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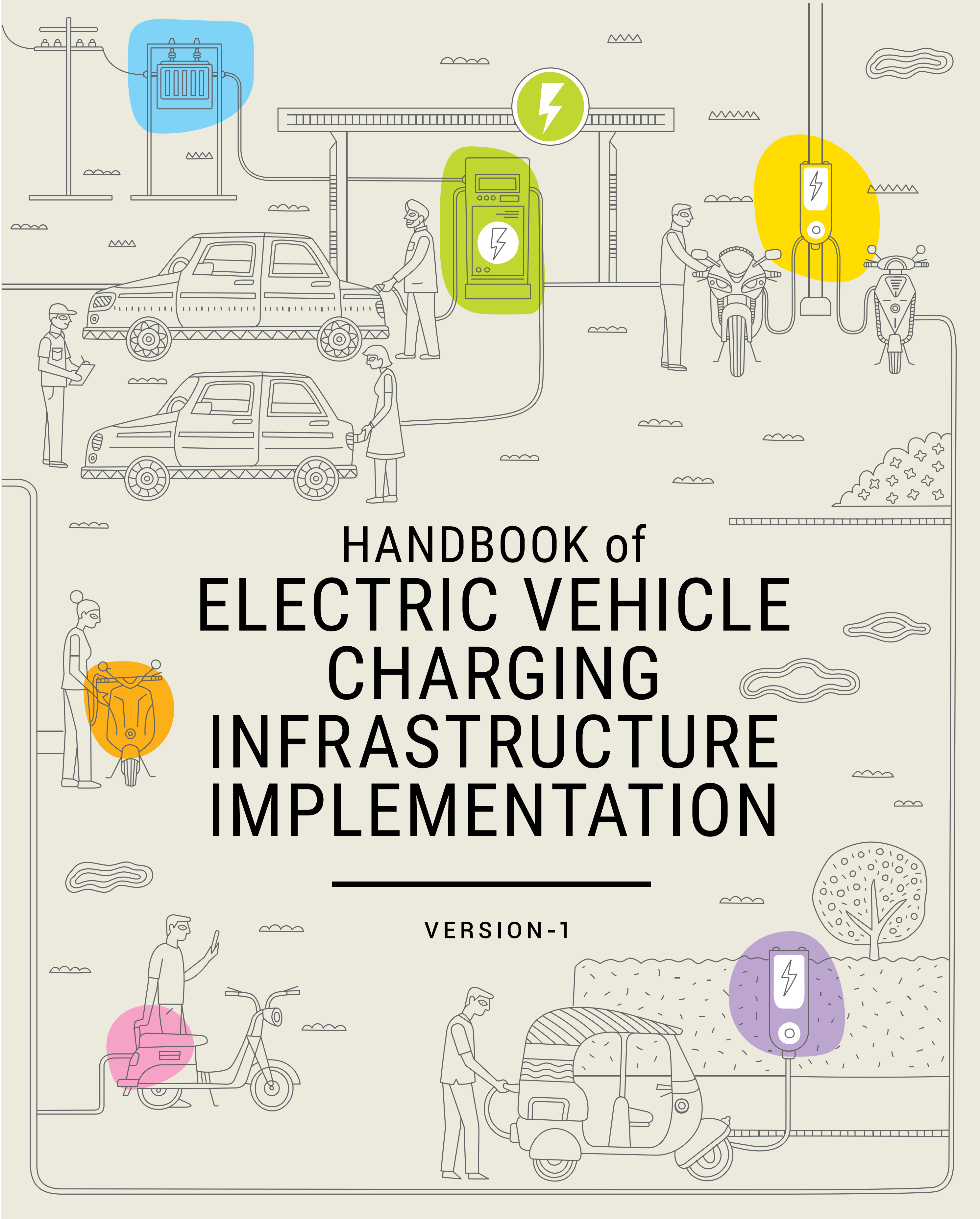
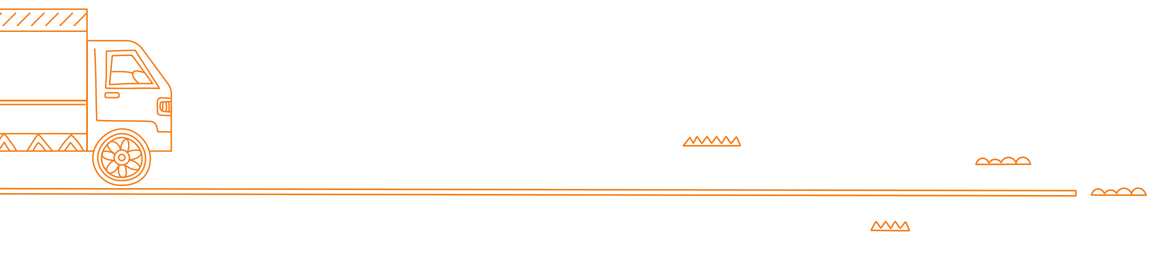


HANDBOOK of ELECTRIC VEHICLE CHARGING INFRASTRUCTURE IMPLEMENTATION

VERSION-1



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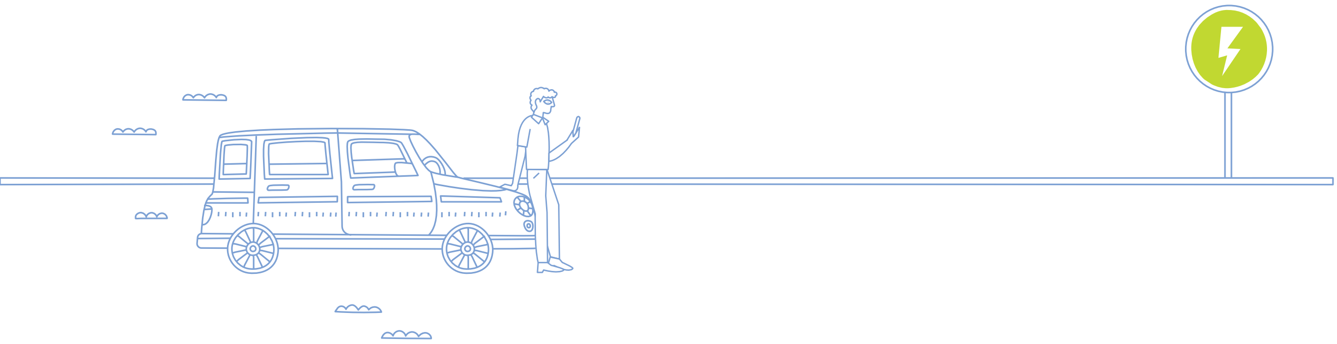

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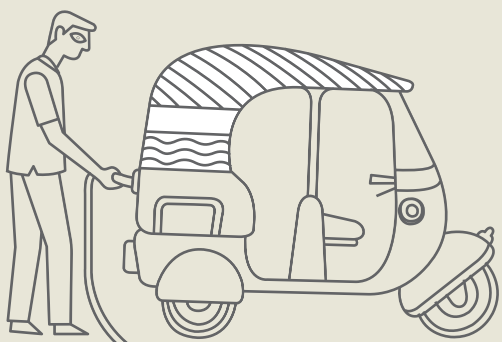

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LIST OF ABBREVIATIONS

2W: two-wheeler
3W: three-wheeler
4W: four-wheeler
AC: alternating current
BEE: Bureau of Energy Efficiency
BIS: Bureau of Indian Standards
CEA: Central Electricity Authority
CMS: Central Management System
CNA: Central Nodal Agency
CPO: charge point operator
C-rate: charge rate
DC: direct current
DDC: Dialogue and Development Commission of Delhi
DER: Distributed Energy Resources
DERMS: Distributed Energy Resources Management System
DHI: Department of Heavy Industry
DISCOMs: distribution companies
DT: distribution transformer
DTL: Delhi Transco Ltd
ECS: equivalent car space
EESL: Energy Efficiency Services Limited
e-MSPs: e-mobility service providers
EV: electric vehicle
EVCI: electric vehicle charging infrastructure
EVSE: electric vehicle supply equipment
FAME-II: Faster Adoption and Manufacturing of Electric Vehicles
FC: fast charger
GNCTD: Government of National Capital Territory of Delhi
HT: high tension
IEC: International Electrotechnical Commission
kV: kilovolt
kW: kilowatt
kWh: kilowatt hour
kWp: kilowatt peak
LCV: light commercial vehicle
LEV: light electric vehicle
MBBL: Model Building Byelaws
MCV: medium commercial vehicle
MoHUA: Ministry of Housing and Urban Affairs
MoP: Ministry of Power
MoRTH: Ministry of Road Transport and Highways
MoU: Memorandums of Understanding
OCPI: Open Charge Point Interface
OCPP: Open Charge Point Protocol
OEM: Original Equipment Manufacturer
OpenADR: Open Automated Demand Response
PCS: public charging station
PPAs: Power Purchase Agreements
PPP: public private partnership
PSU: Public Sector Undertaking
RTA: Regional Transport Authority
SC: slow charger
SERC: State Electrical Regulatory Commission
SLD: Service Line cum Development
SNA: State Nodal Agency
ToD: time-of-day
ToU: time-of-use
TWh: terawatt hours
UDA: urban development authority
ULB: urban local body
UMTA: Unified Metropolitan Transport Authority
UT: Union Territory

PURPOSE OF THE HANDBOOK

The transition to electric mobility is a promising global strategy for decarbonizing the transport sector. India is among a handful of countries that support the global EV30@30 campaign, which targets to have at least 30% new vehicle sales be electric by 2030.

An accessible and robust network of electric vehicle (EV) charging infrastructure is an essential pre-requisite to achieving this ambitious transition. The Government of India has instituted various enabling policies to promote the development of the charging infrastructure network. However, given the novel characteristics of this new infrastructure type, there is a need to customize it to the unique Indian transport ecosystem and build capacity among stakeholders to support its on-ground expansion. A contextual approach is needed to ensure the efficient and timely implementation of EV charging infrastructure, such that it meets local requirements and is optimally integrated within the electricity supply and transportation networks.

The Handbook for Electric Vehicle Charging Infrastructure Implementation - Version 1 offers a systematic approach that guides implementing authorities and stakeholders on planning, authorization, and execution of EV charging infrastructure. It presents an overview of the technological and regulatory frameworks and governance structures needed to facilitate EV charging, along with a step-by-step approach to build out the implementation roadmap. While the handbook focuses on the present needs of charging infrastructure development, it also touches upon considerations for future planning.

The primary audience for this handbook include public and private sector stakeholders that are responsible for charging infrastructure implementation, such as electricity distribution companies, municipal corporations, urban development authorities, and charge point solutions providers and operators. The secondary audience is the regulatory authorities in state and central government agencies responsible for creating an enabling governance framework to support implementation.

The handbook is expected to be a living document, and it will be updated on a periodic basis as the characteristics and needs of the dynamic EV market evolve.

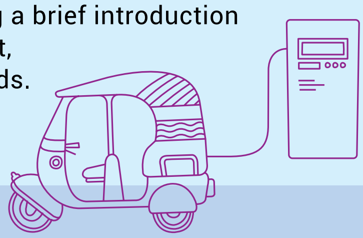
EXECUTIVE SUMMARY

The handbook provides a step-by-step approach to build out the EV charging infrastructure roadmap, moving from an assessment of EV charging requirements to location planning and arranging electricity supply to models of on-ground implementation.

A summary of the different chapters is provided here.

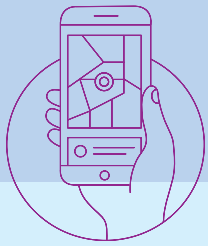
Chapter 1

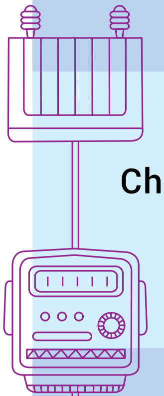
Orients the reader to EV charging infrastructure, providing a brief introduction to technical concepts of electric vehicle supply equipment, AC and DC charging, power ratings, and charging standards.



Chapter 2

Lays out the governance structure of the EV charging ecosystem by identifying the regulatory and executive government agencies involved in charging infrastructure implementation, and by defining the roles of charge point operators and e-mobility service providers.



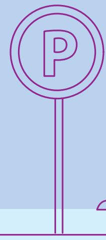


Chapter 3

Initiates the planning process with an overview of the access- and demand-based approaches for setting targets (for number of public chargers required), and defines a methodology for assessing energy demand for public EV charging.

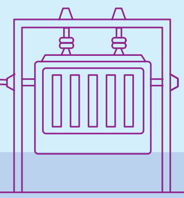
Chapter 4

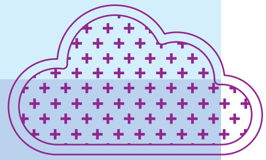
Covers the location and site planning aspects for EV charging, by framing the principles of location planning and demonstrating a methodology for spatial allocation of charging demand, and identifies enabling processes and policies to integrate public charging in urban planning.



Chapter 5

Focuses on supply of electricity for charging infrastructure, familiarizing readers with the regulations that govern electricity supply for EV charging, the role of DISCOMs in provision of EV charging connections, and the three methods of arranging for power supply for charging infrastructure.



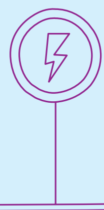


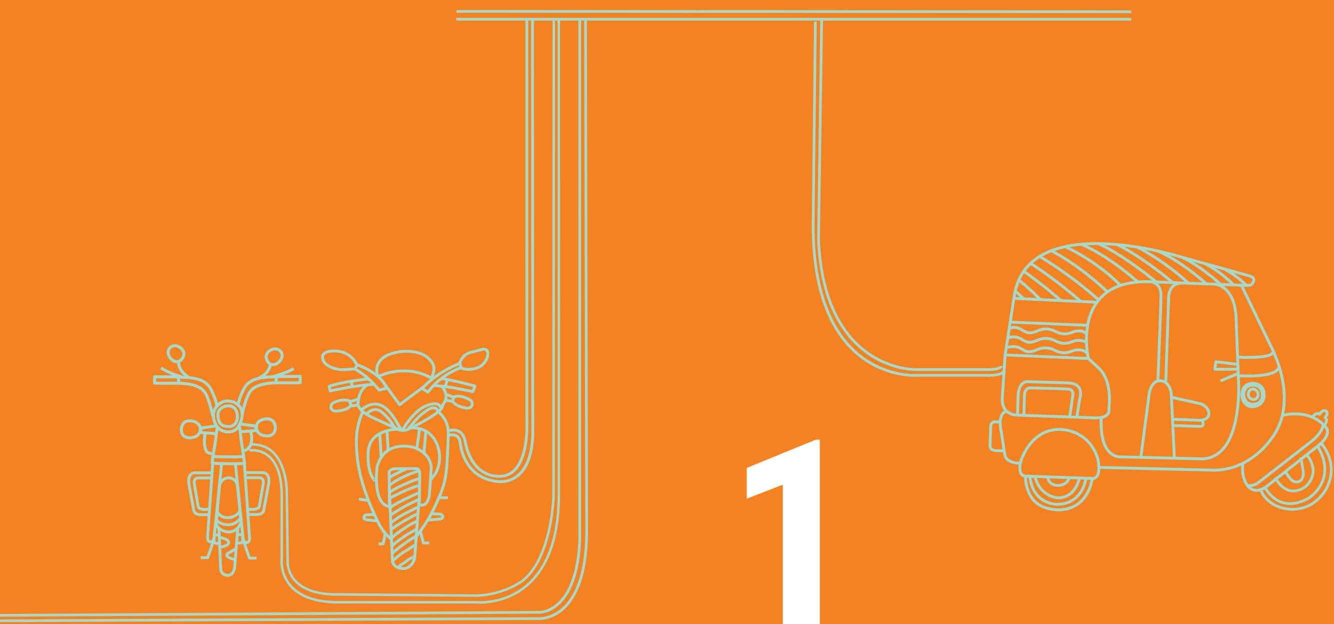
Chapter 6

Zooms out from site-level considerations for supply of electricity to assess grid-level impacts, and then highlights the need for smart charging to minimize adverse impacts of EV charging loads on the grid.

Chapter 7

Defines the typical roles within an implementation model for EV charging infrastructure and identifies three models in India – the government-driven model, the consumer-driven model and the charge point operator-driven model – for charging infrastructure implementation.





1

AN OVERVIEW OF EV CHARGING INFRASTRUCTURE

Electric vehicles (EV) can be charged in a variety of ways, depending on location and requirement. Accordingly, charging infrastructure for EVs is of different types and designed for different applications. Specifications and standards for EV chargers, also known as electric vehicle supply equipment (EVSE), vary from one country to another, based on available EV models in the market and the characteristics of the electricity grid.

This chapter explains the technical concepts of electric vehicle charging infrastructure, and highlights the need for a contextual approach to local planning and implementation of EV charging networks.

1.1

CHARACTERISTICS OF EV SUPPLY EQUIPMENT

Electric vehicle supply equipment (EVSE) is the basic unit of EV charging infrastructure. The EVSE accesses power from the local electricity supply and utilizes a control system and wired connection to safely charge EVs. An EVSE control system enables various functions such as user authentication, authorization for charging, information recording and exchange for network management, and data privacy and security. It is recommended to use EVSEs with at least basic control and management functions, for all charging purposes.

Conductive charging, or plug-in (wired) charging, is the mainstream charging technology in use. Requirements of EVSE for conductive charging depend on factors such as vehicle type, battery capacity, charging methods, and power ratings.

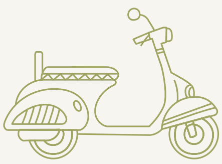
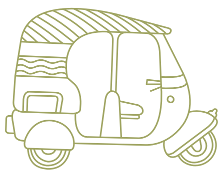
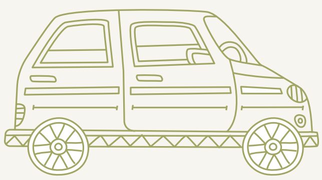
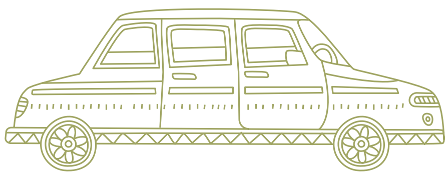
1.1.1
BATTERY SPECIFICATIONS OF DIFFERENT EV SEGMENTS

In India, transport electrification over the next decade is expected to be driven by light electric vehicles (LEVs), comprising two-wheelers (scooters, motorcycles) and three-wheelers (passenger and cargo). Apart from these, cars and light commercial vehicles (LCVs) are the other key vehicle segments being electrified. Electric buses will also be present in significant numbers but are not included in the scope of this handbook.

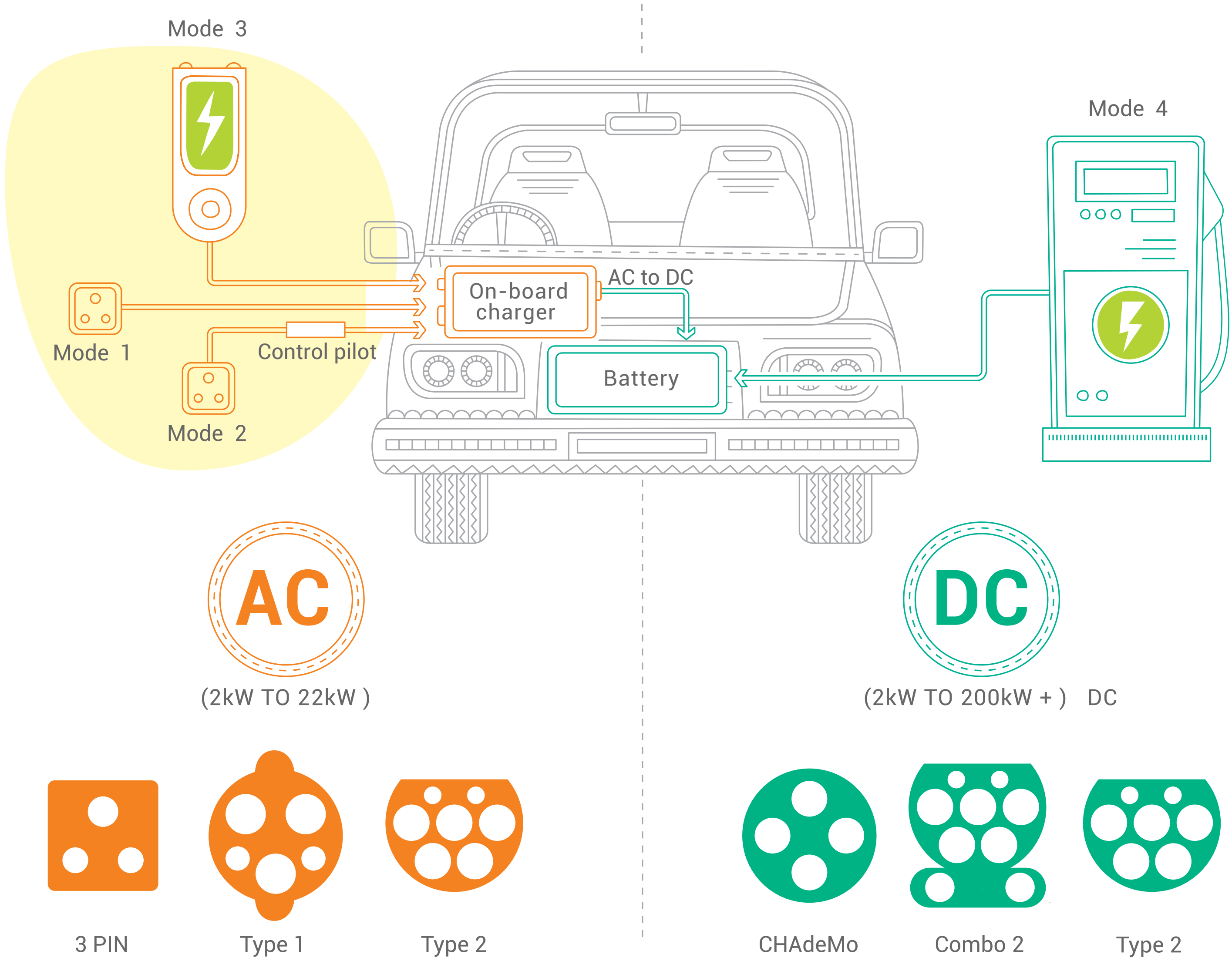
EV charging requirements depend on the specifications of EV batteries, as power must be supplied to the battery at the right voltage and current levels to permit charging. Typical capacity and voltage of EV batteries vary among the different EV segments, as shown in Table 1.

E-2Ws and e-3Ws are powered by low-voltage batteries. The first generation of e-cars is also powered by low-voltage batteries. However, these are likely to be phased out in the future, even if they continue in specific use cases such as taxis. The second generation of e-cars, as seen in the upcoming e-car models, is powered by high-voltage batteries. Electric LCVs will comprise of both low-voltage and high-voltage vehicles, depending on their load-carrying capacity.

TABLE 1: TYPICAL BATTERY SPECIFICATIONS FOR DIFFERENT EV SEGMENTS

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

Source: Compiled from market data of available EV models (as of July 2021)



1.1.2

CHARGING METHODS AND POWER RATINGS

EV charging involves supply of direct current (DC) to the battery pack. As electricity distribution systems supply alternate current (AC) power, a converter is required to provide DC power to the battery.

Conductive charging can be AC or DC. In the case of an AC EVSE, the AC power is delivered to the onboard charger of the EV, which converts it to DC. A DC EVSE converts the power externally and supplies DC power directly to the battery, bypassing the onboard charger.

AC and DC charging are further classified into four charging modes, with Modes 1-3 pertaining to AC charging and Mode 4 pertaining to DC charging.

Modes 1 and 2 are applicable for connecting an EV to a standard socket outlet, utilizing a cable and plug. Mode 1, also known as dumb charging, permits no communication between the EV and EVSE and its use is not recommended. The portable cable used in Mode 2 has an inbuilt protection and control capability and is typically used for home charging. Modes 3 and 4, which provide a separate charger device to supply power to the EV, have improved control systems and are used for commercial or public charging

TABLE 2:
EVSE POWER RATINGS

	Power level	Current type	Compatible EV segments
Normal power charging	P ≤ 7kW	AC & DC	E-2Ws, e-3Ws, e-cars, other LCVs (up to 1 ton)
	7kW < P ≤ 22kW	AC & DC	
High power charging	22kW < P ≤ 50kW	DC	E-cars, LCVs and MCVs (1-6 tons)
	50kW < P < 200kW	DC	

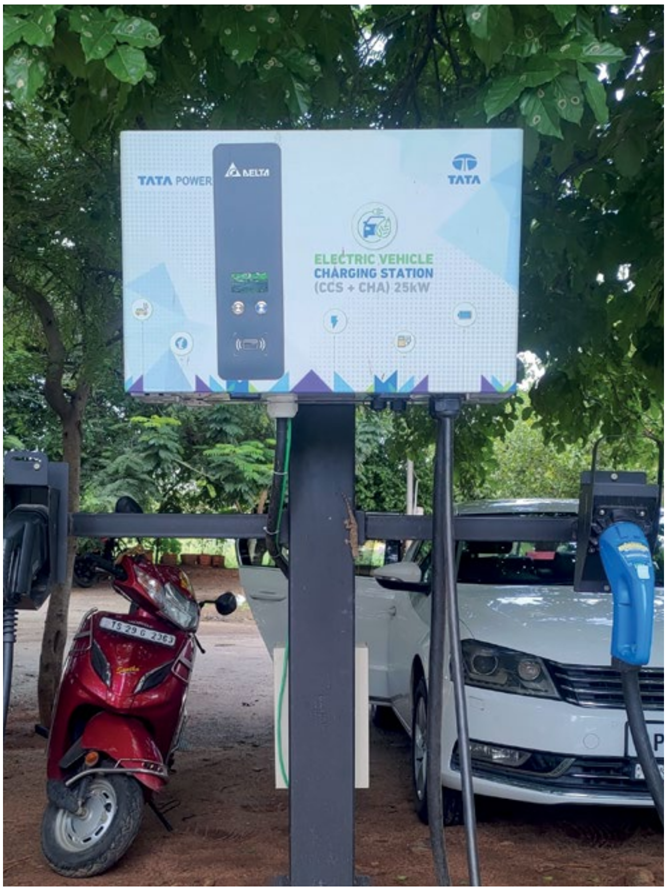
POWER RATINGS

EVSEs have different power ratings or levels based on charging requirements, which in turn determine the input power requirements for charging infrastructure.

Table 2 categorizes EV charging by power level, with normal power charging going up to 22kW and high-power charging going up to 200kW. While EVSEs with power ratings up to 500kW are globally available, they are largely applicable for heavy vehicles like buses and trucks.

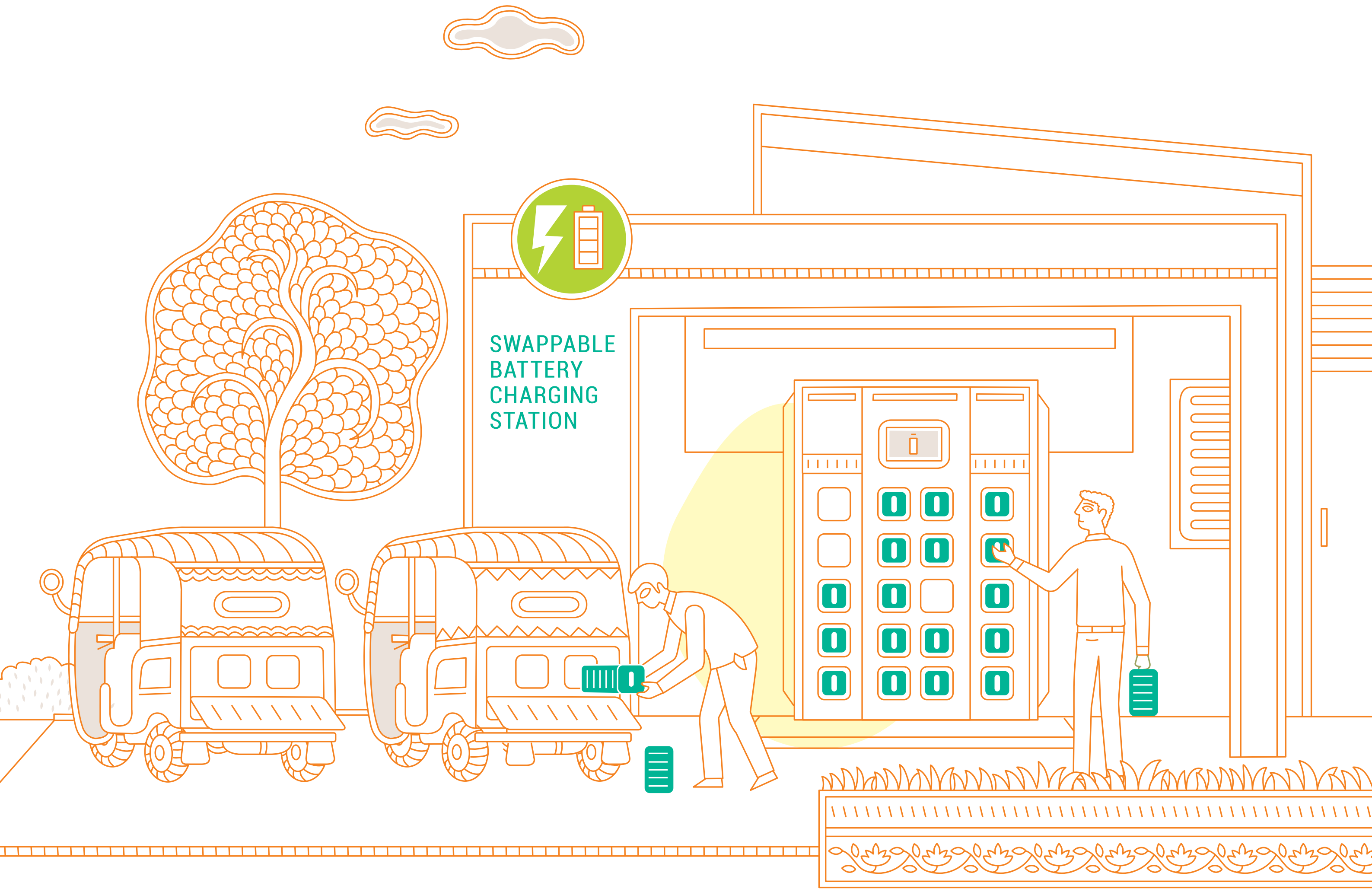
Normal power AC charging is adequate for e-2Ws, e-3Ws and e-cars. Normal power DC charging is unique to India, due to the prevalence of LEVs, and the use of low-voltage batteries in e-cars. Single-phase AC chargers, with a maximum power rating of 7kW, are adequate for LEVs and cars with single phase on-board chargers. Three-phase AC chargers, with a power rating up to 22kW, are required for e-cars with larger on-board chargers. Input power supply for normal power charging can be provided from the standard electricity distribution network.

For high-voltage e-cars with battery capacities between 30-80kWh, high-power DC charging of 50kW is used. The power level of DC chargers in the market ranges between 25kW and 60kW. However higher-powered DC chargers will be available in the near future. While high-power DC charging takes less time for e-cars, it requires higher electricity supply with additional infrastructure. Normal power charging points are therefore adequate for most charging requirements, including slow or overnight charging of e-cars.



1.1.3
BATTERY SWAPPING

An alternative battery recharging method that is receiving global attention is battery swapping, in which a depleted EV battery is removed from the vehicle and replaced with a fully charged one. The technology is being tried out for various EV segments, including e-2Ws, e-3Ws, e-cars and even e-buses.



TYPES OF BATTERY SWAPPING

Manual:
The battery swapping station is a standalone device, in which batteries are placed and removed manually from the individual slots, usually by hand. Manual swapping stations are modular and occupy a minimal amount of space. These are used for 2W and 3W battery applications, as the battery pack sizes are smaller and the weight can be handled by one or two persons.

Autonomous:
A robotic arm is used in these types of swapping stations with the battery swapping process being semi/fully automated. Robotic swapping is used for 4W and e-bus applications as battery packs are larger and heavier, and require mechanical assistance. These swapping stations are also more expensive and have a higher land requirement.

Battery swapping has some distinct advantages over plug-in charging but is also confronted with several challenges in its development as a mainstream charging method (see Table 3 below).

TABLE 3:
ADVANTAGES AND CHALLENGES OF BATTERY SWAPPING

Advantages	Barriers
EV recharging is completed in minutes	Lack of standardization among EV batteries
Batteries can be charged away from swapping point, allowing more freedom in setting up swap facilities	Unsuitable battery pack design to enable ease of swapping (weight, dimensions and ergonomics)
Reduction in upfront cost of EV, as battery ownership is replaced by battery leasing	Greater number of batteries needed to power same number of EVs
Increased predictability of battery life due to controlled charging conditions	Shorter commercial life of battery packs due to customer preference for new batteries with higher range
-	Slow adoption of charging method by OEMs
-	Higher costs of battery leasing over the life of the EV
-	Higher GST on separate battery (18%) vs battery sold with EV (5%)

At present, battery swapping is considered a feasible solution for commercial EV fleets, especially in the e-2W and e-3W segments. The Ministry of Road Transport and Highways (MoRTH) has allowed the sale and registration of EVs without batteries, which provides a huge boost to battery swapping solutions. Further, industry stakeholders are making large investments in developing the battery swapping ecosystem. This indicates that battery swapping will emerge as a distinct part of EV charging networks in India in the coming years.

1.2

EV CHARGING STANDARDS FOR INTEROPERABILITY

Standards ensure interoperability and compatibility of any EVSE with all EVs. The Bureau of Indian Standards (BIS), the national standards body of India, is responsible for formulating EV charging standards for the country. BIS is a member of the International Electrotechnical Commission (IEC), which is the global body that is developing reference standards to ensure interoperability and minimize trade barriers for electric vehicles and their components. While Indian standards for EV charging are compliant with global standards, local climate considerations and the difference in vehicle types available in the country necessitate modifications that are specifically applicable to India.

INDIAN STANDARDS FOR AC CHARGING

IS 17017 is the key EV charging standard in India comprising three parts and six sections. IS-17017-Part-1 provides the basic features of all EV charging systems. An AC EVSE must adhere to this standard, and specific AC connector standards in the IS-17017-Part-2.

Both AC and DC EVSE need to conform to the technical standards IS-17017-Parts 21 & 22.

Additional Indian standards for AC EVSEs have been approved for light EVs and e-cars (in the form of low-cost charging points), for use in parking areas.

INDIAN STANDARDS FOR DC CHARGING

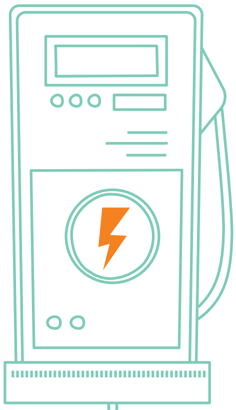
IS-17017-Part-23 describes the requirements for DC charging stations, with power output of 50kW to 200kW. Beyond this, high power charging standards are required to cater to buses and other heavy vehicles. Recently, the BIS has finalized the IS-17017-Part-25, which is specifically for providing low DC power of less than 7kW for light EVs.

Due to the requirement of digital communications between the DC EVSE and the EV, data communication standards are specified in IS-17017-Part 24. When the Combined Charging System (CCS) standard is deployed, which can provide both AC and DC charging, communications will be as per the IS-15118 series.

INDIAN STANDARDS FOR BATTERY SWAPPING

Separate projects have been initiated for battery swapping standards for LEVs and buses. They will be two series of standards documents, covering the form factor of the battery pack, inter-operable connection systems, communication between the battery management system (BMS) and the EV and charging station, and network management. Any EV may utilize a battery pack conforming to these standards. The removable battery packs can be charged using AC or DC charging systems.

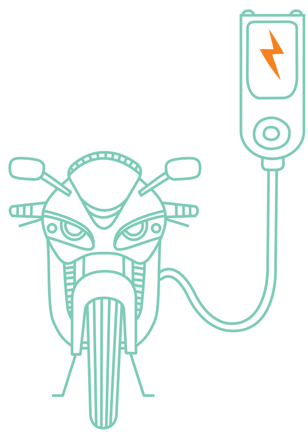
The BIS is yet to develop Indian standards for EV roaming and grid-related management functions.



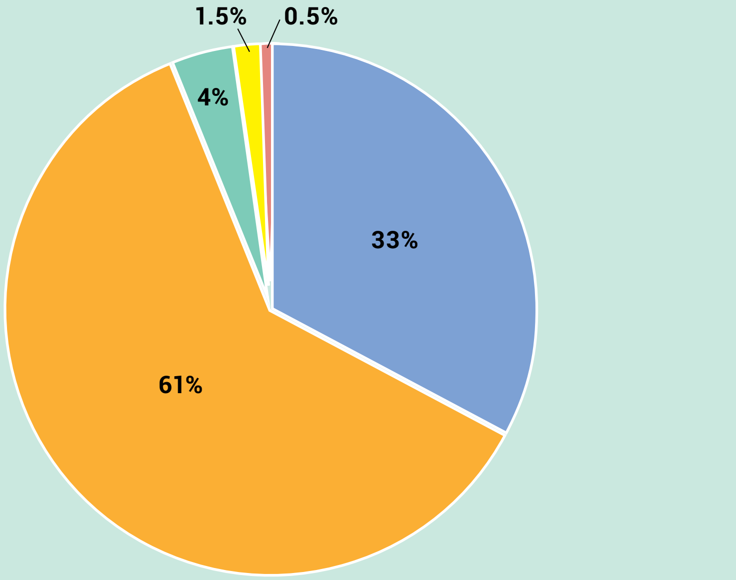
1.3

FROM CHARGING STATIONS TO CHARGING POINTS

Charging stations refer to high-power EVSE, typically Mode 3 or Mode 4 charging, often with multiple charging guns. Charging points refer to normal power EVSE that can be accessed by a portable charging cable. While the initial deployment of public charging infrastructure in India focused on charging stations, it is increasingly evident that most public charging needs can be served by a densely distributed network of charging points (as seen in Box A).



PUBLIC CHARGING POINTS BY POWER RATING



BOX A: PUBLIC CHARGING POINTS IN THE EU

Normal power charging points comprise the major share of all charging points among European countries. By end-2019, public charging points in the EU numbered about 175,000. Of these, normal power charging points comprised 94%, while high power and ultra-high power charging points only comprised the remaining 6%.

An EV charging network comprising many normal-powered charging points is preferable to one with limited high-power charging stations. For EVs, any parking location where the vehicle is stationary, and which has access to an EV charging point, can be an opportunity to recharge the vehicle battery. This is also known as destination charging, as opposed to “on-the-go charging” in which vehicles rapidly top up their battery charge to drive onwards to their destinations. Therefore, EV charging infrastructure should be provided in locations where vehicles are parked on a regular basis, rather than carving out new locations for EV charging hubs.

This approach to charging infrastructure implementation promotes a distributed network of EV charging points for users to plug into at various locations - at residences, apartment buildings, office campuses, shopping malls, metro and railway stations, bus depots, etc. Such a distributed network approach has multiple advantages for users and operators, ranging from ease of access to financial viability.

EASE OF ACCESS TO EV CHARGING

By providing EV charging points at locations where vehicles tend to park, EV users can charge their vehicles while they are parked, thereby saving time, and eliminating the distance one must travel to access public charging.

USE OF NORMAL POWER CHARGING POINTS

A dense network of normal-power EV charging points reduces the need for high power and ultra-high power charging points, which are more expensive and can be detrimental to EV battery health if over-used.

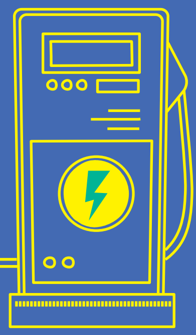
COST-EFFICIENCY OF CHARGING INFRASTRUCTURE

Normal power charging points are not only less expensive, but they also require less electricity and less space, which further reduces capital costs. They can be connected to low-voltage single- and three-phase distribution networks, which are widely available in buildings and public spaces.

FINANCIAL VIABILITY OF EV CHARGING

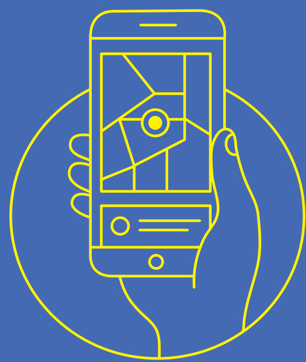
Lowering the upfront costs of setting up charging infrastructure reduces the need for government subsidies and improves the viability of private sector participation in charging operations.

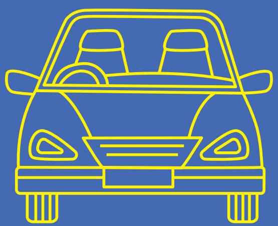
An efficient rollout of EV charging infrastructure for a young EV market needs to focus more on increasing the number of accessible charging points. The distributed provision of many normal power charging points, supplemented by a small share of high-power charging stations, can ensure that EV charging needs are efficiently met.



2

MULTI-STAKEHOLDER GOVERNANCE OF EV CHARGING





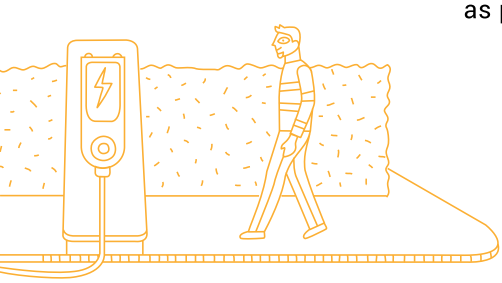
The EV charging ecosystem comprises of multiple components and processes – the provision of land and supply of electricity for EV charging, specification and installation of EV charging equipment, day-to-day operations and maintenance of EV charging facilities, and services allowing EV owners to use charging facilities.

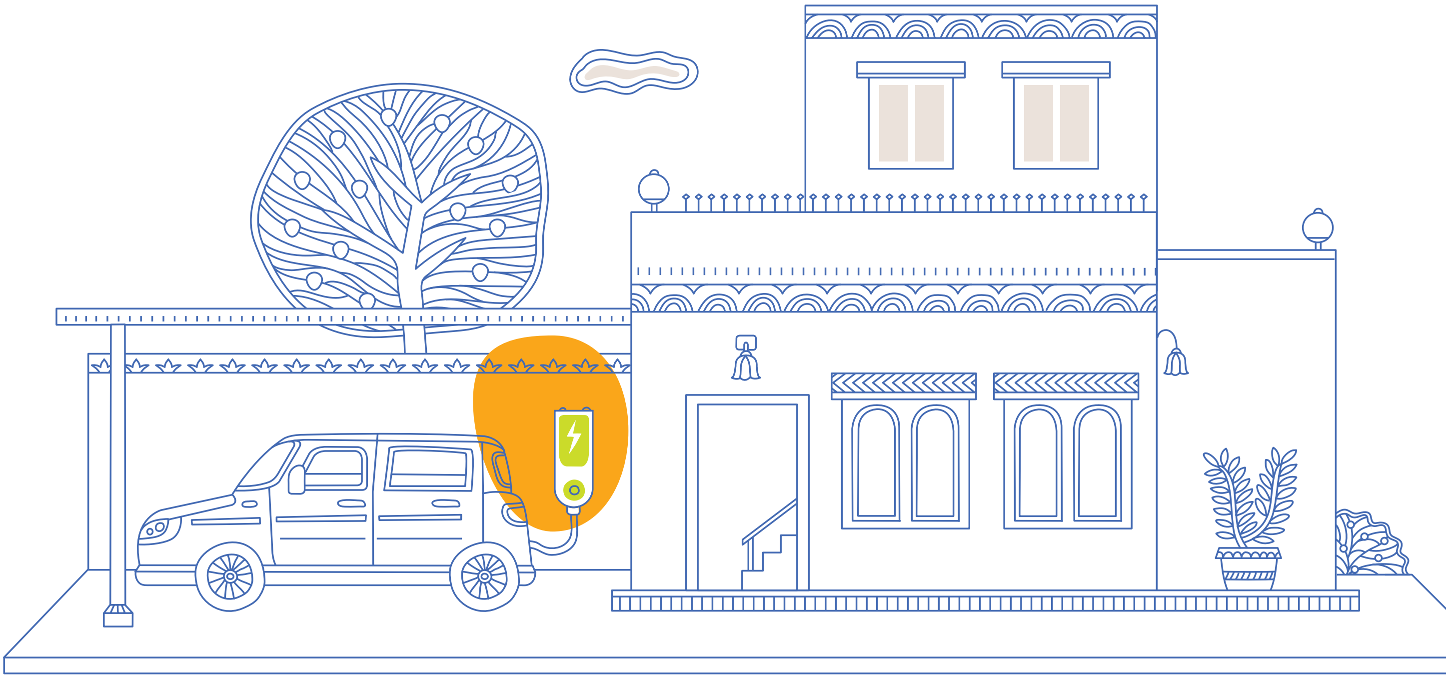
This chapter identifies the public and private stakeholders responsible for the governance of EV charging, and highlights the need for coordination between stakeholder groups for comprehensive planning and implementation of charging networks.

2.1

CLASSIFICATION OF EV CHARGING INFRASTRUCTURE

Broadly speaking, the governance of EV charging infrastructure depends on its ownership and use. Broadly, EV charging infrastructure can be classified as public, semi-public and private.





PRIVATE CHARGING

Usage: Dedicated charging for personal EV or EV fleet owned by one entity

Locations: Independent homes, dedicated parking spots in apartments/offices; for fleets – any location with land availability

Ownership: Individual EV owners, EV fleet owners/ operators

Operation: Self-operated or CPO-managed (for EV fleet charging)

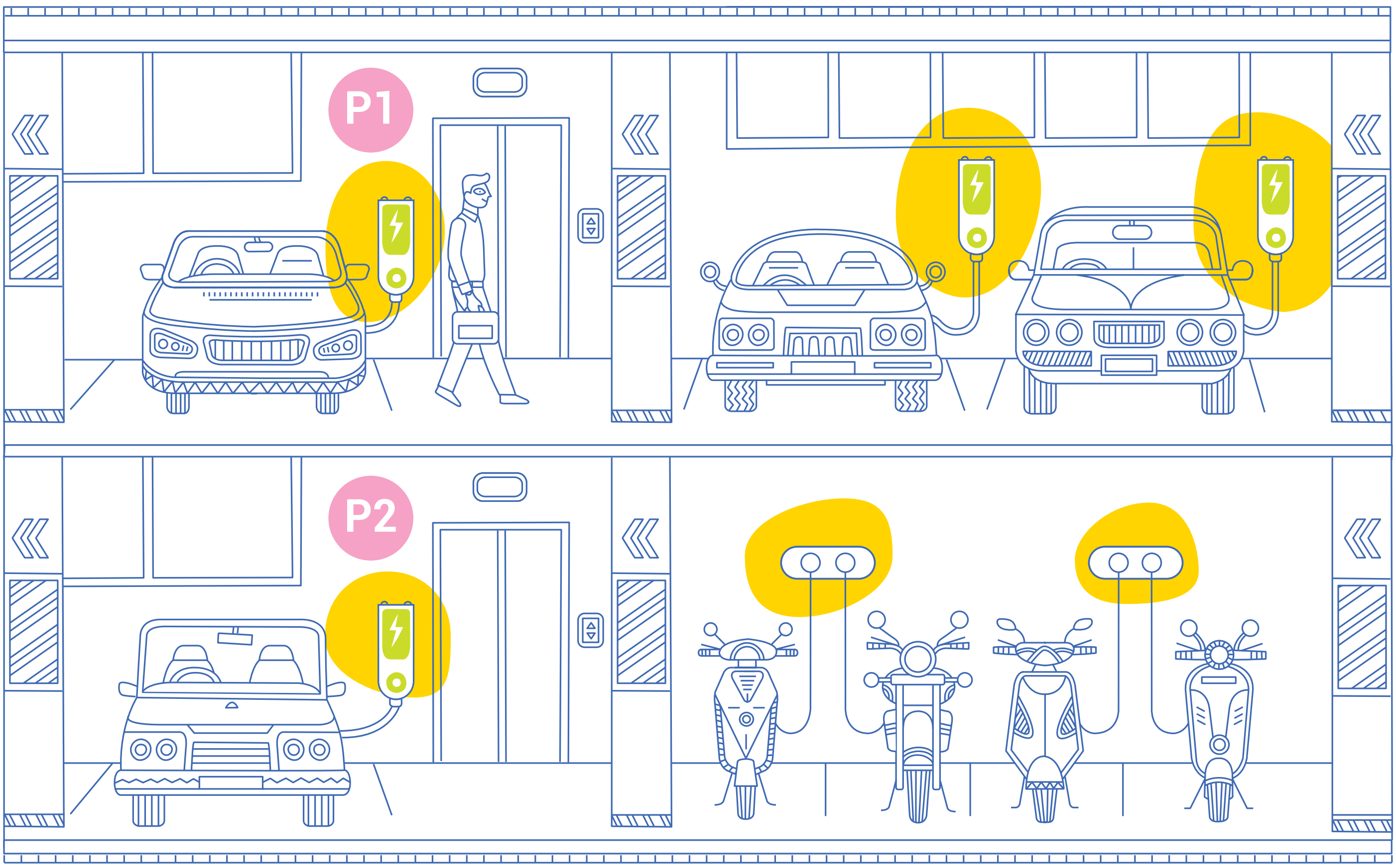
SEMI-PUBLIC CHARGING

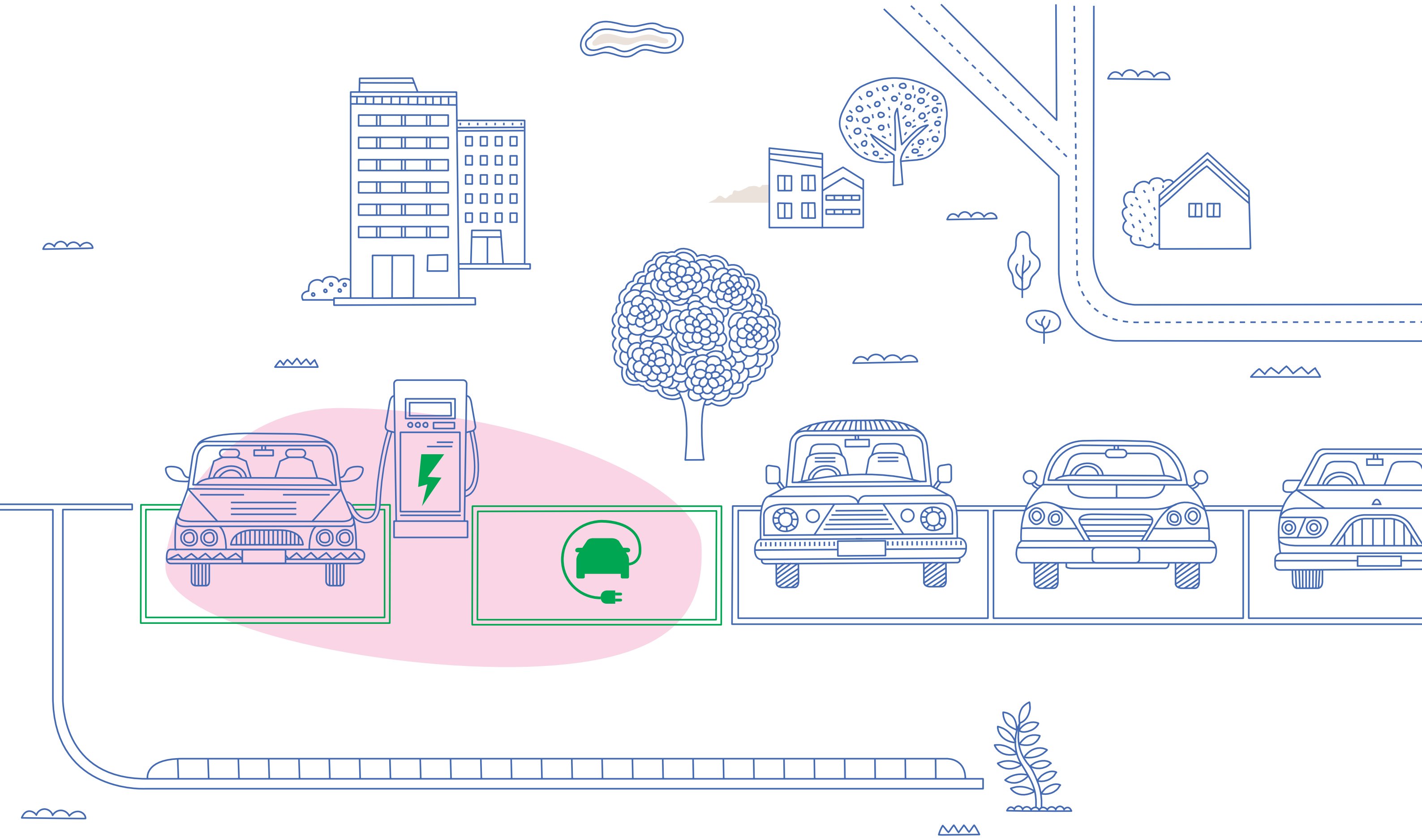
Usage: Shared charging for a restricted set of EV users

Locations: Apartment complexes, office campuses, gated communities, shopping malls, hospitals, universities, government buildings, etc.

Ownership: Host properties, Orginal Equipment Manufacturers (OEMs) & Charge Point Operators (CPOs)

Operation: CPO-managed





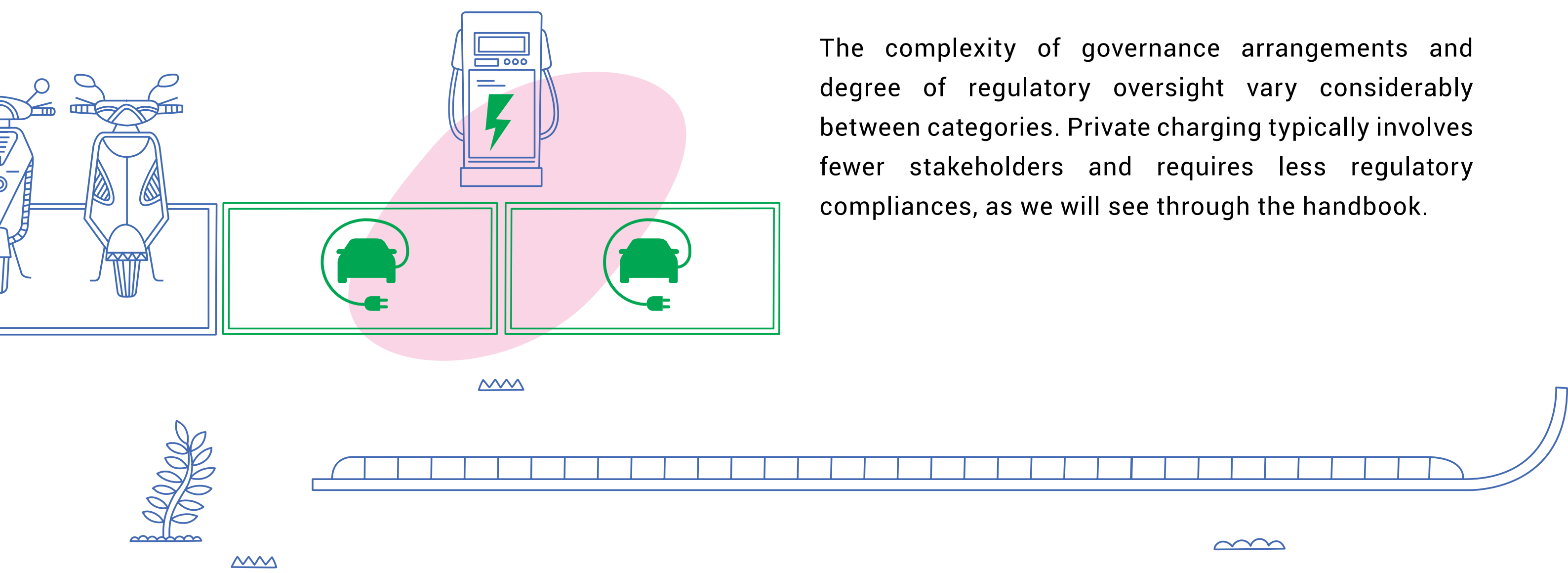
PUBLIC CHARGING

Usage: Open for all EV users

Locations: Public parking lots, on-street parking, charging plazas, petrol pumps, highways, metro stations

Ownership: Municipal authorities, PSUs, CPOs, host properties

Operation: CPO-managed



These are not fixed categories and some charging facilities may demonstrate hybrid characteristics. For instance, charging infrastructure owned by EV fleet owners/operators for captive use is considered private, but it can be opened to the public as a paid charging service when fleets are in circulation. EV charging infrastructure at bus depots or metro station parking may be semi-public or public, depending on whether they are open only for transit users or for all EV users.

The complexity of governance arrangements and degree of regulatory oversight vary considerably between categories. Private charging typically involves fewer stakeholders and requires less regulatory compliances, as we will see through the handbook.

2.2

ROLES AND RESPONSIBILITIES OF GOVERNMENT STAKEHOLDERS

Many government bodies at the center, state, and local levels are responsible for governance of EV charging. The roles played by these bodies can be categorized as policy-making and regulatory functions, and executive or implementing functions.

2.2.1

POLICY-MAKING AND REGULATORY AUTHORITIES

These government bodies are responsible for formulating policies, making regulations, and establishing standards and specifications for EV charging infrastructure.

The supply of electricity is a key requirement for implementation of charging infrastructure. Electricity being a subject on the Concurrent List of the Constitution, both central and state-level bodies are involved in regulating electricity supply for EV charging.

- The **Ministry of Power (MoP)** issued the Charging Infrastructure Guidelines and Standards for public charging infrastructure, which laid out an enabling framework for implementation. In its capacity as a legislative authority, the MoP clarified that the operation of EV charging services did not require licensing under the Electricity Act 2003.

- The **Central Electricity Authority (CEA)** is responsible for defining technical standards and regulations for EV charging.

- The **State Electrical Regulatory Commissions (SERCs)** set the EV tariff and other regulations concerning electricity supply for EV charging.

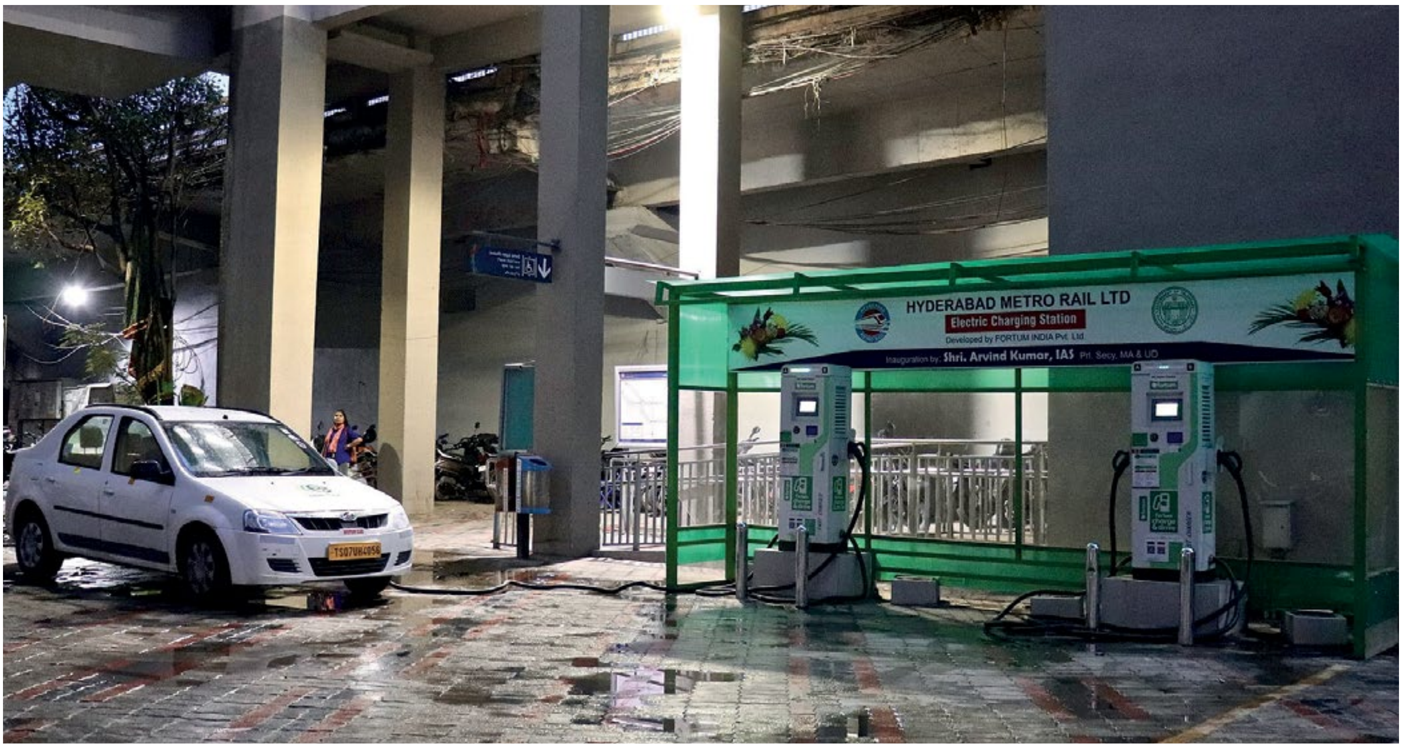
Another important input parameter for setting up EV charging is the provision of land or parking spaces to locate charging facilities. Land and urban development are mandates of state governments, with urban development further devolved to municipal corporations in many regions.

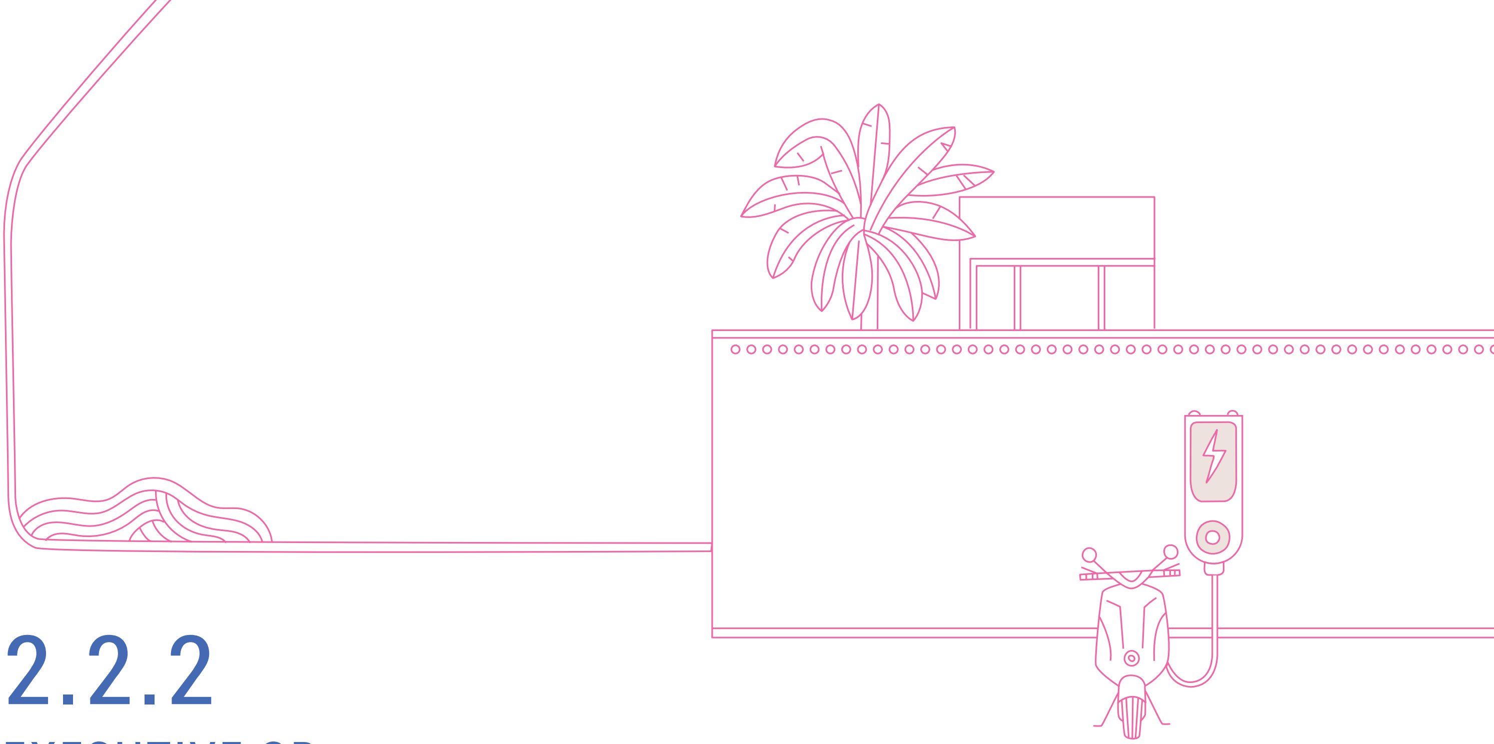
- The **Ministry of Housing and Urban Affairs (MoHUA)** amended the Model Building Byelaws 2016 and the Urban and Regional Development Plans Formulation and Implementation Guidelines 2014 (URDPFI) to include provisions for EV charging. These are recommended amendments for states to implement.

- The **Urban Development Departments** at the state level are responsible for amendments to the building byelaws and other urban planning frameworks as suggested by MoHUA.

- Where authority is further devolved, it is the **urban development authorities (UDAs**) or the municipal corporations that are responsible for amendments to building byelaws and urban planning frameworks to include provisions for EV charging.

Apart from land and electricity supply, EV charging standards are defined by the **Bureau of Indian Standards (BIS)**, the standards-making body of the country. Annexure A provides a detailed overview of GoI notifications, guidelines, and regulations for EV charging infrastructure.





2.2.2

EXECUTIVE OR IMPLEMENTING AUTHORITIES

Government bodies with executive roles are responsible for the day-to-day governance of EV charging infrastructure, which includes functions of planning, permitting, and supporting implementation of EV charging.

The MoP designated the **Bureau of Energy Efficiency (BEE)** as the central nodal agency (CNA) for the rollout of EV public charging infrastructure implementation across the country. The **Department of Heavy Industry (DHI)** is the other central agency involved in implementation of public charging. It is responsible for administering the FAME-II scheme, which includes subsidies for public EV charging infrastructure.

Under the MoP's direction, states have nominated **state nodal agencies (SNAs)** to govern the implementation of public charging. SNAs are mandated to select implementing agencies to install, operate and maintain public charging stations and battery swapping/ charging facilities in the state. Unless otherwise specified by the state, state electricity distribution companies (DISCOMs) are the SNAs by default. A complete list of SNAs is provided in Annexure B.

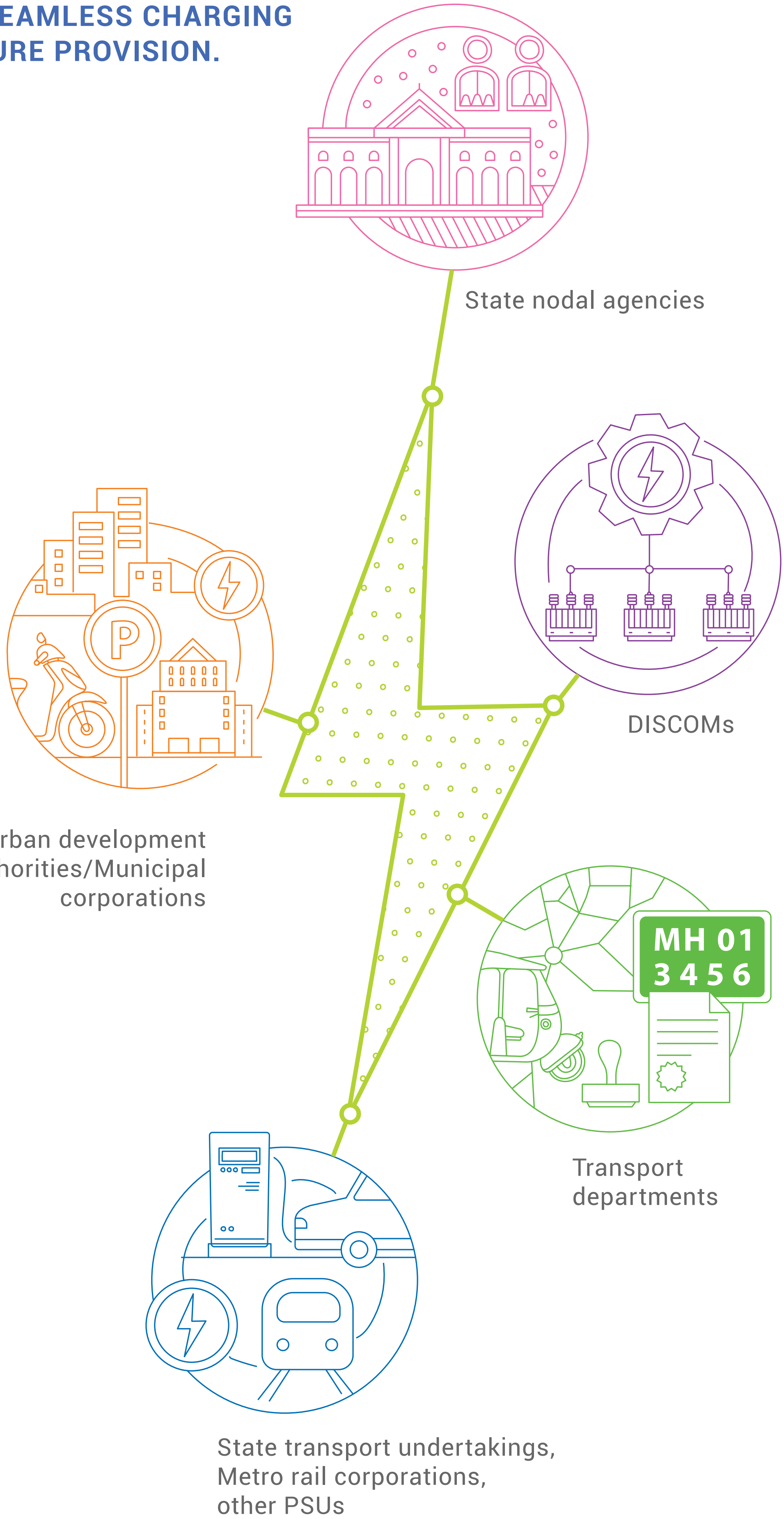
At the local level, DISCOMs and urban local bodies (ULBs) are responsible for planning, permissions, approvals, and certifications needed for EV charging infrastructure. ULBs include municipal corporations, municipal councils and any other statutory governing bodies at the city level. They are responsible, alongside UDAs in some cases, for approving building permits, enforcing building byelaws, and managing public parking (prime location for public EV charging).

DISCOMs are responsible for providing electricity connections for EV charging, implementing the EV tariff established by SERCs, ensuring that EV charging infrastructure is connected and operating properly, preventing improper use of EV connections, managing the distribution network, and undertaking grid upgrades based on growth in load including from EV charging.

In cities where **unified metropolitan transport authorities (UMTAs)** are operational, they may support the SNAs and ULBs with planning measures for public charging infrastructure.

Apart from these, land-owning government agencies are often called upon to provide land parcels for setting up public EV charging facilities. Further, the **state and regional transport authorities (RTAs)** are important stakeholders in planning for public charging infrastructure, as they have information on EV penetration trends in the city or region through vehicle registration data.

IMPLEMENTING AUTHORITIES AT THE STATE AND LOCAL LEVELS NEED TO WORK CLOSELY TOGETHER IN ENABLING SEAMLESS CHARGING INFRASTRUCTURE PROVISION.



2.2.3

WORKING GROUP FOR PUBLIC EV CHARGING INFRASTRUCTURE

Multiple state and local government bodies are responsible for the successful rollout of public charging infrastructure. However, at present, there is no mechanism for cooperation between the different agencies.

A working group for EV charging infrastructure can support the necessary coordination between different government agencies. Such a working group would comprise of all relevant nodal and executing agencies, including SNAs, DISCOMs, municipal corporations, and urban development authorities. The SERCs and transport authorities may also be represented. The working group should include high-ranking officials from the energy or urban development departments and may be headed by a Chief Secretary to ensure the necessary inter-departmental coordination. Box B describes the working group set up in Delhi for this purpose.

For large cities and metropolitan regions, it is advised to constitute city committees for EV charging, led by the municipal corporation commissioners or by heads of the serving DISCOMs. Nodal officers for EV charging should be assigned within ULBs and DISCOMs, to lead the implementation processes. Capacity building among local officials will be essential to increase awareness and knowledge of requirements for EV charging infrastructure.

BOX B: WORKING GROUP FOR ACCELERATED ROLLOUT OF CHARGING INFRASTRUCTURE IN DELHI

The 'Working Group for Accelerated Rollout of Charging Infrastructure in Delhi' was formed in 2019 by the Department of Power of the Government of National Capital Territory of Delhi (GNCTD), to support timely coordination between different government agencies in implementing the strategy for setting up charging infrastructure for EVs in Delhi.

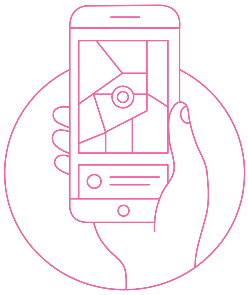
MEMBERS OF THE GROUP:

Headed by the Vice-Chairman of the Dialogue and Development Commission of Delhi (DDC), the working group comprises of high-level officials from the power and transport departments, the three municipal corporations, the New Delhi Municipal Council, the three power distribution companies operating in the region, and Energy Efficiency Services Limited (EESL.) Special invitees may join deliberations of the working group with the approval of the Chairman.

FUNCTIONS OF THE WORKING GROUP

The main functions of the working group include the following:

- To take a holistic view of opportunities and challenges for rollout of EV charging infrastructure and recommend strategies to accelerate progress towards the same, in keeping with the Delhi EV Policy.
- To identify and address coordination issues between various departments and agencies of GNCTD, DISCOMs, local authorities, and the Government of India.
- To monitor the progress of rollout of charging infrastructure in Delhi at various stages of implementation.
- Any other policy or coordination issues to accelerate the rollout of EV charging infrastructure in Delhi.

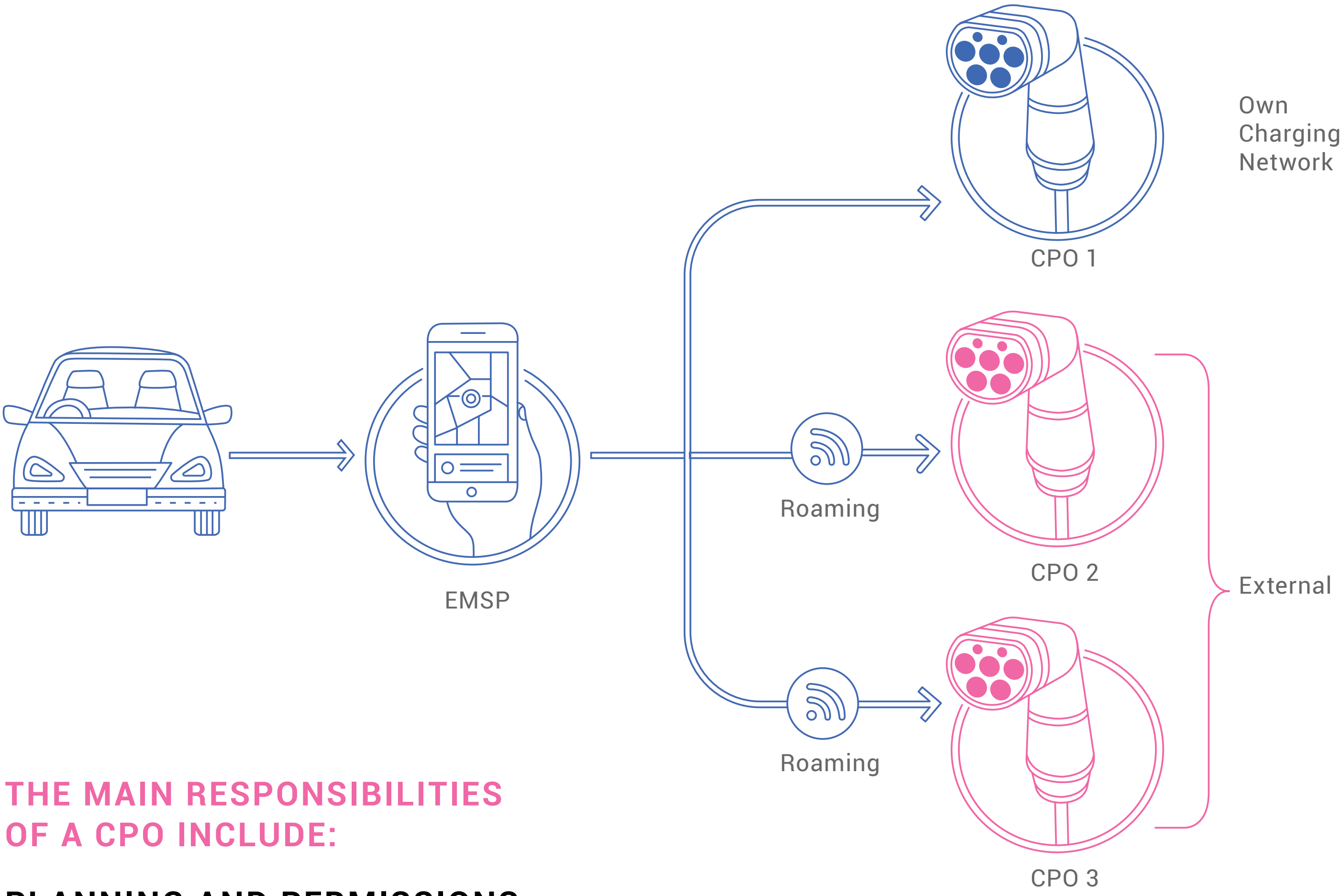


2.3

CHARGE POINT OPERATORS AND E-MOBILITY SERVICE PROVIDERS

Charge point operators (CPOs) and e-mobility service providers (e-MSPs) manage and enable day-to-day operations of EV charging infrastructure, for semi-public and public charging facilities. CPOs and e-MSPs are also responsible for setting up the framework architecture, protocols, and processes to enable centralized management of charging facilities and their communication with the DISCOMs, and ensure efficient access to EV charging services for consumers.

Charge point operators set up, manage, 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 MAIN RESPONSIBILITIES OF A CPO INCLUDE:

PLANNING AND PERMISSIONS

- Assess space and power requirements for EV charging at each site, vis-à-vis availability, to design optimal EV charging installations.
- Coordinate with nodal and executing authorities to get the requisite permissions, connections, approvals, and certifications for EV charging facilities.

INSTALLATION AND COMMISSIONING

- Procure EVSE hardware adhering to requisite specifications, depending on charging demand, charging patterns & required charging functionalities.
- Install a centralized system management software for backend network management, including user registration and permissions management, EV charger classification (by location and charger type), and remote monitoring.

OPERATION AND BILLING

- Manage operational functions including scheduling charging availability, revenue collection, live tracking of charger use, load balancing, performance diagnostics, etc.
- Set service charges for EV charging, based on market principles or in compliance with government norms.
- Provide specified data to DISCOMs and other government agencies, as required by law.

The CPO can be a public utility or a private entity. In many parts of the world, public energy utilities are taking a leading role in public charging infrastructure implementation and operations, due to their advantage in managing the energy infrastructure. At the same time, most CPOs in India at present are private entities building up the market for public charging.

E-mobility service providers offer charging services to EV users by connecting them with different CPO-operated EV charging networks. E-MSPs help EV users locate and conduct transactions at EV charging points. They also enable “roaming” (where applicable) for EV users subscribed to one CPO, to use charging networks of other CPOs. In some cases, CPOs may also act as e-MSPs.

3

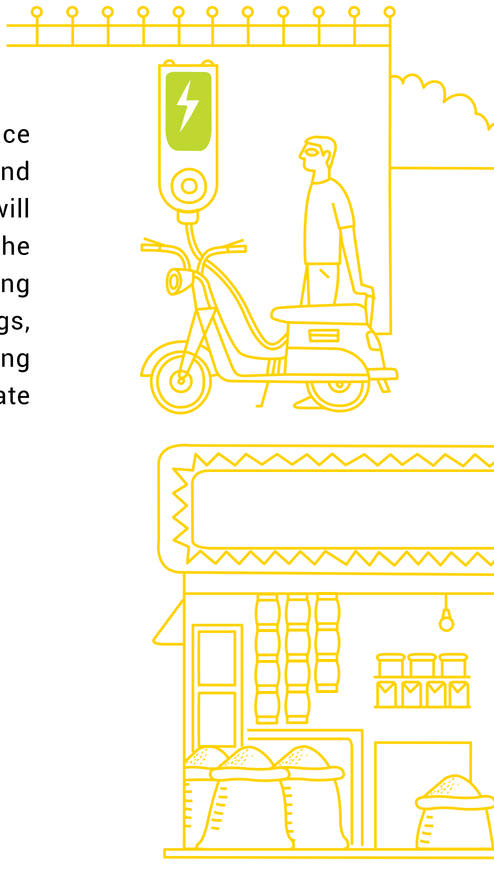
ASSESSING CHARGING DEMAND AND SETTING TARGETS

In planning EV charging infrastructure, stakeholders must consider potential charging demand as well as constraints of land and power supply. The next three chapters will provide details on EV charging infrastructure planning.

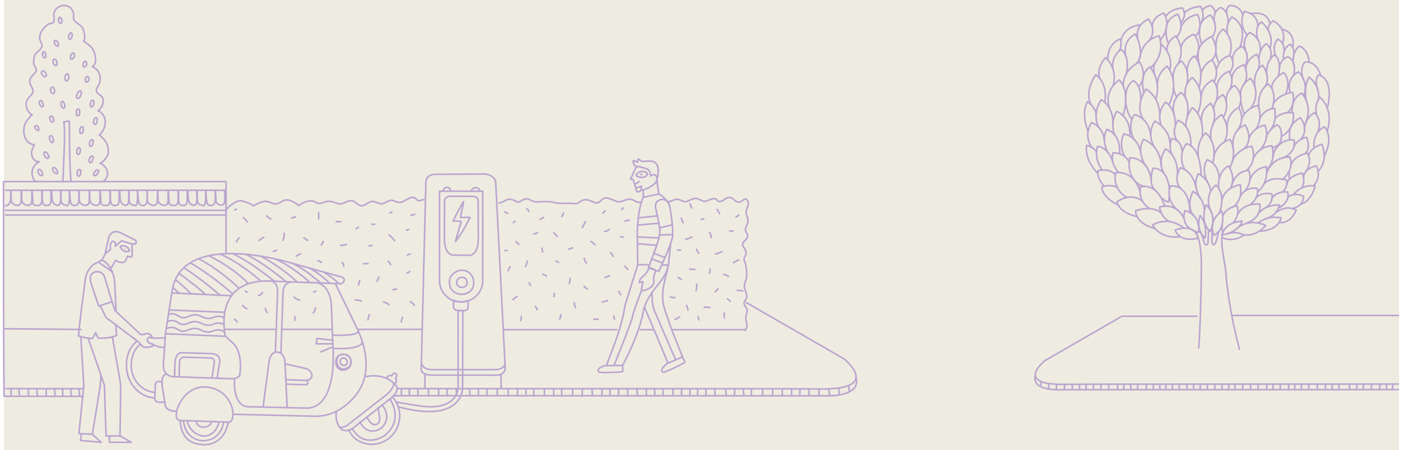
The first step of the planning process is to assess the EV charging demand, which is based on the current or projected number of EVs on the road. At the same time, availability of EV charging infrastructure is also a pre-requisite to achieve EV adoption targets. Hence regulatory authorities may set targets for EV charging infrastructure, too. This chapter gives an overview of targets that govern EV charging provision, and an assessment methodology to estimate the number of EV chargers required for a city or region.

3.1

SETTING TARGETS FOR EV CHARGING INFRASTRUCTURE



Targets for EV charging provision vary from one place to another, given the levels of vehicle ownership and projected transport electrification trends. They will also vary over time as EV penetration increases. The MoP and MoHUA have set targets for public charging provision and for provision of EV charging in buildings, respectively (see Box C). State and local planning bodies may adopt these suggested targets or mandate more ambitious targets for their regions.



BOX C: GOVERNMENT OF INDIA TARGETS FOR EV CHARGING INFRASTRUCTURE

MOP TARGETS FOR PUBLIC CHARGING

In its Charging Infrastructure Guidelines and Standards, the Ministry of Power (MoP) provides the following minimum requirements for the location of public charging stations:

- At least one charging station should be available in a grid of 3km x 3km.
- One charging station to be set up every 25km on both sides of highways/roads.

As per MoP guidelines, public charging stations may contain one or more, or any combination, of chargers from a list of specified EVSE and connector types. Charging stations for e-2Ws and e-3Ws can install any charger, provided they adhere to technical and safety standards laid down by the Central Electricity Authority (CEA).

MOHUA TARGETS FOR SEMI-PUBLIC CHARGING

The Ministry of Housing and Urban Affairs (MoHUA) amended its Model Building Byelaws (MBBL) 2016 to include the provision of EV charging in buildings. Amendments are made to Chapter 10 (Sustainability and Green Provisions) of the MBBL-2016, with Section 10.4 titled "Electric Vehicle Charging Infrastructure".

- Charging infrastructure shall be provided for EVs at 20% of all 'vehicle holding capacity'/'parking capacity' at the premises.

- The building premises will have to have an additional power load, equivalent to the power required for all charging points to be operated simultaneously, with a safety factor of 1.25.

The amendments are applicable to all buildings except independent residences. Further provision norms for slow chargers (SC) are provided based on the number of EVs to be serviced, by segment. Norms for fast chargers (FCs) are not compulsory.

	4Ws	3Ws	2Ws	PV (buses)
PROVISION NORMS FOR CHARGING POINTS	1 SC per 3 EVs 1 FC per 10 EVs	1 SC per 2 EVs	1 SC per 2 EVs	1 FC per 10 EVs

TARGET-SETTING FOR PUBLIC CHARGING INFRASTRUCTURE

Targets for public charging infrastructure are generally based on considerations of accessibility or of EV charging demand.

ACCESS-BASED TARGETS aim to ensure minimal coverage across a city or region, and are typically measured in terms of "number of charging points/unit area." They are more appropriate in the early stages of EV adoption, due to low EV charging demand.

DEMAND-BASED TARGETS aim to provide sufficient public charging infrastructure for a growing number of EVs on the road. They are based on EV penetration rates and the number of electric kilometers driven. Demand-based targets are useful for a planned expansion of the public charging network, in line with projected EV growth. The next section covers the process of EV charging demand assessment for target-setting.

Urban or regional targets for public EV charging should ideally be set by the working group for public charging infrastructure, in states where such a working group has been established. In its absence, targets may be set by the SNA, urban development authorities, municipal corporations or other local bodies involved in EV charging infrastructure planning.

BUILDING BYELAWS FOR SEMI-PUBLIC CHARGING

The MoHUA's suggested amendments to the building byelaws ask for charging infrastructure to be provided at 20% of parking spaces for all new buildings. However, only states have the power to adopt and enforce amendments to building byelaws, through urban development authorities or municipal corporations. With buildings typically having a lifespan of 50 years or more, states are recommended to adopt the EV charging infrastructure amendments at the earliest to ensure that all new constructions are EV-ready.

Building byelaw amendments requiring an EV charging infrastructure provision also have implications for electrical power supply connections and for the governance of parking spaces in different building types. These will be discussed in greater detail in the following chapters.

While building byelaws are applicable only to new buildings, existing buildings should also integrate EV charging as an amenity for occupants and visitors. The number of chargers to be installed can be estimated based on EV charging demand and available power capacity of the electricity connection. In some cases, governments may issue orders to commercial and institutional establishments to install EV charging infrastructure (see Box D).

BOX D:
DELHI GOVERNMENT MANDATES 5% PARKING FOR EV CHARGING

In March 2021, the Delhi Government directed all commercial and institutional buildings with a parking capacity of more than 100 vehicles to set aside 5% of their parking spaces for EV charging. This includes shopping malls, hospitals, hotels, offices, educational institutions, movie theaters, etc.

Properties will be required to set up slow EV chargers (at a minimum) at the reserved parking spots, and will be able to avail of a subsidy of INR 6,000 per charging point, as provided by the Delhi EV Policy.

3.2

ASSESSING EV CHARGING DEMAND

An EV charging demand assessment can feed into different aspects of charging infrastructure planning. It can be used as input data to setn targets for the number of public EV chargers, as we will discuss in this chapter. It can also be used for location planning for public charging infrastructure and to analyze grid capacity and the need for enhancements, as we will see in later chapters.

EV charging demand at an urban or regional level depends on per capita vehicle ownership rates, EV penetration levels, and vehicle utilization patterns. As it is typically used for public planning processes, such an assessment should be conducted or commissioned by government planning authorities responsible for charging infrastructure.

For estimating the requirements of public charging infrastructure, an EV charging demand assessment should focus on the projected demand for public charging for different vehicle segments. This can help calculate the number of public chargers required, which in turn can be used to set annual targets for public charging infrastructure.

Steps for the EV charging demand assessment and charging infrastructure estimation are given below.

Step 1 Based on target EV penetration rates, estimate EV sales for different vehicle segments for horizon years 2025 and 2030. Segments can be divided into 2Ws, passenger and cargo 3Ws, personal and commercial cars, and other LCVs.

Step 2 Arrive at the daily kilometers driven by each vehicle segment, based on transport planning data or data from city development plans.

Step 3 Based on average battery capacity and driving range of each vehicle segment, calculate the daily energy requirement for EV charging.

Step 4 Based on existing research or through surveys with existing EV users, assign the share of charging to be fulfilled at public charging infrastructure for different vehicle segments. For instance, personal 2Ws and cars may fulfil most of their charging requirements at homes or offices, and may only depend on public charging for 10% of their charging needs.

Step 5 From Steps 3 and 4, calculate the daily EV charging demand at public charging infrastructure for different vehicle segments.

Step 6 Based on the types of chargers available in the market, categorized by voltage level and power rating, specify the charger types that will service the different EV segments.

Step 7 For an assumed charger utilization, (for example- 25%), calculate the number of chargers of different types needed for the public charging infrastructure.

EXAMPLE: DEMAND-BASED TARGET SETTING FOR EV CHARGING INFRASTRUCTURE IN BENGALURU

Based on the projections of EV penetration within different vehicle segments, the charging demand, and the share of charging to be fulfilled by public charging stations, the number and type of public chargers required in Bengaluru for the horizon years 2025 and 2030 are calculated below.

STEP 1: EV PROJECTIONS FOR HORIZON YEARS, BY SEGMENT.

VEHICLE SEGMENTS	Annual growth rate	EV penetration rate - 2025	Total number of EVs - 2025	EV penetration rate - 2030	Total number of EVs - 2030
E-2W	5.88%	10%	1,00,477	30%	6,12,353
E-3W (passenger/cargo)	5.57%	40%	30,376	70%	1,15,804
E-car (personal)	3%	3%	4,519	15%	42,561
E-car (commercial)	15.80%	10%	4,775	30%	41,992

STEP 2-3: CHARGING DEMAND BY VEHICLE SEGMENT

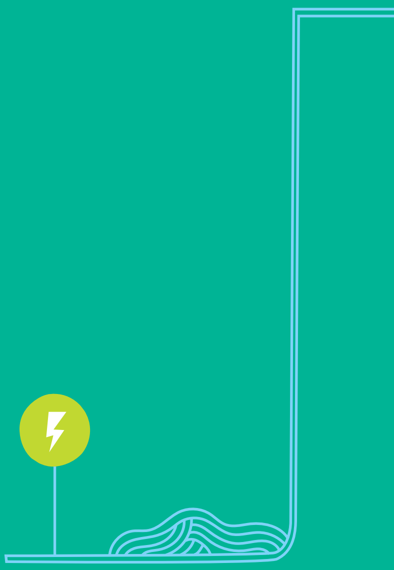
VEHICLE SEGMENTS	Daily kms driven	Battery capacity in kWh	Driving range in km/full charge	Daily charging demand in kWh	Total daily charging demand in kWh - 2025	Total daily charging demand in kWh - 2030
E-2W	40	2.5	80	1.25	1,25,596	7,65,442
E-3W (passenger / cargo)	120	7	100	8.4	2,55,162	9,72,757
E-car (personal)	40	30.2	312	4	17,498	1,64,786
E-car (commercial)	100	21.2	181	12	55,931	4,91,838

STEP 4-7: TYPE AND NUMBER OF PUBLIC CHARGERS (25% UTILIZATION)

VEHICLE SEGMENTS	Share of public charging	Charger Types	Number of chargers - 2025	Number of chargers - 2030
E-2W	10%	Single phase 15A charger	634	3,866
E-3W (passenger / cargo)	20%	Single phase 15A charger	2,557	9,826
E-car (personal)	10%	Type-2 AC (70%) 50kW DC charger (30%)	32	306
E-car (commercial)	25%	Type-2 AC (60%) 50kW DC charger (40%)	262	2,303

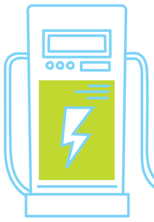
4

LOCATION PLANNING AND LAND ALLOCATION



EV charging requires space to set up an EVSE and to park the EV for the charging duration. For private and semi-public charging, this space is allocated in the parking areas of independent homes, apartment buildings, or of commercial and institutional establishments. For public charging, however, it is necessary to plan for a network of chargers that are conveniently located and well-distributed across a city or region.

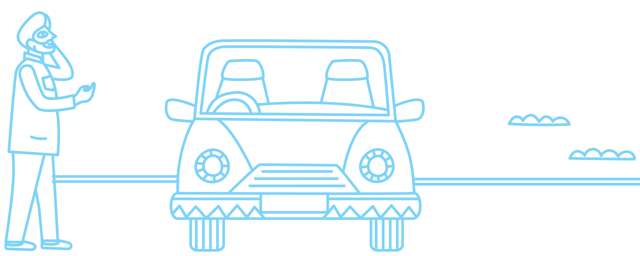
This chapter offers a framework for location planning of public charging infrastructure that integrates top-down spatial analysis with bottom-up site selection. It also highlights the institutional arrangements and policy reforms needed to scale up public charging.



4.1

PRINCIPLES OF LOCATION PLANNING FOR PUBLIC EV CHARGING

Location planning for public charging infrastructure helps identify optimal locations for setting up public charging facilities. It can be undertaken at different scales, from a city-level exercise to one at a neighborhood level. SNAs or ULBs may conduct or commission a location planning study as part of their mandate to ensure a well-planned public charging network. CPOs that are setting up charge point networks may also carry out location planning to identify optimal locations with high charging demand.



KEY PRINCIPLES FOR A LOCATION PLANNING FRAMEWORK

MAXIMIZE ACCESSIBILITY

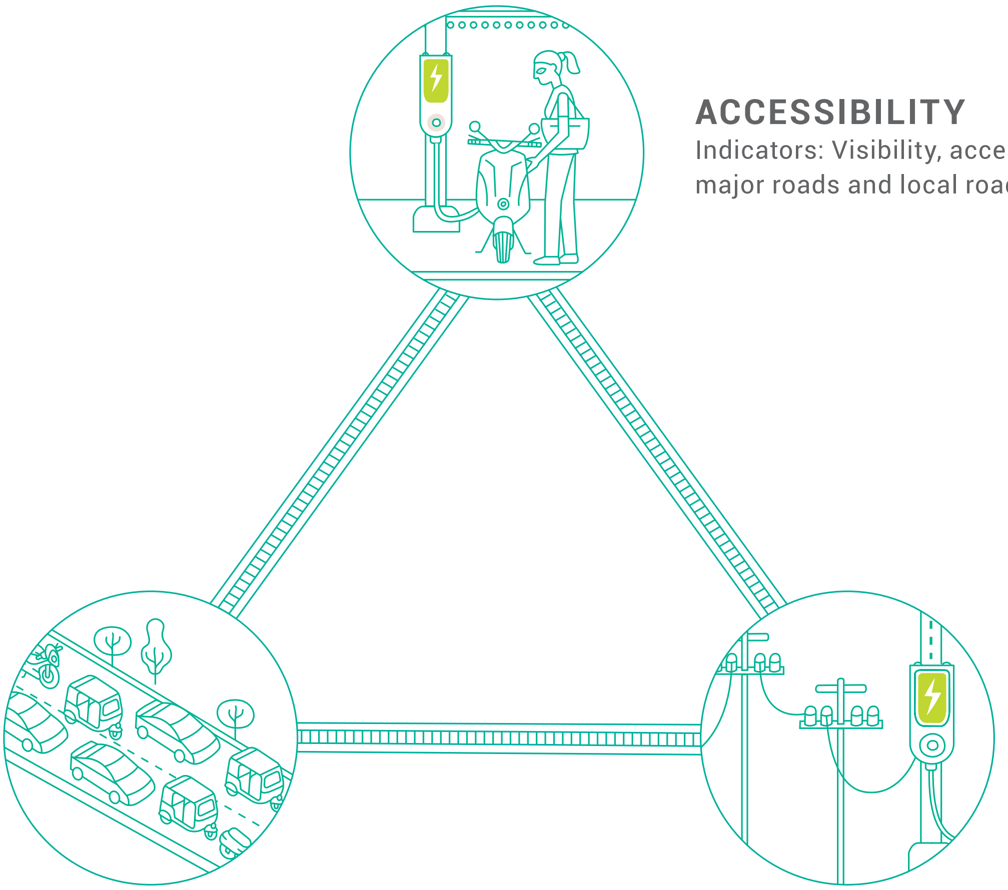
Accessibility may be understood as the ease of finding and getting to public charging facilities from any location. This includes areas of low estimated charging demand, which still need a minimum provision of charging infrastructure. Network planning and site selection play a role in improving EV charging 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.

MAXIMIZE UTILIZATION

Public charging infrastructure should be located in areas with charging demand to ensure high utilization. Public charging demand at a given location will depend on multiple parameters, including population and employment densities, parking availability, traffic volumes, presence of points of interest such as commercial establishments, transit stations or tourist destinations, etc. It also depends on the availability of other private or semi-public charging facilities in the area.

MINIMIZE COST

The cost of public charging infrastructure primarily depends on three factors – the cost of EVSE, cost of land, and cost of power supply. All three can be significantly reduced by opting for a distributed charging network of normal power charging points that are less expensive and require less space and electricity at any given location.



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

4.2

GEOSPATIAL ANALYSIS AND SITE SELECTION

Location planning for public charging infrastructure can be conducted through a digitized geospatial analysis or as an on-ground exercise, depending on the scale of planning and the quality of geospatial data available. At an urban or regional scale, a mixed approach to location planning is recommended.

A macro-level geospatial analysis can be conducted to identify potential charging demand and the resultant public charging requirements at a unit area level. At the area level, site selection for installation of public chargers can be carried out on-ground, in consultation with landowners and local government representatives in the area.

4.2.1

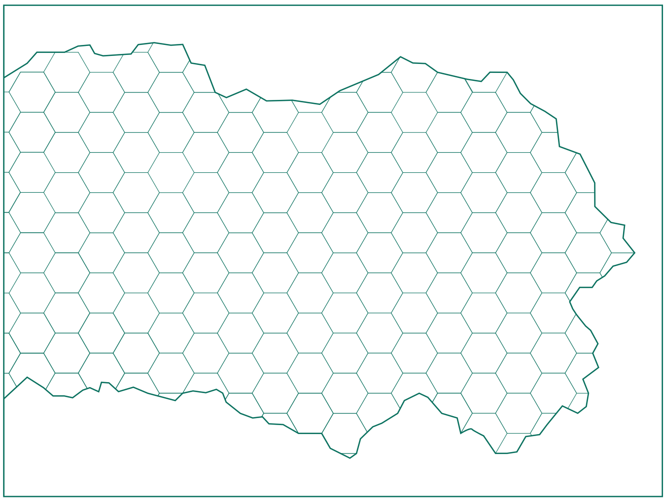
GEOSPATIAL ANALYSIS FOR DISTRIBUTION OF EV CHARGING DEMAND

In Chapter 3, we saw how to assess the EV charging demand at an aggregated level. Here, we will map the geographic distribution of potential EV charging demand through a spatial analysis methodology. Geospatial analysis helps map the relative EV charging demand at different locations. This can then be used to distribute public charging infrastructure in different areas, in proportion to the charging demand.

Typically, such an analysis is useful to assess charging demand distribution across a city or region. For smaller areas like neighbourhoods, the efficacy of a geospatial analysis will depend on the availability of highly disaggregated spatial data.

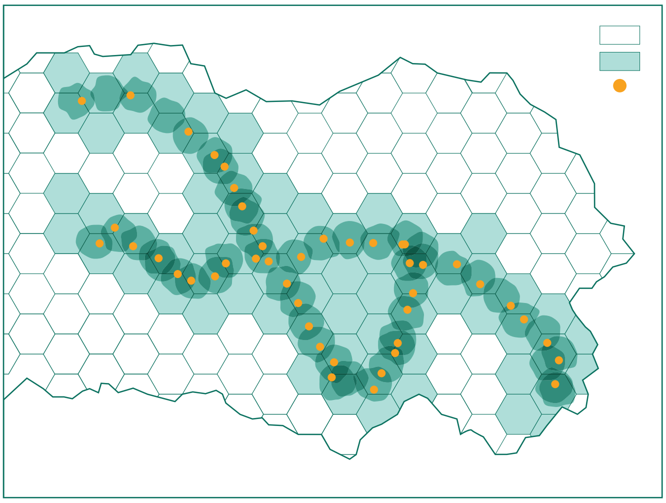
STEP-BY-STEP METHODOLOGY FOR GEOSPATIAL ANALYSIS OF CHARGING DEMAND DISTRIBUTION

1



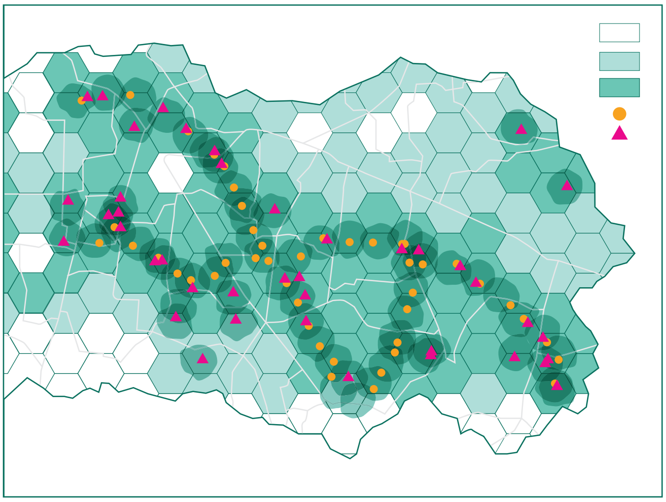
Divide the area under planning into cells of 1 sq km size (square or hexagonal); cell size may be bigger or smaller, depending on the scale of the exercise and the disaggregation of available data.

2



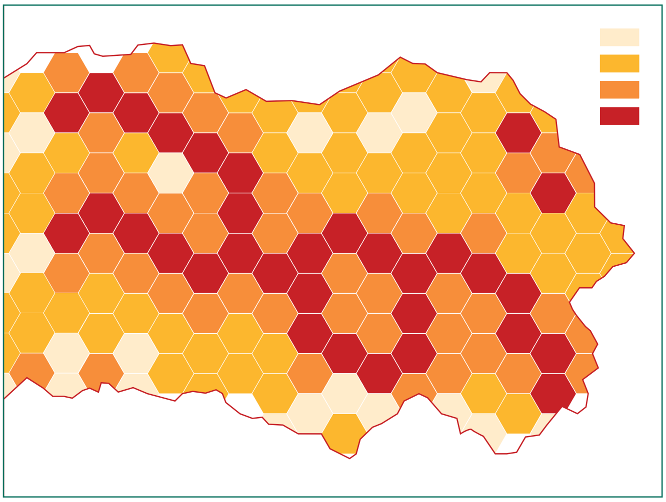
Identify parameters that indicate potential charging demand (as discussed in the previous section) and collate spatialized data for selected parameters using multiple sources.

3



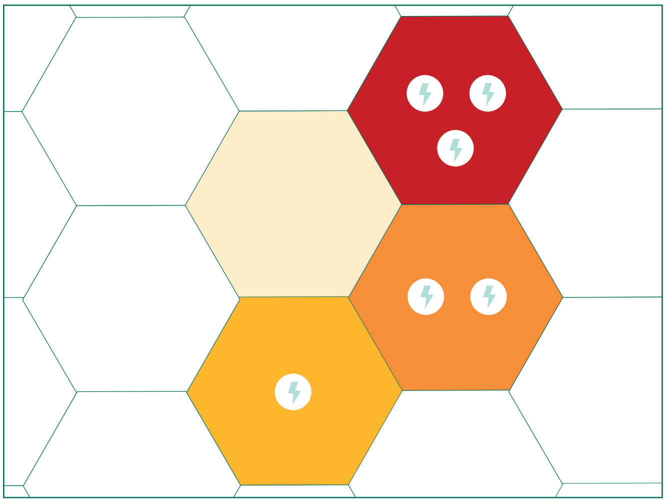
Map the data values on to the grid cells. Parameters such as points of interest or existing charging points may have influence zones which can also be assigned to respective grid cells around their locations.

4



Assign weightages to different parameters and their values based on their impact on potential demand. Combine the values of all parameters for the cells and categorize them based on potential demand, ranging from high to low.

5



Based on the charging demand for each cell, calculate the required number of charging points in the cell as a proportionate share of the total number of public charging points for the planning area. In cells where charging demand is very low, ensure that accessibility targets are met with a nominal charger allocation as required.

At the end of this process, an area-level requirement for public charging facilities is established. Alternatively, local authorities can assess the relative attractiveness of selected public sites for EV charging using geospatial analysis, as in the case of FAME-II charging stations (see Box E).

BOX E: SPATIAL PLANNING FOR FAME-II CHARGING STATIONS

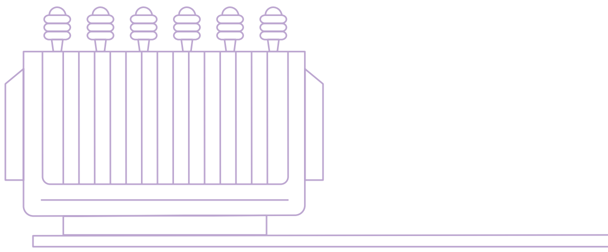
The FAME-II scheme, currently under implementation, is deploying 2,622 EV charging stations, each with 6-8 charging points, across 62 cities. This will add between 15,000 and 20,000 charging points across the country, which can significantly boost access to charging infrastructure. However, if charging stations are inaccessibly or inappropriately sited, FAME-II investments will not effectively address charging requirements.

As local authorities look for available land parcels at which to install EV charging stations, they must also compare the relative accessibility and charging demand at each location to select the best sites for installing charging infrastructure. Spatial analysis is thus critical for site selection of capital-intensive EV charging stations to ensure their effective utilization.

4.2.2

SITE SELECTION AND PLANNING

Site selection for public charging infrastructure should optimize accessibility, visibility, and ease of navigation for charging facilities. For a given charging demand in an area, a distributed planning approach may be used to select multiple charging sites, with varying configurations of the number of chargers and power levels as required. This can reduce the space and electricity load requirements at each site, and enable more efficient network implementation.



Sites for public charging may include on-street parking spots, off-street public parking, transit station parking areas, or any other location with adequate space and access for all EV owners. Ownership of sites may vary and may require multiple agreements for reserved charging use.

SPACE REQUIREMENTS FOR CHARGING FACILITIES

At any EV charging facility, adequate space must be allocated for vehicle parking and movement, installation of charge points, signage and barriers, and any upstream electrical infrastructure that may be required. The requisite space for a car parking bay is generally 5 x 2.5 meters. Including the vehicle circulation space, the Equivalent Car Space (ECS) for car parking is 23 to 32 square meters, depending on whether it is open parking or basement parking. This can be used as a thumb rule to determine the number of chargers to be provided. Depending on the parking location and the charger specifications, wall-mounted or pedestal-mounted chargers may be deployed, which will add to the required space in the parking area.

Exclusive distribution transformers (DTs) are not a universal requirement, and are typically required only in case of high-tension (HT) electricity connections with multiple high-power charging points. Chapter 5 will cover electricity supply planning for EV charging and how to determine the need for upstream electrical infrastructure. Approximate on-site space requirements for DT installations are provided in Table 4 below.

SITE PLANNING FOR EV CHARGING

Site planning is an important aspect of integrating EV charging in parking areas. It depends on the type of parking area as well as the number and type of EV charge points that need to be accommodated at the site. For instance, normal power chargers can be wall-mounted, which is a less expensive and more space-efficient option. Charging installations in residential or commercial buildings may choose this option. For high-powered chargers in public off-street parking lots, pedestal-mounted charging equipment permits better maneuverability and can host multiple charging points in a single EVSE.

When planning for EV charging integration at a given site, the following planning guidelines should be kept in mind:

- Allocate space that is easily accessible and clearly visible from the site entrance.
- Select the charging location to minimize civil work and wiring requirements, where possible.
- Follow all safety provisions for EV charging planning as defined by the CEA (Measures relating to Safety and Electric Supply) (Amendment) Regulations, 2019.
- Clearly demarcate the parking spaces reserved for EV charging with appropriate signage and markings.
- Provide ample space for vehicle circulation i.e. to enter and exit the charging bays.
- Ensure that the charging area is secured against theft and vandalism.

CPOs should work with site owners to adhere to the planning guidelines. Indicative site plans for two types of charging sites are provided on the next page.

TABLE 4: SPACE REQUIREMENTS FOR UPSTREAM ELECTRICAL INFRASTRUCTURE

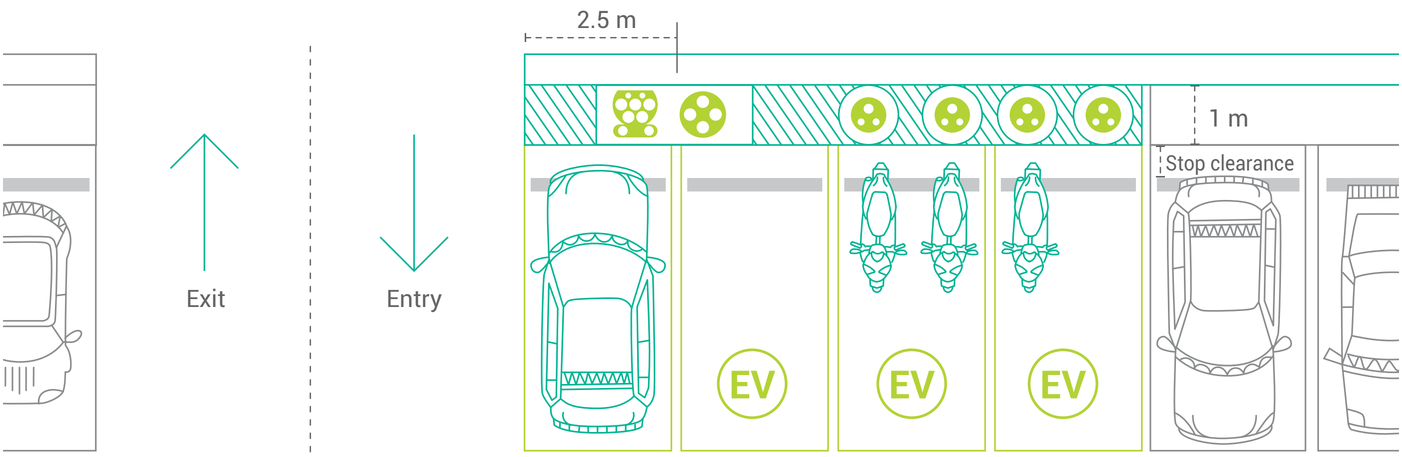
Estimated load	Recommended DT set-up	Minimum area requirement
100 kW to 300 kW	Installation of one 11 kV pole or plinth mounted DT	4 m x 4 m (pole) 8 m x 5 m (plinth)
300 kW to 700 kW	Installation of one 11 kV plinth mounted DT	9 m x 5 m
700 kW to 1,500 kW	Installation of two 11 kV plinth mounted DTs	10 m x 8 m

CHARGING LAYOUT FOR OFF-STREET PUBLIC PARKING

CHARGING INFRASTRUCTURE INSTALLATION WITH 6 CHARGERS

2 nos. DC chargers-1 x 25 kW (CCS2 and Chademo)
4 nos. AC chargers- 1 x 3.3 kW (industrial socket)

4 EV parking bays- 2.5m x 5m each
2 bays for e-cars, 2 bays for e-scooters/e-autos

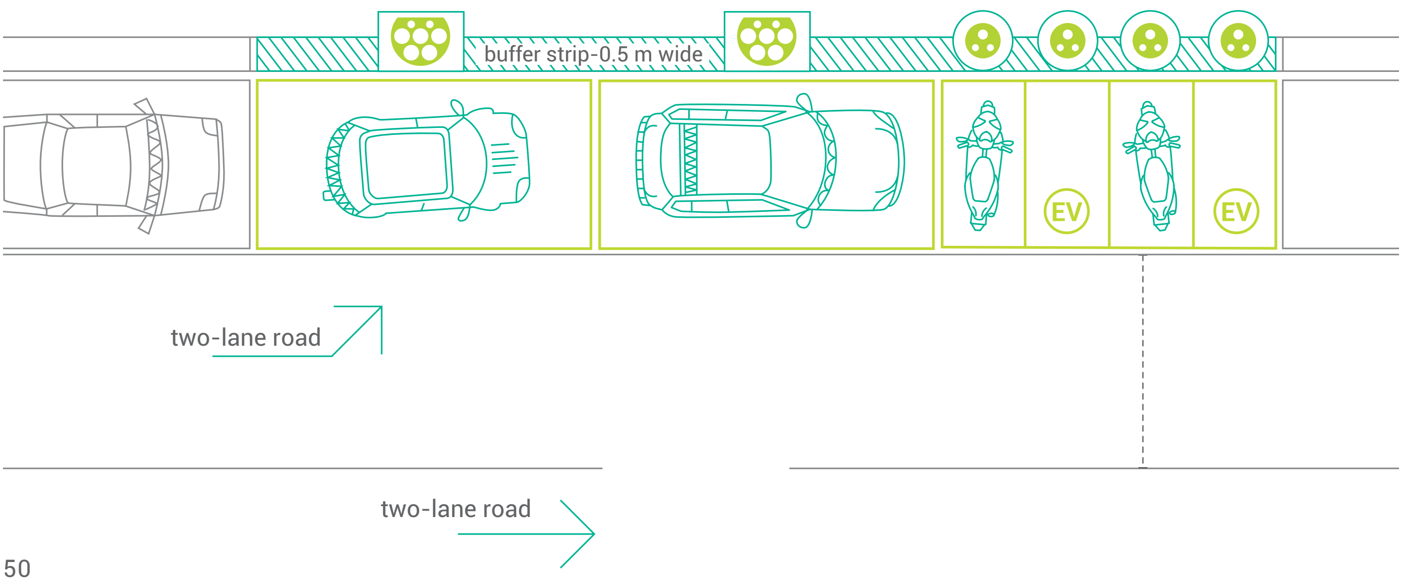


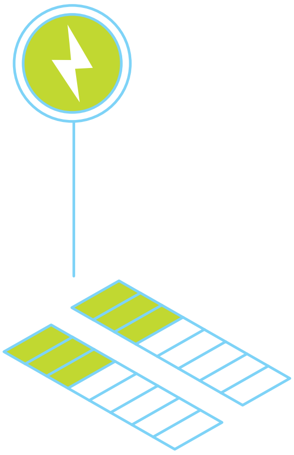
CHARGING LAYOUT FOR ON-STREET PUBLIC PARKING

CHARGING INFRASTRUCTURE INSTALLATION WITH 6 CHARGERS

2 nos. AC charger- 1 x 7.4 kW (Type 2 connector)
4 nos. AC chargers- 1 x 3 kW (industrial socket)

6 EV on-street parking bays
2 nos. e-car bays- 2.5m x 5.5m
4 nos. e-scooter bays- 2.5m x 1.4m

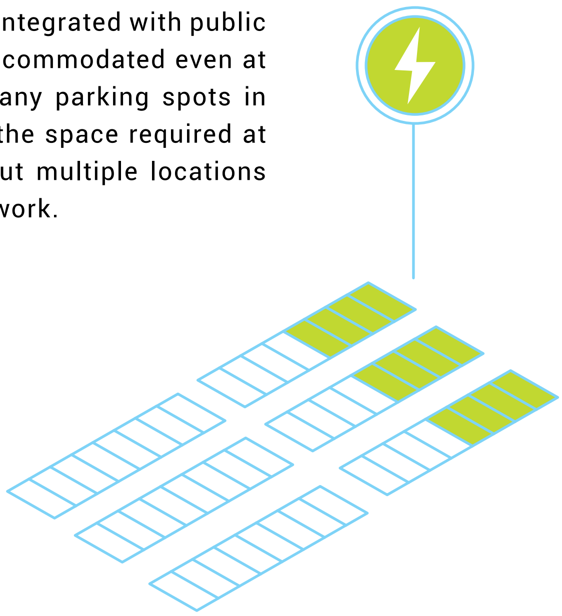


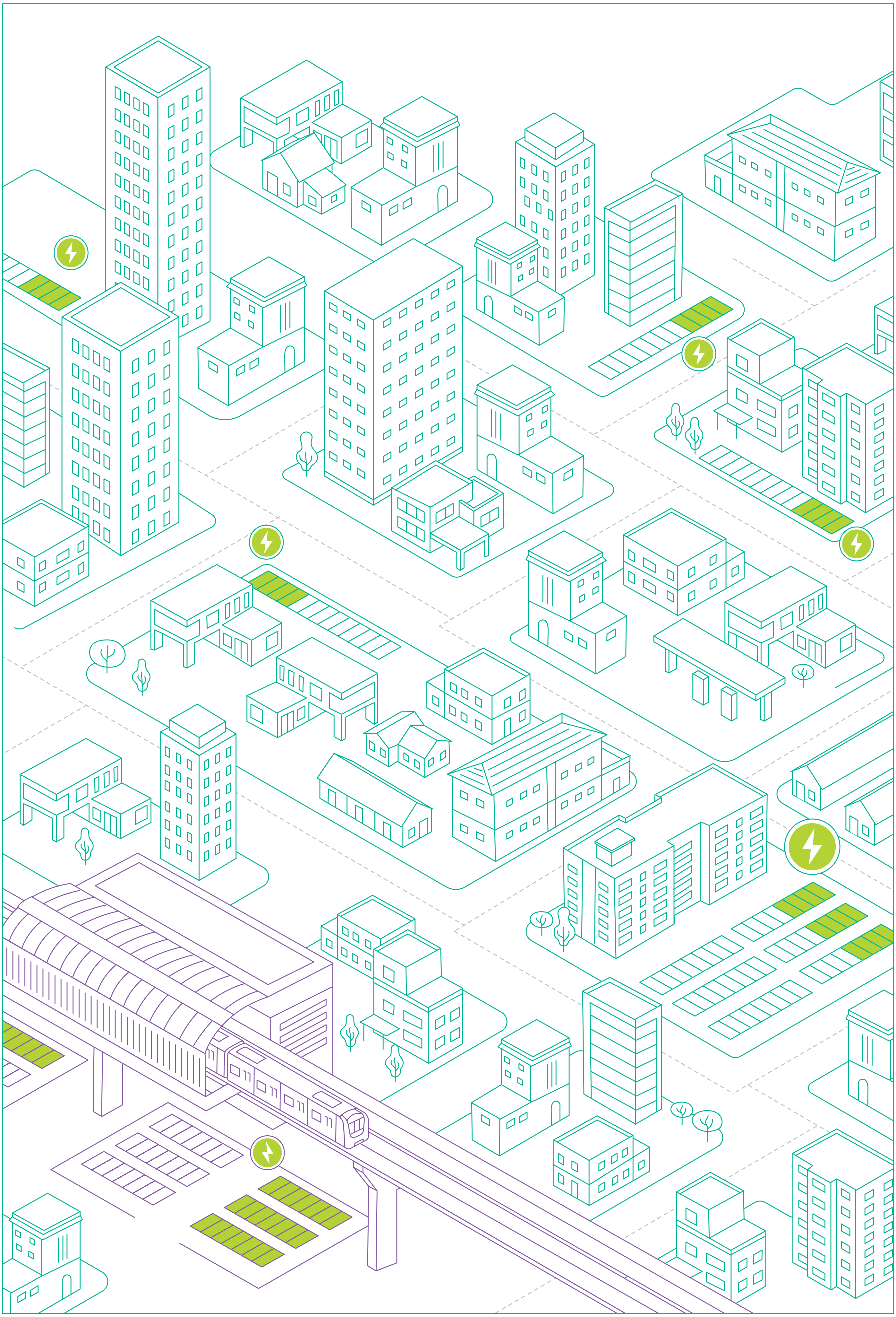


4.3

LAND ALLOCATION FOR PUBLIC CHARGING INFRASTRUCTURE

A distributed approach to public charging infrastructure aims to achieve a dense network of normal power charging points, integrated with public parking. EV charging can be accommodated even at a single parking spot, or at many parking spots in a large parking lot. Therefore, the space required at each location may be small, but multiple locations are needed for an effective network.





However, CPOs generally do not own the land for setting up charging infrastructure, and often there may be challenges in setting up public charging facilities in high-traffic, accessible locations for various reasons.

- **LACK OF CLARITY ON LAND OWNERSHIP:** In many cases, the ownership of the land parcel on which EV charging is to be installed is not clear. For instance, while commercial shops and other establishments often govern the street parking outside their premises, this is often publicly owned land that can be reclaimed at any time for road widening or other such purposes.

- **POOR PLANNING AND REGULATION OF PARKING:** Many established on-street or off-street parking spaces are illegal. While the parking activity is condoned, allied activities such as EV charging are not permitted. At the same time, there is paucity of planned public parking in several areas, which results in no space available to set up charging.

- **HIGH COST OF URBAN LAND:** Where ownership is clear and legal parking is available, the cost of urban land can be prohibitive. Public parking is often operated by contractors that are unwilling to provide space for EV charging at sub-market rates. This poses a high entry barrier for CPOs due to the lack of assured demand for public charging during the early stages of EV adoption. This is also the case with government-owned land such as municipal parking, metro station parking, and other public parking areas.

SNAs and urban planning authorities can alleviate these challenges, in turn supporting a more rapid scale-up of public charging infrastructure. Short-term measures allow immediate action to unlock land for EV charging, while more significant policy changes are needed to integrate EV charging in planning processes.

MOUs BETWEEN MUNICIPAL AUTHORITIES AND CPOs

Land-owning authorities such as municipal corporations, urban development authorities and other local government bodies can provide access to desirable parking sites through Memorandums of Understanding (MoUs) with CPOs. The MoUs would be for a fixed period and would allocate the use of selected sites for EV charging. Revenue-sharing mechanisms with the CPO or an independent allocation of advertising rights at charging points could provide revenues to the government authority without burdening the financial viability of nascent EV charging services.

This mechanism is most appropriate for empty plots and informal parking spaces outside shops and other buildings. Selected sites should be vetted by the traffic police to ensure that vehicular circulation is not disrupted. Site selection should ensure proximity to electricity supply points, to minimize civil work costs.

SUPPORT LOW-COST CHARGING POINT IMPLEMENTATION AT PUBLIC PARKING LOCATIONS

Innovations such as light EV charge points, streetlight chargers and other low-cost EVSE solutions are providing affordable solutions for charging infrastructure. ULBs can work with EVSE manufacturers and CPOs to integrate these low-cost charging points into existing parking areas, by permitting integration with street furniture such as streetlights and bollards, as seen in the example in Box F.

This is appropriate for legally designated public parking, both for on street and off-street parking areas. As implementation costs are highly reduced, ULBs and CPOs can share the costs and revenues from the charging infrastructure.

BOX F:
LEVERAGING STREET INFRASTRUCTURE FOR EV CHARGING

A Berlin-based startup has developed physical and digital infrastructure that allows the upgrade of existing street infrastructure including streetlights and bollards into e-car charging points at low cost. The startup works with local authorities to integrate EV charging into existing street infrastructure, resulting in public EV charging infrastructure that is affordable, accessible, and convenient.

The system, which includes billing systems and e-car charging cables, also allows users to charge their vehicles with their own electricity. Users can connect to the charging points using their mobile electricity contracts and a smart cable that has an integrated electricity meter. Charging and billing data are shown live in the user portal and the user receives a bill for all charging transactions.

There are now multiple EVSE products available, globally and in India, which enable street charging for ease of public charging infrastructure provision.

IMPLEMENT COMPREHENSIVE URBAN PARKING POLICIES

Parking policy reforms in cities are essential to integrate public charging in parking spaces. This will not only organize public parking in urban areas, but it will also ensure that all existing and future public parking has reserved EV charging spots. This improves access to public charging infrastructure and can especially support expansion of public charging in residential or institutional zones with on-street parking availability.

In the short term, local authorities can mandate that a share of existing public parking spaces be reserved for EV charging.

INTEGRATE PUBLIC EV CHARGING IN URBAN PLANNING PROCESSES

Methods such as town planning schemes and land pooling schemes are used for planned urban growth and expansion. They incorporate parking requirements for planned development. Reserved parking and ancillary infrastructure for public EV charging should be integrated into urban and transport planning practices.

EV charging may also be included at transit stations to create integrated and multimodal transport systems.

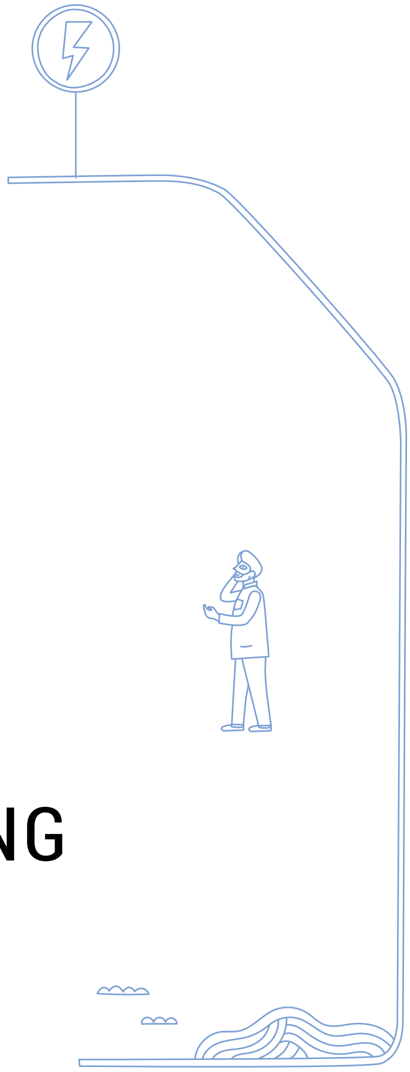
5

CONNECTING EVs TO THE ELECTRICITY GRID

Accessible, reliable, and affordable electricity is a prerequisite for adequate charging infrastructure provision. For a rapidly scalable EV charging network, the ubiquitous low-tension (LT) electricity distribution infrastructure should be leveraged wherever feasible to provide electricity connections for EV charging. A distributed approach to charging infrastructure, comprising primarily of normal-power charging points, ensures that most charging points can be connected to the LT electricity network.

This chapter explores the regulatory and governance provisions that impact EV charging connections, and lays out three methods for arranging electricity supply to private or public charging facilities.

5.1



REGULATORY FRAMEWORK FOR EV CHARGING CONNECTIONS

Electricity supply in India is a highly regulated market, with regulations at the central and state levels. Provision of electricity connections for EV charging comes under a set of regulations and guidelines, some of which are general and others which have been formulated specifically for charging facilities.

CENTRAL TECHNICAL REGULATIONS AND GUIDELINES

The CEA has notified amendments to existing regulations to facilitate grid connectivity for charging infrastructure. Key regulatory provisions for EV charging are highlighted below.

TECHNICAL STANDARDS FOR CONNECTIVITY OF THE DISTRIBUTED GENERATION RESOURCES (AMENDMENT) REGULATIONS, 2019

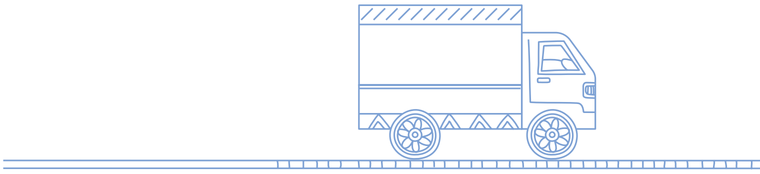
- Defines "charging stations" and "charging points"
- Recognizes EVs as an energy generation resource
- Introduces standards for charging stations connected or seeking connectivity to the electricity supply system

MEASURES RELATING TO SAFETY AND ELECTRIC SUPPLY (AMENDMENT) REGULATIONS, 2019

- Specifies safety requirements for charging infrastructure including general safety for EV charging stations, earth protection system, fire safety, testing of charging stations, inspection and periodic assessment, maintenance of records, and safety provisions as per international standards that need to be followed.

STATE REGULATIONS

With electricity distribution and supply being a state subject as per the Indian Constitution, regulations at the state level determine the rules around connection and supply of electricity. The State Electricity Supply Code & Performance Standards Regulation, the purview of SERCs, is the key regulatory framework governing the provision of electricity connection and supply by DISCOMs.



This regulatory framework differs from one state to another, and appropriate state regulations should be considered when planning or installing charging facilities. Among the provisions of the state supply code, the following issues especially impact electricity connections for EV charging.

TYPE OF ELECTRICITY CONNECTION

The type of connection – i.e., single-phase LT, three-phase LT, or high-tension (HT) – is decided based on the required sanctioned load, and directly impacts the cost and time for getting a connection, the tariffs, and the need for ancillary upstream infrastructure like Distribution Transformers (DTs). An HT connection attracts higher installation and monthly demand charges, involves more time for energization, and requires the set-up of ancillary electrical infrastructure by the applicant. The sanctioned load ceilings for LT and HT connections vary significantly between states.

SUPPLY OF POWER FROM EXISTING NETWORK

The rules governing supply of power from the existing network can have cost and time implications for commissioning an EV charging connection. Getting a connection from an existing network (without the need for expansion) is easier and more economical than a case which requires extension of the distribution system. Network extension is not only time-consuming but may also require the applicant to share the costs.

NEED FOR SYSTEM AUGMENTATION FOR NEW CONNECTIONS

A system upgrade is advised when the capacity utilization of the nearest feeder is expected to exceed the permitted threshold (commonly 70%) upon award of a new connection such as a charging infrastructure connection. Augmentation of the distribution network can be an expensive and time-consuming affair.

A distributed public charging network can optimize the time and costs associated with getting power connections for EV charging, with lower sanctioned loads and fewer charging points at each site.

In cases where a greater number of charging points is required or mandated through building byelaws and other government orders, these provisions can also lead to higher capital and operational costs, and can disincentivize EV charging installations. SERCs and DISCOMs need to recognize EV charging as a new type of consumer requirement, distinct from existing consumer categories, and adapt the supply code to enable affordable and reliable electricity supply for charging infrastructure.

5.1.1

TARIFF – AN IMPORTANT TOOL

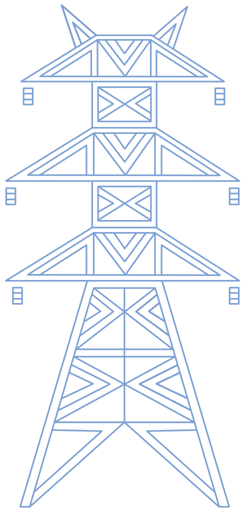
Electricity tariff is a critical fiscal and regulatory tool available to state governments, and tariffs and tariff designs vary from state to state. EV charging is a new addition to the consumer basket of a DISCOM, and recognizing it as a distinct consumer category in the tariff schedule can facilitate power connections for EV charging.

Introducing an EV-specific electricity tariff has multiple benefits. Tariffs can be designed to send clear price signals to EV users, and can also be used to manage load profiles of EV charging. Electricity tariffs are also a major operating cost for CPOs providing charging services and can impact the business case for public EV charging. Further, a separate tariff category for EV charging will allow state governments to offer "EV-only" incentives in order to encourage adoption, with features such as:

EXEMPTED DEMAND CHARGES: The fixed or demand charge for an electricity connection is levied on the sanctioned load for the connection or the maximum power demand registered during the billing period, which must be paid irrespective of the actual power usage. Considering the low demand for charging during the early phase of EV adoption, demand charge exemptions for EV charging connections can improve the business case for setting up charging points.

REDUCED ENERGY CHARGES: Energy charges are the variable component of an electricity tariff, applied on the total volume of energy/electricity consumed during the billing period. Reduced energy charges for EV charging benefit CPOs, which can reduce their operational expenditure, and EV users benefit through lower charging costs.

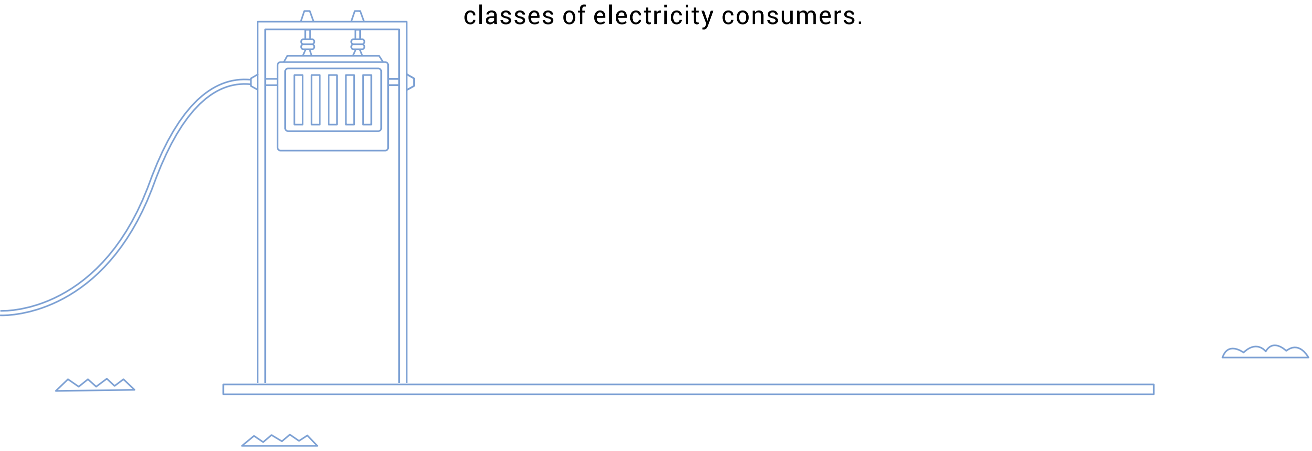
As of March 2021, 21 states and Union Territories have introduced specific tariffs for EV charging with reduced energy charges and/or demand charge exemptions. Details of state EV tariffs are provided in Annexure C.



5.2

ROLE OF DISCOMS IN PROVIDING POWER CONNECTIONS

DISCOMs are responsible for providing electricity connections for EV charging infrastructure. They enforce and execute the electricity supply rules and regulations on-ground and interact with different classes of electricity consumers.



EV owners and CPOs are a new class of customers for DISCOMs, with power connection requirements that are distinct from other consumer classes. In order to cater to these requirements, DISCOMs will have to implement regulatory measures such as EV tariff categories, establish standard operating procedures, and become familiar with planning and providing power connections for EV charging infrastructure. As the interface between the electricity network and the CPOs or EV users, DISCOMs can streamline the process of providing electricity connections for charging infrastructure. SERCs should mandate that all DISCOMs undertake the following measures:

- Provide clear public guidelines on the application process for metered connections for EV charging and create a single-window system for processing the applications.

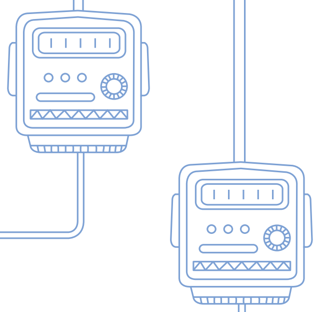
- Prescribe a technical pre-feasibility check for public charging connections, for CPOs to assess the feasibility and estimated cost of procuring the required sanctioned load for a proposed charging facility at a given location.

- Set maximum timelines for expedited inspection and certification of charging facilities and award of EV charging connections.

- Publicly share the criteria and requirements for different types of connections and associated charges in a simplified format for CPOs.

- Lay out clear guidelines for owners of private charging (e.g. in homes and offices) on the requirements and processes to apply for metered EV connections, to take advantage of any available benefits like EV-specific tariffs and customized EV charging programs.

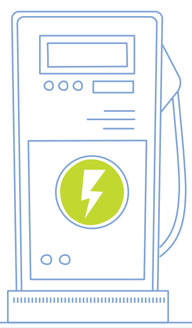
- Create a dedicated internal team, like an e-mobility cell, to respond to queries, coordinate with interested applicants and carry out site visits concerning EV charging connections.



5.3

ARRANGING FOR ELECTRICITY SUPPLY FOR CHARGING

There are different means by which an EV owner or CPO may arrange for the electricity connection for an EV charging point or charging facility (with multiple points). CPOs or EV owners should select the optimal option based on their requirements.



The first step in arranging for the electricity supply for EV charging is to estimate the required power demand in kilowatts (kW). This is equivalent to the sum of the rated input requirements of all the charging points that are part of the planned installation at a given location. In case of a battery charging system, this would be equivalent to the power required to simultaneously charge the total number of batteries housed in the charging system.

Once the required power demand is known, an EV owner or CPO may choose from three options to provide electricity for the EV charging infrastructure:

i Draw electricity from an existing power connection

ii Arrange for a new electricity connection

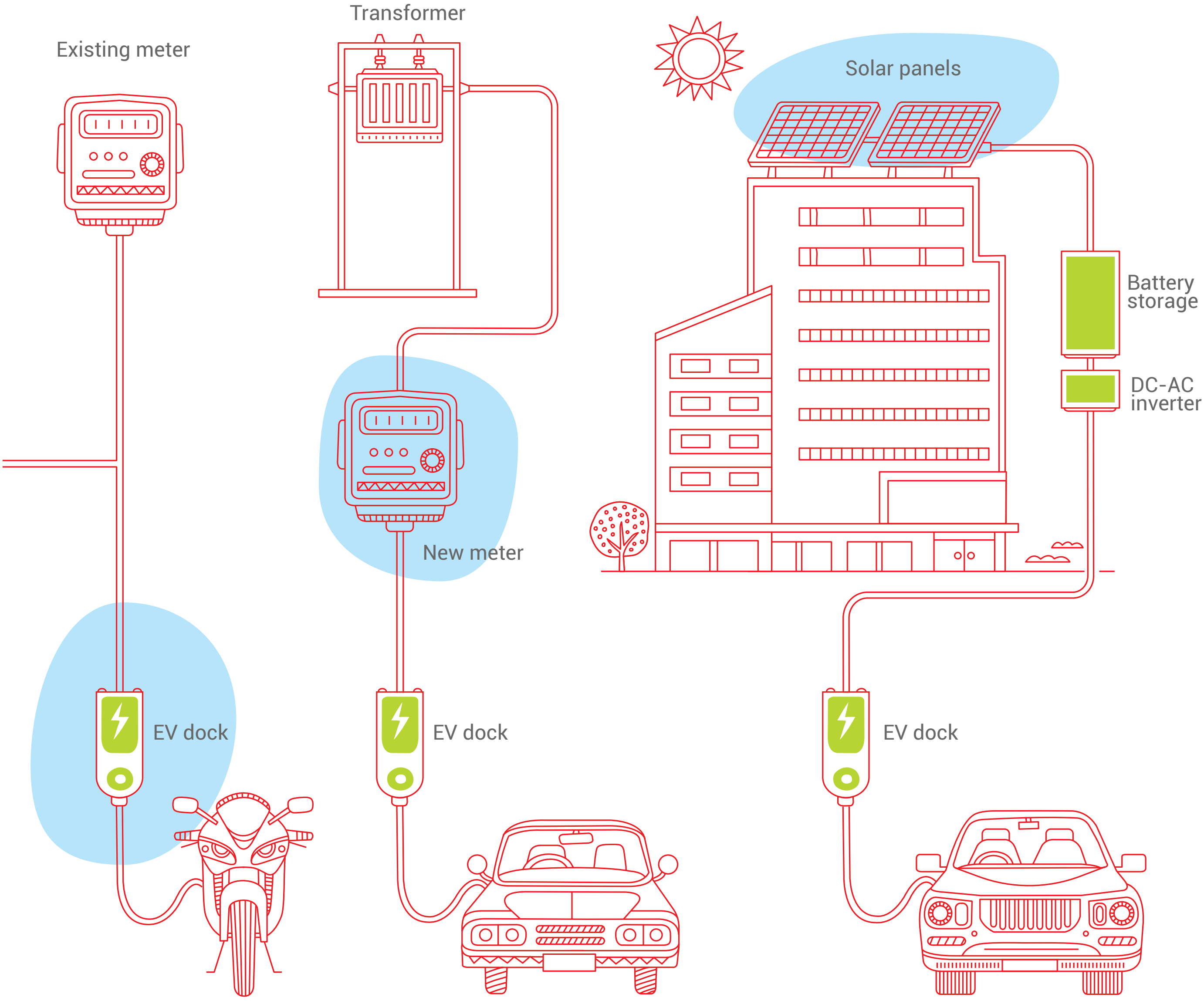
iii Use a captive renewable energy generation system

OPTION 1: DRAW ELECTRICITY FROM AN EXISTING POWER CONNECTION

For private charging, where a single charging point is being installed in a home or office, EV owners can draw the electricity from the existing power connection. Where semi-public or public EV charging is built within a host facility, the CPO may choose to draw electricity from the existing power connection provided the host establishment owner permits it.

When connecting the EV charging infrastructure to an existing power connection, the following steps must be followed.

i Check the type of connection available at the host establishment, and whether the estimated power demand of the charging infrastructure can



be supported by the available sanctioned load. DISCOMs should provide a standard operating procedure for assessing whether the sanctioned load is adequate to accommodate the power demand for EV charging.

ii If the sanctioned load of the existing connection is not sufficient, the owner of the host facility must apply to the DISCOM for an increase in the sanctioned load. This may entail additional charges and take time to become operational.

iii If the existing connection type is single phase LT or three-phase LT and the increase in sanctioned load crosses the allowed power demand threshold for the category (as stipulated in the state supply code), the owner of the host establishment must apply for a three-phase LT connection or an HT connection, respectively. This involves changing the meter, and the applicant will have to pay certain fees such as Service Line cum Development (SLD) charges, charges for meter change, etc.

iv For upgrading to a three-phase LT connection, the available capacity of the serving DT needs to be assessed. If the DT is found to be loaded close to its capacity threshold, a new DT along with necessary 33/11 kV cables may have to be set up by the DISCOM. Alternatively, the host facility owner may opt to install an exclusive DT on their premises at their own expense, to avoid delays in grid augmentation.

v If an HT connection is needed, the applicant will have to install their own DT and 33/11 kV cables, which will entail considerable cost and time.

This option is typically selected in cases where there is excess capacity in the sanctioned load of the existing connection, or in cases where competitive tariffs for EV charging are not an issue. It is best suited for private and semi-public charging which is offered as an amenity by the host establishment for occupants and visitors.

To benefit from special EV tariffs, the CPO or EV owner will have to apply for a separate metered connection (a pre-paid connection is also an option) exclusively for EV charging as stipulated by the SERC concerned.

OPTION 2: ARRANGE FOR A NEW ELECTRICITY CONNECTION

CPOs or EV owners can apply for an exclusive electricity connection for EV charging within a host establishment or for standalone charging facilities. The steps in arranging for a new electricity connection are similar to those described in Option 1.

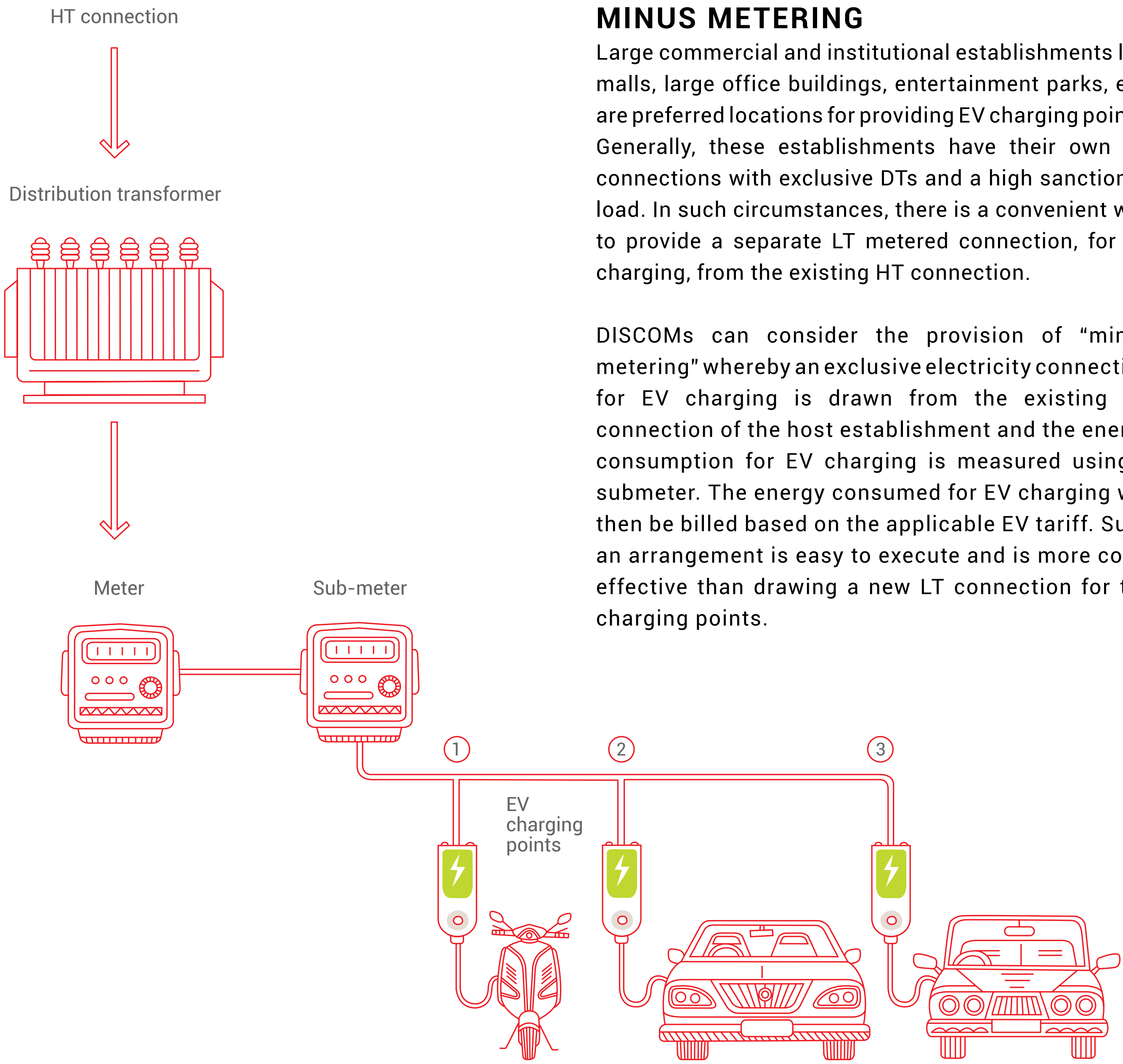
i Check whether the estimated power requirement falls within single-phase LT, three-phase LT or HT categories, and apply for a new connection following the procedure defined by the DISCOM. If the state in which the charging facility is being installed has a separate EV tariff category, the DISCOM should have separate guidelines for application.

ii For an HT connection, the CPO must install its own DT along with 33/11kV cables. For an LT connection, the CPO should take the available hosting capacity of the nearby DT into account when planning the charging installation and required power demand at a given site. This can reduce the need for expensive grid upgrades.

iii If a new DT needs to be installed to serve the new connection, the DISCOM may undertake this as part of their planned grid upgrades. Alternatively, the CPO may need to pay for the installation of a new DT, especially if it is for the exclusive use of the charging facility. This will depend on the provisions of the state supply code and may vary between states.

iv In case the charging facility is housed within a host establishment, the CPO may not be able to apply for an exclusive connection if it does not have the ownership of the charging space. However, the CPO can apply for a separate pre-paid EV metered connection for the charging facility up to a certain load, provided there is a formal rent or lease agreement for the space with the owner and that such pre-paid connections are permitted by the SERC concerned.

Additional measures may be permitted by DISCOMs to enable the provision of EV connections within existing host establishments. Measures include minus metering and separate EV connections without demand charges.



MINUS METERING

Large commercial and institutional establishments like malls, large office buildings, entertainment parks, etc. are preferred locations for providing EV charging points. Generally, these establishments have their own HT connections with exclusive DTs and a high sanctioned load. In such circumstances, there is a convenient way to provide a separate LT metered connection, for EV charging, from the existing HT connection.

DISCOMs can consider the provision of "minus metering" whereby an exclusive electricity connection for EV charging is drawn from the existing HT connection of the host establishment and the energy consumption for EV charging is measured using a submeter. The energy consumed for EV charging will then be billed based on the applicable EV tariff. Such an arrangement is easy to execute and is more cost-effective than drawing a new LT connection for the charging points.

SEPARATE EV CONNECTION WITHOUT DEMAND CHARGES

For a separate EV connection at a host establishment, the applicable demand/fixed charges must be paid separately for the EV connection. This is the case even if there is adequate sanctioned load on the existing electricity connection to support the power demand from EV charging.

DISCOMs can consider waiving demand charges for separate EV connections in such cases, provided that the aggregate peak demand from both connections always remains lower than the sanctioned load of the original connection. To be eligible for this demand charge waiver, the EV connection must be linked to the same customer profile as the existing connection.

Such arrangements extend a clear benefit to host establishments such as malls, office buildings, entertainment venues, etc., in setting up charging points. They also rationalize the sanctioned load requirements for new EV connections which may be very high when demand charges are waived entirely. Host establishments can deploy smart chargers and central management systems to manage the EV charging load, so that the cumulative load does not exceed the sanctioned load.

EXAMPLE: FINANCIAL ASSESSMENT FOR EV CHARGING CONNECTION

A family based in Delhi is planning to purchase an electric four-wheeler with a battery capacity of 45 kWh. It is evaluating whether an EV metered connection is economical, considering that the alternative is to use the existing domestic electricity connection. The family's average monthly electricity consumption from April to September is about 380 units and its sanctioned load has headroom to meet an additional load of about 3 kW. What is the most economic option for the family?

Energy charges (₹/kWh) based on monthly consumption				
0-200 units	201-400 units	401-800 units	801-1,200 units	>1,200 units
3.00	4.50	6.50	7.00	8.00

A domestic household connection in Delhi attracts energy charges based on consumption slabs, as shown in the table above. Delhi's EV tariff has an energy charge of ₹ 4.50 per unit and no demand charge.

For the family's requirement, the EV needs to be charged every five days, from 20% to 100% state of charge. The monthly electricity consumption from EV charging thus comes out to approximately 216 units.

USING EXISTING DOMESTIC CONNECTION

The average electricity consumption per month is expected to reach about 596 units (380 +216). Based on the applicable tariffs, the corresponding monthly energy charge is estimated to be ₹2,774 per month.

Slab-wise per unit energy charge (₹/kWh)	Pre-EV charging		Post EV charging	
	Number of units billed	Energy charge (₹)	Number of units billed	Energy charge (₹)
3.00	200	600	200	600
4.50	180	810	200	900
6.50	-	-	196	1,274
Total energy charge (₹)		**1,410**	**-**	**2,774**

USING A DEDICATED EV METERED CONNECTION

The electricity consumed for EV charging will be charged at a flat rate of ₹ 4.50 per unit which will amount to a monthly total energy charge of ₹ 972. Therefore, the family will incur a total monthly energy charge (including the existing non-EV consumption) of ₹ 2,382.

With this level of EV utilization, availing of a separate EV metered connection will make more economic sense for the family. Moreover, it can benefit from any future Time of Day (ToD) tariffs when the regulator includes EV charging under the ToD tariff regime.

OPTION 3: POWERING BY CAPTIVE RENEWABLE ENERGY GENERATION

CPOs may choose to meet the energy requirement for EV charging, partly or in full, through captive electricity generation. However, the feasibility of this option needs to be assessed on a case-by-case basis.

Captive electricity generation for EV charging is typically enabled through solar photovoltaic (PV) or solar-wind hybrid systems, supported by stationary energy storage for reliable power supply. The surface area available for installing the generation system, and the site characteristics in terms of solar insolation and wind profile, are critical parameters in assessing feasibility. An area of about 10 sq m is commonly required to set up a 1 kWp solar PV system. The system can be designed as a roof over the charging facility to maximize space utilization, or it can be mounted on the roof of the host establishment where applicable.

- A technical feasibility study needs to be carried out to evaluate the electricity generation potential and required storage capacity at the site.
- Depending on the feasibility study, the CPO must evaluate the share of the required power demand for the EV charging installation that can be fulfilled through captive generation. Where the power demand can only be partly met through on-site electricity generation and storage, the CPO will need to arrange for a secondary electricity supply source, either through an existing grid connection or through a new metered connection.

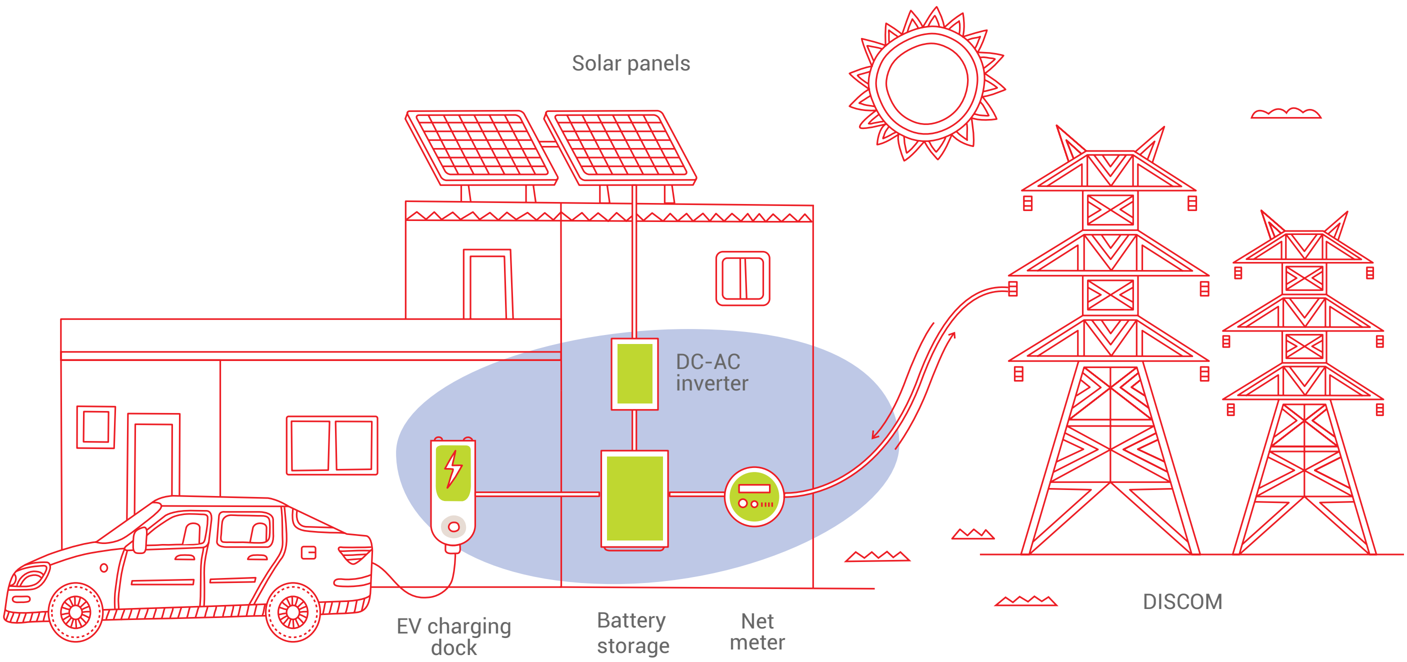
CPOs will need to assess the economic benefits of captive electricity generation vis-à-vis the capital costs of setting up the energy generation and storage system, including the periodic replacement of storage batteries. CPOs may find merit in setting up captive generation systems at locations where the quality of power supplied by the DISCOM is a major issue.

NET METERING

Net metering or net billing enables the deduction of electricity produced on-site using renewable energy from the total electricity consumed in a billing period. This helps lower a prosumer's electricity bill (a "prosumer" is an agent that consumes electricity from the grid and can also inject electricity into the grid). The prosumer either pays for the difference in units or gets paid by the DISCOM for extra units at the end of the billing cycle.

Many states have notified their Net Metering Regulations, which specify the parameters for consumers to participate by setting up renewable energy generation systems on their premises. DISCOMs should encourage CPOs and host establishments to avail of net metering provisions. SERCs may also offer incentives to EV owners who utilize captive renewable energy generation to charge their EVs.

NET METERING CONNECTION

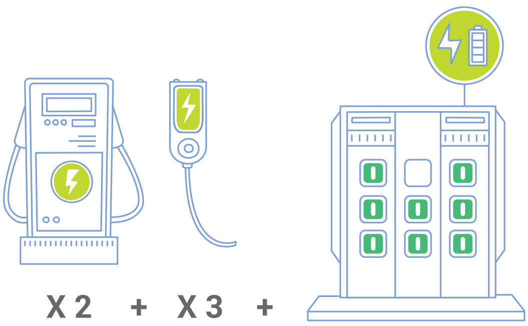


CASE-BASED DEMONSTRATION

A CPO has identified a location for setting up a standalone charging facility and wants to install two 50 kW chargers, three 7 kW chargers, and a 9-unit stack battery charging system. After consulting the DISCOM, it is found that the nearby DT has available capacity to support an additional load of 48 kW, beyond which its capacity would need to be augmented. Moreover, the supply code stipulates 7 kW and 65 kW as the maximum sanctioned load limits for single-phase LT and three-phase LT electricity connections, respectively.

What is the optimal connection type and configuration for the charging facility?

The total power demand for the desired configuration is 133 kW which exceeds the available hosting capacity of the nearest DT and the three-phase LT connection limits. The CPO has three main options to get the electricity supply:

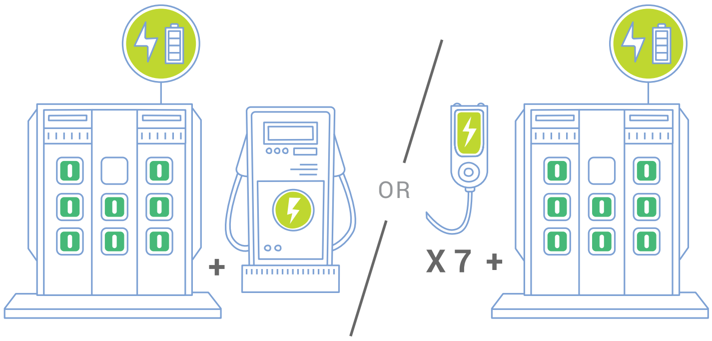


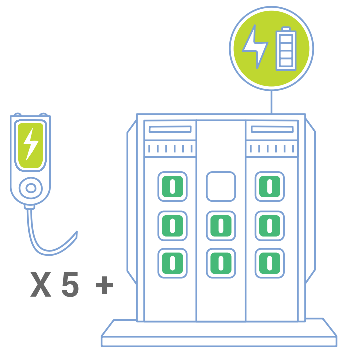
APPLY FOR AN HT CONNECTION AND SET UP OWN DT

This option gives the CPO the liberty to accommodate the charging facility as planned. However, it must bear the cost of the DT along with the associated 33/11 kW cables, which can cost up to ₹ 2.5 lakhs. The CPO will also need additional space at the identified site for the ancillary electrical infrastructure (as seen in Chapter 4). Moreover, charges associated with the application for an HT connection, such as SLD charges, are higher, and the CPO may have to pay higher demand charges in its electricity bills.

RECONFIGURE THE CHARGING PLAN SO THAT THE SANCTIONED LOAD FALLS WITHIN THREE-PHASE LT CATEGORY

With a maximum sanctioned load of 65 kW, the CPO can either retain one 50-kW charger and the stack battery charging system or change the configuration to seven numbers of 7-kW chargers and the stack battery charging system, provided the necessary parking space is available at the site. The selected configuration depends on the charging requirements at the site location. However, this exceeds the available capacity at the nearby DT which therefore needs to be upgraded. The CPO can apply to the DISCOM for a new DT, which the DISCOM may take up as part of its standard grid upgrades. In this case, the CPO will not have to bear any additional cost for the DT. This is contingent on the DISCOM's discretion and the applicable provisions of the state supply code regulations. Such arrangements may take considerable time to get implemented, which can delay the commissioning of the charging facility.





RECONFIGURE THE CHARGING PLAN SO THAT EXISTING DT CAN SERVE THE CONNECTION"

Reducing the total power demand to fit within the available hosting capacity of the nearby DT enables easier and faster award of electricity connections. For a maximum load of 48 kW, the charging facility can accommodate five 7-kW charging points along with the stack battery charging system. This load can be supported by the existing nearby DT without any need for immediate capacity augmentation. Additional charging demand, if any, can be accommodated at a nearby site with available load capacity.

6

ACHIEVING EFFECTIVE EV-GRID INTEGRATION

The total electricity demand for EVs, at 33% EV penetration rate by 2030, is projected to be 37 TWh (as per a 2018 Brookings India report). This constitutes less than 2% of the total electricity demand across the country by 2030. Therefore, meeting the overall energy demand for EVs is not expected to be a challenge in India.

However, high charging capacities of EVs and their spatial concentration may lead to significant volatility in their power demand. Combined with bottlenecks in distribution capacity at the local level, this can result in barriers to the seamless provision of EV charging connections, and can impact grid stability for all electricity consumers.

This chapter highlights measures to improve the utilization of the existing grid infrastructure as well as to integrate EV charging loads into electrical network planning and expansion.

6.1

IMPROVING THE UTILIZATION OF THE ELECTRICITY GRID

In the previous chapter, measures to optimize power connections for EV charging at the site level were discussed. At the feeder and network level, energy management measures and distributed charging network planning can help optimize grid utilization and significantly reduce the immediate need for expensive upgrades.

Here, we look at three means by which EV charging loads can be managed.

DISTRIBUTED DESIGN OF 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 is implemented in a distributed manner to limit the power demand for charging at any location.

PASSIVE MANAGEMENT OF EV CHARGING LOAD

Passive EV charging management entails influencing the charging behaviour 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 overloading the electricity grid. ToD tariffs are effective at managing EV charging loads without excessive financial burden on EV owners or CPOs.

ACTIVE MANAGEMENT OF EV CHARGING LOAD

Active charging management involves remotely-controlled EV charging that responds to triggers like changes in 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.

6.1.1

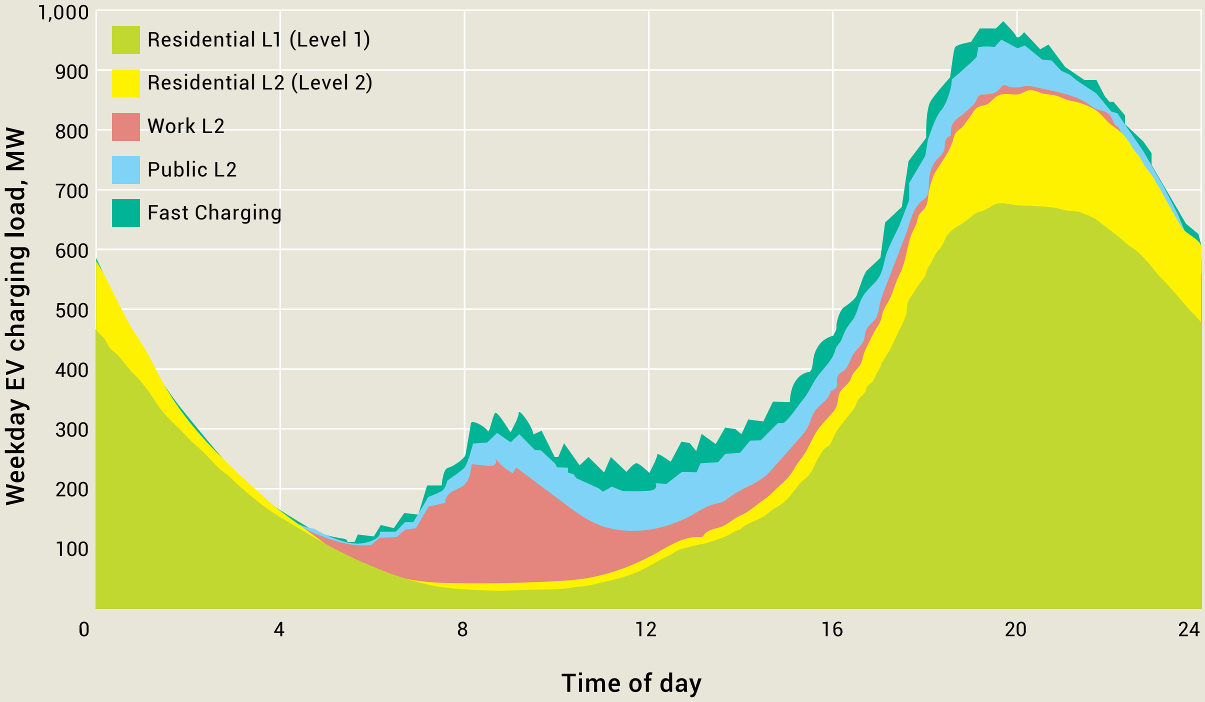
EV CHARGING LOAD MANAGEMENT

With growing EV adoption, increased charging loads pose risks at multiple levels, from the DISCOM's service area to the feeder level. On one hand, aggregated charging demand may exacerbate the peak demand in a DISCOM's service area or create new demand (secondary) peaks, as observed in the modelling of the EV charging load in California, USA (see Box G).

On the other hand, intermittent spikes in EV charging loads can adversely impact the distribution network, particularly in areas where electricity feeders have low available hosting capacity.

Unmanaged EV charging, often referred to as simple or dumb charging, can hamper smooth operation of the electricity distribution system by causing voltage instabilities, harmonic distortions, power losses, and degradation of reliability indices. In cases where EV charging points draw electricity from an existing connection, dumb charging can cause voltage instability in the electrical circuit of the host establishment.

BOX G: PROJECTION OF EV CHARGING LOAD IN CALIFORNIA



Source: California Energy Commission and NREL

The figure above shows the projected state-wide aggregated EV charging load in California, USA, on a typical weekday in 2025. The blue band shows the projected load from Level 1 charging that uses a standard household outlet (single-phase 120V). The output power of these chargers ranges from 1.3 kW to 2.4 kW, and they typically do not have any load control feature.

The diurnal peak in EV charging demand, driven by residential charging, coincides with the typical evening peak for overall residential electricity demand. To minimize grid upgrade requirements and distribute charging demand over other times of the day, residential charging loads should be managed through passive and active demand management.

In contrast, smart charging uses passive and active energy management measures to balance charging demand more evenly and to minimize the negative impacts of EV charging loads on the distribution system. Pilot projects in different parts of the world have demonstrated that smart charging in coordination with passive management measures is effective in shifting a substantial share of the EV charging load to off-peak times, while still satisfying customers' charging needs. Further, managed EV charging can be leveraged to achieve higher renewable energy uptake, by synchronising optimal vehicle charging times with peak renewable energy generation periods.

Smart charging is also useful in charging use-cases where electricity for EV charging is drawn from an existing power connection. Smart chargers with requisite capabilities can limit charging load by controlling charging power levels, in response to overall power demand to avoid exceeding the sanctioned load. At a feeder level or within a DISCOM service area, smart charging devices respond to signals to control the rate of charging, in order to provide frequency response services and load balancing services.

6.1.2

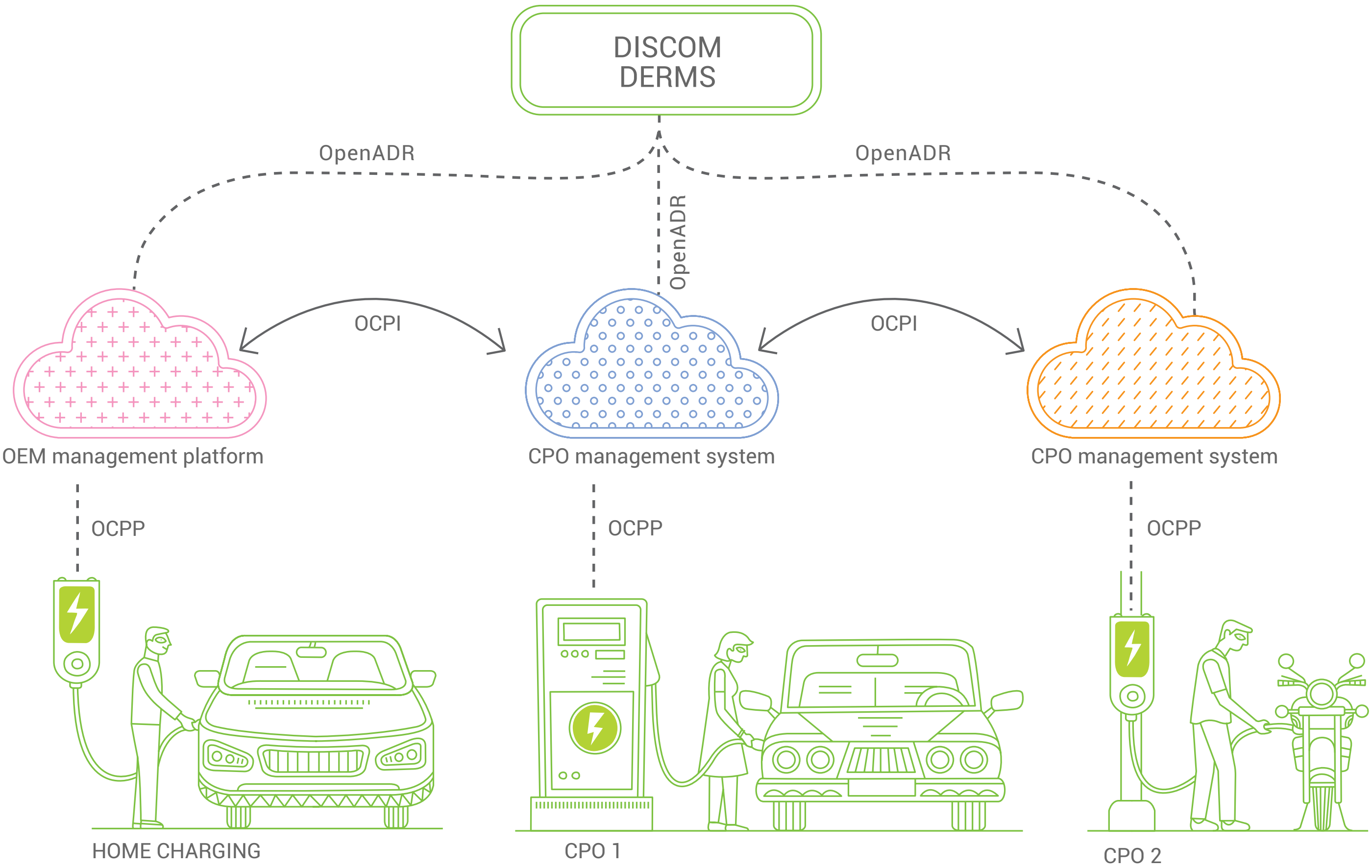
MAKING EV CHARGING SMART

Smart charging encompasses a range of functions and capabilities. For private charging, an EVSE with basic functions is adequate for programming according to ToD tariffs. For more advanced solutions at commercial charging facilities or rapid charging hubs, a wider range of functions is needed to enable dynamic load management, respond to ToU tariff signals, and operate different subscription plans for seamless charging transactions.

An EVSE with advanced smart charging capabilities has the following characteristics:

- i It can be programmed to respond appropriately and autonomously to signals from DISCOMs (e.g. electricity tariff), Central Management System (CMS), etc., to coordinate with ToD and ToU tariffs
- ii It can be monitored and managed over an app
- iii It is equipped with GPRS, 3G/4G or wired connection, and is connected to a cloud service
- iv It shares a data connection with an EV and a charging network
- v It is compatible with the back-end communication protocol

BACK-END ARCHITECTURE FOR SMART CHARGING



BOX H: COMMUNICATION PROTOCOLS FOR SMART CHARGING

Smart charging at scale requires uniform communication architecture to allow interactions between the different levels of the system i.e. between EVSEs and charging networks (or central management systems) between different charging networks, and between the Central Management System (CMS) and Distributed Energy Resources Management System (DERMS) hosted by the DISCOM or a third-party aggregator.

EVSE-CMS COMMUNICATION

The Open Charge Point Protocol (OCPP) is an open-source, freely available standard that enables communication between an EVSE and a CMS, also known as a charging station network. It allows interoperability among different charging equipment, software systems, and charging networks, allowing users to switch between charging networks. It has features for device management, transaction handling, security, smart charging, etc.

CPO-CPO COMMUNICATION

The Open Charge Point Interface protocol (OCPI) supports information exchange between e-mobility service providers (e-MSPs) and charge point operators to enable automated roaming between charging networks for EV owners. Supported features include charge point information, charging session authorization, tariffs, reservation, roaming, and smart charging.

CMS-DERMS (UTILITY CONNECTION)

The Open Automated Demand Response (OpenADR) protocol facilitates demand response signals between DISCOMs and EV users. The DERMS platform helps DISCOMs manage their distributed energy resource (DER) assets, which include electric vehicles. OpenADR enables energy demand management for EV charging through demand response signals, by throttling power drawn by EVSEs during periods of high demand.

In addition, a smart charging system comprises the following features:

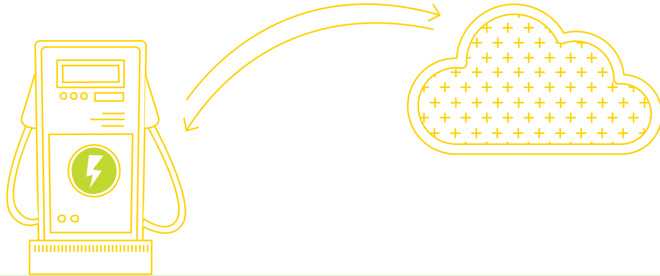
- An intelligent back-end solution that enables real-time data sharing between the EV, EVSE, and CPO, known as the Central Management System (CMS). This is the backbone of smart charging.
- A uniform communication layer for all the charging devices within the CPO network. For DISCOMs, a standard communication layer needs to encompass all charging networks of different CPOs in their service area, for charging load management at the grid level. See Box H for more details.
- Time-based tariffs like ToD using ToD meters for EV charging, to begin with; later, more dynamic time-of-use (ToU) rates can be applied.

Smart charging is typically deployed for commercial charging facilities, and smart chargers with backend communication capabilities should be used for semi-public and public charging. Private charging at home or for personal use is usually Mode 2 charging (Mode 1 is not recommended), and does not have smart charging capabilities. This makes home charging loads difficult to manage, as seen in the California example described earlier

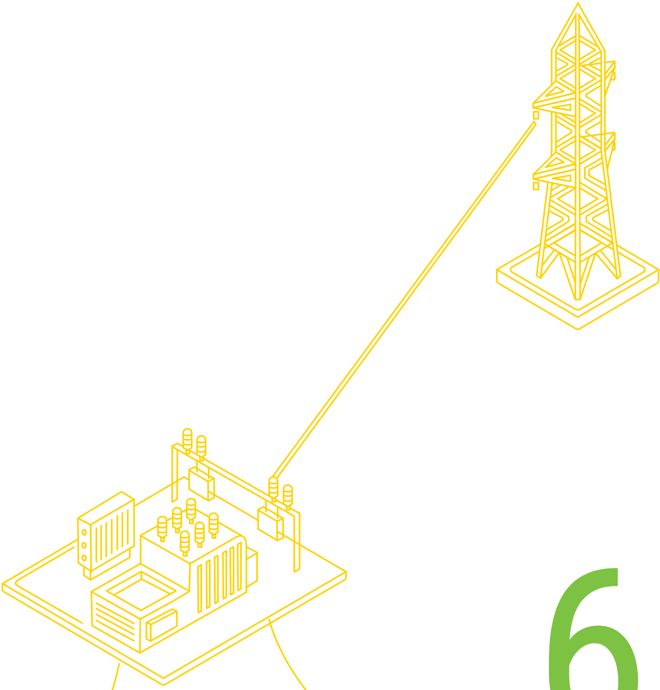
To partly address this issue, it is suggested that a market be created for low-cost chargers that can be programmed to synchronize with ToD tariffs. This will allow for passive management of private charging events, which can reduce excess demand on the grid during peak hours. As DISCOMs mandate smart charging capabilities for private charging, EV users can upgrade their chargers at that time.

Establishing a managed charging framework requires the involvement of multiple stakeholders identified in Table 5, along with their roles and responsibilities.

TABLE 5: STAKEHOLDERS AND THEIR RESPONSIBILITIES IN ENABLING MANAGED CHARGING



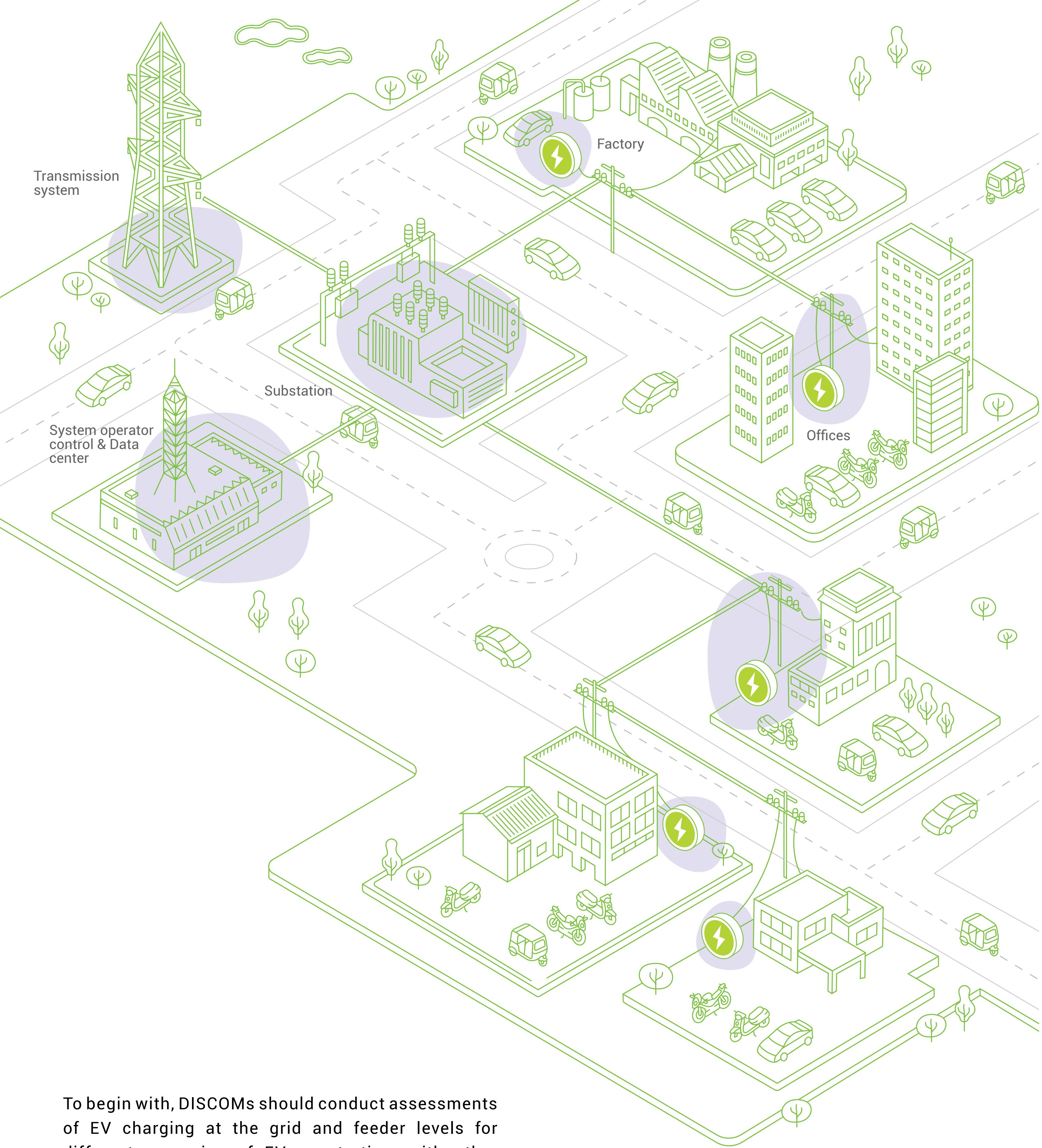
Stakeholder	Key actions
Private EV user	• Apply for separate EV connection with ToD meter • Use programmable EV chargers with pre-set charging functions • Charge EV in accordance with ToD tariffs, where applicable
CPO	• Install charging equipment compliant with OCPP1.6 or higher version • Adopt OpenADR or equivalent communication, when notified by the concerned authority
DISCOM	• Enable passive management measures by designing appropriate ToD tariffs • Develop guidelines on minimum data sharing requirements by CPOs • Offer bundled services to private EV owners, with EV metered connections and programmable EV chargers • Tie up with charger manufacturers to certify charging devices that meet the minimum criteria for managed charging
SERC	• Stipulate installation of ToD meter for EV charging, including for private charging and battery charging for swapping • Introduce time-varying rates for EV charging based on the availability of grid-tied renewable energy • Structure demand charge to minimize financial burden to LT-charging points while also discouraging unmanaged EV charging
CEA	• Mandate DISCOMs to adopt OpenADR and create a Distributed Energy Resources Management System (DERMS) at the back end • Make installation of ARAI-approved charging equipment compliant with OCPP1.6 or a higher version mandatory for all charging use-cases • Stipulate CPOs to adopt a uniform CMS template that is: - Based on OCPP for network communication - In sync with OpenADR for communication with DERMS of the serving DISCOM
SNA	• Promote smart charging to avoid lock-in with unmanageable dumb chargers • Provide a platform to the EV charging service market for bulk procurement of smart chargers



6.2

INTEGRATING EV CHARGING IN GRID PLANNING

Readiness of the electricity grid to cater to EV charging demand is critical to achieve rapid and large-scale transition to EVs. Application of smart charging measures can help manage EV charging loads to a certain degree without the need for grid upgrades. However, going forward, DISCOM planning processes for grid upgrades and network expansions will need to account for EV charging loads.



To begin with, DISCOMs should conduct assessments of EV charging at the grid and feeder levels for different scenarios of EV penetration, with other factors of interest such as spatial concentration of EVs, differential EV charging patterns, and the modelled impacts of ToD measures. This will help DISCOMs devise their load management strategies, develop grid upgrading plans, and plan for increases in power purchase agreements (PPAs) as needed. Subsequently, DISCOMs should develop EV readiness plans based on charging load impacts on the grid infrastructure.

National and state regulators are advised to direct DISCOMs to undertake impact assessments and prepare EV readiness plans. Box I provides an example of an impact assessment study undertaken by DISCOMs in Delhi.

BOX I: IMPACT OF EV CHARGING ON POWER DEMAND

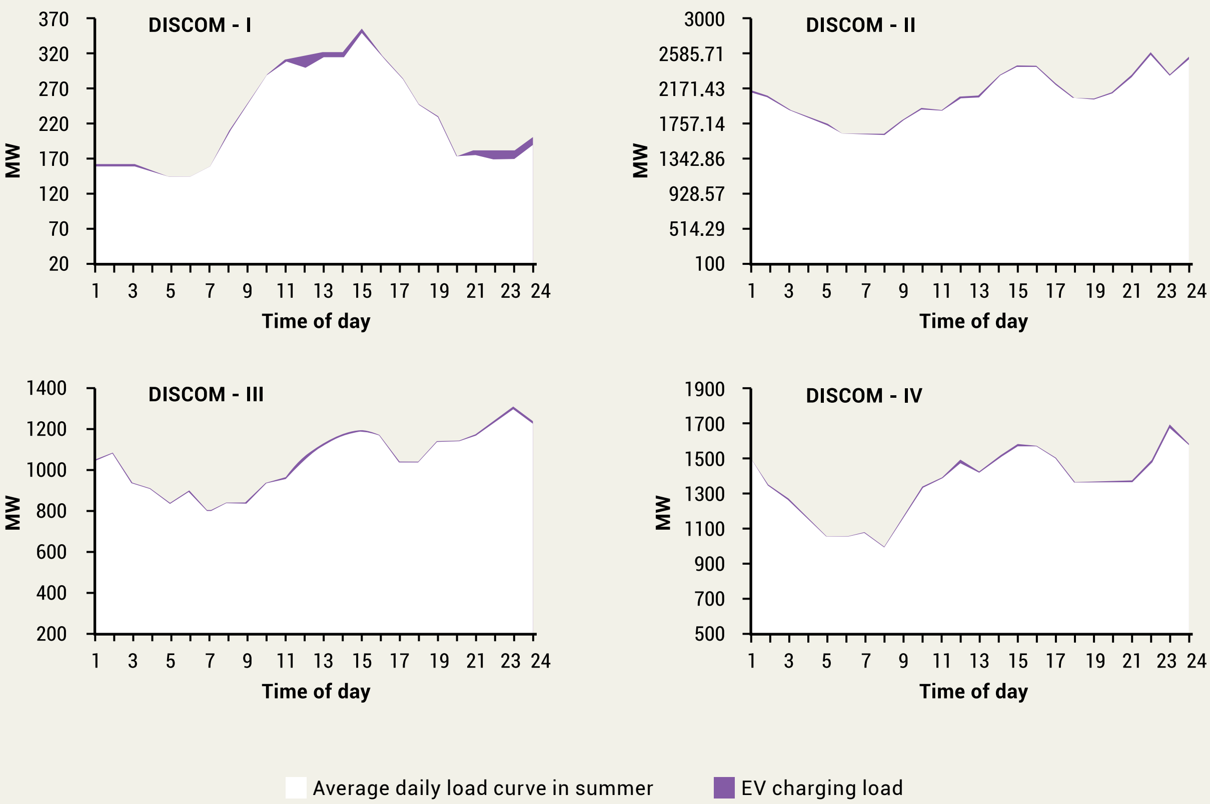
The study "EV – A New Entrant To India's Electricity Consumer-Basket" evaluates the seasonal impact of charging requirements for 10,100 EVs (comprising 7,100 e-2Ws, 1,550 e-3Ws, 1,350 e-4Ws and 100 e-buses) on the peak power demand of each of the four DISCOMs in Delhi. The study developed an Excel-based model to evaluate the change in load profile of a DISCOM due to EV charging, based on the following input data:

- Load data for the DISCOM for different seasons from the State Load Dispatch Centre (SLDC)
- EV population scenario based on publicly available projected data
- Vehicle and charger specifications for different EV categories
- Charging requirements and time-based charging patterns for different EV segments

The study indicates that immediate EV charging demand constitutes only a marginal fraction of the total demand in a DISCOM's service area. However, even at this stage, EV charging can potentially exacerbate peak loads or fill out the off-peak hours for electricity demand, based on EV charging patterns. Further, while the study considered approximately 10,000 EVs in a DISCOM service area in Delhi, there were more than 23,000 EVs registered in Delhi in 2019. This figure is expected to grow to more than 200,000 EV registrations per year by 2030. At the projected rate, EV charging demand as a component of total electricity demand in a DISCOM service area is expected to grow rapidly.

The impact of EV charging is expected to be more pronounced at the distribution transformer (DT) level, which can be projected through impact assessments of localized charging loads on grid infrastructure at the feeder level.

PROJECTED IMPACT OF EV CHARGING ON AVERAGE DAILY LOAD CURVES OF DELHI DISCOMS IN SUMMER SEASON



7

MODELS OF EV CHARGING IMPLEMENTATION

The EV charging infrastructure market in India is young, with fewer than 2,000 charging stations established across the country as of March 2021. However, with the market expected to scale up rapidly in the next few years, companies from various sectors are entering at different points in the value chain.

Multiple stakeholders are exploring business models and implementation partnerships to set up EV charging, driven by profit motives or regulatory requirements. This chapter identifies the typical stakeholder roles in the implementation of charging infrastructure and defines the common models of implementation seen in India.

7.1

TYPICAL ROLES IN CHARGING INFRASTRUCTURE IMPLEMENTATION

A typical charging infrastructure implementation model involves multiple roles, which may be taken up by one stakeholder or delivered through partnerships between different stakeholders. Apart from the set up of charging infrastructure, other roles include land provision, electricity supply, EVSE supply, charging software solutions, and customer services.

i **Procurement of charging infrastructure:** The stakeholder procuring the charging infrastructure is the driving partner for the implementation. Procurement can be undertaken by the primary user of the charging infrastructure, by the charging service provider, or by the governing authority responsible for providing charging infrastructure. The procurer usually owns the EV chargers as well; however, this is not a necessary condition.

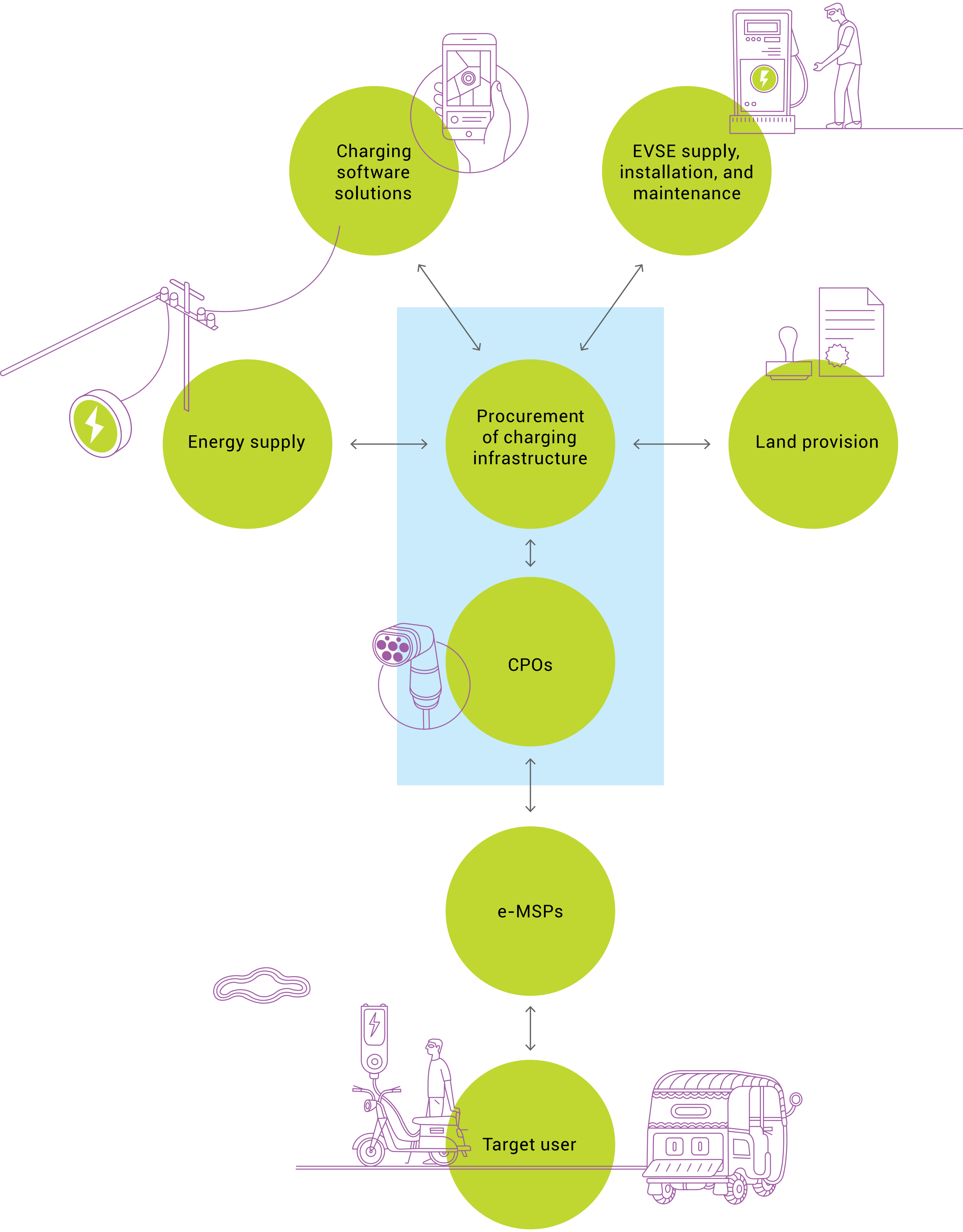
ii **Land provision:** The space required for EV charging may be owned by the procuring stakeholder, or may be acquired on lease or alternative arrangements (revenue sharing, for example). Generally, private and semi-public charging facilities are installed on private land, while public ones may be installed on public or private land.

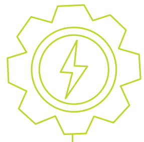
iii **Energy supply:** Energy supply for all EV charging installations is provided by the DISCOMs responsible for power distribution in the region where the charging facility is located.

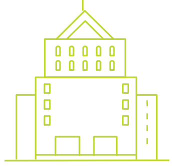
iv **EVSE supply, installation, and maintenance:** EV chargers may be supplied by an EVSE manufacturer or retailer. For semi-public or public charging, CPOs are usually responsible for the selection and installation of the required arrangement of chargers.

v **Charging software solutions:** System management software is used by CPOs to manage their network of charging points, to track and control charging sessions, run diagnostics on the charger equipment, and for other back-end services to manage customer subscriptions, pricing structures, etc. Charging solutions may be offered as white-label solutions from third-party vendors, or may be developed in-house by CPOs.

In addition to implementing stakeholders, CPOs and e-MSPs are responsible for customer services at public and semi-public charging facilities. See Chapter 2 for details on their responsibilities.


Charging software solutions
EVSE supply, installation, and maintenance
Energy supply
Procurement of charging infrastructure
Land provision
CPOs
e-MSPs
Target user

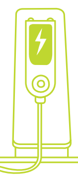




7.2

MODELS OF IMPLEMENTATION

There are three broad implementation models for charging infrastructure, categorized by the stakeholder group responsible for charging infrastructure procurement – the government-driven model, the consumer-driven model, and the service provider-driven model.



7.2.1

GOVERNMENT-DRIVEN MODEL

In many cities, public charging infrastructure provision is led by government agencies. They include local authorities such as municipal corporations and urban development authorities, or state nodal agencies (SNAs) responsible for public charging infrastructure. Public land, aggregated from different government and public sector bodies, is provided for the installation of charging facilities. The charging equipment may be owned by government or by a CPO that is contracted to own and operate the charging services.

For self-owned EV charging facilities, public sector agencies procure the EVSE equipment through an EPC contract with a partner. Charging services may be self-managed or outsourced to a CPO. Alternatively, government authorities may enter a PPP contract with a partner. Here, the relevant government agency invites CPOs to install and operate EV charging facilities for public use. In this model, governments offer financial subsidies, concessional land provision and/or energy supply to incentivize CPOs to reduce capital costs of implementation.

The government-driven model, an example of which is described in Box J, ensures the adequate availability of public charging. This model is likely to be more dominant in the early years of EV ecosystem development, to set up a basic network of public charging facilities.

BOX J: DELHI'S EV CHARGING AND BATTERY SWAPPING STATION TENDER

Delhi Transco Ltd (DTL), as the State Nodal Agency (SNA) for charging infrastructure, has invited bids from private agencies to set up and operate public charging stations (PCS) across the city.

The tender will be awarded to the companies charging the lowest service fees. The concessionaire is responsible for the supply, erection, testing, commissioning, maintaining and operations of the PCS at its own cost for the designated lease period. The concessionaire/ CPO will recover the cost via service fees.

Land for setting up charging stations is provided by the government, with land parcels aggregated from various public agencies. Land is provided on a revenue-sharing basis, and the concessionaires will pay a fixed rate of INR 0.70/kWh of power sold to the site-owning agency, for the duration of the contract period (60 months).

The DISCOMs are mandated to provide electricity connections up to 100kW sanctioned load for the public charging facilities. The concessionaires are responsible for obtaining EV metered connections, and for the energy charges for electricity used.

Regulatory support for applications, permissions, quality checks, site feasibility, approvals, etc. is provided to the concessionaire by the SNA or any other body mandated in the contract. The SNA will also support the concessionaire in taking up early release of the electricity connection with the respective DISCOM.

At the end of the lease period, the concessionaire may choose to take up ownership of the charging infrastructure assets after clearance by the land-owning agency and DISCOMs.

This is a typical example of a public-private partnership (PPP) for EV charging implementation. SNAs in other states are considering similar models.

7.2.2

CONSUMER-DRIVEN MODEL

The consumer-driven model is employed for private and semi-public charging facilities. Primary procuring stakeholders include private entities such as malls, commercial or institutional establishments, retail shops, restaurants, etc, that have parking available on their premises to host EV charging facilities. They will most commonly partner with a CPO to take care of EVSE supply, installation, and maintenance, as well as the management of service operations. While EVSE procurement by the private entity is typically through direct purchase, new models around leasing of EVSE equipment from suppliers or CPOs are also evolving.

Other consumers using this model include private EV owners and fleet operators. The implementation model is straightforward for EV owners, who may procure the EV charger from their automobile OEM, an EVSE retailer, a CPO or their DISCOM. Depending on the type of charger and power connection, software services may be available to the EV owner through a mobile application to control charging sessions, take advantage of ToD tariffs, etc.

Fleet operators require charging facilities for their EV fleets. In this case, land is provided by the fleet operator, who may own or lease it. EVSE equipment supply, installation, and maintenance are through direct contracts with suppliers or CPOs, and charging management services may be handled in-house or contracted to a CPO. Box K highlights the consumer-driven model in action for new property developments.

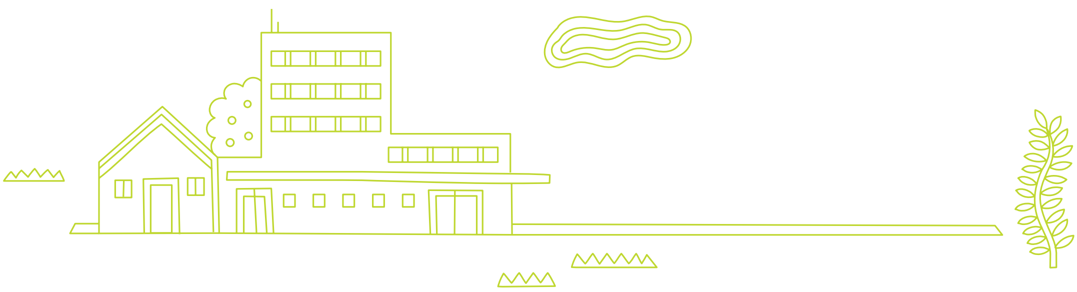
BOX K: SEMI-PUBLIC CHARGING FACILITIES FOR RESIDENTIAL DEVELOPMENTS

Access to charging infrastructure in residential townships and office campuses is essential to enabling higher rates of EV adoption. Many host establishments have started installing EV charging infrastructure in their properties, either to fulfil government mandates or as an amenity for occupants and visitors.

To cater to this growing demand, private CPOs are providing plug-and-play solutions for semi-public charging facilities, for both existing and new developments. One CPO has developed two wall-mounted charger models, 3.3kW AC and 7.5kW AC, for use in residential communities.

As part of its service offering, the CPO provides end-to-end hardware, software, installation, operations, and maintenance support. The charger comes integrated with wireless monitoring and data logging, which is enabled via the CPO's online and mobile platforms. The user software integrates with the existing facility management software of residential societies, streamlining authentication and billing processes for residents. There is no dedicated manpower required for operations or fee collection, which is managed through a mobile application. The CPO works with the DISCOM for installation of the EV billing meter, as well as for performing a safety audit of the charging installation.

As building bye laws come into effect and EV charging facilities become essential amenities, this model is expected to scale up significantly.

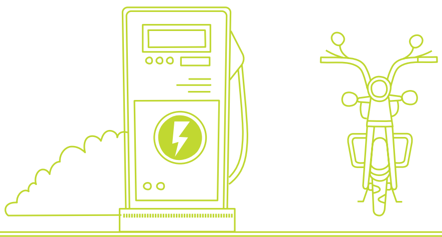


7.2.3

SERVICE PROVIDER MODEL

In the service provider model, it is the CPOs that drive EV charging provision for public and semi-public charging. The key distinguishing features of the service provider model are:

- EVSE equipment is usually owned by the CPO
- Land is sourced from a variety of owners, including public and private entities (this is especially true for private CPOs), and
- Charging services are offered under the brand of the CPO.



Private CPOs aim to establish a network of charging facilities in strategic locations with high potential charging demand. They source land parcels in selected locations from public or private entities, install EVSE equipment supplied by manufacturing partners, and operate paid EV charging services for public or semi-public use. CPOs may enter revenue-sharing arrangements with host establishments or other landowners for the use of land.

DISCOMS (public and private) are also entering the charging infrastructure market as CPOs, as seen in Box L. These agencies typically use their own land to set up public EV charging facilities and operate them as paid services. DISCOMs may also provide bundled charging services for private EV owners, and recover the capital and operating costs through electricity tariffs. Other stakeholders driving the service provider model of EV charging implementation include industrial companies that are moving into charging infrastructure, and EV manufacturers that are setting up charging infrastructure networks as allied services.

BOX L: GROWTH OF CPO-DRIVEN CHARGING NETWORKS

A mix of public and private CPOs is currently leading the development of public charging infrastructure. EESL (Energy Efficiency Services Limited), a public-sector undertaking, had more than 200 charging stations operational by January 2021. Private-sector DISCOMs such as BSES Rajdhani and Tata Power have also been active in public charging infrastructure provision. Tata Power's EV charging network comprises over 500 chargers in 100 cities.

BSES Rajdhani, in July 2021, floated a tender to empanel charging infrastructure providers to deploy normal-power AC and DC chargers for semi-public and private use in Delhi. This is the first-of-its-kind tender that will certify CPOs and provide a single-window facility for streamlined installation of EV charging.

Private CPOs with notable networks of public chargers include Fortum, Magenta, Charge+Zone, Volttic, Statiq, and Charzer, among others. Some CPOs specialize in different public charging use cases, ranging from 50-60kW DC fast charging stations to compact 3.3kW AC charge points and streetlight charging solutions. Battery charging and swapping providers include Sun Mobility and Lithion Power. Ather Energy, an EV manufacturer, has its own network of DC chargers for electric two-wheelers.

Public and private CPOs are working with multiple partners, including oil and gas companies and EV manufacturers, to deploy and scale up public EV charging infrastructure.

ANNEXURE A

GOI GUIDELINES, NOTIFICATIONS, AND REGULATIONS FOR EV CHARGING

MINISTRY OF POWER

- Issued the "Guidelines and Standards for Charging Infrastructure for Electric Vehicles" in 2018, amended in 2019. [1] Salient points of the guidelines are:
  - o Bureau of Energy Efficiency is the central nodal agency (CNA) for all public EV charging infrastructure.
  - o State governments need to appoint state nodal agencies (SNA) for setting up public charging infrastructure.
  - o Provision of guidelines and requirements (including charger types, electrical infrastructure requirements, testing and certification, and phased rollout) for public charging infrastructure.
  - o Electric vehicle charging equipment to be tested by any lab/facility accredited by National Accreditation Board for Testing and Calibration Laboratory (NABL).
  - o EV charging operations to be considered as a service and not as sale of electricity.
  - o No license required for operating EV charging stations.
  - o Notification for setting maximum tariff for private charging at residences and offices, tariff not to be more than average cost of supply plus 15 percent.

CENTRAL ELECTRICITY REGULATORY AUTHORITY (CEA)

- Amended the "Technical Standards for Connectivity of the Distributed Generation Resources 2019," to include the following points:
  - o Defines "charging point" and "charging station" separately.
  - o Recognizes EV as an energy generation resource.
  - o Introduces standards for charging stations connected or seeking connectivity to the electricity system.
- Amendment to "Measures relating to Safety and Electric Supply" to include EV charging stations. [2]
  - o General safety, fire prevention, and periodic maintenance and assessment.
  - o Maintenance of technical, safety and performance standards, specifications, and protocols to be followed by public charging station installers/operators.

BUREAU OF ENERGY EFFICIENCY

- Responsible for national rollout of public EV charging infrastructure across the country.
- Provision of technical support for the Go Electric awareness campaign at the national and state levels (to the SNAs).

DEPARTMENT OF HEAVY INDUSTRY

- Responsible for administering FAME-II subsidies for EV charging infrastructure.
- Released the Bharat Public EV Charger specifications to facilitate FAME-II public charging stations. [3]
- Responsible for subsidy allocation for EV charging infrastructure along national highways across the country. [4]

MINISTRY OF HOUSING AND URBAN AFFAIRS

- Amended the "Model Building Bye Laws 2016" to include requirements for parking spaces to be equipped with charging infrastructure in private and commercial buildings. [5]

DEPARTMENT OF SCIENCE AND TECHNOLOGY

- General requirements for EV charging notified by Bureau of Indian Standards.
- Support for development of Indian Standards for EV charging infrastructure.

BUREAU OF INDIAN STANDARDS (BIS)

- Notification of standards for "Electric Vehicle Conductive Charging System" that cover Product Specification, dimensions, methods of testing and safety standards for EV charging stations. [6]
- Notification of standards for "Road vehicles - Vehicle to grid communication interface" that describe the network and application protocol requirements as well as physical and data link layer requirements. [7]

GST COUNCIL

- Reduced GST on chargers from 18% to 5%. [8]

1 MoP: https://powermin.gov.in/sites/default/files/uploads/Revised_MoP_Guidelines_01_10_2019.pdf
2 CEA: https://cea.nic.in/ev-charging/?lang=en
3 DHI: https://dhi.nic.in/writereaddata/UploadFile/Standardization%20of%20protocol.pdf
4 DHI: https://dhi.nic.in/writereaddata/UploadFile/EoI%20EV%20Charging.pdf
5 MoHUA: http://mohua.gov.in/upload/whatsnew/5c6e472b20d0aGuidelines%20(EVCI).pdf
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7 BIS: https://www.services.bis.gov.in:8071/php/BIS/PublishStandards/published/standards?commttid=Mzc5
8 GST: https://pib.gov.in/newsite/PrintRelease.aspx?relid=192337

ANNEXURE B

STATE NODAL AGENCIES FOR EV CHARGING INFRASTRUCTURE

S.No.	State	State Nodal Agency (SNA)
1	Andhra Pradesh	New and Renewable Energy Development Corporation of Andhra Pradesh (NREDCAP)
2	Gujarat	Gujarat Energy Development Agency (GEDA)
3	Himachal Pradesh	Himachal Pradesh State Electricity Board Limited (HPSEBL)
4	Karnataka	Bengaluru Electricity Supply Company Limited (BESCOM)
5	Meghalaya	Meghalaya Power Distribution Corporation Limited (MePDCL)
6	Mizoram	Power & Energy Department, Govt of Mizoram
7	Odisha	E.I.C. (Elect.)-cum-PCEI Odisha, Bhubaneswar
8	Punjab	Punjab State Power Corporation Limited (PSPCL)
9	Rajasthan	Jaipur Vidyut Vitran Nigam Limited (JVVNL)
10	Uttarakhand	Uttarakhand Power Corporation Limited
11	Telangana	Telangana State Renewable Energy Development Corporation Ltd (TSREDCO)
12	West Bengal	West Bengal State Electricity Distribution Company Limited (WBSEDCL)
13	Delhi	Delhi Transco Limited (DTL)
14	Lakshadweep	Lakshadweep Energy Development Agency (LEDA)
15	Jammu & Kashmir	EM&RE Wing Jammu as " Nodal Agency for Jammu Division"
		EM&RE Wing Kashmir as "Nodal Agency for Kashmir Division"
		EM&RE/Generation Wing Ladakh as "Nodal Agency for Ladakh Division"
16	Kerala	Kerala State Electricity Board Ltd (KSEB)
17	Madhya Pradesh	M.P. Power Management Co.Ltd (MPPMCL)
18	Maharashtra	Maharashtra State Electricity Distribution Company Ltd (MSEDCL)
19	Haryana	Uttar Haryana Bijli Vitran Nigam Limited (UHBVN)
20	Andaman & Nicobar Islands	Directorate of Transport
21	Sikkim	Power Department, Sikkim
22	Arunachal Pradesh	Central Electrical Zone, Deptt. of Power, Itanagar
23	Bihar	Transport Department
24	Tamil Nadu	Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO)
25	Puducherry	Electricity Department
26	Chhattisgarh	Transport Department

Source: BEE India. Available at (last accessed in July 2021): https://bit.ly/3ArCgdT

ANNEXURE C

EV TARIFFS IN DIFFERENT STATES

State	EV TARIFF		
	ENERGY CHARGE	DEMAND CHARGE	
		Low tension	High tension
Andhra Pradesh	Rs 6.7/kWh	-	-
Assam	Rs 5.25 to 6.75/kWh	Rs 130/kW per month	Rs 160/kVA per month
Bihar	Rs 6.3 to 7.4/kWh	-	-
Chhattisgarh	Rs 5/kWh	-	-
Delhi	Rs 4.5/kWh	-	-
Gujarat	Rs 4 to 4.1/kWh	-	Rs 25 to 50 per kVA per month
Haryana	Rs 6.2/kWh	Rs 100/kW per month	-
Himachal Pradesh	Rs 4.70 to Rs 5/kWh	-	Rs 130/connection per month and Rs 140/kVA per month
Jharkhand	Rs 6.00 to 6.25/kWh	Rs 40 to 150/connection per month	
Karnataka	Rs 5/kWh	Rs 60/kW per month	Rs 190/kVA per month
Kerala	Rs 5/kWh	Rs 75/kW	250/kVA per month
Madhya Pradesh	Rs 5.9 to Rs 6/kWh	-	Rs 100 to 120/kVA of billing demand
Maharashtra	Rs 4.05 to 4.24/kWh	-	Rs 70/kVA per month
Meghalaya	Rs 10.09/kWh	Rs 100 to 230/ connection per month	
Odisha	Rs 4.20 to 5.70/ kWh	Rs 200 to 250/kW per month	Rs 200 to 250/kVA per month
Punjab	Rs 5.4/kWh	-	-
Rajasthan	Rs 6/kWh	Rs 40/HP per month	Rs 135/kVA per month
Tamil Nadu	Rs 5 to 8.05/kWh	Rs 70/kW per month	-
Telangana	Rs 6/kWh	-	-
Uttar Pradesh	Rs 5.9 to Rs 7.7/kWh	-	-
Uttarakhand	Rs 5.5/kWh	-	-

Source:
WRI India (2021). A review of state government policies for electric mobility. Available at (last accessed in July 2021): https://bit.ly/3lISlHO

GLOSSARY OF TERMS

Alternating current (AC) power: A form of electricity that is commonly available from power outlets and supplied by the electricity grid. The name comes from the waveform the current takes.

Central Management System (CMS): An intelligent back-end solution that enables real-time data sharing between the electric vehicle, its charger and the charge-point operator.

Charge point operator (CPO): An entity that installs and manages the operations of the charging infrastructure. A CPO may own the charging infrastructure or provide services on behalf of the charge point owner.

Charging modes: A classification standard adopted in Europe based on the charging rates, power output levels and communication between the electric vehicle and electric vehicle supply equipment. There are four modes.

C- Rate: A measure of the rate at which a battery is being charged or discharged. 1 C-rate means that the discharge current will discharge the entire battery in 1 hour.

Conductive charging: Charging via a wired connection between the electric vehicle and the electric vehicle supply equipment.

Direct current (DC) power: A form of electricity that is commonly available from batteries, solar cells, fuel cells, etc. Unlike AC power, it is characterized with one-directional flow of electric charge.

Distributed energy resources (DER): An electricity-producing resource or a controllable electrical load that is connected to a local distribution system or connected to a host facility within the local distribution system. DERs can include solar panels, combined heat and power plants, electricity storage, electric vehicles, and electrical appliances such as air-conditioners and water heaters.

Distributed energy resources management system (DERMS): A platform that helps a power disribution utility manage its Distributed Energy Resource assets including electric vehicles.

Distribution transformer (DT): It provides the final voltage transformation in the electric power distribution system, stepping down the voltage used in the distribution lines to the level used by the customer.

e-Mobility service provider (e-MSP): An entity that offers charging services to EV drivers by providing access to charge points within its network or to other networks through e-roaming.

Electric Vehicle Supply Equipment (EVSE): An EVSE supplies electrical energy to charge EVs. The EVSE system includes electrical conductors, related equipment, software, and communications protocols that deliver energy efficiently and safely to the vehicle.

EV-roaming (e-roaming): It allows EV users to charge their vehicles at at any charging station or charge point, regardless of which charging network it belongs to. E-roaming is enabled by open communication protocols or proprietary roaming networks, which bring different CPOs and e-MSPs on to a common platform.

High tension (HT) connection: The electrical connection that is served by a supply line operating at a voltage between 11 kV and 33 kV.

kilovolt (kV): A unit equal to 1,000 volts, used to express voltage of electricity transmission and distribution lines.

kilowatt (kW): A unit equal to 1,000 watts, used to express the power of an electrical appliance or generator.

kilowatt-hour (kWh): A unit equal to one kilowatt (kW) of power sustained for one hour, used to express the amount of electrical energy consumed by an electrical appliance or produced by an electrical generator.

Open Charge Point Interface (OCPI): An open application protocol that supports connections between e-mobility service providers (eMSPs) and charge point operators (CPOs).

Open Charge Point Protocol (OCPP): An open-source, freely available standard that enables communication between an EVSE and a CMS, also known as a charging station network.

Open Automated Demand Response (OpenADR): A protocol designed to facilitate demand response signals between power distribution utilities and EV users.

Public charging station (PCS): It is an EV charging facility that is typically accessed by all EV users for charging.

Power Purchase Agreement (PPA): It is a contract between two parties, one which generates electricity (the seller) and one which is looking to purchase electricity (the buyer).

Smart charging: Unidirectional active management of electric vehicle charging, including ramping charging levels up or down.

Time of Day (ToD) tariffs: Different electricity rates at different times of the day, with higher prices in peak periods of high electricity consumption and lower prices in off-peak periods.

CONCEPT AND BOOK DESIGN:

The design of illustrations in the handbook is inspired by Madhubani and Gond Art, art forms that originate in the rich and varied heritage of regions across our country. Madhubani Art is a style of Indian painting that was traditionally created by the women of communities from a region in Bihar. Gond Art is a form of folk art practiced by one of the largest tribes in India- the Gonds- who are predominantly from Madhya Pradesh but also inhabit parts of adjoining states.

The handbook aims to demystify electric vehicle charging, a highly technical topic and a critical component of electric mobility. In selecting the design style, the objective was to bring a story telling aspect to the content, in the form of illustrations like primitive art that could support the text and improve the reader's understanding of the subject. A mix of Madhubani and Gond art, with the right amount of detailing and simplification of forms, was found to be the perfect style for rendering the illustrations. One will find the influences of Gond Art in the detailing of the masses in the vehicles and influences of Madhubani Art in the rendering of the eyes and the anatomy of human forms.

This has resulted in a contemporary style of illustrations with the integration of the two art styles, representing a modern yet rooted India. The colour palette represents the cultural vibrancy of India, with the bright colours complemented by the contemporary typography to balance the design.

Credits:
Book Design and Illustration Concept by
Y STUDIO
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Illustrations by:
LOCOPOPO
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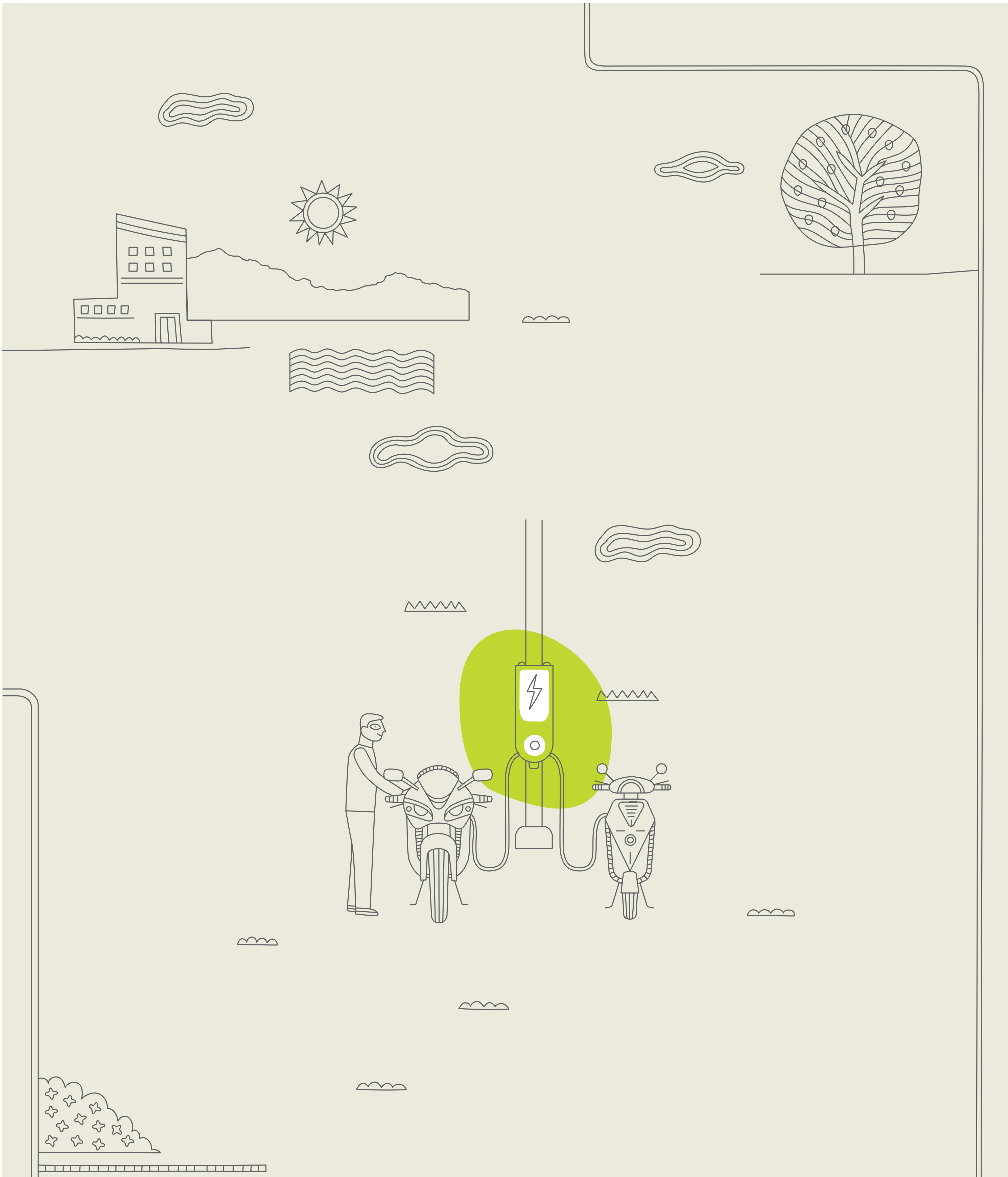

HANDBOOK of

ELECTRIC VEHICLE CHARGING INFRASTRUCTURE IMPLEMENTATION

VERSION-1