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Article *in* Journal of Green Engineering · January 2018

DOI: 10.13052/jge1904-4720.813

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Electric Vehicles in India: Market Analysis with Consumer Perspective, Policies and Issues

Pritam K. Gujarathi[1,*], Varsha A. Shah[1]
and Makarand M. Lokhande[2]

[1]*Department of Electrical Engineering, Sardar Vallabhbhai National Institute of Technology, Surat, Gujarat-395007, India*
[2]*Department of Electrical Engineering, Visvesvaraya National Institute of Technology, Nagpur, Maharastra-440010, India*
E-mail: pritamgujarathi@rediffmail.com; vas@eed.svnit.ac.in; makarandlokhande@gmail.com
[*]*Corresponding Author*

Received 22 January 2017; Accepted 10 May 2018;
Publication 18 June 2018

Abstract

Early in the 21st century, new companies were formed to take advantage of the absence of the large car manufacturers in the EV market, such as Tesla Motors in the U.S, Think in Norway, BYD in China and REVA in India. Globally all these new manufacturers had released one or more EV models and changed the equation of Auto Industry. Looking into Indian Scenario, still, long way to go, the paper presents the current Indian EV market, market players in two and four-wheeler with recent developments along with the current status of Indian road transportation. Policies and initiatives of government are discussed. A case study is presented with consumer's perspective to understand ground reality. Tariff for EV charging is discussed. Challenges for Indian market growth, policies, and promotions required are discussed with feasible options along with global scenario.

Keywords: Consumer, Electric Vehicle, India, Market Analysis, Policy.

Journal of Green Engineering, Vol. 8_1, 17–36. *River Publishers*
doi: 10.13052/jge1904-4720.813

1 Introduction

Innovators in Hungary, the Netherlands and the United States created some of world's first small-scale electric cars, yet it was 1900 where electric cars and autos were practically used in the US. 28% of cars were worked on electric with two third of electric autos were on road [1]. Latter due development of low cost IC engine technology, ICE dominated the Market. Slowly the entire world was grasped by the problem of pollution irrespective of several efforts and contribution for alternative/hybrid fuel and technology. It was unable to reduce environmental emissions until the first hybrid electric car came into the market by Toyota Prius in 1997 in Japan. Nearly 18,000 units were sold in the same year [2]. It was after 2000 where revolution took place when Tesla in the US, Reva in India, Think in Norway and BYD in China put their model in the market and dominated IC engine car manufacturers had to take a call to shift toward the electric car. Recently Tesla Semi Truck is in the market with four independent motors with maximum power and acceleration and provides the lowest energy cost per mile [3]. Global electric vehicles (EV) sales created a record high to deliver more than 1,70,000 vehicles in December 2017, and the figure surged 67 percent compared to the same period in 2016 in the US, EU and especially in China. The few among top selling cars are BAIC EC 180, Tesla Model S, Toyota Prius Prime-PHEV and Nissan Leaf [4].

Indian Scenario is different as the current market share of EV/PHEV is around 0.1%. At present almost, all vehicles relay on fossil fuel-based transportation. These pollutes atmosphere by the emission of greenhouse gases & causes global warming. Indian transportation sector is growing very fast. The gap between domestic crude oil production and consumption is widening. India is a country which imports around 70% of oil required per year [5]. Hence there is urgent need to investigate factors and challenges for the development of sustainable and clean alternatives for transportation systems. Towards electrified vehicles is one of the promising, clean and sustainable transportation. The current scenario of road transportation sector can be highlighted as

- Energy consumption : 524 million tons of oil equivalent
- Vehicle to people ratio : 1:56.3
- Per capita energy : 442 kg of oil equivalent
- GHG emissions : 1730 million tons of CO_2 equivalent
- Electric Vehicle (EV) sold (2016) : 25000 (all) and 2000 (cars) [6]

Unlike other countries the vehicle to people ratio is very high, however, the population is more and emission is high. India stands third with the CO_2 emission of 1.726 billion Mt [7]. The top 10 emitting countries account for nearly two-thirds of the world CO_2 emissions as shown in Figure 1 [8]. Hence there is urgent need to focus towards EV technology which has capability towards zero emission for sustainable transportation. In addition, due to urbanization and decentralization of city area, a rapid increase in personal vehicles has been observed. The statistics of the vehicle can be seen in Table 1.

The transportation sector is expected to grow about tenfold over the next four decades [11], driven by increasing uptake as incomes rise which is a challenge in aspects of traffic, road infrastructure etc. Looking into the growth, the current level of pollution and depletion of fossil fuel, there is strong need to shift from conventional IC engine vehicle towards the electrified vehicle. At the moment demand for EV in India is quite small. By industry estimates, less than 5% of the passenger car market in India would comprise of electric

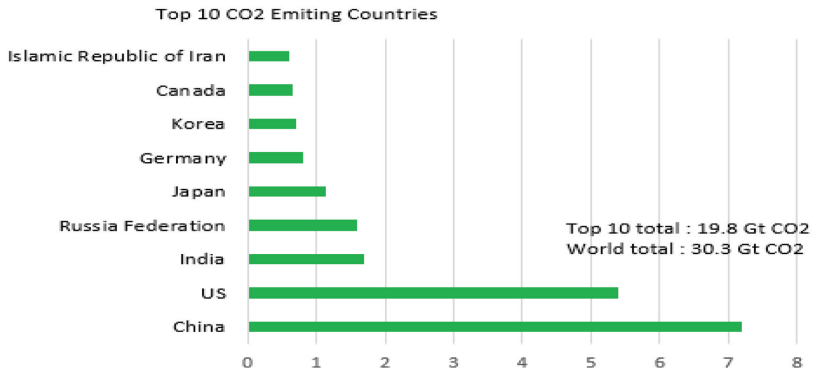

Figure 1 Top Ten CO_2 Emitting Countries [10].

Table 1 Indian Statistics of Vehicle [6, 9]

Year	Car	Two/Three-Wheeler	Commercial Vehicles	EV	PHEV
2008–09	14.15	89.28	5.49	0.37	–
2009–10	15.52	92.76	4.27	0.16	–
2010–11	19.70	115.52	5.78	0.35	–
2011–12	24.30	146.70	7.53	0.45	–
2012–13	27.70	166.28	9.02	1.43	–
2013–14	26.79	171.62	8.73	0.19	0.19
2014–15	31.80	196.70	10.0	0.41	0.48
2015–16	34.80	215.70	10.9	1.0	1.0

Note: All figures are in Lakhs except EV/PHEV (in thousands).

cars over the next 5–7 years; at 1,75,000 units [12]. Currently, the cars sold in India are electric vehicles (EV), Hybrid Electric Vehicle (HEV) and Plug-in Hybrid Electric Vehicle (PHEV). However electric vehicles sale is not very promising irrespective of EV/HEV/PHEV can be more beneficial for Indian road due to following reasons

1. Hybrid or electric powertrains operate at much higher efficiency at low Indian driving speeds than an Internal Combustion Engine (ICE).
2. A higher share of energy per Indian trip is lost in braking, which is almost recovered in a hybrid-electric vehicle (HEV) and EV (Regenerative braking).
3. HEVs and EVs use no fuel during idling and the share of idling time in traffic is much higher in India (than the U.S. & Europe).
4. The average range travelled in India is much smaller than in the U.S. & Europe, making EVs much more feasible and with no range problem with a single charge.
5. Vehicle use and vehicle distance – Urban driving cycle patterns have a frequent start and stop, high traffic benefits to provide high efficiency by electric vehicle.

This paper gives detail insight on Indian EV status, market, market players, policies, issues related along with policy options. In addition, the consumer's perspective with case study is presented.

2 Indian Government Initiative

Considering all above aspects Indian government has taken an initiative & declare the National Mission for Electric Mobility (NMEM2020). The National Mission for Electric Mobility (NMEM) has its two interrelated key objectives:

1. National energy security
2. Growth of domestic manufacturing capabilities in full range of electric vehicle technologies

In January 2012, the ministry of heavy industries unveiled its ambitious draft action plan for Electric Mobility 2020, which targets almost six to seven million vehicles on the road by 2020. With vision to encourage reliable, affordable and efficient XEVs (all type of electrical vehicles) that meet consumer performance and price expectations through Government – Industry collaboration for promotion and development of indigenous manufacturing capabilities, required infrastructure, consumer awareness and technology.

Table 2 Initiative of Indian Government towards EV

2015	FAME India-Faster Adoption and Manufacturing of (Hybrid and Electric) Vehicles in India
2014	Member Country of Electrical Vehicle Initiative
2013	National Electric Mobility Mission Plan 2020
2011	National Mission on Electric Mobility

Thereby helping India to emerge as a leader in the XEV two-wheeler and four-wheeler market in the world by 2020, with total XEV sales of 6–7 million units thus enabling Indian automotive Industry to achieve global XEV manufacturing leadership and contributing towards National fuel security [13, 14] with target of 400,000 passenger battery electric cars (BEVs) by 2020 $\sim$ avoiding 120 million barrels of oil and 4 million tons of CO_2 which will lower vehicle emissions by 1.3 percent by 2020. The total investment required is INR 20,000–23,000 Cr. There is a slow progress as such till now, however, after the announcement of FAME (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles), there is little push. Linking FAME India and Make in India there is hope that there will be the faster adoption of EV in India as it is a need of an hour.

Under the central scheme, a subsidy of INR 1,800 to INR 22,000 is offered to two-wheelers, INR 11,000 to INR 1.38 lakh to cars, INR 13,000 for mild hybrids [15].

3 Market Players and Brands in India

Few players are there in the market who has launched their EV in the market, however, XEVs (EV/HEV and PHEV) are available but at a very high price.

a) EV
   Mahindra Reva – e2o – 4.99 lakhs (Now e20 plus is available in the market – INR 7.46 lakhs)
   EVerito – INR 9.22 lakhs

b) Hybrid
   BMW i8 – INR 2.62 Cr.
   Lexus ES 300h – INR 55.27 lakhs
   Toyota Prius – INR 45.23 lakhs
   Honda Accord Hybrid – INR 37.35 lakhs
   Toyota Camry – INR 37.*22* lakhs
   Maruti Suzuki Ciaz Diesel – INR 8.23 lakhs (recently launched in 2017)
   Maruti Suzuki Ertiga Diesel – INR 7.55 lakhs (recently launched in 2017)

Note: Showroom prices are shown for starting model [16].

It can be seen that prices are still high to afford. Other companies have demonstrated their vehicle in one of the auto shows held in India, however not launched in Market. Honda Cars India had to withdraw the Civic hybrid from the Indian market within months of its launch in 2008. The reason as there were no policies declares from the government. Recently the polices came to market. However not very impressive and the market surveys show that high initial cost of the vehicle is a major hurdle in India. The companies showed their EV in AUTOEXPO in Indian market but not launched are Hyundai i10 – Electric/Tata Magic-Iris Electric/Starbus Urban EF-Parallel Hybrid Bus/Maruti-SX4 and EC0/Chevrolet E-Spark/Nissan-Leaf.

Moreover, there is growth in the sale of E-rickshaws and two-wheelers are observed recently. Kinetic is currently the market leader in the E-rickshaws segment, selling over 10,000 units last year. With 10 lakh e-rickshaws on the road – as compared to two crore autos [17]. In case of two-wheeler market, there are many companies offering a moped solution with a top speed limited to 25 km/hr. like Electrotherm Motor Ltd./Hero Electric Ltd./BSA Motors Ltd./Ampere/Aveon/TVS etc. As maybe there is no licensee & approval certification requirement for above. There are some of the models of Hero electric ltd with a top speed of 40 km/hr. However, there is no company who has launched the vehicle compatible with normal bikes above or comparable to 125 cc available in the market.

Some of the pilot projects/announced promotionally related to Electric Vehicles are

- Mumbai Metropolitan Regional Authority (MMRDA)
- Apr 2015 – Floated RFP for 25 AC electric/hybrid buses from Bandra Kurla Complex to 3 railway stations
- New Delhi Municipal Corporation
- Proposes to operate three-wheeler electric vehicles from Metro stations
- Battery Operated vehicles inside Airport
- Bangalore: All Electric Bus

BYD Company Ltd. China has provided electrified public transportation with affordable solar power, information technology and more environmentally friendly storage battery technology. It have led to the development of the BYD Iron Phosphate (or "Fe") Battery [18]. This fire-safe, completely recyclable and incredibly long-cycle technology has become the core of their clean energy platform. The features of the bus are zero emission which runs for 250 km with 6 hours of charging costs INR 2.7 crore compared to Volvo INR 88 lakh with the requirement of 3 phase special charging point. Project shelved as a corporation is cash-strapped and cannot afford a 3 crore INR bus with charging and maintenance cost.

Table 3 Technical Specifications Comparison of Sample Models available in Indian Market [19, 20]

Specifications	Electric Vehicle	Hybrid Luxurious Car	
	Mahindra Reva e20  Starting INR 4.99 Lakhs	Toyota Camry  Starting INR 31.92 Lakhs	Toyota Prius  Starting INR 38.10 Lakhs
Weight Kerb/Gross	830 kg	1635/2100 kg	1385/1805 kg
Electric Motor Max Output Max Torque	Induction Motor 19 kW @ 3750 rpm 53 N-m (0–3400 rpm)	Permanent magnet Synchronous Motor 105 kW, 650 V, 270 N-m	Permanent magnet Synchronous Motor 60 kW, 650V, 207 N-m
Battery	Li-Ion 48 V	Ni-MH 245 V 204 cells @ 6.5 Ah (34 modules)	Ni-MH 201.6 V 204 cells @ 6.5 Ah (28 modules)
Engine Max Output Max Torque	–	2493 cc 118 kW@ 5700 rpm 213 N-m@ 4500 rpm	1798 cc 73 kW@ 5200 rpm 142 N-m@ 4000 rpm
Hybrid Total Max. Output	–	151 kW with ECO and EV mode	–
Top Speed Range Charging Time	81 km/hr. 120 km range 5 hr. 10 min. (220 V,15 A Socket)	–	–

4 Case Studies – Consumers Perspective Cost Analysis of Market Available EV with Convectional Vehicle

The purchase price of EV is higher than for gasoline cars in India, which can be made comparable with a subsidy of government. However, running cost of EV is far less than ICE vehicle. To get a feel of practicability and to get the idea of actual capital and running costing in Indian scenario, the calculation for both types of diesel and petrol car along with EV for two distances are presented and comparative analysis is shown from calculations obtained from the company website [19].

Consider a person with the option to purchase ICE or EV. Car purchase can be done with the facility of EMI which is to be paid per month for a period of 5 years or cash. The capital cost of conventional car is INR 6 Lakhs and cost of EV is INR 6.5 Lakhs (more than petrol/diesel based car by INR 50,000/- 10.83% extra). The cost comparison for 5 years is given for a distance of 40 km and 100 km for both diesel and petrol based ICE cars calculated from the company website.

The case one considered a person traveling 40 km per day. The EMI, energy/fuel cost, maintenance and saving per year calculated on the web of company for diesel, petrol and REVE e20-EV is shown in Figures 2 and 3.

The five years comparison chart for diesel car vs. EV for a distance of 40 km per day is shown in Figure 2.

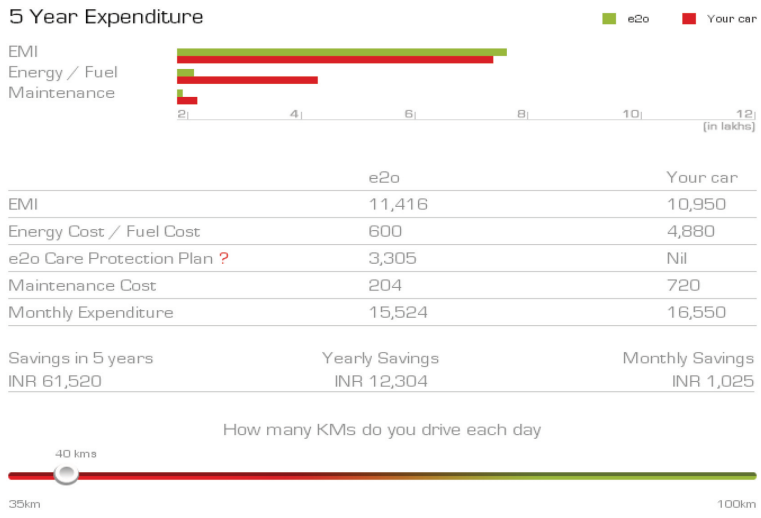

Figure 2 Five Years Comparison Chart for Diesel Car vs. EV for a distance of 40 km per day.

It is observed from Figure 2 that if anybody has the option to purchase diesel ICE or EV, then EMI of EV based car in India will be slightly higher than an ICE based car, however, there is saving in fuel cost and maintenance. By putting INR 50000/-extra, the person will save around INR 61,500/-in 5 years which is not very lucrative. However the procedure of calculation of fuel cost is not given on the website.

The five years comparison chart for petrol car vs. EV for a distance of 40 km per day is shown in Figure 3.

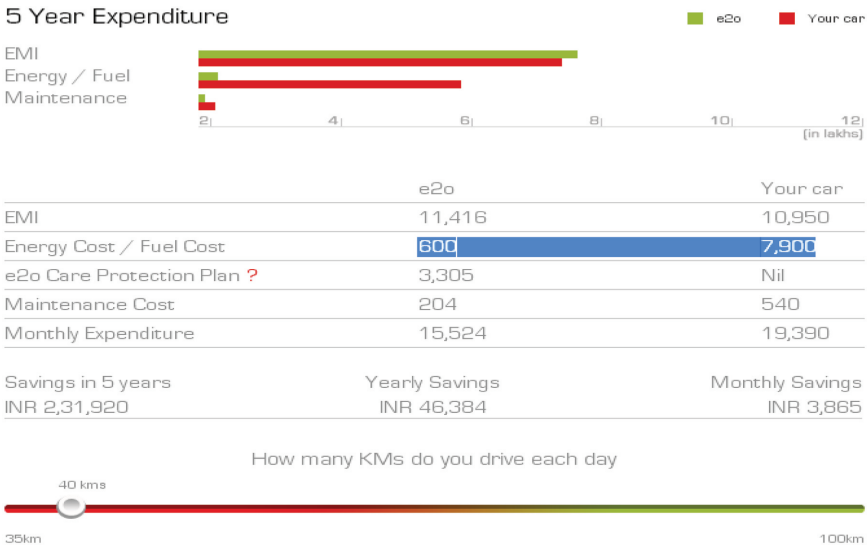

Figure 3 Five Years Comparison Chart for Petrol Car vs. EV for a distance of 40 km per day.

It is observed from Figure 3 that for the option of purchase petrol ICE or EV, then EMI of EV based car in India will be slightly higher than an ICE based car, however, there is saving in fuel cost and maintenance. By putting INR 50000/-extra, the person will save around INR 2,31,900/-in 5 years which is good, however, how fuel cost calculation of petrol car is not shown and shown very high.

The case two considered a person traveling 80 km per day with all above parameters. The EMI, Energy/Fuel Cost, Maintenance and saving per year calculated on the web of company for diesel, petrol and REVE e20-EV is shown in Figures 4 and 5.

The five years comparison chart for diesel and petrol car vs. EV for a distance of 80 km per day is shown in Figures 4 and 5.

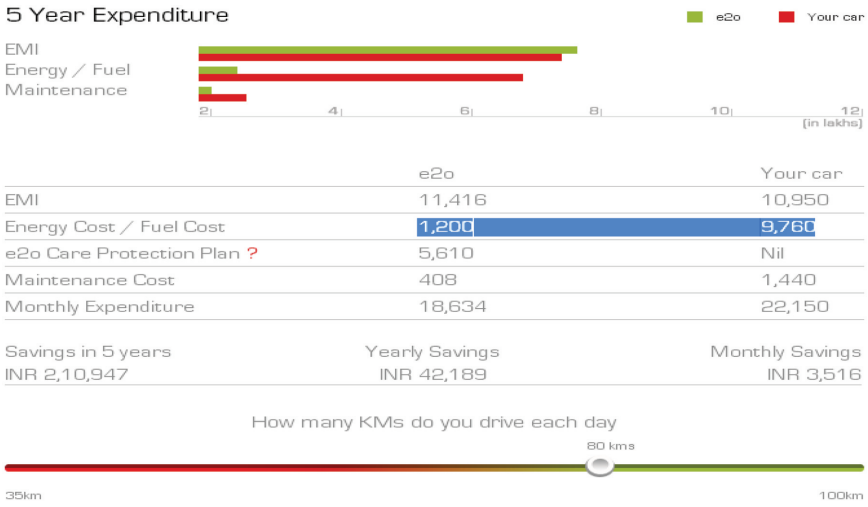

Figure 4 Five Years Comparison Chart for Diesel Car vs. EV for a distance of 80 km per day.

It is observed from Figure 4 that there is saving in fuel cost and maintenance. By putting INR 50000/-extra, the person will save around INR 2,10,900/-in 5 years which is good, however how fuel cost calculation of diesel car considered is not shown and considered very high.

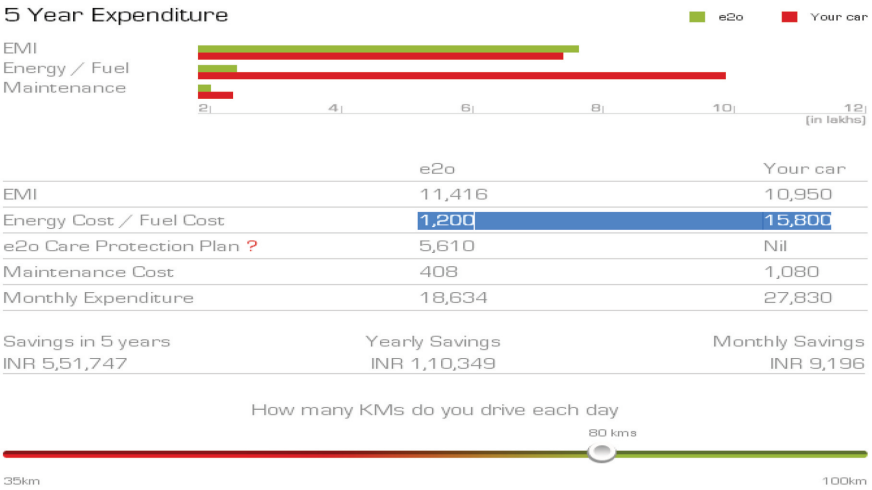

Figure 5 Five Years Comparison Chart for petrol Car vs. EV for a distance of 80 km per day.

It is observed from Figure 5 that there is saving in fuel cost and maintenance. By putting INR 50000/-extra, the person will save around INR 2,31,900/-in 5 years which is good, however, how fuel cost calculation of petrol car is considered is not shown and shown very high and same performance car are available in the market starting around INR 3,00,000/-.

Conventional vehicles in Indian market gets much more superior features then EV available in the market. Some of the shortcomings need to take into consideration is less power and torque capability, less seating capacity, less top speed and range. However, advantages of automatic gearing, lower fuel consumption, less turning radius with more ground clearance is observed.

The Figure 6 summarizes the Driving Range, Charging Time, and Price of electric four-wheelers (E4Ws) for Indian and Global Models.

It can be seen that the price of E4W is very high. As the range increases price increases nonlinearly. Also nonlinearity is there in charging time with reference to price.

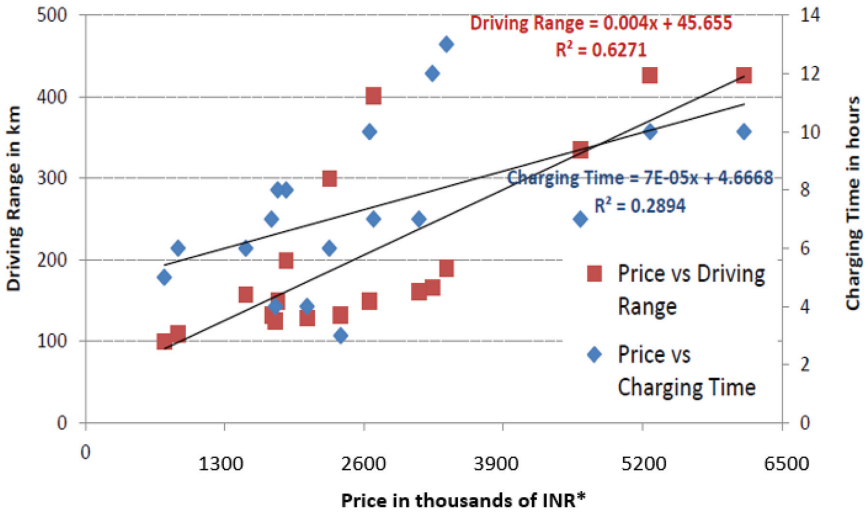

Figure 6 Driving Range, Charging Time, and Price of E4Ws for Indian and Global Models (* calculated as 1 USD = 65 INR) [21].

The survey done by CII and Aarya Company in Figure 7 shows the parameters considered before the purchase of electric vehicles in minds of the consumer. It can be seen that the barriers in purchase of EV is High Charging Time (64%) as major barriers as it will affect long trip travel

by electric vehicle, Low Acceleration/Pick Up (49%), Battery Life (48%), Limited Running Range (43%) and Low Top Speed (42%) are other barriers which reduce adoption rate of electric vehicles [22].

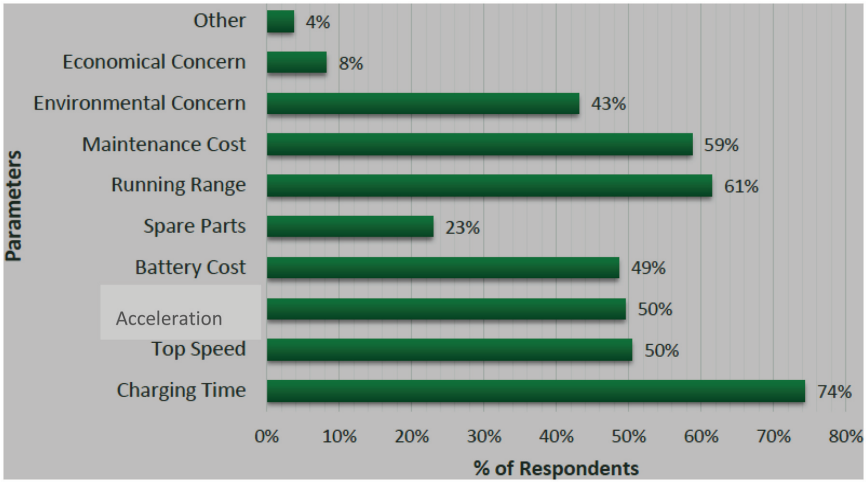

Figure 7 Parameters Considered before Purchasing EV in India [22].

5 Tariff in India and EV Tariff Consideration

The electricity tariff rates are different in different parts of India and there are different types of consumers. The consumers related to our interests are Low Tension (LT) and High Tension (HT). The current tariff rates in some of the state like Gujarat and Maharashtra for reference are given in Table 4 [23]. The LT and HT consumer tariff for the commercial and industrial consumer is given in Tables 5 and 6 [24].

Considering above table of HT and LT tariff, it can be seen that there is no need to consider separate tariff for EV, as tariff will conveniently adjust rate as per charging. The consumer who will charge vehicle at residential complex in single phase 230 V, 15 A socket will need more time for charging and rates can be around INR 6 to 8 per kWh and it's quite comfortable. Fast charging of vehicle is possible with commercial/industrial consumers and rates can be around INR 8 to 11 per kWh. However, TOD tariff will be applicable which is plus point for the consumer as they will get benefit from night charging. Charging done from any type of consumer from anywhere will get charged accordingly and will balance on both side supply and consumer.

Table 4 LT Consumer Tariff in India

State	Slab Low	Slab High	Rate (in INR)
Gujarat-Torrent-Surat (As per tariff order dated 29th April 2014)	1	50	3.2
	51	100	3.65
	101	250	4.25
	251	above	4.95
Maharashtra (Applicable from 1st Aug 2012)	1	100	3.36
	101	300	6.05
	301	500	7.92
	501	1000	8.78
	1001	above	9.5

Table 5 HT Tariff for Commercial Consumer

Load	Consumption Slab (kWh)	Fixed/Demand Charge	Energy Charge (INR./kWh)
0–20 kW	0 to 200 units per month	INR 190 per month	5.85
	Above 200 units per month (only balance consumption)		8.38
20 kW to 50 kW	–	INR 190 per month	8.44
$>$ 50 kW	–	INR 190 per KVA per month	10.91

Table 6 HT Tariff for Industrial Consumer

Consumer Category	Fixed/Demand Charge	Energy Charge (INR/kWh)
0–20 kW	INR 190 per month per connection	5.06
	INR 130 per kVA per month	7.01
TOD Tariffs (in addition to above base tariffs) (optional for 0–20 KW)		(INR/kWh)
0600 to 0900 hours		0.00
0900 to 1200 hours		0.80
1200 to 1800 hours		0.00
1800 to 2200 hours		1.10
2200 to 0600 hours		–1.00

Note:*TOD Tariff applicable as in Table 6 in addition to above.*

The only care need to be taken for Distribution Company is charging should not be done from agriculture points as rates are very low for agriculture.

6 Strategies to Focus and Probable Solutions

Some of the key points required to focus for the development of EV in India are

1. Retrofitting conversion of Public Transport (Bus), Taxi and Three-Wheeler (Auto) to PHEV.
   This is one of the key requirement to move towards sustainable transportation. It will not only balance emissions but also reduce the load on infrastructure requirement.
2. Government Incentives
   Another key factor for XEV market to lift up will be identification of strategic incentives for electric vehicles. This will increase adoption rate and decrease main element barrier of the price of electric vehicles to customers. The incentive can be subsidy scheme for electric vehicles bridging gap price between the conventional and electric vehicle in similar performance range.

   > e.g. if the cost of internal combustion engine car is INR 5 lakh and that of the electric vehicle is INR 6.5 lakh, the government can intend to offer discount or subsidy of the differential cost.

   In addition benefit of Discount on VAT//Discount on Registration/Discount on Toll Plaza to motivate sell of EV can be planned.
3. Charging Infrastructure
   Charging infrastructure development will occur with the development of XEV market. However, motivation can be provided by developing grid-connected charging station with the moderate tariff, promotion to standalone renewable (solar/wind) charging station, add on facility at petrol pump and bus stops for charging and state transport charging stations and permitting the development of private renewable charging stations.
4. Electrical Propulsion System (EPS)
   Currently no Indian manufacturer provide electrical propulsion system (EPS) manufactured in India, even REVA has a tie-up with Italy for EPS. Hence support and positive atmosphere buildup in manufacturers in one of the critical tasks. Development of clear policies for supporting the growth of supply, manufacturing, and recycling of propulsion system.

Power electronics converter and motor technology development are feasible as technology base is available in India, however currently used cost effective Li-ion technology of battery development is challenging task as the majority of lithium stock are available in China and USA. In addition, battery replacement/swapping can be one of the promising and viable options in India.

5. Development of Skilled Manpower
   Consideration of safety and advanced technology involved, development of certified skilled technician and professionals is one of the requirements.
6. Awareness
   Awareness on benefits of XEV and promotions of the government can play a significant role in development. It can be done with the help of extensive advertisement at airport/bus station/cinema halls/government offices/public places using banners/hoardings, use of print media-newspaper/magazines/periodicals, digital media/radio/e media-internet, TV shows, expert talks, providing micro-funding for projects/conferences in schools, colleges and industry, supplying R & D grants to research scholar/institute/industry. The promotional highlights for the consumer can be

   a) Good for the environment/Lowers Emission: Electric vehicles emit lower levels of a range of air pollutants, e.g. nitrogen oxides, particulate matter and greenhouse gases (e.g. carbon dioxide-CO_2) than vehicles using conventional petrol and diesel engines.
   b) Cheaper to run/Improve Fuel Economy: As electricity is cheaper than petrol or diesel, the running costs of EVs are less than conventional vehicles.
   c) Less Life Cycle Cost.
   d) Perfect for urban use: Reduced levels of pollution and noise make EVs ideal for inner city and urban use.
   e) Smooth acceleration and deceleration: EVs benefit from smooth gearless acceleration and deceleration, as a result of the characteristics of the electric motor.
   f) Quieter than conventional vehicles: EVs are also quieter than conventional vehicles. Battery operated cars operate in almost complete silence except noise from the tires.
   g) Proved Technology (a sharp rise in the market of XEV all over the world).

7 Conclusion

Considering development, historic government policies implementation, Indian people buying concerns, response to new technologies and economics, the growth of IC engine technology will remain in demand with automatic transmission vehicle demand will rise in future. Hybrid fuel technology growth will be limited due to cost. Conversion of the conventional vehicle into the plug-in hybrid electric vehicle by retrofitting may have a tremendous market in India. EV and PHEV will have promising future in India, however, its current growth will be limited and the limit is decided by policies and awareness creation. A way towards sustainable transportation will go in slow space for some more time due to lack of EPT manufacturer, clear policy and its implementation.

8 Appendix

The Specification of recently launched eVERITO [25].

A1. Specification of eVERITO

Motor	72V 3-phase AC Induction Motor
Emission	Zero Tailpipe Emission, Green Vehicle
Max. Gross Power	30.5 kW (41 hp) @ 3500 rpm
Max. Gross Torque	91 Nm @ 3000 rpm
Transmission	Direct Drive Single Speed Transmission
Tyres	185/70 R14 tubeless (Low Rolling Resistance Tires)
Battery Capacity	200 Ah
Turning Circle Radius	5.25 m
Gross Vehicle Weight	1700 kg
Wheelbase (mm)	2630
Seating Capacity	5 Seater
Max Speed @ Gross Vehicle Weight	86 km/hr
Normal Charging Time	8 hours 45 mins*, 0–100%
Fast Charging Time	1 hours 45 mins*, 0–80%
Full Charge Range	110 km**

A2. Upcoming cars (2018) in Indian Market

1. TATA NEO (JAYEM NEO)

   Propulsion system: 30 kW electric motor Price: INR 6.5 lakh
   Range-around 160 km

2. NISSAN NOTE E-POWER

   Propulsion system: 1.2L + 70 kW electric motor
   Price: INR 20 lakh
   Extender hybrid mileage-40 kmpl

3. TATA TIGOR Electric

   Propulsion system: 30 kW electric motor
   Price: INR 12 lakh
   Range-around 150 km

4. TATA-TIAGO Electric

   Propulsion system: 30 kW electric motor
   Price: INR 11 lakh
   Range-around 150 km
   Range-extender hybrid-40 kmpl

References

[1] http://blog.evbox.com/electric-cars-history-infographic
[2] http://www.pbs.org/now/shows/223/electric-car-timeline.html
[3] https://www.tesla.com/semi
[4] http://www.chinadaily.com.cn/a/201802/08/WS5a7b829ca3106e7dcc13b653.html
[5] International Energy Agency-IEA Report 2009.
[6] Global EV Outlook, International Energy Agency-IEA Report 2016.
[7] Gujarathi, P. K., Shah, V. A., and Lokhande, M. M. (2015). Design, Modeling, Simulation and Analysis for Conversion of Conventional Tata Indica Car into Plug in Hybrid Electric Vehicle. In *The 28th International Electric Vehicle Symposium and Exhibition (EVS28), KINTEX, Korea*.
[8] BP Statistical Review of World Energy- www.bp.com/statisticalreview, June 2012, accessed on 08/04/2016.
[9] "Statistics Report 2013", Central Statistics Office, National Statistical Organization, Ministry of Statistics and Programme Implementation Government of India.

[10] https://www.cia.gov/library/publications/the-world-factbook/
[11] Understanding the electric vehicle landscape to 2020, Global EV Outlook 2013.
[12] "India's CO2 emissions pathway to 2050" www.metoffice.gov.uk/media/pdf/b/f/AVOID_WS2_D1_41.pdf.
[13] The National Electric Mobility Mission Plan-2020, Ministry of Heavy Industries & Public Enterprises, Government of India, Available at: http://dhi.nic.in/NEMMP2020.pdf
[14] Electric Vehicles in India Policies, Opportunities and Current Scenario ADB Open Innovation Forum, Manila, 2015.
[15] http://auto.economictimes.indiatimes.com/news/industry/electric-vehicle-sales-up-in-india-in-2016-but-so-are-polluting-diesel-hybrids/57459487
[16] https://autoportal.com/newcars/hybrid-cars-in-india+electric-cars-in-india-cf/
[17] https://swarajyamag.com/infrastructure/india-the-ev-nation-here-is-how-the-government-may-be-planning-that
[18] www.byd.com
[19] http://www.mahindrareva.com/reva-home.html, accessed on 11/03/2016.
[20] https://www.toyotabharat.com/showroom/prius/
[21] Promoting low carbon transport in India: Electric Vehicle Scenarios and a Roadmap for India, United Nations Environment Program, Transport Unit, http://staging.unep.org/transport/ lowcarbon /PDFs/ElectricVehicleScenarios.pdf
[22] Aarya Market Research Survey Report on Consumer Perspective on E-mobility - Confederation of Indian Industry-CII, Ahmadabad, India, 2014.
[23] https://www.bijlibachao.com/news/domestic-electricity-lt-tariff-slabs-and-rates -for-all-states-in-india-in 2014.html
[24] http://www.mahadiscom.in/tariff/Tariff-Booklet-aug-2012.pdf.
[25] http://www.mahindraverito.com/everito/discover-the-new-verito.aspx
[26] https://www.autocarindia.com/car-news/new-cars-for-2018-upcoming-electric-cars-407064

Biographies

Pritam K. Gujarathi has completed masters from Visvesvaraya National Institute of Technology, India. He is a research scholar at Sardar Vallabhbhai National Institute of Technology, Surat, India. He has 15 years of experience in academic, industry and research environment. He published around 18 papers at national and international level. He has organized and attended National and International Conferences/Symposium. He delivered invited talks and provided training and consultancy services. He is also certified energy auditor. His research interests are Power Electronics and its application to Sustainable Power System, Electric Vehicles and Transport Electrification.

Varsha A. Shah, Associate Professor in Electrical Engineering Department of Sardar Vallabhbhai National Institute of Technology, Surat has received her Ph.D. Degree in Electrical Engineering from Sardar Vallabhbhai National Institute of Technology, Gujarat, India. Her research activity is related to hybrid electric vehicles, smart grid and power quality issues.

Makarand M. Lokhande, Assistant Professor in the Department of Electrical Engineering of Visvesvaraya National Institute of Technology, Maharashtra has received the Ph.D. Degree in Electrical Engineering from Indian Institute of Technology Bombay, Maharashtra, India. His research activity is related to hybrid electric vehicles and Renewable Energy and Management.