so every people according to their budget can buy e vehicle. and also the last point is e vehicle should have low cost than petrol or diesel vehicle"

"It would be quit a big challenge to setup the initial infrastructure required, but it the requirement of the time."

"The distance between the two charging stations is not more than 100 kms, The cost of E - vehicles must be lower than 5 lakhs."

"Availability of charging stations are at 50 km distance apart from each other. The time required to fully charged is max 1 hour."

"It will take more time for fully implementation as there are still many problems like availability of charging stations, time of charging and many more. It is possible only the charging time gets reduced."

"There should be charging station in all areas, and their cost should be cheap."

Q-Tell us about anyone EV brand you know? And if you are Kind, Please Suggest "How Good is the Indian Market for Electric Vehicles?"

"Tesla"

"tata"

"Currently the Indian market is ready and yet not ready for electric vehicles. As petrol and diesel prices are increasing ... the upper middle class (the upper class as well but their reasons will be different) would want to buy cars that are cheaper in the long run. But at the same time, the lack of information among the common mass and infrastructure on such vehicles including the initial cost will make them reluctant to buy it"

"Tata Nexon EV , MG ZS EV , Tata Tigor EV , Hyundai Kona Electric"

"Tesla, Bajaj. People in India are not that much aware of E vehicles. There should be some awareness."

"Tesla Tata Hyundai Mahindra India is a good market for electric vehicles if the cost cuts down. Indians prefer cheap and pocket friendly products over environmental safety."

"TATA, Ather, OLA..... due to limited reservoir nd regular prize hikes in petroleum, I have a soft corner of EVs. Even most of people I know are willing to shift to EVs. Their only hesitation is Changing points and low Range like you mentioned in earlier 'Mahabaleshwar' wala question. EVs might be ruling the market by may be 2035. Let's see the Indian's response to OLA EV Scooter, that's going to launch on 15th August 🎆,That's it, ."

"Tesla is the world wide, But india TATA has launched many electric modules. But looking for only electric cars is not economical for rational perspective in Indian market. Rather, Electrical bikes, Scooters and Rickshaws should be first pioneered for E- Vehicles revolution. Also firstly all public or government vehicles should be converted to Electric"

"Tata Nexon EV With a 3 Phase Permanent Magnet Synchronous Motor, the Nexon EV is one of the most impressive EV SUVs out there. Its Li-ion Polymer battery is equipped with liquid cooling to ensure that temperatures remain relatively low even after a long drive and it really helpful for Indian EV market."

"Bajaj Chetak. Indian Market Is just started investing EVs production we should wait 5-6 years to such a good impact for that."

"Tesla. Indian market is not ready yet to buy EV. Because Reliance industries having market share around 50% So it's difficult to compete with them. In next 25-30 years, it would gain huge demand."

6.5 Conclusion -

With the depletion of fossil fuels and constant hike in fuel prices, there is a need for energy transition in vehicles in India. Govt has taken initiative to fight pollution levels by promoting EVs and giving subsidies on purchase. To boost its production, Govt has eased the FDI norms. Various emerging brands are launching EVs in India. The Government and manufacturers should join their hands to build the infrastructure and create positive environment for EVs. The respondents are aware of global climate conditions and are ready to change their preference from conventional to eco-friendly vehicles. Cost is an important factor while considering the purchase of EV. Respondents are willing to consider EVs as their future purchase option, if proper infrastructure is available. Initial cost of purchase, a smaller number of charging stations and the time required to recharge the battery is creating limitation in boosting consumer confidence.

7.Industry perspective

7.1 Electric Vehicle Industry in India

The global automotive industry is undergoing a paradigm shift at present in trying to switch to alternative/less energy intensive options. India, too, is investing in this electric mobility shift

The burden of oil imports, rising pollution, and as well as international commitments to combat global climate change are among key factors motivating India's recent policies to speed up the transition to e-mobility.

7.1.1 Growth targets:

The Indian automotive industry is the fifth largest in the world and is slated to be the third largest by 2030. Catering to a vast domestic market, reliance on the conventional modes of fuel intensive mobility will not be sustainable. In an effort to address this, federal policymakers are developing a mobility option that is "Shared, Connected, and Electric" and have projected an ambitious target of achieving 100 percent electrification by 2030..

By making the shift towards electric vehicles (EVs), India stands to benefit on many fronts: it has a relative abundance of renewable energy resources and availability of skilled manpower in the technology and manufacturing sectors.

According to an independent study by CEEW Centre for Energy Finance (CEEW-CEF), the EV market in India will be a US$206 billion opportunity by 2030 if India maintains steady progress to meet its ambitious 2030 target. This would require a cumulative investment of over US$180 billion in vehicle production and charging infrastructure.

7.1.2 Existing EV ecosystem in India and investment outlook

Regardless of the country's ambitious targets, India's EV space is at a nascent stage. However, looking at it differently – India offers the world's largest untapped market, especially in the two-wheeler segment. 100 percent foreign direct investment is allowed in this sector under the automatic route.

The federal government is also prioritizing the shift towards clean mobility, and recent moves to amend the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles in India (FAME) II scheme to make electric two-wheelers more affordable, is a case in point.

The government has also rolled out a **Production-Linked Incentive Scheme (PLI) for ACC Battery Storage Manufacturing**, which will incentivize the domestic production of such batteries and reduce the dependence on imports. This will support the EV industry with the requisite infrastructure and will significantly cause a reduction in cost of EVs. Many leading battery producers like Amara Raja Batteries, are picking cue from theses incentives to orient new investments into green technologies, including in lithium-ion batteries.

Responding to the opportunity that India's EV industry presents, leading players like OLA Electric Mobility Pvt, Ather Energy, and Mahindra Electrics are rapidly growing their market presence. Moreover, certain states like Karnataka and Tamil Nadu are rolling out innovative and timely investor-friendly policies besides building necessary infrastructure.

Recently, the American electric vehicle and clean energy company Tesla Inc. marked its entry into India by incorporating its subsidiary, Tesla India Motors and Energy Pvt Ltd, in Bengaluru.

In February 2021, Ather Energy, India's first intelligence EV manufacturer moved its US$86.5 million factory from Bengaluru (Karnataka) to Hosur (Tamil Nadu). Ather Energy's factory is said to have an annual production capacity of 0.11 million two-wheelers.

In March 2021, Ola Electric, the subsidiary of the unicorn Indian ride-hailing start-up, also announced that it would be setting up the world's largest electric scooter plant in Hosur (which is a two and a half-hour drive from Bengaluru) over the next 12 weeks, at a cost of US$330 million, and aiming to produce 2 million units a year. By 2022, Ola Electric wants to scale up production to pump out 10 million vehicles annually or 15 percent of the world's e-scooters.

There have also been positive developments in the expansion of charging infrastructure across the country – states like Andhra Pradesh, Uttar Pradesh, Bihar, and Telangana are setting impressive targets for the deployment of public charging infrastructure to increase uptake of electric vehicles in the country.

Recently, Sterling and Wilson Pvt Ltd (SWPL), India's leading engineering, procurement, and construction company announced its entry into the electric mobility segment in India. It has signed a 50-50 joint venture with Enel X, to be incorporated on April 1, 2021, to launch and create innovative charging infrastructure in India.

The key reasons why these states are doing better than others are local fiscal sops, better logistics, an investor-friendly government policy, business facilitation through easier access to authorities, supply chain connectivity, and the availability of suitable land.

Karnataka was the first state to introduce a comprehensive EV policy and has emerged as a hotspot for EV businesses in India, both in EV and EV ancillary manufacturing as well as R&D segments. Tamil Nadu is also leaping forward at a commendable pace, owing to its supply ecosystem, larger land parcel, proximity to ports, and proactive investor support through administrative portals like Guidance Tamil Nadu.

Nevertheless, while growth in the EV industry is on an upward tick, it has much ground to cover to be able to realize the government's ambitious 2030 target. The COVID-19 pandemic not only slowed the industry's progress, but also dampened overall market demand.

Still, market sentiment has retained positivity in some segments. In FY 2020, EV sales for two-wheelers in India increased by 21 percent. For EV buses, the sales for the same period increased by 50 percent. In contrast, the market for electric cars remained grim, registering a five percent decline. As for total EV sales, after suffering an initial setback in 2020, sales appear to be slowly picking up. In January 2021, 15,910 units of EVs were sold in India, and out of these, the maximum units were sold in Uttar Pradesh, followed by Bihar and Delhi.

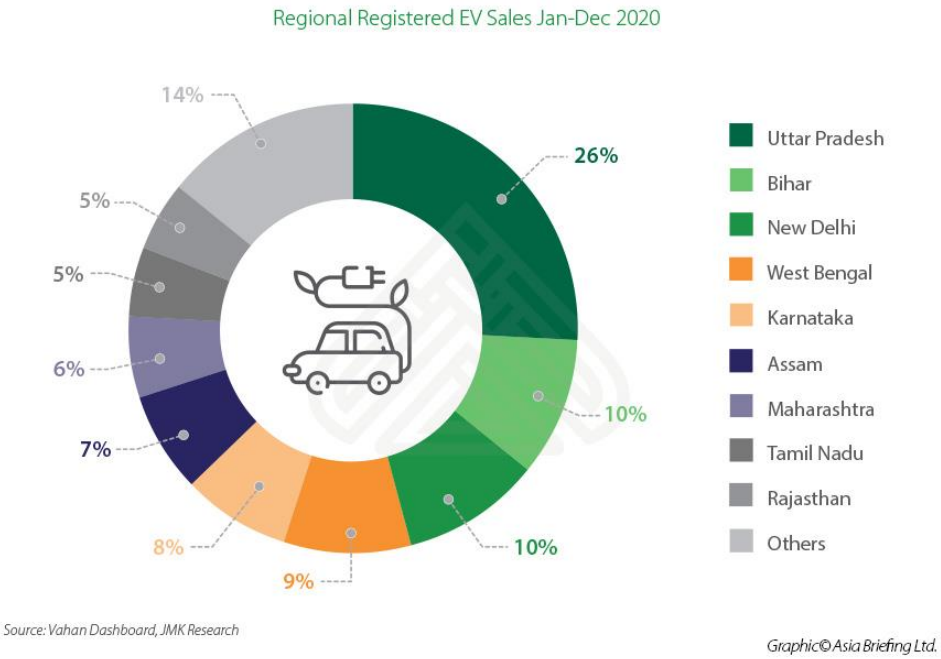


Fig 7.1 Registered EV sales

7.2 Challenges faced by EV industry

7.2.1 Insufficient charging infrastructure:

In 2019, there were only 650 charging stations in India as against over 0.3 million in China. Lack of sufficient charging infrastructure is one of the primary reasons why customers often refrain from purchasing EVs.

7.2.2 High costs:

Along with the range anxiety (kms/charge), another major concern among the potential customers is the current high price of EVs. As compared to lower-end (internal combustion engine) ICE cars, electric cars in the same segment tend to be more expensive. This is mainly because of the higher cost of technology used in the EVs, which constitutes a substantial portion of the cost, not leaving much scope for other features usually available in premium cars. It is expected that in future, with increased R&D and market competitiveness, the price factor will be rationalized to suit the price sensitivity, which in India is a primary factor influencing purchase, especially in the lower-end car segment.

With the recent announcement of subsidies, the price rationalization of EVs in the two-wheeler segment is on cards. Since the government's fast-changing priorities

are now biased towards sustainable, clean electric mobility, industry watchers expect a similar push towards easing adoption of other electric vehicles like cars and buses soon.

7.2.3 Limited options:

Since it is still a budding industry in India, customers have a very limited range of products to choose from. Increased investment in the sector will make it more competitive in due time and this will help create further demand.

7.2.4 Lower mileage:

Since the industry is young, there is immense scope for R&D. As of today, EVs in India are not cost competitive to an average customer as internal combustion engine (ICE) vehicles prove to be more cost effective.

7.2.5 Higher dependency on imports:

Reliance on imports of battery as well as other components is also one of the factors adding to the cost of EVs in India.

7.2.6 Grid challenges:

Another concern is regarding the price of charging EVs at private charging stations once EVs become mainstream. According to Brookings India, projections for 2030 show that even with a fair penetration of EVs, the increase in demand for electricity is likely to be about 100 TWh (tera watt-hours) or about four percent of the total power generation capacity. So, increasing methods of power generation are necessary to meet that growth in demand.

7.3 Tata Motors to look at fund raising for EV business, charts 25% sales from battery-powered cars

Tata Motors is looking to raise capital for its electric vehicle (EV) business to fuel its ambitious target of generating one-fourth of its sales from EVs in the medium to long term, N Chandrasekaran, Chairman of Tata Motors said at the 76th annual general meeting.

The Mumbai-based company will launch one or two electric vehicles every year to have a portfolio of 10 such vehicles before 2025. Chandrasekaran did not elaborate the scale of investments Tata Motors is planning to do in the EV business unit but mentioned that the company has lined up a capital expenditure of Rs 3,000-Rs 3,500 crore for FY22.

"We have a very ambitious goal for electric vehicles. From the current 2 percent we have planned to have at least 25 percent of our sales coming from EVs in the medium

to long term. We will be launching at least 10 models before 2025. Towards this we will also do a capital raise for EV segment alone at the appropriate time," Chandrasekaran said.

Tata Motors has a lion's share of the electric passenger vehicle market of India. Powered by the Nexon EV, Tata Motors controls 77 percent of the domestic EV market. Since its launch in early 2020, the Nexon EV has seen sales of more than 4000 units of the Nexon EV.

Tata Motors has a strong orderbook for the Nexon EV extending to 14-16 weeks, the company had informed recently. During Q1FY22 the Nexon EV saw sales of 1715 units, the highest in a quarter since launch. Demand for the electric version of the Tata Nexon is now on par with the diesel variant of the SUV in markets such as Maharashtra and Gujarat where the electric model is available.

Tata Motors will also look at launching more affordable EVs in the future compared to the Nexon EV whose prices start at Rs 14 lakh. This is in addition to plans to launching EVs for the last mile application like an electric version of the Tata Ace or similar vehicle. These mini trucks are targeted at intra-city commercial purposes.

"We will be launching the Tigor EV with a higher range in FY22 and we will also be looking at more affordable EVs in the future. We don't have definitive dates to announce about that today," Chandrasekaran added.

Tata Motors is also working with group company Tata Power to set up charging stations across the country. Chandrasekaran added that Tata Motors is expanding its charging infrastructure to at least 25 cities and goal is to have at least 10,000 charging stations in the coming years.

7.4 Hero MotoCorp's EV game plan

Hero MotoCorp is all set to launch its own electric scooter in FY22 and an electric three-wheeler may also not be too far away, MD and Chairman Pawan Munjal

"Hero's first e-scooter has been fully developed by Hero's R&D teams in Jaipur and Munich. First Hero MotoCorp product will catch the fancy of a large section of the population," he said in a detailed conversation with CNBC-TV18.

Munjal said that Hero MotoCorp would not only launch electric vehicles, but a complete ecosystem comprising of Hero MotoCorp's own charging stations, Ather Energy's charging grid and Gogoro's battery swapping stations.

"Hero MotoCorp is committing 50 percent of its investments towards electric vehicles and going forward there will be more partnerships and collaborations on electric vehicle solutions," said Munjal.

On August 9, 2021, Hero MotoCorp celebrated its tenth anniversary. Exactly 10 years ago, on this day, brand Hero MotoCorp was formally launched after the Hero Group parted ways with its 28-year-old Japanese partner, Honda Motor Company. Today, Hero MotoCorp holds a 37 percent market share in India and is getting ready for the future -- a future that will depend on electric vehicles, premium motorcycles and exports.

Unlike its peers such as TVS and Bajaj, Hero MotoCorp has not launched its own electric vehicle but has been actively evaluating the market through electric two-wheeler manufacturer Ather Energy in which it has a 38 percent stake. Recently, Hero entered a partnership with Taiwan's Gogoro on battery swapping and electric vehicles. With these partnerships, Hero MotoCorp is now getting ready to unleash its EV strategy.

Munjal explained that Harley Davidson was a key part of Hero's premiumisation journey and the company would like to achieve at least 15 percent sales through exports by 2025.

7.4.1 Here are the top five takeaways from the Pawan Munjal interview:

1. **Hero's first EV**

Hero's first electric vehicle will be an electric scooter, to be launched in the next six months. Pawan Munjal has indicated that this will be a mass market electric vehicle, fully developed by Hero MotoCorp. It will have a fixed battery as opposed to a swappable one.

2. **Charging infra**

Before the launch of the electric vehicle, Hero MotoCorp will put in place its own charging stations in select cities. The company would also be setting up battery swapping stations in collaborations with Gogoro. Eventually as the EV market grows, Hero MotoCorp plans to leverage charging networks of Ather and Gogoro, along with its own.

"Hero will be open to offering charging infrastructure to multiple players in future. Once volumes grow it makes imminent sense for many of us to pool investments and give comfort to consumers," said Munjal.

3. **Future vs products**

Pawan Munjal said that Hero MotoCorp has a range of EV products in the pipeline. The company's startup Quark Motors has developed a modular electric three-wheeler which will be launched soon, though a date has not been announced. The company will also launch Gogoro's electric vehicles in India but not in this fiscal. Reiterating that Hero's 200 millionth vehicle may not be a two-wheeler, Munjal indicated that nothing is off the table for the future. Going forward, the company will be committing 50 percent of its investments towards electric vehicles.

4. **Product pipeline and Harley bike**

Hero MotoCorp has said that it will launch 10 new products or come up with upgrades every year. Munjal confirmed that the company was also developing a flex fuel vehicle which could be launched in future as per market demand. He said that the partnership with Harley Davidson had been a great learning for Hero MotoCorp and the R&D teams of the two companies have been working together closely. When asked about the launch of a Hero-made Harley badged motorcycle, Munjal said that such a vehicle was definitely under works but will not be launched in this fiscal. Harley Davidson's latest product, the Pan America 1250 was launched in India on Monday.

5. **Export strategy**

Going forward, Hero MotoCorp is well aware that the company cannot rely on India alone and will have to deliver strong export growth. Pawan Munjal said that the company was looking to achieve 15 percent sales through exports by 2025. "Focus now on global business is very big. Hero wants to re-focus on Nigeria and has entered new markets like Mexico," he said.

The industry veteran said that while so far Hero MotoCorp's production and sales had not been impacted due to the semi-conductor shortage, the company was managing the production every week and month. Munjal said that the semi-conductor shortage may see an improvement in six months.

"Commodity prices have been very steep. We have not passed on full cost to consumers. Hero MotoCorp is taking a lot of cost efficiency measures to protect EBITDA and margins,"

8.Conclusion

8.1 Overview

For a new technology to be adopted, the consumer should be aware of it and perceive it to have more value than the existing technology. Our perception survey found that a majority of the respondents are not well aware of EV technology as a whole.

With the driving range of EVs rising and their cost falling, driven by reduction in battery prices over the last few years, consumer perception seems to have emerged as the final barrier to their large-scale adoption.

This survey throws light on the major factors that influence EV purchase decisions. While range anxiety appeared to be the topmost stumbling block, an interesting facet was that concerns related to high upfront costs were accompanied by concerns around existence of a used-car market and the vehicle's resale value. The cost and frequency of battery replacement was also considered important.

The issue of choice of brands also appeared important to consumers. It is clear from the analysis that both existing and potential customers have similar concerns and that has its impact on the individual EV purchase and ownership.

The survey found that lack of awareness about EV features and charging prevents even those who can afford the high upfront costs from buying such vehicles. Among the other consumers, there can be mass adoption only when the upfront cost is competitive as compared to ICE vehicles. Overall, however, consumer sentiment is positive and it appears they would prefer electric travel as it is more environment friendly.

While the global EV market is rapidly gaining momentum towards the target set by Electric Vehicle initiative (EVI) of global deployment of 20 million electric vehicles by 2020, Electric vehicles in India are still at a nascent stage.

Is India ready for Electric Vehicles?

8.2 Yes, India is ready-

1. India has been manufacturing indigenously and successfully using Electric Locomotives that pull train coaches with thousands of tons of load. This has not only saved conventional fuel like coal, diesel but has also saved the environment from getting polluted further. Accordingly, manufacturing and using the electric cars is not a big hurdle.
2. According to a report by NITI Aayog, India can save 64% of anticipated passenger road-based mobility-related energy demand and 37% of carbon emissions in 2030 by pursuing a shared, electric, and connected mobility future.
3. This would result in a reduction of 156 mega toe in diesel and petrol consumption for that year. At USD 52/bbl of crude, this would imply a net savings of roughly Rs 3.9 lakh crore (approximately 60 billion USD) in 2030. These figures clearly indicate an urgent requirement for replacement of conventional vehicles with electric vehicles.
4. While prominent manufacturers such as Maruti Suzuki India, Hero Electric Vehicles, Mahindra and Mahindra are already registered electric manufacturers in India, latest collaborations such as Suzuki and Toyota, are planning to launch electric vehicles in India.
5. On the same lines India's first EV manufacturer Mahindra and Mahindra has forged a partnership with Ford to develop electric mobility solutions that are affordable for the Indian consumers.
6. Among the world's 20 most polluted cities in the world, 13 are in India. Vehicular pollution is one of the major contributors to air pollution. India is in the group of countries that has the highest particulate matter (PM) levels. Its cities have the highest levels of PM10 and PM2.5 (particles with diameter of 10 microns and 2.5 microns). These figures are six times more than the WHO "safe" limit of 25 micrograms and represent the exigency for Electrical Vehicles.
7. As a signatory to the Paris climate agreement, India is obligated to bring down its share of global emissions by 2030. Thus the government of India is making key initiatives such as launch of National E-Mobility Programme, planning guidelines to encourage the use of such vehicles by NITI Aayog etc. to promote EVs in India.

8.3 No, India is not ready-

1. More Indians prefer petrol, diesel or gas driven cars. They do not seem to be ready to buy and use the electric cars due to their slow pick up, slow speed and non-availability of electric charging centres in the vicinity of their area.
2. As per the data of Society of Manufacturers of Electric Vehicles, only 22,000 units of EVs were sold in India by March 2016, of which 2,000 were four wheelers. At the same time, sales of electric cars grew at a staggering rate of 94% from 2011 to 2015 worldwide, led by China, US, and Europe.
3. Just after nine months of the launch of Ola's ambitious Electric Vehicle project in Nagpur, it faced major roadblock with Ola drivers wanting to return their electric cars and switch back to petrol or diesel variants. The reason being high operating expenses and long wait times at charging stations.
4. In 2015, the government had launched Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME), a scheme that offered incentives for clean fuel technology cars with the long-term objective of boosting their sales. However, despite incentives as high as INR 140,000 on some cars, the scheme received a lukewarm response.
5. Sales of electric and hybrid cars contributed to only a fraction of the 3 million passenger vehicles sold in India in 2016.
6. India lacks significant infrastructure and necessary technology to support Electric Vehicle manufacturing. Efficient components such as high-density batteries remain a key challenge.
7. A robust supply ecosystem of charging stations is another challenge for Electric vehicles.

Though the market in India has given a tepid response to electric vehicles but there exists immense opportunity for the growth of electric vehicles. The government of India is dedicated towards adoption of Electric Vehicles for a cleaner and greener environment. Robust supporting infrastructure with lower tax on EVs could help to achieve the dream faster.

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