Session 9: Emerging Technologies and Use Cases
PART A: Electric Mobility

Session Contents

- Growth of Electric Vehicles (EV)
- EV and EV Charging Fundamentals
- Electric Mobility and its Impact on Electric Grid
- Bus Fleet Electrification – Electric Bus Revolution in Shenzhen City
- Battery Swapping Stations

Speaker

Reji Kumaar Pillai

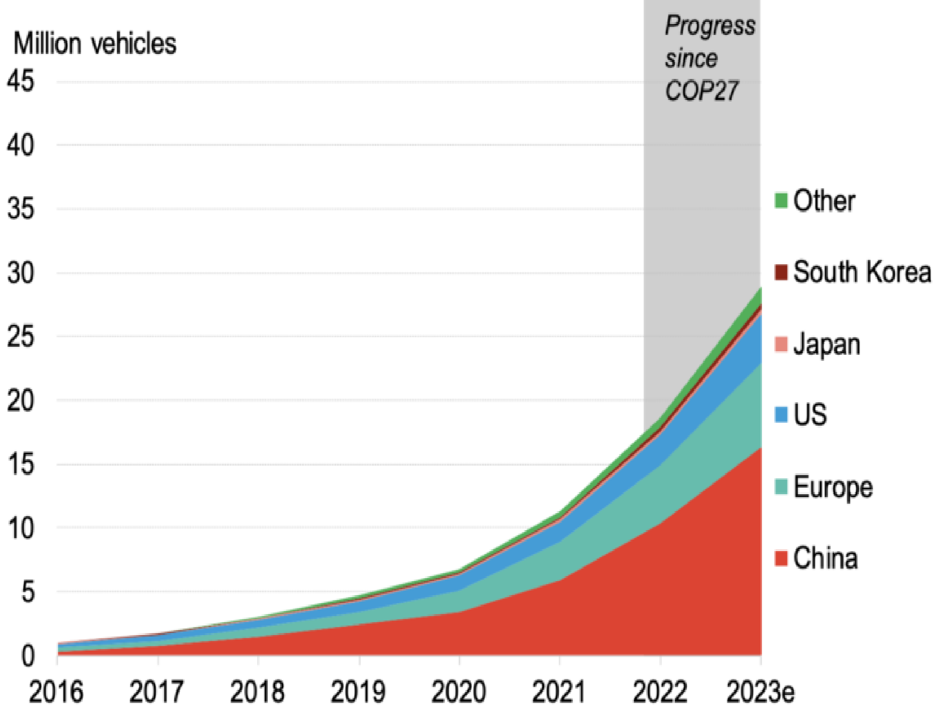
President - India Smart Grid Forum
Chairman – Global Smart Energy Federation

Traffic in New York City in 1900 and 1913

Growth of Global EV Fleet (1/2)

- EV (cars and buses) sales reached > **14 million** in 2023; against 6.5 million in 2021 and 10.5 million in 2022
- A cumulative total of **41 million** EVs sold by end of 2023–first million achieved in 2016 only!
- EVs displaced **1.8 million barrels per day of Oil Demand** in 2023
- **80% of EVs are in China and Europe -** 22 million in China 12 million in Europe
- Largest markets for **2/3-Wheeler EVs are China, India and Southeast Asia**
- Global lithium-ion battery manufacturing capacity has increased **31% since 2022**, from 1.7 TWh to 2.2 TWh

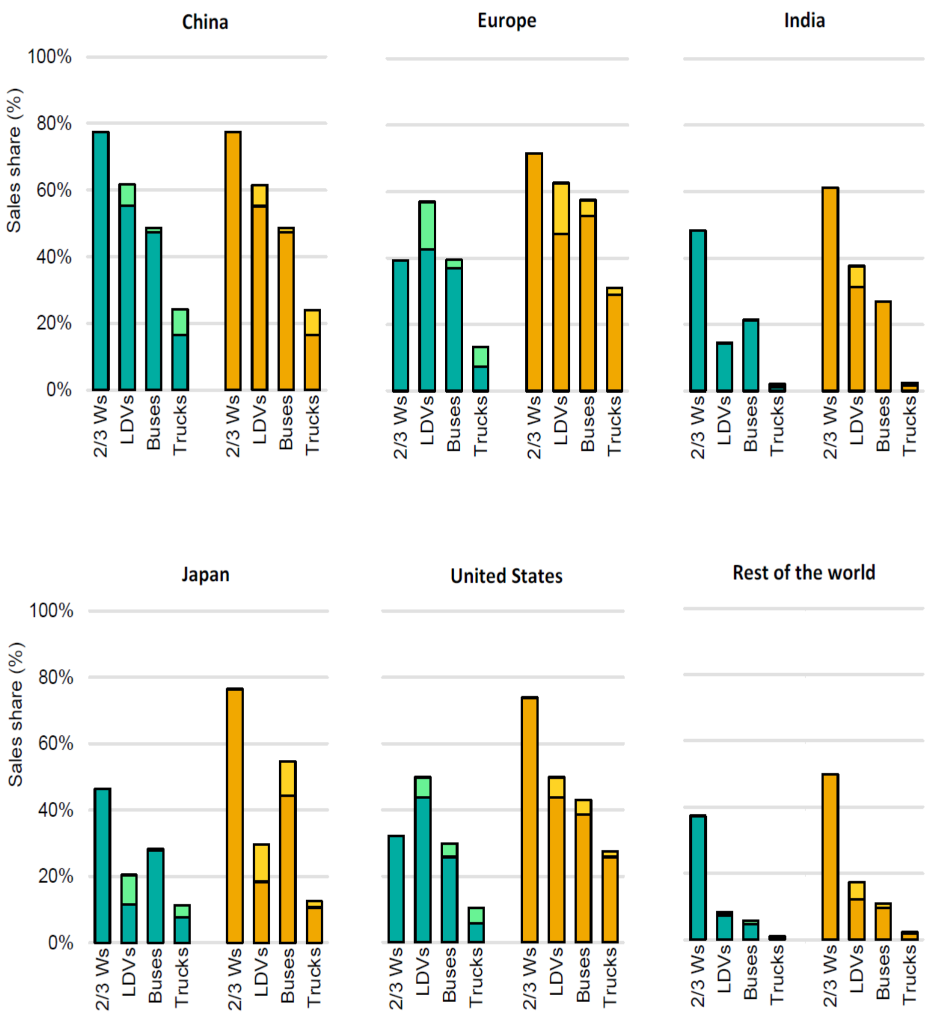
Global Passenger EV Fleet



Source: BNEF

Growth of Global EV Fleet (2/2)

- Annual sales of Light Duty EVs projected to reach >**20 million** in 2025 and 40 million in 2030
- Electric bus fleet reaches **1.4 million** in 2025 and **2.7 million** in 2030
- Electric trucks stock **3.5 million** by 2030
- Electric 2/3-wheelers > **220 million** in 2030
- Stock of home chargers > **135 million** in 2030
- By 2030, the total installed charger capacity >**1.9 TW**
- In Europe, the stock of public chargers >**2.4 million** in 2030
- UK has announced a target of **300,000** public chargers by 2030 and a minimum of **6,000** fast chargers by 2035
- Japan's target is **150,000** charging points by 2030, including **30,000** fast chargers
- In India, public electric charging points > 550,000 in 2030



Source: IEA Global EV Outlook 2023

EV Scenario in Africa

- EVs are gaining popularity in Africa – key drivers being rising fuel prices, increasing awareness about increasing air pollution and sustainability, and government policies on clean energy
- Several African countries have set ambitious targets for EV adoption – Kenya: 5 million EVs by 2030; Rwanda: 100% EV sales by 2030; South Africa: 1.4 million EV manufacturing capacity per year by 2035
- Main challenges: limited charging infrastructure, high upfront costs of EVs, and a lack of awareness about the benefits of electric mobility
- Key Market Players: Nissan, Volkswagen, Tesla, Geely Auto, BMW etc
- In 2022, Agilitee Africa, the South Africa based EV producer released its first self-charging four-wheeler electric vehicle, the Agility-Go with a range of 300km
- UNEP is currently working on introduction of electric 2/3-Wheelers in Ethiopia, Togo, Kenya, Rwanda, Uganda, Burundi, Madagascar, Sierra Leone, and Tanzania
- Electric Light Duty Vehicles program by UNEP/UNIDO in Ghana, Mauritius, Mozambique, Tunisia, Cote d'Ivoire, and Zambia
- Zero and low-emissions buses programs by UNEP in Cote d'Ivoire, Senegal, Seychelles, South Africa, and Tanzania
- African countries should focus on Electric 2/3-Wheelers and Electric Buses – that can improve air quality in cities, and create new economic opportunities
- Many lessons to learn from India on low-cost transformation to electric mobility

EVs and EV Charging Infrastructure – Fundamentals

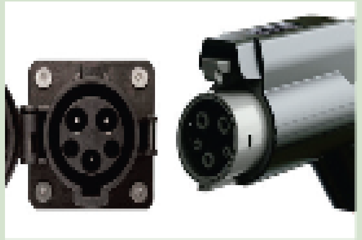
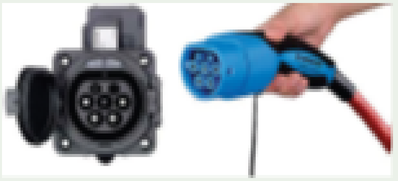
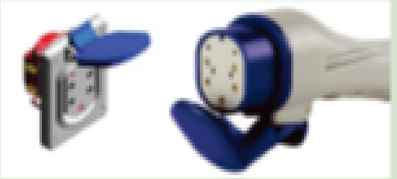
- **Evolution of Electric Vehicles (EV)**
  - Electric Vehicles with Lead Acid Batteries – early 1900s
  - Hybrid Electric Vehicles – Toyota Prius (since 1997) and Honda Insight
  - Plug-in Hybrid Electric Vehicles (PHEV) – since early 2000s
  - Electric Vehicles with Lithium Ion Batteries (LiB) – Tesla Roadster in 2008, Model S in 2012; and Nissan LEAF in 2010
- All EVs have electric motor as the prime-mover which is powered by electricity stored in the rechargeable batteries
- **Rechargable Batteries require DC power which is supplied through**
  - AC power from the grid which is converted to DC by an AC-DC convertor (On Board) in the EV
  - DC charger connected to the grid which converts AC to DC and supplies DC directly to the EV battery
- **Charging Speed of an EV battery depends on**
  - Battery chemistry – all types of batteries can not be fast charged
  - DC power output of the on-board AC-DC Converter in case of AC charging
  - DC power output of the DC Charger in case of DC charging
  - Ambient temperature

EVs and EV Charging Fundamentals

EV Charging Fundamentals

- EV charger is called **Electric Vehicle Supply Equipment (EVSE)**
- Most EVs have On Board AC-DC converter to convert AC supply from the grid to DC to charge the Battery
- Typical On-Board AC-DC converters are small capacity (1kW to 7kW) to keep the size small and cost low
- DC Chargers can supply DC power directly to the EV batteries (bypass the On Board AC-DC converters)
- There are different Charging Standards:
    - CHAdeMO (Japanese Standards for DC Charging; used across the globe)
    - GB/T (Chinese Standards)
    - Combined Charging System (CCS) – the European or IEC Standards
    - Tesla Super Charger (proprietary)
    - North American Charging Standards (NACS) – see notes below

Types of EVSE – AC Chargers

Chargers Types & Sockets	Picture	Origin and Popular EV Models	Maximum Power Output & Communication Protocols
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)

Types of EVSE – DC Chargers

Chargers Types & Sockets	Picture	Origin and Popular EV Models	Maximum Power Output & Communication Protocols
CHAdeMO		Origin from Japan; Most popular DC charger in the world; used in Japan, Korea and parts of USA and Europe; Nissan Leaf, Mitsubhi, 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

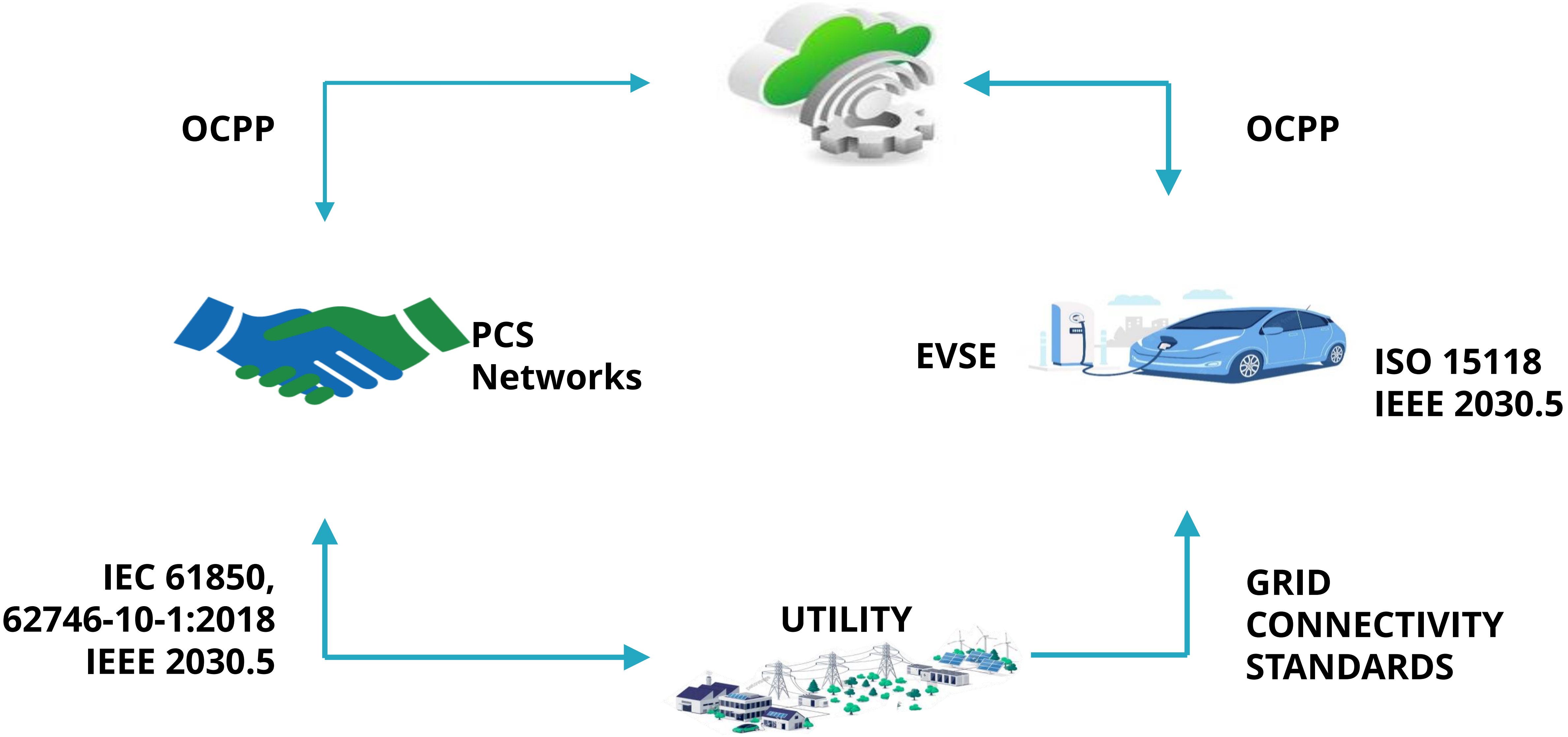
Types of EVSE – Combined (AC and DC) Chargers

Chargers Types & Sockets	Picture	Origin and Popular EV Models	Maximum Power Output & Communication Protocols
SAE Combined Charging System (CCS)		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.

Battery Chemistries and Charging Speed

- Charging Rate (C-Rate) of the batteries depends on the battery chemistry and ambient temperature
  - 1 C: Battery can be fully charged in 1 Hour (LFP, NMC, LTO)
  - 2C: Battery can be charged in 30 Minutes (NMC, LTO)
  - 4C: Battery can be charged in 15 Minutes (presently only LTO)
  - 10C: Battery can be charged in 6 minutes (LTO)
- Old models of EVs have 0.3C (3 hours to charge) or 0.5 C (2 hours to charge) batteries
- All new EV models have 1C or 2C batteries now
- By 2027, most EVs may have 4C batteries
- <u>To charge a 50kWh battery at 4C rate, 200kW charger is required</u>

EVSE Communication Protocols



Electric Vehicles – Impact on the Grid

EV Load Impacts on Electricity Generation Adequacy

- In most countries, new power plants may not be required to meet the energy needs for EV charging, provided EVs are not charged during peak hours
- With regulated or smart charging (V1G), load on the grid can be managed with in limits or shifted to off-peak hours
- Since EV buying behaviour is influenced by friends and neighbours, EV offtake tend to create **pockets of EV concentration** - when all EV owners in a locality charge their EVs at the same time, the grid equipment gets overloaded
- Battery sizes vary from 13kWh (for entry level electric cars) to 30 kWh (for mid-size cars), 40-50 kWh for Nissan Leaf, Chevy Bolt etc; and 65-90 kWh for Tesla
- When a middle-class home with an electricity connection of 5-10 kW buys an electric car and installs a 7.2 kW charger, the load of the house doubles!
- In most cases, higher capacity distribution transformers and bigger size cables may be required for installing DC fast chargers and very high capacity chargers for buses (MW-scale chargers)
- The distribution grid upgrades cost to accommodate EV charging stations could be several times more than the cost of the EV charging stations

Impact of EVs on the Distribution Feeders

- EVs are usually plugged on to the low voltage distribution grid for charging
- In most developing countries, distribution grid is always overloaded – particularly during peak hours

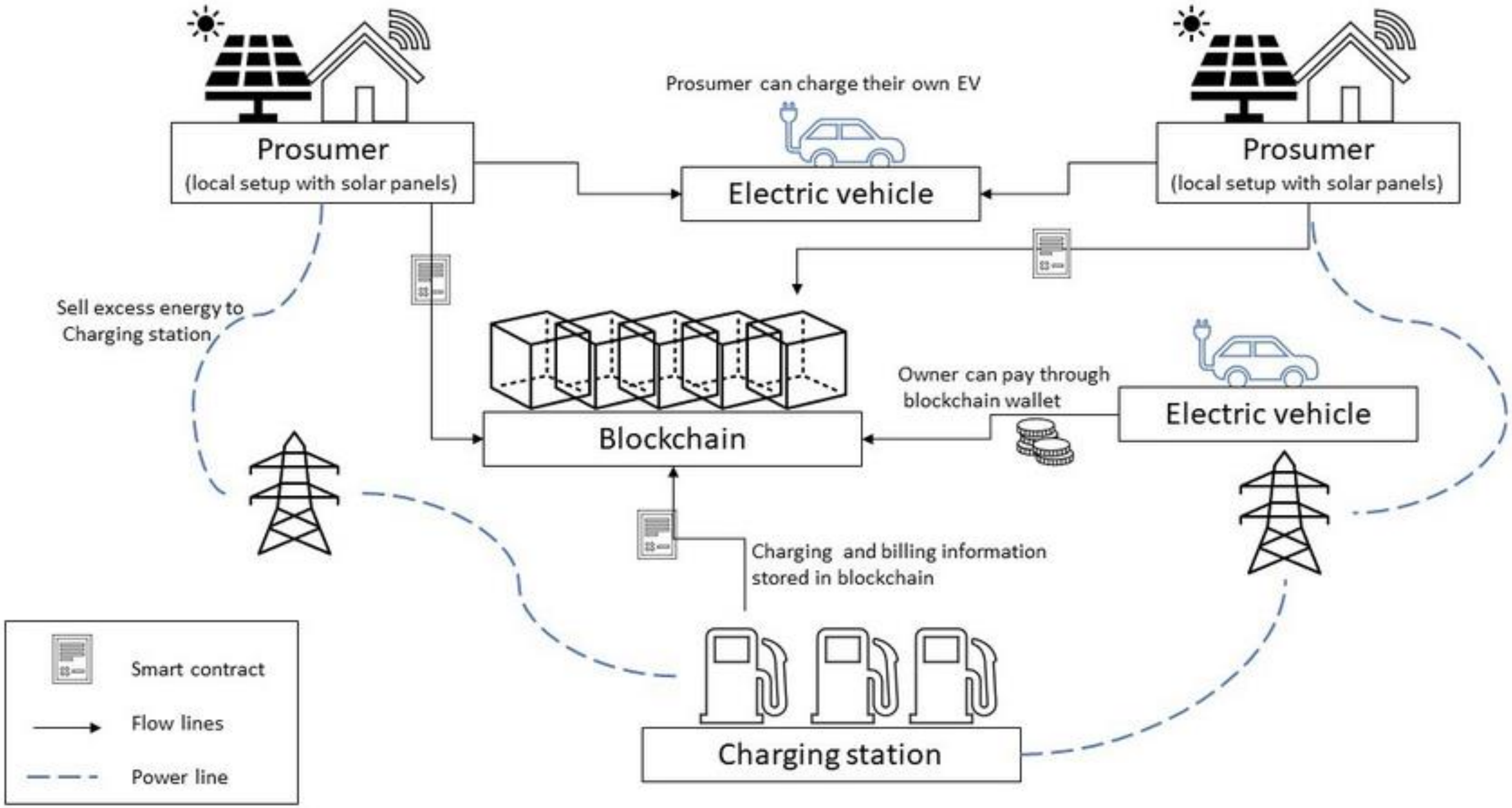
EV Load Impacts on Distribution Grid Equipment

- Large-scale EV deployment in particular locations could overload distribution transformers (DTs), reduce the life of the DTs and increase system (T&D) losses
- The increased demand due to EVs could cause voltage drops
- Rooftop PV systems connected to the feeders with EVSEs could compliment each other

EV Load Impact on Power Quality

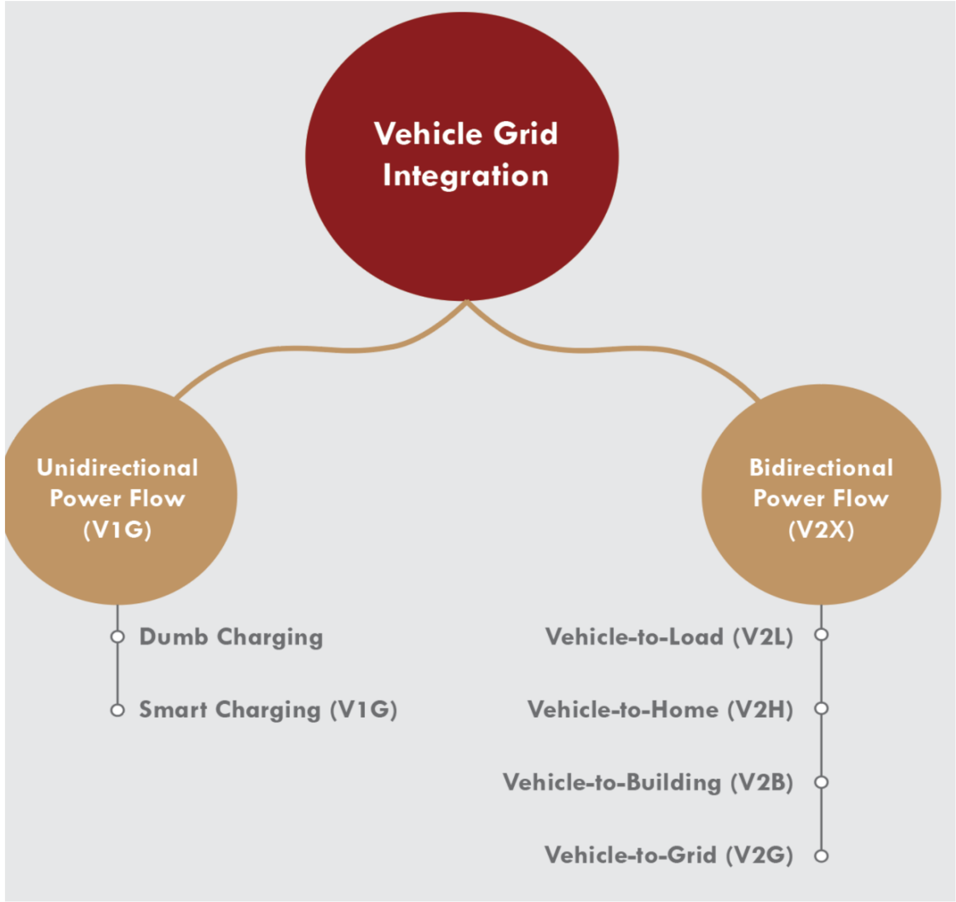
- AC is converted to DC while EV charging which sends harmonics (current and voltage harmonics) back to the grid
- Harmonics cause power quality problems on the grid – over heat cables and other grid equipment
- Installation of EVSEs require proper planning with data on the loading of the distribution grid equipment; and modelling studies to determine the level of harmonics and plan mitigation measures

EV Charging with Green Electricity



Vehicle Grid Integration – Evolving Era in Electric Mobility

- Vehicle-Grid-Integration (VGI) technologies have been successfully tested in several research labs and universities and are commercially deployed in few places
- Traditionally EV OEMs were apprehensive of the effect of VGI methodologies on battery life and battery warranties - the warranty of a battery is based on the number of charge-discharge cycles
- VGI can provide a variety of benefits to EV owners, electricity customers and the grid:
  - Brings down total cost of ownership (TCO) of EVs
  - Mitigate the variability/intermittency of renewable energy (RE) resources (rooftop solar)
  - Large number of EVs connected to the grid can be leveraged as Virtual Power Plants (VPP)
  - Surplus power on the grid at certain periods can be stored in EV batteries – reduce curtailment of RE generation



V2x Systems

V2H Architecture

V2L Architecture

V2B Architecture

V2V Architecture

Bus Fleet Electrification

- Electrification of Public Transportation, particularly of bus fleet - should be the prime objective of electric mobility plans in every country/city
- It brings the highest benefits - emissions from a bus is equivalent to a dozen cars; and it could take thousands of cars off the road if implemented meticulously – compounded emission reduction potential is huge!
- Electric buses are airconditioned and offers fatigue-less travel experience (no emissions, no noise, no vibrations) which motivates people to opt for buses rather than driving their own cars – in Shenzhen City where all buses (16,500+) were made electric in 2016, in the first year itself >30,000 private car owners started taking electric buses to work every day!
- Bus fleet electrification require close coordination between the electric utility, bus operator and the municipal authorities – most bus depots would require MW-scale power connections which may be a major challenge particularly in congested cities
- For oil importing countries, electrification of public transportation could bring added economic benefits

Electric Bus Revolution in the Shenzhen City (1/2)

- Shenzhen is the only city in the world where all the public buses are electric **- Shenzhen had 16,500+ electric buses in operation in 2016**
- Public transportation in Shenzhen is very well planned and efficient
- Before introduction of Electric Buses, the public bus service was run by Shenzhen City Government owned Shenzhen Bus Group and several private operators
- In 2007, Shenzhen City Government decided to move from diesel buses to electric buses and electric taxis
- The first step was to aggregate bus operations in 3 companies
    - **Shenzhen Eastern Bus Company Ltd (SEBC-5805 buses)**
    - **Shenzhen Bus Group (5600 buses)**
    - **Shenzhen Western Bus Company Ltd (4400+ buses)**

Electric Bus Revolution in the Shenzhen City (2/2)

- Electric buses are mostly 10.5 meter in length, seating capacity of 32 plus with 20-30 passengers standing – at times in some routes there may be 80+ people on-board
- All buses have similar specifications and bought from same manufacturer
- Buses have LFP battery of 252 kWh with minimum 200 km driving range per full charge and are charged with OEM supplied 80kW (3 Phase, 415 Volt) AC chargers installed in the bus depots
- **SEBC has 86 Depots and 2200 chargers for 5805 buses**
- Bus charging in the depots are under industrial tariff - during the 8 hours of off-peak tariff (11pm to 07 am), all buses are fully charged
- In the first year itself >30,000 private car owners decided to take electric buses rather than driving own cars to work!

Electricity Tariff for Bus Charging

Tariff Category	Tariff (RMB)	Time Period
Normal Tariff	0.7234/kWh	7 AM – 9 AM; 11:30 AM – 2 PM; 4:30 PM – 7 PM ; 9 PM – 11 PM
Peak Tariff	1.0759/kWh	9 AM – 11:30 AM; 2 PM – 4:30 PM; 7 PM – 9 PM
Off-Peak Tariff	0.2794/kWh	11 PM – 7 AM

1 RMB = INR 11.78

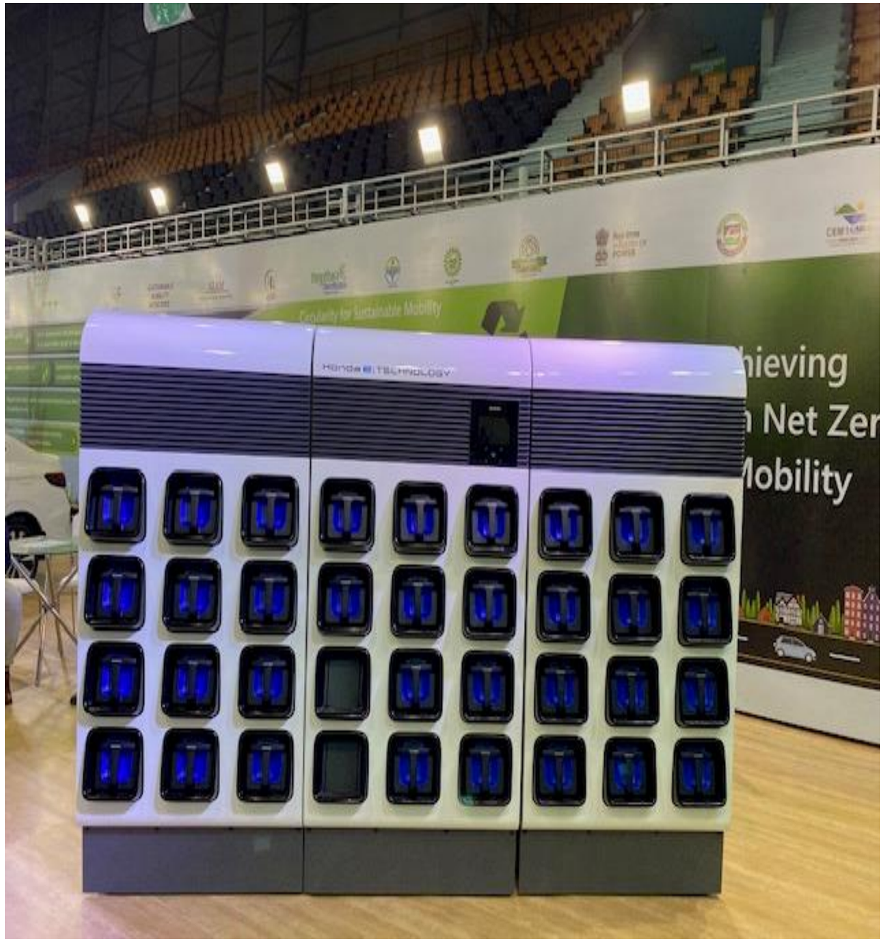
Battery Swapping

- Battery swapping is gaining momentum – particularly for 2/3-Wheelers
- Presently there are over a dozen companies in the Indian market, including Gogoro from Taiwan
- Gogoro network has more than **12,000 battery swapping stations to support over 500,000 electric 2-wheelers** across nine countries
- Gogoro plan to expand their fleet in India to **200,000 electric 2-wheelers across 30 Indian cities by 2025** with an outlay of USD 25 million
- Sun Mobility has over **210 swapping stations across the India** for electric 2 and 3-wheelers
- In 2022, more than **12,000** battery swapping-enabled electric trucks were sold in China
- NIO, which produces battery swapping-enabled cars and runs more than 1,300 battery swapping stations in China
- NIO has set a target of **4,000 battery swap stations globally by 2025** and each swap station can perform over 300 swaps per day, charging up to 13 batteries concurrently at a power of 20-80 kW
- Battery Swapping Stations can provide Grid Services like V2G
- **An electric 2/3-wheeler without battery cost half of regular ones with batteries**

This is a very important domain for AFRICA to focus as 2/3-Wheelers without batteries will cost only half of regular electric 2/3-Wheelers – entry cost to e-mobility can be halved!

Battery Swapping Stations in India

Swapping Stations of Exicom, Sun Mobility and Honda Technology



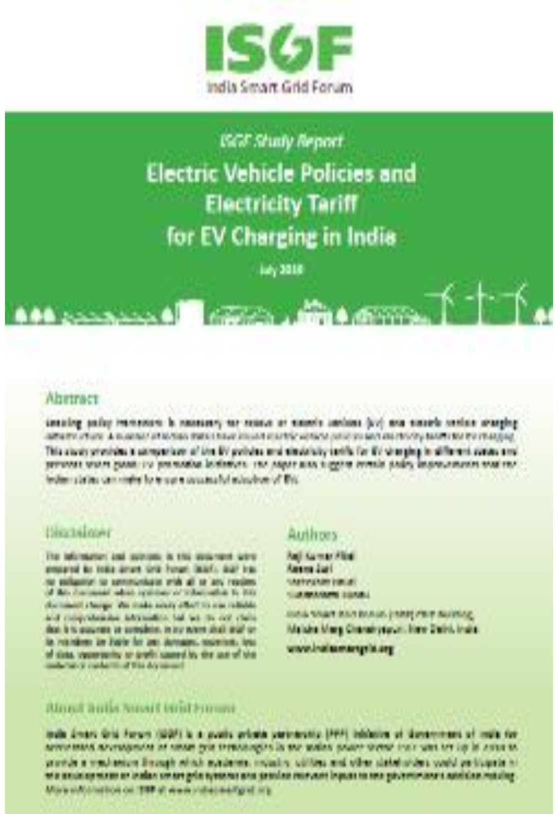
Battery Swapping Stations in India

Robotic Swapping Station for Electric Buses in Ahmedabad, India

Sun Mobility in collaboration with Ashok Leyland developed a robotic-assisted battery swapping system and deployed it successfully for a fleet of 40 electric buses in Ahmedabad in 2018
Buses have 37.5kWh batteries which can be swapped in 3 minutes

https://www.youtube.com/watch?v=XLSyJg0cQ7Q

ISGF's Popular White Papers on Electric Mobility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ISGF Study Report
Electric Vehicle Policies and Electricity Tariff for EV Charging in India
Abstract
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ISGF White Paper on Electric Vehicle Policies and Electricity Tariff for EV Charging in India
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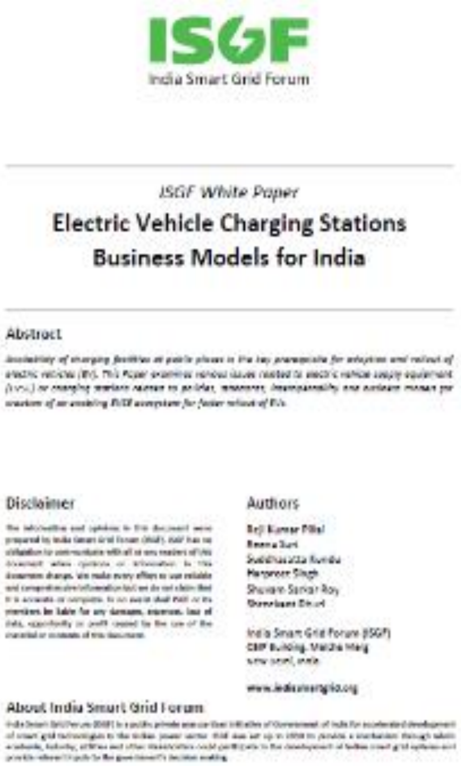
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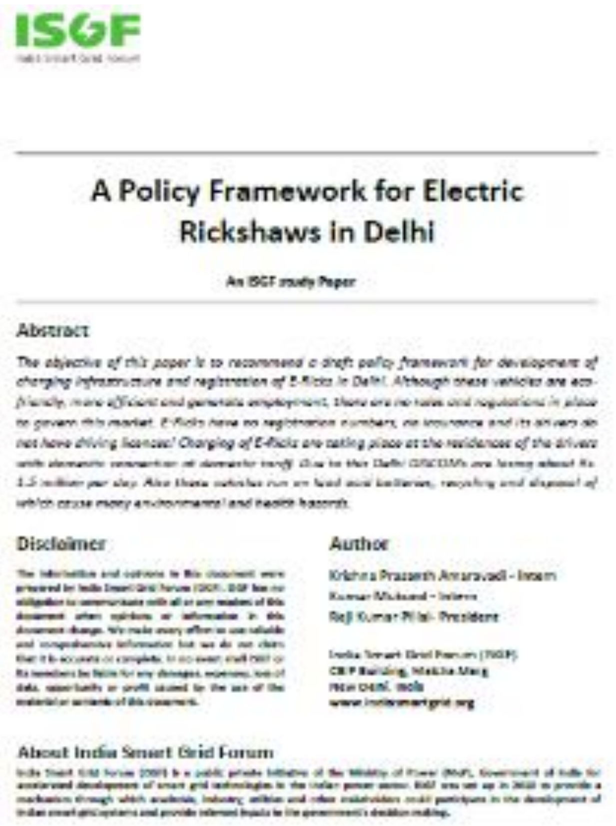

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A Policy Framework for Electric Rickshaws in Delhi

An ISGF study Paper

Abstract

The objective of this paper is to recommend a draft policy framework for development of charging infrastructure and registration of E-Ricks in Delhi. Although these vehicles are eco-friendly, more efficient and generate employment, there are no rules and regulations in place to govern this market. E-Ricks have no registration numbers, no insurance and its drivers do not have driving licenses! Charging of E-Ricks are taking place at the residences of the drivers with domestic connection at domestic tariff. [illegible] 1.5 million per day. Also these vehicles run on lead acid batteries, recycling and disposal of which cause many environmental and health hazards.

Disclaimer

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About India Smart Grid Forum

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ISGF White Paper on A Policy Framework for Electric Rickshaws in Delhi
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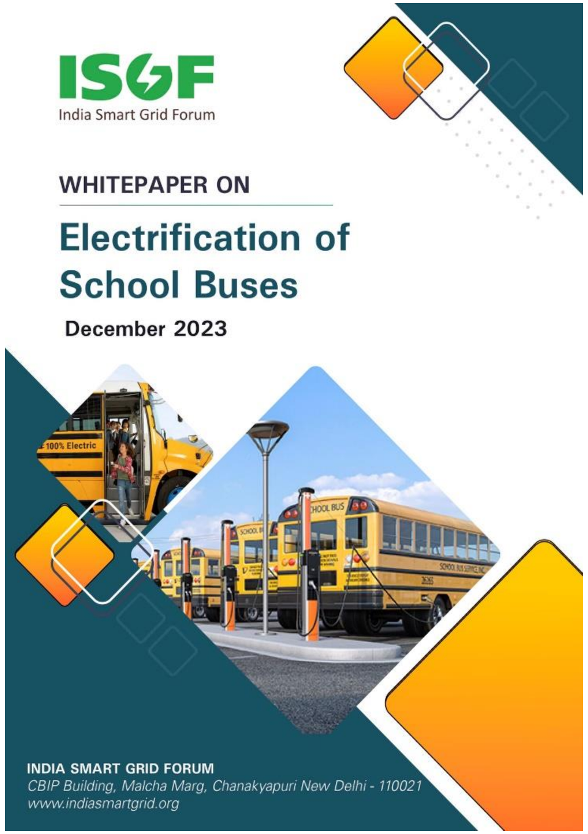

ISGF White Paper on Electrification of School Buses
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ISGF's Training Programs on Electric Mobility

Sl No	Training Program	Duration	Next Edition
1	Physical Training Program	2 (Two Days)	July 2023
2	Online Training Program	1 (28 Hours)	ONLINE since 2021

Thank You

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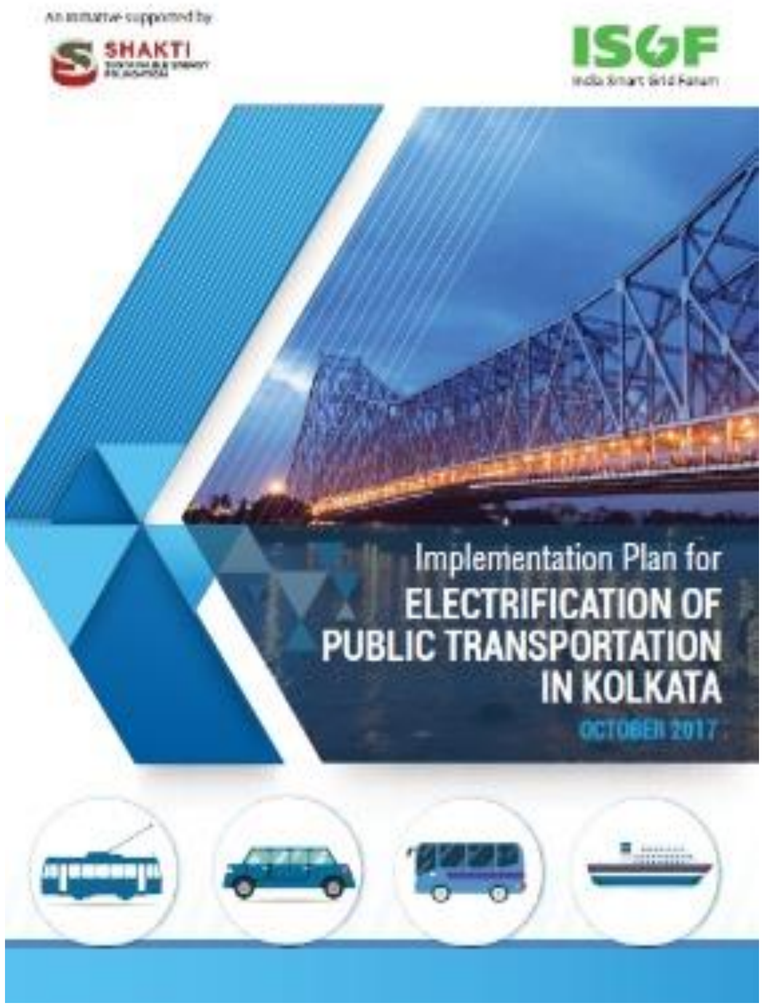
Initiatives for Promoting Electric Mobility in India

- Key inputs to the state specific EV Policies in several states in India – Karnataka, Kerala etc.
- Based on ISGF recommendations, Ministry of Power has allowed **sale of electricity as 'service' for charging of electric vehicles** in 2018 (*before this sale of electricity required licenses as per Electricity Act*)
- ISGF Reports and Recommendations led to following important policy interventions by GoI:
  - ***Separate (concessional) Electricity Tariff for EV charging (24 states + 1 Union Territory) –*** *ISGF presentation to Forum of Regulators (FOR) in December 2016*
  - ***Green Number Plates for EVs*** *– ISGF reports in 2014, 2017 and 2018*
  - ***"Right Sizing" of Batteries in Electric Buses (brought down the prices of electric buses by 65%) -*** *ISGF Study Report on Electrification of Public Transportation in Kolkata (2017)*
  - ***20% parking space in new buildings to be built with EV charging points*** *– proposed in ISGF White Paper in 2019*
  - ***Sale of 3-Wheelers and 2-Wheelers without batteries – charged batteries can be rented from battery leasing agencies or battery swapping stations (new business models) –*** *proposed in ISGF Study Report in 2017*

Implementation Plan for Electrification of Public Transportation in Kolkata

- Analyzed the 925 bus routes in Kolkata and prioritized the routes for introduction of Electric Buses; and selected the most congested ten routes for pilot rollout
- Evaluated the battery size options for the buses and conducted cost-benefit analysis (CBA) for electric buses with 100 kWh, 200 kWh and 300 kWh batteries
- CBA proved that electric buses with 100 kWh and 200 kWh batteries do not require viability-gap-funding (VGF) – this study was ground breaking and proposed that State Transport Undertakings (STU) should buy electric buses with "right size' of the batteries for the electric buses according to the route lengths instead of what the electric bus OEMs are offering
- Conducted feasibility studies for electrification of Taxi Fleets, 3-Wheelers and Ferries in Kolkata
- Studied the trams operations and suggested to introduce dedicated Goods Trams between Sealdah and Howrah stations to transport goods to different points in the city that will de-congest the city roads by avoiding hundreds of mini-trucks that are currently used for transporting goods coming from country-side to these two railway stations
- This study was supported by Shakti Sustainable Energy Foundation (SSEF)



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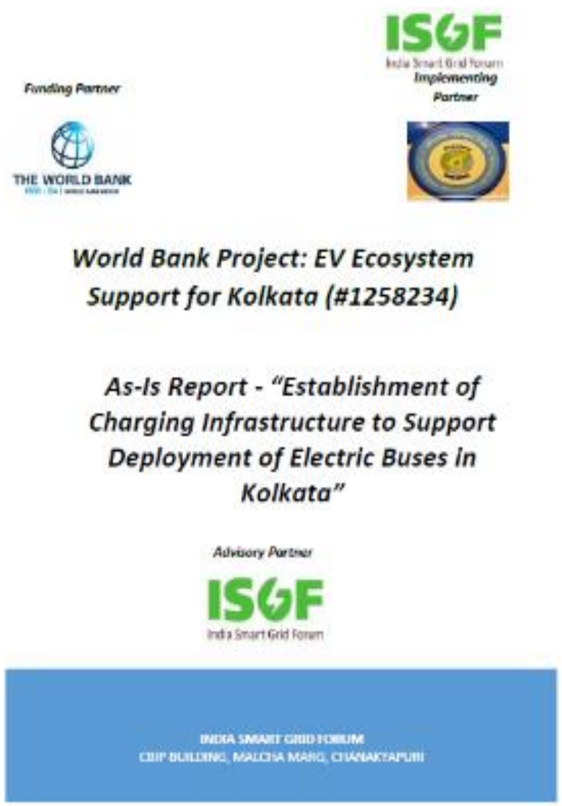
Support to WBTC for Rollout of 80 Electric Buses in Kolkata in 2019

- West Bengal Transport Corporation (WBTC) procured 80 electric buses and 80 charging stations under FAME-I scheme which were installed at 10 bus depots (overnight charging) and 8 bus termini (opportunity charging) in Kolkata City
- ISGF prepared the RFP for 9M buses with 120 kWh batteries and 12M buses with 180 kWh batteries – the prices came down to INR 8.8 million and 11.5 million respectively
- Route selection and identification of bus depots and bus termini for installation of charging stations were done by WBTC
- ISGF conducted assessment of civil and electrical infrastructure in the bus depots and termini for installation of charging stations; and estimation of additional electrical load and equipment upgradations
- ISGF prepared the equipment calculations and drawings for installation of chargers in 10 depots and 8 termini
- ISGF managed the laisoning with the Utilities (CESC and WBSEDCL) for load enhancement; and supervision for installation of the chargers
- ISGF developed the framework for capturing bus and battery performance
- Project was supported by World Bank


Funding Partner

ISGF
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Implementing Partner

THE WORLD BANK

World Bank Project: EV Ecosystem Support for Kolkata (#1258234)

As-Is Report - "Establishment of Charging Infrastructure to Support Deployment of Electric Buses in Kolkata"

Advisory Partner

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Study on Infrastructure and Enabling Environment for Road Electric Transport in SAARC Member States

- South Asian Association for Regional Cooperation (SAARC) Energy Centre awarded the project **“Study on Infrastructure and Enabling Environment for Road Elect in SAARC Member States”** to India Smart Grid Forum in 2018.

Project Purpose	Readiness assessment for transition to electric mobility and subsequent formulation of EV implementation plan for the SAARC member nations			
Key Focus Areas	Global EV Scenario	EV infrastructure & policy requirement	Global best practices for EV adoption	Readiness assessment for SAARC countries
Key Interventions	Policy & regulatory	Business model & tariff design	Electric grid upgradation	Institutional development
Outcome	Creation of enabling environment for EV adoption in each SAARC member nation.			

https://bitly.ws/38vp6

- ISGF assessed the readiness of each of the SAARC member states using ISGF’s Electric Vehicle Maturity Model (EVMM) Framework for EV adoption in terms of policy, infrastructure, technology, institutional arrangements, electric grid readiness, customer willingness etc and provided recommendations on various action points for phase-wise transition to e-Mobility
- Project was supported by SAARC Energy Center

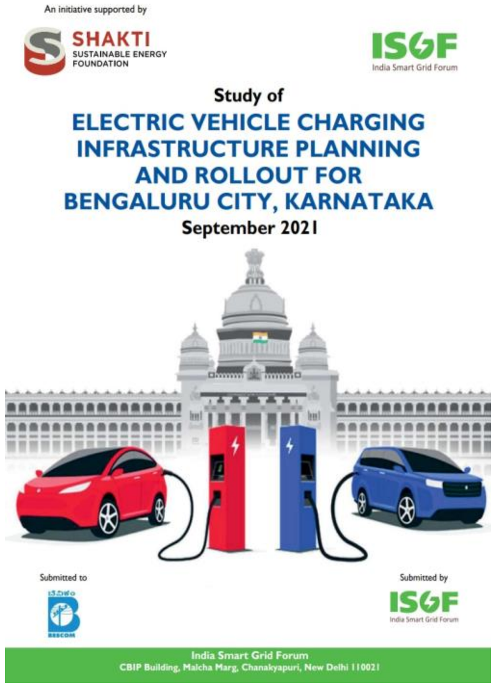
Feasibility Study on Introducing Electric Vehicles in Island Parts of Indian Sundarbans

Sundarbans islands, a global eco region, uses diesel/ kerosene oil driven engine vans and ferries for local commute. This study covered:

- Assessment of technical and commercial feasibility of replacing engine vans with battery based e-rickshaws on eight routes (mainly forest fringe parts of Sundarbans)
- Assessment of electric vehicle policy and technology landscape to identify the key requirements for introducing e-rickshaws in Sundarbans
- Consultations with all relevant stakeholders
- Assessment of the electrical infrastructure in the selected routes for charging stations
- Assessment of cost of operation and payback period for e-rickshaws (both lead acid and lithium-ion battery variants) as compared to engine vans
- Evaluation of existing financing options like Grameen Bank, Self Help Group etc. and recommendations on various business models and financing options to accelerate deployment of e-rickshaws
- Defined the role of various institutions like Gram Panchayat, Zilla Parishad etc. to facilitate deployment of e-rickshaws
- Project was supported by World Wide Fund for Nature (WWF), India

Study for Electric Vehicle Charging Infrastructure Planning and Rollout for Bangalore City, Karnataka

- ISGF undertook detailed planning studies to understand the impact of EV charging load on low voltage and medium voltage grid
- Modelled 12 number of 11kV Feeders on which EVSE are connected in Bengaluru City; and conducted load flow studies for different scenarios of EV charging load and Solar Rooftop PV (SRTPV) in 2020, 2022 and 2025
- The feeders in the 2020 scenario was found overloaded and struggling with multiple under voltage sections
- For EVSE integration on the Ittamandu feeder, DT augmentation (from 63 kVA to 100 kVA) and installation of double-tuned harmonic filters; and augmentation and cable were recommended for a planned loading of 80%
- The study found that SRTPV generation helped reduce the voltage drop, especially when connected to the tail end of feeders
- The highest current harmonics were observed majorly at odd frequencies - 3rd, 5th, 7th and 11th orders
- Total Demand Distortion (TDD) was found as high as 22% for cables connecting to EVSE at the LT side of DT, which was beyond the acceptable limit as per IEEE- 519, whereas it was around 6% at the HT side, which is within the acceptable limits
- Project was supported by Shakti Sustainable Energy Foundation (SSEF)



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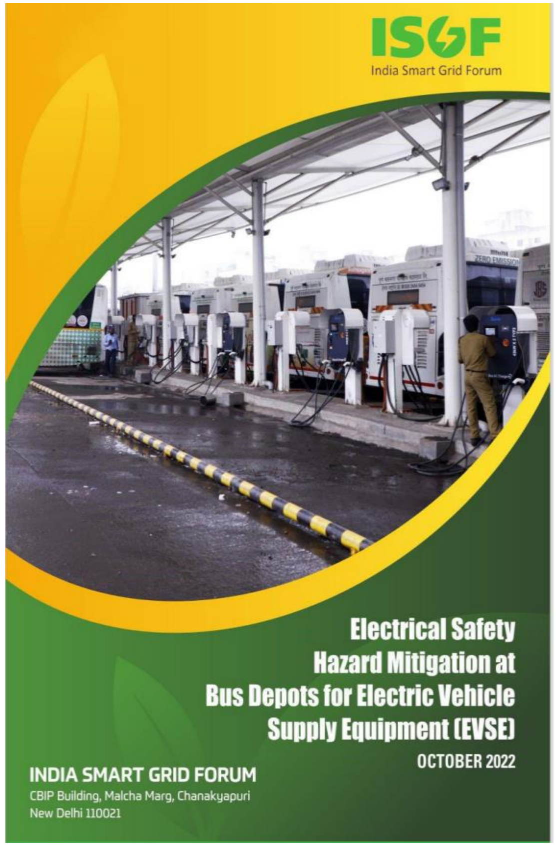
Electrical Safety Hazard Mitigation at Bus Depots for Electric Vehicle Supply Equipment (EVSE)

- ISGF conducted the study of Electrical Safety Hazard Mitigation at Bus Depots for Electric Vehicle Supply Equipment (EVSE) at bus depots in Bhekrainagar, Pune and Lake Depot, Kolkata
- Installed Class-A power quality meters (PQM) in bus depots at Bhekrainagar, Pune and Lake depot, Kolkata which could measure up to 100th harmonics; and the PQM readings were collected in a server in ISGF office in Delhi from September 2021 to August 2022
- Analyzed the PQM readings to assess the impact of bus charging on the electric grid; as well as voltage sags and other power quality issues on the grid and its impact on the bus charging operations
- Modelled the electrical network in the two bus depots and conducted load-flow studies for various scenarios of charging load in 2022, 2024 and 2027
- Analyzed the need of active or passive harmonic filters and other mitigation measures
- Standard Operating Procedure (SOP) for EVSE installation and commissioning, operation and maintenance; and recommendations for electric utilities and bus operators
- In Pune during the study period of one year, 65 voltage sags measured were below 60% of the rated voltage which is harmful to all electronic and semiconductor devices – the studies indicate that these voltage sags emanated from the transmission grid which needs to be mitigated
- In Kolkata, during the study period, several Rapid Voltage Change (RVC) were observed and all of them were outside the limits prescribed by EN50160 standards. The RVCs observed have higher severity level and have the potential to damage electronic and semiconductor devices
- Project was supported by New Venture Fund (NVF)



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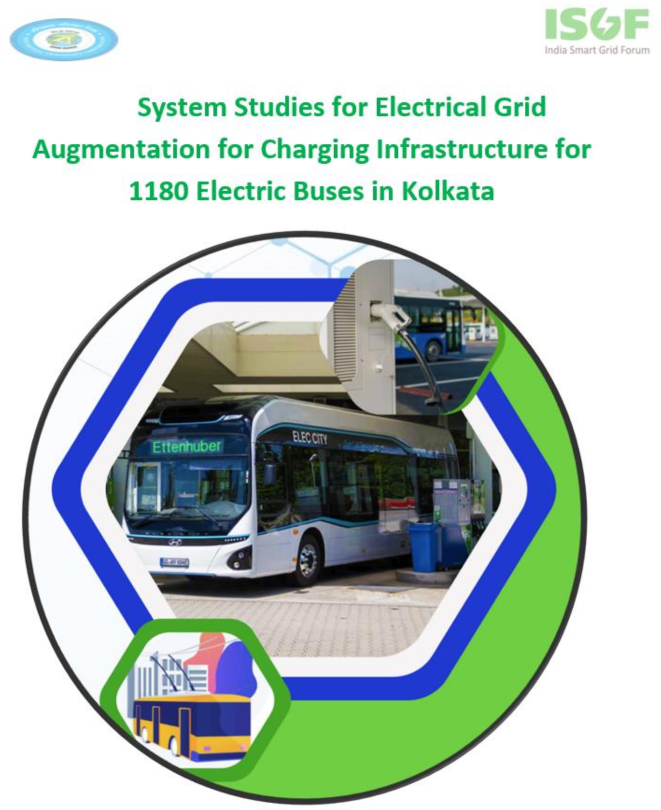
System Studies for Electric Grid Augmentation for Charging Infrastructure for 1180 Electric Buses in Kolkata

- Under FAME II, WBTC has contracted 1180 electric buses which will be housed in 14 bus depots in Kolkata. Each of these depots require new power connections of 4-6 MW capacity and ISGF conducted a detailed planning studies that covered:
  - *Sampling of bus depots based on fleet deployment plan of WBTC*
  - *Adequacy assessment of electrical infrastructure in source substations (220/132kV/33kV/11kV) for power supply to the bus depots including alternate sources of feed, reliability, and availability analysis of incoming sources*
  - *Nearest feeding substations and the route for power cabling that has minimum capex for each of the 14 depots*
  - *Detailed modelling and load-flow studies in 8 bus depots*
  - *Arrangements for power supply at the depots for secure operations including requirements of switchgear, reactive power compensation and power factor improvements*
  - *Power distribution arrangements inside the bus depots including estimation of bill of quantities (BOQ) and cost*
- Project completed in July 2023; Project partners were Larsen & Toubro Limited and Siemens



Pilot Demonstration of Electrification of Goods Transport in Industrial Corridors in North India

- ISGF is carried out a Feasibility Analysis and Pilot Demonstration of Electrification of Goods Transport in Industrial Corridors in Northern India in two phases
- Phase-1: conducted route survey of major industrial corridors in Northern India and identified two routes for pilot demonstrations for running electric trucks – (i) Delhi-Chandigarh – Ludhiana; (ii) Delhi – Kanpur
- Phase-2: Running of electric truck(s) on the selected routes in association with a cargo operator
- Conducted consultations with key stakeholders – EV OEMs, Fleet Operators, Logistics Companies; Charge Point Operators (CPO) and Electricity Distribution Companies (DISCOMS) and State Electricity Regulators
- Training of Electric Truck Operators and CPO Operators
- Executed pilot run of 2 electric trucks:
- (i) a retrofit truck with 3 Ton cargo capacity on Delhi- Chandigarh route (250 km) – warehouse to Warehouse distance: 347 km
- (ii) a 25 Ton electric truck on Delhi – Ludhiana route (320 km) – warehouse to Warehouse distance: 415 km
- Made key policy recommendations to create charging infrastructure on Highways to promote movement of cargo by electric trucks
- Project was supported by New Venture Fund (NVF)

Vehicle to Grid (V2G) Demonstration Project (Starting in Feb 2024)

- ISGF has received grant for undertaking a Vehicle-to-Grid (V2G) demonstration project which will commence in February 2024
- ISGF in technical collaboration with University of Delaware, USA will execute this first-of-its kind V2G demonstration in Delhi and Trivandrum, Kerala
- Indian make EVs will be fitted with bi-direction on-board AC-DC converters; and bi-direction AC EVSEs will be deployed to demonstrate V2G functionalities
- Project Partners:
  - V2G Technology: University of Delaware, USA
  - Utilities: BSES Rajadhani Power Limited (BRPL) and Tata Power Delhi Distribution Ltd (TPDDL) in Delhi; and KSEBL in Kerala
  - Observers: Central Electricity Authority (CEA), Delhi Electricity Regulatory Commission (DERC)
- Project Timelines: Feb – October 2024

EVSE Standards in India (1/3)

On the request of ISGF, Bureau of Indian Standards (BIS) constituted a Technical Committee (ETD 51) in 2016 to prepare standards for EVSE

Sl No	IS No	Title
1	IS 17017 (Part 1) : 2018	Electric Vehicle Conductive Charging System Part 1 General Requirements
2	IS 17017 (Part 2/Sec 1) : 2020	Electric Vehicle Conductive Charging System Part 2 Plugs Socket-Outlets Vehicle Connectors and Vehicle Inlets Section 1 General requirements
3	IS 17017 (Part 2/Sec 2) : 2020	Electric Vehicle Conductive Charging System Part 2 Plugs Socket Outlets Vehicle Connectors and Vehicle Inlets Section 2 Dimensional compatibility and interchangeability requirements for a c pin and contact-tube accessories
4	IS 17017 (Part 2/Sec 3) : 2020	Electric Vehicle Conductive Charging System Part 2 Plugs Socket Outlets Vehicle Connectors and Vehicle Inlets Section 3 Dimensional compatibility and interchangeability requirements for d c and a c d c pin and contact-tube vehicle couplers

EVSE Standards in India (2/3)

Sl No	IS No	Title
11	IS 17017 (Part 2/Sec 6) : 2021	Electric Vehicle Conductive Charging System Part 2 Plugs Socket Outlets Vehicle Connectors and Vehicle Inlets Section 6 Dimensional compatibility requirements for DC pin and contact
12	IS 17017 (Part 21/Sec 1) : 2019 IEC 61851-21-1:2017	Electric Vehicle Conductive Charging System Part 21 Electromagnetic Compatibility EMC Requirements Section 1 On-board chargers
13	IS 17017 (Part 21/Sec 2) : 2019 IEC 61851-21-2:2018	Electric Vehicle Conductive Charging System Part 21 Electromagnetic Compatibility EMC Requirements Section 2 Off-board chargers
14	IS 17017 (Part 22/Sec 1) : 2021	Electric Vehicle Conductive Charging Systems Part 22 AC Charging Configurations Section 1 - AC Charge Point for Light Electric Vehicle
15	IS 17017 (Part 23) : 2021	Electric Vehicle Conductive Charging Systems Part 23 dc Electric Vehicle Supply Equipment
16	IS 17017 (Part 24) : 2021	Electric Vehicle Conductive Charging System Part 24 Digital Communication between a DC Electric Vehicle Supply Equipment and an Electric Vehicle for control of DC Charging
17	IS 17017 (Part 25) : 2021	Electric Vehicle Conductive Charging System Part 25 DC EV supply equipment where protection relies on electrical separation
18	IS 17896 (Part 1) : 2022 IEC TS 62840-1:2016	Electric vehicle battery swap system - Part 1 General and Guidance
19	IS 17896 (Part 2) : 2022	Electric vehicle battery swap system - Part 2 Safety requirements

EVSE Standards in India (3/3)

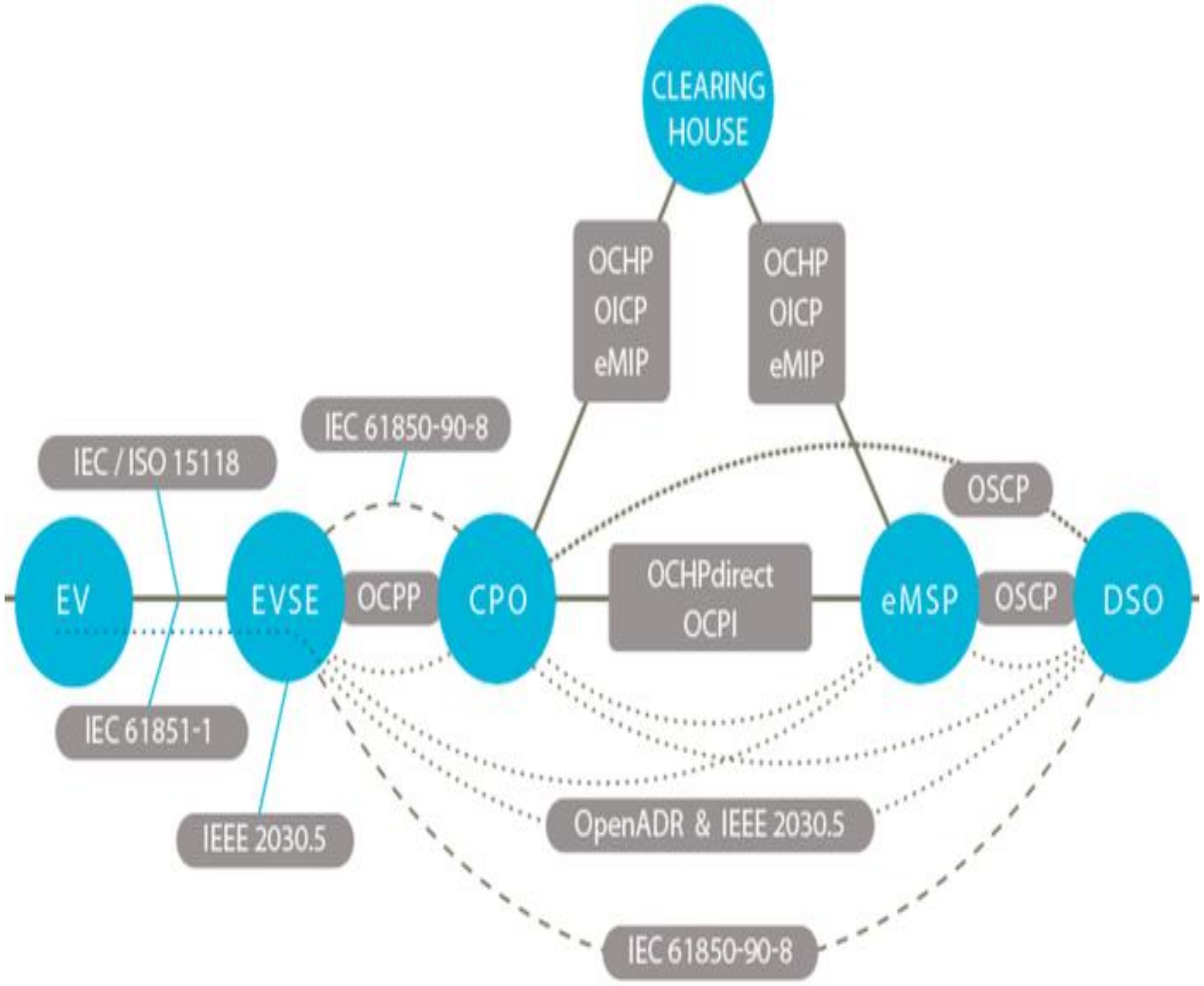
Sl No	IS No	Title
1	IS/ISO 15118-1 : 2013	Road vehicles - Vehicle to grid communication interface Part 1 general information and use - Case definition
2	IS/ISO 15118-2 : 2014	Road vehicles - Vehicle - To - Grid communication interface Part 2 network and application protocol requirements
3	IS/ISO 15118-3 : 2015	Road vehicles - Vehicle to grid communication interface Part 3 physical and data link layer requirements
4	IS/ISO 15118-4 : 2019	Road vehicles - Vehicle to grid communication interface Part 4 network and application protocol conformance test
5	IS/ISO 15118-5 : 2018	Road vehicles - Vehicle to grid communication interface Part 5 physical layer and data link layer conformance test
6	IS/ISO 15118-8 : 2020	Road Vehicles --- Vehicle to Grid Communication Interface Part 8 Physical Layer and Data Link Layer Requirements for Wireless Communication First Revision

All the above ISO 15118 adopted by BIS as IS/ISO in 2019-2020
ISO 15118-20 issued by ISO in 2022 for V2G will be adopted soon

Automakers Electrification Targets

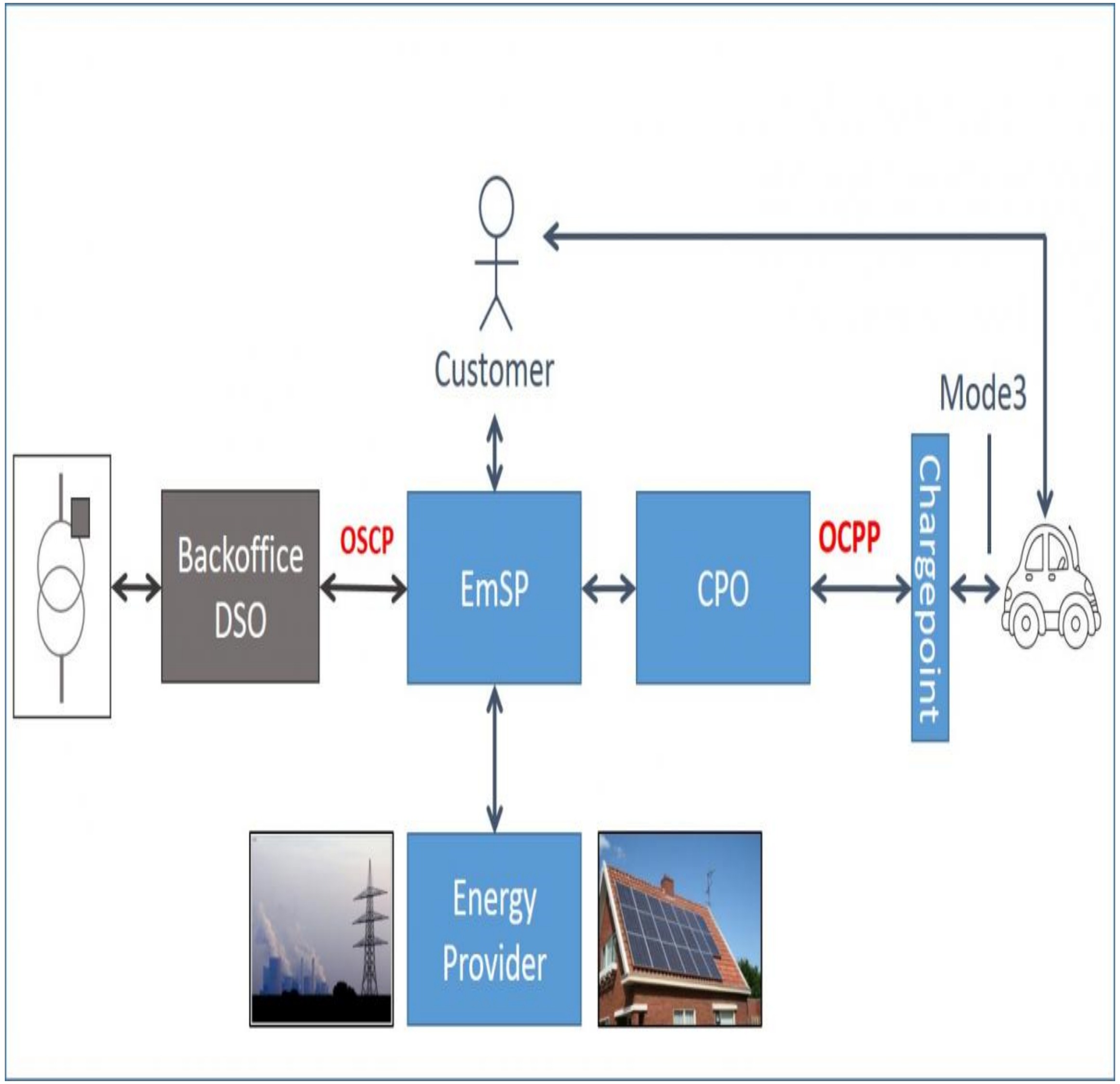
Sl No	Automaker	Target	Region
1	Ford	600,000 BEV sales by 2026	Europe
2	General Motors	400,000 EV sales from 2022-24; 1 million EV production capacity in 2025	North America
3	Volkswagen	Targets fully electric production by 2033 (brought forward by two years)	Europe
4	Toyota	1,500,000 BEV sales; introduce 10 additional models by 2026; committed to a multi-pathway approach to reduce CO_2, including continuing development of FCEVs and PHEVs	Global
5	Mazda	Expects at least 25% of sales globally to be BEV in 2030	Global
6	Honda	Aims to launch 30 EV models globally by 2030, with production of more than 2 million units annually	Global
7	Nissan	Updated global target to 44% EV sales by 2026 and to 55% EV sales by 2030	Global
8	Mitsubishi	Plans for 100% of EV sales by 2035 and 50% EV sales by 2030 in their Environmental Targets 2030	Global
9	Porsche	80% of sales to be electric by 2030	Europe
10	BMW Group	Cumulative sales of over 2 million EVs by the end of 2025; EV sales shares of 30% by 2025, 50% by 2030	Global
11	Mini and Rolls-Royce	Aims to have fully electric line-up by 2030	Global
12	Lancia	All new model launches from 2026 to be electric; to sell 100% EVs by 2028	Global
13	Jaguar	Aims to go all-electric by 2025	Global
14	Land Rover	Aims to go all-electric by 2036	Global
15	BYD	Ceased ICE vehicle production; has produced only EVs since March 2022	Global
16	Geely	600 000 EV sales over this year	Global
17	SAIC-GM-Wuling	Annual sales of 1 million NEVs by 2023 including small EVs; 40% NEVs in total sales by 2025	China
18	BAIC Group	NEVs to make up 1 million of 3 million in total sales in 2025	China
19	FAW Group	Half of its total 1 million sales target by 2025 to be NEVs; 1.5 million vehicles (mostly NEVs) sold by 2030	China

ISO 15118



- Specifies communication between EV and EVSE
- Describes communication between EV Communication Controller (EVCC) and EVSE Communication Controller (SECC)
- Does not specify the vehicle internal communication between battery and charging equipment and the communication of SECC to other equipment
- ISO 15118 – 20 is published by ISO in 2022 – this is for V2G

Open Charge Point Protocol (OCPP)



- Developed by Open Charge Alliance (OCA), Netherlands based association promoted by the Dutch Government
- It is an important component of an EV Charging Network – the Communication Protocol for Charging Station Management Software
- Communication between EV Charging Stations and Charging Station Networks/EV Drivers
- Tells the charging stations to communicate and send data to a particular service provider (EVSP)
- OCPP is being adopted by IEC