

A Review on Factors Affecting Adoption of Electric Vehicles

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Abstract—Environmental pollution is a global concern at present. One of the primary air pollutants is toxic emissions from internal combustion engines. Electric vehicles are being aggressively promoted around the world in order to alleviate the effects of fossil-fuel emissions and address environmental issues. Different governments encourage people to switch to electric vehicles by encouraging a change. Evidence of the high costs of the electric car, the lack of charge infrastructure, the need for time and distance are obstacles to consumer acceptance. Earlier studies showed that by 2030, the India government wants to replace all conventional vehicle to clean energy vehicles only be used. This article is contemporary and examines the various factors affecting the adoption of a consumer EV. Here, A number of journal papers have been reviewed and we tried to find out different factors influencing EV purchasing behaviour in India. A strong mediator was the attitude, influencing electric cars' adoption. Although electric vehicles are on the market, consumer acceptance is less than traditional vehicles. Consequently, this study becomes significant in identifying factors influencing electric vehicle adoption in India. Some of the factors / barriers investigated in literature are social and technological barriers such as limitations in the electric battery spectrum, less charging stations, unsuitable government policies, sustainability, consumer reactions, etc. The impact of each factor in adoption can be established with statistical methods. A case analysis can be performed using qualitative and quantitative methods. Therefore main factors / inhibitors and related steps for successful electric vehicle adoption can be identified.

Index Terms— Electrical vehicle(EV), Adoption , Alternate energy in transportation, review.

I. INTRODUCTION

Transport is the major source of excessive energy consumption, and is entirely reliant on petroleum products. Climate change mitigation, decarbonization of transport is a key obstacle. Transport accounts for 25% of global carbon dioxide (CO₂) emissions and is projected to grow to 50% by 2035 (McCollum et al . 2018). The transport sector has been described as the major contributor to pollution and greenhouse emissions. It is really important to reduce air pollution and reliance on fossil fuels in order to reduce greenhouse gas emissions. Hence, this offers a caution to current transport to require changes to the existing transport system. A significant amount of the overall emissions accounts for the transport industry and the other important contributors are various forms of manufacturing. The transport industry is responsible for the emission of various kinds of gases, of which carbon dioxide , nitrogen dioxide , nitrogen oxides , argon , carbon monoxide , sulphur dioxide are the key components and some of the above are very hazardous to human health, the atmosphere and the living

beings. Low-carrying vehicles such as passenger cars and small trucks emit much of their CO₂ emissions. The reduction of CO₂ emissions from electric vehicles (EVs) could help to decarbonise transport. As a result, the rise in the rate of adoption of EVs may be a crucial factor in deciding whether the world meets its CO₂ reduction goals. Despite comprehensive government support, most EV adoption measures are behind the initial objectives. An electric Vehicle (EV) is a car where the main driving source is an electric motor. EVs use batteries that can be recharged for electricity saved. EVs have great advantages of zero harms of the tailpipe emissions and petroleum fuel loss, which can have several advantages over internal combustion (IC) engine vehicles. The EVs are not responsible for any greenhouse gases or air pollution. Compared to the traditional vehicles, upstream emission generated by generating electricity used for charging electricity is substantially less.

Governments in automotive producing countries want competition for their local manufacturers. The industry has a huge effect for these countries on jobs and exports. Governments are generally consumer centric in policy making. Regulation are made to promote faster EV adoption. However, policymakers must first consider the factors that enable customers to buy EVs and whether early adopters are pleased with their purchases, in order to develop the necessary policy styles. In particular, policymakers need to understand factors which determine consumer satisfaction with consumer driving EVs.

When EVs have been used, emotional answers (e.g., fear or anxiety) and mental stimuli impact their decision-making. It's likewise essential to investigate early EV adopters due to their impact by word of mouth on later adopted persons.

II. LITERATURE REVIEW

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When EVs have been used, emotional answers (e.g., fear or anxiety) and mental stimuli impact their decision-making. It's likewise essential to investigate early EV adopters due to their impact by word of mouth on later adopted persons. CO₂ emissions can be greatly reduced assistance for the adoption of EV, particularly for electricity Charging for EVs is created by renewable energy Wind, fossil, water and solar energy sources Power. 24 percent of gross carbon emissions Transport sector emissions, which are planned Up to 2030 a rise of 50%. As in 2017 in IEA. This illustrates the Instability and even the current transport sector the value of transition to change present and greenhouse gas emissions mitigation scheme, Air pollution and the use of fossil fuel. The analysis shows that the various financial subsidies EV promotion policy and incentives are really relevant useful to control the customer's behaviour EVs also found a very poor market relation Intention to accept EVs and subsidies for purchase Buy subsidies happily. EV consumer implementation has a disagreement Outcome. Outcome. But several of the economic benefits have been found.

The policies, price of fuel and subsidies for non-consumer goods also include Positive effect on EVs adoption. The intergovernmental strategy The Panel on Climate Change (IPCC) noted that the environment becomes a serious threat to economic and physical living conditions due to the increase of the concentration of greenhouse gases, and thus has a deep and negative effect on the biodiversities, an ecosystem which endangers 25-35 percent of plant and animal species. The Government has taken steps to minimise CO₂ emissions through production regulation, environmental protection measures, and adoption of EVs. Although the amount of EVs sold is still

very small, despite its many positive and positive effects and benefits for the climate. The rate of adoption of EVs is still not as high as expected even under many government policies. They found, however, that some of the factors are yet to be identified. There have been several studies in different countries, which have included new factors including demographic factors and more socio-technical factors. Current society requires effective logistical transport, but the logistics system is considered the most unsustainable system of transport. To achieve a stronger method of logistics. It needs more effort to reduce the harmful effects of the system in order to eliminate waste and emissions from the goods and services system. The consumer acceptance of EVs is much less. The variables like Fuel price rise, strict pollution regulations, economic Market assistance etc. is known as benefits and subsidies. The automotive industry needed for EVs to grab. The person's intention to use an EV relies on personal aspects and characteristics.

The technical and social characteristics, cost factors, rewards, grants and demographic factors may impact the individual's perception of adopting an EV. The consumer acceptance of EVs does not depend entirely on the charging station, purchasing subsidies, the tax relief and the concession of monthly road taxes to environmental regulations. The cost for EVs is higher than the cost for ICEVs. The policy of benefits for electrical vehicles, free parking, the use of special lanes, etc. can not cover the disadvantage. The key drawback due to the bad demand for EVs is not covered by these policies. In 2017 just 0,06% of the EVs sold in the US, in the EU, and in several of Asia's leading car manufacturers out of 51.1 million private cars. This adoption rate affects customer behaviour towards adopting EVs. The way of living has a big influence on customers New technology thinking and embracing. The study done in Canada shows that people interested in technical change and environmental thinking are more ready to implement EVs quickly. EVs are taken in the advanced lifestyle of people. In a study comparing EV technology to other technologies, battery-powered vehicles are much better than fossil fuels, ethanol fuel, and so on. Compared to all other fuel substitutes, batteries offer a higher performance and environmental quality. In order to implement EVs faster, the Governments must take an initiative. The agencies must stress the need to transition from traditional to electric vehicles, and the legislation relating to electric vehicles needs to be re-checked to enable common citizens to buy electric vehicles. For faster adoptions of EVs, the types of motives must be identified.

The psychology and the buyer's actions play a key role in EVs. Some of the buyers struggle with eco-friendly considerations and some take the economic side into account. Usage material is also closely associated with the purchase motive. Some consumers are more worried about electricity and other fuel costs. Cost driving factors affect electric vehicle acceptance, the rise in subsidies will shift the demand and consumers are more likely to purchase electric vehicles. Above Table provides an overview by year, research region, study conclusion and corresponding outcomes of the literature review.

TABLE I. SUMMARY OF LITERATURE REVIEW

Author & Year	country	Conclusion of the study	Relevant outcome
Fan.Jing-Li et.al (2017)	China	A number of primary factors, including government policies and economic advantages, environmental benefits, psychological needs and environmental consciousness are factors for EV adoption.	Government strategies, economic gains, efficiency qualities, psychological needs and environmental consciousness, infrastructure building and social effects
Dash Ajitabh (2020)	India	A statistically significant relationship was studied between environmental concern, EV awareness, subjective standard and EV attitudes. Similarly, a big difference in adoption decision is responsible for the attitude.	Environmental concern, knowledge of EV, subjective norm & attitude towards EV
Wujin Chua et.al(2019)	china	Study of psychological and behavioural factor among EV adopters in two countries	Economic,environmental reasons are the main factors for the early adopters in Korea and China.
Ahmadi.Lena(2015)	Canada	Analyzed the effect of socio-economic influences on the pace of acceptance of alternative fuel vehicles in Ontario between 2012 and 2050.	Age, gender, venue, monthly insurance, normal driving distance and traffic, aggressive, average and mild all-in costs are the factors o adoption of EV.
Rajeev Ranjan Kumar, Kumar Alok(2020)	India	It encompasses the recognition of factors in five distinct categories: antecedents, mediators, moderators, effects, and socio-demographic. The review process revealed many valuable insights into testing methodology and regionally relevant trends.	Identification of factors in five distinct categories: antecedents, mediators, moderators, effects, and socio-demographic.

Ghasria.Milad et.al(2019)	Australia	The findings showed that the perceived benefits can be expressed in the form of three important variables. The first variable is a design that incorporates customer understanding of practical and aesthetic elements, including prestigious appearance, and effective and consistent efficiency. The second variable is the atmosphere that represents the perceived environmental impacts of EVs, and the third is protection.	Consumer's perception towards EV's advantages has a significant impact on their adoption decision
Roger Bennett et.al(2017)	UK	Playing the game has improved the likelihood of the respondents' EV stereotypes and their attitude to EVs. They were more likely to adopt in the future.	The relationship between adoption of electric vehicle with the stereotype as well as attitude of its buyers
Wenbo Li et.al(2017)	china	Demographic factors, situational factors, psychological factors in support of adoption of BEV users along with its barriers.	Deduced the reasons for BEV adoptions along with its barriers.
Simon Shepherd et.al(2012)	UK	The study focuses on determining whether electric commercial vehicles, as a potential challenger to traditional diesel trucks, are more cost-effective than conventional diesel counterparts.	Creation of the UK system dynamics model forecasting the electric vehicles for the next 40 years.
Wei Feng , Miguel Figliozi(2013)	USA	Adopting EV in Deterministic Model Formulation: Potential costs such as purchasing cost, fuel cost, salvage value, repair cost, fuel and energy cost per kilometre and several other economic and technological considerations are believed to be known time (age) and vehicle type functions. Given the uncertainty associated with some of the main input parameters (fuel and maintenance, battery life and price, etc.)	Tradeoffs on economic and technical considerations for the introduction of electric vehicles in the USA
Taeseok Yong et.al(2017)	South Korea	Countries with a high economic standing and tax exemption and purchasing incentives, such as Norway, the United States, Iceland, Netherlands , Sweden, the United Kingdom, Germany and Belgium, are more likely to follow EVs. Policy funding, such as tax incentives and discounts, has an impact on the spread of electric cars. Furthermore, environmental considerations, such as the economic level and the status of charging stations for electric cars, have also been impacted.	Factors impacting the deployment of electric vehicles and the drawing up of policy consequences for the encouragement of the deployment of electric vehicles.
Kumar.Rupesh et.al(2020)	India	The vital role of sharing the economy and public services in fostering EV acceptance, considering the high cost of EV, lack of infrastructure and low buying power of Indian consumers. The shared economy outlook presents the government with a range of ways to leverage capital (electric-powered transport) in an optimum manner. In addition , the analysis contrasts the global context when assigning the goal estimates.	The challenges facing India for the introduction of electric vehicles (EV) by 2030. The report further explores the steps taken by the Government of India (GOI) to encourage research and development in the EV field and what remains to be achieved.
Jena.Rabindra(2019)	India	The suggested framework would allow the consumer to receive a high-level description of feelings about the different aspects of the product which would significantly reduce the length of the text expected to be helpful to potential customers, advertisers and suppliers.	To extract opinions valuable to prospective buyers , marketers and manufacturers using Deep Learning techniques
Adnan.Nadia et.al (2017)	Malaysia	Environmental concerns, personal norms , attitudes, ownership of vehicles Costs, driving range, charging time, motive, subjective norm , perceived behavioural regulation, and personal norm are factors of EV adoption in Malaysia	Study of predicting Malaysian consumer behaviour towards widespread adoption of PHEV/EV

Kumar,Shalender et.al (2020)	India	There was relationship between buying behaviour and attitude, subjective norm, perceived behaviour control, Moral norm, Environmental concerns	Attitude, subjective norm, perceived behavioural influence, moral norm, environmental considerations are also reasons for EV adoption in India.
Wang, Shanyong, et al (2016)	China	Empirical findings suggest that customer perceptions, subjective norms and perceived behavioural influence have a substantial effect on the expected acceptance as hypothesised. We also find that the personal moral standard of customers also has a positive effect on their decision to follow them, as predicted.	Customer perceptions, subjective norm, perceived behavioural influence, moral norm, environmental considerations are also reasons for EV adoption in China
Aasness, Marie Aarestrup, and James Odeck.(2015)	Norway	With multiple incentives from government like exemptions, such as exemption from toll payments, exemption from purchasing duty and authorization to use transit lanes, which enable road users to purchase and use EVs.had also adverse impact as there is sizable loss of tolled revenue. The road cost is same as earlier.	We could say that these kinds of policies should not be implemented without considerations as the cost of road is same only.
Naor, Michael, et al. (2015).	USA	The study generates product / service design technologies for infrastructure, together with multi-stage organisational diffusion techniques for EVs, were used to overcome both practical (use, utility and risk) and psychological (tradition and image) barriers to mass market acceptance.	Different barriers in the path of EV adoption were found out.
Nimesh,Vikash et.al (2020)	India	The comparative study of air pollution from combustion engine directly and electricity producing thermal powerplants. It was found that EV was way better and cleaner source for transportation.	It gave us broader view point for looking at the pollution factors in both cases.
Ona Egbue, SuzannaLong(2012)	USA	This study examines possible socio-technical obstacles to consumer acceptance of EVs and evaluates whether sustainability concerns impact consumer decision-making to buy EVs. This research offers useful insights into the desires and expectations of technology from consumers as they compare with conventional vehicles.	The different socio-technical barriers of EVs for its adopters.
Sohaib Rafique, Graham E. Town(2019)	Australia	This study determined that even though all EVs were recharged from non-renewable coal operated power plants, the higher efficiency of EVs would result in a reduction of 18 per cent of CO2 (equivalent) of GHG emissions across NSW. The findings suggest the potential for widespread EV adoption in Australia.	Comparative analysis of environment pollution with use of EV and conventional vehicles.
Ning Wang, 2018	China	This study Explains of demographic factors in the adoption of EV in Shanghai	Market research and customer behaviour, based on demographic factors, on the adoption of EV.

III. DISCUSSION

The study gives an insight into the reasons why electric vehicles are welcomed on the market. The literature is dominated by age , gender, income, education , skills, public policies , environmental issues, financial factors, domestic charging stations, support for driving comfort and technology, vehicles, looks / style, sustainability and safety, maintenance, battery supplies, culture, public charging stations, etc. Others, such as behaviour, geography, etc. can affect adoption in addition to these factors. A hypothetical sample may be used to determine the effects of variables. Most of the study done earlier have consider less number of people in the survey and from only one country or one place. It would be better approach if survey is taken from more number of people and different places in the world. If people from multi disciplines and different places come together more progress can be achieved in this field. Different statistical approaches including quantitative and qualitative instruments can be assessed for each factor.

IV. CONCLUSIONS

The objective of this study is to determine the factors that affect EVs in India. The reduction of toxic pollution, energy use and air quality appear to be extremely important. The transportation industry must be turned into a

green car sector. The literature on implementation of EVs and implementation of emerging technologies is a first step in a research model. It is evident from the literature review that various consumer-related factors affect the use of electric vehicles. Many of these factors also play an important role because many countries have not adopted new technology in EVs up to full extent. A thorough analysis may help find the impact and contribution of each study variable. For the detailed analysis, numerous statistical tools can be used. The studies will recognise obstacles for adopting EVs, as well as reasons for faster concentration. The research will recognise obstacles to the use of EVs and also the reasons for faster adoption.

REFERENCES

- [1] Fan, Jing-Li, et al. "Determinant changes of consumer preference for NEVs in China: A comparison between 2012 and 2017." *International Journal of Hydrogen Energy* 45.43, 2020, pp. 23557-23575.
- [2] Dash, Ajitabh. "Determinants of EVs adoption: a study on green behavior of consumers." *Smart and Sustainable Built Environment*, 2020.
- [3] Chu, Wujin, et al. "Psychological and behavioral factors affecting electric vehicle adoption and satisfaction: A comparative study of early adopters in China and Korea." *Transportation Research Part D: Transport and Environment*, 2019, pp. 1-18.
- [4] Ahmadi, Lena, et al. "Effect of socio-economic factors on EV/HEV/PHEV adoption rate in Ontario." *Technological Forecasting and Social Change*, 2015, pp. 93-104.
- [5] Kumar, Rajeev Ranjan, and Kumar Alok. "Adoption of electric vehicle: A literature review and prospects for sustainability." *Journal of Cleaner Production*, 2020, pp. 119911.
- [6] Ghasri, Milad, Ali Ardeshiri, and Taha Rashidi. "Perception towards electric vehicles and the impact on consumers' preference." *Transportation Research Part D: Transport and Environment*, 2019, pp. 271-291.
- [7] Li, Wenbo, et al. "A review of factors influencing consumer intentions to adopt battery electric vehicles." *Renewable and Sustainable Energy Reviews* 2017, pp. 318-328.
- [8] Shepherd, Simon, Peter Bonsall, and Gillian Harrison. "Factors affecting future demand for electric vehicles: A model based study." *Transport Policy* 2012, pp. 62-74.
- [9] Feng, Wei, and Miguel Figliozzi. "An economic and technological analysis of the key factors affecting the competitiveness of electric commercial vehicles: A case study from the USA market." *Transportation Research Part C: Emerging Technologies*, 2013, pp. 135-145.
- [10] Yong, Taeseok, and Chankook Park. "A qualitative comparative analysis on factors affecting the deployment of electric vehicles." *Energy Procedia*, 2017, pp. 497-503.
- [11] Kumar, Rupesh, et al. "Addressing the challenges to electric vehicle adoption via sharing economy: an Indian perspective." *Management of Environmental Quality: An International Journal*, 2020.
- [12] Jena, Rabindra. "An empirical case study on Indian consumers' sentiment towards electric vehicles: A big data analytics approach." *Industrial Marketing Management*, 2020.
- [13] Shalender, Kumar, and Naman Sharma. "Using extended theory of planned behaviour (TPB) to predict adoption intention of electric vehicles in India." *Environment, Development and Sustainability*, 2020, pp. 1-17.
- [14] Wang, Shanyong, et al. "Predicting consumers' intention to adopt hybrid electric vehicles: using an extended version of the theory of planned behavior model." *Transportation*, 2016: pp. 123-143.
- [15] Adnan, Nadia, et al. "A market modeling review study on predicting Malaysian consumer behavior towards widespread adoption of PHEV/EV." *Environmental Science and Pollution Research*, 2017, pp. 17955-17975.
- [16] McCollum, David L., et al. "Interaction of consumer preferences and climate policies in the global transition to low-carbon vehicles." *Nature Energy* 3.8, 2018, pp. 664-673.
- [17] Aasness, Marie Aarestrup, and James Odeck. "The increase of electric vehicle usage in Norway—incentives and adverse effects." *European Transport Research Review* 7(4), 2015, p.34.
- [18] Naor, Michael, et al. "Overcoming barriers to adoption of environmentally-friendly innovations through design and strategy." *International Journal of Operations & Production Management*, 2015.
- [19] Coffman, Makena, Paul Bernstein, and Sherilyn Wee. "Electric vehicles revisited: a review of factors that affect adoption." *Transport Reviews* 37.1, 2017, pp. 79-93.
- [20] Malik, Ashish, and Shivam Kohli. "Electric tractors: Survey of challenges and opportunities in India." *Materials Today: Proceedings*, 2020.
- [21] Schuitema, G., Anable, J., Skippon, S., et al., "The role of instrumental, hedonic and symbolic attributes in the intention to adopt electric vehicles". *Transp. Res. A Policy Pract.* 48, 2013, pp. 39-49
- [22] Diamond, D., "The impact of government incentives for hybrid electric vehicles: evidence from US states". *Energy Policy*, 37 (3), 2016, pp. 972–983
- [23] Jonn Axsen, Josh Cairns, Nichole Dusyk, Suzanne Goldberg, "What drives the Pioneers? Applying lifestyle theory to early electric vehicle buyers in Canada", *Energy Research & Social Science* 44, 2018, pp. 17–30