

Impact of charging infrastructure growth on EV market in India

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Executive Summary

India has a huge import of fossil fuel for transportation and it is continuously growing year over year. India imported 82.2% of its oil in 2016–17, up from 80.9% in 2015–16 [1]. India has abundant potential to produce electrical energy with domestic energy sources and hence it is a natural candidate for highest growth of Electric transportation. As per Paris Climate Agreement in 2015, global EV transportation system has to be 20% of total road transport vehicles by 2030 in order to limit the global temperature rise to be less than 2 degrees or less [2]. Recently in May 2017, the government of India has already announced to eliminate petrol & diesel vehicle sales from the year 2030 [3]. The government of India is also supporting the sales of EV's by providing lesser taxes and higher incentives but still the EV market growth is lagging behind the conventional ICE vehicle market. This paper explains the factors affecting the EV market growth, availability of charging infrastructure and the challenges in charging infrastructure growth in India. . In this context, the analysis here explains the impact of charging infrastructure growth on electricity demand and also deals with the gaps to improve the charging infrastructure in India.

Keywords: EV Market, Charging infrastructure, Energy demand, charging time, Government initiatives

1 Introduction

India, with its rising population, the demand for the automobiles is growing at a rapid rate. The domestic sales of automobiles during the year 2016-17 was about 21.86 million vehicles (includes the passenger, commercial, 2-wheeler & 3-wheeler) with a 6.8% growth when compared to the previous year 2015-16 [4]. The diesel & petrol consumption during the year 2016-17 is about 76MMT & 23.765MMT respectively which is close to 1.8% of diesel consumption & 8.8% of petrol consumption higher than the previous year 2015-16 [5]. Out of the total diesel & petrol consumptions, the transportation sector alone consumes about 70% of the diesel & 99.6% of the petrol [6]. The growth in the demand of conventional ICE vehicles results in a huge demand of diesel & petrol consumption which increases the greenhouse gas emissions. To prevent this, the government of India has announced to ban the petrol and diesel vehicle sales from the year 2030 and earlier in 2012, it has also launched NEMMP-2020 (National Electric Mobility Mission Plan) to deploy 6 to 7 million hybrid & electric vehicles by 2020 [7]. The cumulative number of EV's in India are close to 0.4 million by 2016 which is about 0.1% of the existing conventional vehicle market [8]. Out of this, more than 95% of electric vehicles on Indian roads are low speed electric scooters (less than 25km/hr) that do not require registrations and licences. Almost all electric scooters run on lead acid batteries to keep lower prices, however the life and failure of batteries have become major limiting factors for sales besides the government subsidies. The government of India (Department of Heavy Industries – DHI) is already providing incentives through FAME scheme (Faster Adoption and Manufacturing of Electric Vehicles) from the year 2015 in order to reduce the price of EV's [9]. Under this scheme, about 99000 hybrid/electric vehicles (xEV's) have been

given direct support by way of demand incentives since the launch on 1st April 2015. The government has also approved pilot projects, charging infrastructure projects and technological development projects aggregating to nearly Rs.155 Crores [10]. Despite these demand incentives at the central level, only 20% of the budget for FY 2016 and FY 2017 has been utilised, and India sold just 22,000 BEV's in 2016, well short of its target [11]. The factors affecting the EV growth and subsequently the factors affecting the charging infrastructure growth is further detailed in the below sections.

2 Factors affecting the EV growth in India

The key barriers to the EV market growth in India includes lack of charging infrastructure, higher charging times, price vs. range factor, non-awareness of EV's and lack of EV manufacturers. In contrary to this, rising fuel prices & government initiatives are helping to boost the sales of EV's in India.

2.1 Lack of charging infrastructure:

Currently in India, there are very few DC fast charge stations which are installed by EV manufacturers. But to install on a large scale, support from the government is required. The public AC slow charge points are also existing in India with less than 3.3kW rating which is limited by on-board charger capacities of EV's. The availability of free AC & DC fast charging infrastructure makes people to show interest towards EV's at least in the major cities in India. The charging infrastructure (public AC slow charge points) needs a less investment when compared to a fuel stations but still the growth of charging infrastructure in India is not up to the mark as it requires continuous support from the government, utility grid authorities & EV manufacturers. The factors influencing the charging infrastructure growth & ways to improve the infrastructure to meet India's mission plan is explained clearly in section 3.

2.2 Higher Charging times:

The available electric cars in India takes 7 to 8 hours for full charge if charging is initiated from 230V single phase supply. Typically close to 50% of Indian customers' needs charging time to be less than 2 hours and another 30% of the customer's needs charging time to be less than 4 hours [12]. The DC fast charging stations reduces the charging time to less than 2 hours but the availability of these stations are limited as it cannot be installed in domestic places. The charging time of an EV can be reduced by increasing the on-board & off-board charger power ratings for which charging infrastructure should be developed because of limitations on the residential loads.

2.3 Price Vs. Range factor:

Currently in India, the price vs. range is a barrier to the EV growth because the BEV's are having higher prices with the limited range when compared with conventional ICE vehicles. Currently in India, there are nearly 25 models of two wheeler battery operated vehicles and out of this only 4 to 5 models are using lithium ion batteries [13]. Around 19 models are limited to less than 25kmph for which vehicle registration & license are not required. In four wheeler segment, only Mahindra Electric is making fully battery operated vehicles with four models in the market (3 passenger & 1 commercial) which are using lithium ion batteries. Most of the respondents in India are considering the BEV as a secondary car to commute in the cities because of limited range. More than 60% of the respondents are expecting the range around 300km per charge for BEV's and currently BEV's in market are limited to less than 150km per charge [12]. The range anxiety of an EV will not be a barrier if there is an abundant charging infrastructure within & between the cities in India [11].

2.4 Lack of awareness & Lack of EV manufacturers:

The surprising factor for the impediment of EV growth is lack of awareness to more than 60% of the drivers in India. This is due to the non-existence of EV's on the roads and also due to the lack of EV manufacturers. Currently in India there are nine electric two wheeler companies and out of this only one company is making the two wheelers with Lithium ion batteries and only Mahindra Electric is making electric cars in four wheeler segment. The EV manufacturers are already conducting campaigns for the awareness and the government is expected to support on a large scale.

2.5 Rising fuel prices:

The fuel prices are slowly rising in India [14, 15] and it is likely to be increased in the near future because of the demand in transportation & power generation sectors which is shown in figure 1. As per the survey conducted, 70% of respondents in India will consider the EV's if the fuel prices (either diesel or petrol) goes beyond 4.8 USD per gallon. The running cost per km for an EV in the passenger car segment is typically in the range of 8-10 times when compared to conventional ICE vehicles.

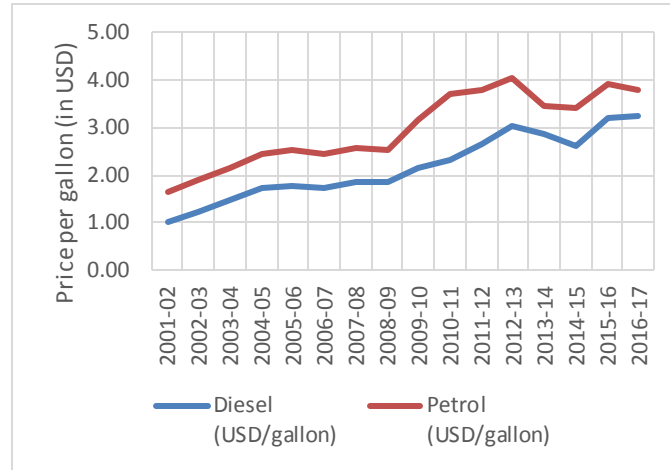


Fig. 1 Diesel & Petrol prices in India

2.6 Government Initiatives:

The government of India (DHI - Department of Heavy Industry) has formulated a scheme namely FAME-India (Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India) in 2015. The Phase-1 of the scheme has been implemented over a 2 year period i.e. FY 2015-16 and FY 2016-17 commencing from 1st April 2015 is shown in the figure 2 (1 USD = 67 INR).

Component of the scheme	2015-16 (In million USD)	2016-17 (In million USD)
Technology platform (Including testing infrastructure)	10.5	18
Demand Incentives	23	50.7
Charging Infrastructure	1.5	3
Pilot projects	3	7.4
I&EC/Operations	0.8	0.8
Total	38.8	79.9
Grand Total	118.8	

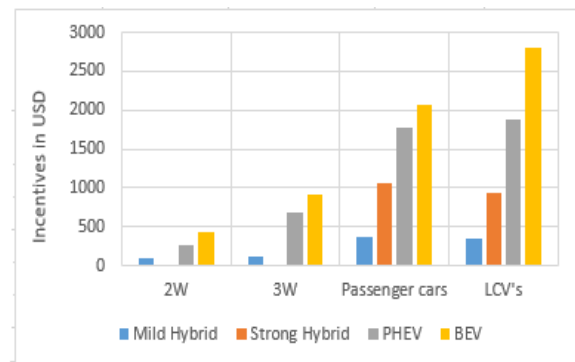


Fig.2 FAME – India scheme budget allocation

The Phase-1 of the FAME scheme has ended in March 2017 and the government has decided to extend the Phase-1 of the FAME scheme further to six months i.e. up to 30th September 2017 or till the approval of Phase-2, whichever is earlier [16]. Further to this, the mild hybrid technology is excluded from benefits under the FAME India scheme w.e.f 1st April 2017.

3 Charging infrastructure in India

As announced by the government of India to ban petrol and diesel vehicle sales from the year 2030, the charging infrastructure plays a crucial role for the EV market growth. Even though the standards are not in place till 2017, there are some existing charging stations (both AC & DC) installed in major cities across India apart from the home or private chargers. Currently in India there are more two wheeler electric vehicles

compared to a four wheeler electric vehicles. The two or three wheelers typically uses lead-acid batteries or lithium ion batteries with lesser storage capacities (up to 5kWh) and operates on voltages either at 24V, 48V and 72V. Similarly the four wheeler electric cars uses lithium ion batteries with medium storage capacities (up to 20kWh) and operates at 48V and 72V. All the EV's in India are operating with less than 100V battery systems including the electric cars whereas globally all the electric cars are operating at a higher voltage systems close to 400V.

3.1 Available private & public chargers

Currently the two wheelers in India are charging with a maximum power having 1kW and hence most of these vehicles are charged at homes or offices. In four wheeler electric cars, Mahindra Electric [17] is the only company which makes the electric cars in India, and these vehicles are operating on either 48V or 72V with a maximum of 20kWh battery (lithium ion) capacities. Most of these vehicles are using CEE 16 (IEC 60309) charging inlet with basic RCD protection for AC charging and GB/T connector for DC fast charging. Hence the publicly available AC charging points in India are rated below 3.3kW and this power can be drawn from 230V single phase supply. The number of private or home chargers are equal to the total number of EV's with the assumption that each EV is supplied with an EVSE to charge either at residences or offices. The public chargers are of two types which is categorized as AC & DC. The AC public charge points are installed in various public places with less than 3.3kW rating which will fall under Mode 1 as per IEC 61851-1 [18] because it doesn't have any control pilot communication. There are a few DC fast charge stations are installed with GB/T connectors. Currently in India, around 400 public AC charge points installed with less than 3.3kW rating and nearly 35 DC charging stations installed with less than 15kW rating.

3.2 Factors affecting the charging infrastructure growth

In this section, the challenges in charging infrastructure growth are clearly explained.

3.2.1 Increase in Electricity Demand

As the charging infrastructure is installed on a large scale, the energy required from the utility grid increases. In the following sections, the demand in electrical energy from the utility grid is projected if all the conventional vehicles were converted to BEV's based on the available data of fuel consumption in transportation sector in India.

a) Conventional Vehicle market:

The automobiles production in India is at a CAGR of 9.03% from 2007 to 2017. The vehicles includes 79% of two wheelers, 15% of passenger cars, 3% of three wheelers & 3% of commercial vehicles. Out of these, close to 99.9% are conventional ICE vehicles which are burning petrol & diesel for traction. The figure 3 shows the historical vehicle production data along with the estimated production volumes by 2030 which is indicated with blue line and also it shows the historical & estimated fuel (both petrol & diesel) consumption in MMT (million metric tonnes) which is indicated with red line.

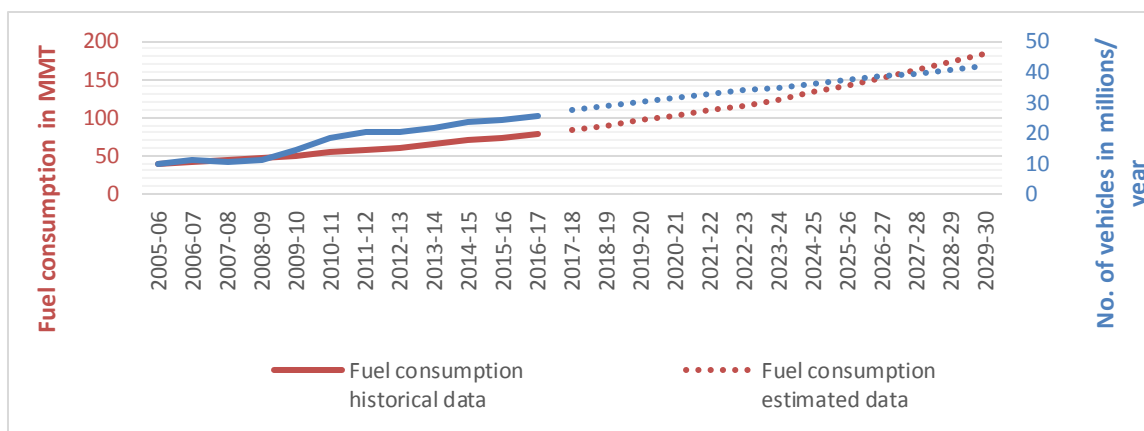


Fig. 3 Fuel Consumption & Vehicle production data

The equivalent energies (TWh – Tera Watthour) of petrol & diesel is calculated as product of energy densities in MJ/kg and its weight (MMT – Million Metric Tonnes). The following table 1 shows the calculation of energy used for traction in both petrol & diesel vehicles during the year 2016-17.

Sl.No.	Parameter	Petrol	Diesel
1	Energy density in MJ/kg (ρ)	44 MJ/kg	49MJ/kg
2	Fuel consumptions during the year 2016-17 in MMT (w)	23.5 MMT	53.2 MMT
3	Equivalent energy in TWh , $E_{equ} = \frac{\rho*w}{3.6}$	287.2 TWh	724.1 TWh
4	Efficiency of conventional vehicle (η_{ICE})	40%	40%
5	Used energy for traction in TWh, $E_{used} = (\eta_{ICE} * E_{equ})/100$	115 TWh	289.6 TWh

Table 1. Calculation of energy used for traction in conventional vehicles

Similarly, the energy used for traction from 2001 to 2017 is calculated and it is shown in the figure 4 along with the fuel consumption of diesel and petrol in transportation sector.

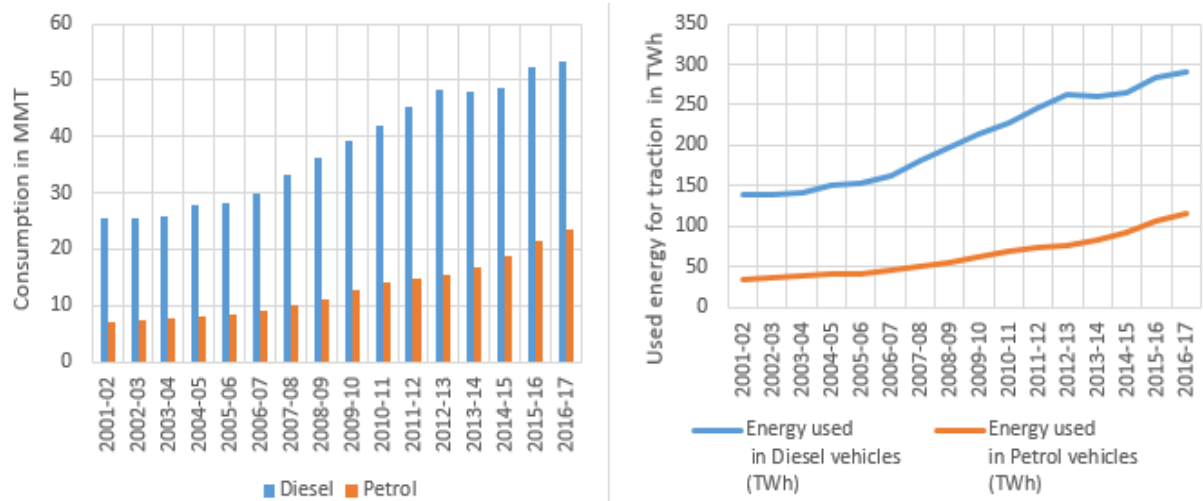


Fig. 4 Fuel consumption and traction energy of petrol & diesel vehicles

b) Conversion of existing vehicles to BEV's:

Typically for an electric vehicle, the plug to wheel efficiency is more than 85% and therefore the energy losses are minimal. If all the conventional vehicles (both petrol & diesel) in the Indian market are converted into BEV's during the year 2016-17, the total energy required for the traction in the transportation sector is sum of the energies of petrol & diesel vehicles. The table 2 shows the electrical energy required to generate from the power plants if all the conventional vehicles were converted to BEV's during the year 2016-17.

SI.No	Parameter	Value
1	Total energy required for traction in TWh $E_{traction} = E_{used_diesel} + E_{used_petrol}$	404.6 TWh (115 TWh for petrol & 289.6 TWh for diesel from Table 1)
2	Typical Efficiency of a BEV (η_{BEV})	85%
3	Total Energy required at the BEV charging inlets in TWh $E_{inlet} = (E_{traction} * 100) / \eta_{BEV}$	476 TWh
4	Avg. Transmission & Distribution losses in India (T&D loss)	23%
5	Required electricity generation in TWh for 100% BEV's $E_{gen_tr} = (E_{inlet} * 100) / T\&D\ loss\ %$	618 TWh
6	Total electricity generated in TWh during the year 2016-17 (E_{gen_total})	1160 TWh
7	Additional demand (%) required in transportation sector for 100% BEV's during the year 2016-17 $= (E_{gen_tr} / E_{gen_total}) * 100$	53.27%

Table 2. Electricity required for 100% of BEV's during 2016-17

The total electricity generation in India during the year 2016-17 is 1160TWh [19] which is used in domestic, commercial, industrial & agriculture sectors. The total electricity required, if all the existing ICE vehicles are converted into BEV's during the year 2016-17 is 618TWh which is 53.27% additional to the existing electricity generation. By 2030, the electricity generation (E_{gen}) in India will grow along with the demand in the domestic, commercial, industrial & agriculture sectors which is shown in the figure 5 (indicated with blue). Apart from this, there will be a growth in the production of automobiles in India by 2030 and if all these vehicles are 100% BEV's the required electricity generation (E_{gen_tr}) demand on the utility grid increases which is also shown in the figure 5 (indicated with red).

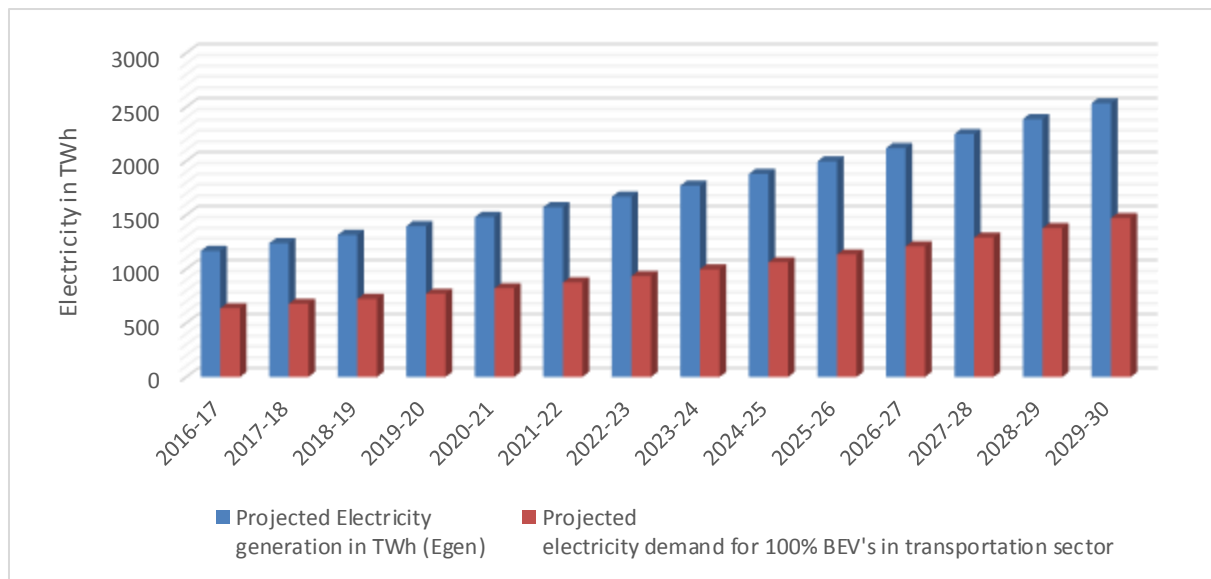


Fig. 5 Projected electricity demand up to 2030

c) Charging infrastructure energy demand by 2030 :

As described in the previous section, the projected electricity demand in transportation sector would be more than half of the existing electricity generation in India if all the vehicles are 100% BEV's in transportation sector. The estimated electricity generation in 2030 by considering the growth rate in domestic, commercial, industrial and agriculture sectors is around 2500TWh which is more than two times of the existing electricity generation in India. By 2030, the cumulative vehicles are estimated as 0.5 billion and if all these vehicles are assumed to be 100% BEV's, the required electricity from the utility grid increases by 56% in addition to the estimated electricity generation of 2500 TWh in 2030. Whereas if only 50% of the vehicles are assumed to be BEV's by 2030, the required electricity from the utility grid increases by 30% in addition to 2500 TWh. Similarly, figure 6 shows the required electricity for BEV's & additional demand on utility grid w.r.t the percentage of BEV's in 2030.

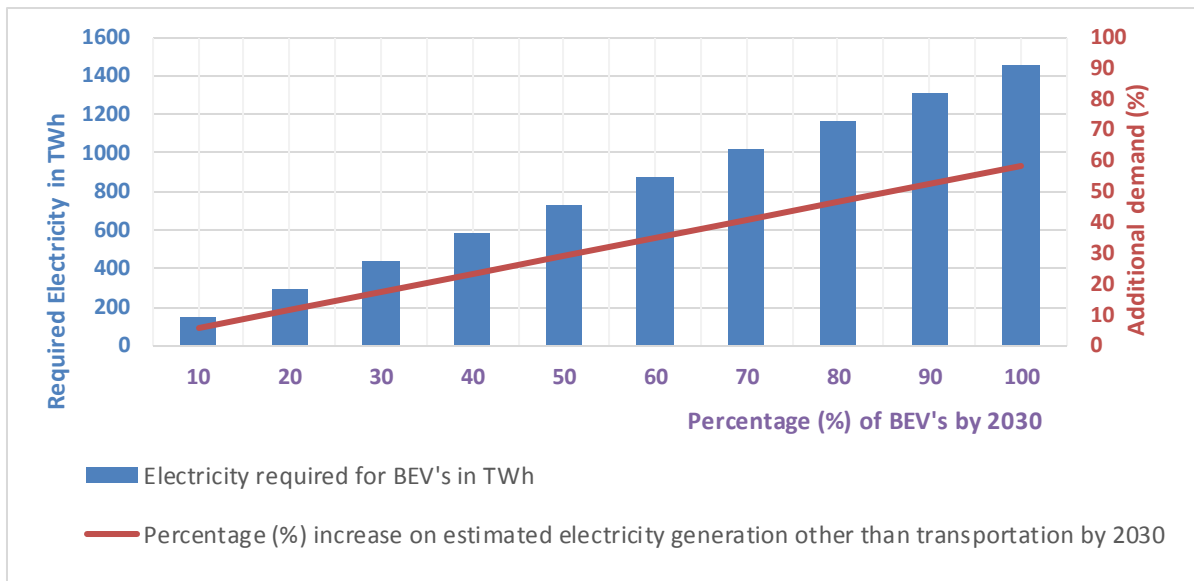


Fig. 6 Electricity demand in 2030 for transportation sector

Hence by 2030 in India, 20% of BEV's would require an energy of 291 TWh. If all the required energy is produced by renewable energy sources which helps in meeting the minimum criteria mentioned as per Paris declaration.

3.2.2 Non-availability of Indian Charging Standards

Till now the EV manufacturers in India (either 2W, 3W & 4W) are free to select any charging inlet & any charging protocol even without any basic protections as there is no defined standard. In such cases, the infrastructure support from the government will be difficult if there are multiple charging connectors & multiple charging protocols. Hence the growth of charging infrastructure is lagging because of undefined standards. Currently in India, the BEVC-AC001 for AC charging with less than 3.3kW power rating & BEVC-DC001 with less than 15kW power rating are going to be notified for both 48V & 72V systems [21]. Meanwhile the Automotive Research Authority of India (ARAI) also published AIS 138 Part 1 (Electric Vehicle conductive charging system) AC charging standard [8] in May 2017 and the AIS 138 Part2 DC charging standard [9] is still in a draft stage which are derived from IEC 61851.

3.2.3 Non-adaptability of global DC charging infrastructure

Globally there are multiple charging protocols and connectors are available for electric vehicle DC charging (which is referred as fast or quick charging). At present, the available DC connectors are GB/T, Chademo, Type1 combo, Type 2 combo and Tesla super charger. Each of these connectors are physically different and also having various communication protocols like CAN & PLC. The table 3 shows the voltage ranges & communication protocols of available global DC charging connectors.

S.No.	DC Charging connector	Voltage range	Current	Power	Communication protocol
1	Chademo	50V-500V	Up to 125A	50kW	CAN
2	GB/T	Up to 750V	Up to 250A	50kW	CAN
3	Type 2 CCS	Up to 1000V	Up to 200A	150kW	PLC
4	Type 1 CCS	Up to 600V	Up to 200A	100kW	PLC
5	Tesla supercharger	Up to 500V* *Estimated	Up to 300A* *Estimated	120kW	-

Table 3. Global EV DC charging connectors

Currently in India, the available EV's are operating on either 48V or 72V and globally all the passenger cars are operating on 400V systems. The Type 2 CCS & Type 1 CCS fast chargers mostly operating from 200V to 600V or 1000V which are not suitable for charging low voltage vehicles (< 100V). The Chademo & GB/T DC connectors are operating from lower voltages and can be adapted easily to charge the low voltage vehicles but because of the maximum current limits of these connectors, the output power is limited.

3.2.4 Lack of incentives for charging infrastructure

The government of India is providing incentives for purchasing the electric vehicles and it is expected to provide incentives for installing the public charging infrastructure also. Currently in India, the BEV manufacturer Mahindra Electric is installing the DC charging stations compatible with GB/T connector. As per the FAME scheme, the government allocated 300 million INR (5 million USD) for the charging infrastructure during the year 2015-17 but the major contribution of this budget is allocated for the standardization and for running few pilot projects regarding the charging infrastructure.

3.3 Overview of Charging Standards & Regulations

As described in the previous section, standardization is one of the factor affecting the charging infrastructure growth in India. The BEVC-AC001 [20] & AIS 138 part1 [21] standards describes EV conductive AC charging which are derived from the IEC 61851 sub-parts. The BEVC-DC001 [20] describes the EV conductive DC charging for 48V & 72V systems which is derived from GB/T 20234 standard whereas AIS 138 part2 [22] standard describes the EV conductive DC charging which is also derived from IEC 61851. The following sections will explain the comparison of all these standards.

3.3.1 Similarities between Global & Indian charging standards

The BEVC-AC001 standard describes the AC charging up to 3.3kW power rating. The connector used for this is derived from IEC 60309 which doesn't have any control pilot communication. The AIS 138 part1 also describes the similar connector for less than 3.3kW rating and Type2 AC connector for above 3.3kW power rating which is having control pilot communication. The AIS 138 Part1 is derived from the IEC 61851 sub parts and there are some similarities between the standards because the power distribution system in India is similar to that of European countries. The BEVC-DC001 standard describes the conductive DC charging with 10kW & 15kW power ratings suitable for 48V & 72V systems respectively. The communication is derived from IEC 61851-24 standard & connector used for this DC charging is derived from GB/T 20234.3 standard. The AIS 138 Part 2 standard is in a draft stage and it describes the conductive DC charging with PLC communication which is most likely Type2 CCS connector. The following types of AC & DC charging modes and the similarities between BEVC, AIS138 & IEC 61851 standards is described as follows.

a) **AC Slow Charging mode:**

Connection of EV to the single phase EVSE with < 15A current rating including basic RCD protections.

Recommended Interface: CEE 16 (IEC 60309)



Fig. 7 CEE 16 Connector

Types of connection between EV & EVSE:

- 1) AC Slow Cable A: EVSE to Power Converter and Power Converter to EV
- 2) AC Slow Cable B: EVSE to EV
- 3) AC Slow Cable C: Attached to EVSE

This mode is described in both BEVC-AC001 & AIS Part1 standards. This mode of charging is prohibited in many countries because it doesn't have any communication between EV and EVSE which is similar to Mode1 of IEC 61851-1.

b) **AC fast Charging mode:**

Connection of EV to the EVSE with <63A, 415V three phase including control pilot communication & RCD protections

Recommended Interface: TYPE 2



Fig. 8 Type 2 connector

Types of connection between EV & EVSE:

- 1) AC Fast Cable D: EVSE to EV
- 2) AC Fast Cable E: Attached to EVSE
- 3) AC Fast Cable F: Extension Cable for D to connect to EV

This mode is described only in AIS Part1 standard and it is similar to Mode2 & Mode3 of IEC 61851-1.

c) **DC Charging for low voltage vehicles (48V or 72V):**

- a) **Type 1:** Single vehicle charging at 48V or 72V with a maximum of 10kW power, or a 2W vehicle charging at 48V with maximum power of 3.3 kW.
- b) **Type 2:** Single vehicle charging at 48V with a maximum of 10kW power or 72V with a maximum of 15 kW power or a 2W vehicle charging at 48V with maximum power of 3.3 kW.

Recommended Connector used for 10kW or 15kW:

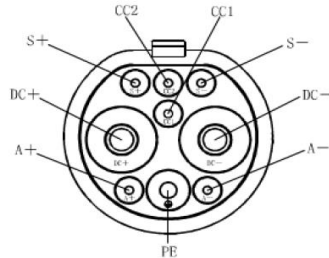


Fig.9 GB/T Connector

This DC charging mode is described only in BEVC-DC001 standard for low voltage vehicles. The connector for 3.3kW DC charging for 2W vehicles is not yet finalized. The communication between DC charging station & EV is as per IEC 61851-24 and the connector is as per GB/T 20234.3 standard.

4 India’s Mission Plan

To achieve India’s mission plan on deployment of 6 to 7 million electric vehicles by 2020 and to ban petrol and diesel vehicle sales from 2030 onwards in order to reduce the greenhouse gas emissions, the growth of charging infrastructure plays a crucial role. The large scale charging infrastructure requires a sufficient energy from the utility grid and generating this using renewable energy sources will help to achieve the mission. As per IEA’s India Energy Outlook 2015 [23], the projected electricity generation by 2040 with the available sources is shown in the figure 10.

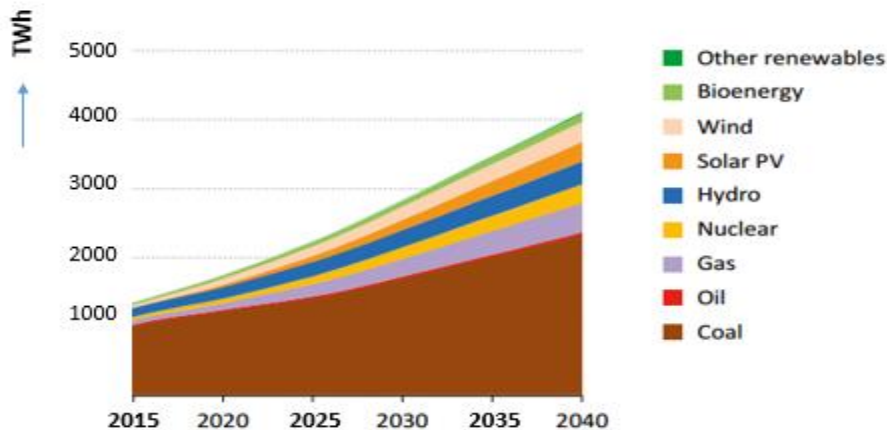


Fig.10 Estimated electricity generation in India from various power plants

As per IEA, the estimated electricity generation in India by 2022 from the renewable energy sources (Solar, Wind, Hydro, bio-energy & other renewables) is less than 30% of the total electricity generation. Whereas, the Government of India is targeting to install the renewable energy capacity to 175 GW by the year 2022 which includes 100 GW from solar, 60 GW from wind, 10 GW from bio-power and 5 GW from small hydro-power [24]. Currently in India, the total renewable installed capacity is 57.2GW out of which installed solar power is 12.5GW & wind power is 32GW [25]. The electricity generation calculations from the installed solar system capacities (existing & future) is shown in the table 4. The table 4 also compares the electricity required in transportation sector for 100% BEV’s with the generated electricity from solar plants (with the assumption that all the generated electricity from solar plants is used in transportation sector only).

Parameter	Existing (As on Apr'2017)	Future FY 2022-23
Installed capacity of solar (P_{inst_solar})	12.5GW	100GW (Target)
Average annual DNI (Direct Normal Irradiance) in India	5.0-5.5 kWh/m ² /day	
The peak power of typical solar panel per sq. meter (J_p)	150-200 W/m ²	
Area required for installed capacity in m ² , $A = \frac{P_{inst_solar}}{J_{p_min}}$	0.083 x 10 ⁹ m ²	0.667 x 10 ⁹ m ²
Solar energy generated in a year in TWh $E_{gen_solar} = \frac{DNI_{min} * A * 365}{10^{12}}$	151.4 TWh	1217 TWh
Typical efficiency of solar cell to convert radiation into DC current (η_{pv})	20%	
DC output of installed solar capacity ($E_{dc} = E_{gen_solar} * \eta_{pv}$) (15% is considered for calculations)	30.28 TWh	243.4 TWh
Conversion losses from DC to AC (η_{conv_loss})	20%	
AC output of installed solar capacity ($E_{ac} = [E_{dc} * (100 - \eta_{conv_loss})] / 100$) (25% losses are considered for calculations)	24.22 TWh	194.7 TWh
Required electricity generation in TWh for 100% BEV's in transportation sector (E_{gen_tr}) from Fig.5	618 TWh (Up to Apr'2017)	934 TWh (Estimated during 2022-23)
% of electricity generated from solar systems w.r.t required electricity in transportation = $(E_{ac} / E_{gen_tr}) * 100$	3.9%	20.8%

Table 4. Electricity generation calculations from solar plants (Existing & Future)

As on Apr'2017, if India was having 100% BEV's in transportation sector, only 3.9% of energy would have been accommodated from existing solar plants and remaining energy would have been accommodated from other sources (assuming all the electricity generated from solar system is exclusively used for only transportation). But with the target of 100GW solar power by 2022, 20.8% of the required energy (934 TWh) can be accommodated from solar plants for the existence of 100% BEV's during the year 2022-23. The achievement of national solar mission (100GW solar power) in 2022 will help in reducing the emissions and thereby it helps in achieving the NDC (Nationally Determined Contribution) targets given in Paris Climate Agreement.

The government of India has also announced the taxes on conventional & electric vehicle sales as per the new GST rules which is applicable from July 2017. The taxes on conventional passenger cars is 12.5% and for electric vehicles it is 6% which helps in encouraging the growth of EV market [26]. Also the government of India is supporting the India's largest private vehicle fleet company OLA which was launched BEV's for

public transportation in Nagpur city in the month of May 2017 [27]. OLA has deployed 200 BEV's and out of which 100 BEV's are four wheeler passenger cars from Mahindra Electric and remaining BEV's includes three wheelers & electric buses from various companies. It has also setup a four charging stations in the city with approximately 50 charge points which includes both AC & DC. With this support from the government many organizations & start-up companies has already started working on building EV's and developing the charging infrastructure. This helps in creating the awareness in people and also helps in creating the competitive market.

5 Conclusion

The barriers to the growth of EV market in India are lack of charging infrastructure, higher charging times, range anxiety, lack of awareness & lack of EV manufacturers. The range anxiety & higher charging times will not be a barriers if the charging infrastructure is installed on a large scale. The large scale growth of charging infrastructure depends on meeting the energy demand from the utility grid, charging standards availability & support for installation from the government through incentives. In India, the electricity required for the existence of 100% BEV's would be 56% higher than the estimated electricity generation by 2030. The government of India is planning to notify the charging standards for the large scale charging infrastructure growth. The government of India has also announced lesser taxes on electric vehicles compared to a conventional ICE vehicles and planning to release the Phase-2 of FAME-India scheme by September 2017. The Ministry of New and Renewable Energy sources (MNRE) has planned to work on a National Solar Mission to install 100GW of solar power by 2022. The achievement of solar mission would generate 137TWh of electricity which covers the 20.8% of electricity required for 100% BEV's during the year 2022-23. Hence by 2030, all these initiatives will improve the availability of large scale charging infrastructure in India and subsequently the EV market growth will improve at a rapid rate and India can easily achieve the ban of petrol & diesel vehicles. With this, India will also achieve the NDC targets (Nationally Determined Contributions) for Paris Climate Agreement.

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