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*ISGF White Paper*

# Electric Vehicle Charging Stations Business Models for India

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## Abstract

*Availability of charging facilities at public places is the key prerequisite for adoption and rollout of electric vehicles (EV). This Paper examines various issues related to electric vehicle supply equipment (EVSE) or charging stations related to policies, standards, interoperability and business models for creation of an enabling EVSE ecosystem for faster rollout of EVs.*

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## About India Smart Grid Forum

India Smart Grid Forum (ISGF) is a public private non-partisan initiative of Government of India for accelerated development of smart grid technologies in the Indian power sector. ISGF was set up in 2010 to provide a mechanism through which academia, industry; utilities and other stakeholders could participate in the development of Indian smart grid systems and provide relevant inputs to the government's decision making.



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## Executive Summary

Electric Vehicle Supply Equipment (EVSE) or charging equipment are prerequisite for electric vehicle (EV) adoption by vehicle owners. Various countries adopted different approaches and business models for creation of EVSE ecosystem with mixed results. As India is gearing up to unleash an EV revolution, few key questions related to EVSE continues to haunt the stakeholders in the EV space:

*What are the standards for EVSE in India?*

*Who will own, operate and maintain EVSE? Utilities? Franchisees of the Utilities? Or third parties - fleet operators, parking lot operators and entrepreneurs?*

*What will be the electricity tariff for EV charging? Will there be capacity charges (minimum monthly fee per kW of capacity) or only energy charges?*

*Who will pay for the electric grid upgrade charges (higher capacity distribution transformers and new cables where ever required) – EVSE owner or that cost will be passed on to regular grid upgrade capex of the utility?*

*Where will the public EVSEs be located and land for the same be allotted free, at concessional rates or at market value?*

This Paper attempts to put together the summary of considerable work already done by various stakeholders on the above issues and look at sustainable business models for creation of EVSE ecosystem that will enable rollout of EVs on fast track.

## 1.0 Introduction to Electric Vehicle Supply Equipment (EVSE)

### 1.1 Types of EVSE

The EVSE or charging equipment can be broadly classified as AC charging and DC charging devices. The battery in the EV require direct current (DC), which a DC charger can supply directly to the EV battery. Alternatively, an AC-DC convertor on-board the EV can convert the AC supply from the AC charger and supply DC to the EV battery. For AC charging the vehicle should have an AC-DC convertor on-board which would add to the cost and weight of the EV. However, almost all EVs have a small size AC-DC convertor so that the EV can be charged from any AC supply. In case of AC charging, the charging speed depends on the DC output from the on-board AC-DC convertor. For example a single phase 220V AC, 15 Amps supply (AC output- 3.3 kW) connected to an EV with a 10 kWh battery and on-board AC-DC convertor with an output of only 1 kW DC could take 10 hours to fully charge the battery. AC chargers with high power output are available which can fast charge the batteries depending on the battery chemistry and battery management system (BMS) in the EV.

DC Fast Chargers (DCFC) with high power output can supply DC power to the battery and can charge the EV battery much faster. A 50 kW DCFC can charge an EV with a 25 kWh battery in 30 minutes (theoretically). DCFCs are more economical as AC-DC conversion takes place in the EVSE itself rather than inside the vehicle. When an EV is connected to the EVSE a hand-shake is established between the EV and EVSE; and the BMS in the EV takes control over the charging process.

There are different types of AC and DC Chargers with different communication protocols which are briefed in the table below:

| Charger Types & Sockets     | Picture   | Origin and Popular EV Models  | Maximum Power Output and Communication Protocols  |
|-----------------------------|---|---|---|
| <b>A. AC Chargers</b>       |   |   |   |
| Type-1 with Yazaki Socket   |    | Japan, USA (uses separate standard – JSAE 1772 due to 110 Voltage)  | Up to 7.4 kW (32 Amps, Single Phase)  |
| Type-2 with Mennekes Socket |    | Europe (Germany) – many European cars   | Up to 44 kW (63 Amps, 3 Phase)  |
| Type-3 with Le Grand Socket |    | France and Italy – some European cars   | Up to 22 kW (32 Amps, 3 Phase)  |
| <b>B. DC Charger Types</b>  |   |   |   |
| CHAdeMO                     |  | Origin from Japan; Most popular DC charger in the world; used in Japan, Korea and parts of USA and Europe; Nissan Leaf, Mitsubishi, Kia etc | Up to 400 kW DC charging (1000 Volts, 400 Amps); Control Area Network (CAN) for communication between EV and EVSE |
| GB/T                        |  | Used in China; as well as Bharat Chargers in India; Chinese Vehicles and Mahindra Electric in India   | Up to 237.5 kW DC charging (950 Volts x 250 Amps); CAN for communication between EV and EVSE                      |
| Tesla Super Charger         |  | Tesla has its own supercharger. Tesla also sells adapter for connecting to a CHAdeMO charger  | Up to 135 kW DC charging (410 Volt x 330 Amp); CAN for communication between EV and EVSE                          |


| C. Combined (AC and DC) Chargers   |   |  |  |  |
|------------------------------------|---|--|--|--|
| SAE Combined Charging System (CCS) |  <p>CCS 1</p> <p>CCS 2</p> | CCS-1 and CCS-2 versions available; same plug used for both AC and DC charging; Most European Cars - Audi, BMW, Daimler, Ford, GM, Porsche, VW etc | Up to 43 kW AC and up to 400 kW DC (1000 Volt x 400 Amp) Power Line Communication (PLC) for communication between EV and EVSE. |  |

Table-1: Types of EVSE

Interoperability between the EVSEs is a challenge. While Japan and Korea have adopted CHAdeMO, Europe have gone for CCS; and USA have all four types of EVSEs. Tesla have built their own super chargers in popular Tesla markets. China have developed fast chargers based on the Chinese GB/T standards. Nissan Leaf cars are sold in Europe with CCS Adaptors while Tesla sells an adapter to connect to CHAdeMO chargers. Some makes of EVSE come with CCS and CHAdeMO guns that can charge both types of vehicles.

## 1.2 Charging Rate

All batteries cannot be fast charged. In the battery parlance the C-rate is used to refer the charging rate. 1C rate refers to full charging in one hour; 2C rate refers to full charging in 30 minutes; and 10C refers to full charging in 6 minutes. And C/2 means two hours to fully charge. Maximum rate at which various types of batteries can be charged are given in the table below:

| Battery Chemistry                          | Maximum C Rate | Max Temperature (Degree C) | Life (Maximum Cycles) | Power Density (Wh/kg for cell) | Average Module Price (US\$/kWh in 2018)* |
|--|----------------|----------------------------|-----------------------|--------------------------------|--|
| Lithium Ion Iron-Phosphate (LFP)           | Up to 2C       | 40                         | 1500-3000             | 100-130 Wh/kg                  | 270                                      |
| Lithium Ion- Nickel Manganese Cobalt (NMC) | C/2            | 40                         | 1000-2000             | 230-250 Wh/kg (for NMC 811)    | 250                                      |
| Lithium Ion- Nickel Manganese Cobalt (NMC) | 3C             | 40                         | 3000-4000             | 200 Wh/kg (for NMC 811)        | 400                                      |
| Lithium Nickel Cobalt Aluminium (NCA)      | 2C             | 40                         | 1000-1500             | 250-270 Wh/kg                  | 230                                      |
| Lithium ion Titanate Oxide (LTO)           | 6C             | 60                         | 7500-10000            | 50-80 Wh/kg                    | 700                                      |

Table-2: Types of EV Batteries and its Features (\*Values in this table are indicative only and it is changing as technologies are improving constantly; some manufacturers do not disclose the properties of their latest batteries in public owing to confidentiality from competition)

The BMS is tightly integrated with the battery chemistry and its thermal properties. BMS determines the charging rate depending on the input voltage, current, ambient temperature; and the residual charge remaining in the battery.

## 2.0 EVSE Standards for India

In 2016, on the request of ISGF, Bureau of Indian Standards (BIS) setup ETD 51 Committee for preparing the Indian Standards for EVSE. The EVs need to be connected to the electric grid for charging the battery and hence must comply with electricity grid code like other electrical equipment. Characteristics of the Indian power system is similar to that of Europe – 230V and 50Hz (unlike America: 110V and 60Hz) and we follow IEC standards.

ETD 51 Committee with participation of all stakeholders had extensive deliberations and have finalized on following standards:

| Indian Standards             | Description  | Status   |
|------------------------------|--|--|
| IS:17017 series of Standards | Primarily based on IEC 61851; IEC 62196 and ISO 15118 series of Standards  |  |
| IS:17017-1                   | General Requirements and Definitions of EVSE (Adapted from IEC 61851-1)  | Published by BIS in August 2018                            |
| IS:17017-21                  | EV requirements for connection to AC/DC Supply (Adapted from IEC 61851-21)   | Work in progress; expected to be published in October 2018 |
| IS:17017-22                  | AC EVSE (Adapted from IEC 61851-22)  | Work in progress; expected to be published in October 2018 |
| IS:17017-23                  | DC EVSE (Adapted from IEC 61851-23)  | Work in progress; expected to be published in October 2018 |
| IS:17017-24                  | Control Communication between DC EVSE and EV (Adapted from IEC 61851-24)   | Work in progress; expected to be published in October 2018 |
| IS: 17017 – Part 2*          | IEC 62196 Part-1, Part-2, Part-3 Standards for the plugs, socket outlet, vehicle couplers and vehicle inlets. These are being adapted as IS:17017 Part 2 – A, B and C* | Work in progress; expected to be published in October 2018 |
| IS/ISO:15118*                | ISO 15118 series for communication between the EV and the EVSE. There are seven documents in this series.<br><br>These are adopted as it is.                           | Work in progress; expected to be published in October 2018 |

(\* these Standards and IS numbers are under finalization by BIS)

Table-3: EVSE Standards in India



The IS:17017-1 published by BIS in August 2018 recommends both CCS-2 and CHAdeMO. In 2017, a Committee constituted by Department of Heavy Industries (DHI) issued Bharat Charger specifications for AC and DC chargers which follows GB/T, the Chinese standards. These documents are:

- ✓ For AC: Bharat EV Charger AC001
- ✓ For DC: Bharat EV Charger DC001

These are slow chargers with DC output below 120 Volts. BIS has agreed to retain these standards which are supporting the EVs presently operating in India. These are expected to wither away as new EVs are rolled out with batteries capable of fast charging with DC output in the range of 400-500V or higher.

As can be seen all standards will co-exist in India: CCS-2, CHAdeMO and the Bharat Chargers which are GB/T. Tesla might offer their super chargers when they start operations in India.

The status is summarized as:

- Buses with battery sizes >100kWh will be sold with proprietary charging standards recommended by the battery manufacturer. These batteries will cost several million rupees and it is not advisable to charge from any public EVSE. Bus operators need to install the charging devices supplied (or recommended) by the bus manufacturer at bus depots and bus terminuses as required.
- Two wheelers comes with small size batteries which in many cases can be pulled out and taken to homes/offices/shops and charged from normal wall sockets; or can be connected to any public EVSE.
- 3-Wheelers are ideal candidates for battery swapping. In this scenario, batteries may be charged in a large industrial scale facility and charged batteries are trucked to points of 3-Wheeler concentration where a 3-Wheeler driver can swap the used battery with a fully charged one. Here again the large charging station setup may be proprietary technology. 3-Wheelers could also be charged from any public EVSE.
- Present models of electric cars have the batteries on the chassis which are not suitable for swapping. Cars comes with various sizes of batteries - 11kWh (Mahindra e20) to 40kWh (Nissan Leaf) to >90kWh (Tesla Model S). These EVs require DCFCs for fast charging. The whole issue of inter-operability of EVSE for different EV models is essentially limited to cars.

In India so far only Mahindra Electric and Tata Motors have launched electric cars. The present batteries in these cars are not suitable for charging above 1C rate. The offtake of electric cars may be slow as individual buyers might watch the space and move with caution as in other geographies. The initial push for electric cars is expected from taxi fleet operators, Government departments, public sector undertakings and large corporates.

In nutshell, BIS standards is not a show stopper on the e-Mobility programs in India; and the complete set of standards are expected to be published by BIS by end of 2018.

### 3.0 Who Can Own EVSE?

Per Electricity Act 2003, resale of electricity require electricity distribution licence. Hence, strictly going by the present law, anyone other than DISCOMs require a licence to setup EVSE which is not feasible. This point was brought to the attention of both Ministry of Power (MoP) and Forum of Regulators (FOR) by ISGF way back in 2016. After several stakeholder consultations, MoP has issued an order in

April 2018 clarifying 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.

## 4.0 Electricity Tariff for EVSE

For the first time in the country, Delhi Electricity Regulatory Commission (DERC) in its tariff order in 2017 introduced a separate tariff for EV charging which is substantially lower than the commercial tariff – Rs 5/kWh for charging from HT supply and Rs 5.5/kWh for charging from LT supply. Also there is no minimum monthly charges for capacity. This was intentionally kept lower in order to promote EV rollout as well as creation of EVSE ecosystem. In 2018, Karnataka and Maharashtra State Electricity Regulatory Commissions have also introduced separate tariffs for EVs while DERC retained the 2017-18 tariff for 2018-19. We expect separate tariffs for EVs all across the country in the coming years which will be variable based on time of use (ToU).

## 5.0 Grid Upgrade Cost for EVSE

In most parts of India, the distribution transformers (DT) and overhead wire/underground cables are generally overloaded. When large number of EVs are connected to the low voltage lines from one particular DT, the DT might burn. Since buying behaviour of EVs is influenced by friends and neighbours, initial trials with EVs in almost all geographies have experienced creation of pockets of EV concentration where grid equipment needed upgrade. ISGF study in Kolkata in 2016-17 noticed that 8 months in a year (except November to February when air conditioners are seldom used) the existing DTs may not be able to accommodate DC Fast Chargers. If the grid upgrade cost which will run in to millions of rupees is passed on to the EVSE establishment, the cost of electricity will be so high that e-mobility will not take-off.

Instead, ISGF has been advocating to regulators and policy makers that the benefits of e-mobility (such as reduced air and noise pollution, fatigue less travel in air conditioned electric buses etc.) are available to entire population in a city; and hence grid upgrades for accommodating EVSE should be part of the annual capex of the DISCOMs. Why this is so important for establishment of an enabling EVSE ecosystem will be clear from the Cost Estimates and Revenue Model for EVSE described in section 7 of this Paper.

## 6.0 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, Campuses, Railway Stations, Bus Stands, Airports, and Office Complexes etc), the EVSE business will be unviable.

ISGF proposes that at least minimum 10% of parking spaces may be reserved for EVSEs without any lease rent.

## 7.0 Cost Estimates and Revenue Model for a Typical EVSE Setup

The Capex and Opex of a typical EVSE Station with One Bharat Charger, One AC Type-2 Charger and One CCS 2 DCFC (25 kW) are estimated here:

| Type of Charger   | Number of Chargers in the EVSE Station | Power Input       | Power Output | Approx Cost including GST @18% (INR)   | Number of EVs that can be charged simultaneously | Maximum Power sold to EVs per Day (20 hours/day assumed) kWh |
|---|--|-------------------|--------------|--|--|--|
| <b>CAPEX</b>  |  |                   |              |  |  |  |
| Bharat Charger AC 001   | 01                                     | 3 Phase 415 Volt  | 3 x 3.3 kW   | 70,000   | 3  | 198  |
| Type-2 AC Charger   | 01                                     |                   | 7.2 kW       | 75,000   | 1  | 144  |
| CCS-2   | 01                                     | 3 Phase, 415 Volt | 25 kW*       | 700,000  | 1  | 500  |
| New Electricity Connection (50kW), LT Cabling (100 meters), Panels, Breakers, Energy Meter etc. |  |                   |              | 200,000  |  |  |
| Civil Works (Flooring, Boards, Painting, Branding, Shed/Cover etc.                              |  |                   |              | 75,000   |  |  |
| EVSE Management Software – Integration with Chargers and Payment Gateway                        |  |                   |              | 25,000   |  |  |
| CCTV Camera System  |  |                   |              | 25,000   |  |  |
| <b>Total Capex</b>  |  |                   |              | <b>11,70,000</b>   |  | <b>842</b>   |
| <b>OPEX</b>   |  |                   |              |  |  |  |
| Technicians (one technician @25k/month considered for first 6 months)                           |  |                   |              | 150,000  |  |  |
| Server and Storage Fee per Year (on public cloud)   |  |                   |              | 5,000  |  |  |
| EVSE Management Software Fee (considered as 10% of net margin on electricity charges)           |  |                   |              |  | Refer Table-5 on Revenue projections             |  |
| Payment Gateway Fee (2-3% of total money collected)   |  |                   |              |  | Pass through to customer is considered           |  |
| Land Rent   |  |                   |              | Not considered   |  |  |
| Advertising (@5000/month)   |  |                   |              | 60,000   |  |  |
| <b>Total Opex</b>   |  |                   |              | <b>215,000 + EVSE Management Software Fee in First Year</b><br><b>65,000 + EVSE Management Software Fee from second year onwards</b> |  |  |

Table-4: Capex and Opex of a typical EVSE Setup

\*DCFCs usually comes with 50 kW or higher power outputs. A 50 kWh DCFC cost over Rs 1.5 million. Since present models of EVs sold in India cannot be charged above 1C rate and batteries are 11kWh to 25 kWh capacity, investment in DCFC of over 25 kWh is not considered in this estimation

Revenue projection from the EVSE business is calculated in the next table based on the following assumptions:

- 20 hours of charging operations for 25 days/month (300 days x 20 hrs = 6000 hours maximum capacity)

- Capacity Utilization Factor (CUF) of EVSE setup considered at 10% for Year-1, 20% for Year-2, 35% for Year-3, 55% for Year-4 and 80% for Year-5 (which is very ambitious targets)
- Electricity tariff to the DISCOM is considered as pass through and no minimum monthly charges considered
- A margin of Rs 2 on electricity tariff is considered in Scenario-A and Rs 3 is considered in Scenario-B.
- Payment Gateway charges (2-3%) is considered to be added to the EV customer bill
- Land Rent is not considered
- EVSE Management Software fee considered @10% of net margin on electricity tariff (Rs 0.20 in Scenario-A and Rs 0.30 in Scenario-B)

| Description   | YEAR-1<br>10% CUF | YEAR-2<br>20% CUF | YEAR-3<br>35% CUF | YEAR-4<br>55% CUF | YEAR-5<br>80% CUF | Total in 5<br>Years |
|---|-------------------|-------------------|-------------------|-------------------|-------------------|---------------------|
| Electricity Sold to EVs/Year (kWh): 842 kWh per day maximum x 300 days per year considered as 100 % CUF                               | 25,260            | 50,520            | 88,410            | 138,930           | 202,080           | 505200              |
| Estimated Revenue (INR)   |                   |                   |                   |                   |                   |                     |
| SCEANRIO-A: Margin of Rs 2 on electricity tariff  | 50,520            | 101,040           | 176,820           | 277,860           | 404,160           | 10,10,400           |
| SCENARIO-B: Margin of Rs 3 on electricity tariff in Year 1 & 2; margin of Rs 2.5 in Year 3 & 4 and margin of Rs 2 from Year-5 onwards | 75,780            | 151,560           | 265,230           | 416,790           | 606,240           | 15,15,600           |
| Opex from Table-4   | 215,000           | 65,000            | 65,000            | 65,000            | 65,000            | 475,000             |
| EVSE Management Software Fee (10% of net Revenue): Scenario-A   |                   |                   |                   |                   |                   | 101,040             |
| Total Opex Scenario-A   |                   |                   |                   |                   |                   | 576,040             |
| EVSE Management Software Fee (10% of net Revenue): Scenario-B   |                   |                   |                   |                   |                   | 151,560             |
| Total Opex Scenario-B   |                   |                   |                   |                   |                   | 626,560             |
| Net Revenue: Scenario-A   |                   |                   |                   |                   |                   | 434,360             |
| Net Revenue: Scenario-B   |                   |                   |                   |                   |                   | 889,040             |

*Table-5: Revenue Projections from a typical EVSE Setup*

As may be observed from Tables 4 and 5, for an initial investment of Rs 1.17 million to setup the EVSE facilities, the net cumulative return in 5 years is Rs 0.43 million under Scenario-A with a margin of Rs 2 per unit of electricity sold to EVs, and Rs 0.89 million under Scenario-B with a margin of Rs 3 per unit of electricity sold. In both the cases there is no incentive for third parties to setup and operate EVSEs. Levying a margin more than 3 rupees will make the EV tariff at par with commercial electricity tariff.

## 8.0 EVSE Scenario in Other Countries

Worldwide 4 million EVs have been sold until end-August 2018. Another million EVs are expected to be on road by March 2019. By end of 2015, there were about 1.45 million EV charging points of which

87% were privately owned slow chargers (or home chargers). Number of EVSE in some countries is given in the table below:

| Number of EV Charging Points in few Countries<br>(indicative only) |       |        |        |
|--|-------|--------|--------|
|  | 2015  | 2016   | 2017   |
| USA  | 31674 | 40473  | 45868  |
| Canada   | 3508  | 4215   | 5841   |
| Japan  | 22110 | 24372  | 28834  |
| Korea  | 790   | 1566   | 5612   |
| Norway   | 5703  | 7758   | 9530   |
| France   | 10568 | 15567  | 15978  |
| Netherlands  | 18044 | 26448  | 33431  |
| Germany  | 5328  | 17509  | 24289  |
| China  | 58758 | 141254 | 213903 |
|  |       |        |        |

Table-6: Number of EVSE in some countries (Source: IEA-CEM EV Outlook 2018)

Different countries have adopted different approaches in creation of EVSE ecosystem with mixed results. There are two main approaches as described below:

**Integrated Model:** The electric utility owns the EVSE and operate it either directly or through their franchisees (or contractors). The EVSE assets forms part of the regulated assets of the utility who are responsible for distribution of electricity as well as operation and maintenance of the EVSE. Most popular example of this model is Ireland and British Columbia in Canada. The main advantage of this model is that the utility need not worry about low volume of business in the initial years as the assets are created under regulated capex route.

**Independent Model:** In this case independent private (or public-private partnerships) players set up EVSE under licences from local governments or municipalities. They may appoint EV Service Providers (EVSP) for charging operations and payment settlements who ensures certain level of interoperability amongst different EVSE network owners. UK and Netherlands are examples of the Independent Model. Different countries and local governments offer different incentives, tax breaks etc to EVSE network owners to compensate for low volumes of business in the initial years.

Both models exists in different parts of USA. In almost all European countries and USA different financial packages are offered under different policy initiatives to incentivize both EVs and EVSE ecosystem.

A comparative table of EVSE ecosystem in select countries is given below:

|  | <b>United Kingdom</b>  | <b>Ireland</b>  | <b>Netherlands</b>   | <b>United States</b>   | <b>Germany</b>   |
|--|--|---|--|--|--|
| <b>Total EV stock</b>                          | 137,680  | 2,687   | 119,332  | 563,700  | 59090  |
| <b>Normal Charge Points</b>                    | 11,497   | 837   | 32,120   | 40,862   | 22,213   |
| <b>Fast Charge Points</b>                      | 2,759  | 172   | 755  | 6,266  | 2,076  |
| <b>Total Charge Points</b>                     | 14,256   | 1,009   | 32,875   | 47,128   | 24289  |
| <b>Charging Market Model</b>                   | Independent  | Integrated  | Independent  | Independent  | Independent  |
| <b>Public Charging Organization</b>            | By local authorities, over discrete platforms  | By the grid operator  | By local authorities, over open access platforms                     | By charging network operators and property owners on discrete platforms                  | Over three quarters of charging points are operated by electricity companies |
| <b>Private Operators of Public Charging</b>    | 5-10   | 0-5   | 15-20  | 10 networks , many property owners   |  |
| <b>EVSE Owner</b>                              | Infrastructure is tendered by lower governments like cities, regions or municipalities | Infrastructure in the hands of e-cars, a subsidiary of ESB (grid operator). ESB tenders charging hardware and installation. | Cities and provinces tender public charging infrastructure           | Third party charging service provider, individual residents, homeowner associations etc. | Municipal governments & private investors                                    |
| <b>EV Service Providers (EVSP)</b>             | Operation is done by private parties that subcontract their energy supplier            | Sub-contractors of ESB operates the EVSE  | Private companies, energy companies and contractors operate as EVSPs | Private EVSPs  | Private EVSPs  |
| <b>Entity Responsible for Grid Upgradation</b> | Grid operator  | ESB-Ireland's grid operator   | EVSE Owner   |  | Private investor but the Govt funding will cover network connection cost     |

|                         |  |  |   |  |   |
|-------------------------|--|--|---|--|---|
| <b>Interoperability</b> | No national interoperability between EVSEs in different UK regions, however, interoperability within regions is organized by EVSPs | EVSPs offer subscriptions to EV Owners and delivering interoperability in return, using an RFID card for authentication in the transaction | National interoperability is organized through the Central Registry Interoperability and is managed by non-commercial organization eViolin to which all EVSEs and EVSPs are connected | No national interoperability between EVSEs in USA. | Ladenetz, a government-sponsored consortium of utilities, universities, and private EVSPs in Germany and the Netherlands, is creating a Europe-wide network of interoperable charging stations. |
|-------------------------|--|--|---|--|---|

*Table-7: EVSE Business Models in select Countries*

*(Note: Number of EVSEs in Tables 6 and 7 may not match as these figures are taken from different reports that were published in 2017 and 2018)*

## 9.0 Conclusions and Recommendations

### 9.1 Standards

Rollout of Electric Buses are not constrained by EVSE standards as buses will be charged from the EVSEs supplied (or recommended) by the bus manufacturer which will be installed in bus depots and bus terminuses. The cost of EVSE for bus may be bundled in the cost of the bus itself. Bus Operators should ideally own and operate the EVSE for buses; and electricity to be supplied by respective DISCOMs. Grid upgrade charges if any to be considered in the annual Capex of the DISCOM – it should not be burdened on e-mobility program.

3-Wheelers are ideal candidates for battery swapping. Battery Leasing Agencies (BLA) may be encouraged in each city. BLAs will own the batteries; and they will rent charged batteries to 3-Wheelers. BLAs will setup and operate charging stations for mass charging of 3-Wheeler batteries. These charging stations may or may not follow IS standards.

2-Wheelers may be allowed to charge from any single phase electricity connection or EVSE as permitted by the vehicle manufacturer.

Bharat Chargers are presently being installed by EV owners and operators which follow GB/T standards. IS:17017 recommends both CCS-2 and CHAdeMO standards. Whenever Tesla starts operations in India, they might offer Tesla Superchargers. So India will have all charging standards co-existing.

DST/BIS is planning to launch a Grand Challenge for designing a universal plug that can be applicable for all the standards. Recently China Electricity Council (CEC) and CHAdeMO Alliance have announced a collaborative development effort for next generation ultra-fast EV charging standard (New QC Standard) with DC power output of 900 kW (1500 Volt x 600 Amp) which will have backward compatibility with previous versions of GB/T and CHAdeMO chargers (GB/T 2011 and 2015; CHAdeMO R4-2.0 and 3.0)

## 9.2 EVSE Business Models

As explained in Section-7, in the present scenario, EVSE business is not viable for any entrepreneurs to invest. Even if grid upgrade cost is absorbed by the DISCOM and land for EVSE is allotted free by City Governments and the cost of EVSE have halved (owing to large volumes which we do not expect before 2025) still there is no return on investment in running an EVSE business. This scenario is true globally. Centre for Climate and Energy Solutions (C2ES) in their 2015 report **“Business Models for Financially Sustainable EV Charging Networks”** concludes that:

*“Charging station business models that rely solely on direct revenue from EV charging services currently are not financially feasible. The analyses completed for this study focused on DC fast charging stations, capable of charging a Nissan LEAF to 80 percent in less than 30 minutes, and alternating current (AC) Level 2 charging stations, which can fully charge a Nissan LEAF in 3.5 to 7 hours. The analyses show that investment in a single DC fast charging station results in a net loss of more than \$44,000 for a private project developer over a 10-year period. Similarly, investment in a charging site with five slower, lower powered, and lower cost alternating current (AC) Level 2 charging stations results in a net loss of more than \$26,000 for a private project developer over the same 10-year period. To build a business case that will attract capital and convince the private sector to invest in EV charging, total revenues must be greater than the project’s total cost, and an acceptable level of profit is necessary. There are four general ways to improve the financial performance of charging station projects: increase revenues, decrease capital costs, decrease operating costs, and/or decrease the cost of funds for the project. One promising opportunity to improve the financial performance of charging station investments is to develop business models that, through private partnerships and joint investment strategies, capture other types of business value in addition to selling electricity. This might include tourist revenue for retailers and tourism businesses that get more sales from EV drivers when located near EV charging stations; automakers selling more EVs; and “clean energy” marketing and brand-strengthening opportunities for businesses visibly involved in EV charging deployment projects.”*

Another report titled **“Electric Vehicle Charging Infrastructure in Israel: Implementation Policy and Technical Guidelines”** (May 2018) by Samuel Neaman Institute for National Policy Research and EV CONSULT states that:

*“Based on indications from the well-developed market of the Netherlands, the initial cost to install an AC public charger with 2 sockets is about €3,000-4,000 (€1,500-2,000 per charging point), and the running cost for a charger with annual sales of 2,000-8,000 kWh amounts to €930-1,280 per year, respectively. Costs of entry-level 50kW DC fast chargers range from €15,000 to €30,000 for the hardware, with costs of grid connections and construction varying widely, averaging at a total cost for a highway location fast charging station with 2 chargers at about €250,000. The rate between the operational expenditure (OPEX) to capital expenditure (CAPEX), as well as the variability with respect to sales volume, goes to show the importance of charger utilization (i.e. sales) for the business case of public charging”*

Since business volumes in the initial years being very low attracting private investments for EVSE network creation proved to be a challenge in every country; hence resorted to the route of grant funding or capex by electric utilities in most places. In Japan, EV owners pay a monthly fee to EV manufacturers for using the charging facilities and the consortium of EV manufacturers subsidises the EVSE owners and operators (this is besides Government subsidies to EVSE owners). In France the largest EVSE network owner Blue Solutions (Bolloré Company)’s primary business is renting EVs. However, other EV owners can also use their EVSE network against a fee. From our analysis of the current market scenario it will be difficult to build EV charging network in India as a standalone business. 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:

- a. Electric utilities may be mandated to setup EVSE network in strategic locations in their service area under capex for grid upgrades (regulated asset)
- b. City governments/Municipalities and Highway Authorities may be mandated to allot space for EVSE networks on long lease at concessional (or free) through transparent selection route avoiding creation of monopolies
- c. Bundle EVSE as mandatory in new buildings through Building Codes for all categories of buildings exceeding certain built area - in this case the impact of EVSE infrastructure cost in the per square meter cost of the buildings will be negligible
- d. EV manufacturers to contribute a certain percentage of the vehicle cost towards EVSE Fund which will be utilized to build EVSE network in respective cities/states
- e. EVSE infrastructure may be clubbed with Highway construction cost – again it will have negligible impact on per kilometre cost of highways
- f. In commercial centres, tourist places, religious places etc the shop owners may be encouraged to invest in EVSE infrastructure and entry of petrol and diesel vehicles may be banned
- g. Allot land and licences to setup large EVSE stations at strategic locations which will also have following facilities:
  - Café/ATMs
  - Convenient Store/ Grocery/Vegetables Shops
  - Health Club (Gym)
  - Gaming Stations/Barbershops/Beauty Parlours/Massage Centres
  - Air and Tyre changing services
- h. Public sector undertakings and large private companies (above certain turnover) may be mandated to setup (or contribute towards) EVSE infrastructure in their area of operation
- i. Oil distribution companies may be mandated to create EVSE infrastructure nearer to their retail outlets (subject to clearances for operating at high voltages) on highways (with in cities it may not be possible owing to space limitations and high cost of land)
- j. EV manufacturers consortiums may promote EVSE networks and collect monthly subscription from EV owners and pay to the EVSE owners and operators (Japanese model)
- k. Fleet operators and car rental companies may be allowed to setup EVSE networks
- l. Other incentives for EVSE infrastructure could include:
  - a. Tax concessions
  - b. Free or concessional land on long term lease
  - c. Transparent allocation of EVSE locations preventing formation of monopolies







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