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Investigating the Impact of Electric Vehicles on Urban Transportation: A Study with Special Reference to India

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Abstract:- *Due to the continuous usage of fossil fuels we are almost reaching a point of no return with catastrophic consequences in terms of climate change. With this issue in mind some companies, specifically in the automotive industry, have decided to go green with several BEV fleets which are changing and forcing cities to adapt to these changes and to the new APV options appearing with the purpose of enhancing and facilitate the mobility inside the cities. In this sense, the present investigation aims to estimate the impact and changes in the INDIAN transportation sector, as well to assess the customer perception and identify the decision-making factors of an electric vehicle. An online questionnaire was used as a mean to collect the higher and broader number of respondents and its analysis was performed based on a qualitative analysis, hypothesis testing and correlations.*

The results predict a growth of the APV in INDIA along with average age of the INDIAN automotive car parc. It also expected a growth of the charging points infrastructure and the mobility options within the city. A BEV buyer usually considers itself as an ambitious person, seeking for new information about technology, sociable and always looking for ways to improve their life's and considers the running costs of an EV to be lower than a conventional car. Moreover, the Price and Autonomy are the two most valued factors in an EV and the Brand and Technology the least.

The Indian Electric Vehicle ecosystem is currently in the initial stages of development but has been gaining traction. In 2021, EV registrations amounted to ~330k units, a jump of 168% from 2020. The sales were led by 2- and 3-wheelers – ~48% and ~47%, respectively – followed by passenger vehicles at
~4%. E-rickshaw/e-kart category (top speed less than 25km/ hr) takes the major share among three wheelers with ~45%. E-buses are included in others with a share of 0.36%..

Keywords: *BEV, APV, Electric Vehicle, Questionnaire, Mobility*

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I. INTRODUCTION

There has been a global paradigm shift in how the future of vehicles will evolve. While flying cars may not be seen as a feasible option in 2022, we have come a long way from the traditional fuel-guzzling vehicles to alternatives such as EVs, both in two-wheeler and four-wheeler segments. While Indian sentiments are clearly more oriented towards two-wheelers which occupy almost 70% of road presence, this does not seem to be limiting the development of four-wheeler EVs. India is actively investing in and promoting a market which is predicted to hit over a 9 million units mark per annum by the year 2027. The need to shift to an alternative fuel can be attributed to rising fuel costs and adopting cleaner energy sources. Climate change is an increasingly relevant concern, with every major nation actively acknowledging the problem and looking at real time solutions, which provides a further impetus to the shift to EVs.

The Indian automobile industry places heavy reliance on the use of traditional fossil fuels and non-renewable forms of energy which has raised concerns regarding its impact on the environment, climate change and the depletion of the non-renewable resources. To adopt a cleaner and more eco-friendly energy alternative, India has formulated policies to shift from traditional ICE vehicles to vehicles using alternate forms of energy, specifically EVs. Further, dependance on fuel imports and the consistently rising prices of conventional fuels have also prompted consumers to seek more cost-efficient sources of transportation. These initiatives for adoption of clean engines for both commercial and private vehicles has led to an increase in the number of manufacturers of EVs in the short and long distance transportation and last mile connectivity arenas. Mahindra & Mahindra, an Indian manufacturer of automobiles, plans to aggressively expand its range of EVs being offered in the Indian market and has planned for an investment of approximately USD 400 million whilst also looking at foreign investors. TVS Motors, a two-wheeler manufacturer, is also in discussion with global private

equity investors looking at investment of approximately USD 296 million to USD 493 million for business expansion into EVs through the launch of a new line of electric two-wheeler.

1.2 Context Analysis

Nowadays, the energy sector emerges as a vital sector for the economy. The irrational use of energy has implications on the energy bill, therefore it is necessary to adopt policies that encourage the rational use of energy that are integrated with environmental policies. Internationally, all countries have witnessed a revolution in the energy sector. This revolution is due to the fluctuations in fossil fuel prices, climate changes, scarcity of energy sources and also because of the economic situation of countries which lead them to change their attitude towards future energetic questions.

The eminent exhaustion of primary energy sources, the energetic dependence on oil and the environmental impact that results from it, contributes to make different choices that rely on new energetic models for transportation which intend to better improve the quality of life of the populations and the reduction of the national energetic bill. The United States alone, consume 70% of all oil for transportation usage. From this transportation oil, 70% is used by passenger vehicles. Worldwide, an escalating middle class in India and China is triggering demand for passenger cars to surge, and with it, demand for oil. Hence the importance of alternative fuels. By 2020, there may be as many as 1.5 billion cars on the road, in contrast to 750 million in 2010. The primary goal is to contribute for a sustainable transportation network, optimizing the advantages and integrate the renewable energies as an alternative to fossil fuels.

1.3 Role of Electric Vehicles in India's Mobility Scenario

In 2017, with total vehicular production over a 25 million in numbers, India's auto industry was the fourth largest producer of cars and largest producer of two wheelers. Though penetration levels of the private vehicles is still among the lowest in the world, the sheer number of vehicles on roads presents some challenges. Emissions from vehicles are source of local pollution and is one of the challenges towards achieving India's climate change targets. Switching to alternate powertrains can help in reducing the emissions. As per the analysis in this report among all the alternate powertrain options- biofuel, hydrogen fuel, and CNG- electric powertrain promises to be more close to mass deployment.

Electric powertrains will not only help in reducing urban air pollution but also mitigating GHG emissions, and enhancing energy security. This report further validates the narrative by calculating the actual impact of electric vehicles on emissions, and energy consumption in possible EV adoption scenarios.

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1.4 Emission and Energy Impact of Electrification of Two- Wheelers in India

According to TERI analysis, Two-wheelers which composed of more than 80% of the vehicle sales in India were responsible for about only 13% of the emissions from all on-road vehicles in 2018-19.

To estimate the emission and energy savings from phased adoption of electric two- wheelers, the analysis followed a bottom-up approach. Growth scenarios in two- wheelers by 2025 and 2030 across different segments were projected based on GDP and population growth. This was followed by estimation of EV penetration under three scenarios. In the business as usual (BAU) scenario, a growth trend similar to what has been observed till now for this segment is assumed. The other two future scenarios are based on technology improvement and high ambitious policy pursued by the government with a very high degree of policy push along with technological improvements. Further savings in energy consumption and CO2 emission were calculated under these EV penetration scenarios.

1.5 Specific Objectives

Resulting from the general objective there are some specific insights that the dissertation intends to aim which will all contribute to the concretization of the general objective. They are:

1.Analyze the growth of Electrical Vehicles;

2.Assess the descendent r on fossil fuels and the growth of green alternatives;

3.Estimate the impacts and changes on the transportation sector, more specifically on the Indian automotive car parc;

4.Assess the customer perception towards APV;

5.Identify the main aspects of an EV that are a decision-making factor for the consumer.

II. LITERATURE REVIEW

2. **1.García-Olivares (2018**) says that transport is vital in the current globalized economy since it allows commercial trades, communication between populations and their citizens and it is also responsible for being

one of the main reasons of suburbanization in cities. He adds that the biggest challenges that the present world economy faces are energy security, sustainability, pollution and climate change impacts. Nowadays transportation relies a lot on fossil fuels, approximately 94% of total energy demand for transports is provided by oil only 1% by electricity at this phase, making the transportation sector responsible for more than 25% of world energy consumption (Juan A. A. et al. 2016).

2. 2. Mersal (2017) building an ecocity might be the answer for solving those material demand products since the ecocity methodology does not rely on emergent new technologies, finding new revenue sources or even developing new concepts. An improved mean is already in our reach. The main goals of a sustainable city are to satisfy the basic needs and realize structures for human care such as mobility, creating barrier-free accessibility to transport networks and to provide the best conditions in terms of healthcare. The challenge here, which is appointed to be the main challenge in every main city, is the transportation sector. There are a lot of problems related with congestion, incomplete public transport networks, accessibility and the continuous increase of private vehicles that make a transition to a sustainable city more difficult to achieve without first changing the habits and the way transport in cities is approached. Block (2017), on his study that there is an urge for transportation system planning to be thoroughly harmonized with the planning struggles for electrical power systems.

2. 3.(García-Olivares A. 2018) In a short term is very hard to change the mindset of people, change the way they are educated to use transports and the way they travel. This will be the most difficult part because in order to alter the habits of millions of people it takes a lot of years and a lot of investments so that people tend to be more aware of the actual panorama. However, some big companies are already moving towards this change investing a lot of money in research and development of EV's, some are even renewing their entire fleet into zero emission cars. Like any type of new transformative technology, EV's generate a diversity of powerful economic development challenges and opportunities. Despite the fact the electric vehicle market is still at an initial stage of development, it is set to redesign businesses, industries and communities all over the globe (Xue A., et al. 2015).

2.4. Smith (2014) evaluates the impact of spatially heterogeneous demand over a hybrid transit system considering a transit network design with elastic demand.

2.5. Mahmood, Khalid, Hyung-Sik Yang & Won-Beom Kim (2011)

The development of shallow passages of tunnel in densely populated metropolitan areas will influence the surface structure close to the vicinity of the tunnel passage due to which displacement of soil is observed. This paper reports the result of a parametrical analysis on displacement of the surface structure due to the influence of passage of tunnel. The mathematical model utilized in this appraisal was FLAC 2D. In this review, the settlement of pile results was accessed on by changing the parameters of rock, for example, modulus, tensile strength, angle of friction at a location where piles are located.

2.6. Li et al. (2013) proposed a system equilibrium model to optimize a primary road network density. The model applied to a two-dimensional monocentric city considers four agent types: local authorities, housing agencies, households, and workers. The optimization model determines the density of main roads maximizing the social welfare of the system**.**

2.7. **Afroz (2015)** and his colleagues published a study to investigate how individual values and attitudes influence consumers' purchasing intentions for electric vehicles. Customers from Malaysia are the focus of the study. Individual consequences (ICNs), such as measures of convenience, product size range, and perceived utility, were found to be adversely connected to green purchasing intention in the study (PIN). While consumers consider fuel efficiency, consumption, and comfort of a car when making a purchasing decision, they may choose an electric vehicle if the manufacturer offers a battery recycling facility. PIN has no statistically meaningful link with ECN's environmental impacts.

2.8. Craig Morton (2016) and co-authors observed the impact of consumer innovation as well as perceptions of electric vehicle functional capabilities on customer demand for electric vehicles in their study on consumer preferences for electric vehicles. The study proposes a framework for analyzing the impact of consumer innovation and attitudes on electric car functional qualities.

2.9.Nazneen (2018) and co-authors aimed to identify customer perceptions of EV benefits in terms of the environment, car cost, comfort, trust, technology, infrastructure, and social acceptance in their study. Consumers are fully aware of the benefits to the environment. More infrastructure facilities are needed by the government. Governments and manufacturers must invest to shape consumer perceptions and deliver the expected characteristics.

III.Theoretical Developement

3.1 Methodology Research Design):

In order to answer the investigation questions the qualitative approach was chosen since it was better suited for the thematic, although the data was treated using the quantitative approach in terms of interpretation. Furthermore, in this case the questions made in the questionnaire are opinion questions where the goal is to try to understand the motivations of a certain sample and to perceive and interpret the tendencies around it whereas the quantitative approach is used to quantify a problem and understand its size. Having this mindset in mind a series of questions were developed to seek answers for the investigation questions.

3.2 Methodology Workflow

Since the steps that were made in order to make the methodology were already described above, it is only necessary now to present a workflow of how the whole process works

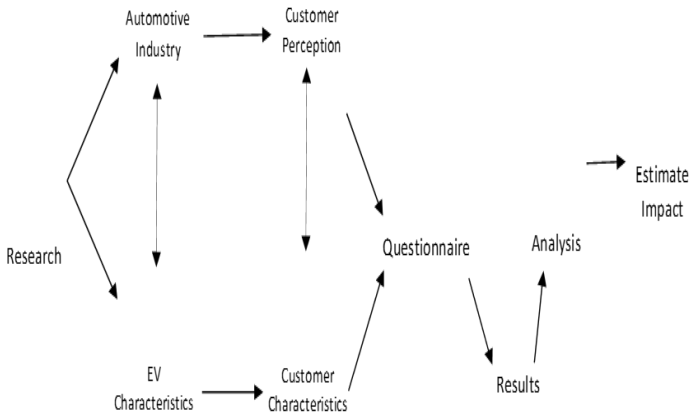

Figure- Process Workflow

3.3 Electrical vehicles and the urban environment

It can be said that the main reason for urging towards the introduction of Electric Vehicles in the private vehicle market is its possibility to reduce the pollutant emissions in the urban environment. This consideration only partially holds for greenhouse gases and in particular for the carbon dioxide (CO_2). Indeed considering that a high percentage of electric energy is produced by means of power plants using fossil fuels and that the impact of greenhouse gases has to be seen at a global level, it is worth estimating the possible reduction (if any) of the total CO_2 emitted by the vehicle fleet in an urban environment. It is obvious that to be able to do this an estimation of the electric vehicle market penetration and its evolution in an urban environment is required

3.4 Market penetration of electric vehicles:

The deployment of electric vehicles will depend on a large variety of factors. This includes the performance and costs of batteries, the access to the distribution grid and its efficiency, the type of business model implemented to supply the consumer with reliable batteries and electricity, the acceptance by the consumer of new vehicle types and possible implied driving habits.

3.5 Potential EV impact on the overall CO_2 emission in an urban environment.

In 2009, both the European Union (EU) and G8 leaders agreed that CO_2 emissions must be cut by 80% by 2050 if atmospheric CO_2 is to stabilize at 450 parts per million (CO_2 equivalent) keeping the global warming below what it is considered to be the safe level of 2ºC. But 80% decarbonization overall by 2050 requires 95% decarbonization of the road transport sector.

3.6 Cost of EV as compared with other technologies

Consumers buy a new vehicle because many and diverse reasons, including purchase price (one of the main concerns of the majority of buyers when approaching to purchase a new vehicle), depreciation rate, styling, performance and handling, brand preference and social image. However, car owners tend to underestimate the costs of running a vehicle. Although they are very well aware of fuel costs, road tax and insurance, they do not always account for servicing, repair and cost of depreciation. Therefore, if one is interested in comparing the cost of EV with other competing vehicle technologies the parameter of interest should be the Total Cost of Ownership (TCO). The TCO takes into consideration not only the purchase price but

also the running cost of the vehicle (i.e. the cost of maintenance, replacement and repair costs, reliability, insurance premiums, taxes, and fuel/energy cost) in other words it describes the costs associated over the vehicle's entire lifetime

IV. RESEARCH OUTCOME

4.1 Charging Infrastructure.

One of the major hurdles in adoption of EVs in India is the unavailability and slow development of charging infrastructure. Charging infrastructure is the foundation on which the EV market is built and India has not achieved an expeditious pace of establishment and use of charging infrastructure which creates a barrier in both production and sale of EVs in India. Factors like unsurety in utilization rates of charging stations, huge operating costs, load on electricity DISCOMs, etc., create a negative environment for operators to establish charging stations and discourage investment when there are not sufficient number of EVs in Indian roads for operators to realise the returns on their investments.

However, as discussed above, Indian policymakers are taking steps to address the lack of charging infrastructure and providing legal regulatory support for setting up of charging infrastructure for EVs. A smart, low cost, AC charge point has been developed by the DST and the office of the PSA to the Government of India with NITI Aayog for light EVs (e-scooter and e-autorickshaws) which may be installed in metros, railways, parking spaces, shopping malls, offices, residential areas which will give a much needed push for EVs. Since this low cost AC charge point requires lower investment the dependance on subsidiaries and concessions from the government can also be reduced.

4.2 Batteries used in EVS:

EVs use lithium-ion batteries that require the use of metals like lithium, magnesium, cobalt, nickel, etc. This means that to successfully incorporate EVs as mainstream vehicles adequate resources of these metals are required to manufacture the batteries used in EVs. For countries deficient in these resources, manufacture of EVs become dependent on availability of the same mainly through imports which increases the cost of procurement of raw materials and manufacturing of EVs. In the financial year 2019-2020, India imported approximately 450 million units of lithium-ion batteries at a cost of approx. USD 865 million. Lithium ion batteries also have a huge environmental impact. Lithium extraction requires a huge amount of water, harms the soil, and contaminates the air. In addition, recycling of lithium-ion batteries is also not efficient since they degrade over time and cannot be used as new batteries.

However, alternatives to lithium-ion batteries are being developed by major manufacturers in the automobile industry. A prime contender of replacement of lithium-ion batteries is a dual carbon battery which is both less toxic and cheaper than lithium- ion batteries. Research is well underway to intensify the energy density of such batteries. Another way forward is the use of aluminum-air batteries to shift reliance to bauxite and aluminum from lithium which is of limited availability in the country.

4.3Research and development

India still falls behind on strong R&D capability and consequently, manufacturers rely mostly on technological know-how borrowed from their foreign counterparts for EV components. Main research areas related to EV components are the constituents of the cells of lithium-ion batteries since these constitute the most expensive components requiring significant research in these areas. Research is required to be undertaken on high priority on EV components to make way for affordable and efficient adoption of EVs. However, this scenario is also changing, and the ARAI has been leading research on EVs and fast charging technologies as per the requirements of the Indian market**.**

4.4 Pollution

Compared to traditional vehicles that burn fossil fuel for energy, EVs are a cleaner, greener and better alternative in curbing depletion of natural resources and greenhouse gas emissions from the automobile industry. However, it cannot be denied that manufacture and use of EVs also contribute to environmental degradation. A major reason for pollution attributable to EVs is the use of traditional fossil fuels like coal to generate electricity for charging infrastructure. Establishment and operations of charging stations depend largely on the thermal power plants that further contribute to pollution. Therefore, it is important that the source of power generation for charging infrastructure be cleaner alternatives like solar or wind or hybrid power plants since using traditional power generating methods may defeat the main purpose of adoption of EVs.

As discussed above, extraction of metals for manufacture of lithium-ion batteries also causes contamination of soil and air and require huge amount of water. Disposal of batteries of EVs also is an arena of concern. Only a small number of batteries are recycled and most batteries end up in garbage dumps or are used for extraction of metals through other unclean technologies.

V. CONCLUSION

5.1 CONCLUSION & FUTURE SCOPE

There has been a lot of buzz and hype around the EV industry in India and the Indian government also has placed EVs as the primary alternative to traditional combustion engine vehicles. However, before placing reliance on EVs, a holistic analysis is required to be undertaken involving the polluting effects of EVs, EV components and EV infrastructure along with other alternative technologies like hydrogen powered vehicles, etc. Still, the impact of EVs in a market with huge greenhouse gas emissions cannot be downplayed.

Mr. Nitin Gadkari, the minister of MoRTH, Government of India has been quoted to mention that the government intends to have EV sales penetration of 30% for private cars, 70% for commercial vehicles, 40% for buses, 80% for two and three-wheelers by 2030 and that the government is supporting localisation of all EV components and Rs 57,000 crore have been allotted for the same through the PLI schemes. He also said that the government has also allocated Rs 18,100 crore for the manufacturing of advanced battery cells.

While these investments are welcome, the government has been primarily focused on reducing India's reliance on fossil fuels and other traditional non-renewable forms of energy. However, India is still at a nascent stage of EV adoption and needs to further strengthen its laws and regulations to realise its objectives of EV saturation in Indian market. There are still some limitations to manufacture and use of EVs as compared to combustion engine vehicles which has inhibited the demand side from accepting EVs with open arms. Formalization of the legal regime, initiatives for public awareness, redressal of logistical issues in the EV market are still required for seamless and fast adoption of EVs.

To increase EV adoption in India, Indian regulators must:
1.Push more for demand-side incentives to reduce parity between the prices for EV and ICE variants.
2.Focus on extending the mechanism for safety ratings (particularly used for ICE variants) toward EVs. This will help instill confidence in the consumer before making the purchase.
3.Focus on providing incentives to companies for rapid product development of their truck portfolio and setting up CV-specific charging stations.

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