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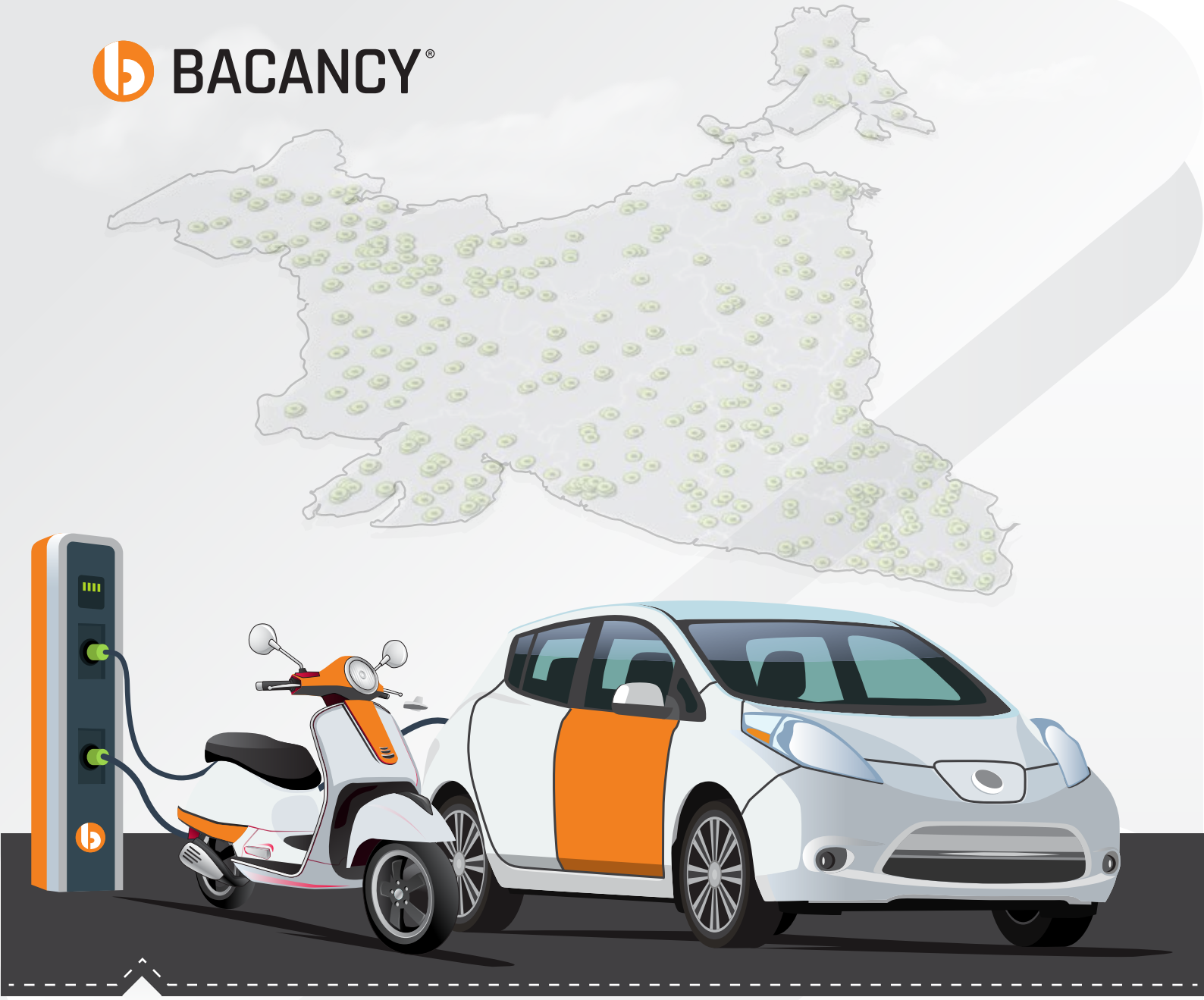

# EV Charging Infrastructure in INDIA- Research Paper

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# 1. Introduction

The rising oil prices and increasing energy demand have added to the high cost and capital consumption, as the dependence on fossil fuels - nonrenewable energy sources has played an unfavorable role in the transport ecosystem for the past years. Considering the environmental impact, the commercial and non-commercial transport sector constitutes a large percentage of CO2 emissions, increasing greenhouse gas (GHG) emissions enormously.

The U.S. Greenhouse Gas Inventory Report 2011 states that 30% of carbon dioxide emissions in the US solely arise from the transportation sector. Similarly, for Canada, the transportation sector depicts 35% of energy demand, with 23% being the second-highest source of GHG emissions.

Fast forward to a decade, the Scripps Institute of Oceanography data at the University of California showed that in the second week of May 2022, Earth had recorded the highest daily average concentration of atmospheric CO2, which accounts for 421.37 parts per million (ppm). The CCPI 2022 indicator for GHG emissions per capita in India has been reported to be at 31.42, with the highest score being 33.93. Henceforth, fulfilling the energy demands for future transportation energy by finding alternative energy sources, preferably renewable ones, has been in rising demand and has gained much attention lately.

Introduced more than a century ago, with a small electric car prototype followed by a fleet electrification model for 60 electric taxis in New York City, the EV technology was already adopted for commuting shorter distances. Although the high cost of acquiring an electric car, added to the lack of proper infrastructure, led to the EVs fading away by the 1930s.

Looking at the current scenario, the motor vehicle IC engine market has been fully optimized and saturated, with few advancements in technology by the auto-maker. With environmental deterioration and energy depletion, the transition to electric mobility is a reassuring yet advanced global strategy for decarbonizing the transport sector. India ranks among a few countries that support the global EV30@30 campaign to have at least 30% of new vehicle sales be electric by 2030.

# 1. Introduction

In 2021, the Ministry of Heavy Industries had sanctioned 2,877 EV charging stations in 68 cities across 25 states/union territories. Additionally, under Phase II of the FAME India Scheme, 1,576 charging stations were sanctioned across nine expressways and 16 highways.
A robust network and accessible network of electric vehicle (EV) charging infrastructure is an essential requirement for accomplishing the enterprising transition.

The GoI (Government of India) has formulated multifarious policies to promote and enable the EV charging infrastructure network development in India. However, the charging infrastructure is quite unexplored yet with unique characteristics. It is, therefore, necessary to customize it as per the distinctive Indian transport ecosystem based on geographical, and climatic conditions and facilitate interoperability amongst stakeholders to sustain its expansion at the grassroots levels

A contingent approach is required to make sure that there is timely and efficient implementation and execution of the EV charging infrastructure. It is crucial to ensure that the charging infrastructure caters to the local requirements for EV and fleet owners and is optimally integrated with proper transportation network distribution and electricity supply.

## EV charging infrastructure strategy in India

**2022**

- Further consultation on the CO2 regulatory regime, including the design of a ZEV mandate on manufacturers.
- Launch of the Local EV infrastructure Fund.

**2024**

- New regulatory regime, including a ZEV mandate on manufacturers.

**2025**

- Grants for charge points in homes, workplaces, and on-street parking will continue until at least 2024/25.
- Favourable company car tax rates and exemptions from Vehicle Excise Duty will continue to apply to ZEVs until at least March 2025.

**2027**

- The Government has a target for its car and van fleet to be 100% zero-emission by 2027.

**2030**

- The Government has a target for at least 2,500 high-powered charge points to be in place across the Strategic Road Network by 2030.
- Sale of new petrol and diesel cars and vans to end by 2030.
- All new cars and vans to deliver significant zero-emission capability from 2030 to 2035.

**2035**

- All new cars and vans to be 100% zero-emission at the tailpipe.

# 1. Introduction

Even though EVs have been successfully expanding their base for adoption, acquiring a significant share in the total auto sales YoY. The presence of adequate and reliable charging infrastructure is lagging. The majority of EV owners charge their cars at home through a wall-mounted charger. The arrangement is suitable given the EV usage is well within the range of the average distance commuted and time available to charge the EV, i.e. overnight.

However, there are certain challenges that arise, pointing to the need for installing scalable, secured, and reliable charging stations in India.
The first one is concerned with the parking garages that are rarely rigged with charging infrastructure for EV owners who stay in apartments or do not have a driveway facility in order to charge at their homes. For them to install such infrastructure can be a constraint on the cost and area required for the operation.

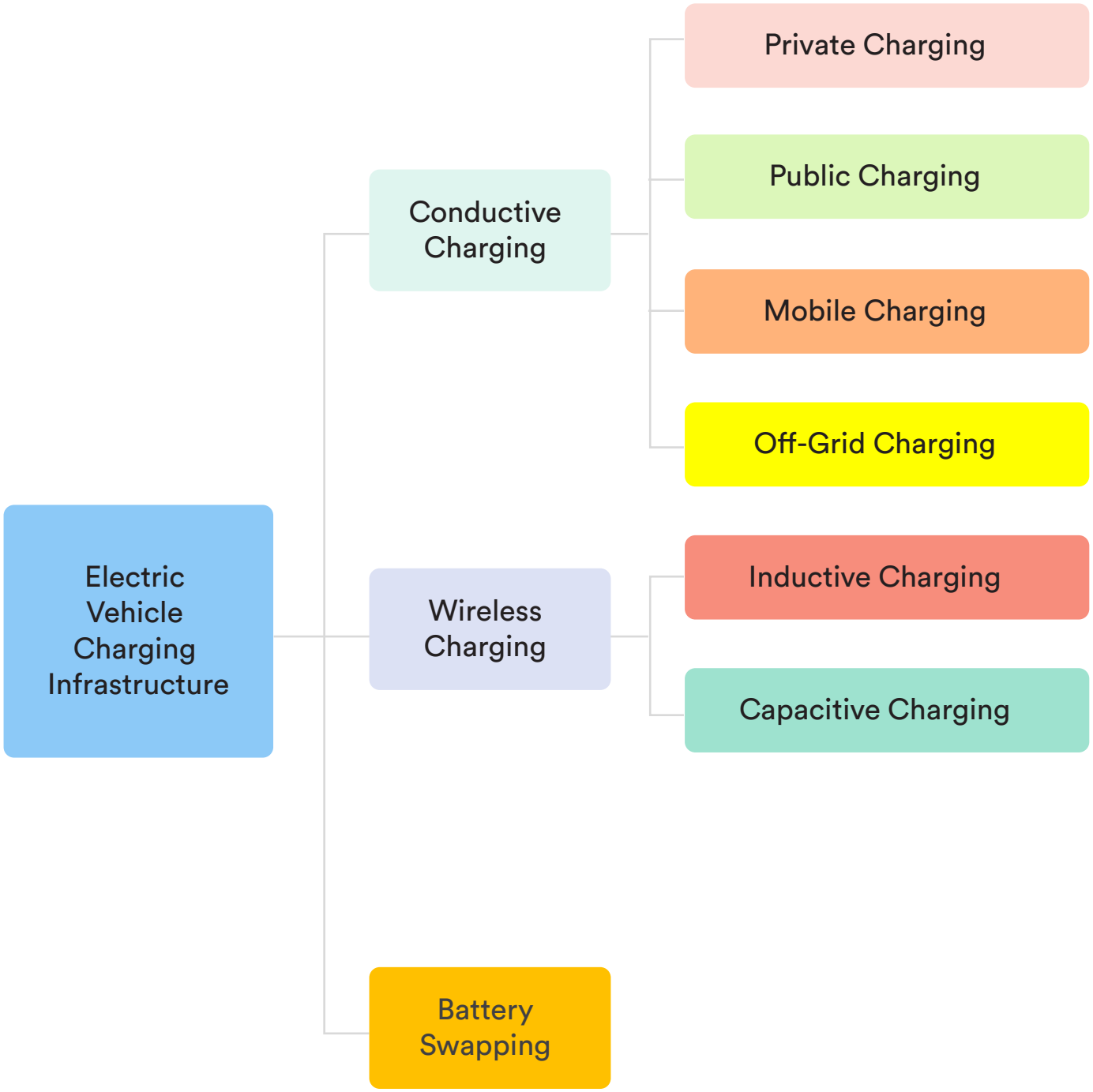
The second reason is that extended charging infrastructure is required for EVs to curb the 'range anxiety of the drivers in order to make longer commutes with minimum wait times in charge. Range anxiety is the fear amongst the drivers for the car to run out of power before reaching an EV charging station. Hence, it is important to build a robust public "powering" network of charging stations to successfully cater to the EV market.

Generally, the home, followed by the workplace, continues to be the favorite establishment for charging an EV. The argument above directly implies that the most scalable market for public charging stations is in DC fast charging targeted for go-to, interstate driving with minimal wait times (under an hour) even in emergency situations. The benefit of having fast DC charging stations is a win-win situation for both EVSE suppliers, manufacturers, and EV owners, saving the capital cost and time to acquire an onboard charging setup.

The ever-evolving EV ecosystem raises a lot of curiosity, depicted as a chicken-versus-egg scenario. The question is, whether greater EV adoption demand a more exhaustive public charging infrastructure or does the public charging stations aid to drive EV adoption?
There has been a hysteresis loop for large projects, resulting in unprofitable due to greater upfront costs. For such models, the volume for EV use needs to be very high to secure the

break-even point before earning a profit-driven business model. Looking at the current trends, the ideal state for the Indian EV market is sustainable, with optimism for a larger penetration into the auto market.

## EV charging infrastructure strategy in India



## Efforts to improve fast charging performance

### Preheating Batteries

Tesla's feature - The On-Route Battery Warmup - heats the battery while navigation to a supercharger to ensure you arrive at the optimal temperature to charge, reducing average charge time for owners by 25%

### Intelligent Battery Management

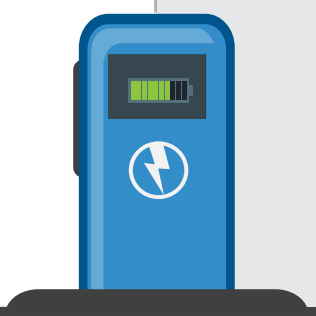
Software that combines adaptive charging algorithms with battery health and safety features, E.g. Qnovo's software uses real time diagnostic data as input to adjust the rate of charging to optimize battery performance and lifetime.

### Fan & Liquid Cooling

In order to reach 150+ kW charging, high voltages and currents are used. To avoid overheating or large cross section cables, power units and cables are actively cooled via integrated fans and a dielectric coolant, respectively, as opposed to traditional passive air cooled units.

### Cloud-Based Management Platforms

Used to monitor overall charger status and perform data analytics. Allows updates remotely which facilitate the long term maintenance and management of the charger. E.g. Tritium's Pulse and Chargepoint's Assure software.



# 1. Introduction

**High-power charging (HPC) or DC Fast Charging (DCFC)**

High power or DC fast charging refers to Level 3 DC fast charging with a power rating of 50 kW or more. To reduce the charging times similar to conventional refueling, DCFC will play a vital role. Since the capital costs are high along with the need for large installation setup areas, such chargers will mostly be seen in public charging stations.

For EV owners, this will remarkably reduce the wait times and curb the range anxiety by fast charging the EV at 80% within 30 minutes. With the charging power of the HPC, chargers can deliver all the power the new 800 V architecture-based EVs of the market can utilize. This report covers the infrastructure for EV charging installations, benchmarks, standards and regulations, implementation and integration of the EV grid.

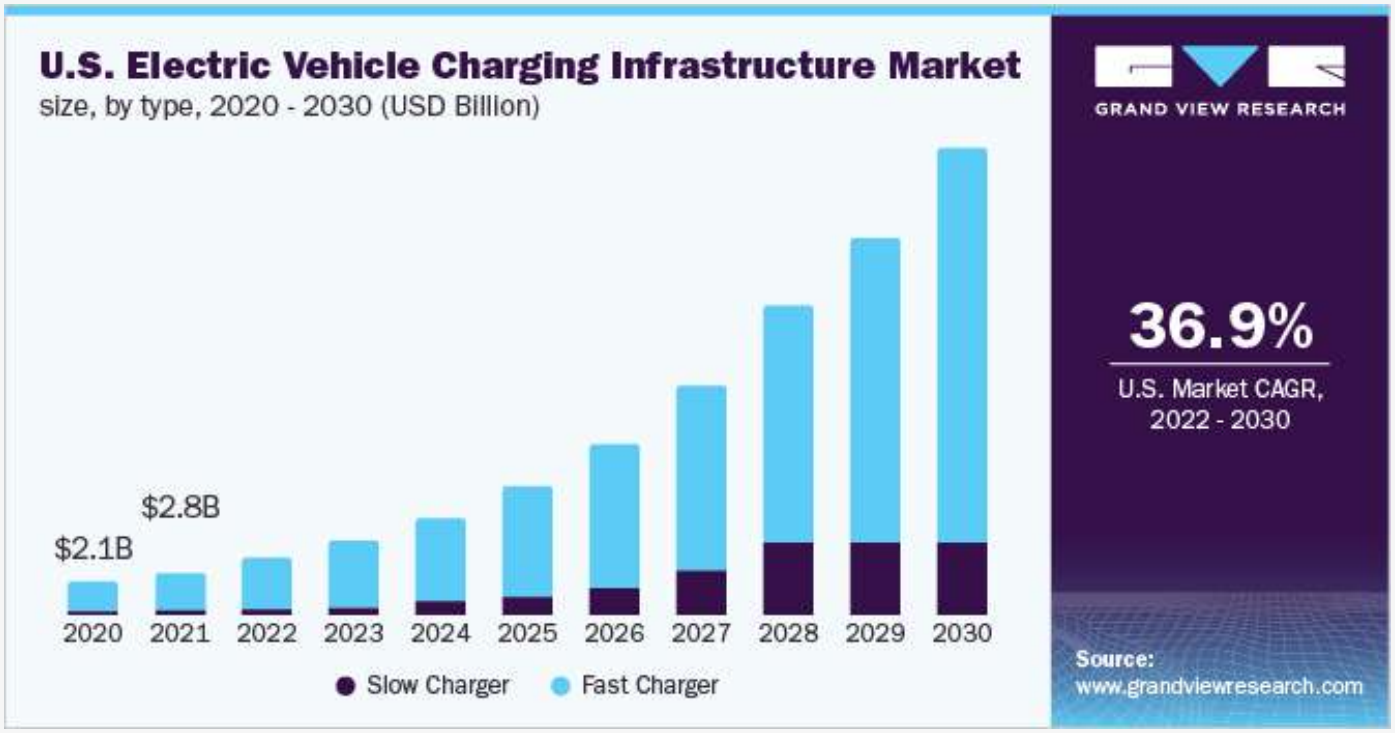
**Fleet Charging**

The electric fleet charging comprises less than 10% of the total charging infrastructure in terms of volume, it forms more than 15% of the total market value due to the added cost involved with the high-power requirements.

The electric vehicle fleets like trucks and buses need completely different charging infrastructure solutions than passenger cars, such as charging to overhead catenaries, multiple mega-watt depots, and battery swapping.

Looking into the future, e-mobility combined with the leverage to autonomously charge is anticipated to dominate the passenger vehicle segment in the urban environment eventually. Mobility service companies will need to widely deploy automatic charging so that the vehicles can extend their driving range without incurring extra labor costs.

## EV charging infrastructure strategy in India




According to the report published by Reports and Data, the global EV charging infrastructure is expected to reach USD 144.2 billion by 2028 and accounts for a revenue CAGR of 32.6% over the highlighted forecast period.

The necessity for faster adoption of electric vehicles has been significantly triggered by the rising levels of carbon emission, GHGs (GreenHouse Emission Gases), and the release of other obnoxious gases from transportation. Correspondingly the need to ramp up EV charging infrastructure has been the center of focus for the government and private OEM players.

As per the Research and Markets' India Electric Vehicle Ecosystem Market Outlook 2030, the Indian EV industry is forecasted to grow at a robust CAGR of 43.13 percent from 2019 to 2030. Correspondingly, the installation of EV charging infrastructure is predicted to raise at a 42.38 percent CAGR.

# 2. Analyzing the global EV Charging Market

The global regulatory bodies have been institutionalizing the necessary frameworks and raising capital investments to boost the transition from ICE to EV. The Asia Pacific and European markets are estimated to account for greater revenue shares in the global EV market. Although fulfilling the size of investment seems to be a challenge for the stakeholders, the associated benefits such as curb in GHGs, air pollution, and reduced oil requirements will lead to a major breakthrough in the mobility segment in the next coming years.

### BY LEVEL OF CHARGING

- Level 1
- Level 2
- Level 3

### BY ELECTRIC BUS CHARGING TYPE

- Off-board Top-down Pantograph
- On-board Bottom-up Pantagraph
- Charging Via Connector

### BY CHARGING POINT TYPE

- AC (Normal Charging)
- DC (Super Charging)
- Inductive Charging

### BY CHARGING INFRASTRUCTURE TYPE

- CSS
- CHADEMO
- Normal Charger
- Tesla Super Charger
- Type 2 (IEC 62196)
- GB/T

### BY CHARGING SERVICE TYPE

- EV Charging Service
- Battery Swapping Service

### BY INSTALLATION TYPE

- Portable Charger
- Fixed Charger

# 2. Analyzing the global EV Charging Market

### BY APPLICATION

- Private
- Public

### BY DC FAST CHARGING TYPE

- Fast
- Ultra-fast

### BY REGION

- North America
- Europe
- Asia Pacific

### BY IOT CONNECTIVITY

- Non-connected Charging Stations
- Smart Connected Charging Station

## 2.1 Demand

### Key highlights

- Public Chargers will be the fastest-growing market during the above forecast period.
- The Asia Pacific is expected to be the largest and fastest-growing market during the forecast period.
- Europe to be the second-largest region during the forecast period.

The availability of public EV charging plays an important role in purchasing electric vehicles across the globe. Public charging and access to fast charging are key criteria when buying an electric vehicle. This is anticipated to bolster revenue growth for the public charging segment. The Asia Pacific region continues to install public chargers significantly due to the rising number of EV users, especially in China, India, and South Korea. These countries have implemented policies to increase EV usage by providing subsidies and reducing taxes.

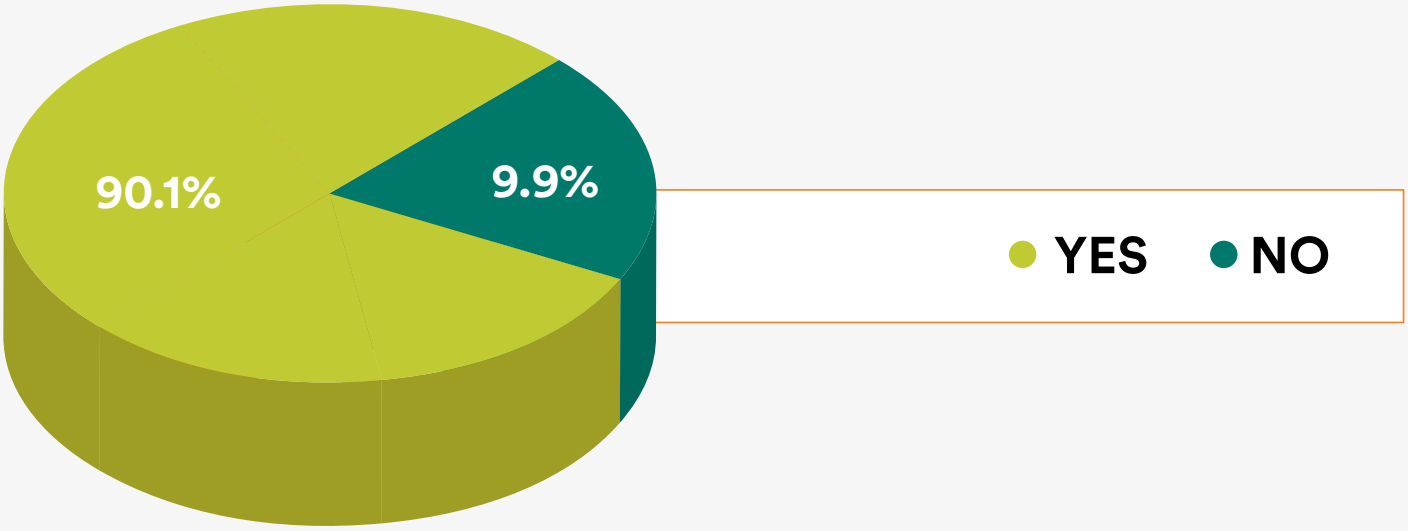
They also encourage the growth of EV manufacturers and related industries by providing grants or implementing preferential policies for EV-related companies to enable them to expand faster. A steady surge in economic growth, urbanization, travel demand, etc., coupled with increasing investments toward electric mobility to contribute to energy storage and environmental sustainability, is anticipated to bolster the growth of the public charging station segment.

## 2.2 Consumer Mindset

The European Journal of Molecular and Clinical Medicine published a research paper in 2020 to analyze the consumer mindset and perception of the purchasing of EVs in India.

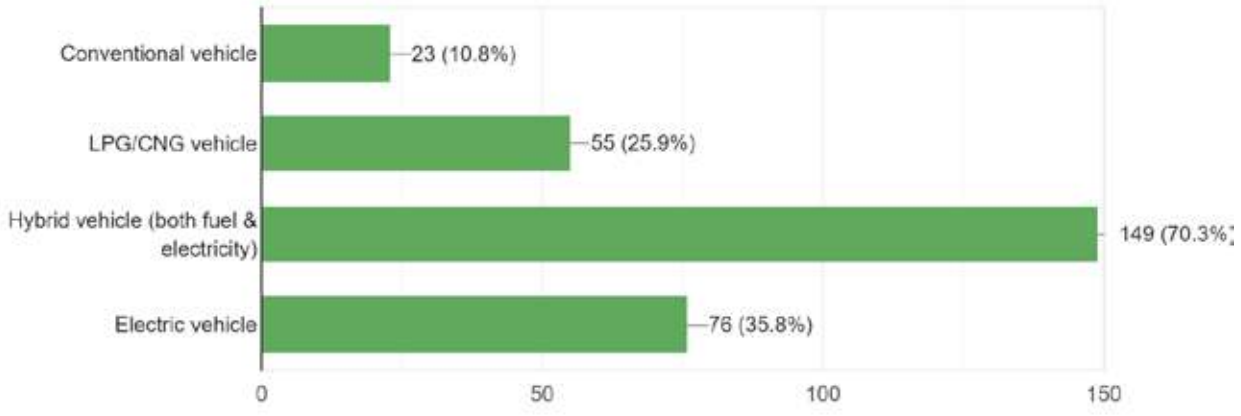
A sample space of 212 respondents was considered to draw inferences from the primary research which was conducted using a descriptive research methodology.

# 2. Analyzing the global EV Charging Market



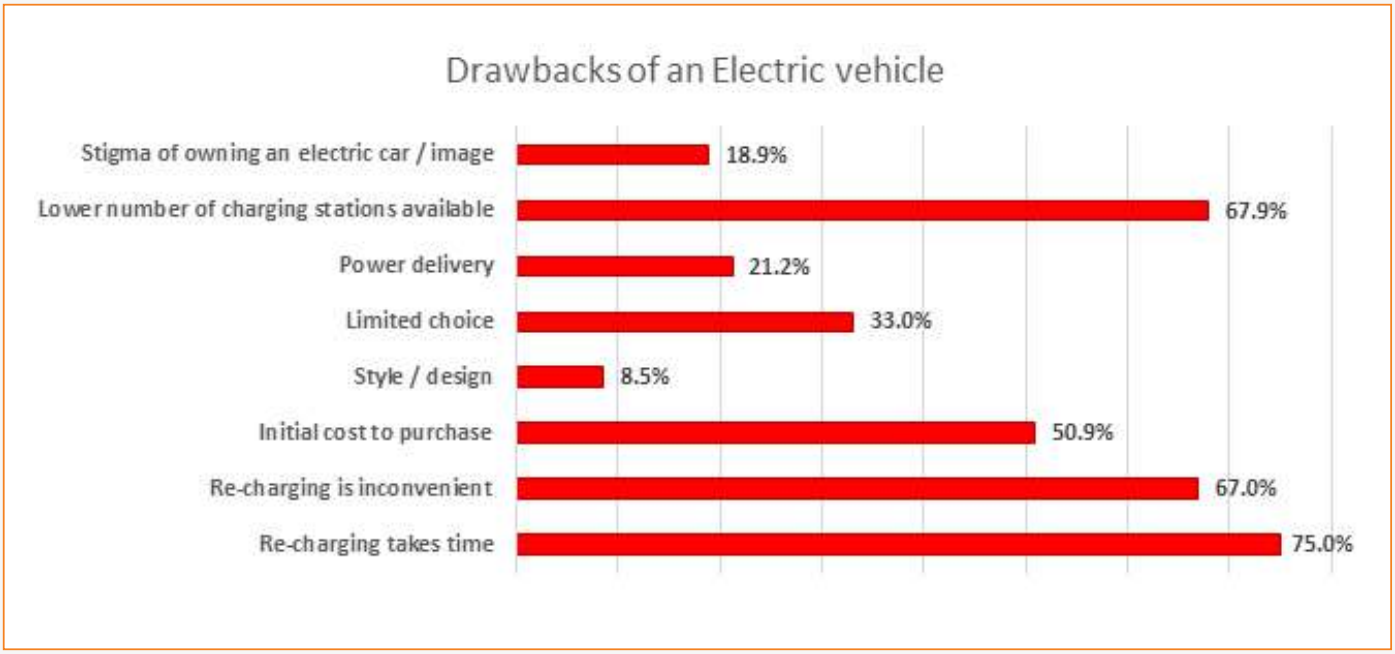

- **90.1%** supported using eco-friendly vehicles, and 9.9% preferred conventional vehicles. Respondents were aware of climate conditions and were ready to shift their preference to eco-friendly cars.

**Which of the following would you prefer?**




- **70%** of the respondents chose hybrid vehicles when asked regarding their choice of vehicle.

However, every new technology and adoption possesses certain quirks, and for EV owners, one such apprehension is range anxiety.




More than 60% of the respondents considered limited charging stations, recharging time, and difficulty in charging as major drawbacks/limitations, considering EVs in the current market scenario.

## 2.3 Stakeholders Involved

There are mainly three types of stakeholders at different points of the value chain. The multi-point stakeholders for planning, implementing, and driving the EV infrastructure comprise policymakers, implementing authorities, and working groups.

### 2.3.1 Policy makers

The government bodies at the central, state, and local levels are responsible for the administration, governance, and management of the EV charging infrastructure in India. The functioning of these bodies can be classified under formulating policies, regulatory functions, and executive or implementing functions.

These government bodies formulate policies, make regulations, and devise standards and specifications required for scaling up the EV charging infrastructure.

Electricity, the power source and the fundamental unit of supply, is the key parameter for implementing the charging infrastructure. It is worth noting that the involvement of central and state governments is equally likely in regulating the electricity supply for charging electric vehicles.

Here are the major government stakeholders involved in electricity supply.

- The **Ministry of Power (MoP)** devised the Charging Infrastructure Guidelines and Standards for public charging infrastructure, laid out an enabling framework for execution and implementation. The MoP as a legislative authority, at its utmost potential, clarified that the EV charging operational services doesn't not require licensing under the Electricity Act 2003.

- The **Central Electricity Authority** (CEA) is the main body specifying technical regulations and standards for EV charging.

- The **State Electrical Regulatory Commissions** (SERCs) have fixed the EV tariff and other regulations related to the electricity supply for EV charging.

The provision of parking spaces and available land for setting up EV charging is another important aspect or input parameter to locating charging facilities.
The state government holds the land and urban development authority, with urban development delegated to the Municipal Corporations in most regions.

The Bureau of Indian Standards (BIS) defines the EV charging standards for the manufacturing body, and OEMs in the country.

## 2.3.2 Implementing Authorities

The government bodies holding executive roles govern the EV charging infrastructure, including planning, support, permitting, and charging implementation. The following bodies are the stakeholders for the same.

- The **Bureau of Energy Efficiency** (BEE) is designated by the MoP for the rollout of the public charging infrastructure for electric vehicles.

- The Department of Heavy Industry (DHI) monitors the essentials required for the FAME-II scheme, including all the subsidiaries required for setting up the public charging infrastructure.

- The Ministry of Power has directed the states to appoint SNAs **(State Nodal Agencies)** that govern EV charging infrastructure.

By default, the SNAs are the DISCOMS involving state electricity distribution companies that are directed to choose
Enforcing agencies to install, operate and maintain
battery swapping/charging facilities and public charging stations in the state.

DISCOMs are state-controlled regulatory bodies authorized to offer electricity connections required for EV charging and ensure that EV charging infrastructure is operated and interconnected appropriately. DISCOMs ensure that there isn't any overuse/misuse of EV connections, manage the distribution network, and undertake grid upgrades based on the increase in load that may arise from EV charging.

## 2.3.3 Working group

Various state and local government authorities are the stakeholders in the working group for the accelerated rollout of the EV charging infrastructure.

The working group's role for EV charging infrastructure is to support the essential coordination and interlinking between various government agencies and regulatory bodies. Generally, a working group involves all the associated executing and nodal agencies, such as the municipal corporations, urban development authorities, DISCOMS, and SNAs.

# 2. Analyzing the global EV Charging Market

**The key functions of the working group is:**

- To take a complete 360-degree stance of the wide range of challenges and opportunities for the rollout and faster adoption of the EV charging infrastructure and guide the right strategies to boost the progress.

- To assess and manage coordination matters between agencies and various departments under the GoI (Government Of India) DISCOMs, local authorities, and GNCTD.

- To critically observe and measure the progress of rollout of charging infrastructure at the center, state level, and at multiple stages of implementation.

- To look for any other policy or coordination issues to accelerate the rollout of EV charging infrastructure at the center and state level.

## EV Charging Infrastructure Overview

The EV charging ecosystem is vast and comprises various components like regulation and standards, infrastructure classification, charging characteristics, network, and distribution.

## 3.1 Regulation & Standards for Interoperability

### INDIAN AC CHARGING STANDARDS

This Indian Standard covers all the operating conditions and characteristics with the particular specifications of connection between the EV and the EVSE, including all the prerequisites for electrical safety.

IS 17017 is one of the core Indian charging standards consisting of 3 parts and six sections. The IS17017-Part 1 is the basic EVSE (Electric Vehicle Supply Equipment) standard for EV charging. It consists of a rated supply voltage up to 1000 V AC/1500 V DC and a rated output voltage up to 1000 V AC/1500 V DC.

IS-17017-Part-2 involves specific AC connector standards and AC EVSEs must obey the standard. Both DC and AC EVSEs should adhere to the technical standards under IS-17017-Parts 21 & 22.

Furthermore, the Indian standards for AC EVSEs have been authorized for e-cars and light EVs (in the form of low-cost charging points), with their utility in parking areas.

# 3. EV Charging Infrastructure Overview

## INDIAN DC CHARGING STANDARDS

The IS-17017-Part-23 emphasizes the essentials for DC charging stations extending a power output upto 200KW. Any value above the set limit shifts the high power charging standards to cater to buses and other heavy vehicles.

Based on the digital communication requirement between EV data and DC EVSE, the Bureau of Indian Standards has recently finalized the IS-17017-Part-24. The IS-17017-Part-25 section has been set specifically for light EVs operating on DC power less than 7KW. The IS-15118 is a communication standard that involves adopting a combined charging system (CCS) for both AC and DC charging types.

## INDIAN BATTERY SWAPPING STANDARDS

The battery swapping policy stipulates the minimum operational and technical requirements the ecosystems need to achieve for reliable, efficient, effective, safe, and customer-friendly battery swapping implementation of battery-swapping infrastructure.

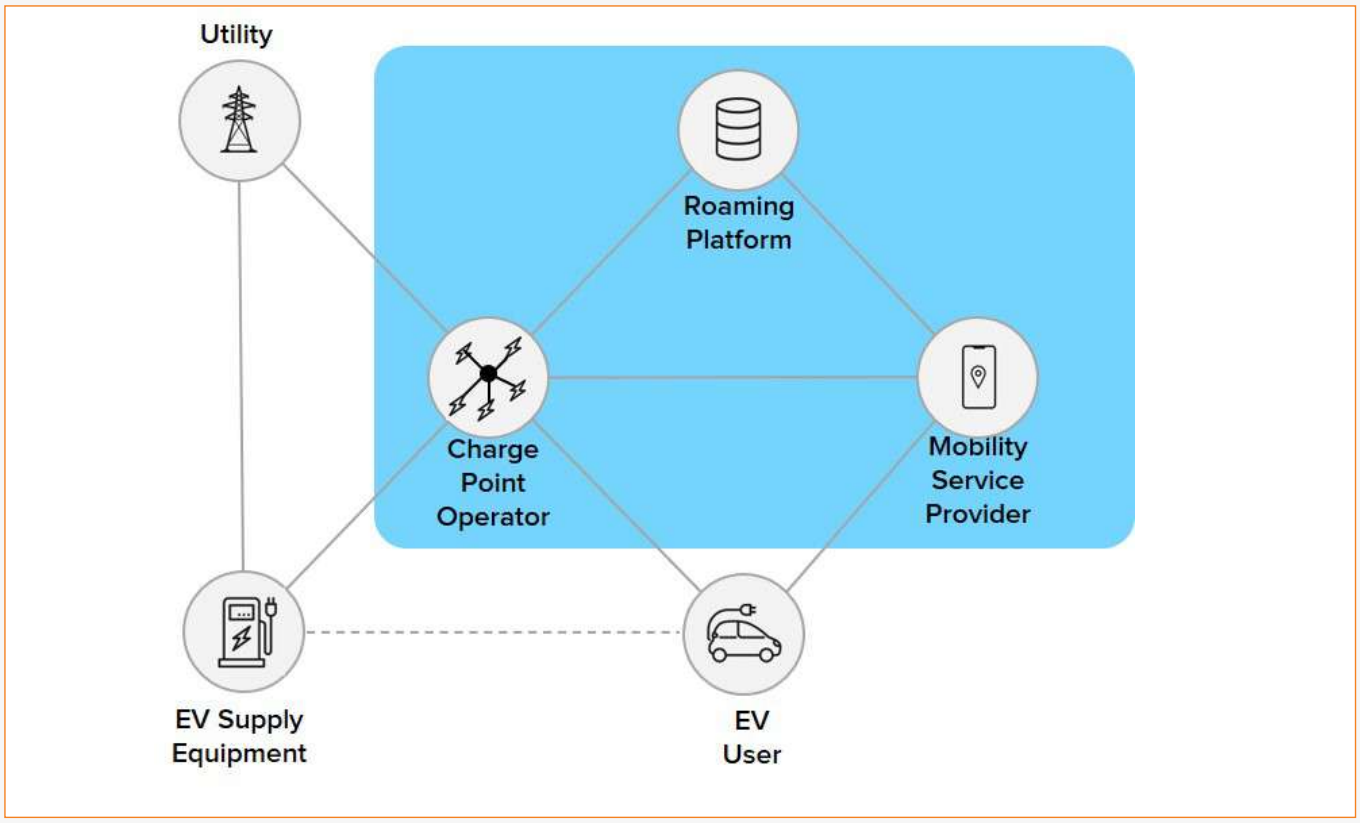
It emphasizes enabling innovation in adopting possible business models and derisking the investment in required infrastructure to encourage private sector participation and attract affordable financing. The battery swapping policy underlines the probable ways in which Public Sector Enterprises (PSEs) and government agencies at various levels may extend a helping hand through financial support to EV users and battery manufacturers. Also, considering the upfront cost of buying an EV to ramp up EV adoption by lowering the costs of EVs for users relative to ICE vehicles.

## STANDARDS FOR INTEROPERABILITY

Standards for interoperability ensure the ease of compatibility between the EVs and EVSE. The International Electrotechnical Commission (IEC) is a universal body responsible for developing reference standards to facilitate interoperability. The BIS (Bureau of Indian Standards) and the national standards body of India are the regulatory authorities for formulating Indian EV charging standards for interoperability and cutting down the barriers involved for EVs and the associated components. Although the charging standards in India are aligned with the global EV standards of charging, factors such as climate and different vehicle variants open room for customizations and modifications applicable.

# 3. EV Charging Infrastructure Overview

The interoperability standards serve as a common ground for EV stakeholders, market players, and EV drivers to operate, access, and utilize resources without restriction. With the aid of a single application provider, EV owners can access multiple charging stations and avail facilities from various charging service providers. The consensus amongst market players, including charge point operators (CPO), mobility service providers (MSP), and roaming platforms, can enable such integrations.




## 3.2 EV Infrastructure Classification

The classification of EV infrastructure depends upon the ownership and utility. Majorly, the EV charging infrastructure is classified as private, semi-private, and public.

**1. Private Charging:**

Private charging is a dedicated entity for EV fleet-owned or personal EV or by a private group owner. This type of charging is prevalent in dedicated parking facilities as per land availability and independent homes. The ownership belongs to EV fleet owners/operators and individual EV owners. These are self-operated or managed by a charge point operator (in the case of EV fleet charging)

**2. Semi-private Charging:**

This model is confined to a group of EV users. The locations include apartment complexes, office campuses, gated communities, shopping malls, hospitals, universities, government buildings, etc. The stakeholders who own semi-private charging are Orginal Equipment Manufacturers (OEMs), host property owners, and Charge Point Operators (CPOs). The charging operation is managed by CPO.

**3. Public Charging:**

Public charging can be availed by all the EV users in areas such as parking lots, charging plazas, metro stations, on-street parking, petrol pump, and highways. Generally, the station is owned by municipal authorities; Charge Point Operators manage CPOs, PSUs, host properties, and the operation (CPO)

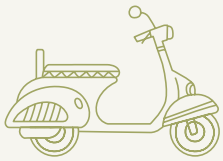
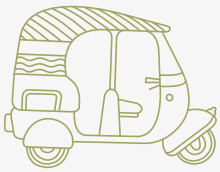
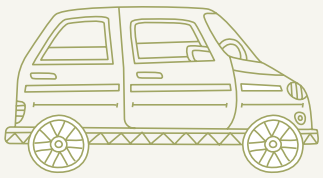
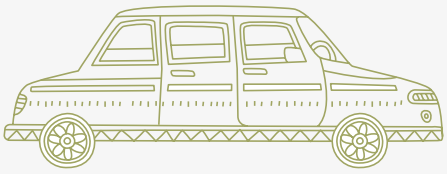
## 3.3 EVSE Characteristics

The Electric Vehicle Supply Equipment is the heart of the charging infrastructure. EVSE is a protocol that protects the electric vehicle and charging infrastructure from battery damage, hardware faults, electric short circuits, and in some cases, potential catastrophes such as fire. It facilitates two-way communication between the car and the charger to authorize and authenticate charging, exchanges data for network management, and ensure privacy and data protection. Generally, EVSEs are equipped with support to accommodate all types of charging standards.

The main charging technology for electric vehicles is conductive or plug-in (wired) charging. Prerequisites for conductive charging in EVSE depend on factors like battery capacity, power rating, and charging methods (type of charging).

India's EV market is dominated by LEVs (Light EVs) consisting of E-bikes, three-wheelers, 4-wheeler, light commercial vehicles (LCV), and EV fleets. The charging requirements of EVs majorly depend on battery specification since the right voltage, and current are required to enable safe charging. The table below shows typical battery capacity and voltage characteristics for the major 4 types of electric vehicles.

# 3. EV Charging Infrastructure Overview

| VEHICLE SEGMENT | BATTERY CAPACITY | BATTERY VOLTAGE |
|---|---|---|
| **E-2W**  | 1.2-3.3 kWh | 48-72V |
| **E-3W** (passenger/ goods)  | 3.6-8 kWh | 48-60V |
| **E-cars** (1st generation)  | 21 kWh | 72V |
| **E-cars** (2nd generation)  | 30-80 kWh | 350-500V |

## 3.4 EV Charging Classification

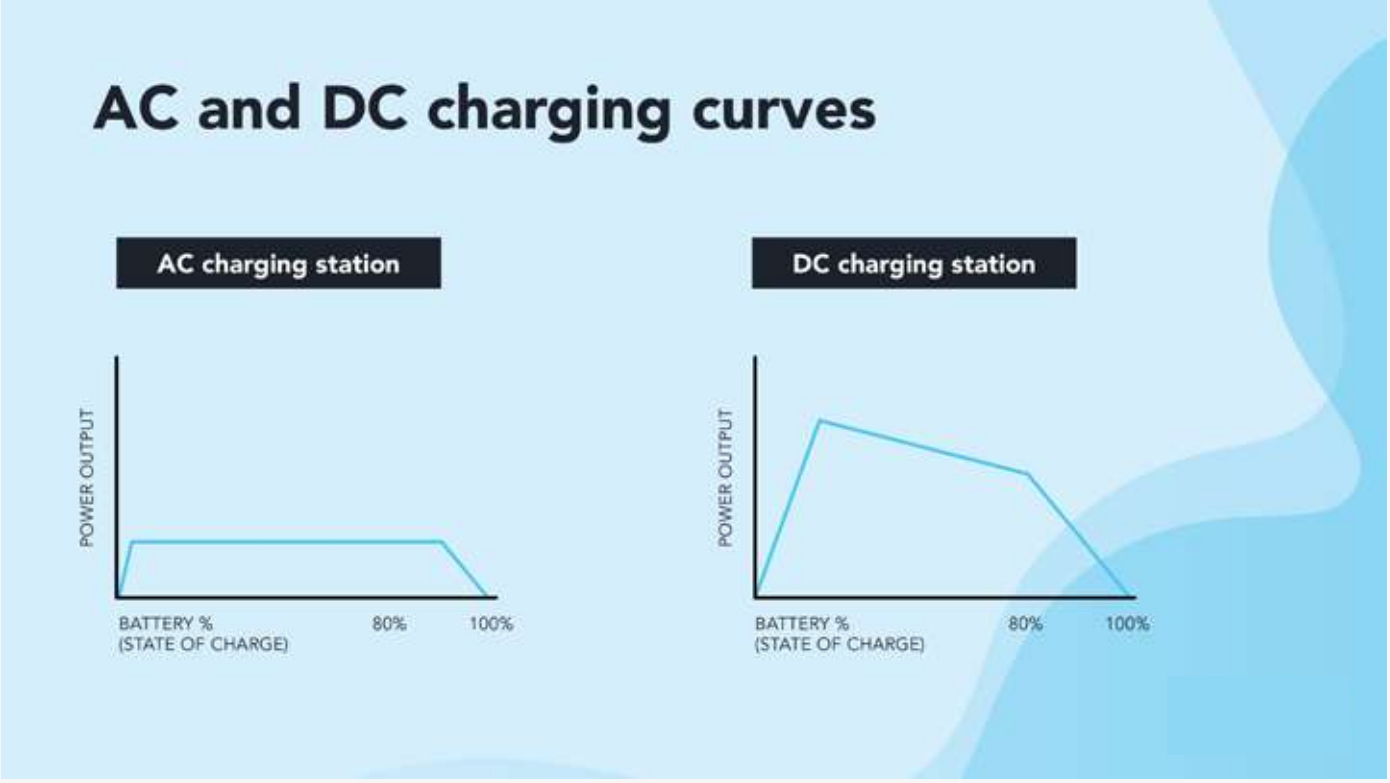
The EV charging is divided into 3 types of charging till date. Depending on the input voltage, the chargers are classified as level 1, level 2, and DC fast charging.

Level 1 and 2 charger employs AC charging type. In the figure below, the power supplied by the charging station is constant and represents a steady flat line. The onboard converter is small sized and can accommodate only a certain amount of power input at a time.

Level 3 or DC fast charging depicts an instantatneous peak followed by a gradual fall. The nature of the peak and falls is justified because of the presence of large converters and fast power input.

Eventually, as the battery gradually reaches a higher state of charge (SoC) it will draws less power as input.

Generally, electric cars demand less power after the battery attains 80% charge and that's why the final phase of the charging is relatively slower.




**Level 1 Charging:** The L1 charging uses a 110 V outlet for drivers to use the charging cord set that is provided with EVs in places equipped with a proper electricity connection. Full charging of an EV takes the longest time compared to the other types of charging.

The power output during charging varies marginally, i.e., between 12 and 16 amps. Level 1 charging at this output level delivers a driving distance range of 3.5 to 6.5 miles per hour of charging. Level 1 charging benefits drivers with a commuting range of 30-40 miles per day and can charge overnight. The average charging time to achieve full charge varies from 11-20 hours.

**Level 2 Charging:** The level 2 charging type is generally employed at residential locations, parking areas, and commercial areas/ workplace settings. Most offer higher power output

than Level 1 chargers and have additional functionality not available with Level 1 chargers. Level 2 chargers are generally distinguished between non-networked and networked chargers.
Based on the power output a charging station delivers and the type of vehicle used for charging, L2 charging can deliver a full charge at a rate 5 to 15 times faster than a regular socket.

**Level 3 (DC Fast Charging):** The fast DC charging method or level 3 charging uses a DC supply and delivers more power in less time. DC fast chargers don't require an onboard charger since the current supplied by the charger is directly stored in the vehicle's battery pack. Power output is required for Level 3 charging. A DC fast charger can deliver a maximum power supply output of 350 W at once, achieving a full charge in 15 minutes.

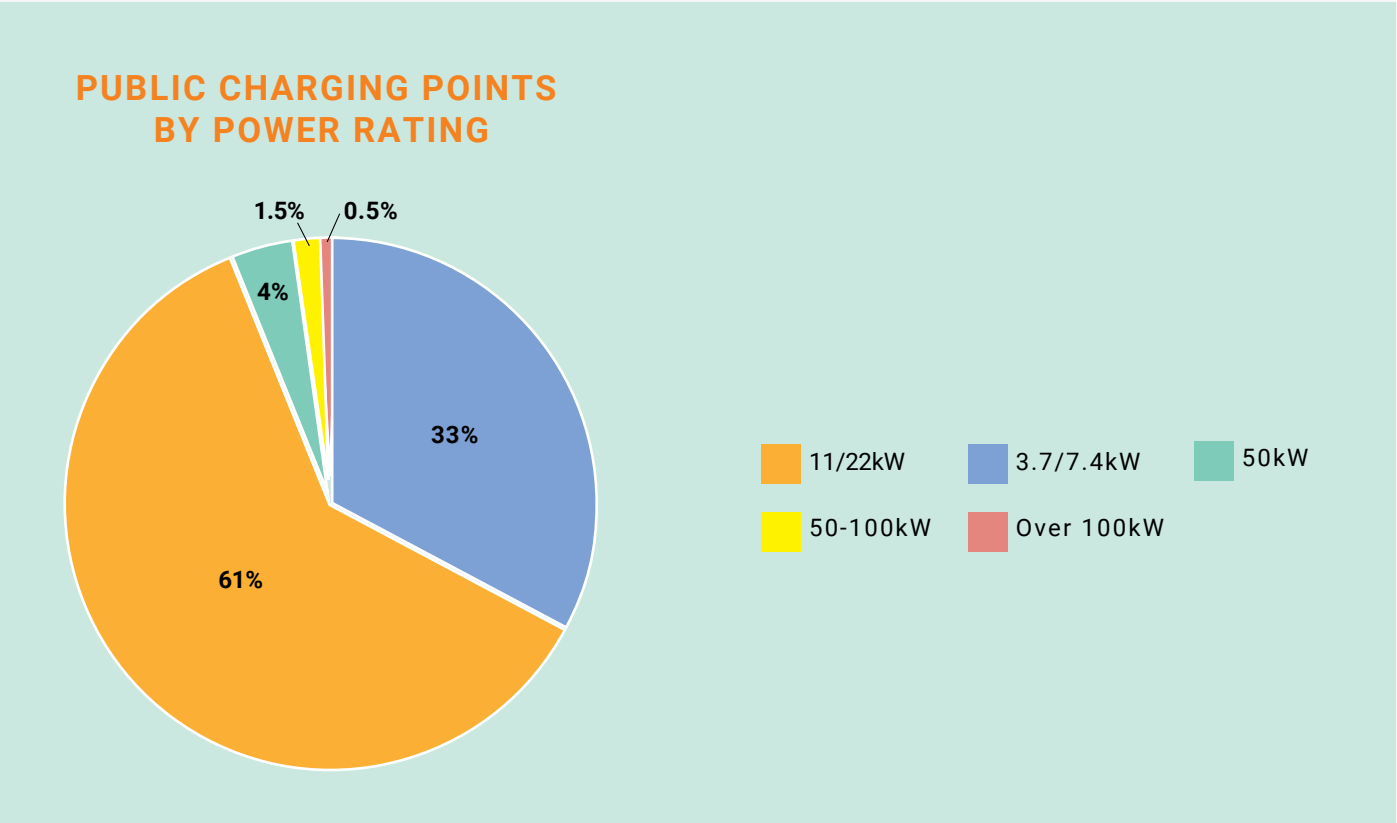
## 3.5 EV Charging Network and Distribution

The EV charging report by Vahan 4 data as of March'22, highlights that the number of EVs on the road has crossed 10 lakh and is supported by 1,700 public charging stations which are operational in PAN India.

The Bureau of Energy Efficiency has laid out action plans for eight cities in India that are Bengaluru, Delhi, Mumbai, Kolkata, Ahmedabad, Chennai, Surat, and Pune. The planning for the installation of chargers has been laid out considering different category-wise scenarios such as moderate and aggressive.

The Indian Minsitry of Health has invited the stakeholders from government organizations and PSUs(Public Sector Undertaking) to develop and operate public EV charging stations under the FAME-II scheme.

# 3. EV Charging Infrastructure Overview




To focus on the charging distribution, it is obvious that having numerous small EV charging stations distributed across a significant range of networks is a more effective strategy than focusing on limited high-power charging stations centered in a particular domain/region. Moreover, to ramp up EV adoption, it is advisable to install charging stations near parking locations instead of allocating new locations for developing the charging infrastructure.

Implementation of the EV charging infrastructure model involves various stations that users can plug into. These involve residences, apartment buildings, shopping malls, metro, office campuses, railway stations, and bus depots. Etc. The distributed network approach benefits the charging ecosystem in multiple ways for operators and users, ranging from ease of accessibility and feasibility. Here are the top benefits of adopting a distributed network.

**1. Longevity in Battery Life:** The distribution of normal power charging points reduces the exposure of an EV battery pack to high/ultra high power charging points that can deteriorate the battery health in the long run.

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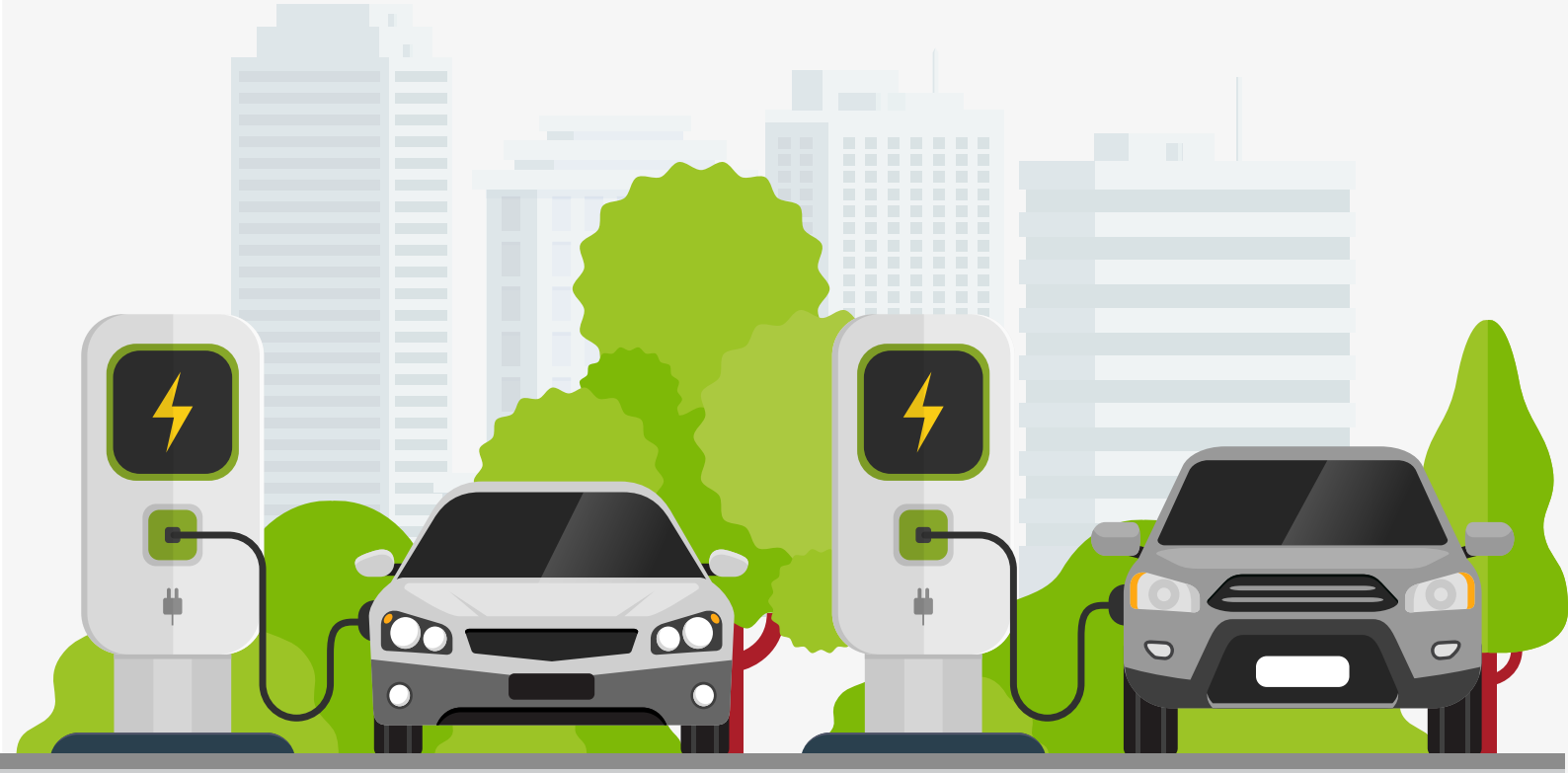
**2. Cost and Captial Effectiveness:** Not only do the normal charging points incur lesser costs in full charging an EV, but the setup and capital cost also support the cause's viability. The charging station can be connected to low-voltage, single and three-phase distribution networks available in public spaces and buildings.

**3. Feasibility of EV Charging:** The advantage of setting up a distributed network of normal charging points lowers the upfront costs involved in setting up charging infrastructure. Additionally, it reduces the need for government subsidies and increases grounds for private players to participate in charging operations.

It is important to strike a balance between a distributed network of normal charging and a slight share of fast DC/high power charging stations to cater to an EV driver's charging needs, thereby cutting down the range anxiety and enabling faster EV adoption.

# 4. Implementation Models for EV Charging



The EV charging infrastructure is at a nascent stage, with around 1742 public charging stations in operation as of April'22. However, with faster EV adoption backed by FAME-II and net-zero carbon policies, over 1 million EVs have been sold as per the latest trends and figures by Vahan 4 data.

The Indian EV market segment is predicted to scale exponentially in the coming years. Companies from multiple sectors are connecting and introducing products and services at various points in the value chain of the EV ecosystem. Driven by regulatory frameworks, climate concerns, and profit motives/regulatory requirements, the typical models driven by stakeholders for implementing charging infrastructure in India involve:

**1. Government Driven:** The provision for public charging infrastructure is led by government agencies. These involve local authorities like urban development authorities, municipal corporations, or SNAs accountable for public charging infrastructure. The installation for charging facilities is provided through the aggregation of charging facility installation from public sector bodies. A government regulatory body or a CPO (Charge Point Operator) with a tenure to own a charging facility/setup service

**2. Consumer-Driven:** This model applies to semi-public/private charging facilities. Malls, commercial institutions, retail shops, corporate offices, and restaurants with parking facilities in their region/premise to host EV charging facilities. Generally, in a consumer-driven approach, the partnership is with a CPO to ensure the EVSE supply, setup and maintenance, and service management operations.

EV owners and fleet operators fall under this category. The EV owners procure EV chargers from their respective CPO, DISCOM, OEM, and EVSE retailers. For fleet owners, the land is offered by the fleet operator, who may lease or own it. Supply, maintenance, and installation logistics are leased through supplier/CPO contracts.

**3. Service Provider:** The Service model approach involves CPOs that own and drive EV charging equipment facilities for semi-public/public charging. Various owners from the public and private entities lease the land for charging station installation. Usually, the charging station is branded under the ownership of a CPO. A revenue-sharing model is encompassed between the CPOs, the landowners, and the associated entities.

Other stakeholders include DISCOMs and industrial companies that are shifting towards charging infrastructure. Additionally, EV manufacturers are installing and managing EV charging infrastructure as part of allied services.

## 4.1 Charge Point Operators (CPO)

The role of a charge point operator is to manage, set up and operate a network of EV charging points for semi-public or public use. They may own the EV chargers or may operate the chargers on behalf of the charge point owners. CPOs cater to different arrangements and can simultaneously manage a mix of client-owned and self-owned charge point networks.

### The responsibilities of a CPO include

**Planning and Permissions**

**Installation and Commissioning**

**Billing and Operations**

## 4.2 Modes of Implementation

There are multiple roles in implementing a charging infrastructure model that an individual stakeholder would cater to or through partnerships between different stakeholders. Other than the charging infrastructure setup, other roles include land provision, EVSE supply, customer service, charging software solution, and electricity supply.

**1. Charging infrastructure procurement:** The key driving partner who procures the charging infrastructure is responsible for implementing the same. There is no specific guideline or requirement for the procuring body, which can be undertaken by the charging service provider, by the governing authority accountable for providing charging infrastructure, or by the primary user of the charging infrastructure.

**2. Land provision:** The area needed for EV charging may be possessed by the procuring stakeholder through alternative arrangements like revenue sharing or acquired on lease.
It is obvious but important to state that the semi-public, private charging facilities are set upon private land. In contrast, the public charging infrastructure can be installed on public or private land.

**3. Energy supply:** The DISCOMs provide the energy supply for almost all the EV charging installations responsible for electricity distribution for the city in the region where the charging facility is located.

**4. EVSE supply, installation, and maintenance:** The EVSE manufacturer and retailer supply the EV chargers for public or semi-public charging. CPOs are usually liable for the selection, management, and installation of the necessary array of chargers.

**5. Charging software solutions:** The CPOs use system management software to monitor their charging point networks, control, and track charging sessions, carry out diagnostic events on the charger equipment and conduct other back-end services to handle customer subscriptions, govern pricing structures, etc.

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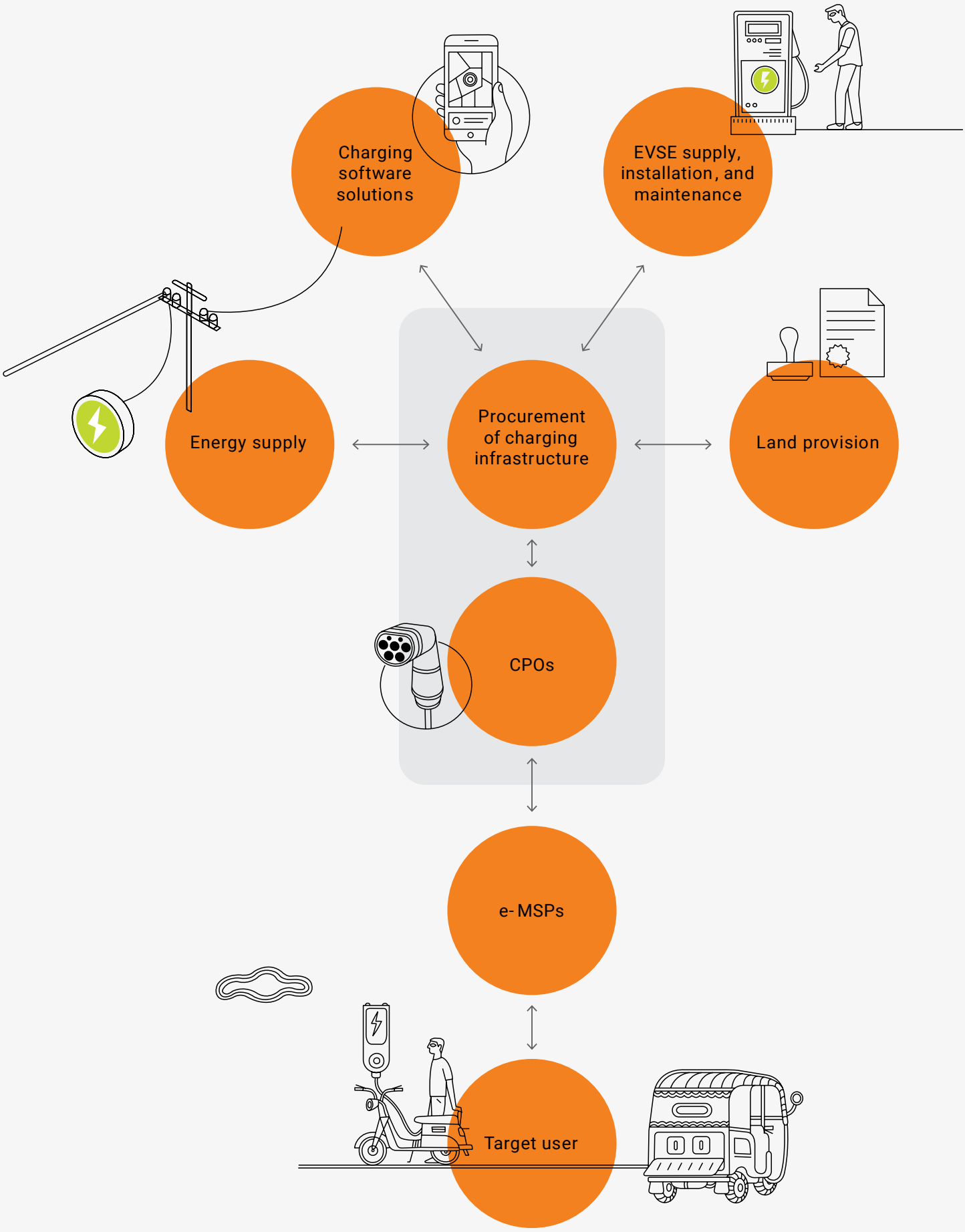
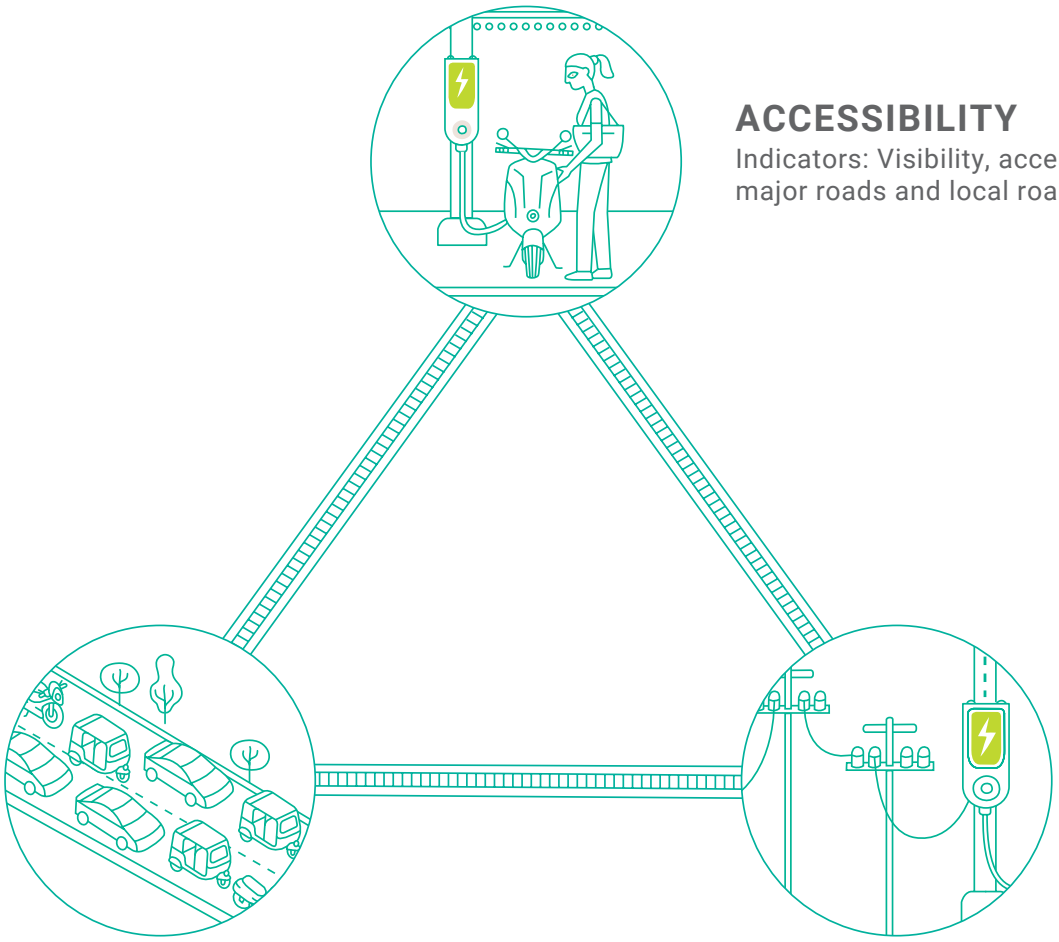


## 4.3 Planning and Allocation



**ACCESSIBILITY**
Indicators: Visibility, access from major roads and local roads, 24x7 access

**UTILIZATION**
Indicators: Population and employment densities, traffic volumes, point of interest, transit stations

**COST**
Indicators: Cost of EVSE, land, and power supply connection

### 4.3.1 Maximize Accessibility:

Accessibility may be understood as the ease of finding and getting to public charging facilities from any location. This includes areas of low estimated charging demand, which still need a minimum provision of charging infrastructure. Network planning and site selection play a role in improving EV charging accessibility. A greater number of distributed charging points in an area reduces the average distance EV users must travel to access public charging. Further, visibility of charging facilities, ease of entry and egress at charging sites, and their proximity to major roads can also influence their accessibility.

**4.3.2 Utilization:**

Indicators: Population and employment, densities, traffic volumes, point of interest, transit stations

**4.3.3 Accessibility:**

Indicators: Visibility, access from major roads and local roads, 24×7 access

**4.3.4 Cost:**

Indicators: Cost of EVSE, land, and power supply connection

# 5. The Essence of Effective EV Grid Integration

According to the Brookings India report, the EV penetration rate by 2030 at 33% is forecasted to be 37 TWh constituting less than 2% of total electricity demand across the country by 2030.

It is clear that fulfilling the total energy demand is not a challenge for India. However, the presence of spatial concentration linked with high charging EV capacities may result in substantial variations in the demand and distribution of power.

Incorporated with the distribution capacity, these bottlenecks at the local level can cause barriers to the seamless EV charging connection provisions. This can influence the stability of the grid for consumers of electricity. Here are some measures to enhance the existing grid infrastructure's utilization and integrate EV charging loads into electrical network expansion and planning.

### 5.1 Distributed Design of EV Charging Infrastructure

A concentration of charging points at one location, especially of high-power chargers, increases the load requirement for EV charging. This, in turn, can necessitate infrastructure upgrades when the permissible utilization threshold for a feeder is exceeded. Hence, it is recommended that charging infrastructure be implemented in a distributed manner to limit the power to demand charging at any location.

### 5.2 Passive Management of EV Charging Load

Passive EV charging management entails influencing the charging behavior of EV users through specially designed electricity tariff instruments. Time-of-Day (ToD) tariffs are designed so that EV charging is more expensive during peak hours, to reduce the overloading of the electricity grid. ToD tariffs are effective at managing EV charging loads without an excessive financial burden on EV owners or CPOs.

### 5.3 Active Management of EV Charging Load

Active charging management involves remotely controlled EV charging that responds to triggers like changes in the tariff, power demand, etc. Depending on the inputs, EV charging sessions can start or stop, and charging levels can ramp up or down automatically. “Smart chargers” with specific capabilities are needed to carry out active EV charging. Smart chargers can also handle passive management instruments like ToD tariffs and more dynamic regimes like Time-of-Use (ToU) tariffs, in which electricity tariffs are adjusted in real time based on demand. Employing passive and/or active EV charging management can unlock multiple system-wide benefits beyond optimal grid utilization. These include reduced electricity costs for consumers, improved integration of renewable energy in electricity supply, and more reliable and resilient grid services.

# 6. Conclusion

The constant depletion of fossil fuels and continuous hike in fuel prices, there is a need for the energy transition in vehicles in India. The Government of India has taken necessary initiatives to curb the pollution, CO2 and GHG emission levels by promoting EVs and giving subsidies on purchase. To boost its production, Govt has eased the FDI norms. Various emerging brands are launching EVs in India. The Government and manufacturers should join their hands to build the infrastructure and create positive environment for EVs. The respondents are aware of global climate conditions and are ready to change their preference from conventional to eco-friendly vehicles. Cost is an important factor while considering the purchase of an EV.

Respondents are willing to consider EVs as their future purchase option, if proper infrastructure is available. Initial cost of purchase, less number of charging stations, and the time required to recharge the battery is creating limitation in boosting consumer confidence. Bacancy's DC fast charger is set to disrupt the EV ecospace with its extendable - single/ dual (30 KW) and custom gun (upto 200KW) for achieving fast building fast DC chargers, saving the development time and cost to market.

Bacancy's extended venture Bacancy Systems is serving the e-mobility segment with its wide range of revolutionary future ready EV products like: Battery Management System, Motor Controller, CCS2 Controller and DC fast charger. If you are looking for EV infrastructure solutions, drop us a line at **systems@bacancy.com**