ELECTRIC VEHICLE CHARGING STATIONS IN INDIA

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ABSTRACT: - This paper review the overview of the electric vehicle chargers (EVSE) and business model become trending issue in Indian market. Electric vehicle is type of vehicle which takes power from a rechargeable energy storage device. The rechargeable storage device is charged with the help of EV chargers (EVSE). EVSE is an electrical device that converts alternating current (AC) energy to regulated direct current (DC) for replenishing the energy storage device. EV chargers are divided into two main categories: conductive (wired charging) and inductive

charging (wireless charging). In India there are inductive chargers for now.

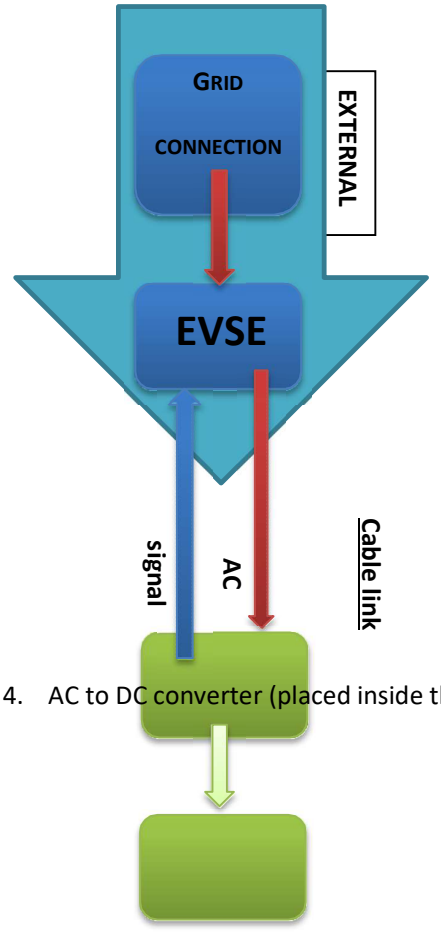
In this paper, EV chargers methods, charging levels, charging modes and future business model are explained clearly

KEYWORDS: - EV Charging methods, level of charging, modes, and future business model for India.

INTRODUCTION: - EV charger is an electrical device that converts alternating current (AC) to direct current (DC) for recharging energy storage device (i.e. battery). An EVSE is a wall mounted small device that supply electric energy for recharging of electric vehicle batteries. EVSE enhance safety by doing two way communications between the EV charger and the electric vehicle. In India ARAI and Bharat EV specs recommend to use simple 15 Amp 240 V socket on charging stations.

The EV charging system mainly involve: -

1. Grid connection (electricity source)
2. EVSE (charger)
3. Cable (for transferring AC/DC to vehicle)
4. AC to DC converter (placed inside the vehicle)
5. Battery (energy storage device)



AC/DC

DC

BATTERY

Figure 1: main components of conductive charging station

The above figure 1, shows how a electric vehicle get charged here, EVSE (charger) will take alternating current from the power grid connection. After taking AC it will transfer AC safely according to standards set of the safety organisations to the AC to DC convertor with the help of cables. Then AC to DC convertor will concert AC to DC and transfer DC to the Battery. Grid connection, EVSE and cable links are the external parts

and AC/DC convertor with battery are located inside the electric vehicle.

EV CHARGING METHODS

EV charger is an device required to transfer energy from constant frequency, constant voltage supply network to the direct current (DC), variable voltage EV traction battery bus for the purpose of charging the battery. Generally, there are two type of charging methods:

- Conductive charging
- Inductive charging

CONDUCTIVE CHARGING

Conductive charging system use direct contact between EVSE (charger) and electric vehicle with the help of cable. The main drawback of this charging

method is that the driver needs to plug in the cable from charger to vehicle. We will see EV charging levels and different modes of charging in conductive charging method.

1. EV charging levels: The charging level describes the "power level" of a charging output. There are three levels in charging method.

A. Level 1 charging: It is also known as "Home charging". It provides charging from standard residential 120-volt AC outlet, its power consumption is approximately equal to a toaster. Level 1 recharging will add approximately 5 miles of travel per hour. A completely depleted PEV battery could take up to 20 hours to completely recharge.

Figure 2: level 1 charger (source: solar united neighbors)

B. Level 2 charging: It provides charging using 220-volt residential and 208-commercial AC electrical service, its power consumption is approximately equal to that of cloths washing/drying machine. Level 2 charging will supply up to approximately 15 miles of travel for one hour of charging. A completely depleted PEV battery could be recharged in approximately 7 hours using level 2 chargers.

Figure 3: level 2 charger (source: solar united neighbors)

C. Level 3 charging: It is also known as "DC fast charging". It requires commercial grade grade 480-volt AC power service and its power consumption is equal to 15 average size air conditioning units.

Figure 4: level 3 charger (source: BTC power)

Level 3 charger will add approximately 80-10 miles of travel with 20-30 minutes of charging. this charger is different from both level 1 and 2 as in DC fast charger EVSE itself convert AC to DC and then transfer high-power DC directly to the PEV battery.

	LEVEL 1 CHARGER	LEVEL 2 CHARGER	LEVEL 3 (DC FAST CHARGER)
VOLTAGE	120v 1-phase AC	208v or 240v 1-phase AC	280v or 480v 3-phase AC
AMPS	12-14 Amps	12-80 Amps	<125 Amps
CHARGING LOADS	1.4-19 KW	2.5-19.2 KW	<90 KW
CHARGING TIME FOR VEHICLE	3-5 miles per hour of charge	10-20 miles per hour of charge	Full charge in 10-30 min.
INSTALLA--TION	self	By Profession--als	By Professiona--ls

Table 1: overview of charging levels

2. EV charging modes: The safety communication protocol between electric vehicle and charges (EVSE) is called charging mode. They are standard worldwide. There are 4 modes for charging and electric vehicle.

A. Mode 1 (household socket and extension cord): This mode is used as home charging with a simple extension cord. There is no safety controls between cord and EV. The socket outlet doesn't exceed 16A and 250V in AC 1-phase. In some countries mode 1 charging is outdate as they don't have any safety features. Connecting your EV to socket is like connecting your toaster to the socket.
They connect with electric vehicle having in-board charging with EVSE which take care of the input supply and transfer it to battery. Below we can the connection between socket and electric vehicle.

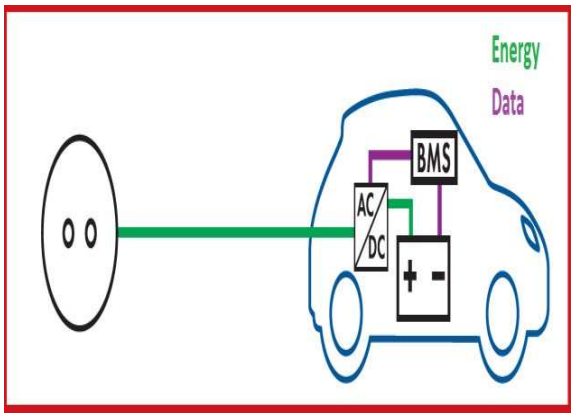


Figure 5: mode 1 type connectivity (source: SCHRACK, 2017)

B. Mode 2 (Domestic socket with protection device): This mode is also generally used in homes but with special in-cable EVSE. In this mode socket is firstly connected with EVSE then transferred to electric vehicle. The power transferred to the vehicle doesn't exceed 32A and 250V in AC 1-phase. The in-cable EVSE provide in cable RCD, over-current flow protection, over-temperature and power will only supplied when EVSE detected by vehicle.

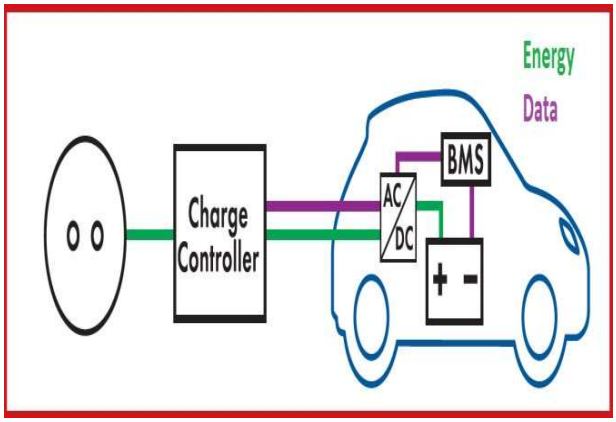


Figure 6: mode 2 type connectivity (source: SCHRACK, 2017)

C. Mode 3 (specific socket on dedicated circuit): The vehicle is connected directly to the electrical network through specific socket and plug and then a dedicated circuit attached. A control and protection function is also installed in the installation. This is charging mode give the applicable standards regulating electrical installations. It also allows load-shedding so that electrical household appliances can be operated during vehicle charging.

Mode 3 Charging is that wired-in AC charging station, either in public places or at home, allowing a higher power level than Mode 2. The safety protocol is identical to Mode 2. This charging mode is consists of connection of the EV to the AC supply network (mains) utilizing dedicated EVSE which is permanently connected to the AC supply network (mains).

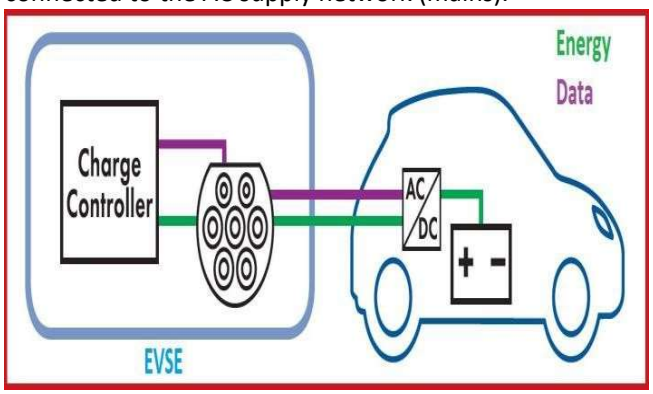


Figure 7: mode 3 type connectivity (source: SCHRACK, 2017)

D. Mode 4 (direct current connection for fast charging): The electric vehicle is connected to the main power grid through an external charger. Control and protection functions and the vehicle charging cable are installed permanently in the installation. Mode 4 Charging is wired-in DC charging station installed mainly in public places. In DC charging stations, the AC/DC convertor is part of the charging station, not part of the vehicle.

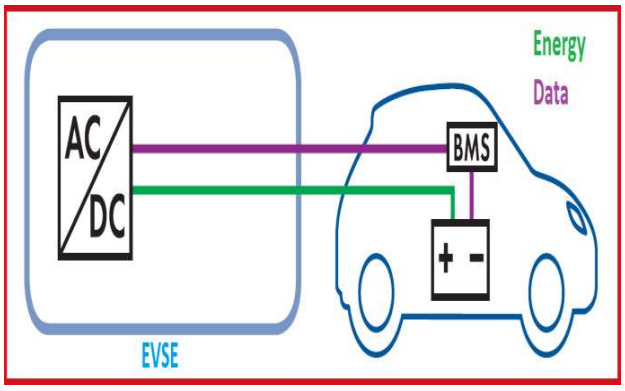


Figure 8: mode 4 type connectivity (source: SCHRACK, 2017)

INDUCTIVE CHARGING

Inductive charging is also known as "wireless power transfer (WPT)". Inductive charging uses an electromagnetic field to transfer energy between two objects. This is usually done with a charging station. Energy is sent through an inductive coupling to an electrical device, which can then use that energy to charge batteries. Induction chargers use an induction coil to create an alternating electromagnetic field from within a charging base, and a second induction coil in the portable device takes power from the electromagnetic field and converts it back into electric current to charge the battery. The two induction coils in proximity combine to form an electrical transformer. Large distances between sender and receiver coils can be achieved when the inductive charging system uses resonant inductive coupling. Improvements to this resonant system include using a movable transmission coil and the use of other materials for the receiver coil made of silver plated copper or sometimes aluminium to minimize weight and decrease resistance due to the skin effect.

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Advantages of Inductive Charging:

- Protected Connections
- Low infection risk
- Durability
- Increased convenience and aesthetic quality
- No need for cables

Disadvantages of Inductive Charging:

- Slower Charging
- More expensive
- Inconvenience

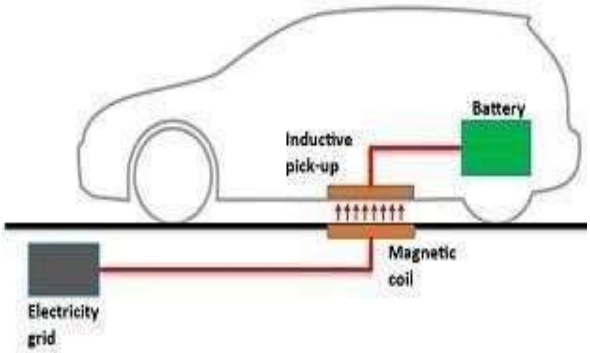

Figure 9: Inductive charging (source: green energy, 2016)

BUSSINESS PLAN FOR INDIA

1. Who Can Own EVSE? : As Per Electricity Act 2003, resale of electricity requires electricity distribution licence. Hence, strictly going by the present law, anyone other than DISCOMs requires a licence to setup EVSE which is not feasible. This point was brought to the attention of both Ministry of Power and Forum of Regulators by ISGF way back in 2016. After consultations, MoP has issued an order that EVSE's buying electricity from DISCOMs and selling to EVs is not considered as resale or trade of electricity. This has given much needed relief to potential EVSE entrepreneurs. Now anyone can apply for new connections for EVSE and commence the business.

2. Land for EVSE: EVSE itself require little space and can even be wall mounted. But the EVs that will be connected to the EVSE require parking space for several minutes/hours. The land for the same can be

expensive in cities. Even if a small rent is levied for the same by municipalities or property owners (Malls, Hospitals, Railway Stations, Bus Stands, and Airports etc), the EVSE business will be unviable. At least minimum 10% of parking spaces may be reserved for EVSEs without any lease rent for now in India as to boost by the electric vehicles.

COST ESTIMATE AND REVENUE FOR SETTING EVSE:

Considering that in a station there are three chargers two level 2 charges and one is DC fast charger. The total cost for installing charger would be approx. Rs.11,70,00 -/ and add by adding other expense Rs.1,55,000-/ hence total of will cost for first year will be Rs.2,15,000+EVSE management software fee and Rs.65,000-/ for next years.
Hence we can find that total investment for setting up EVSE charging station will cost Rs.8,21,83,725 cr.

By considering margin of Rs.3 per unit in electricity and zero land cost, the net cumulative return in 5 year will be Rs.6,25,13,600 cr.

Therefore, From our analysis of the current market scenario it will be difficult to build EV charging network in India as initial investment of Rs8,21,83,725 cr. to setup the EVSE facilities, the net cumulative return in 5 years is Rs6,25,13,600 cr. with a margin of Rs3 per unit of electricity sold. There is no incentive for third parties to setup and operate EVSEs.

Innovative business models to incentivize the EVSE investors and government and municipality interventions with respect to concessional allotment of land and other sops are required. Some of the suggestions are listed below:

1. Electric wholesalers and retailers may be mandated to setup EVSE network in strategic locations.

2. State governments to allot space for EVSE networks on long lease at concessional (or free).

3. EVSE as mandatory in new buildings through Building Codes for all categories of buildings

   exceeding certain built area.

4. EVSE stations can be included with Highway construction cost –again it will have negligible impact on per kilometre cost of highways

5. Shop owners may be encouraged to invest in EVSE stations and entry of petrol and diesel vehicles may be banned.

6. Allot land and licenses to setup large EVSE stations at strategic locations which will also have following facilities:

- Restaurants for families
- Café and ATMs
- Convenient Store/ Grocery/Vegetables Shops
- Health Club (Gym)
- Gaming Stations/Barbershops/Beauty
- Parlours/Massage Centres
- Air and Tyre changing services

7. Large private companies may be mandated to setup (or contribute towards) EVSE charging stations in their area of operation.

8. Oil distribution companies may be mandated to EVSE install to retail outlets.

9. EV manufacturers may promote EVSE networks and collect monthly subscription from EV owners and pay to the EVSE owners and operators (Japanese model)

10. Car rental companies may be allowed to setup EVSE networks

11. Other incentives for EVSE infrastructure could include:

- Tax concessions
- Free or concessional land on long term lease
- Transparent allocation of EVSE locations preventing formation of monopolies

Analysis and Result

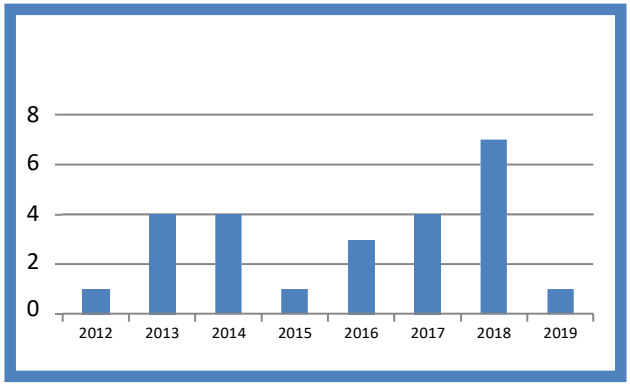

Figure 10: Reviewed papers on Supply Chain Management per year across the period of the study.

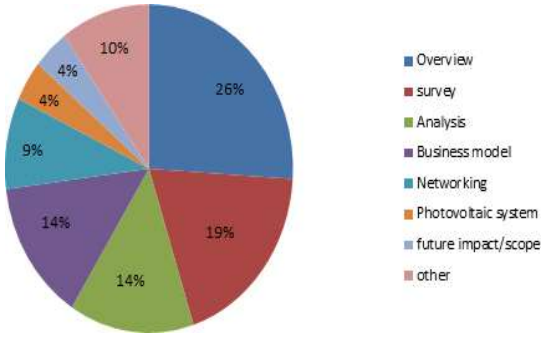

Figure 11: Distribution of the reviewed papers by research method.

FIGURE 10, graph shows the year verses work done on this topic for that particular year, it gives us information that how much work is done on this topic from last 8 years, from analyses it can be seen that in 2018 maximum number of work is done on EV chargers. From FIGURE 11, we can see pie chart which gives us information about different methodology used in last 8 year for research papers like overview of chargers, survey, analysis, business model, networking, future impacts and other methodologies. We see that maximum work which is 26% work is done on overview or general information about chargers, then 19% in surveys , 14% in analysis and business model both, 9 % in networking, 4% in future impacts and 10% in other methodologies. Hence, from above two charts we can analyse work done on EV chargers so far.

Conclusion

In this paper, the different EV charging methods are presented. An electric vehicle can be charged with conductive or inductive charging method. Using the conductive method the battery is connected by a cable and plugged directly into an electricity provider. The inductive method, in contrast, works through electromagnetic transmission without any contact between the EV and the charging infrastructure.

Also, the EV charging levels, modes and types are examined in this study. The charging level describes the "power level" of a charging outlet. There are three levels in charging technology. These are Level 1, Level 2 and Level 3 charging.

The charging mode describes the safety communication protocol between EV and charging station. There are four different charging mode namely Mode 1, Mode 2, Mode 3 and Mode 4. Also, the DC Charging and inductive charging topics are reviewed in this paper. The advantages and disadvantages of inductive charging is given in article. Also, Very beneficial document about EV Charging technologies is prepared for EV manufacturers or EV charging stations. This paper helps manufacturers or charging station owners to interpreting the charging levels, modes and business plans for setting up of charging stations or manufacturing chargers.

At last, graphs and pie charts are also explained in this paper to give an overview and analysis that how much work is done on this topic form last 8 years, the graph shows the year verses work done on this topic for that year and the pie chart shows how much work is done in percentages for specified methodology for last 8 years.
Hence, this paper give all the information about chargers like overview, business plan for india and analysed data for work done on this topic or on specified methodologies.

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