A Futuristic Study of Electric Vehicles in Indian Scenario: Emergence of Battery Swapping Technique

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Abstract **- Electric vehicles (EVs) are the sustainable mode of transport and its use will help in reducing air pollution in the World and India. Thereby, a feasible alternative of conventional ICEs. The objective of this paper is to analyze the barriers in the adoption of EVs which are restricting the penetration of more EVs in the Indian market such as Travel Range, Battery charging period, Initial cost, Charging Infrastructure, etc. The synergistic efforts of the manufacturing companies and the government in electrifying the mobility in the vision of making our country cleaner and greener. The emergence of the Battery Swapping technique as a potential solution to the challenges of EV technology.**

Index Terms **- Adoption of EV, Battery Swapping, Battery Charging Period, Charging Infrastructure, EV Technology, Traveling Range.**

Abbreviations**: EV, Electric Vehicle; FAME, Faster Adoption and Manufacturing of (Hybrid) and Electric Vehicles; ICEs, Internal Combustion Engine; NEMMP, National Electric Mobility Mission Plan; OEM, Original Equipment Manufacturer; SIAM, Society of India Automotive Engineers.**

I.INTRODUCTION

The air pollution causing very critical health issues in India. In 2019, there were 21 in 30 the highly polluted cities of India and our country ranked fifth severely polluted country around the globe [1]. In our country,27% of the overall air pollution is caused due to on-road automobiles. Whereas in India, there is a rapid growth in of automobile sector as being the world's 2nd most populated country with 1.38 billion people [2]. The typical ICE based vehicles emit greenhouse gases (GHGs) which are harmful to human health, cause global warming as well as climate change. This is an alarming situation for health as well as environmental concerns in our country.

Therefore, we have to switch from our present ICE based vehicles towards electric vehicles (EVs) for the sake of our country. In recent trends, the EVs are emerging as the replacement of typical ICE based vehicles globally. The worldwide sale of electric vehicles (EVs) amplified by 92%, i.e., 765,000 units (up to mid-2019) in comparison to 397,000 units in 2018. The EV demand is growing continuously after all the challenges.

India endeavors to be on a path of the mobility transformation. Therefore, The NEMMP 2020, put in motion in 2013, was designed for breaking the ice in shifting towards EVs from fossil fuel-driven mobility. As the part of initiative, the government launched a scheme known as the FAME in 2015 with the objective of incentivizing the EVs and HEVs. These steps taken by the Indian government are the steppingstone for the acceptance of EVs in our country [3].

EVs have low operational costs as well as high efficiency with respect to conventional ICEs. But as the concept of EVs is in the developing phase thus there are several technical challenges to overcome and these obstacles are acting as the barriers in the adoption of EVs via the viewpoint of the consumer.

This objective paper is to discuss the challenges in the acceptance of EVs and the technologies and strategies to address them.

II.PRESENT SCENARIO OF EVs IN INDIA

In India, according to the statics shown by SIAM [4], the two-wheelers contribute to 81% of the domestic

market share whereas three-wheelers contribute to only 3% (Figure1).

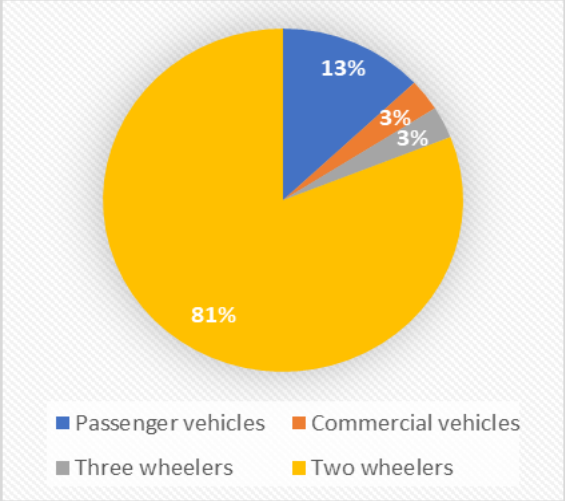

Figure 1: Domestic Market Share for 2019-2020.

From this figure, we can observe that the passenger vehicle sector is a minor contributor (only 3%) to the overall sales of vehicles in India. Yet, the original equipment manufacturer (OEM) of India are trailing to launch their EVs in this sector due to the evolution observed from the international markets. By this race, the customers of India will get advantages of progressive technology, more convenience, made in India products at an affordable cost of EVs [5]. Some OEMs in India are motivated by the footprints of EVs in the Auto Expo 2020 held at Delhi, where several EVs were exhibited and started working towards the development of EVs.

An overview of key specifications of existing available EVs in the Indian mobility market is shown in the table below.

Table1: Pure electric car brands available in India with key specifications

Model	Cost (lakhs#)	Travel Range	Battery Capacity(kWh) &Type	Charging time (Standard[1]/fast[2])	Battery warranty (years)/(lakh-Kms)
Tata Nexon EV	13.99	312	30.2 Li-ion, 3-phase PMSM	8hrs,60min	8/1.6
MG ZS EV	20.88	340	44.5 Li-ion, 3-phase PMSM	16hrs,50min	8/1.5
Hyundai Kona Electric	23.75	452	39.2 Li-ion, 3-phase PMSM	6.1 hrs,57min	8/1.6
Tata Tigor EV	9.54	213	21.5 Li-ion, 72V-3-phase ACIM	11.5hrs,90min	5/1
Mahindra E Verito	9.12	110	13.91 Li-ion, 72V-3-phase ACIM	8.5hrs,80min	5/1

#Ex-showroom price of base model;1-standard charging @ 220V (0-100%);2-DC fast charging (0-80%)

From table 1, we can conclude some points

- The travel range of EVs is dependent on battery capacity. which means for more travel range we have to pay more money.
- Charging time varies differently in different EVs. It is independent of cost and rather depends on the size of the battery.
- A permanent magnet synchronous motor (PMSM) is used for high power EVs (SUVs). Whereas, alternating current induction motors (ACIM) are used for low power EVs (sedans).
- Battery warranty from manufacturers is based upon the years as well as travel range, whichever hits first.
- The cost of EVs is very high in comparison with the same model in the gasoline variant.

All the vehicles listed in table1 are only available in 30 specific cities in the country because of the limited charging infrastructure development by the EV manufacturers. For more infiltration of EVs in our country, we have to increase the charging infrastructure all over the country. India instructed uber India and ola cabs to electrify 40% of the fleets by 2026. Ola cabs launched “Mission: Electric” to put 10,000 EVs on road by end of 2021, for the trial purpose they are testing 200EVs including taxis, busses, rickshaws in Nagpur [6]. Uber India is preparing to increase its taxi fleet of 350 EVs to 1500 by 2020. Therefore, Uber has started electric auto in Chandigarh in alliance with a startup known as Sun Mobility, Sun mobility provide energy facilities that comprise swappable smart batteries and quick

interchange stations. Uber and Mahindra also formed a partnership where the manufacturing company will deploy its E2O plus and eVeritio in Delhi and Hyderabad. Lithium Urban Technologies (100% electric taxi fleet, Bengaluru based startup 2015) expanded to register 1,100 electric four-wheelers (E4W) operating in 9 cities of the country.

In India, the majority population is dependent on two-wheelers implies the potential for electric two-wheelers (E2W). Due to the low power and travel range requirement, they employ budget-friendly lead-acid and Ni-MH batteries. Thus, E2W starts with a range of 70k. Yulu e-bikes, a Bengaluru based startup in partnership with Ola have projected to hit 450 cities in the country by next year. The leading manufacturers of E2W are Bajaj, ESSEL, Hero electric, Arther Energy, Okinawa, Ampere, Lectro electric, Avon, etc. Whereas in India, the need for electric three-wheels (E3W) is potentially high in the transport sector. Thus, several E3W based startups are launching their EVs. The top leading companies in these segments are Mahindra Electric, Hero Electric, Lohia Auto, Terra Motors, Bajaj Auto, Piaggio, etc.

III.BARRIERS IN THE ADOPTION OF EVs

The electric vehicles (EVs) delivers a lot of potentials but still, they are not in demand as compared to ICEs because of the immature technology and major challenges. The main reason behind this situation is the concerns of the consumers and OEMs [7].

A.Technical Challenges

The major setbacks that have discouraged the EVs to dominate the market are the allied concerns with the EVs. These contribute to the total weight of the vehicle and weight is a significant factor in the propulsion of EVs. Charging time and driving range, these parameters are dependent on the battery itself.

B. Financial Challenges

The price of EVs is considerably high due to costly battery packs, lack of charging infrastructure, government policy.

C. Social Challenges

Before buying a vehicle, few concerns arise from the consumer's perspective which is dependent on technical and financial challenges. Therefore, the consumers have anxiety in the acceptance of EVs as compared to ICEs.

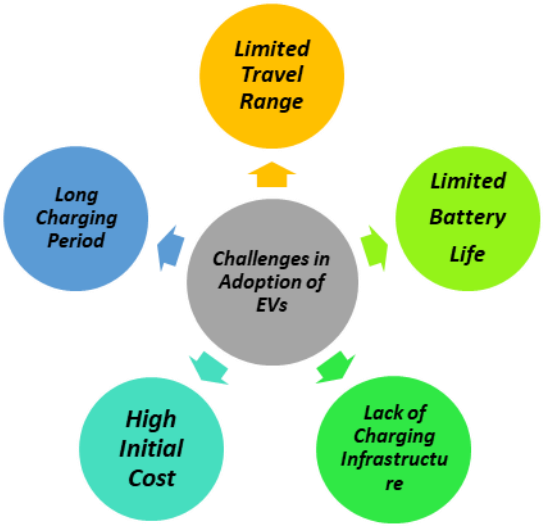

Figure 2: The Major Challenges In The Adoption of EVs.

IV.GOVERNMENT'S INITIATIVES FOR ADOPTION OF EVs

Various countries have adopted the EVs as a part of transport policy, their consequences are diverse corresponding to their state of economic development, technological abilities, political prioritization in implications to energy resource, and climate change.

In India, a specific set of situations that are very conducive to a renewable motion paradigm have given a chance for faster adoption of EVs over ICE vehicles. These circumstances lead India to follow an EV policy that assures that India's EV development program retains its momentum with a global scenario [5].

The main idea of the improved EV policy are:

- To reduce oil consumption in the automobiles sector.
- Facilitate the customer for the adoption of sustainable and electric vehicles.
- Encourage the development of advanced technology in India via research, adaptation, and adoption.
- Reduction of pollution in the cities of the country.
- Setup EV manufacturing plants with capacity that is comparable to global competition.
- Facilitate growth in employment by this sector.

A.Steps Taken by Government for encouraging and adaptation of EVs

- Modification of EV Policy in India
- Making the EVs Economically Viable

- MAKE IN INDIA - Import Duty and Taxes
- Policy for Charging stations / Battery Swapping stations
- Attention on Small as well as Public Vehicles to create a nearly Impact

V. POTENTIAL SOLUTION TO SIMPLIFY THE EVs ADOPTION

India needs a lot of optimization processes in the aspect of EVs development as shown in Figure 3. EVs use different methods to minimize the energy loss and intensification of efficiency. Dropping the coefficient of drag, reduction in weight, regenerative braking techniques, and smart energy management system are some optimization techniques. Additional research and development directions can enhance aerodynamic designs, the materials with lower weight and desirable strength, are the paths for regeneration and restoration of the energy lost [8].

Some of the effective potential solutions are:

- The use of high-efficiency Batteries with high energy density (Wh/kg) [9].
- Enhanced Battery Chemistry to optimize temperature profile fluctuation.
- Development of Fast Charging Infrastructure in urban areas.
- Weight reduction for enhanced Performance Attributes of the vehicles (e.g., Torque, Acceleration)
- Lower the Drag Coefficient factor and rolling resistance of tires in the design phase
- Operation Research-based algorithms for charging sequence
- Connected car technologies by using artificial intelligence for the SoC and distance to empty scrutiny.
- Installing more charging stations all over the country.
- Improvised Battery Swapping technologies.

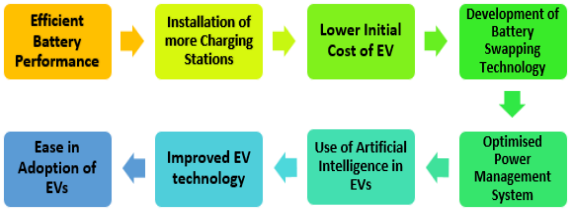

Figure 3: Optimization Process For Ease in Adoption of EVs

VI. CONCEPT OF BATTERY SWAPPING MODEL

There is a different kind of charging technique called as battery swapping. It is not a typical charging technique. Basically, it is the swapping of the batteries at the charging platform. Hence, the owner of the EV can go to the battery swapping station and exchange his existing battery pack unit with the pre-charged battery pack unit available with the same configuration and specification as that of an existing battery of the vehicle. This process will hardly take around 5 to 10 minutes, which is very convenient for the vehicle consumer. Also, the operating cost of EV is very low as compared to gasoline-powered vehicles. For example, Tata Nexon EV is equipped with a 30.2kWh battery with a travel range of 312km per charge and the electricity charges in India are ₹ 8-10 per unit (i.e. 1kWh = 1unit = ₹8-10). Assuming 1unit costs ₹10 implies the operating cost to travel 312km is ₹302 (30.2 x 10=302) that is less than ₹1 per km. Furthermore, the discharged batteries, which were taken by the charging stations can charge those batteries during the off-peak periods, which means during the nighttime. Since at this time the load on the power system is less since the maximum manufacturing industries are not operational at this time. So, in this way this kind of charging scheme also doesn't put any stress on the existing power system, rather it helps it. The major setback of this type of scheme is that it needs a large area for the start of charging to mechanically swap the batteries. It also needs standardization of the battery pack units, to aid this type of system to be successful because several automobile companies use battery pack units of different capacities and specifications. And if a swapped battery is placed in the vehicle which is rated with other specification can result in loss of efficiency or failure in the power system of the vehicle.

A. Implementation Strategies

- Standardization of the battery pack units for ease in swapping.
- The cost of battery unit should not be added to the overall price of the vehicle rather battery manufacturing companies should provide batteries on a lease or rent basis.

- Development of battery swapping infrastructure in the country.
- Battery charging levels should be linked via artificial intelligence to get an alert notification on the display of EV as well as smartphones to avoid full discharge of the battery.

B. Advantages of the battery swapping model

- The travel range anxiety among consumers will decrease.
- Charging time will reduce drastically from 8-10 hours to 5-10 minutes.
- The effective initial cost of EVs will be reduced.
- The penetration of more EVs will not create a huge impact on the power grid.
- Customers' fear of battery unit warranty will vanish because the battery is on rental
- Social acceptance will increase.
- Lower operating costs.
- Growth of employment opportunities.
- Low maintenance on comparing to typical ICEs.

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VII.CONCLUSION

EVs have immense potential to be the future mode of transport and by gradually shifting on Evs India's oil import would significantly reduce. They are a feasible alternative to our conventional vehicles that directly dependent on fossil fuel. As ICE-powered vehicles are the main contributor to pollution in the country, their replacement by Evs will surely improve enhance the air quality index. An overview of available Evs in the country and their challenges are enlightened. From the study, we have observed that the existing techniques are not sufficient enough to overcome the challenges of Evs and now it is the time to look after the battery swapping technology model though is not much popular in India. The Battery swapping model requires a detailed study, as it comprises Battery selection, driving profile, sizing, planning, and standardization norms. This paper discusses the barriers in the present Evs including the probable solutions to overcome the drawbacks and government policy. A summary of the current scenario of Evs in the Indian market is presented. The main objective of this paper is to study and summarize the Evs to get a clear picture for further research and developments.

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