Propelling Electric Vehicles in India

A STUDY ON ADAPTATION OF ELECTRIC VEHICLES AND CHARGING INFRASTRUCTURE

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CERTIFICATE

This is to certify that **Mr. Rohit Ranjan** having Roll No. 2k20EMBA31 has submitted the project report titled **"Propelling Electric Vehicles in India-A STUDY ON ADAPTATION OF ELECTRIC VEHICLES AND CHARGING INFRASTRUCTURE"** in partial fulfilment of the requirements for the award of the degree of Master of Business Administration (Executive) from Delhi School of Management, Delhi Technological University, New Delhi during the academic year 2020-22.

Signature of Guide **Signature of Head (DSM)**

Seal of Head

Place:

Date:

DECLARATION

I Rohit Ranjan, student of **EMBA 2020-22** of Delhi School of Management, Delhi Technological University, Bawana Road, Delhi – 42, hereby declare that the project report **“Propelling Electric Vehicles in India-A STUDY ON ADAPTATION OF ELECTRIC VEHICLES AND CHARGING INFRASTRUCTURE”** towards fulfilment and award of degree Master of Business Administration (Executive), is the original work conducted by me.

The information and data given in the report is authentic to the best of my knowledge.

This report is not being submitted to any other University, for award of any other Degree, Diploma or Fellowship.

Place:

Rohit Ranjan **Date:**

ACKNOWLEDGEMENT

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Our sincere gratitude goes out to my colleagues whose participation in the project gave many valuable inputs for its completion.

Rohit Ranjan

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EXECUTIVE SUMMARY

Electric vehicles have perturbed the roads of most western countries, but they still remain a far-fetched dream on Indian roads due to a variety of reasons. A viable marketplace for passenger vehicles powered by battery power is being driven by the rapid and significant improvements in energy storage technologies pertaining to batteries. Concerns over reliability of hydrocarbon supplies in addition to the anxiety around climate change are fuelling this move to electric vehicles. Consumer behaviour can be manipulated to not reflect their stated and normal objectives and be more emotional by the use of marketing. Inspite of the accelerating EV sales, more often than not, it is not clear if buying an electric-vehicle is advantageous from an environmental or economic point of view.

Powering India's electric mobility initiatives: Challenges

Inspite of being one of the most rapidly growing economies in the world, India's the growing dependence on oil imports to meet our energy needs, growing environmental concerns as well as an expanding need for sustainable transport solutions is resulting in severe economic and social problems.

- **A challenge to energy security - rising crude oil imports**

  There has been a marked exponential increase in India's crude oil imports from the early 2000s. This reached a record high value of 4.3 million barrels per day in the year 2016, the same year when India became the world's third largest crude oil consumer. The growth during this time has been at a rate faster than that of other major net importers of the world, namely the United States (0.7%) and China (2.9%).

- **A rise in pollution - the environmental challenge**
  India alone accounts for 6% of worldwide carbon-dioxide emissions from the combustion of fossil fuels, and is the third largest emitter of carbon dioxide overall. In addition to this, India is home to 14 of the world's 20 most polluted cities, according to the data from the WHO Global Air Pollution Database (2018).

- **Growing population – A challenge to sustainable-mobility**

  India's population is expected to grow to 1.5 billion by 2030, a rise from the present 1.2 billion population. From the 1.5 billion people, nearly 40% will reside in cities, which was only 34% in the 2018 population projection. The mere 6% rise in urban population will put extraordinary strain on the already struggling urban infrastructure, which will also be accompanied by a growing demand for solutions for sustainable transportation.

- **Evolution of the automotive market – The challenge of transitioning manufacturing**

  The fourth biggest internal combustion vehicle manufacturer in the world is India. India's automobile market grew at the fastest rate in the world in 2017, rising at a rate of 9.5 percent. If the transition to sustainable mobility solutions is not planned well enough, or the manufacturing skills and infrastructure is not developed to stand up to this challenge, the recent changes in automotive technologies globally and a widespread adaptation of electric cars will most certainly pose a challenge to the current automotive sector.

This report identifies potential answers to the issues that the growing electric transportation sector faces. The research covers a look at the technological, commercial, and regulatory elements of installing charging stations, as well as a look at best practises in established regions and a look at worldwide EVSE and testing standards. Studies at the city level were undertaken for Delhi to examine the impact of predicted EV adaptation in order to create grassroot solutions.

The report includes a worldwide landscape overview as well as optimistic stories from the United States, Finland, Germany, Japan and China. The Indian market was next assessed, which included a look at the legislative and regulatory framework, a look at market actors' preparation for the adoption of electric vehicles, and a look at existing testing standards and EVSE. Techno-commercial analyses were done to evaluate the feasibility of setting up charging stations based on best methods discovered in worldwide research as well as findings from assessing the Indian market landscape.

We also try to gauge the perception of the consumers and public regarding electric vehicles in the Indian context. Primary data will be collected through a questionnaire to be filled by people, which will contain questions regarding their personal choices and perceptions about the scenario of electric vehicles. Analysis of this data will be done to ascertain the reason why we don't see electric vehicles becoming mainstream and if the government can achieve its ambitious target of phasing out oil powered vehicles to integrate a majority of electric vehicles on the Indian roads in the near future

Target Audience: Indian Population

Questionnaire:
https://docs.google.com/forms/d/e/1FAIpQLSeYxPKsvPkpOmHbULCxm76nSZCq4bIvmE3j76kDA-azeGIahQ/viewform?usp=sf_link

TABLE OF CONTENT

INTRODUCTION

In the road transport industry, India strives to be on an energy transformation route. The National Electric Transportation Mission Plan (NEMMP) 2020 which was launched in 2013 sought to lay the way for a transition away from fossil fuel-based mobility toward electric mobility. By 2020, the mission gave a lofty goal of 6–7 million electric vehicles in the country. The influence of proceeding programmes and initiatives by the Indian government, mostly through the channel of the FAME programmes, on fulfilling the NEMMP objectives has been modest. Since its inception in April 2015, the FAME scheme has sold just over 2.7 lakh electric vehicles, which includes 1.7 lakh electric two-wheelers as of June 2019. The government has promised that by 2030, the country would have completely electric public transportation and 30% electric private automobiles, greatly advancing the electrification target.

According to recent data, 54,800 electric two-wheelers and 1200 electric four-wheelers were sold in the 2017–18 fiscal year. When compared to total automobile and two-wheeler sales, these statistics represent a tiny percentage. Two-wheeler electric vehicles accounted for 0.002% of the total two-wheeler vehicle sales in 2017–18. Electric automobiles accounted for only 0.0003% of total car sales in the same financial year (FY) in India. India has made progress toward electric vehicle adoption, although it is gradual. Total market sales in FY 2016–17 were just 39,000 (electric two-wheelers and four-wheelers).

The slow development in comparison to the envisioned Society of Manufacturers of Electric Vehicles; India statistics clearly demonstrates the presence of unanticipated hurdles inhibiting the desired electrification. In the absence of a defined policy, insufficient grasp of technology issues, infrastructure shortcomings, and a lack of consumer acceptability and awareness in the Indian market, a speedy shift, while desirable, may be difficult to achieve.

Rapid technology changes may potentially have negative employment market consequences. It is critical to gain a better understanding of these challenges in order to speed up the adaptation of EVs. In this regard, TERI, in collaboration with the Society for Development Studies (SDS), proposes to conduct a research study with the goal of bridging the critical gap between consumer and industry expectations in relation to government policies, initiatives, and activities.

RESEARCH METHODOLOGY

1. Primary Study was done wherein interview of random people were taken to assess their perception around EVs.
2. A secondary study was done using a survey that was circulated randomly across the population of India. (Please refer to the survey in Annexure 2).
3. I received around 74 responses. (Please refer the survey data in Annexure 3)
4. Based on the data received by the survey I tried to find out the what is the current mindset of the Indian population regarding the adaptation of electric vehicles.
5. The problem statement was then derived from the above analysis and then a study was carried out to assess the current scenarios and future recommendations.
6. We also try to build a business model for setting up charging infrastructure.

INTERVIEWS TAKEN TO ASSESS THE PERCEPTION OF PEOPLE AROUND EVs

1. Interviewee Biography

Age: 28 Years

Gender: Man

Professional Background: Software Engineer

Daily Commute: Personal Car, 48 kms one way from Model Town to Gurgaon

Do you know about some of the electric vehicles available in the Indian market?

Yes. I am aware about EVs being offered by TATA Motors, Hyundai, MG among others. I have also been following the news on the launch of Tesla Motors in India, although this may cater mainly to the luxury segment.

Since commuting is a daily activity for you, have you considered switching to an electric car? If yes, why have you not made the switch yet? If not, what can make you more optimistic about considering owning an EV?

I commute around 90 kms a day, and at the current fuel costs, it takes me anywhere from 800 to a 1000 rupees daily in fuel costs. I have considered buying an electric car primarily to save on my cost of commuting. In addition to this, I am aware that electric vehicles demand far less maintenance than what my current car needs. Overall, an EV translates into heavy savings for me. Not to mention the fact that it will help me play my part in reducing pollution. The only reason I have not made the switch is because I cannot charge the car at home. I live on the third-floor of a building and my car is parked by the side of the street. There is no way to set up a charging point near my building to charge my car. I tried looking for MCD setup charging stations near my house, but could not find any.

Do you think it would get more feasible to own an EV in the near future?

Definitely. I believe that as EV technology is developed and the infrastructure for powering it is put into place, the upfront cost of buying and owning EV will go down. I am waiting for more charging points to come up near the place I live and where I work. The government has started working towards setting up EV charging points in parking lots of places like South Extension and Saket, but I think there is still some time before it reaches a level where it is possible to charge your car at every street corner.

2. Interviewee Biography

Age: 35 Years

Gender: Man

Professional Background: Journalist

Daily Commute: A combination of personal car and public transport

Do you know about some of the electric vehicles available in the Indian market?

I am aware of a few brands offering EVs in Delhi right now. MG and Hyundai are the two brands I have my eyes on since they offer a longer range with their EVs.

Have you considered switching to an electric car? If yes, why have you not made the switch yet? If not, what can make you more optimistic about considering owning an EV?

An EV would be the perfect vehicle for me to drive on a daily basis. My daily maximum commute falls well within the range of most of the EVs on offer in the markets. Not to mention the fact that since EVs perform most efficiently in city traffic, it would be just the perfect companion for my daily needs. The only reason I do not already own one is that even with government subsidies, they are priced a little on the higher side. While it is true that I will be able to recover the extra costs in some time after buying the EV, the high upfront cost has been the biggest deterrent in me buying an EV.

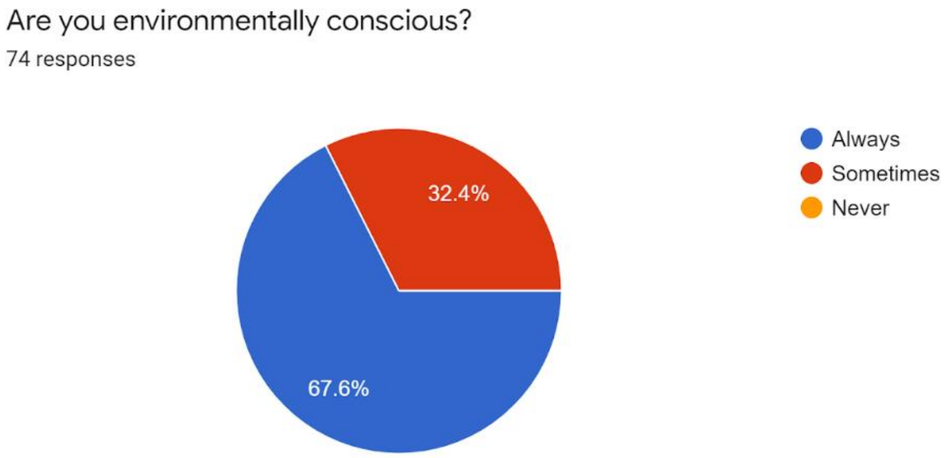
Do you think it would get more feasible to own an EV in the near future?

I certainly hope so. All of us are aware about the poor air quality in Delhi. Moving to EVs gradually will ensure that we breathe cleaner air in the long term. EVs are very likely to become more feasible assets in the near future primarily because of the push my the governments, as well as the fact that EVs will get cheaper with time.

ANALYSIS OF THE RESPONSES RECEIVED IN SURVEY

- **Environmental Consciousness**

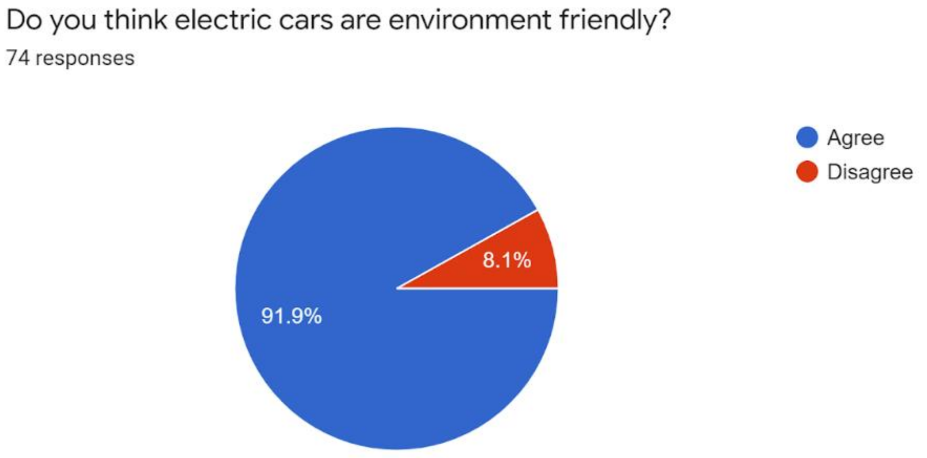
Out of the respondents, 67.6% answered that they keep up environmental consciousness at all times, while 32.4% answered that they are only occasionally environmentally conscious. None of the respondents chose the option of never being environmentally conscious.



Source: Self-analysis

- **On the ecological viability of EVs**

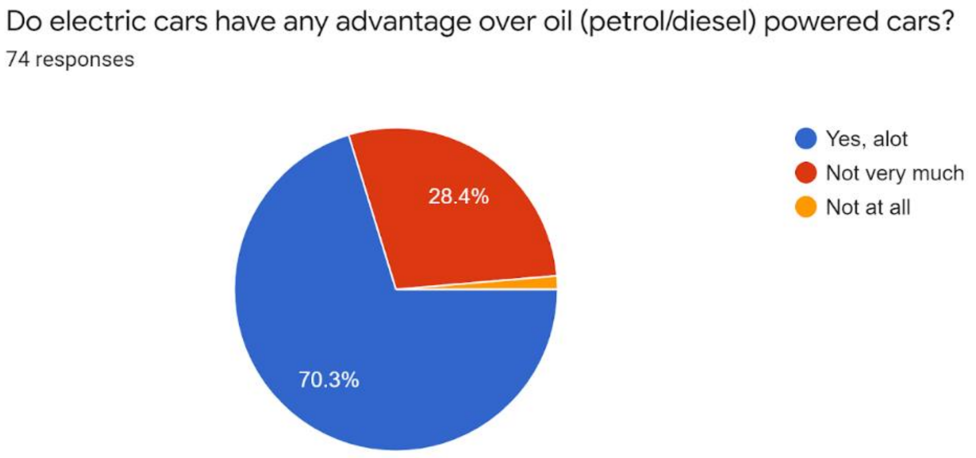
Out of the 74 respondents, 91.9% agreed with the ecological viability of EVs, while 8.1% disagreed with the same.



Source: Self-analysis

- **Advantage over conventional oil powered engines**

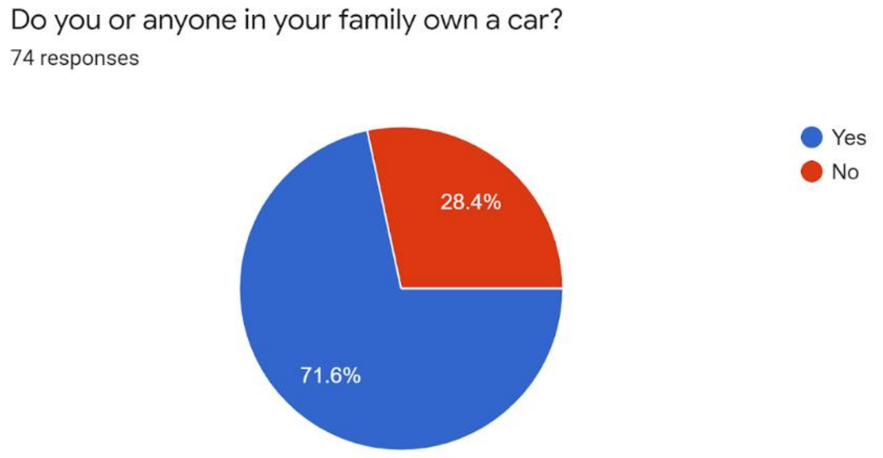
70.3% of the respondents agreed with EVs having a clear advantage over oil powered vehicles, whereas as much as 28.4% of the respondents said that the advantage isn't significant.



Source: Self-analysis

- **Ownership of a family four-wheeler**

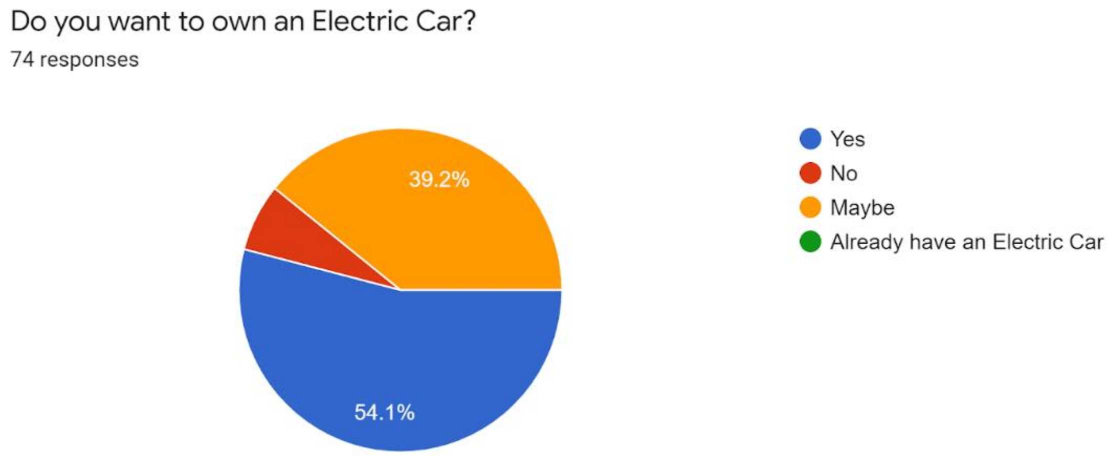
As many as 71.6% said that they already own a car (i.e four wheeler vehicle) while 28.4% said they did not.



Source: Self-analysis

- **Opinion about owning an EV**

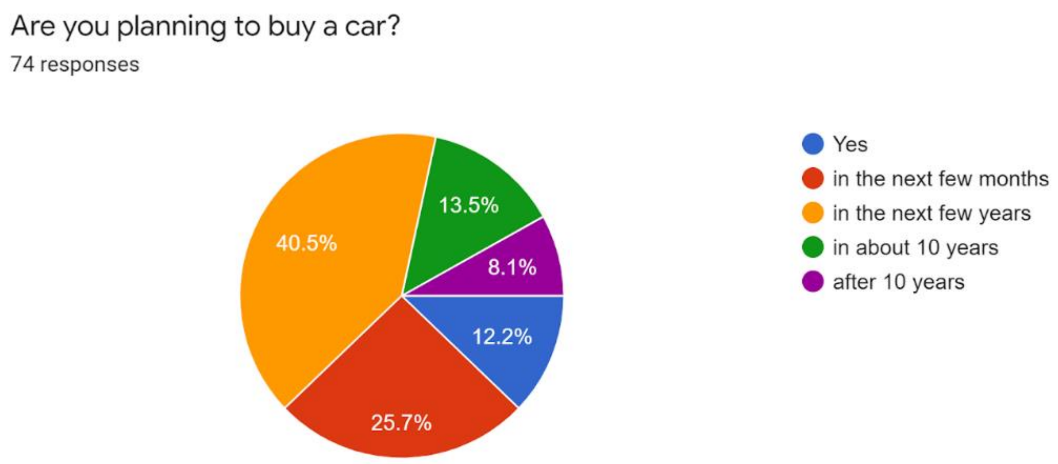
54.1% agreed to wanting to own an EV, 39.2% were unsure about it, and the remaining outright refused any desire to own an electric vehicle. A surprising result here is that none of the respondents claimed to already owning an EV.



Source: Self-analysis

- **Timeline of being a potential buyer in the automotive market**

A majority of respondents answered that they were planning to buy a car in a few years (40.5%), while others were divided across different timelines ranging from a few months to after 10 years. One interesting point worth noting is that all customers who are planning to buy a car in the next few years to next 10 years and beyond are a potential market for EVs.

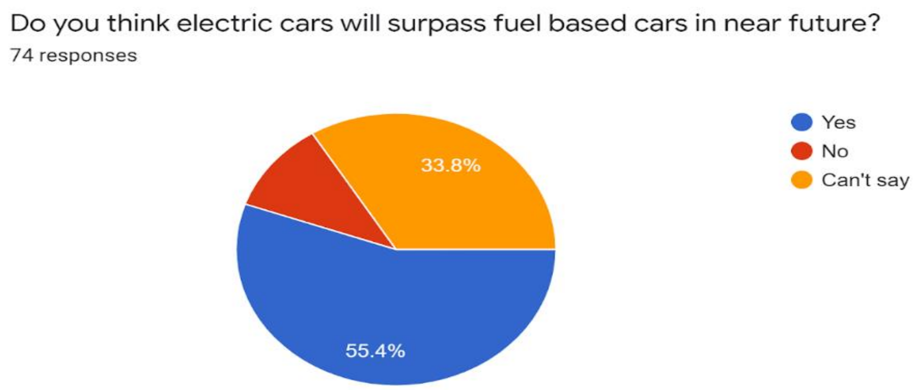


Source: Self-analysis

- **EVs vs Oil based vehicles**

In spite of EVs outperforming the most premium fuel based cars as, there is a certain skepticism among the buyers, which can also be seen here, where a little less than half of the respondents are either unsure of the performance improvement or are outright refusing the better performance offered by EVs.

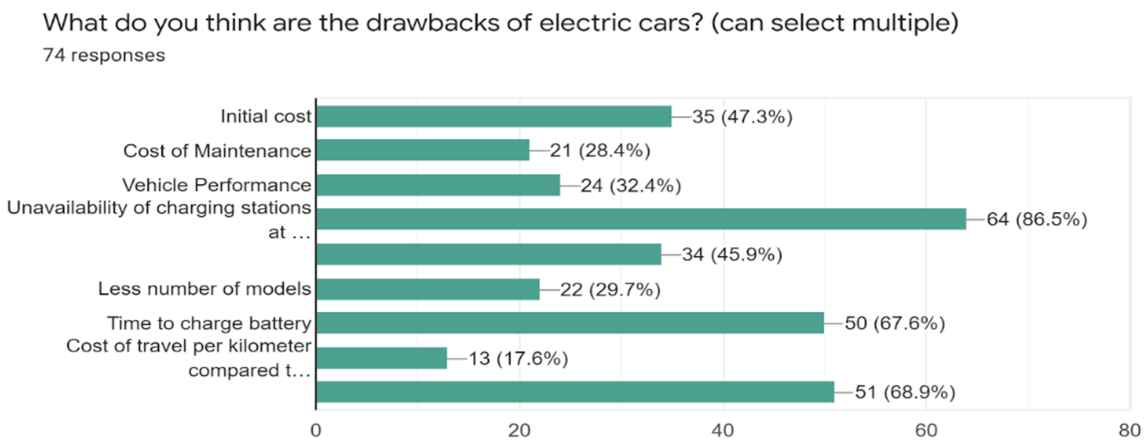
Source: Self-analysis



- **Perception of drawbacks associated with EVs**

The respondents believe that the lack of charging stations and the limited range and the time of charging that comes with an EV is the most significant drawback (86.5%). Inspite of widespread knowledge that maintenance costs for EVs is far lesser than oil based vehicles, 28.4% respondents believe this to be a drawback.

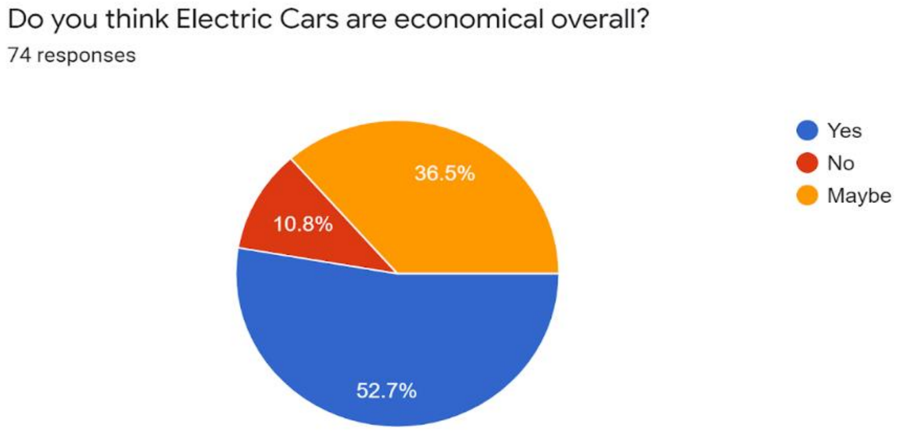
A similar trend of lack of knowledge can be observed with the option of "cost of travel per kilometer" too, where 17.6% respondents believe that this is a drawback, whereas electricity costs far less to travel one kilometer on than oil.



Source: Self-analysis

- **Overall economic viability of EVs**

52.7% of respondents believe that EVs are in fact more economical overall, yet there remain nearly half of respondents who are either unsure about this or reject this idea of viability.

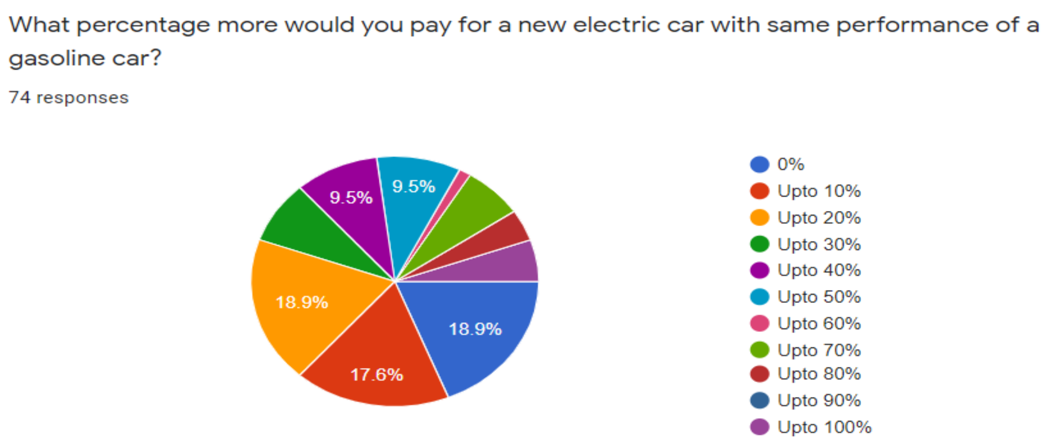


Source: Self-analysis

On the higher costs of EVs

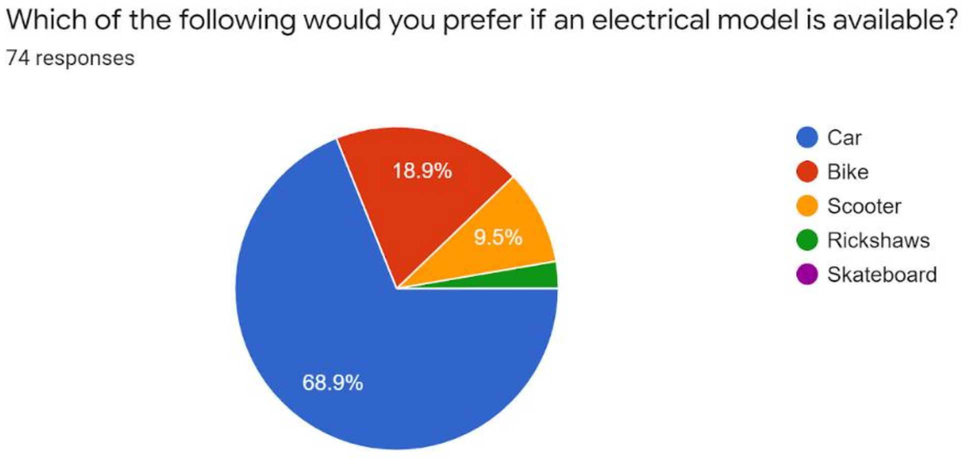
Respondents were asked how much more they would be willing to pay in comparison to a conventional vehicle. More than half of respondents lie within the 0%-20% region, signifying that the initial cost of EVs could be a huge factor in turning the market highly competitive.

Source: Self-analysis



- ## Type of vehicle

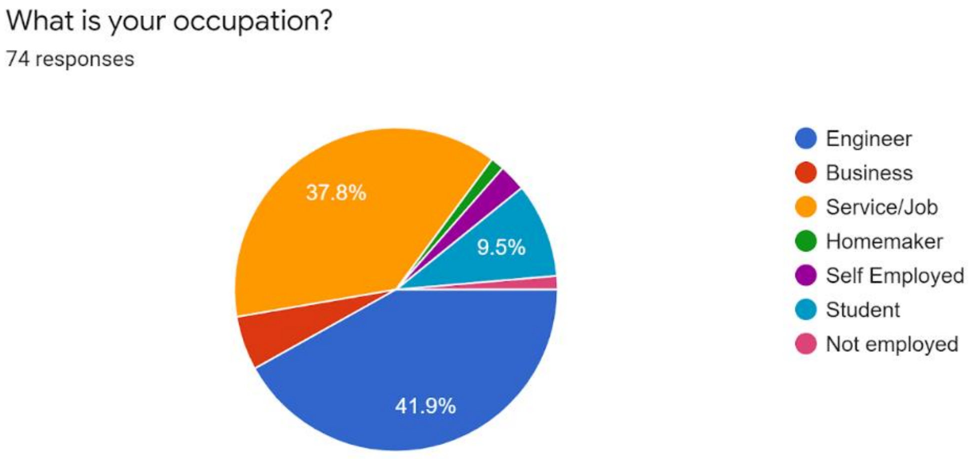
As expected, respondents expect mainly four and two wheeler vehicles in the electric segment, as is the trend with conventional vehicles too.



Source: Self-analysis

- ## Occupation of respondents

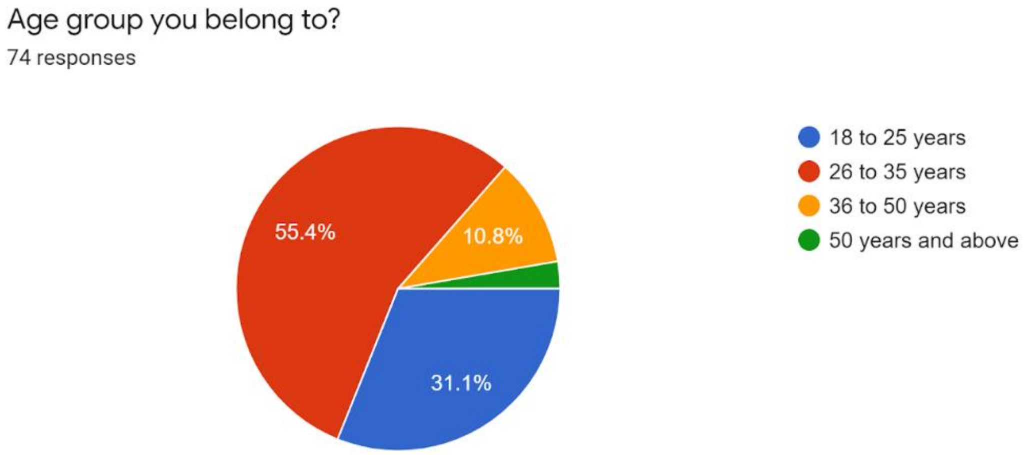
Majority of respondents fell in the category of either an engineer or in service/job. Some respondents were also students.



Source: Self-analysis

- **Age of respondents**

Most of the respondents fell within the 26 to 35 years of age category, which is near the mean age of the Indian population (27 years). This age bracket consists of working youth, equipped with the internet in the age of information and well aware about the future knocking at our doors in the form of EVs.



Source: Self-analysis

The results of the survey conducted can be summarized in the following points as given below:

- 67.6% of respondents claimed to be environmentally conscious, yet only 54.1% said that they want to own an electric car. This disparity can be attributed to various reasons which include, but are not limited to, the initial cost of the car, the limited range offered and unavailability of regularly spaced charging stations across the country.
- Economic viability of EVs is a proven fact since the cost of travel per kilometer on electricity is far lower than oil, and the zero after maintenance of EVs also contributes to making them far more economical than oil based cars. Yet, only about half the respondents (52.7%) believe in the superior economic viability

of EVs, which shows a marked lack of awareness about new technologies especially in the automotive sector.

- We can also conclude that in spite of the higher initial cost of EVs, buyers are ready to pay as much as 20% more as compared to an oil based car in the same segment.
- The maximum fraction of respondents were youth and were either in a job/service sector or were in the technical domain as an engineer. Taking this sampling as a basis for a larger population as well, we find that the maximum number of potential EV buyers are well educated and learned youth who are most likely to buy the vehicle in the next 10 to 15 years.

From the above analysis we can conclude that the lack of charging infrastructure is the major reason behind slow pace of adaptation of electric based transport in India.

THE GLOBAL LANDSCAPE OF ELECTRIC VEHICLE CHARGING INFRASTRUCTURE

The number of working electric car chargers surpassed 2 million in 2017. As of December 2017, there were about 6 times as many EVs on the road as there were public charging stations. In 2017, the number of publicly accessible chargers increased by 70%. Because of the quick deployment in established areas like China, the number of deployed fast chargers has increased dramatically. The fast track set up of electric car chargers was made possible by a number of government policy and regulatory efforts.

Apart from subsidy assistance, other incentives of either the fiscal or the non-fiscal nature have defined the increase in the financial feasibility around putting up charging stations, according to a market assessment research conducted in the United States, Germany, China, Japan, and Finland. The table below summarises the most important drivers of growth in each of these countries.

Table 1. Key drivers of growth in the countries studied
Source: Self-analysis

Country	Key growth drivers							
	EV Policy	Tax holidays	Unregulated tariff	Utility involvement in deployment	EV purchase incentives	Incentives for public charging infrastructure	Time of Use tariff	Indirect incentives (access to reserved lanes)
The USA	✔	✔	✔	✔	✔	✔	✔	✔
China	✔	✔	✕	✔	✔	✔	✔	✔
Japan	✔	✔	✕	✔	✔	✔	✔	✔
Germany	✔	✔	✔	✔	✔	✔	✔	✔
Finland	✕	✔	✔	✔	✕	✔	✔	✕

The sections below go through the important events that contributed to market growth in the United States, Germany, Japan, China, and Finland. This includes a review of the power market structure, as well as major growth drivers such as legislative and regulatory measures, technology advancements, and utility-centric charging station business-models.

The sections below go through the important events that contributed to market growth in Japan, the United States, Germany, China, and Finland. This also contains a review of the structure of the power market, as well as major growth drivers such as legislative and regulatory measures, technology advancements, and utility-centric charging station business-models.

United States of America

Several states in the United States have taken varied methods to EV charger distribution. California has become one of the country's major markets for electric vehicles. California has been a leader in environmental reform in the United States. California's government has an ambitious goal of about 5 million zero-emission cars (ZEVs) on the road by the 2030s, as well as a quarter million electric vehicle charging stations by 2025. California continues to work towards green mobility via different legislative reformations in order to achieve this goal.

Germany

Germany has a strong presence in the car industry and has been a centre for key research and development. The German government's desire for greener technology has accelerated the country's adoption of electric transportation. The German Federal Ministry of Finance has aggressively worked on both the regulatory and legislative front in order to reap the many benefits of EV market adoption. The electric vehicle industry offers chances for cross-sector collaboration and necessitates the creation of a specialised organisation to develop long-term strategy. The Joint Agency for Electric Mobility was established in February 2010 by the “Federal Ministry of Economics and Technology (BMWi) and the Federal Ministry of Transport, Building and Urban Development (BMVBS)” as a specialised Electric Mobility coordination agency.

The institution was founded specifically to group and coordinate the federal government's electric transportation projects. National Electric Mobility Platform has been established by the federal government, consisting of 20 individuals in 7 working groups charged with coordinating as well as creating the proliferation strategy for EV. Both the Federal Government and the National Electric Mobility Platform are being assisted by GGEMO in implementing and expanding the “National Electric Mobility Development Plan”.

Finland

Power markets in Finland, like in Germany, are liberalised and dominated by TSOs and DSOs. The wholesale power market in Finland is a part of Northern Europe’s electricity market. The wholesale energy markets in the countries of Finland, Denmark, Sweden, Estonia, Norway, Lithuania, and Latvia” have all been interconnected. Furthermore, the Finnish market has been liberalised and exposed to competition over time. As a result, since 1998, consumers have been permitted to select their preferred electrical source.

Finland's electric vehicle environment is comparable to Germany's, owing to similar market structures. Fortum charge and drive and the network of charging places built and operated by Virtapiste, also known as Liikennevirta Oy, are the two largest operators in the sector of electric vehicle charging stations. Virtapiste serves firms like

Helen in Finland serving the roles of infrastructure developer and manage the network. It also manages electric car charging payment systems and also give an application to make payments and also to result in easier customer service.

Japan

The ratio of Japan's EVSE (rapid charging stations) to EV increased to 0.039 in 2017. The rapid charging points have surpassed 5,000 units in the country with another 5,990 public quick charging stations. There are 17,260 non-residential slow charger stations, that accounts for about 1% of Japan's 2 million non-fast charger objectives. The number of EV charging stations in Japan surpassed the number of gasoline stations in the year 2016. Nissan, a Japanese automaker, has commented that the total number of charging stations which include residential chargers has surpassed the 40,000 mark, as opposed to 35,000 gas outlets.

Over the years, the policy framework has been substantially developed and adapted to support and achieve the government's goals. The "Roadmap for EVs and PHVs Towards the Dissemination of Electric Vehicles and Plug-in Hybrid Vehicles" aims to consist of 50% - 70% of sale of next-generation vehicles sales from the total number of new car sales by the year 2030. The government in Japan positioned itself as a development facilitator, providing both R&D funding and artificially establishing specialised markets, as well as paving the way for particular technology through law and norms.

China

The federal government places a high priority on encouraging the development of charging infrastructure in order to accelerate the adoption and marketing of electric cars. The government has been aggressively restructuring the state electric power sector to increase the installation pace of new EV charging stations by dissolving energy monopolies of distribution on the sales and progressively opening up of the electric power market to the public.

In China, there are between 300,000 and 350,000 charging poles, including 50, 000 public ports and 49, 000 specialty ports. Due to significant regulatory backing, large cities such as Beijing, Shanghai, Guangdong, and Shenzhen have seen the most rapid increase in charging infrastructure. The number of public EV chargers increased from 50,000 in 2015 to 150,000 at the end of 2016.

THE LANDSCAPE OF ELECTRIC VEHICLE CHARGING INFRASTRUCTURE: INDIA

India's electric mobility market is distinct from those of nations with higher levels of electric car adoption and more developed market circumstances. The disparity is mostly attributable to many factors such as geographic location, government policy, societal standards, and the economy. Several challenges to widespread adoption of electric cars include heterogeneous urban growth, a huge population, a lack of public infrastructure, and a lack of cost. Both at the federal level and state, governments have taken active measures to overcome the impediments. Initiatives like the “National Electric Mobility Mission Plan (NEMMP)” and “FAME (Faster Adoption and Manufacture of (Hybrid and) Electric Vehicles)” have been critical in expanding private sector engagement in the electric mobility area. Furthermore, MOP's landmark clarification that infrastructure for charging operation will not be considered as the resale of electricity, has boosted the sector. Standardization, with various policy as well as regulatory initiatives, is fundamental to the widespread adoption of any technology.

However, in internationally developed markets, adopting a technology agnostic approach (allowing standards to be adopted according to market conditions) has shown to be a vital strategy for improving market penetration. As a result, stations may supply EV consumers with all alternatives (Bharat charger AC001, DC001, CHAdeMO, CCS, and GB/T) on a single board/kiosk. The electric mobility market has seen strategic alliances amongst the different companies in the EV supply chain as a result of policymakers' proactive attitude. This was done with the dual goals of broadening the product range and lowering operational risks, allowing the sector to better adapt to the electric mobility upheaval. As a result, the section below provides an overview of India's policy and regulatory environment for electric mobility, as well as an assessment of automotive firms' supply chain preparedness and a comparison of India's standardised landscape to worldwide markets. Based on this, policy level efforts, essential methods for partnerships between the parties on the supply side, and the most widespread standards for EVSE, EVs and the standards for testing, have all been recommended.

Policy landscape in India

The unwavering commitment to increased energy security, less greenhouse gas emissions, and improved air quality from India has ushered in a major shift toward electricity based transportation in India. India is expected to save US $330 billion (INR20 lakh crore) by phasing out oil imports by 2030 if electric mobility is widely adopted. This will also result in a decrease of 300 MT of CO_2 emissions by 2030.

- **Institutional Framework**

  Initially, the Ministry of Heavy Industries and Public Enterprises (MoHIPE) spearheaded EV initiatives in India, launching the "National Electric Mobility Mission Plan (NEMMP)" in 2013 and the "Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME India)" scheme in 2015.

  It was later discovered the topic of electric mobility is complicated with connections spanning the entire energy as well as transportation value chain.

  As a result, multiple government departments were enlisted in order to approach a multi-stakeholder situation. The NITI Aayog has been tasked with establishing India's EV policy plan. The following diagram depicts the crucial functions that many ministries play:

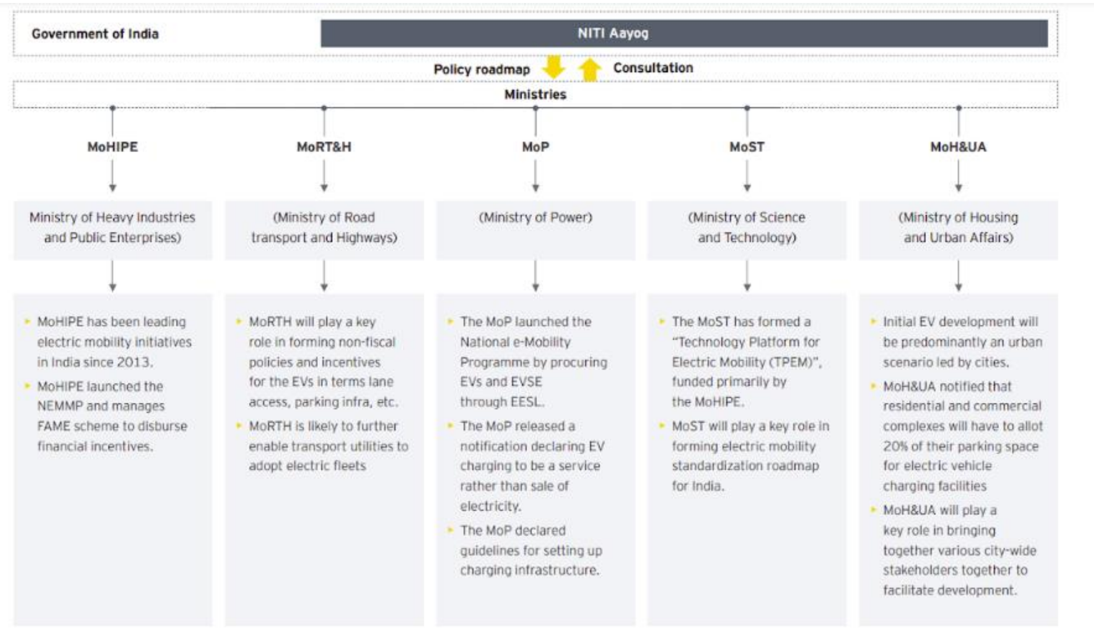


Figure 1: Key role played by various ministries in India
Source: Ministry of Heavy Industries. GOI

- **Policy Roadmap**

  The Alternate Fuels for Surface Transportation Program was started by the Ministry of New and Renewable Energy (MNRE) in 2010, followed by the National Electric Mobility Mission Plan (NEMMP) in 2013. By establishing a goal of 6-7 million electric vehicles by 2020, NEMMP lay the groundwork for India's electric mobility growth. The table below shows India's electric mobility policy roadmap since its start.

Table2: Key initiatives for electric mobility Source: Ministry of Heavy Industries, GOI

Key initiatives for electric mobility proliferation			
S.no.	Initiative	Timeline	Description

1	Alternate Fuels for Surface Transportation program	2010	• The program promotes research, development and demonstration projects on electric vehicles.
			• Incentives given include:
			  • Package worth INR950 million was provided
			  • 20% on the ex-factory prices of electric vehicles

2	National Electric Mobility Mission Plan (NEMMP)	2013	• NEMMP envisaged a total investment of US$6-US$7 billion for the promotion of electric mobility with investments in R&D and electric vehicle infrastructure.
			  • Proposed investment by the government is US$2.7-US$3 billion.
			  • Proposed investment by private sector US$4-US$4.5 billion.
			• Demand incentives have been included in government investments.
			• Target to achieve 6 to 7 million on road electric vehicles by 2020.
			• The vehicle target will enable fuel savings of 2.2 to 2.5 million tonnes.
			• Savings from the decrease in the consumption of liquid fossil fuel as a result of a shift to electric mobility alone will far exceed the support provided, thereby making this a highly economically viable proposition.
			• Carbon dioxide emissions as a result of vehicular emissions will decrease by 1.3%-1.5% in 2020.
			• Develop phase-wise strategy for research and development (R&D), demand and supply incentives, manufacturing and infrastructure upgrade.

3	Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles	2015 Phase 1: 2015- 2017 (extended till September 2018) Phase 2: 2019 - 2023 (Expected)	• The program promotes research, development and demonstration projects on electric vehicles. • Incentives given include: • Package worth INR950 million was provided • 20% on the ex-factory prices of electric vehicles • By 2017, under the government's FAME I scheme, incentives worth INR211.74 crores (~US$31.6 million) have been disbursed[114] . • 11 cities across India were selected for pilot projects to promote electric vehicle developments. These include: • 390 electric buses • 370 electric taxis • 720 electric autos • INR40 crores for charging infrastructure • The following subsidy will be provided based on the vehicle class

	Vehicle segment	Minimum subsidy	Maximum subsidy
Scooter	Two-wheeler	INR1,800	INR22,000
Motorcycle	Two-wheeler	INR3,500	INR29,000
Auto rickshaw	Three-wheeler	INR3,300	INR61,000
Cars	Four-wheeler	INR11,000	INR1,38,000
Light commercial vehicle (LCVs)	Light commercial	INR17,000	INR1,87,000
Buses	Buses	INR3,00,000	INR66,00,000

• FAME II scheme, with a subsidy package of INR9,381 crores (~US$1.4 billion), is expected to be launched for a period of five years from 2018-2023.

4	Clarification on charging infrastructure for electric vehicles	2018	The MoP clarified that EV charging will be considered a service and not a resale of electricity. The charging of battery involves utilization of electrical energy which gets stored in the battery. Thus, the charging of battery of an EV involves a service by the charging station and earning revenue from the EV's owner. The electricity is consumed within the premises owned by the charging station and hence is not a sale of electricity. This landmark notification has opened the charging infrastructure market and within a month of the notification, various projects were launched within the country.

- **State electric mobility policies**

Various states have established special strategies to increase EV market acceptance in addition to the federal ones. The following are some of the policies' highlights:

Table3: State Policy
Source: Ministry of Heavy Industries, GOI

State policy			
S.no.	Policy/ initiative	Timeline	Description

1	Karnataka	2017	• Separate tariff has been included (4.85/kWh) for EVs
			• Government of Karnataka intends to make Karnataka the EV capital of India and aims to achieve 100% electric mobility by 2030 in the following segments:
			  • Auto rickshaws
			  • Cab aggregators
			  • Corporate fleets
			  • School buses/vans
			• Karnataka aims to attract investments of INR31,000 crores
			• Four strategies defined by the state are:
			  • Special initiatives for EV manufacturing
			  • Support for charging infrastructure
			  • Support for R&D and skill development
			  • Incentives and concessions
			• State transport - BMTC, KSRTC, NWKSRTC and NEKRTC will introduce 1,000 EV buses during a time period of five years.
			Support for charging infrastructure
			• **Certifications/standards:** the government will encourage private players to set up ARAI compliant/BIS standards EV charging infrastructure.
			• **Land identification and leasing:** the government will identify potential places and allocate government lands wherever available on long lease for setting up of EV fast charging stations and battery swapping infrastructure by following a transparent bidding process.
			• **Subsidy:** the government will offer incentives in the form of capital subsidy based on the type of charging stations.

<table>
<tr><td></td><td></td><td></td><td>
<table>
<tr><td></td><td>Fast charging stations
Battery swapping stations</td><td>Battery swapping stations</td></tr>
<tr><td>Eligibility</td><td>First 100 stations</td><td>First 100 stations (2W/3W)
First 50 stations (4W)
First 50 stations (buses)</td></tr>
<tr><td>Subsidy amount</td><td>25% on equipment and machinery (maximum INR10 lakhs per station)</td><td>2W/3W swapping station
25% on equipment and machinery (maximum INR3 lakhs per station)
4W swapping station
25% on equipment and machinery (maximum INR5 lakhs per station)
Buses swapping station
25% on equipment and machinery (maximum INR10 lakhs per station)</td></tr>
</table>

Building code amendments: the amendments will be made to building bye-laws for providing charging infrastructure for EVs in all high-rise buildings/technology park/apartments in the state.
The government has exempted EV users from paying taxes on all electric non-transport and transport vehicles including e-rickshaws and e-carts.

Incentive and concessions for EV and component manufacturing enterprises

Investment promotion subsidy

For micro enterprises: 25% of the value of fixed assets (maximum INR15 lakhs)
Small enterprises: 20% of the value of fixed assets (maximum INR40 lakhs)
Medium manufacturing enterprises: INR 50 lakhs

100% exemption from stamp duty on loan agreement, credit deeds, hypothecation deeds, etc.
Concessional registration charges for all loan documents and deeds.
100% reimbursement of land conversion fee from agriculture to industrial use.
Subsidy for setting up effluent treatment plant (ETP).

One-time capital subsidy up to 50% of the cost of ETP, subject to a ceiling of INR50 lakh till medium level enterprises and INR 200 lakhs for large and above enterprises.

Exemption from tax on electricity tariff.
Interest free loan on net SGST to large and above large-scale enterprises for certain number of years.

</td></tr>
<tr><td>2</td><td>Maharashtra</td><td>2018</td><td>
Incentive and assistance for EV charging

Separate tariff has been included (2.06 /kWh) for EVs.
Common charging points in residential areas, societies, bus depots, public parking areas, railway stations, fuel pumps, etc. will be allowed. After the receipt of the application for setting up a charging point, the concerned planning authority and electricity supplying agency shall grant the permission within 15 days.
Petrol pumps will be allowed to setup charging stations freely subject to the areas qualifying under fire and safety standard norms under relevant acts/rules.
Commercial public EV charging stations for two-wheelers, two-wheelers, cars and buses will be eligible for 25% capital subsidy on equipment/machinery (limited up to INR10 lakhs per station) for the first 250 commercial public EV charging stations.
As per the requirement, the facility of robotic battery swapping arm will be created at public bus stations.

</td></tr>
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<table>
<tr><td></td><td></td><td></td><td>Incentives and provisions for EV buyer
▸ The following incentives (user subsidy) in addition to central subsidy will be provided to the private/public passengers whose vehicles are registered in the state over a policy period of five years
▸ Exemption from road tax and registration fees for electric vehicles.
<table>
<tr><th></th><th>2-wheeler</th><th>3-wheeler</th><th>4-wheeler</th><th>5-wheeler</th></tr>
<tr><td>Eligibility</td><td>First 70,000 EVs</td><td>First 20,000 EVs</td><td>First 10,000 EVs</td><td>First 1,000 EVs</td></tr>
<tr><td>Subsidy on base price</td><td>15% (maximum limit of INR5,000 per vehicle)</td><td>15% (maximum limit of INR12,000 per vehicle)</td><td>15% (maximum limit of INR1 lakh per vehicle)</td><td>10% (maximum limit of INR20 lakhs per vehicle)</td></tr>
<tr><td>Subsidy Realization</td><td>3 months from the purchase date</td><td>3 months from the purchase date</td><td>3 months from the purchase date</td><td>3 months from the purchase date</td></tr>
</table></td></tr>
<tr><td>3</td><td>Delhi</td><td>2017</td><td>Separate EV tariff has been included (5.5/kWh) for kWh for LT and HT connection</td></tr>
<tr><td>4</td><td>Telangana</td><td>2017</td><td>▸ Telangana State Transport Corporation has set a target of 100% electric buses by 2030 for intra-city, intercity and interstate transport (key milestones – 25% by 2022, 50% by 2025 and 100% by 2030).
▸ Government vehicles (owned and contractual) are planned to switch to electric by 2025, in a phased manner. Contract carriage permits will be given to private operators with EV fleet operations.
▸ Corporate offices with annual turnover of INR100+ crores operating within Greater Hyderabad Municipal Corporation (GHMC) limits to compulsorily migrate 25% of their employee commuting fleet to EVs by 2022 and 100% by 2030.</td></tr>
<tr><td>5</td><td>Andhra Pradesh</td><td>2017</td><td>▸ Separate tariff has been included (INR6.95 /kWh) for EVs.
▸ The state government is seeking to attract investments of INR30,000 crores in the EV industry by providing capital subsidies to automakers and charging-equipment manufacturers.</td></tr>
<tr><td>6</td><td>Gujarat</td><td>2017</td><td>▸ 1000 EV buses will be introduced by the state by 2030, in different phases Separate tariff has been included (INR4.1/kWh) for EVs.</td></tr>
<tr><td>7</td><td>Uttar Pradesh</td><td>2018</td><td>▸ 1000 EV buses will be introduced by the state by 2030, in different phases - 25% in phase I by 2020, remaining 35% in phase II by 2022 and the rest (40%) in phase III by 2030.
▸ UP will incentivize manufacturing of Lithium batteries with higher mileage per charge. The state will also incentivize manufacturing of hydrogen-powered fuel cells and solar powered cells, as an alternative clean energy source.
▸ The state government will also provide 100% road tax exemption for EVs purchased in Uttar Pradesh.</td></tr>
</table>

To significantly enhance EV demand in India, policymakers must focus on financial and non-financial incentives. At the federal, state, and local levels, these incentives must be sustained. Early adopters will generally come from metropolitan regions, with metro cities accounting for the majority of purchases because to their huge populations and high salaries. As a result, city-level rules will be critical in the growth of India's EV ecosystem. To achieve this goal, each state has begun drafting its own EV policy paper. This policy statement will provide all stakeholders with clear rules, objectives, and a path. To encourage investments in various states, the policy should reward stakeholders (manufacturers, users, service providers, and so on) throughout value chains.

READINESS OF EV SUPPLY CHAINS AND R&D IN INDIA

Electric vehicles in big numbers will inevitably upset the automobile industry's current supply chain. This shift from internal combustion engines to electric motors can be anticipated to create new possibilities for technology-based organisations and start-ups. As a result, incumbent players must reinvent themselves to be ready for the adaptation to new EV technologies before losing their companies to newer players.

Because electric cars have fewer moving components than ICE vehicles, their design complexity is lower. Once the technology advances, this might lead to the vehicle becoming commoditized. In this situation, existing players must raise the value of their proposition to ensure differentiability of their offerings in the market. Owning specialised charging stations while also giving free charging, after-sale care, warranty, and incentives as services are examples of these offers. Various supply chain stakeholders have embraced various ways of collaboration in order to distinguish product offers, decrease the risk of market disruption, and increase operational efficiency. The following section discusses the major components of the EV supply chain, the influence of electric mobility adoption on the previous value chain of the automotive industry, and potential partnerships.

Components of EV supply chain

Some vehicle categories which are seeing penetration in India include personal 2 and 4-wheeler market, commercial 3,4-wheeler as well as buses, public transport intra or inter city buses as well as logistic solution mobility in forms of 2,3,4 wheelers. New models are being introduced and developed by existing and new automobile manufacturers. Lithium-Ion batteries are the lifeblood of all electric vehicle. This remains the most expensive part of an electric vehicle. The entire performance of the vehicle will be determined by chemistry at the smallest level of the cell, battery packs, and various heat management systems. Range, power density (kWh per unit kilogram), deterioration of battery capacity with use, maximum charging and discharging power, faster charging, as well as the number of charge-discharge cycles in the life of the battery are all important battery performance factors. A trade-off exists between cost and various battery attributes. In terms of cost and performance, NMC batteries are the cheapest, LTO batteries are the most expensive, and LFP batteries are in the middle.

Electric motors: Electric motors will take the place of internal combustion engines. The essential characteristics of vehicle performance, such as max speed, will be defined by motor technology. Advanced controllers and microprocessors will be used to control and coordinate the communication between the power train and other vehicle components. Brushless DC and AC traction motors, both are common in today's industry. Though brushless DC motors offer superior efficiency, higher degree of control, they cost more due to the high cost of using permanent magnets in the design, and they also are dangerous to the supply chain with greater quantities. Switch Reluctance Motors (SRM), for example, are undergoing research and development. Although SRM motors do not require permanent magnets, their design is complicated and difficult to operate.

Chargers: The charger design would be determined by the kind of vehicle (2W, 3W, 4W, and buses), which is determined by the battery choices, electronics of the vehicle, and architecture of the system. Either one of an AC or a DC charger can be used to charge electric vehicles. During the use of an AC charging outlet, a portable charger is required to obtain DC from AC and then charge the batteries. Speed with which complete charging takes place is determined by the charger's power level and the EV's capacity to utilise that power level. Generally, AC chargers charge slowly (4 to 8 hours), but DC charges take less time (half an hour to 2 hours). To maintain optimum safety during charging, protocols for communicating between the charger-grid and charger-EV are usually required for high-power charging. For low voltage EV applications, India has adopted AC-001 (15A, 3.3kW, IEC 60309 connection) and DC-001 (200A, 15kW, GB/T 20234 connector). Similar standards in the medium and high voltage uses are being developed in India. Inverters and DC-DC converters will be in more demand as EV chargers become more common.

Charging network operator: This is a level playing field for all market players. The charging infrastructure will be in great demand on most metropolitan roadways as well as highways. For the charging infrastructure company to succeed, a solid charging facility and demand aggregation plan are essential. Different ownership arrangements (private, public, PPP), pricing tactics (rupees/full-charge, rupees/km, rupees/min, rupees/kWh, subscription based pricing, etc.), and choices to pay will arise as a result. Every charging stations and chargers are required to be brand new to the grid, while the grid must receive some indication on charging demand in order to improve managing power during peak loads. A new business opportunity will emerge in the data analytics for EV charging. The absence of mechanical engines in EVs will reduce demands for consumables like lubricants and oil, as well as the expense of after-sales maintenance . New electric vehicles will have more electrical components, necessitating specialised labour and skill up of existing workers.

Re-cycling: Various OEMs offer a host of battery life warranties, from 3 to 8 years. Because e-mobility is new to India, there isn't much historical data on how lithium-ion batteries function in Indian usage and power circumstances (road, use, temperature, etc.). All of the variables influence battery capacity degradation and life cycle consumption significantly. Once lithium-ion batteries have completed their stipulated life in EVs, it is intended to utilize them for various stationary applications while they wait for being recycled. With present technology, re-cycling can recover 80-100 percent of the precious metals used in the cells/batteries126, and provide a crucial connection to limit the risk of precious metal supply for producing new cells/LIB.

Automotive supply chain impact of the EVs

The influence of electric vehicles on the automotive supply chain is seen in the map below. This might be useful in determining target areas and investing for capacity growth and diversifying the portfolio.

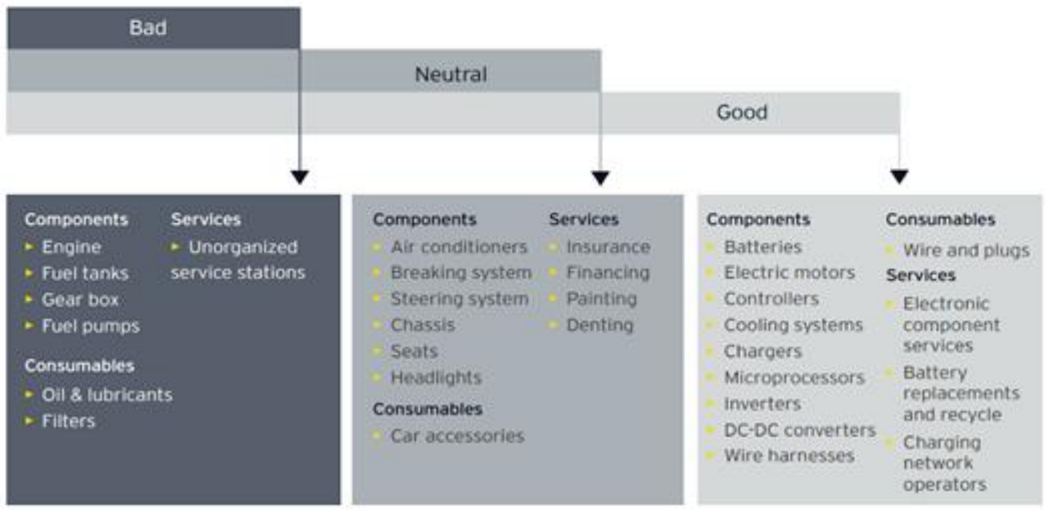


Fig2: Impact of EVs on automotive supply chain
Source: Self-Analysis

The adoption of electric vehicles is predicted to increase demand for the raw materials listed below:

- Aluminum: A very light weight material results in better vehicle dynamics, while managing to account for the weight of the battery pack.
- Copper: Wiring harnesses and the windings of electrical motors.
- Carbon fibre: High prices, currently, keep demand low. Lightweight, strong material for improved dynamics as well as low overall vehicle weight.
- Lithium: used primarily in the production of Lithium-Ion batteries.

As discussed above, OEM value addition will decrease as the market for electric vehicles grows. OEMs must concentrate on in-house battery development and manufacture in order to maintain their share of the complete value chain. The influence on the value chain will also be determined by the vehicle makers' design approach. Conversion design or purpose design are two options for this method. The conversion is based on traditional vehicle principles. In this design, just the electric motor replaces the combustion engine, which keeps the traditional layout. Body structures can be changed. The primary benefit of this technique is economies of scale and lower initial R&D and manufacturing line investments. The majority of players are expected to choose this method as a strategy for entrance in the market. Purpose design, on the other hand, aims to create new vehicles that allow for additional innovations, features, and functions. The design was created specifically to fulfil the requirements of electric mobility. As a result, the design strategy chosen will have an influence on the vehicle manufacturers' value chain and their capacity to distinguish their product offers. The supply chain interruption might have an impact on logistics management as well. Managing the flow of products used to be simple, but the batteries in electric vehicles will provide new issues. The battery in electric vehicles is expensive, heavy, and big, and it contains toxic chemicals. To keep logistics, freight, and insurance costs under control, one critical component would be the distance from the battery plants to the assembly lines.

Modes of collaborations

Battery technology and logistical management, as previously said, would be critical to success. The following are some of the tactics that vehicle manufacturers might use to maintain their relevance in the sector:

- Joint venture: For instance, a joint business venture between the manufacturers of the battery and those of the automobile.
- Acquisition: For instance, the acquisition of the battery manufacturer by the automobile organisation.
- Vertical integration: For instance, an in house R&D team is developed by the automobile manufacturer in addition to a production line.
- Strategic suppliers: Procurement of batteries by the auto manufacturer continues from their strategic partners.

As a result, some involved parties have already started to expand the products they offer while reducing risks on the supply-side. Producers of components used in EVs, OEMs, fleet procurers, as well as operators of charging stations, all took strategic steps in the area below.

CLASSIFICATION OF ELECTRIC VEHICLE SUPPLY EQUIPMENT

Electric Vehicle Supply Equipment (EVSE) is a of equipments with specialised functionalities for supplying electrical energy to an EV for the purpose of charging from a fixed supply network and/or electrical installation. EVSEs are classified in several ways based on their power source (AC or DC), power rating levels, charging speed, and communication and connection type. Each of these classes is briefly described in the sections below.

Fast charging

They are chargers with a higher output power that can be used to charge a car upto 80% in upto 15 minutes of time. These charging ports are already popular and vary from 20 to 50 kW. In the medium future, 100kW charging systems may be accessible. These are excellent for use on the majority of road networks, motorways, as well as other locations where a speedy charge may be needed by the driver for the trip onwards, while 20 kW chargers may be a feasible alternative in the case where electrical supplies are limited. Fast charging is also employed when huge cars with large batteries require more power to accomplish a reasonable charge time.

Swapping Batteries

In the battery switching system, the battery is separated from the car and will be owned by an energy operator rather than the vehicle owner (providing charged battery as a service). The energy company can purchase the batteries, charge them, and lend them to car owners at “charge-cum-swap” locations. These batteries may be replaced at a dedicated station through exchanging a depleted battery with a charged one in this mechanism. As a result, the cars do not require quick charging or huge battery packs.

Systems for extending range (RE) systems

These are fitted into vehicles that have a tiny fixed battery built in addition to a detachable secondary battery known as “range-extension swappable lock smart (LS) batteries” (or RE battery). This lesser capacity battery may be conductively charged on a regular basis to cater to shorter journeys, while the RE battery can be switched in for a longer travel. As a result, RE systems lower vehicle upfront costs and reduce the weight of the vehicle, which remains an important efficiency factor in electric vehicles.

Wireless charging

In-motion (dynamic) wireless charging have come up as a promising option to provide better uptime, lighter battery packs, and autonomous solutions in EVs. Qualcomm Technologies, Inc. announced the HaloTM Wireless Electric Vehicle Charging (WEVC) system, which supports power transfers wirelessly of 3.7 kW, 7.4 kW, 11 kW, and 22 kW using one primary base pad with a power transfer efficiency of more than 90%. in the wireless regime. Wireless charging presently has two major drawbacks: alignment of electric-vehicle chargers and interference from foreign objects.

Renewable energy charging

The environmental effect of driving an electric car is mostly determined by the power sources utilised to charge the vehicles' batteries. The use of wind and solar-powered charging for electric vehicles might boost renewable energy adoption and penetration. This will boost EVs' green energy charging ratio even further. The marriage of renewable energy sources (RES) and electric vehicles (EVs) necessitates synchronisation of the charging periods of EVs with RES production periods, as well as the capability to discharge EVs in the event of a significant production shortfall in RES or if capabilities for vehicle to grid power transfer are available.

ASSESSMENT OF THE VIABILITY TO SET UP CHARGING STATIONS

Quick development and deployment of charging infrastructure commensurate with the growth in EV numbers is necessary for speeding up the adoption of EVs. As a result of low assimilation of EVs which causes even lower utilization of assets in terms of hour duty cycle of charging stations, skepticism is common among investors in development of such infrastructure. In addition to this, as a result of quick developments in battery technology and hesitancy towards the EVSE standards, the technological risk appears greater. For the purpose of addressing the concerns of potential investors regarding these apprehensions, the Government of India is planning to lean towards technological agnosticism for the adoption of the standards and assessing the Viability Gap Funding (VGF) instruments give encouragement to the market. The analysis here dives deeper to assess the viability of operations of charging stations and further focuses on determination of the key drivers of cost to assist the policy-makers as well as investors in taking steps to ensure that the operations are sustainable.

Assessment of viability for deploying a DC fast charger: In addition to capital subsidy

A major barrier towards widespread adaptation of EVs is touted to be the range anxiety associated with owning an EV. For organisations that maintain large fleets, or even private vehicle owners who wish to drive their vehicles out of the state, DC fast chargers are inevitable for sustainably fulfilling the energy needs of their operations.

As a result of the lower number of EVs in operation at this point, lower utilization may result in assets being stranded and a higher price loading on the retail pricing of an already expensive DC charger, which also faces stiff difficulties in capital recovery.

These factors might deter the general populace and EV users from using public DC fast chargers. In this section, we cover a model that looks to determine the feasibility of a DC fast charging station, while managing to capture the elements that could ease the deployment for the same.

Scenario for Deployment

A typical charging station might be located at a public parking lot owned by a city corporation that has leased the parking lot to an agency for maintenance and revenue collection. The charging stations in this setting might consist of a slow AC charger, faster DC chargers or both; which depends on the location, duration as well as the general purpose of the given parking lot. For the purpose of this study, we developed a model on a scenario that the parking operator sets up a fast DC charging station of 22 kW power. This station consists of a lone DC charging outlet and is primarily for charging batteries that have a capacity of around 18.55 kWh. Based on the electric cars currently available in the Indian markets, we assume a full charged range of 120 kms from the EV. We also assume the losses across active and passive components as well as conversion to be about 20%.

Since a fast charger operating on DC charges an EV to 80% capacity in a CC (constant current) mode, the charging station operator needs to obtain ~20% more power in order to account for the power losses and might even load the losses to the consumer. As a result, parking-lot deployed DC fast chargers will need to apply for a metered connection seperately for the sole use of EV charging from the DISCOM.

The DISCOM bills the operator at a tariff of of INR 7.5 per kWh. The operator must apply for a low tension commercial connection or it may also be a EV charging special consumer category. The operator must not charge a mark up on the electricity to share the benefits of the special tariffs, if provided by the DISCOM. However, the operator can charge a 30% mark-up upon the fixed costs to recover initial investments for the purpose of installations as well as operating the station.

Location of deployment of a charging station: Assumptions

- The model explores the setting-up of one DC fast charger which includes a single rapid charging outlet at public parking lot of Municipal Corporation of Delhi.
- Parking price is typically are about INR 20 an hour, with a 5% YOY (year-on-year) escalation.
- A 30% mark-up is also considered on top of the INR 20 parking charges an hour for the purpose of recovering the initial investments put into the charging station.
- We have also considered the fact that the operator must pay INR 10,000 a month as rent to the agency which has leased the lot, or its owner.
- The charging station operates for a period of 30 days annually.
- One charging point is available in the DC rapid charging station.
- The DC rapid-charger is taken to be rated for a power of 22kW.
- One DC fast-charger is assumed to cost INR 2.5 Lakh.
- A 75% capital subsidy is considered on the DC fast charger.
- A 10 year operational life of the charger is assumed.
- The cost of installation is taken to be 25% of the cost of capital of the DC rapid-charger.
- 1% of capital cost is assumed reserved for annual maintenance, and a YOY escalation of 2% is considered.
- We also assume that the electric vehicle brought to this station will be charged to 80% capacity.

- Charger loss is assumed to be 20%.
- A 6-hour a day duty cycle is assumed with a YOY improvement of about 2%.

A cost-of-debt of 10% with a 10-year repayment period is assumed, and the WACC (weighted average cost of capital) is 13%. Ratio of debt and equity for the model is taken at 70:30. Moratorium period for repayment has not been considered since the duration of charger installation ranges from anywhere between a few days to a month.

Other assumptions

- A spread out over 10 years is taken for the depreciation, which is equal to the life of the charger, for straight line value method (SLM).
- 80% depreciatoin is assumed by the written down value method (WDV).
- Taxes: MAT – 19%, Cess – 3%, Surcharge – 12%, basic tax – 30%.

Revenue model

The operator of the charging station is billed by the DISCOM for power on a per unit basis (kWh). EV users who park their vehicle and charge it are billed by the operator. The operator, thus, charges EV owners in the units of time (per minute). Since the benefit of the electricity tariff for owners is passed on to them, a markup of about ~30% on the INR 20 an hour parking charges will be taken for the purpose of capital investment recovery done by the operator. EV user is charged a complex price on a per unit time basis that comprises of parking as well as power charges.

Figure3: Deployment model for a DC fast charging station in a public parking EV charging
Source: Self Analysis

The given figure described the model of deploymeny for a DC rapid charging station in a parking lot. The table below summarizes a summary of the assumptions taken for the model.

Table 4: Assumptions taken for the model developed

Deployment location	MCD parking lot
Charger type	DC fast charger
Installation cost (INR)	2,50,000
Capital subsidy %	75%
Installation cost (INR)	62,500
Maintenance cost %	1%
Cost of electricity (INR/kWh	7.50
Mark up on cost of electricity (%)	0%
Duration of charge event (hours per charge)	0.84
Number of charge events per day	7.12
Retail price per minute of charging paid by EV user (INR/min)	4.00
Weighted average cost of capital (WACC)	13%

On equity, the internal rate of return (IRR) is found to be 30.2% and net present value (NPV) was found to be INR 48,161.

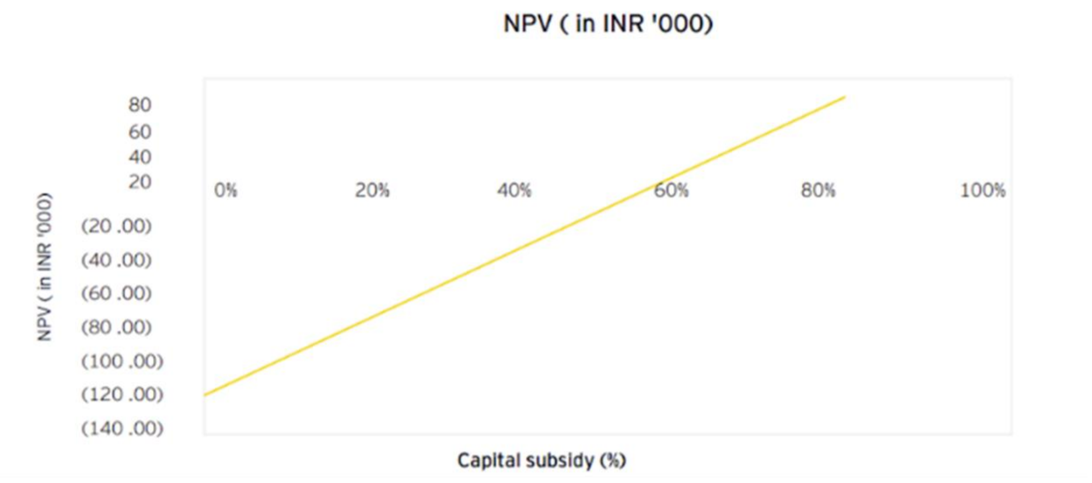


Figure 4: Net present value dependence on capital subsidy
Source: Self-Analysis

The given Figure 4 tries to delve into NPV sensitivity as a function of capital subsidy percentage on the EVSE purchase cost. The project was concluded to be viable, i.e NPV is determined to be positive and non zero, in the case when the capital subsidy is more than 45%. Furthermore, deducing from the figure, the effort turns out to be feasible if more than 45% subsidy is given, since NPV goes beyond 0, whereas the equity IRR equals 30.2%, that is greater than the weighted mean of the capital cost.

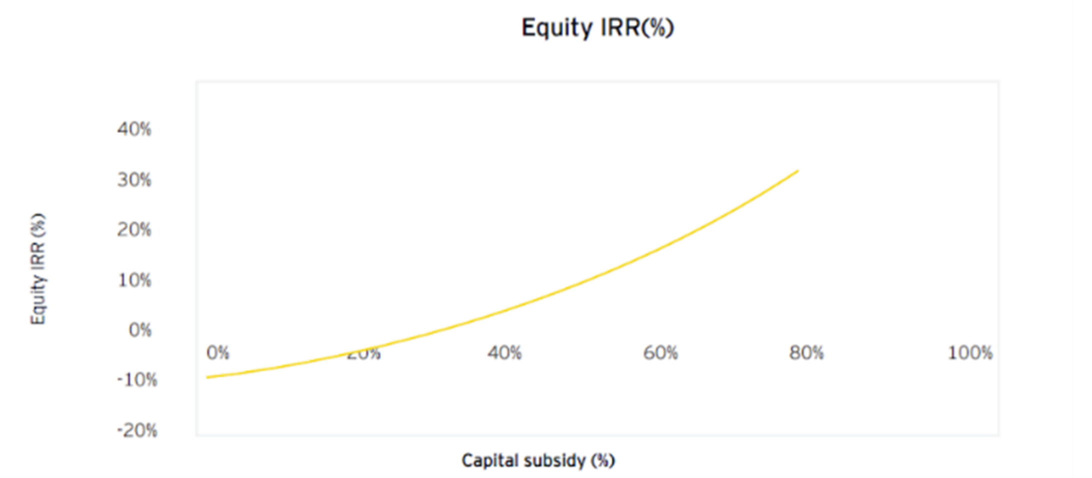


Figure5: Equity IRR variation with capital subsidy

Source: Self-Analysis

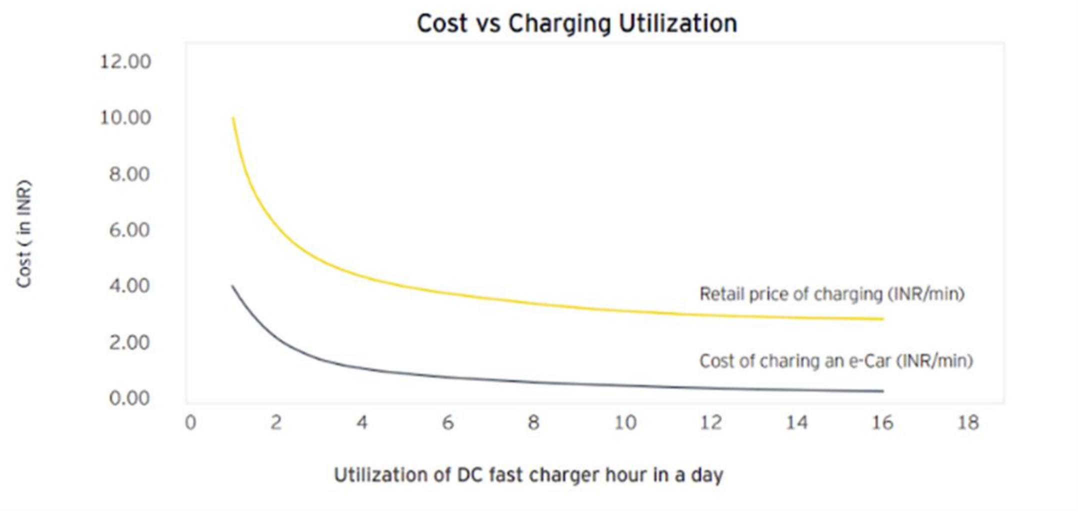


Figure 6: Change in retail price of charging with hours of use of a DC fast charger
Source: Self-Analysis

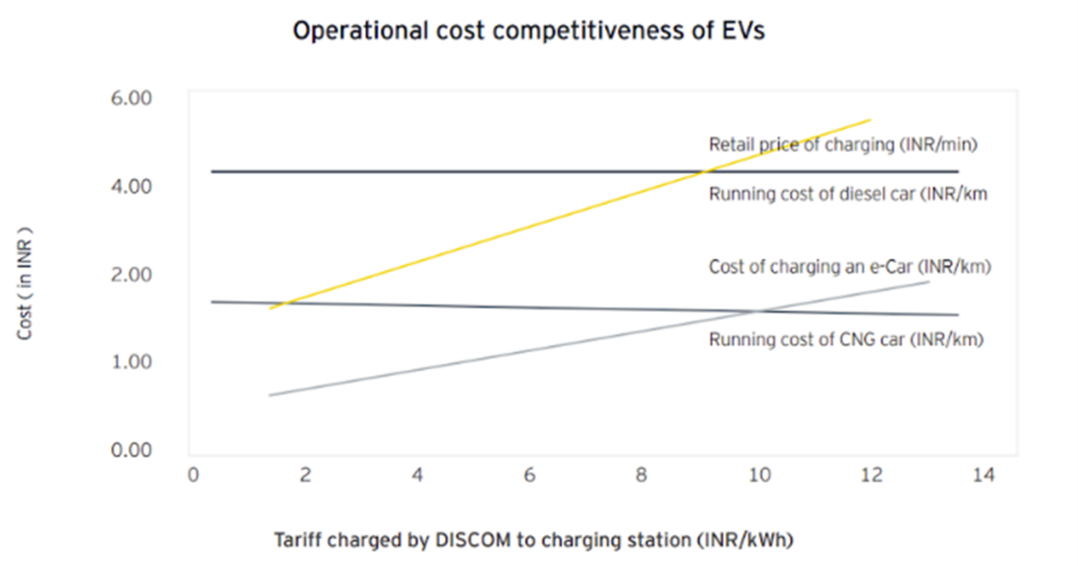


Figure 7: Operational Cost competitiveness of EVs
Source: Self-Analysis

We observed and concluded that more utilization of the EVSE corresponds to lower retail per minute costing charged by the operator of the charging station. The retail pricing was observed to be INR 4 for every charging minute, and while the charging station operator will bill the owner of the EV taking into consideration the fact that the charging station will effectively be utilized about 6 hours a day and a total duration of 330 days in a year. The model also takes into consideration the fact that 35 days a year on average will be downtime for the charging station due to maintenance. Thus, operating an EV 4 wheeler with a full charge range of 130kms and 18.55kWh of storage in the battery, is calculated to be about INR 1.54 per kilometer. In contrast, the cost of running a similar class diesel or CNG powered internal combustion engine (ICE) car was found to be INR 4.20 and INR 1.85 per kilometer respectively. However, given that the tariff paid by the operators to the DISCOMS goes beyond the cost of INR 8.5 for every unit, we then concluded the fact that the EVs fall behind in their lower operational cost advantage.

According to the "Charging Infrastructure for Electric Vehicles – Guidelines and Standards – Regulation (dt. 14th December 2018)", a cost of average supply cost plus 15% is the maximum cost for supply of electricity for the purpose of Public EV Charging Stations. This is a landmark guideline, if we consider the fact that once ACS takes into account the losses as well as the power purchase cost, DISCOMs can be adequately compensated for losses. As a result, this guideline is unlikely to financially burden DISCOMs unless the losses run beyond 15%. Thus, it manages to keep the EV operational cost low enough to maintain the advantage of price for operators of fleets and private owners to move from fossil-fuel based transport to electric vehicles. The operations of the DISCOMs are further supported through this, in widening their consumer base and generating more revenue for the purpose of taking up infrastructure augmentation work in order to make their distribution networks more robust.

CONCLUSION

We expect that the adaptation of electric mobility will be a development led by cities, where a collaboration of various city-level stakeholders in order to minimize the risks (for eg. availability of land) by the use of sustainable and viable business models. The perfect adaptation of these at the city level must be built on a phased manner of planning and procurement, all the while considering the city-specific technological and commercial needs.

The following critical areas need to be factored into the implementation plans:

1. Identification of strategic locations by employing route planning as well as the electric load analysis at the feeder level.
2. Transport infrastructure assessment.
3. Analysis of viability for structuring pilots and for the purpose of exploring alternatives for PPP models.

It is essential to develop a detailed and suitable DPR as well as planning the intricacies for the implementation which factors in the various targets for adaptation, (which can be phase-wise), CAPEX requirements as well as assessing the needs for augmentation of the infrastructure both for the uses of transportation as well as energy. It must also consider the lessons from pilot programs underway or completed in other parts of India or the world.

ANNEXURE 1: BUSINESS MODEL DATA SHEETS

Source: Self-analysis

Charging requirement	
Battery capacity (kW. H)	17.6
Number of chargers at station	1

Taxes	w/o cess	eff.
Corporate tax	30%	35%
MAT	19%	21%
Surcharge	12%	
Education cess	3%	

Depreciation	
Book depreciation	6.67%
Tax depreciation	80.00%
WDV (no. of years)	15
SLM (no. of years)	15

Source of Funds	
Debt	70%
Equity	30%
Interest rate	5%
Repayment yrs.	10
Discount rate	13%

Useful conversions	
Minutes in an Hour	60
Hours in a day	24
Months in a year	12
Days in a year	365
Discount rate	13%

Type	Charger cost	Charging rate	Charging time	Installation cost	Maintenance cost %	Maintenance cost	Escalation in maintenance cost
Unit	(INR)	(kW)	(hrs)	(INR)	(% of installation cost)	(INR)	(%)
DC Fast charger	2,50,000	44	0.50	12500	1%	125	2%

Revenue assumptions	Commercial space
Cost of electricity (INR/kWh)	3.50
Escalation in cost of electricity	0%
Mark up on cost of electricity (%)	57%
Cost of electricity to consumer (INR/ kWh)	5.5
Duration of charge event (hrs per charge)	0.50
# of charge events per day	48
Charger utilization (hrs per day)	24.0
Per charge fixed fee	0
Escalation in per charge fixed fee	1%
Discount on charging fee (% per session)	0%
Monthly membership fee (INR/ month)	0
Number of charges	0
Lease expenses (INR/ month)	0
Escalation in lease rental	0%
Overheads (% of maint. Cost)	0%
Fixed revenue sharing with EVSP	0%
Var. revenue sharing with EVSP	0%
Total project cost	1,68,000
Debt	1,17,600
Equity	50,400

	6-Jul-18	6-Jul-19	6-Jul-20	6-Jul-21	6-Jul-22	6-Jul-23	6-Jul-24	6-Jul-25	6-Jul-26	6-Jul-27	6-Jul-28
Revenue											
Variable fee		70,664	70,664	70,664	70,664	70,664	70,664	70,664	70,664	70,664	70,664
Total revenue		70,664	70,664	70,664	70,664	70,664	70,664	70,664	70,664	70,664	70,664
Cost											
Electricity cost		44,968	44,968	44,968	44,968	44,968	44,968	44,968	44,968	44,968	44,968
Maintenance cost		125	125	125	125	125	125	125	125	125	125
Lease expenses		-	-	-	-	-	-	-	-	-	-
Total operating costs		45,093	45,093	45,093	45,093	45,093	45,093	45,093	45,093	45,093	45,093
EBITDA		25,571	25,571	25,571	25,571	25,571	25,571	25,571	25,571	25,571	25,571
Depreciation		17,500	17,500	17,500	17,500	17,500	17,500	17,500	17,500	17,500	17,500
Interest expenses		5,586	4,998	4,410	3,822	3,234	2,646	2,058	1,470	882	294
PBT		2,485	3,073	3,661	4,249	4,837	5,425	6,013	6,601	7,189	7,777
Tax		530	656	781	907	1,032	1,158	1,283	1,409	1,534	1,660
PAT		1,955	2,417	2,880	3,342	3,805	4,267	4,730	5,192	5,655	6,117
Cash flows											
Capex	(50,400)										
Subsidy	-										
Loan movement		(11,760)	(11,760)	(11,760)	(11,760)	(11,760)	(11,760)	(11,760)	(11,760)	(11,760)	(11,760)
Depreciation		17,500	17,500	17,500	17,500	17,500	17,500	17,500	17,500	17,500	17,500
FCFE	(50,400)	7,695	8,157	8,620	9,082	9,545	10,007	10,470	10,932	11,395	11,857

	6-Jul-18	6-Jul-19	6-Jul-20	6-Jul-21	6-Jul-22	6-Jul-23	6-Jul-24	6-Jul-25	6-Jul-26	6-Jul-27	6-Jul-28
Less: Tax Depreciation		(2,10,000)	(42,000)	(8,400)	(1,680)	(336)	(67)	(13)	(3)	(1)	(0)
Less: Tax Depreciation		(1,90,015)	(2,11,442)	(1,98,681)	(1,78,612)	(1,56,611)	(1,33,753)	(1,10,254)	(86,155)	(61,467)	(36,190)
MAT		530	656	781	907	1,032	1,158	1,283	1,409	1,534	1,660

Income Tax	-	-	-	-	-	-	-	-	-	-
Tax Payable Before Accounting for Mat Credit	530	656	781	907	1,032	1,158	1,283	1,409	1,534	1,660
Opening MAT	-	530	1,186	1,967	2,874	3,907	5,064	6,348	7,756	9,291
MAT Credit Earned	530	656	781	907	1,032	1,158	1,283	1,409	1,534	1,660
MAT Credit Setoff	-	-	-	-	-	-	-	-	-	-
Closing MAT	530	1,186	1,967	2,874	3,907	5,064	6,348	7,756	9,291	10,950
Tax to be paid	530	656	781	907	1,032	1,158	1,283	1,409	1,534	1,660
Effective tax rate of PBT (%)	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%

	6-Jul-18	6-Jul-19	6-Jul-20	6-Jul-21	6-Jul-22	6-Jul-23	6-Jul-24	6-Jul-25	6-Jul-26	6-Jul-27	6-Jul-28
NPV	155										
Eq. IRR	13.1%										
Book Depreciation schedule											
Opening block		2,62,500	2,45,000	2,27,500	2,10,000	1,92,500	1,75,000	1,57,500	1,40,000	1,22,500	1,05,000
Book Depreciation		17,500	17,500	17,500	17,500	17,500	17,500	17,500	17,500	17,500	17,500
Closing block for book dep.		2,45,000	2,27,500	2,10,000	1,92,500	1,75,000	1,57,500	1,40,000	1,22,500	1,05,000	87,500
Tax Depreciation Schedule											
Opening block		2,62,500	52,500	10,500	2,100	420	84	17	3	1	0
Tax Depreciation		2,10,000	42,000	8,400	1,680	336	67	13	3	1	0
Closing block for tax dep.		52,500	10,500	2,100	420	84	17	3	1	0	0
Interest schedule											
Opening debt		1,17,600	1,05,840	94,080	82,320	70,560	58,800	47,040	35,280	23,520	11,760
Interest expenses		5,586.00	4,998	4,410	3,822	3,234	2,646	2,058	1,470	882	294
Repayment		11,760	11,760	11,760	11,760	11,760	11,760	11,760	11,760	11,760	11,760
Closing debt		1,05,840	94,080	82,320	70,560	58,800	47,040	35,280	23,520	11,760	-
Tax schedule											
PBT		2,485	3,073	3,661	4,249	4,837	5,425	6,013	6,601	7,189	7,777
Add: Book Depreciation		17,500	17,500	17,500	17,500	17,500	17,500	17,500	17,500	17,500	17,500

ANNEXURE 2-SURVEY

Adaptation of Electric Vehicles in India

I appreciate you taking the time out to fill this survey. The objective of my research is to understand our current feelings towards, and our expectations of the future of the electric car. Your responses will be held confidential and will only be used for educational purposes. This online survey will not take more than 1 to 2 minutes.

* Required

1. Are you environmentally conscious? *

Mark only one oval.

- Always
- Sometimes
- Never

2. Do you think electric cars are environment friendly? *

Mark only one oval.

- Agree
- Disagree

3. Do electric cars have any advantage over oil (petrol/diesel) powered cars? *

Mark only one oval.

- Yes, alot
- Not very much
- Not at all

4. Do you or anyone in your family own a car? *

Mark only one oval.

- Yes
- No

5. Do you want to own an Electric Car? *

Mark only one oval.

- Yes
- No
- Maybe
- Already have an Electric Car

6. Are you planning to buy a car? *

Mark only one oval.

- Yes
- in the next few months
- in the next few years
- in about 10 years
- after 10 years

7. Do you think electric cars will surpass fuel based cars in near future? *

Mark only one oval.

- Yes
- No
- Can't say

8. What do you think are the drawbacks of electric cars? (can select multiple) *

Check all that apply.

- [ ] Initial cost
- [ ] Cost of Maintenance
- [ ] Vehicle Performance
- [ ] Unavailability of charging stations at all places
- [ ] Lack of knowledge and awareness about Electric Vehicles
- [ ] Less number of models
- [ ] Time to charge battery
- [ ] Cost of travel per kilometer compared to oil
- [ ] What if the car is out of charge in middle of the journey

9. Do you think Electric Cars are economical overall? *

Mark only one oval.

- Yes
- No
- Maybe

10. What percentage more would you pay for a new electric car with same performance of a gasoline car? *

Mark only one oval.

- 0%
- Upto 10%
- Upto 20%
- Upto 30%
- Upto 40%
- Upto 50%
- Upto 60%
- Upto 70%
- Upto 80%
- Upto 90%
- Upto 100%

11. Which of the following would you prefer if an electrical model is available? *

Mark only one oval.

- Car
- Bike
- Scooter
- Rickshaws
- Skateboard

12. What part of India are you from? *

Mark only one oval.

- North
- South
- East
- West
- Central

13. What is your occupation? *

Mark only one oval.

- Engineer
- Business
- Service/Job
- Homemaker
- Self Employed
- Student
- Other: ______________________

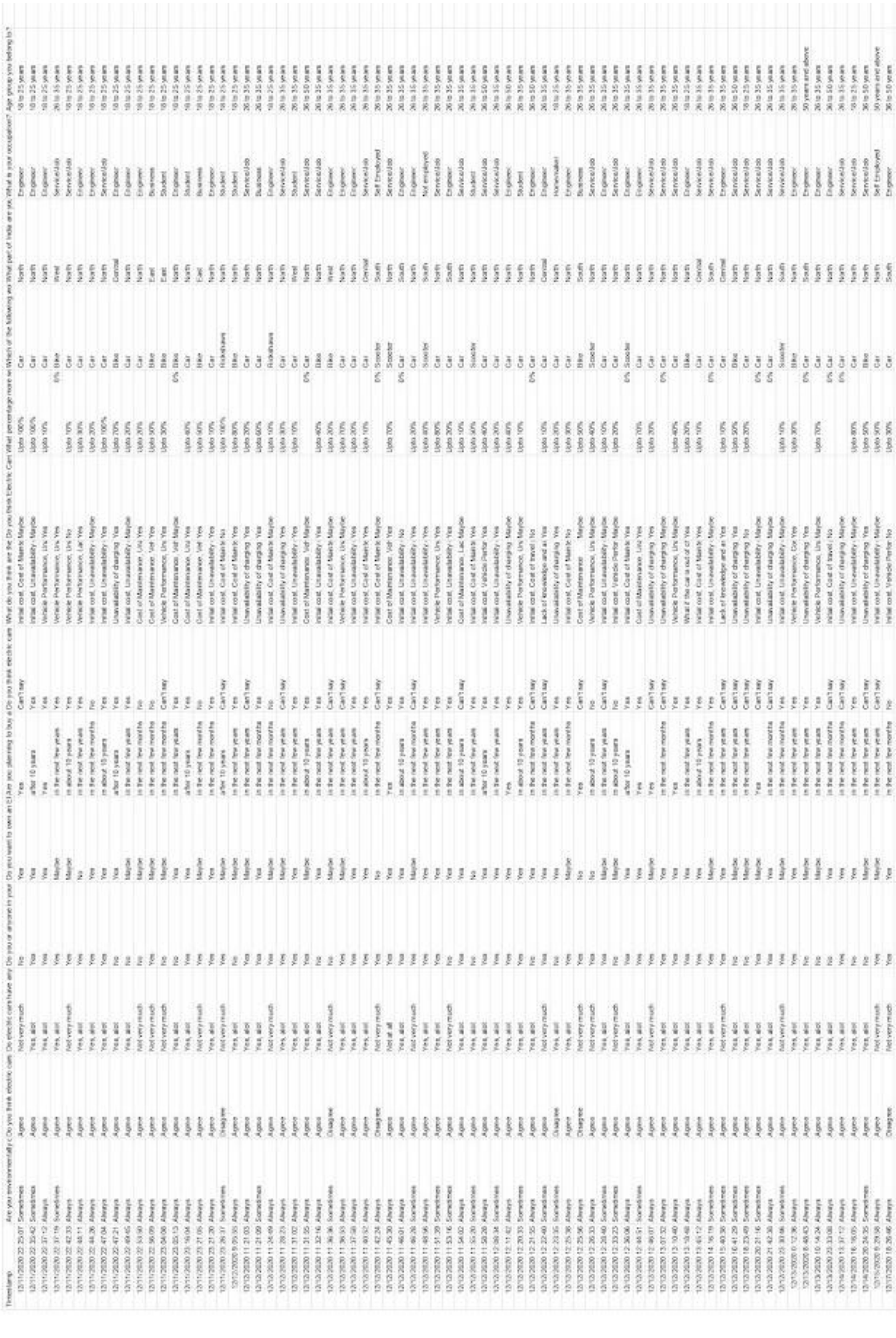
14. Age group you belong to? *

Mark only one oval.

- 18 to 25 years
- 26 to 35 years
- 36 to 50 years
- 50 years and above

Google Forms

ANNEXURE 3-SURVEY RESPONSES



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