Review on Barriers of Electric Vehicles Adoption

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ABSTRACT

Electric vehicle is gaining considerable recognition as the world is trying to adapt to sustainable methods of transportation. The study aims to identify the key barriers for adoption of Electric Vehicles from a review of existing literature. This work further makes an attempt to categorize the barriers to recognize the most important barrier category and ranking of specific barriers within the categories to the adoption of electric vehicles in India. Through the existing literature, the barriers for adoption of Electric vehicles can be classified into four categories. i.e. Technology, infrastructure, market, policy and reforms. This research is useful to the government and policymakers for eradicating the potential interference for adoption of electric vehicles in developing countries like India. The aim of this study is to synthesize highly relevant literature on electric vehicle adoption barriers by means of a systematic literature reviews found in journals and articles published during last ten years. The barriers for adoption of electric vehicles are many. Most significant barrier in one country becomes a negligible barrier in another country. The barriers are dynamic and inconsistent. Hence, there is no single barrier in adoption of electric vehicles which dominates globally. The automobile industries and government policy makers in India should consider these studies for helping the population adopt to electric vehicles as there is lot of stress on sustainable development. There is sufficient amount of specific studies related to adoption of electric vehicles in India. This study aims to fulfill the gap of India's standing in the barriers of electric vehicles adoption

Keywords
Electric vehicles, Adoption, sustainability, challenges.

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Introduction

One fourth of the earths greenhouse gases emissions and urban air contamination is due to the transport sector. [1] When the non-renewable sources are burned, it impacts in two ways. Many urban occupants are affected with air borne diseases and there is a climatic change. And lately there is huge spike in the car sales which will result in more awful climatic condition [2]. India is one among the (EVI) Electric Vehicles Initiative, a multi- government policy forum was enforced to quicken the penetration of Electric Vehicles. The EVat30 battle, started in 2017, sets an aggregate optimistic objective for all EVI individuals to have EVs add to 30% of all vehicle deals by 2030. In 2013, Administration of India started a National Electric Mobility Mission 2020. Under this the Scheme of ('FAME India') Faster Adoption and Manufacturing of (Hybrid & Electric Vehicles) in India was launched in March, 2015 with a financial plan of Rs. 895 crores for 2 years as Stage I, which was in this way extended up to 31st march, 2019. A few states like Kerala, Karnataka, Maharashtra, Telangana, and Uttar Pradesh and Andhra Pradesh have additionally reported their EV strategy to complement [3]. India revealed (NEMMP) 'National Electric Mobility Mission Plan 2020 to address the issues of National energy security, vehicular contamination and development of local manufacturing abilities. The goals of the National Mission Electric Mobility (NMEM) are National energy security, extenuation of the opposite effect of vehicles on nature and rise of domestic manufacturing capacities. The NEMMP 2020, the mission report for the NMEM that was affirmed by the (NCEM) National Council for Electric Mobility on 29th August 2012, sets the vision, lays the imprint and gives the joint Government – industry vision for understanding the immense potential that exists for full scope of productive and environmental friendly electric vehicle (Including Hybrids) technologies by 2020 [4]. EVs in India, as welcomed as they are, come with challenges that might severely affect the population. One of foremost significant concern is the availability of "electricity". The power requirement for Electric Vehicles is projected to be 79.9 gigawatt hours (GWh) by 2020 which will rise up to 69.6 terawatt hours (TWh) by 2030 [5]. This simply means that a substantial increase in electricity production is required to offset the overloading of local transformers and the grid. The risk of overloading of grid is particularly high during peak hours when most of the EV owners plan to simultaneously recharge. The power infrastructure will be put to test especially in the urban areas. Rebuilding of transformers, grids and electrical components are necessary for better vehicle charging. Renewable sources like solar and wind can be complemented for power demand this also can be seen as the solution in long-term. By 2022 under (ISA) International Solar Alliance India would have harnessed 100 GW of solar power by exploiting the sub-tropical geolocation. Dependency on foreign countries can be reduced as the solar power is reliable and cheap. Apparently, Electric Vehicles can obtain large momentum based on the increase in solar power capacity of India.

Barriers In Electric Vehicles

In implementation of EVs there are several advantages and also some barriers in adoption. Generally, all barriers in EVs can be classified into four sections: Infrastructure, Technology, policy and market.

Infrastructure

For the adoption of EVs the infrastructure needs to be in place [6]. Many tell that it is like a chicken and egg problem, some say infrastructure should be made first. But some say EVs must be bought first for the infrastructure to fall in place, it is debatable point. Some the barriers in infrastructure are

Charging Infrastructure

The energy required to run EVs are supplied by batteries. For these reasons EV batteries should be charged sufficiently. To cater to all the EVs sufficiently more charging stations are required [7]. While installing charging stations fast charging technology should be deployed as it is a time-consuming process, so waste of time can be prevented. The charging point must possess its own local body [8]. The GPS mapping helps the electric vehicles to optimize the sub-stations and power demand of the EV. It also helps to control and regulate stations which require power and also adjust the issue of switching out and in of the charging stations. The filtering of harmonics should be ensured while designing the charging stations. However, if they are not taken into consideration properly it should be at least ensured in sub-station level filters. Restructuring of station feeders for balancing of load by forecasting and financial scheduling will affect the national and state grid performance. The substation should be given regulated supply of energy for feeding charging station by proper coordination of hydro, thermal, renewable energy and gas plants. A cyber hack is also a major threat to the system which will lead to load-shedding issues in charging stations. Smart sensors are used to monitor real time charging stations.

Smart grids

V2G Technology: - the government is encouraged by the environmental issues, fossils depletion, and always growing oil demand to produce electric vehicles. National electric mobility was launched by GOI and ministry of heavy industries. One grid connected to one set of EVs for power supply and transaction is called V2G technology. Ninety percent of the time the EVs are in rest. The connection to the grid can done in this time. Some benefits of V2G.

- Spinning Reserve – power generation units can be increased with the additional power available.
- Peak load Shaving – with the help of V2G technology EV batteries can be charged in non-peak hours and energy stored in battery can be provided to the grid in peak-hours.
- The main factors in electric grid reliability and operation are the need of the regulation of power efficiency and voltage.
- Harmonics – these are injected into electric grid by EV charges which are non-linear loads. The harmonic and other non-linear loads produced with grid and EV charges can be filtered out with appropriate regulating and monitoring od EV charges.

There are some disadvantages of V2G –

- Battery Degradation – the ageing of the batteries depends on temperature and voltage. By charging and discharging the cells get gradually get deteriorated.
- High investment cost – the software and hardware and infrastructure related to it is very expensive.
- Social barriers – the EVs should always have some amount of buffer charge for the owners so that it can be used in emergency and unpredictable situations.

By balancing the load demand, filling valley and shaving peak, v2g supports the grid requirements. (GCC) grid control center, aggregator and EVs are required for communication in V2G. The aggregator is given information about the electricity demand by GCC day to day and short-term trading with brokers, marketers, power pools and other parties for meeting varying load, this plays an important role.

The communication between the aggregators and EVs takes place. The aggregators combine all the electric vehicles and helps us to contribute electricity to the grid. The aggregator acts as a mediator between EVs and grid control centers. This also encourages EVs to participate in V2G. the electric vehicle owners are encouraged and attracted to contribute power to the grid as they receive incentives in free parking slots and charging. The communication link and power transaction are needed between the aggregator and electric vehicles. They are two types of customers

(a) The aggregator does not get the permission from the uncompromisable load to control charging procedure. (b) the aggregators get the permission from the uncompromisable load to control charging procedure. Trading od bids can be done by aggregators in energy markets and additional services. Organizations like (ISO) International Organization for Standards, (IEC) International Electro- Technical Commissions and IEEE have set up standards for communication interface between EVs and grid.

Battery recycling

Battery consists of harmful chemicals like cadmium, nickel, lead etc. Battery is one of the most significant components of Electric vehicles [9]. There are some regulations in place for the disposal of the batteries. As the batteries contain many environmental harmful substances. Life cycle cost of the batteries can be reduced by the recycling of batteries. In recycling procedure, the cost is the most significant factor. The parameters which decides if the recycling is cost-effective or not, is further discussed in [10]. One significant parameter is the ability of the market to monetize recycle batteries. The ability of market differs for different types of chemicals found. As stated in the exclusion principle [11]. There are limited markets available for expensive materials and low price for materials which are found abundantly. Therefore, all these factors should be taken into account while planning the process of recycling.

Dedicated lanes for E-2 wheelers

There is a need for separate lanes in the roads because EVs speed is minimal compared to the conventional vehicles. Hence, there is always a danger of collision. If there is separate lane dedicated only to EVs then the riders will feel much safer while riding EVs.

Technology

Limitations in technology are the main factors that must be considered for operations and design of EVs. There are some very significant factors that must be taken into account during the design phase. Some of the factors are:

Lite-weight material

EVs important concern is to decrease the energy need of the vehicles. In Electric Vehicles few mechanical elements are substituted with electrical parts and these spare parts of EVs are interconnected dynamically with mechanical parts of the vehicle. More energy is required if the parts are heavy. So, manufactures should try to make vehicles which are less in weight and energy efficient. A few lightweight materials, for example fibers, plastics, rubber and glass should be utilized in manufacture of EVs. Due to this dead load of the vehicle is drastically reduced. Advance high-quality steels are created in order to reduce the thickness of the sheet metals ([12]. Lightweight materials like magnesium and aluminium are utilized for the designing the bodies of EVs [12].Some other lightweight materials, for example, natural fiber fortified composites are additionally utilized in assembling [13].

Motor and their Suitability for EVs

Engines like permanent magnet motors, dc motors, switched reluctant motor, induction motor are generally considered for traction applications. The robust and simple control of the dc motor is the main advantage. Heat losses and deterioration of brush is located in the rotor these are certain disadvantages. The losses of rotor can be decreased by using copper squirrel cage rather than using aluminium, by this method the induction motor overcomes the problems. But in order to do this it requires tiny air gaps to maximize efficiency and decrease reactive current. Hence, this is a drawback. For low speeds higher pole number is less apt and generally induction motor is not well suited to it. Permanent motors have high manufacturing costs and they are extremely sensitive to temperature. But permanent motors have high power density and efficiency, and ohmic losses occur when compared to other motors. Switched reluctance motors have certain restrictions such as vibrations high torque ripples and noise. But these motors are fault tolerant phases and cheap are mechanically and electrically reliable, isolated for utilization at elevated temperature and higher speed. In synchronous reluctance motor the absence of magnets decreases the machines fragileness to destruction caused by short circuits. Synchronous reluctance motor completely eliminates all rotor magnets and through this it achieves less losses in the rotor when they are no conductors or magnets in the rotors. It limits the values of saliency ratio which decreases the machines compactness of torque when compared to permanent motor machines.

Efficiencies of batteries

The dire need of the hour is to manufacture efficient EVs, better motors, better tyres and decrease the battery size. The eco-system of the batteries can be maintained by making cell (30%), pack manufacturing (30%), chemicals (40%). Additionally, swapping and charging infrastructure requirement as battery swapping, fast charging and slow charging. The battery life span thoroughly relies upon dynamic temperatures which reduces the life by 20% to 30%. This slow charging batteries have a better life span than that of fast charging batteries. The general conventional type of batteries used worldwide are lead acid batteries and these batteries have less energy and volume ratio. The disadvantage of nickel-cadmium batteries is, they use heavy metal cadmium which is harmful for the environment when disposed, however these batteries have the highest life span compared to other batteries. Lithium-ion batteries have limited life cycle, but also have huge energy storage capacity [14]. The batteries in EVs system are based on chemicals like lead-acid, nickel and lithium ion. Differentiation of these batteries and parameters are seen in table-1.

Sl. No	Parameter	Comparison
1	Cost wise	Li-ion>>Ni>>Pb
2	Safety	Pb>>Ni>>Li
3	Capacity	Li>>Ni>>Pb
4	Life Cycle	Li=Ni>>Pb
5	Charging time	Pb>>Ni>>Li
6	Weight	Pb>>Ni>>Li

Table 1 Comparison of Different Batteries

The main challenge for any battery is that it should be of light weight and it should have high storage capacity. Moreover, EVs are based on efficiency and high battery capacity [15]. In the coming five years lithium-Sulphur batteries, sodium ion battery would have more energy retaining ability than li-ion battery. The peak power demand and fast charging can be met by the introduction of super capacitors. BEVs battery performance depends on the parameters like safety, capacity, cost, life cycle, charging time and weight. The efficiency of the fuel cell batteries is more but procuring purest form of hydrogen is a difficult task. By using the chemicals like natural gas and methional pure hydrogen can be obtained [16]. Hence, for heavy vehicles which are travelling long distance the fuel cells are more suited than huge capacity battery which will be tough to manufacture and will be costly [17]. Fuel cells are safer than diesel, petrol and CNG and these are also cheaper than others.

Driving range of EVs

In the electric vehicles the driver always as to put up with the less driving range because these vehicles have little driving range than conventional vehicles [18] [19]. The conventional vehicles which use petrol and diesel as fuels have five times more driving range than a fully charged electrical vehicle [20]. The record for the highest driving range for a single charge is on the name of tesla model S vehicle [21]. The fuel anxiety is always in the minds of the driver because of little driving range. In spite of modern technologies, the fuel displays can be seen but it does not show the history of usage of fuel. To overcome these challenges several steps should be taken. Such as – fast charging batteries, increase in charging stations. All these measures will take time and would include huge initial expense [22].

Time for Charging

An average electric vehicle with lead batteries or pb-acid batteries or which can be controlled by valves or lithium batteries can be charged completely in a night [23]. The e2o electric vehicle of Mahindra motor company can be charged fully in five hours. The electric scooter E-sprint of Hero motor corporation can be completely charged in eight hours. Due to the lead batteries the 70 percent of the charging can be done in 40 percent time. The rest of the process can be considered as “topping up” process. The battery technology is continually changing with the time but with new technologies comes quicker charging times [24]. There can be a possible answer if the electrical vehicles can be charged in twenty minutes. This can come to possibility by the use of standard connectors which can accept DC quick charging.

It is important to understand and analyze charging stations in real time scenario and because of the scale and penetration of electric vehicle charges. Ex- if the load is adjusted the running of the inverters of solar based PVs will be acceptable. However, in the event that the load is unequal at that point the running of the inverter will plunge and will cause operational debasement pf PVs. The domestic houses can play a helping hand in supplying the power to the grid through the roof top solar panels and which in turn can give power to the charging stations. During charging sound is injected in the battery system. Going in and out of the charging station will cause current and voltage to be in sinusoidal waveform due to the sound. This additionally causes quality issues. So, already existing stations should be amicable with new technologies. The other challenges are due to the pattern of charging and discharging of customers. The relative power balance should be checked regularly. The customer power loads can be managed by installing smart meters which can monitor and predict the voltages. The planning of the charging stations should be grid resilient otherwise the reactive power in the systems will lead to the heat losses which in turn reduces the operating efficiency. Extensive analyzation of the real time travelling in and out of charging stations is needed to examine the performance of local grid. The need of the constant current for the charging stations can be supplied and regulated from the distribution end. The recharging points shall be made in a way that the segments in the charging stations shouldn’t be affected because of the fluctuated output as these fluctuated outputs cannot be controlled by distributing system. By the process of load shedding the situation of unbalancing load can be regulated up to certain extent.

The harmonic analyzers are needed in charging stations to calculate total harmonic distortion (THD). This will help in making existing charging stations compatible with new technologies. The charging stations can be made self-regulated with the help of filtered design. In stations certain parts should be changed in distribution system to match the existing station.

Safety

The significant factor which must be considered while manufacturing EVs is safety. Safety is important in both electrical and mechanical parts. The protection against fire shocks vibration and collisions can be related to mechanical safety. Electrical safety mainly concerned about control of electrical system and their processes [25]. This safety includes safety against over-charging, over-discharging, current protection and short circuit etc.. [26]. The standard of electric vehicles is set up by (IEC) International Electro-Technical Commission and ISO (International organization for standards).

Environmental Impacts

Greenhouse gases like carbon dioxide, carbon monoxide, major hydrocarbons, methane and other gases are reduced because the EVs use electricity in place of fossil fuels [27]. Hence, the electrical vehicles can be called eco-friendly. However, for computing the eco-friendliness index “well to wheel” discharges must be examined. This emission factor will be less if the power is produced from renewable sources and it will be more if it is produced from fossil fuels. As this emission factors takes into account all the pollutants produced at all steps like distribution, processing and fuel generation. In spite electrical vehicles having certain environmental advantages but still they have certain environmental issues attached to the used battery disposal. These batteries should not be disposed in open as they consist of lead, which is very harmful to the environment.

Policy

Other major barriers in adoption of EVs is the challenges with Policies. Policies concerning manufacturing, infrastructure and sales should be standardized by GOI and other stake holders.

Incentives

Incentives will certainly motivate the potential buyers to purchase EVs which in turn will boost manufacturing. Fast adopting countries like Norway (with around 40% EV market) provides exclusive benefits to EV buyers. These benefits include tax rebate, toll waivers, registration fee waivers, free parking etc., resulting in overall cost savings for the consumers [28]. The provided incentives can be recovered from taxing the ICE vehicles which actually emit pollution. Also, as EVs will reduce the nation’s dependence on oil imports, it would in the long-run ultimately contribute towards building the forex reserve [29]. Taking cue from Norway model, SIAM has requested the government to reduce GST to 5% (from current 12%), waive off road and toll taxes along with provision for income tax benefits and free parking. It was also advocated by SIAM to provide 50% reduction in power tariff for charging EVs. Incentives may also be provided for people who are willing to support public charging facilities on their property along with provision of dedicated lanes for EVs on the roads. Thus, imparting initial incentives for popularization of EVs may manifest to be a zero-sum game in the long haul benefitting all [30].

Subsidies on fossil fuels

By importing more crude oil from OPEC (Organization of Petroleum Exporting Countries) the CapEx reserves of the country is affected. India is also very reliant on theses exporting companies. The fuel cost of EVs can be decreased by using renewable sources for electricity generation. By means of this, government can also decrease the subsides for fossils fuels and subsides of EVs can be increased. The penetration of EVs into the market can be dine with this method [31] [32] [33].

Electricity tariff policies

Thermal power plants and other types of conventional power are the main sources of electricity in India. Renewable power can be generated with help of new technologies which in turn helps to reduce the generation cost. This can help in the penetration of renewable sources in the power system. Now the government can give better incentives to the renewable electricity consumer and even the tariff rates.

Market

New technologies have helped us to resolve many technical problems related to EVs mobility and charging. But there are some market related challenges which needs to be resolved as there is an increasing awareness about EVs.

Certification and Testing

The main challenge regarding the best practices during manufacturing and designing are certification and testing of EVs. Both electrical and mechanical parts should be tested in EVs. Like all conventional vehicles mechanical tests include vibration testing, impact testing etc. The extra need for EVs is that it should be also be tested for electrical components. Different types of electrical tests are shown in table 2 [34].

Category	Tests	Description
	Acceleration Test	Various State of Charge (SOC), PPS, Speeds
	Constant Speed Test	Various SOC, PPS
	Braking	ABS stop
Electric vehicle power mapping		Progressive Apply of Various G levels
	Drive Cycle - Power and Thermal	City driving cycle Complete highway driving
	Response time to wheel	Various Rate of throttle Excitation at different SOC
	Range Estimation	Test conducted for various SOC
	Auxiliary Power Drain	Components contribution on battery Power drain at various SOC
	Charging Efficiency Mapping	Recording of a complete charging View of the energy flow in the main power supply during the charging process
Component Level	Inverter	Efficiency of inverter to convert DC to AC with change in load
	Charge Unit	Efficiency of the AC-DC charging unit in vehicle.
	Battery	SOC open circuit voltage Internal resistance Discharge efficiency

Table 2 Types of Tests in EV's

The accreditation and testing is not yet standardized though there is a rise in popularity of EVs. The agencies are still in the initial stages in accreditation and testing of EVs. Hence there is a need of standard and strong accreditation processes to manufacturing EVs.

Vehicle Servicing

The maintenance and servicing of EVs is difficult as they are not popular enough. There is also a shortage of electric vehicles service centers and specialized experts in EV maintenance and servicing. The servicing expenses are much higher than conventional vehicles servicing due to the above-mentioned reason.

High Capital cost and financing

Due to the low cost, availability and the popularity of technology pb-acid battery are generally utilized in Electric

Vehicles. Thanks to technology nickel-metal hydride batteries and lithium ion batteries can be used in EVs. The new studies suggest that super-capacitors can replace these batteries. The cost of EVs is completely dependent on the cost of the batteries. The cost of Electric Vehicles is high when compared to conventional diesel and petrol using vehicles as the technology used in EVs is not very renowned [35].
Financing organizations do not have much awareness about Electric Vehicles. Hence, they are hesitant in financing the purchase and manufacturing of EVs. So, less availableness of finance and high cost of EVs are some significant barriers in adoption of EVs.

Electricity quality

The quality of the power provided by the charging station is the main factor in the battery charging. DC power is used for the charging and storing of energy which is converted from AC power. The quality of the power degrades due to the sound while converting AC to DC. The life span of the battery and charging is affected due to the degraded quality of power. In the light of new technology and power electronics, the quality degradation issues are decreased. However, to ger satisfactory results more efforts should be put into resolving these issues.

Consumer perceptions

People are not coming forward to but EVs as there is still insufficient infrastructure and because of high costs [36]. However, people are open to get information about EVs. To overcome these challenges the perception of the consumer should be changed. With help of GOI, NGOs and other stake holders, awareness can be brought so that the perception of the people can be changed. The consumer’s perception can definitely be changed if the infrastructure is ready, and people get awareness about the incentives, long-term benefits.

Conclusion

The way leading towards significant e-mobility by the year 2030 is a grand challenge in itself for India. But with extensive R and D, meticulous planning and government interference the milestone is achievable. A healthy starting point will be focusing on enhancing the footprint of e-mobility by converting public transit, inter para transit and two-wheelers to electric. Since public and shared transit modes highest proportions of passenger kilometer travelled [37], it makes more sense to electrify them first. As these mode cover larger distances, the high upfront cost can be more readily recovered with low operating and maintenance cost as compared to private EVs which run for shorter distances. The electrification of large fleet of public buses commanded by various governments and transport agencies is favorable for showcasing the EV potential in India. As the EV market is still in its nascent stages in India, a well-rounded policy framework will act as a guiding star for a successful transformation to e-mobility. The intended framework should take into consideration setting up national standards for EV batteries covering both manufacturing and performance criteria [38]. Stringent standard for safety is pertinent as certain cases of battery explosion due to overheating have been recorded. Since the overheating of battery also determines its charging speed, sturdy batteries that will perform efficiently under hot climatic conditions are to standardized for Indian market. Optimum location of charging stations will alleviate “range anxiety” of potential EV users and will encourage them to switch to EVs. Well-founded quantitative research on this aspect will lead to optimization of funds and CRRI has taken lead into researching this area. Standards for charging infrastructure that also include battery swapping system is a promising area as it reduces the waiting time for both commercial and private vehicles. The battery swapping scheme was rolled out as a pilot project in Nagpur for two-wheelers and three wheelers segment and has shown to be efficient [39]. The resolve of the government to shift to significant e-mobility by 2030 is an admirable step towards the sustainability of transport and energy sector. But this ambitious plan will see the day of the light only if the various factors are duly considered and managed for readying the market for electrical mobility. Taking cue from e-mobility adoption plans of successful countries, India can transform its transport and energy sector as well as become a net exporter of EV components especially batteries in the geopolitical region

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