

Mapping Inclination towards Electric Vehicles

Tripti Sagar¹, Vivek Gupta²

*Symbiosis Institute of Business Management Pune;
Symbiosis International (Deemed University) Pune*

Abstract

The global pollution is rising and every effort is being made to make earth a greener and a sustainable planet. India is the third largest greenhouse gas emitter in the world. In order to combat the effects of fuel emissions, The Government of India is promoting the adoption of Electric Vehicles and aims to achieve selling only e-vehicles in India by 2030 with a vision of reducing the carbon emissions. The effect of electric vehicles on air quality and GHG emissions can be favorable. India is currently the 5th largest automobile industry in the world. Currently, e-vehicles sales contribute only around 1% of the total automobile sales. There are multiple reasons because of which the electric vehicles industry in India has been on a back seat. This paper is aimed at mapping the inclination of potential customers towards the factors that are considered most important or the factors that would drive the decision of the customers to purchase and shift to e-vehicles. The factors we are trying to analyze include the range of the vehicle (driving distance), Charging time, Battery recycling, Government policies, Environmental concerns, Speed, charging infrastructure, purchasing cost, maintenance cost, life of the Vehicle and availability of options in each segment at different price points. The methodology used is primary research. Data is collected through a structured questionnaire and the respondents are the potential vehicle buyers

Keywords: *Electric Vehicles, Greenhouse Gases, Charging Infrastructure, Global Warming*

1 Introduction:

Since the pre industrial period, Global warming, which is the long – term heating of the planet’s climate, has been increasing at an alarming rate. According to the 2019 Global Climate Report from NOAA National Centers for Environmental Information, the average rate of increase since 1981 has been twice as great. It is primarily caused by burning of fossil fuels which lead to increase in Greenhouse Gas levels in the atmosphere. India is the third largest greenhouse gas emitter in the world after US and China. India’s higher CO₂ emissions have been stimulated by an increasing consumption of fossil fuels. An overwhelming majority of India's energy is provided by fossil fuels.

The major emissions from motor vehicles because of internal combustion of engines produce greenhouse gases, which lead to climate change and the main GHG being CO₂, but vehicles also produce the greenhouse gases like NO and methane.

An Electric Vehicle is one which is propelled by one or more Electric Motors rather than internal combustion engine. There are majorly four types of electric vehicles:

1. **Battery Electric Vehicle (BEV):** BEVs are fully electric vehicles powered by electricity only and do not have an engine for petrol / diesel, fuel storage or exhaust pipe. For propulsion, they electric motors and motor controllers. They don't have a combustion engine. Electricity is contained in onboard batteries powered by plugging into the power grid. In effect the batteries supply one or more electric motors with power. The initial selling price is greater than equivalent gas-powered vehicles but in the long run one can on gasoline and repair expenses.

2. Plug-in Hybrid Electric Vehicle (PHEV): A PHEV works on fuel and electric power. PHEVs have rechargeable battery packages that offer 20-80 km of all-electric driving, depending on the model, before a fuel engine is needed, for longer journeys. PHEVs have longer average driving ranges than BEVs since they can run on a gasoline engine or generator, they can take advantage of the current network of the gas stations.

3. Hybrid Electric Vehicle (HEV): HEVs are not merely Electric Vehicles. They have both a fuel engine and fuel tank and an electric motor and battery. A hybrid electric generates far less emissions than those generated by pure gasoline-based hybrids which enhance the fuel economy at maximum efficiency. These are cheaper to operate than internal combustion engines because HEVs switch in and out of electric mode. HEVs are more comparable to gas vehicles than EVs, as they do not need charging access.

4. Fuel-cell Electric Vehicle (FCEV): An FCEV produces power from hydrogen and oxygen, rather than store and discharge energy like a battery. Because of the efficiency and water-only pollution of these automobiles, some critics find these cars to be the strongest electric vehicles, even if they are still in the phases of production and face a number of obstacles. Hydrogen extraction from a water molecule is an energy-intensive method that produces greenhouse gas pollution when clean technology is utilized. Over the next few years, FCEVs are predicted to become popular on the market.

The concept of EVs has been around for a long time and it is seen as a replacement for the Combustion Engine Vehicles with the goal of reducing the GHG emissions, pollution and depletion of natural resources. Electric Vehicles are considered to be energy efficient as they convert most of it from grid to the wheels whereas gasoline vehicles convert only around a quarter of the energy stored. They are quieter, operate smoothly, give strong acceleration and require less maintenance. If these are propelled by energy from green sources such as solar, wind or hydroelectricity, the environmental gains of plug-hybrids and electric vehicles increase. The use of EVs would position noise emissions under control. As the EVs would be running on batteries, little or no noise would be produced. This goes a long way to reduce noise pollution, which has become yet another misery on India's busy roads.

There are some concern or pain points in regard to adoption of electric vehicles because of which consumers are hesitant to shift to Electric Vehicles. They have a shorter range of driving than most traditional vehicles, though driving ranges for EV are increasing. Most EVs can travel more than 100 miles per charge, and depending on the model, some can go more than 200 or 300 miles. The EV batteries have long life and the DOE's National Renewable Energy Laboratory's research has shown that batteries in mild climates for 12 to 15 years and in extreme climatic conditions for 8 to 12 years will last. Such batteries are costly, and if they fail, their replacement is expensive.

Thanks to their potential to reduce electricity usage and pollution, electric cars have drawn widespread attention. Scientific knowledge of the precise environmental impacts of electric cars is still emerging, and the impacts of battery manufacturing on the total pollution of electric vehicles is a particularly complex subject. Electric motors are inherently more powerful than combustion engines, and they wind up utilizing more of the electricity in the batteries to power the vehicle. Electric vehicles waste less energy especially while driving in the cities. Emissions of air pollutants including nitrogen oxides and particulate matter do not specifically occur through tailpipe. They still have brake particles and wear due to tyres, but overall, there's a lot less than having a gasoline engine. Health-wise, the biggest advantage is the consistency of the climate. There could be carbon pollution from energy streaming into EVs, though it usually comes from power stations which may have more emission restrictions than in traditional automobiles, and are normally further away from thickly populated zones. Economies of scale would benefit the production of EVs by offering improved infrastructure, more effective production procedures, recycling alternatives and reducing the need for new materials to be mined. Electric cars are not a

solution, but coupled with a larger introduction of renewables and the decarbonization of the power system, they provide a way to substantially minimize greenhouse gas emissions.

In India, a particular set of conditions supporting a sustainable mobility First there is a relative surplus of renewable energy options available to tap. Skilled workers and equipment are widely accessible in the production and IT systems. In addition, India has an infrastructure and market transition that provides opportunities for technology to be implemented at the leap point of growth. It has a shared ethos, which recognizes and encourages the exchange of goods and wealth for the greater good in generally model has provided a capacity for rapid adoption of EVs over ICE vehicles. These conditions have helped India to follow an Electricity Policy that ensures that India's Electricity System is constantly in line with global expectations as major economies continue to take big steps towards the energy of cars. India's growth opportunities give rise to the opportunity for establishing EV leadership in some segments. In this sense, the Strategy will encourage a course that starts with the specific features of India and its automotive industry strategies building on global relevance and execution. The core goals that India would like to achieve with EV strategy are, first, to reduce primary oil use in transport. Second, to promote the use by the consumer of hybrid and renewable powered vehicles In turn, support for this new technology in India by acceptance, adaptation and R & D. There is a chance to enhance the transportation used by the common man. Reducing emissions in cities is also a very powerful driving force. Finally, job growth in the sun-sector can also be encouraged.

The EVs have so far remained in the distance. Nevertheless, technology and battery advances make EVs more appealing to the user due to improved convenience and affordability. EVs have already started to enter the market in a number of Indian cities. Given India's existing auto manufacturing industry, the expected growth in demand for transport and the recent interest in electric vehicles, India has the opportunity to develop a domestic EV industry and to emerge as a global leader in the EV manufacturing market.

E-mobility has already set foot in India. In regard with India, Electric vehicles cannot be disassembled from the effects of emissions, dependence on imports of oil and the desperate need for more renewable energy supplies. This could prove to be a big opportunity for the Automotive Industry. The automotive industry could benefit from seeing it not as a threat, but as an opportunity. The politicians are also beginning to take this seriously, and the social network around the nation is making EV a glittering generality.

The NEMMP 2020 or the National Electric Mobility Mission Plan 2020 is a National Project Document offering the vision and roadmap for the speedier adoption and manufacture of electricity vehicles in the country. This initiative was designed to increase national fuel security, provide inexpensive and eco-friendly transport and make it possible to give lead to the Indian automotive industry worldwide.

The Government has taken many steps to encourage the country's electric mobility. Under the modern GST framework, GST rates on electric vehicles have been held to 12% from 28% GST rate for traditional vehicles. Ministry of Power approved energy purchases to be used as 'service' for electric vehicle charging which would provide an immense opportunity to encourage investment in infrastructure charging. Also, Ministry of Transport Highways have given a notice regarding exemption of permit for Electric Vehicles.

India's goal to sell only EVs by 2030 which the government want to achieve in three phases. First, the goal is to exploit existing economic opportunities, but at the same time planning for strategic alternatives that will be available in the immediate future which includes developing the transportation system. This system includes both the software framework and the physical vehicles on demand. The second phase includes refining and scaling the actions suggested during the first phase, while enabling private players

to participate. The aim of this process is to implement a system-wide solution for mobility. The third step incorporates electricity into the transport system and allows electric vehicles to release energy into the network. By this point all policy benefits will be phased out too. The government is currently working on policies for specific incentives for holders of the two and four-wheeler, and for regions with stronger EV presence.

Through this research project, we aim to study the key factors that can influence a customer's purchase decision. Some the broadly identified factors are:

1. Speed
2. Environmental concerns
3. Driving Range
4. Government Policies
5. Charging infrastructure
6. Battery Recycling
7. Purchasing Cost
8. Manufacturing cost
9. Availability of variants
10. Life of vehicle.

2 Literature Review

Today greenhouse gas emissions are among the world's most significant social concerns. Major improvements in the transport sector are required to reduce pollution, such as reducing the reliance on non-sustainable fuel. [5]. Electric Vehicles are of growing global interest in the sense of long-term pollution goals and have grown into a critical concept. In the Indian EV sector, policy regulations and investment expenditure have also progressed the areas of affordability and charging infrastructures. Electric vehicle purchases (EV) in India in 2019 totaled 0.759 million.[6]

EVs in India have weak acceptance; most people do not have the expertise to deal with EVs. Although the initial selling price for an EV may be high, there are fairly low operational and maintenance costs. This is contrasted with internal combustion engine-driven cars which have higher operating costs. The economic benefits perceived on adoption is one of the variables. As EVs sensitivity is increased, it is also assumed that this variable affects the adoption of EVs. The adoption of high-participation goods will affect self-image and social impact. Attitude is the predictor as the dependent variable of behavioral intent. [8]

There are two aspects of political factors, both of which have a significant relationship with the use of EV and the purchase of EV. Some of the respondents said that the tax incentive for leased electric cars is very important in the Netherlands because many companies now use leasing incentives in particular.

- Tax incentives have the strongest correlation with both EV use and EV purchase.

- 53% of people support government policies and 73% of people support EV-related government incentives.
- The findings justify Gallagher and Muehlegger (2011) who found that the government's financial incentives made consumers decide to purchase EVs. [9]

The purchasing price of Electric Vehicles is one of the financial considerations that may influence the purchasing of EVs. EVs are cost higher than conventional cars and will hinder the embrace of EVs. Another financial factor that car buyers think is the total cost of ownership of EV. As EVs have not been commonly used, and because others have not met, ownership costs cannot be adequately calculated by individuals-i.e. operating and repair costs. The 2013 U.S. public awareness survey found that the benefits of EVs were incorrectly interpreted by two-thirds of respondents. The sales price and expected fuel consumption and maintenance savings were mistaken. One of the main success drivers of EV's is the variety of various tests, with consumers more involved in the longer duration that EV's will run on a fee. Car owners typically require an overnight charge in order to completely charge a EV battery in their house. Research has found that consumers are increasingly likely to pay for extra functions, better EV performance and comfort. Several researchers found that automobile owners had a significant environmental effect on the expected consumption of power. EVs should be most likely to be embraced by consumers who are environmentally conscious and known as eco-friendly citizens. Further, it is possible that EVs would be embraced by citizens involved with environmental concerns and active in environmental organizations. [10]

There has been even more beneficial dynamics of electric-powered cars. Cheap enough for cells. So, as the prices of batteries start to decline, we can soon hit a level where hybrid cars—with their fairly basic electric motors so low renewable emissions—potentially have less costs than traditional automobiles with a more complex internal combustion engine. Companies selling the right hybrid vehicles would have a huge edge over others who only market only intra-combustion automobiles. Greener, convenient, and less efficient, hybrid vehicles are supposed to be. [11]

The effect of EV's financial and technological features on its usefulness, including buying and running costs, drive time, vehicle efficiency and model diversity, has generally been seen to be important. The number of charging stations often affects positively the efficiency of EV which shows the value of charging the construction of infrastructure in the promotion of EV. About the effects of reward programs, the most possible result is a tax deduction (whether purchasing or road tax), although the efficacy of other cost savings such as free parking and a decrease in taxes is also not recognized. [12]

More than 1 million electric cars were registered in 2017, an improvement in the number by 54% from 2016, according to the IEA (International Energy Agency) figures. Further, after global market volume in 2015 and 2016 reached 1 million electric cars, world stocks in 2017 surpassed 300 million, reflecting a 56 percent growth relative to 2016, with China first ranked at 40%. In the eighth ministerial on energy in 2017, the EV30@30 program was initiated to increase the market share of electric cars by 30% by 2030 in all EVI member countries (the Electric Vehicles Initiative). The task consists of increasing the world ownership of electric vehicles, enhancing battery generation and content specifications relevant technologies, installing charging infrastructure for electric cars, conserving electricity and coal, reducing greenhouse gas pollution and other steps beneficial for the sake of health. Customers assume that electric cars have a beneficial impact on the atmosphere and customers trust in factual evidence from these findings. The tests suggested that they do not assume. The methods for supporting electric car manufacturers are currently largely overlooked by network knowledge. The EV producers campaign for environmental conservation and green life to create consciousness and desire among customers for EV. Consumers assume that the EV operating style does not explicitly vary from the conventional style of service. However, electric cars have an efficient driving process relative to conventional automobiles, as a

modern form of green energy device, and they have creative and technical features such as speech commands, electronic parking commands, etc. Electric vehicles producers are also recommended for expanded market incentives in the area of electric vehicle expertise and customer education, extension of electric vehicle scope of influence and enhanced market perception of electric vehicles. Their goal is to be purchased by buyers, which is the amount of filling piles for electric vehicles. The government is then suggested piloting the charging stacks as a model in major cities, and instead depending on the investments of the related manufacturers through subsidies to ease the problem of charging electric vehicles. Their aim is to buy a customer belief and life of batters. This is also recommended that electric car producers implement improved battery facilities such as battery leasing and battery strengthening. Manufacturers of vehicle waste and scraping programs like car assembling and recovery of power batteries are targeted at lowering battery costs by the collection, disassembly and reuse of vehicles, and their components in order to encourage efficient and healthy growth throughout the automotive sector. [13]

3 Research Methodology

This research is formulated as a survey research which asked questions from the respondents and reported their answers. The analysis findings should be in line with the study's objectives. To assess the nature of this analysis, we concentrated on researching the key factors for obtaining the main influencing factors in this study's research process. A quantitative approach has been decided to be used for this study and to conduct research a questionnaire is used to collect data. The data collected will explain our research by performing factor analysis in SPSS software.

1. Research Design: For this research project, we came up with a questionnaire. In the first part of the questionnaire collects the background of the respondents, the demographic factors like age and gender. The second part collects the data on the factors that the respondents think are important and would influence the purchase decision. The questionnaire was designed in English language. Primary data for this research was collected with the help of online questionnaire.

2. Population and Sample: The focus respondents for this research were people who were interested in purchasing new vehicles. The respondents for the survey were captured at the showrooms of some popular car companies and at the Pune Auto Expo. The survey respondents were 120. Of these, 70% of the respondents were male and the rest females. 53.3 % of the population belongs to the 25-29 years of age group, 27.5% to 20-24 years, 10 % to 35 and more years and 9.2 % to 30-34 years of age group.

3. Research Instrument: For the pre-test questionnaire, a 7-point Likert scale was introduced, with responses varying from 1 to 7 with one being strongly disagree and 7 being strongly agree. A Likert scale is a psychometric scale that is widely used in research to measure the views and attitudes of people about a topic or subject matter. All the factor considered in the study are evaluates based on a Likert scale and respondent's response is registered.

4. Statistical Tools and Techniques: We will analyze the data by running factor analysis statistical tool in SPSS software. With the help of SPSS, we will be able to collapse are a large number of factors into a few interpretable underlying factors. We ran Principal Component Analysis to understand how to factors are interrelated. (Figure – 1)

Output received had a correlation matrix which is a basic rectangular sequence of numbers giving the coefficients of correlation between a single variable and the remaining variables.

The Kaiser Meyer Olkin and Bartlett's Test is a test of sampling adequacy in order to assess whether or not the response given to the sample is adequate and near around 0.5 for factor analysis to be statistically significant. A value of 0.5 for as a minimum and values around 0.7-0.8 appropriate and values more than that are considered excellent.

KMO and Bartlett's Test

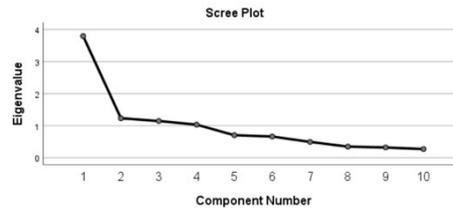
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.739
Bartlett's Test of Sphericity	Approx. Chi-Square	632.678
	df	45
	Sig.	.000

Total Variance Explained:

The Eigen value table has been grouped into Initial Eigen Values, Extracted Sums of Square Loadings and Rotation Sums of Square Loadings. We are concerned with the extracted number of squared loading in order to evaluate and grasp it.

The variance percentage due to each variable after extraction. We therefore agree in this step that there are four dimensions that allow our understanding of our inclination to purchase and shift towards Electric Vehicles.

A Scree plot is a plot of the Eigen values compared to the variables. The plot is helpful in calculating the number of variables to be preserved. The answer is where the curve starts to flatten. It can be seen that between factors 4 and 5 the curve starts to flatten.



Rotation is intended to reduce the number of factors with large loads from variables under analysis. Rotation does not change something but helps the study to be understood.

Rotated Component Matrix^a

	Component			
	1	2	3	4
Maintenance Cost	.824			
Government Policies	.752			
Charging Infrastructure	.729			
Speed		.770		
Driving Range		.747		
Environmental Concern		.642		
Battery Recycling			.836	
Purchasing Cost			.747	
Variants				.765
Life of Vehicle				.653

Extraction Method: Principal Component Analysis.
 Rotation Method: Varimax with Kaiser Normalization.
 a. Rotation converged in 13 iterations.

4 Analysis

We applied exploratory factor analysis which is a tool for interdependence analysis. All the factors that we considered were given equal importance. The goal was to reduce the factors to few more prominent factors which influence purchase decision. We identified 10 different factors based on the literature review. Each variable was asked to be rated on a 7-point Likert scale where 1 was strongly disagree and 7 was strongly agree. We imported the responses in SPSS and applied Dimension Reduction Analysis. The sample size for the survey was 200. Extraction method applied was Principal Component Analysis and Varimax Rotation with KMO and Bartlett's test. KMO measure of sample adequacy resulted to be 0.739 which must be greater than 0.6 to show that the sample size was enough and the data is appropriate for the analysis. The Bartlett's test of Sphericity is statistically significant with $p=.000$ with df 48 suggesting that there is a clearly strong correlation between the factors. SPSS extracted four factors out of ten and the cumulative percentage is 72.029% which explain the 72.029 % variance amongst the factors. The rotated component matrix shows that post detailed analysis, four factors have been identified. First factor consists of three variables which are Maintenance Cost, Government Policies and Charging Infrastructure, 2nd factor consists of three variables which are Speed, Driving Range and Environmental Concerns, 3rd factor consists of two variables which are Battery recycling and purchasing cost and the 4th factor consists of two variables - Variants and life of vehicle based on significant loadings. The objective is to obtain an optimum simple structure, which aims to provide as few variables as possible for each variable load, but maximizes the number of high loads for each variable.

		1	2	3	4
Dimension 1	Maintenance Cost	0.824			
	Government Policies	0.752			
	Charging Infrastructure	0.729			
Dimension 2	Speed		0.770		
	Driving Range		0.747		
	Environmental Concern		0.642		
Dimension 3	Battery Recycling			0.836	
	Purchasing Cost			0.747	
Dimension 4	Variants				0.765
	Life of Vehicle				0.653

5 Conclusion

In order to minimize severe air pollution in India and to achieve a breakthrough on climate change as a shared target, the electrification of the transport sector is crucial. This paper assesses the factors that incline the customers towards electric vehicles. The survey was conducted among the potential vehicle buyers and they were asked to rate the factors based on their buying preference. Upon analyzing the data, the factors in the first dimension, i.e., the maintenance cost, Government policies and charging infrastructure are very important for the consumers to buy electric vehicles. These are the most significant which could lead to the acceptance of EVs. Secondly, the factors in dimension 2 which are Speed, Driving Range and Environmental concerns are also considered fairly important by the consumers. Reducing GHG emissions is the need of the hour and the government also is providing support in the terms of subsidies and tax cuts to encourage the consumers to switch to EVs. If factors in the dimension 1 and 2 are improved and paid attention to, we could see a better and faster trend in adoption of EVs.

References

1. Why are Electric Cars Important to Society? (Benefits of Electric Vehicles). (2020, January 24). Retrieved March 13, 2020, from <https://get-green-now.com/why-are-electric-cars-important/>
2. Miller, M., Holmes, A., Conlon, B., and Savagian, P., "The GM "Voltec" 4ET50 Multi-Mode Electric Transaxle," SAE Int. J. Engines 4(1):1102-1114, 2011, <https://doi.org/10.4271/2011-01->

- 0887.
3. “Types of Electric Vehicles.” CAA, CAA, www.caa.ca/electric-vehicles/types-of-electric-vehicles/.
 4. Unterstaller, A., 2020. Electric Vehicles: A Smart Choice For The Environment. [online] European Environment Agency. Available at: <<https://www.eea.europa.eu/articles/electric-vehicles-a-smart>> [Accessed 20 March 2020].
 5. Afroz, R., Rahman, A., Masud, M.M., Akhtar, R. and Duasa, J.B. (2015) ‘How Individual Values and Attitude Influence Consumers’ Purchase Intention of Electric Vehicles.’ *Environment and Urbanization ASIA*, 6, 2, 193-211.
 6. Wadhwa, N. (1 May 2019). EV sales in India cross 7.5 lakh mark in FY2019. *Autocar*. Retrieved from <https://www.autocarindia.com/car-news/ev-sales-in-india-cross-75-lakh-mark-in-fy2019-412542>
 7. Kim, Eunsung & Heo, Eunyeong. (2019). Key Drivers behind the Adoption of Electric Vehicle in Korea: An Analysis of the Revealed Preferences. *Sustainability*. 11. 6854. 10.3390/su11236854.
 8. Khurana, A., Kumar, V. and Sidhpuria, M., 2019. A Study on the Adoption of Electric Vehicles in India: The Mediating Role of Attitude. *Vision: The Journal of Business Perspective*, 24(1), pp.23-34.
 9. Oz, Serkan Baran. (2017). The Factors Influencing the Electric Vehicle Buying Intentions in the Netherlands.
 10. Thananusak, T., Rakthin, S., Punnakitikashem, P. and Tavewatanaphan, T., 2017. Factors affecting the intention to buy electric vehicles: empirical evidence from Thailand. *International Journal of Electric and Hybrid Vehicles*, 9(4), p.361.
 11. Lee, T., 2020. Every New Volvo Will Be A Hybrid Or Electric Car After 2019. [online] *Vox*. Available at: <<https://www.vox.com/new-money/2017/7/5/15922634/volvo-electric-hybrid-cars>> [Accessed 20 March 2020].
 12. Liao, F., Molin, E. and van Wee, B., 2016. Consumer preferences for electric vehicles: a literature review. *Transport Reviews*, 37(3), pp.252-275.
 13. Tu, J. and Yang, C., 2019. Key Factors Influencing Consumers’ Purchase of Electric Vehicles. *Sustainability*, 11(14), p.3863.
 14. Chetty, P., 2020. Interpretation Of Factor Analysis Using SPSS. [online] *Project Guru*. Available at: <<https://www.projectguru.in/interpretation-of-factor-analysis-using-spss/?cv=1>> [Accessed 21 March 2020].