ELECTRIC MOBILITY IN INDIA: POLICIES AND ADOPTABILITY A STUDY WITH SPECIAL REFERENCE TO PASSENGER CARS

Synopsis

Submitted in the partial fulfillment for the requirement of

Doctor of Philosophy

In

APPLIED BUSINESS ECONOMICS

SUBMITTED BY

AKANKSHA PATHAK

UNDER THE SUPERVISION

PROF. V. K. GANGAL

(Supervisor)

PROF. JYOTI GOGIA

(Co-Supervisor)

DEPARTMENT APPLIED BUSINESS OF ECONOMICS, FACULTY OF COMMERCE

DAYALBAGH EDUCATIONAL INSTITUTE (DEEMED TO BE UNIVERSITY)

DAYALBAGH, AGRA-282005

2022

CONTENTS

1. INTRODUCTION - THE INDIAN AUTOMOBILE INDUSTRY

The automobile industry is a pillar of the Indian economy and a key driver of macroeconomic growth and technological advancement. The automobile industry comprises the automobile and auto component sectors. It includes passenger cars; light, medium, and heavy commercial vehicles; three-wheelers, four-wheelers, etc.; and auto components like engine parts, drive and transmission parts, suspension, and braking parts, electrical, body and chassis parts; etc.

The Indian automobile industry has made rapid strides since the de-licensing and opening of the sector in 1991. It has witnessed the entry of several new manufacturers with state-of-art technology. Thus, the monopoly of few manufacturers in the Indian market comes to an end. The Indian automobile industry is the fourth largest in the world with an annual turnover of

$100 billion and employs about 32 million people. The two-wheeler industry in India is the largest in the world. India is also the largest tractor manufacturer and the eighth largest commercial vehicles manufacturer in the world. India became the fourth largest auto market in 2019 displacing Germany with about 3.99 million units sold in the passenger and commercial vehicles categories. India is expected to displace Japan as the third-largest auto market by 2021. The two-wheelers segments dominate the market in terms of volume owing to a growing middle class and a young population. Moreover, the growing interest of the companies in exploring the rural markets further aided the growth of the sector.

2. ELECTRIC MOBILITY IS A DIFFERENT BALL GAME

'Electric Vehicles' are defined as vehicles that use an electric motor for propulsion instead of an internal combustion engine that generates power by burning a mix of fuel and gases. (Simpson 2011). The electricity used to run the motor could come through either transmission wires, as is the case with electric locomotives, metro trains, and trams, or through a single or a series of connected batteries, as is the case in electric bikes and electric cars or it could be generated on board using a fuel cell. Thus, 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, fuel cells, or an electric generator to convert fuel to electricity.

EVs came in prominence again for a short period briefly after World War II. In the period from the

early 1950s to the late 1980s, there were several attempts to popularize EVs. Along with electric cars, electric trams were among the earliest electric vehicles to gain acceptance in cities. Even today, several cities in developed countries have well-functioning electric trams for public transportation. The trams began declining in the 1960s in favor of diesel buses, which became the preferred mode for public transportation.

EVs include a large range of vehicles from electric two-wheelers, three-wheelers (rickshaws),cars, and electric buses. The term electric two-wheelers (E2Ws) is used for both electric bicycles, and electric scooters, while electric four-wheelers (E4Ws) is used for electric cars, E3W is used to refer to electric 3-wheelers (including E-rickshaws), and E bus to refer to electric buses. In addition, plug-in electric vehicles can be classified into two types: battery electric vehicles (BEVs), and plug-in hybrid electric vehicles (PHEVs). BEVs have anelectric motor in place of a combustion engine and use electricity from the grid stored in batteries. Plug-in hybrid electric vehicles (PHEV) use batteries to power an electric motor and liquid fuel such as gasoline or diesel to power an internal combustion engine or another propulsion source (US DoE, 2014). EVs can go beyond the above-mentioned technology-based classification3 and can be classified based on their attributes such as

i) Charging time,
ii) Driving range, and
iii) The maximum load it can carry. Of these attributes, the charging time of batteries (i.e., the time required to fully charge the battery) and driving range (i.e. the maximum distance an EV can run when fully charged) are perhaps the two most important characteristics of an electric vehicle of concern to the consumer. Charging time depends on the input power characteristics (i.e., input voltage and current), battery type, and battery capacity.

2.1 REASONS FOR ADOPTING ELECTRIC MOBILITY

On 9 January 2013 the Prime Minister of India launched the National Electric Mobility Mission Plan (NEMMP) **to enhance national energy security, mitigate adverse environmental impacts (including CO2)** from road transport vehicles and boost domestic manufacturing capabilities for electric vehicles. **The Mission Plan envisions 6-7 million units of new vehicle sales of the full range of electric vehicles, along with resultant liquidfuel savings of 2.2 – 2.5 million tonnes.**

In this report future scenarios of passenger transport in India have been analyzed with a specific focus on the role of EVs.

The report discusses the global development of electric vehicles from a historical perspective and the emerging trends provides an overview of India's achievement and policy landscape for EVs and analyze three different scenarios for EVs. The scenarios span from 2010 to 2035.The report proposes a roadmap for EVs markets, ongoing research, and touches upon the future of EV technology. The report makes a case for the role of electric vehicles as a sustainable mobility option for India.

As per the IEA report of 2009 fossil fuels-based transportation is the second-largest source of CO_2 emissions globally. In 2030 the global energy consumption is likely to rise by 53% and about three-quarters of the projected increase in oil demand will come from transportation. World over these concerns is driving governments and automotive industries alike to invest heavily towards developing vehicles based on alternate propulsion systems including electric mobility. This coupled with the hardening of the crude prices is leading to increasing the trade deficit. This poses a serious challenge to India's energy (fuel) security. Therefore, all measures need to take to lessoning the dependence on fossil fuels for the country's energy requirements.

3. POLICIES AND INITIATIVES FOR ELECTRIC MOBILITY

The government of India recognizes the urgency to look at sustainable mobility solutions to reduce dependency on imported energy sources, reduce GHG emissions and mitigate adverse impacts from transportation. To mitigate these, a portfolio of interventions has been planned which includes fuel efficiency improvement of vehicles, improving inspection and certification systems for reducing emissions from on-road vehicles, urban planning improving mass transport, shift to alternative fuels and technologies including biofuels and electric vehicles, and overall system efficiency of infrastructure. As part of the Alternative Fuel for Surface Transportation Program, the Ministry of New and Renewable Energy (MNRE) promotes research, development, and demonstration projects on electric vehicles. Recently, India launched the National Electric Mobility Mission Plan (NEMMP) aimed to incentivize electric vehicle production and sales with a total proposed investment of Rs 224 billion (equivalent to US$ 4 Billion) by 2020. The key strategies proposed in the NEMMP are as follows:

National Electric Mobility Mission Plan (NEMMP) 2020 was announced by the government of India to enhance national energy security, mitigate the adverse impact of vehicles on the environment, and growth of domestic manufacturing capabilities (GoI, 2012). The Planenvisages the following:

- A total investment of $ 4 – 4.5 billion which includes investments in R&D and electric vehicle infrastructure by the private sector. The proposed Investment by the government is $
- 2.7 – 3 billion.
- Government investment will include the rollout of demand incentives. The joint government-industry investment will include investment in R&D, power infrastructure, and fuel procurement for power generation
- 6-7 million units of new vehicle sales of the full range of electric vehicles, along with resultant liquid fuel savings of 2.2 – 2.5 million tonnes can be achieved.
- Savings from the decrease in liquid fossil fuel consumption because of the shift to electric mobility alone will far exceed the support provided thereby making this a highly economically viable proposition.
- Substantial lowering of vehicular emissions and decrease in carbon dioxide emissions by 1.3%-1.5% in 2020 as compared to the status quo scenario.
- Phase-wise strategy for Research and Development, demand and supply incentives, manufacturing, and infrastructure upgrade.
- Key Initiatives & Strategies under the National Electric Mobility Mission Plan (NEMMP 2020)

Table 1: Interventions

Focus Areas	Interventions
Demand Creation	Working group on demand and supply to look at demand and supply incentives, hybrid retro fitment kits, to develop schemes, timelines and milestones Look at possible options for including a cash incentive to Original Equipment Manufacturers (OEM), the tax incentive to OEMs,cash incentive or tax exemption to the consumer.
Research And Development	Collaborative approach between academia, research institutes, industries, and government Working group of stakeholders to detail out theimplementation Setting up of enabling rules, guidelines and policies Identifying specific R&D projects, resources required, prioritization and phasing Identifying areas and agencies for international cooperation Three subgroups in the area of Battery Management Systems (BMS) and batteries, power, electronics and motors and testing infrastructure/HR/efficient technologies

Manufacturing	Phase I: Start with local assembly of EVs with local or imported products and increase local sourcing. Industry government collaboration in R&D and product development centers Phase II: Developing indigenousproducts. 25-30% of EV products sourced locally Phase III: Industry to develop indigenous manufacturing capability. Phase IV: Target the export market
Charging Infrastructure	Phase I: the preparatory phase, evaluation of options, assessment of innovative energy delivery business options including battery swapping, smart metering, putting in place the framework, enabling policies, charging infrastructure standards and laws Phase II: Deeper impact assessment studies, roll out pilot projects in cities, consortium building, testing of various strategies and models, business models for recycling of batteries, finalizing standards for infrastructure Phase III: Ensure reliable electricity supply, adequate recharging facilities with convenient access, viable business models, the linkage between EV charging infra and RE supply systems, public charging infrastructure

3.1 RECENT INITIATIVES FOR ELECTRIC MOBILITY

The Government of India encourages foreign investment in the automobile sector and has allowed 100% foreign direct investment (FDI) under the automatic route. Some of the recent initiatives taken by the Government of India are -

- Under Union Budget 2019-20, the Government announced to provide additional income tax deduction of Rs. 1.5 lakh (US$ 2,146) on the interest paid on the loans taken to purchase EVs.
- The Government aims to develop India as a global manufacturing center and a Research and Development (R&D) hub.
- Under NATRiP, the Government of India is planning to set up R&D centers at a total cost of US$ 388.5 million to enable the industry to be on par with global standards.
- The Ministry of Heavy Industries, Government of India has shortlisted 11 cities in the country for the introduction of EVs in their public transport systems under the FAME (Faster Adoption and Manufacturing of (Hybrid) and Electric Vehicles in India) scheme. The Government will also set up an incubation center for start-ups workingin the EVs space.
- In February 2019, the Government of India approved the FAME-II scheme with a fund requirement of Rs. 10,000 crore (US$ 1.39 billion) for FY20-22.

4. REVIEW OF LITERATURE

The reviews present here have been divided in two sections, the reviews 1 to 12 are discussing the reasons of adoptability of electric vehicles due to environmental point of view, the reviews from13 to 32 are related to government policies, government initiatives

and selected variables in study.

1. **Benjamin, Klor (2014):** Electric vehicles (EVs) are considered as a ground-breaking innovation for making transportation services more sustainable. Electric vehicle batteries (EVBs) are the major technological components of electric vehicles and account for up to one- third of the EVs' initial price. Due to continued cell degradation, EVBs need to be removed from the EVs after some time, but might still be reused in different scenarios such as stationary applications. EVBs that cannot be reused must be recycled to retain valuable materials such as cobalt, lithium, and nickel. The purpose of this paper is to develop a business process model for the reverse logistics of EVBs, transporting them from car workshops to their next usage sites or adequate recycling facilities.

2. **Carlos Olavo Quandt (1994)** The California Air Resources Board has mandated that by 1998 2% of new vehicles sold in California must be zero-emission, effectively, electric vehicles. In this paper competing electric vehicle technologies are reviewed, leading public and private electric vehicle research programs worldwide are summarized, and the barriers faced by competing for technological systems in terms of manufacturing and infrastructural requirements are examined.

3. **Fanchao Liao et al. (2016)** Widespread adoption of electric vehicles (EVs) may contribute to the alleviation of problems such as environmental pollution, global warming, and oil dependency. However, the current market penetration of EVs is relatively low despite many governments implementing strong promotion policies. This paper presents a comprehensive review of studies on consumer preferences for EV, aiming to better inform policymakers and give direction to further research. A categorization of influential factors for consumer preferences into groups such as socioeconomic variables, psychological factors, mobility conditions, social influence, etc. is then made and their effects are elaborated. Finally, we discuss a research agenda to improve EV consumer preference studies and give recommendations for further research.

4. **Jane Lina et al. (2015)** This paper presents a General Electric Vehicle Routing Problem (EVRP) that finds the optimal routing strategy with minimal travel time cost and energy cost as well as several EVs dispatched. This is the first EVRP model to consider the vehicle load effect on battery consumption. As demonstrated with a case study in Austin TX, the effect of vehicle load on routing strategy cannot be ignored. Compared to diesel truck VRP, EVRP has comparable travel time and

distance but long en-route re-charging time, which translates into a considerable amount of additional labor cost. Lastly, the network topology greatly affects the routing strategies.

5. **Jonn Axsen et al. (2016)** Plug-in electric vehicles (PEVs), which we refer to in this paper as electric vehicles, have the potential to significantly reduce greenhouse gas emissions from transportation. This includes pure battery electric vehicles (BEVs) that run on only electricity, and plug-in hybrids (PHEVs) that run on both electricity and gasoline with Canada's current electric grid, an electric vehicle could reduce emissions by 45% to 98% compared to a conventional gasoline vehicle. These reductions will become even more substantial as provinces continue to move towards low-carbon sources of electricity.

6. **Ning Wang et al. (2018)** Environmental issues and energy security have led governments to introduce lots of incentive policies on electric vehicle promotion. Benefiting from policy dividend, the global threshold of 1 million electric cars on the road had been exceeded in 2015, closing at 1.26 million. Among these incentive policies, the subsidy scheme was regarded as the most important and effective. However, many governments intend to abrogate subsidies for electric vehicles, such as China, America, and Germany. It`s worth finding out the key factors including incentive measures and additional socio-economic factors that promote electricvehicle adoption.

7. **Scott Hardmana et al. (2018)** This paper presents a literature review of studies that investigate infrastructure needs to support the market introduction of plug-in electric vehicles (PEVs). It focuses on literature relating to consumer preferences for charging infrastructure, and how consumers interact with and use this infrastructure. These studies indicate that the most important location for PEV charging is at home, followed by work, and then public locations. Studies have found that more effort is needed to ensure consumers have easy access to PEV charging and that charging at home, work or public locations should not be free of cost. Research indicates that PEV charging will not impact electricity grids in the short term; however, charging may need to be managed when the vehicles are deployed in greater numbers.

8. **Shiqi Oua et al. (2017)** The Passenger Cars Corporate Average Fuel Consumption and New Energy Vehicle Credit Regulation (dual-credit policy) were enacted by the Chinese government in

2017 to stimulate the fuel-efficient and electrification technologies in China's passenger vehicle market. This study summarizes the dual-credit policy and develops the New Energy and Oil Consumption Credits Model to quantify the impacts of this policy on consumer choices and industry profits, where internal subsidies as decision variables are used to represent industry responses to the policy. Scenarios in 2016-2020 are simulated and discussed. Key findings from the model results include: (1) the Corporate Average Fuel Consumption rules alone may stimulate more plug-in electric vehicle (PEV) sales than the dual-credit policy; however, (2) the dual-credit policy could stimulate more battery electric vehicles (BEVs) in the market, compared to other policy scenarios.

9. **Sovacool, Benjamin K et al. (2019)** in comparing the developments of global corporate product innovation and technological innovations systems around the BMW i3 and the Fiat 500e, we draw numerous conclusions. Although both products can be regarded as a response from automotive firms to the imperative of decarburization, they represent initially different approaches: with the i3, BMW decided on a transformative change-shaping, radical approach to creating new value by launching an innovation project as a niche within the own company to develop sustainable "mega city vehicles" which later became an own sub-brand. They manufactured a new car with a unique design and prominently proclaimed that the "future is electric". With the 500e, Fiat decided on a conservative sustaining, constrained approach to maintaining value.

10. **Uwe Tietge et al. (2016)** reveals Electrifying passenger cars, is seen as a key measure to curbing GHG emissions and to ensuring a healthy environment for the European population. Automakers and governments alike, therefore, are vying for the pole position in electric mobility. Numerous European governments, including Germany, France, the Netherlands, and the United Kingdom (UK), have introduced targets for their electric vehicle (EV) fleet.

11. **Xiaoyu Gu et al. (2017)** Batteries installed on electric vehicles (EVs) should normally be removed when their capacity falls to 70-80%, but they are still usable for other purposes, such as energy storage. This paper studies an EV battery closed-loop supply chain (CLSC) consisting of a battery manufacturer and a remanufacturer. The purpose of this research is to maximize individual profits through optimizing the amount of manufacturing and remanufacturing respectively and optimizing the purchase price of returned batteries.

12. Ziyang Wua et al. (2019) contributes to better understanding the interregional variability in vehicle carbon footprints and presents a case study of China's electric vehicle (EV) charging infrastructure promotion plan (EVSE2020). Based on an integrated hybrid life-cycle assessment(LCA) with new regional electricity mixes and the Thermal Emission Imaging System (THEMIS) model with local inventories, the carbon footprints of battery electric vehicles (BEVs) and internal combustion engine vehicles (ICEVs) are calculated for all size segments.

13. A.K. Digalwar et al. (2015): The automobile industry is at its maximum growth for few years because of revolutionary changes in Information Technology and greater living standards created by the citizens of India. The booming market puts a lot of pressure on the available stagnant resources like crude oil, natural gas, fossil fuels, etc. The supply and demand are crossing the breakeven point and the situation can be worsened if an alternative doesn't replace the existing crisis. The Electric Vehicle (EV) is one of the alternative solutions to overcome the crises. But EV market is at a nascent stage in India when compared with other developed and emerging countries. Many factors affect the growth of the electric vehicle market in India. The present paper discusses the most critical factors for the promotion and development of the EV market in India with the help of an Interpretive Structural Model (ISM).

14. Anu G Kumara et al. (2015) This paper attempts to provide strategies to increase the cost advantage of Electric vehicles by reducing its payback period by exploring the possibility of the vehicle to home(V2H) scheme and thus to increase the willingness to pay (WTP) of thecustomer. The biggest beneficiary of this scheme will be the Indian power grid. This scheme will enable capacity enhancement during peak load hours in the Indian scenario utilizing the stored energy available in the electric vehicle using the V2H system. An electric vehicle can be used as a storage methodology i.e. when electric vehicles are parked and connected to a charger, it acts as a storage space for electrical energy. An Indian 11kV distribution network is used to conduct the case study, to illustrate the effectiveness of the developed concept for reducing peak demand. The hypothesis presented by the author is specific for a State, nevertheless, these findings are heterogeneous enough across the country and this can significantly increase social benefits for the whole nation. Overall results indicate that implementation of V2H can go a long way in addressing two of the present major technological

problems of cost disadvantage of electric vehicles and peak leveling of the Indian power grid by identifying and exploring potential cost-benefit avenues to reduce the payback period of EV's and thereby making them a technology of our everyday life rather than an idealistic plan of a distant future.

15. Brett Smith et al. (2017), have conducted a study, A Stated Choice (SC) survey, employing a Best-Worst choice design, was administered to 440 households in Perth, Australia as part of a major investigation into consumer preferences and attitudes towards electric vehicles. It was noted that 48 (10.9%) respondents chose EV as their best/most preferred option across all six choice replications. They hypothesized that for most of these respondents their choices reflected their desire to present themselves in a favorable light, with social desirability biases manifested in non-trading behavior. There were also 24 (5.5%) respondents who chose EV as their worst/ least preferred option. They hypothesized that for these respondent's lack of interest or confidence in the new technology and inertia may have driven their decisions. The study offers demographic and psychographic profiles of non-traders facilitated by additional items being included in the experiment. While there was little difference between the demographic profiles, the attitudinal scores of the non-traders were significantly higher than for traders, which may indicate social desirability. From a choice modeling perspective, keeping non- traders in the estimation biases the taste parameters and therefore the willingness-to-pay (WTP) measures. However, when incorporating the worst alternatives into the choice models, the 'social desirability' non-traders do appear to be making decisions based on the attributes, whichis consistent with the rest of the sample.

16. Bharti Motwani (2019): This study used 9 independent factors about characteristics of electric cars and developed a regression model for determining the buying behavior of the customer. The analysis was done using R software. The study found that mobility and recharging characteristics were found to be the most significant factors while RTO norms were considered to be the least significant characteristic affecting the buying decision of electric cars.The model developed from our study was 88% accurate and hence can be used for predictingthe buying behavior of the customer. This study is of prime importance to the companies that wanted to launch electric cars in India.

17. Eskinder D et al. (2015) Resource challenges in a short-term time perspective can be better

addressed by including social and geopolitical factors in addition to the conventional indicators which are based on their geological availability. This is more significant for modern technologies such as electronic devices in which critical resources contribute to important components. The case study advances the use of the Geopolitical risk assessment method but does still face certain limitations that need further elaboration; however, directions for futureresearch are promising.

18. John Paul Helveston et al. (2015) They find that with the combined bundle of attributes offered by vehicles available today, gasoline vehicles continue in both countries to be most attractive to consumers, and American respondents have significantly lower relative willingness-to-pay for BEV technology than Chinese respondents. This implies the potential for earlier BEV adoption in China, given adequate supply. While there are clear national security benefits for the adoption of BEVs in China, the local and global social impact is unclear: With higher electricity generation emissions in China, a transition to BEVs may reduce oil consumption at the expense of increased air pollution and/or greenhouse gas emissions. On the other hand, demand from China could increase global incentives for electric vehicle technology development with the potential to reduce emissions in countries where electricity generation is associated with lower emissions.

19. Kaarina Hyvönen et al. (2016) Light electric vehicles may challenge established forms of transport shortly. This paper looks at how different kinds of consumers assess the future uses oflight electric vehicles. Such uses are further characterized by examining how they could replacethe current uses of existing modes of transport such as cycling, cars, and public transport. The paper approaches the takeup of light electric vehicles from the vantage point of technological niches which have the potential to transit to sociotechnical regimes. It considers insights from recent user studies on light electric transport and broadens their scope to include a wider range of vehicles. Data from a representative survey of 1030 Finns are used to analyze and characterize future uses of light electric vehicles. Currently, light electric vehicles remaintechnological niches, but consumers show interest in them, and the paper addresses the match between different kinds of consumers and these vehicles, building opportunities for large-scale use.

20. M.A. Hannan et al.(2013) There are several alternative energy resources being studied for hybrid vehicles as preparation to replace the exhausted supply of petroleum worldwide. The use of

fossil fuel in vehicles is a rising concern due to its harmful environmental effects. Among other sources battery, fuel cell (FC), super capacitors (SC), and photovoltaic cell i.e., solar are studied for vehicle application. Combinations of these sources of renewable energies can be applied for hybrid electric vehicles (HEV) for the next generation of transportation. Various aspects and techniques of HEV from energy management systems (EMS), power conditioning, and propulsion system are explored in this paper. Other related fields of HEV such as DC machine and vehicle systems are also included. Accordingly, this review has been lighted many factors, challenges, and problems for a sustainable next-generation hybrid vehicle.

21. **Pooja Goela et al. (2021):** It is a harsh fact that the introduction of various government schemes to push electric vehicles (EV) utilization does not seem to appeal to the consumers. There are a few barriers that prevent consumers from purchasing EVs. Thus, in the present study, we have tried to identify and analyze the prominent barriers to the adoption of EVs by scrutinizing the existing literature and defining new barriers. From the literature review, 35 barriers have been initially identified in the context of the Indian market. The study uses the Decision-Making Trial and Evaluation Laboratory (DEMATEL) approach for its analysis.

22. **Rachana Vidhi et al. (2018):** Electric vehicles reduce pollution only if a high percentage of the electricity mix comes from renewable sources and if the battery manufacturing takes placeat a site far from the vehicle use region. Industries developed due to increased electric vehicle adoption may also cause additional air pollution. The Indian government has committed to solving New Delhi's air pollution issues through an ambitious policy of switching 100% of the light-duty consumer vehicles to electric vehicles by 2030. To reduce air pollution through the adoption of electric vehicles, the Indian government needs to adopt policies that increase the sale of electric vehicles, increase the percentage of renewable energy in the electricity mix, and prevent air pollution caused by battery manufacturing. The recommended policies can be customized for any market globally for reducing air pollution through the increased adoption of electric vehicles.

23. **Rubal Dua A et al. (2021)** The Indian government is considering plug-in electric vehicle (PEV) deployment as one solution to address the issues of air pollution, energy security, and climate change. We investigate the potential for PEV adoption in India, the challenges in meeting the country's goals,

and ways to overcome them. We utilize a survey of 51 experts in the Indian light-duty vehicle (LDV) ecosystem to address these questions. Most experts indicate that India will marginally miss its 30% PEV sales target by 2030. The main reasons cited for this are PEVs' high upfront cost, a lack of policies promoting PEVs, and alack of charging infrastructure. Experts believe the lack of domestic PEV battery and manufacturing supply chains will limit the supply of low-cost PEVs to the Indian market. The lack of land availability and high land rent prices in Indian cities is cited as the major barrier to the establishment of charging infrastructure. The experts view a PEV sales mandate and incentives, such as 'feebates,' as the most effective policy levers, while believing a ban on conventional vehicle sales by 2030 was unlikely. The findings hold significance for understanding the future of India's LDV sector and the associated energy and environmental impacts, which have global implications.

24. Sai Shao et al. (2017): This study states that an electric vehicle-routing problem (EVRP) is developed to settle some operation distribution troubles such as battery energy limitations and difficulties in finding charging stations for electric vehicles (EVs). Meanwhile, given realistic traffic conditions and features of EVs, energy consumption with travel speed and cargo load is considered in the EVRP model. Moreover, to avoid the depletion of all battery power and ensure safe operation, EVs with insufficient battery power can be recharged at charging stations many times in transit. In conclusion, a large, realistic case study with the road network of Beijing urban, 100 customers, and 30 charging stations is conducted to test the performance of the model and obtain an optimal operation scheme consisted of the routes, charging plan, and driving paths. The EVRP model is solved based on the hybrid genetic algorithm to get the routes and charging plan. The dynamic Dijkstra algorithm with some improvements over the classical Dijkstra algorithm is applied to find the driving paths called the most energy-efficient paths between any two adjacent visited nodes in the routes.

25. Scott Hardman et al. (2016) revealed that the Battery electric vehicle adoption research has been ongoing for two decades. The contribution of this paper, however, is the distinction between two groups of adopters. These are high-end adopters and low-end adopters. It is found that each group has a different socio-economic profile and there are also some psychographic differences. Further, they have different opinions of their vehicles with high-end adoptersviewing their vehicles more

preferentially. Finally, reasons for this are explored by comparing each adopter group's opinions of their vehicles to their future purchase intentions. From this isit suggested that time to refuel and range for low-end battery electric vehicles should be improved to increase chances of drivers continuing with BEV ownership.

26. Siang Fui Tie et al. (2012) The issues of global warming and depletion of fossil fuels have paved opportunities for electric vehicles (EVs). Moreover, the rapid development of power electronics technologies has even realized high energy-efficient vehicles. EV could be the alternative to decrease the global greenhouse gases emission as the energy consumption in the world transportation is high. However, EV faces huge challenges in battery cost since one-third of the EV cost lies on battery. This paper reviews state-of-the-art of energy sources, storage devices, power converters, low-level control energy management strategies, and high supervisor control algorithms used in EV. The comparison of advantages and disadvantages of vehicle technology is highlighted. In addition, the standards and patterns of drive cycles for EV are also outlined.

27. Stefan Trommer et al.2015) The socioeconomic characteristics of early adopters of electric vehicles (EVs) differ from those of buyers of conventional vehicles, as do their attitudestowards new technologies, their mobility, and their awareness of environmental issues. They are found to have a higher average income, a higher level of education, and more cars at their disposal per household. However, most of the existing studies are based on small samples or used stated preference surveys which attempted to describe potential purchasers of EVs. Furthermore, when it comes to the kind of EV, most of the studies analyze the adoption of battery electric vehicles (BEVs) only, with just a few looking at the adoption of plug-in hybrid electric vehicles (PHEVs). An analysis of representative data collected from more than 3,000 owners of BEVs, and PHEVs in Germany partially confirms the findings mentioned but finds that aspects such as socioeconomic characteristics and their attitudes vary greatly among EV users.

28. Subash Dhar et al. (2016) The findings show that: in the reference scenario, the EVs 2- wheelers will achieve a significant share by 2050. Electric 4-wheelers though would have a small share even in 2050; EV push policies though lead to significant diffusion of electric 2- wheelers in India by 2030. These policies enhance the diffusion of electric 4-wheelers only if financial incentives are sustained in

the long-term, iii) the application of global carbon price on the Indian economy in the 2 C stabilization scenario increases the competitiveness of EVs and results in the near-total share of electric 2-wheelers by 2030 and a sizable share of electric 4- wheelers by 2050. The results show asymmetry in the impacts of national and global policieson co-benefits from EV. The EV supply push policies deliver moderate benefits vis-a-vis air pollution and energy security indicators but make insignificant contributions to CO2 emissions reduction. This is complemented by an analysis of general attitudes of EV owners towards factors such as the image of EVs, environmental awareness, and mode choice. To conclude, the willingness to pay for technologies such as fast-charging, inductive charging, and battery sizeselection is analyzed.

29. Sierzchula, William A et al. (2014) stated that Electric vehicles represent an innovation with the potential to lower greenhouse gas emissions and help mitigate the causes of climate change. However, externalities including the appropriability of knowledge and pollution abatement result in societal/economic benefits that are not incorporated in electric vehicle prices. To address resulting market failures, governments have employed several policies. Researchers seek to determine the relationship of one such policy instrument (consumer financial incentives) to electric vehicle adoption. Based on existing literature, we identified several additional socio-economic factors that are expected to be influential in determining electric vehicle adoption rates. Using multiple linear regression analysis, we examined the relationship between those variables and 30 national electric vehicle market shares for the year 2012. The model found financial incentives, charging infrastructure, and local presence of production facilities to be significant and positively correlated to a country's electric vehicle market share. Results suggest that of those factors, charging infrastructure was most strongly related toelectric vehicle adoption. However, descriptive analysis suggests that neither financial incentives nor charging infrastructure ensure high electric vehicle adoption rates.

30. X. D. XUE et al. (2003) Based on the requirements of electric vehicles on electric motor drives, this paper presents three criteria to evaluate the motoring operation of in-wheel switched reluctance motor drives for electric vehicles. They are the average torque, the average torqueper RMS current, and the torque smoothness factor. They indicate the motoring torque, copper loss, and torque ripple, respectively. The model of motoring operation under the current hysteresis control is developed to

investigate the effects of the turn-on angle, the turn-off angle, and the current reference on these criteria. The simulated and measured current waveforms verify the proposed model. The simulated results show that the turn-on angle and the turn-off angles have considerable effects on the motoring operation of switched reluctance drives. The optimal turn-on angle and the optimal turn-off angle can be optimized to maximize the average torque, the average torque per RMS current, or the torque smoothness factor. In addition, the larger current reference results in the larger average torque, average torque per RMS current, and torque smoothness factor. Thus, this study helps develop a new control method to implement the best motoring operation of in-wheel switched reluctance motor drives in electric vehicles.

31. Xingping Zhang et al. (2014): Electric vehicles (EVs) have prominent advantages for reducing CO2 emissions and alleviating the dependence on fossil fuel consumption in the transport sector. Therefore, many countries have set targets for EV development in recent years and have employed several policies to achieve environmental objectives and alleviate the energy pressure. Even though the adoption of EVs has increased in the past few years, more policies, such as financial incentives, technology support, or charging infrastructure, should be made by governments to promote a broader range of use of EVs. In this study, they review the relevant policies that different countries may adopt for stimulating the market of EVs. Based onthis, we analyze the relationship between the policies and the adoption of EVs by taking America as an example. In conclusion, some effective policies are summarized to spur the market. Therefore, each country should learn from each other and employ effective policiesbased on the actual situation.

32. Zoe Long et al. (2019) despite policy support and technological progress, consumer adoption of electric vehicles remains limited globally. One important barrier to electric vehicle adoption may be limited consumer awareness. We investigate trends in consumer awareness, familiarity, and experience with electric vehicles by comparing cross-sectional survey responses from two representative samples of Canadian new vehicle-buyers collected in 2013(n = 2922) and 2017 (n = 1808). While a significantly higher proportion of 2017 respondents have ‘heard of’ key electric vehicle models, stated familiarity and experience are low for both samples. Further, about three-quarters of respondents in both samples are confused about the basic notion of how to refuel (or

recharge) electric vehicles—and how these vehicles differ from hybrids. Conversely, over half of 2017 respondents report having seen at least one electricvehicle charger in public, which is more than double the proportion reported in the 2013 sample. These trends hold in analyses of three Canadian provinces, including two that have engaged in significant consumer outreach activities over this time frame. Overall, in contrast to expectations, our results suggest that consumer awareness remains low and stagnant, which may hinder market growth and inhibit the climate mitigation potential of electric vehicles.

5. RESEARCH GAP

During the review process, the researcher finds the following research gaps:

- Most of the studies are analyzing the policies of advanced countries in respect of Electric Vehicles based on analysis of government policies and plans on electric vehicles. There are few studies in the public domain, analyzing the preparation of the Indian government for replacing fossil fuel and rebuilding of Indian Automobile Industry. **The proposed study will highlight the policies and measures adopted by the Indian Government for clean and green mobility on Indian roads.**
- Numbers of studies describing the options of fossil fuel for the automobile industry worldwide. **The proposed study will try to collect and examine the point views of different experts of the automobile industry in respect of electrifying mobility.**
- Numbers of studies describing the different concept, models developed for adopting the non-traditional sources of fuel may be used by the automobile industry to save the environment worldwide. There are very few studies, evaluating the preparation of the automobile industry in India and comparing its position to the world automobile industry. **In this study, the researcher will try to examine the preparedness of the major manufacturers of passenger cars through their concept models and expenditure on research & development.**
- There is a very little number of studies describing the consumers' perception of Electric Vehicles in India and whatever the studies are available, conducting the consumer survey in metro cities taking an elite class of the society as respondents for it. **Thus, the study will find out the awareness and perceptions about the EVs in** general and passenger cars in particular in two-tier cities of the country takingthe respondents from the middle class of the society.

- The present studies are restricted to find the **'Reasons to Use'** the electric vehicles intheir consumer survey.

5.1 NEED OF THE STUDY

The continuous degradation in the ecosystem compels humans to think differently for their mobility on road. Electronic Vehicles have been identified as the best possible option of fossil fuel for the upcoming future to protect the environment worldwide. Here, the effect andthe awareness of electric vehicles on Indian Consumers and their purchase intention towardsit have not been elucidated yet. Therefore, the purpose of this study will:

- **Include both 'Reasons to Use'** and **'Reasons to Not to Use'** the electric vehicles inits survey.
- Assess the market size of the Indian Automobile Industry, and export potential, itscontribution to employment generation, and contribution to the public exchequer.
- Assess the impact on the ecosystem by electrifying mobility.

6. RESEARCH QUESTIONS

The proposed study will try to find the answers to the following research questions:

- Is it do or die situation for India for electric mobility?
- Do we have effective government policies for electric mobility?
- Will electric mobility improve the air quality of Indian cities?
- Will electric mobility improve the adverse situation of the Indian Balance of Payment?
- Will electric mobility be a big boon for the Indian automobile industry?
- Will Indian society adopt electric mobility easily?
- What would the 'Reasons to Adopt' electric mobility by Indian consumers?
- What would the apprehensions of Indian consumers of 'Reasons not to Adopt' ofelectric mobility?
- Does electric mobility contribution to employment generation, and the publicexchequer?

6.1. STATEMENT OF PROBLEM

During the proposed research, the research will focus to find the answer of the following:

"Will social adoptability of EVs enhance national energy security, mitigate adverse environmental impacts (including CO_2) caused by road transport vehicles and boost Indian Automobile Industry?"

7. OBJECTIVES OF THE STUDY

The main objectives of the study will be:

- To study the rationale of electric mobility in India and examine the policies and the measures taken by the Government of India in respect of Electric Vehicles so far.
- To know the awareness level of Indian Consumers regarding the concept of electronicvehicles and the government policies and list out the possible benefits of using electric vehicles.
- To identify and rank the factors for influencing consumers' purchase intention towards Electric Cars.
- To study the preparedness of the major Indian manufacturers of passenger cars through expenditure on R&D, their concept models.
- To suggest action plan for creating the rapid adoptability of electric vehicles and shares the public opinion and apprehensions with manufacturers and government.

8. RESEARCH DESIGN AND METHODOLOGY

8.1 HYPOTHESES

To make the present study more accurate, the researcher will test the following hypotheses:

Ho_1: There are no significant relationship between policies and measures of Governmentof India and electric mobility in India.

Ho_2: There is no significant relationship between 'Use of EVs' and control of CO_2 emissions.

Ho_3: There is no significant awareness among Indian people regarding the concept of electric mobility, policies, and measures of Government for electric mobility, and advantages of it.

Ho_4: There is no significant difference of Indian car buyers preferred to 'Buy' and 'Not to Buy' the EVs.

Ho5: There is no significant relationship between policies and measures of Government of India and preparations of Indian Automobile Industry for electric mobility.

Ho6: There is no significant relationship between expansion of electric mobility and the expansion of Indian Automobile Industry.

8.2 VARIABLES OF THE STUDY

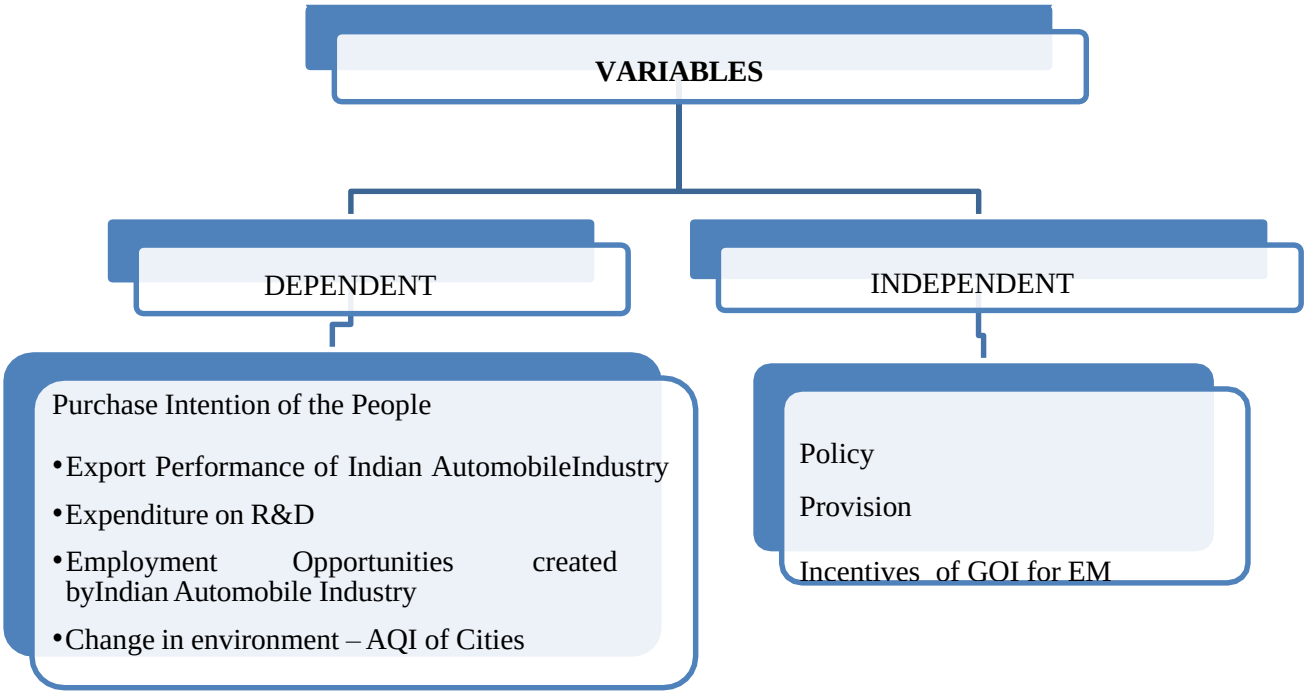

Fig. 1 Variables of the study

8.3 SCOPE OF THE STUDY

In this study, the government policies, different acts related to the automobile industry for controlling the pollution and protecting the environment, committees, and institutions set up, will be included. In addition to major passenger car manufacturers in India (Especially Indians companies) will be included in the study. This study will include the policies, initiatives, and incentives of the government of India. In addition to this, the study will also find out the reasons to adopt and rejects EVs.

8.4 UNIVERSE AND SAMPLE SIZE

Table 2: Universe and Sample Size

SN	Company	Car Model	City	Details
1	Ashok Leyland Ltd	STILE LE 8 STR	Chennai	9th Floor, 1 Sardar Patel Road, Guindy,Chennai – 600032 ,India,Ph : 044 2220 6146/2230 4314 Website: http://www.ashokleyland.com

2	BMW IndiaPvt Ltd	BMW Series 2,3,5,6,7,8,M,X,Z	Gurgaon	2nd Floor, Oberoi Centre, Building No.11, DLF Cyber City, Phase-II, Gurgaon – 122002, India, Ph: 0124- 4566610 Website: http://www.bmw.in/in/en/
3	Fiat India Automobiles Pvt Ltd	Fiat, Urban Cross,Punto, Linea, Evo,Punto Avventura,	Pune	B-19, Ranjangaon MIDC Industrial Area, Ranjangaon, Taluka - Shirur,Pune - 412210 India, Ph : +91-2138-672702 Website : http://www.fiat- india.com
4	Force Motors Ltd	Force Motors Viano	Pune	Mumbai - Pune Road, Akurdi, Pune – 411035, India,Ph : 91-20- 27474488/6381 Website: http://www.forcemotors.com
5	Ford IndiaPvt Ltd	Ford Figo, Aspire	Gurgaon	5th Floor, Plot No. 142, Chimes 142, Sector 44 Road Sector 44, Gurgaon – 122003. India Ph: 91-124-4493000/01 Website: http://www.india.ford.com
6	Honda CarsIndia Ltd	New Amaze, All New City- 5th Generation, City- 4th Generation	NOIDA	Plot No. A-1, Sector 40/41 Surajpur-Kasna Road NOIDA – 203207, India Ph : 95 120-2341313/321/327 Website: http://www.hondacarindia.com
7	Hyundai Motor India Limited	Kona-Elect, Grand I10,I20, I20 N Aura, Verna, Elantra, Venue, Creta, Alcazar, Tucson,	Kanchipuram	Irrungattukottai, NH4, Sriperumbudur Taluk, Dist, Kanchipuram, Kanchipuram – 602105,India Ph: 044-4710 0000 #5108 Website: http://www.hyundai.co.in
8	Isuzu Motors India Pvt Ltd	Mu-X	Chennai	9th Floor, Prestige Centre Court -. Office Block, Vijaya Forum Mall, No 183, NSK Salai, Vadapalani, Chennai - 600035 India, Ph: 044 66111700 Website: http://www.isuzu.in/
9	Kia India Private Limited	Carnival, Forte K5, Niro, Niro-EV, Sportage, Niro Plug-In hybrid Rio, Sedona, Seltos Sorento, Soul, Stinger	Vijayawada	Door No: 27 – 42 – 5, M G Road Governorpet, Vijayawada Krishna, Vijayawada - 520002 India
10	Mahindra & Mahindra Ltd	E-verito Xuv series 300,500,700, Thar, Alturas G4, Scorpio, Bolero Neo Marazzo, Kuv 100 Nxt	Mumbai	Gateway Building Apollo Bunder, Mumbai – 400001 India, Ph: 022-24931441 Fax: 022-24975193 Website: http://www.mahindra.com
11	Maruti India Ltd	Brezza, Dzire, Swift, Alto, Ignis, Baleno Ciaz, XLB	New Delhi	Plot No:1, Nelson Mandela Road, Vasant Kunj, New Delhi - 110070 India Ph: 91 11 4678 1165/66 Website: http://www.marutisuzuki.com

12	Mercedes Benz India Pvt Ltd	Benz EQC Benz A-Class Series of -Benz Amg C 35, 43, 45, 63 Benz Amg E 53 Benz Amg Glc 43, 63 Benz C-Class, Cla 250 Benz E-Class Benz Glb 250, Glc 300 Benz Gle 450, Gls 450 Benz S-Class	Pune	E-3, MIDC Chakan, Phase-III, Chakan Industrial Area, Kuruli & Nighoje, Tq-Khed, Pune – 410501, India Website: http://www.mercedes-benz.co.in
13	MG Motor India Pvt Ltd	Mg Hector, Hector Hector Plus 6-Seater Hector Plus 7 Seater Mg Gloster, Mg Zs Ev	Gurgaon	10th Floor, Milestone Experion Center, Sector-15, Part-II, Gurgaon – 122001, India Ph : 91-124 6111800 Website: http://www.mgmotor.co.in
14	Nissan Motor India Pvt Ltd	Kicks, GT-R Magnite	Chennai	No.36, Vijayaraghava Road T.Nagar, Chennai – 600017, India, Ph: 044-30886000/01 Website: http://www.nissan.in
15	Renault India Pvt Ltd	Kiger, Tribe, Kwid Duster	Chennai	No: 37/38 A S V Ramana Towers 4th Floor Venkat Narayana Road T Nagar, Chennai – 600017, India Ph : 91-44 3910 4210 Website : http://www.renault.co.in
16	Skoda Auto Volkswagen India Pvt. Ltd.	Skoda-Octavia, like the Superb, Laura, Fabia, Yeti and Rapid. Tiguan, Volkswagen- Golf, Jetta or Passat	Pune	E1, MIDC Industrial Area Phase III, Village Nigoje Mhalunge,, Kharabwadi, Tel: Khed, Chakan, Pune – 410501,India Ph: 91-2135-661024 Website:http://www.volkswagen.co.in/en.htm l
17	Tata Motors Ltd	NexonEV Tiago, Altroz, Tigor SUVs- Punch, Safari, Harrier,	Mumbai	Bombay House, 24 Homi Mody Street, Mumbai – 400001,India, Ph : 91-22 – 66657280 : http://www.tatamotors.com/
18	Toyota Kirloskar Motor Pvt Ltd	Glanza, Yaris Vellfire Urban Cruiser, Fortuner, Innova Crysta Camry	Bangalore	Kirloskar Systems Ltd, Embassy Star, 8 Palace Road, Vasanthnagar, Bangalore - 560052http://www.toyotabharat.com/
19	Volvo AutoIndia Pvt Ltd	S60,S90,V90,Cross Country, XC40, XC60 XC90 (PHEV)	Gurugram	BPTP Park Centre, Tower A Gurugram, -122001 India, Ph: 0124 4600450

Sources: Society of Indian Automobile Manufacturers (SIAM)

The above clearly shows that there are 19 passenger cars (Including SUVs & MUVs) manufacturers (5 Indians and 14 MNCs) are working in India at present. The researcher will include all the manufacturers working Indian market as mentioned in the above list. In addition to this, the researcher

will also include the companies coming in the Indian market during the study period, if any.

8.5 COLLECTION OF DATA

To examine and analyze the objectives of the study, both primary and secondary data will be taken into consideration.

Primary Data

The primary data will be collected through structured questionnaires/schedules – one for the public and another for the passenger's car manufacturers. In these questionnaires, the researcher will cover the various aspects of the government policies and acts to electric mobility, public awareness and purchase intention, preparedness of the passenger's car manufacturers, possible changes in environmental conditions, and Problems (Financial, Administrative, and Infrastructural, etc.) faced by people.

In addition to this, the researcher will also talk personally with officials of the Government, Corporate world, financial institutions (Banks and Insurance Companies) Academicians, and NGOs in this regard.

For public survey randomly selected 500 respondents from each city from **table below across religion, caste, gender, income, and literacy will be contacted.**

Table 3: Frame and Smart Cities

SN	FAME* Cities	SN	Others Proposed Smart Cities
1.	Lucknow,	1.	Agra
2.	Jaipur,	2.	Varanasi
3.	Indore,	3.	Jhansi
4.	Jammu	4.	Gwalior

*FAME (Faster Adoption and Manufacturing of (Hybrid) and Electric Vehicles in India) The Ministry of Heavy Industries, Government of India has shortlisted 11 cities in the country for the introduction of EVs in their public transport systems under the scheme.

Secondary Data

The secondary data will be collected from the different ministries of the government of India like MoST, different committees constituted time to time by GoI, different vehicles acts related and for electric mobility, articles in newspapers (Times of India, Hindustan Times, The Economic Times), reports on trend and progress of EVs in India, Journals (The Indian Economy Review, Innovative Journal of Business and Management), Magazines (Auto car India Magazine, Overdrive Automobile

Magazine, Top Gear Magazine, EVO India Magazine, What Car Magazine Motoring World Magazine) and the other different websites (www.financialservices.gov.in, www.rbi.org.in, www.araiindia.com, www.siam.in www.smev.in) of the concerned area.

8.6 RESEARCH METHODOLOGY

The methodology is an important component of the research plan, no research plan is complete withthe proper justification of research methodology.

Table: 4 Objectives Wise Research Methodology

S.N.	OBJECTIVES OF THE STUDY	METHODOLOGY TO BE FOLLOWED
1.	To study the rationale of electric mobility in India and examine the policies and the measures taken by the Government of India in respect of Electric Vehicles so far.	For fulfilling the first two objectives of the study the researcher will examine all the policies of government from 2005 onwards to know the government commitment to electrifying mobility. For this purpose, the government officials, officials of companies, different associations of the Auto industry, and academicians, will be interviewed personally to get in-depth knowledge on the issue. In addition to this, different websites related to the auto industry will be reviewed during the study period. The government officials through the personal interview and survey of the respondents will be used to ratify the secondary information in this regard. The time series analysis will be used for this purpose.
2.	To know the awareness level of Indian Consumers regarding the concept of electronic vehicles and the government policies and list out the possible benefits of using electric vehicles.	
3.	To identify and rank the factors for influencing consumers' purchase intention towards Electric Cars.	For the third and fourth objectives, a public survey will be conducted through the structured questionnaire/ schedule to collect the information regarding knowing the awareness about electric
4.	To study the preparedness of the major Indian manufacturers of passenger cars through expenditure on R&D, their concept models.	vehicles, the socio-economic impact identifies the parameters of adopting and not adopting the electric vehicles. For ranking, each parameter will be assigned based on the weighted mean. So primary data will be used to fulfill the third and fourth objectives.
5.	To suggest action plan for creating the rapid adoptability of electric vehicles and shares the public opinion and apprehensions with manufacturers and government.	Based on the final analysis & results of the data, an action plan will be suggested to achieve the last objective of the study.

8.7 TOOLS AND TECHNIQUES

Both types of statistical techniques **Descriptive and inferential statistics will be used to get reliable results and inferences, Factor Analysis, time series analysis, Regression Model, t-test, ANOVA, Chi-square test,** etc. shall be used for analyzing the data as per the nature of data and requirement of the study.

9. CHAPTER PLAN

CHAPTER 1- A JOURNEY OF INDIAN AUTOMOBILE INDUSTRY: PAST ANDFUTURE

CHAPTER 2- RESEARCH LAYOUT

CHAPTER 3- ELECTRIC MOBILITY IN INDIA: A NEW ROAD AHEADCHAPTER 4-

PROFILE OF RESPONDENTS

CHAPTER 5- ANALYSIS AND TESTING OF HYPOTHESES

CHAPTER 6- FINDINGS, SUGGESTIONS AND CONCLUSION

10. IMPLICATION OF THE STUDY

This study will help policymakers to know the ground reality of electrifying mobility in the country. The study will be helpful to the electric vehicle manufacturers' working in India, the government of India, officials of different associations related to the Indian automobile industry, ancillaries' industries of the Indian automobile industry, General insurance companies to know the public reactions, choices,and apprehensions about the EVs. In this study, an attempt will be made to present a comprehensive action plan for the adoptability of EVs particularly based on urban and semi-urban respondents.

This will help to let down the foundation to raise the voice for the environmental, economic, and social issues connected to the automobile industry especially. The researcher thinks the outcome of this study will be helpful to the policymakers for their future planning related to electrifying mobility in India and major changes in the Indian automobile industry.

11. REFERENCES

- Axsen J, Goldberg S, Melton N, 2016, *Electric Vehicle Policy*, pg. #77, Sustainable transportation action research team- Simon Fraser University
- Gu X, Ieromonachou P, Zhou L, 2017, *Optimizing Quantity of Manufacturing and Remanufacturing in an Electric Vehicle Battery Closed-loop Supply Chain*, ISSN: 0263-5577, Altmetric, Emerald logo Taiwan publication
- Hardmana S, Jenna A, Tala G, Axsenb J, Beardc G, Dainad N, Figenbaume E, Jakobssonf N, Jochemg P, Kinnearc N, Plötzh P, Pontesi J, Refaj N, Spreif F, Turrentinea T, Witkamp B, 2018, *A review of consumer preferences of and interactions with electric vehicle charging infrastructure*,

Vol. 62, 2018, ISSN 1361-9209, Pg # 508-523, Transportation Research Part D: Transport and Environment, Elsevier.

- Klor B, Brauer S, Beverungen D, 2014, *A Business Process Model for the Reverse Logistics of Used Electric Vehicle Batteries*, Vol. 12, 2014, ISBN: 978-3-88579-626-8, ISSN: 1617-5468, pg.# 508-521, Conference Paper, Journal- Transportation Research Procedia
- Liao F, Molin E, Wee B.V, 2016, Consumer *preferences for electric vehicles: a literature review*, Vol. 10, 2016, ISSN: 0144-1647, e- ISSN: 1464-5327, Transport Reviews by Routledge
- Lin J, Zhou W, Wolfson O, 2015, *Electric vehicle routing problem*, Vol. 12, June 19, 2015, ISSN 2352-1465, pg. #508-521, Transportation Research Procedia Elsevier
- Oua S, Lina Z, Qib L, Lib J, Hec X, Przesmitzkic S, 2018, *The dual-credit policy: Quantifying the policy impact on plug-in electric vehicle sales and industry profits in China,* Vol. 121, June- 2018, ISSN 0301-4215, pg. #597-610, Energy Policy
- Quandt C.O, 1995, *Manufacturing the Electric Vehicle: A Window of Technological Opportunity*, Volume: 27, Issue: 6, June 1, pg. # 835-862, Journal- Environment and planning
- Sovacool, Benjamin K, Rogge, Jan-Christoph, Saleta, Claudio and Masterson-Cox, Edward,2019, *Transformative versus conservative automotive innovation styles: contrasting the electric vehicle manufacturing strategies for the BMW i3 and Fiat 500e*, Vol. 33, 2019, ISSN 2210-4224, pg. #45-60, Journal- Environmental Innovation and Societal Transitions, Sussex research online digital repository
- Tietge U, Mock P, Lutsey N, Campestrini A, 2016, *Comparison of Leading Electric Vehicle Policy and Deployment in Europe*, 49(30) 847129-102 pg.# 88, WHITE PAPER, International Council on Clean Transportation Europe
- Wang N, Tang L, Pan H, 2018, A *global comparison and assessment of incentive policy on electric vehicle promotion*, Elsevier, Vol. 44, ISSN 2210-6707, pg.# 597-603, Journal- Sustainable Cities and Society
- Wua Z, Wanga B.C, Wolfram P, Zhanga Y, Suns X, Hertwichb E, 2019, *Assessing electric vehicle policy with region-specific carbon footprints*, Vol.256, 113923, ISSN: 0306-2619, pg.#

- Digalwar A.K., Giridhar G, 2015, Interpretive *Structural Modeling Approach for Development of Electric Vehicle*
- *Market in India*, Vol. 26, 2015, ISSN 2212-8271, pg. #40-45, Procedia CIRP Journal, Elsevier
- Dhar S, Pathak M, Shukla P.R, 2017, *Electric vehicles and India's low carbon passenger transport: a long-term co-benefits assessment*, Vol. 146, 2017, ISSN: 0959-6526, pg. #139-148, Journal of Cleaner Production
- Dua R.A, Hardman S, Bhatt Y, Suneja D, 2021, Enablers *and disablers to plug-in electric vehicle adoption in India*, Volume 7, May 2021, https://doi.org/10.1016/j.egyr ISSN 2352-4847, Pages 3171-3188, journal-Energy Reports
- Gemechu E.D, Sonnemann G, Young S.B, 2015, *Geopolitical-related supply risk assessment asa complement to environmental impact assessment: the case of electric vehicles*, v.22no.1pp.31- 39 ISSN 0948-3349, The international journal of the life cycle
- Goela P, Sharmab N, Mathiyazhagan K, 2021, *Government is trying but consumers are not buying: A barrier analysis for electric vehicle sales in India*, Vol. 28, 2021, ISSN 2352-5509, pg. #71-90, Sustainable Production and Consumption
- Hannan M.A, Azidin F.A., Mohamed A, 2013, *Hybrid Electric vehicles and their challenges: A review*, Vol. 29, 2014, ISSN 1364-0321, pg. # 135-150, Renewable and Sustainable Energy Reviews
- Hardman S, Shiu E, Wilckens R.S, 2016, Comparing *high-end and low-end early adopters of battery electric vehicles*, Vol. 88, https://doi.org/10.1016/j.tra.2016.03.010, ISSN 0965-8564. Pg. #40-57, Journal- Transportation Research Part a: Policy and Practice
- Helveston J.P, Liu Y, Feit E.M, Fuchs E, Klampfl E, Michalek J.J, 2015, Will *subsidies drive electric vehicle adoption? Measuring consumer preferences in the U.S. and China*, Vol. 73, https://doi.org/10.1016/j.tra.2015.01.002 ISSN 0965-8564, pg. # 96-112, Journal- Transportation Research Part A: Policy and Practice
- Hyvönen K, Repo P, Lammi M, 2016, *Light electric vehicles: substitution and future use*, Vol. 19, Pg. #258-268, ISSN: 2352-1465, Transportation Research Procedia

- Kumara A.G, Anmol. M.B, Akhil V.S., 2015, A *strategy to Enhance Electric Vehicle Penetration Level in India*,
- Vol. 21, August 2015, Pages 552-559, ISSN 2212-0173, pg. #552-559, Procedia Technology journal
- Liao F, Molin E, Wee B.V, 2012, *A review of energy sources and energy management system in electric vehicles*, Vol. 20, 2012, ISSN 1364-0321, pg. #82-102, DOI: 10.1109/ICIAS.2012.6306229, Renewable and Sustainable Energy Reviews
- Long Z, Axsen J, Kormos C, 2019, *Consumers continue to be confused about electric vehicles: comparing awareness among Canadian new car buyers in 2013 and 2017*, Vol. 14, 114036, Environ. Res. Lett
- Motwani B, 2019, *Customer Buying Intention Towards Electric Vehicle in India*, Vol. 10, Issue 05, May, ISSN Print: 0976-6340, ISSN Online: 0976-6359, pg. #391-398, International Journal of Mechanical Engineering and Technology (IJMET)
- Shao S, Guan W, Bi J, 2018, *Electric vehicle-routing problem with charging demands and energy consumption*, ISSN: 1751-956X, DOI: 10.1049, Institute of Transportation Engineers
- Smith B, Olaru D, Jabeen F, Greaves S, 2017, *Electric vehicles adoption: Environmental enthusiast bias in discrete choice models*, Vol. 51, ISSN: 1361-9209, pg. #290-303, Transport and Environment
- Trommer S, Jarass J, Kolarova V, 2015, *Early Adopters of Electric vehicles in Germany unveiled*, Vol. 7(4), 2015 https://doi.org/10.3390/wevj7040722, ISSN: 2032-6653, pg. # 722-73, world electric vehicle journal
- Vidhi R, Shrivastava P, 2018, *A Review of Electric Vehicle Lifecycle Emissions and Policy Recommendations to Increase EV Penetration in India*, Harvard Extension School, Harvard University, Cambridge, MA 02138
- William Sierzchula A, N, Sjoerd Bakker B, Kees Maat A, B, Bert Van Wee, 2014, *The influence of financial incentives and other socio-economic factors on electric vehicle adoption*, Vol. 68, 2014, ISSN 0301-4215, ISSN: 0301-4215, pg. #183-194, Journal of Energy Policy

- Xue X.D, Lin J.K, Zhang Z, Cheng, Cheung N.C, 2010, Study *of Motoring Operation of In-wheel Switched Reluctance Motor Drives for Electric Vehicles*, Vol:59, Issue: 3, Print ISSN: 0018-9545, Electronic ISSN: 1939-9359, pg. #1191-1204, IEEE Transactions on Vehicular Technology
- Zhang X, Xie J, Rao R, Liang Y, 2014, *Policy Incentives for the Adoption of Electric Vehicles across Countries*, ISSN 2071-1050, doi:10.3390/su6118056, Sustainability, 6, 8