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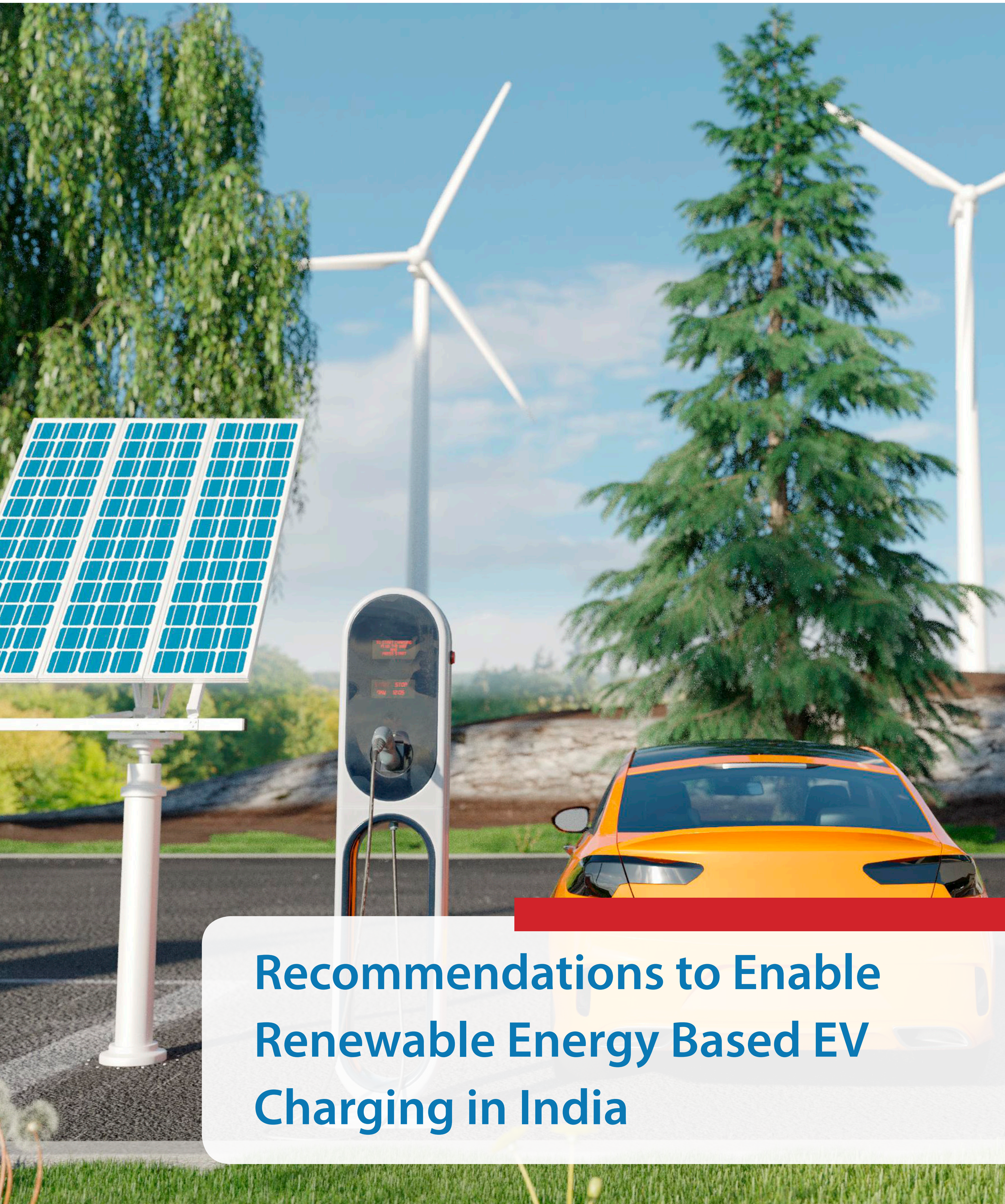

Recommendations to Enable Renewable Energy Based EV Charging in India

Acknowledgement

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List of abbreviations

APPC	Average Power Purchase Cost
ARC	Aggregator of Retail Customers
ARR	Aggregate Revenue Requirement
BESCOM	Bangalore Electricity Supply Company Limited
BESS	Battery Energy Storage System
BIPV	Building-integrated photovoltaics
BMVI	German Federal Ministry of Transport and Digital Infrastructure
CAGR	Compounded Annual Growth Rate
CAISO	California Independent System Operator
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CPO	Charge Point Operator
CPUC	California Public Utilities Commission
DER	Distributed Energy Resources
Discom	Distribution Company
DMS	Distributed Management System
DT	Distribution Transformer
EEG	Renewable Energy Sources Act (German: Erneuerbare-Energien-Gesetz)
EMS	Energy Management System
EU	European Union
EVECC	The EV Energy Control Center
EVPCS	EV-Power Conditioning System
FERC	Federal Energy Regulatory Commission
GEDA	Goa Energy Development Agency
GEIG	Building Electromobility Infrastructure Act
IPP	Independent Power Producer
ISDE	Sustainable Energy Investment Subsidy
ISO	International Organization for Standardization

List of abbreviations (Contd.)

JPY	Japanese Yen
KERC	Karnataka Electricity Regulatory Commission
kW	Kilo watt
LSE	Load Serving Entity
METI	Ministry of Economy, Trade and Industry
MIA	Environmental Investment Allowance (Dutch: Milieu-Investeringsaftrek)
MISO	Midcontinent Independent System Operator
MoST	Ministry of Science and Technology
NEA	National Energy Administration
NKDA	New Town Kolkata, Development Authority
NOK	Norwegian Krone
OEM	Original Equipment Manufacturer
P2P	Peer-to-Peer
PEPCO	Potomac Electric Power Company
PHEV	Plug in Hybrid Electric Vehicle
PPA	Power Purchase Agreement
PV	Photo voltaic
RESCO	Renewable Energy Service Company
RTC	Round the Clock
SERC	State Electricity Regulatory Commission
SRP	Salt River Project
SRTPV	Solar Rooftop Photo Voltaic
STU	State Transport Utility
TOD	Time of Day
TOU	Time of Use
VAMIL	Random depreciation of environmental investments (Dutch: Willekeurige afschrijving voor milieu-investeringen)
VPP	Virtual Power Plant

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01 Introduction

India has initiated its journey towards electrification of transport sector especially roads through plans such as the National Electric Mobility Mission Plan (NEMMP) 2020 and FAME (Faster Adoption and Manufacturing of Electric Vehicles) schemes. The measures are in line with the decarbonization targets of the nation and commitments towards a greener future. However, the true decarbonization through electric vehicles can only be achieved when the charging of electric vehicles are from green energy sources.

Identifying the levers for decarbonizing EV charging, GIZ has deployed a study "Power market Reforms to enable Renewable Energy (RE) based Electric Vehicle (EV) Charging in India" to understand the challenges and opportunities existing in the policy, regulatory, and technological landscape of in India of EV charging to complement RE power generation and efficient grid management. Keeping this in view, three cities viz. Bengaluru, Kolkata and Panaji, were identified to assess their present situation and preparedness with respect to renewable based EV charging. Each of the identified cities provide a view of regions which vary on the RE and EV spectrums.

The city of Bengaluru has substantial number of EVs and the state of Karnataka has significant RE resources with BESCOM being actively involved in deployment of charging stations and aims to install a large number of charging stations. Kolkata has high untapped RE potential and West Bengal's regulations on open access provide a favorable atmosphere for adoption of RE sources. Moreover, the city has witnessed a rapid growth in EV and EV charging infrastructure deployment recently. Goa leads the country in terms of number of vehicles per capita. Although the state has less RE sources developed within the state, the state has witnessed a rapid increase in sale of EVs in the last few years.

The study thus carries out a comprehensive analysis of the three cities, identifies gaps with respect to international best practices and suggests recommendations (financial and non-financial) on the fronts of policy, regulations and technology. The objective of this report is to imbibe the learnings from the analysis carried out on the following and arrive at policy and regulatory recommendations to enable RE based EV charging:

- City level assessments for RE and EV charging (cities include Bengaluru, Kolkata, and Panaji)
- India overview of RE and EV charging
- International policy and regulatory assessment around RE and EV charging
- Technology overview of RE and EV charging
- Technical and commercial aspects of RE based EV charging

The report has the following chapters:

1) **Chapter 2:** this chapter sets the context of RE based EV charging, its need in India, concerned stakeholders, modes of RE procurement and locations for RE based EV charging in different business settings.
2) **Chapter 3:** this section captures all the gaps identified in the Indian RE and EV ecosystem (at the city and central levels).
3) **Chapter 4:** this section covers the best practices in some of the nations such as USA, Germany, Netherlands, Norway, France, Austria, Japan, and China to enable RE based EV charging
4) **Chapter 5:** this section focuses on the recommendations panned out across short-, medium, and long-term for specific stakeholder groups taking into account the gaps identified in chapter 3, best practices identified from chapter 4 and stakeholder consultations carried out

02 Need and benefits of RE based EV charging

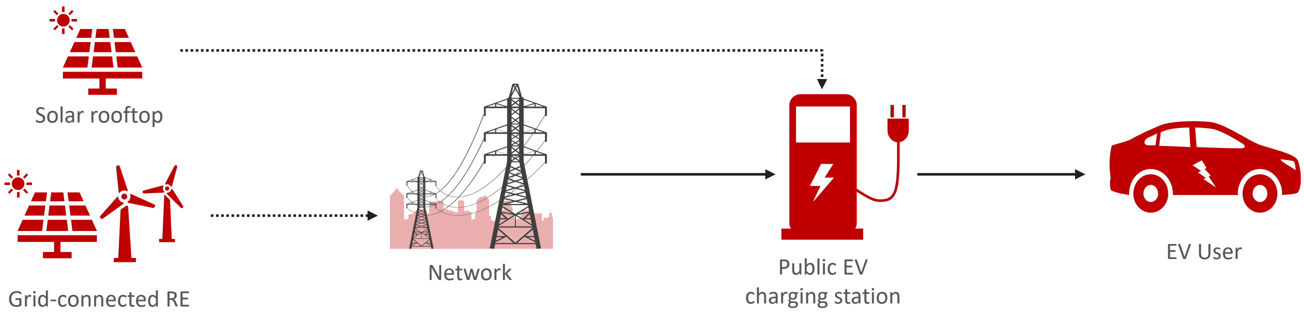


Figure 1: Snapshot of an RE based EV charging arrangement

2.1 About RE based EV charging

In an RE based EV charging arrangement, an EV charging station source its energy from renewable sources (such as solar, wind, hydro, biomass etc.). These sources can be either be co-located with charging infrastructure or can be remotely located (grid-connected).

2.2 Need for RE based EV charging

The EV adoption in India is at a nascent stage but is expected to grow by leaps and bounds. However, higher penetration of EVs poses three primary challenges for the country:

1. An increasing strain on grid: When a large number of EVs will draw electricity from the grid, it will strain the local distribution grid. When the charging is coupled with generation from distributed RE sources, fewer charging points need to depend on the grid. For example, solar panels installed on the property of the charging stations can be used to charge the EV, without causing more demand on the grid.
2. An increasing dependence on conventional sources: An increase in EV charging in peak hours / low RE hours would result in costlier generation being run to serve the charging demand. This would lead to increasing dependence on conventional sources and increase in cost of power purchase for DISCOMs.
3. Emissions and Pollutants: The tail pipe emission from EVs is negligible. However, unless the charging of EVs is coupled with renewable energy, the switch from conventional vehicles to EVs will not be emission free.

Hence, RE based EV charging is the way forward if the country is to ensure a sustainable switch from conventional vehicles to EVs.

2.3 Concerned stakeholders and anticipated benefits from RE based EV charging

In the overall arrangement of RE based EV charging, multiple stakeholders are involved. These stakeholders can be primarily categorized into two categories: energy-sector stakeholders and EV ecosystem stakeholders.

1. Energy-sector stakeholders

2. EV ecosystem stakeholders

Energy-sector stakeholders include power distribution companies (DISCOMs), Renewable Energy Development Authorities, State Electricity Regulatory Commissions, State Energy Departments, State Nodal Agencies, RE independent power producers (RE IPPs). EV ecosystem stakeholders include charge point operators (CPOs), fleet operators, municipal corporations, commercial buildings, and EV end users.

With increasing adoption of RE for EV charging, all of the above stakeholders stand to get the benefits. Details of the potential benefits for each stakeholder is provided in the below figure:

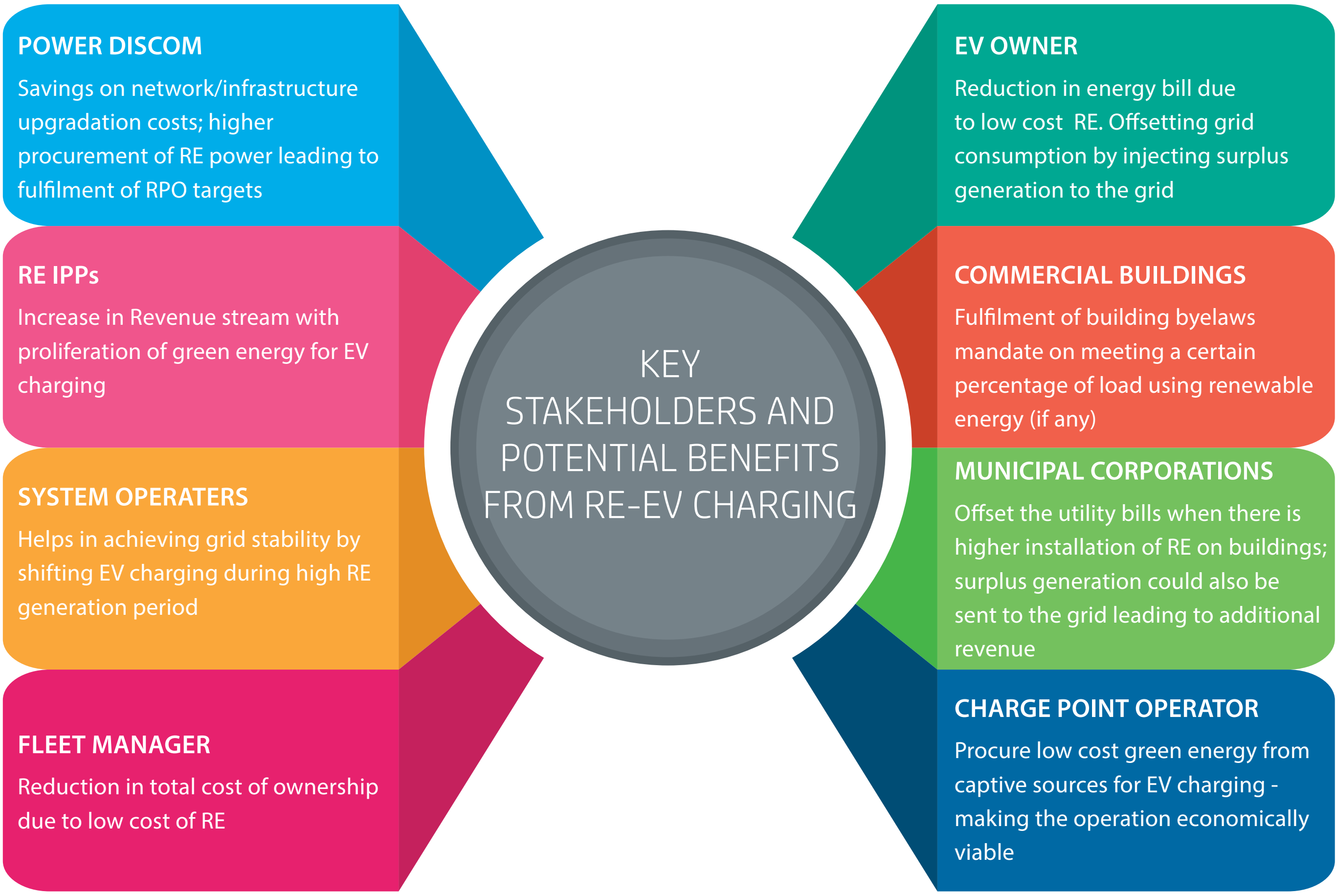


Figure 2: Key stakeholders and benefits

2.4 Suitable location for RE deployment

Location of RE source is a major point to ponder considering the significant capex that is required in their deployment. While some RE sources can be directly co-located with EV charging infrastructure, electricity from others is generally fed into the grid first and then sourced through the transmission and distribution system. Based on the analysis, the table below encapsulates the suitability of the different sources of RE against various parameters.

Table 1: Comparative analysis of different RE sources

Parameter	Solar	Wind	Hydropower	Bio-power
Certainty of availability and ease of prediction	◑	◔	◑	◑
Flexibility of installation	●	◔	○	◑
Possibility for siting in proximity to EV charging station	●	◔	◔	◑
Suitability for co-locating along-with EV charging stations	●	○	○	○
Suitability for coupling with EV charging stations through open access	●	●	●	●

○ Lowest Stability ● Highest Stability

Recommendation:

- Based on the above comparative analysis, solar energy sources are most feasible for co-locating with charging stations. They are easy to install, do not take large spaces and their generation levels are easier to predict.
- Wind, biomass, and hydro power sources can be coupled with charging stations by tying up with power purchase agreements. Such resources are less suitable for co-locating with charging stations.
- The different sources of renewable energy shall be used in combination considering the various parameters including demand, availability, cost etc. to boost the uptake of RE based EV charging infrastructure.

Several criteria define the success of implementation of RE based EV charging. One of the major factors is locational feasibility. If the CPO/ consumer has appropriate and adequate land, roof space, or carports for installation of renewable asset (mostly solar rooftop PV system) the consumers can go for a grid connected onsite RE source for the EV charging.

Consumers who do not have land and appropriate resources for large scale projects can procure renewable energy from a developer of RE project outside its premises. The electricity generated from RE source needs to be wheeled to the consumers using Transmission and Distribution infrastructure. The same also qualifies as a grid connected offsite arrangement.

Residential or small-scale consumers cannot meet the load restrictions for availing open access for EV charging. In addition, they may not have the space availability to install rooftop solar capacity in their premises.

Taking the above considerations into account, the following table summarizes the various avenues for procuring green power for EV charging and the key attributes which are needed to be met.

Table 2: Analysis of avenues for procuring green power for EV charging

Type of Arrangement	Attributes				
	Adequate Land	Roof Space	Green Tariff in State	High Solar/ Wind on the site	Sanctioned Load for Green Open Access
Grid Connected Onsite	✓	✓	-	✓	-
Grid Connected Offsite through Open Access	-	-	-	-	✓
Grid Connected Offsite from DISCOMs	-	✓	-	-	-
Off-Grid	✓	✓	-	✓	-

Having established the benefits, requirements of RE based EV charging, it is vital to assess the gaps in the Indian context for enabling it.

03 Key gaps and challenges in the Indian context for RE based EV charging

The first step in devising the policy and regulatory recommendations is to understand the gaps in the existing policy and regulatory landscape. Since electricity is a concurrent subject in India, it is important to analyze the barriers at city, state as well as national level. Keeping this in view, analyses were carried out for the cities of Bengaluru, Kolkata, and Panaji and the findings were discussed with the stakeholders in these cities. In addition, central level policies and regulations were also analyzed.

The sections that follow highlights the key city-level and national-level gaps and challenges inhibiting the large-scale adoption of RE for EV charging.

3.1 City level analysis, key finding and gaps

Three cities (Bengaluru, Panaji and Kolkata) were selected to conduct the city level analysis for RE based EV charging. The various stakeholders involved in the RE and EV charging ecosystem in these cities are captured below.

Sl.	Stakeholder	Concerned stakeholders in the cities		
		Bengaluru	Panaji	Kolkata
1.	Power Distribution Company	Bangalore Electricity Supply Company Limited (BESCOM)	Goa Electricity Department (ED-Goa)	Calcutta Electric Supply Corporation (CESC)
2.	Renewable Energy Development Agency	Karnataka Renewable Energy Development Limited (KREDL)	Goa Energy Development Agency (GEDA)	West Bengal Renewable Energy Development Agency (WBREDA)

Sl.	Stakeholder	Concerned stakeholders in the cities		
		Bengaluru	Panaji	Kolkata
3.	State Transport Utilities	Bengaluru Metropolitan Transport Corporation (BMTC)	Kadamba Transport Corporation Ltd. (KTC)	West Bengal Transport Corporation (WBTC)
4.	State Electricity Regulatory Commission	Karnataka Electricity Regulatory Commission (KERC)	Joint Electricity Regulatory Commission (JERC)	West Bengal Electricity Regulatory Commission (WBERC)
5.	Municipal Corporation	Bruhat Bengaluru Mahanagara Palike (BBMP)	Corporation of City of Panaji	Kolkata Municipal Corporation (KMC)
6.	State Energy Department	Energy Department Government of Karnataka	Goa Energy Development Agency (GEDA)	Department of Power Government of West Bengal
7.	State Nodal Agency for EV charging infrastructure	Bangalore Electricity Supply Company Limited (BESCOM)	Goa Energy Development Agency (GEDA)	West Bengal State Electricity Distribution Company (WBSEDCL)

A deep-dive on the various policies and regulations focusing on RE based EV charging was carried out to identify enablers and challenges. The same has been detailed in the subsequent section.

3.1.1 Provisions for innovative projects

The focus in the three cities on innovative projects regarding RE based EV charging is highlighted below:

Bengaluru	**Policy[1] envisages**
	❖ promotion of P2P trading which would promote growth of de-centralized solar rooftop installations in the city. Through P2P trading, renewable energy generated in one location can be traded and sold to another location at the distribution level. Karnataka Government aims to promote P2P trading by launching pilot projects, but no pilot has been officially launched till date. Hence, this policy measure is yet to be implemented.
	❖ using existing locations such as retiring thermal station and existing RE Parks for ESS projects. Storage installations along-with RE would also be encouraged. This enables projects to use surplus energy which can be utilized during peak hours.
	❖ pilots and demonstrations on new RE technologies.
Panaji	**Policy[2] envisages**
	❖ setting up of grid connected solar rooftop on government buildings. GEDA may act as an aggregator of demand and facilitate the procurement of systems under capex model or services under the RESCO Model. This enables aggregation of demand from various consumers thereby reducing the fixed costs per unit for the supplier / system integrator.

1. Government of Karnataka. Karnataka Renewable Energy Policy 2022-2027. Retrieved from https://kredl.karnataka.gov.in/storage/pdf-files/Policy/Karnataka%20Renewable%20Energy%20Policy%202022-27%20Notification%20Copy.pdf
2. Government of Goa. Goa State Solar Policy 2017. Retrieved from https://www.goa.gov.in/wp-content/uploads/2019/08/Goa-State-Solar-Policy-2017.pdf, Amended Goa State Solar policy. Retrieved from https://www.goa.gov.in/wp-content/uploads/2020/08/Scheme-and-Policy-GEDA-gazette-for-solar-policy.pdf; Government of Goa. Scheme for promotion of grid-connected solar rooftop system with net-metering system. Retrieved from https://www.goa.gov.in/wp-content/uploads/2020/08/Scheme-and-Policy-GEDA-gazette-for-solar-policy.pdf

Panaji	❖ setting up of decentralized solar plants of 100 kW – 1 MW in the premises and in proximity to 33 kV sub-stations. This would enable localized electricity supply to EV chargers and load centres. This would reduce the distance traversed and, thereby, reduce transmission and distribution losses.
	❖ prioritization for deployment of solar powered charging stations. The state provides capital subsidy to renewable based EV charging stations would improve the financial viability of the projects. This would also incentivize EV charging operators to explore ways for coupling RE sources for their EV chargers.
Kolkata	**Policy[3] envisages**
	❖ use of smart and charging and usage of RE power for EV charging
	❖ active participation by Discoms to establish public charging stations and subsume the costs in the ARR.

All the three cities have committed for demonstration innovative solutions which will enable utilization of RE for EV charging.

3.1.2 Pilot project for RE based EV charging

The status quo of RE based EV charging pilots in the three cities is captured below:

Bengaluru	❖	BESCOM has already conducted a pilot project for EV charging integrated with rooftop solar PV system in Bengaluru1. The pilot also included a battery storage system (40 kWh). The battery storage system stored ~16% of the total daily solar energy (average) generated.
Panaji	❖	No such pilot projects have been conducted.
Kolkata	❖	No such pilot projects have been conducted.

On-site solar installation (RESCO model) with net metering

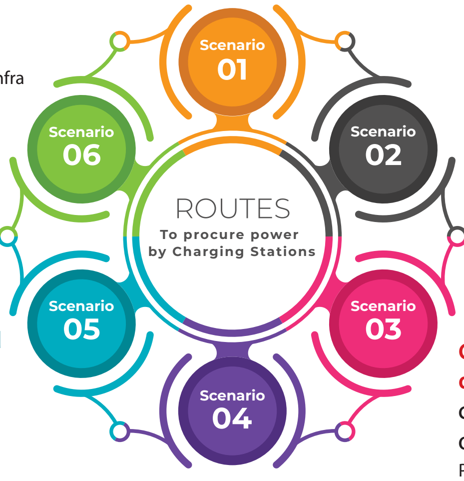
Capital expenditure incurred by charging station developer / operator: Chargers and associated infra

Operational expenditure incurred by charging station developer / operator: Charging station O&M, Personnal cost, PPA tariff and Grid tariff

On-site solar installation (CAPEX based) with net metering

Capital expenditure incurred by charging station developer / operator: Chargers, Solar PV and associated infra

Operational expenditure incurred by charging station developer / operator: Charging station O&M, Solar panel O&M, Personnal cost, Grid tariff



Off-grid solar and battery energy storage system based electricity

Capital expenditure incurred by charging station developer / operator: Chargers, Solar PV, BESS and associated infra

Operational expenditure incurred by charging station developer / operator: Charging station O&M, Solar and BESS O&M, Personnal cost, Grid tariff

Green tariff based electricity from distribution companies

Capital expenditure: Chargers and associated infra

Operational expenditure: Charging station O&M, Personnal cost, Green retail tariff

Third party open access RE electricity based EV charging

Capital expenditure incurred by charging station developer / operator: Chargers and associated infra

Operational expenditure incurred by charging station developer / operator: Charging station O&M, Personnal cost, Tariff for electricity as per PPA with RE developer

Conventional electricity based EV charging

Capital expenditure incurred by charging station developer / operator: Chargers and associated infra

Operational expenditure incurred by charging station developer / operator: Charging station O&M, Personnal cost, Retail electricity cost

3. Department Of Power & Nonconventional Energy Sources, Government of West Bengal. Policy on Co-generation and Generation of electricity from Renewable sources of Energy 2012. Retrieved from https://wberc.gov.in/sites/default/files/policy-renewable-wb.pdf

For the analysis, it has been assumed the charging station has 6 chargers installed. The station has two chargers of CCS (fast), ChAdeMO (fast), and Bharat DC – 001 (slow/moderate) type each. The total connected load of the station equals 230 kW basis the chargers selected. No lease has been considered on land and a levelized cost of rental (INR 1/kWh) has been assumed for this purpose.

Utilization of the chargers has been assumed to reach 30% in the final year of operation and based on that the capacity for solar and battery installations have been computed.

LCOE of public charging in Bengaluru (INR/kWh)

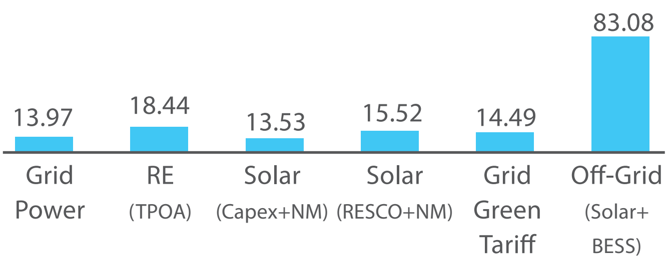


Figure 3: Levelized cost of public EV charging in Bengaluru

The costs for the city of Panaji (considering the subsidy provided by the state on EVSE auxiliary infrastructure) are as follows:

LCOE of public charging in Panaji (INR/kWh)

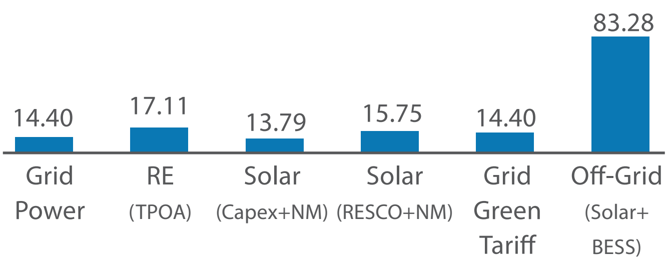


Figure 4: Levelized cost of public EV charging in Panaji

Similarly, the LCOE of public charging for Kolkata is as follows:

LCOE of public charging in Kolkata (INR/kWh)

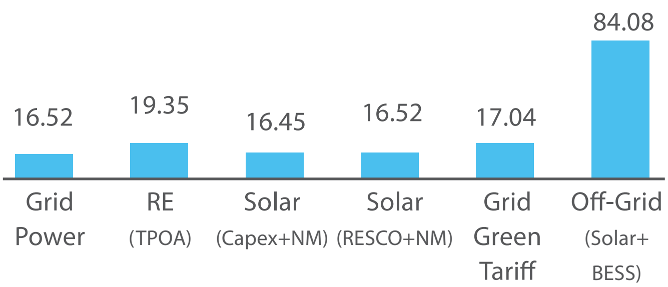


Figure 5: Levelized cost of public EV charging in Kolkata

The levelized cost realized from the grid is the lowest and parity from different routes can be obtained by concessions, subsidies, and waivers on applicable charges.

From the perspective of using a mix of different routes, it is expected that in the case of public charging, a higher share is assigned to green tariffs and third-party open access. The mix considered for arriving at the levelized cost of public EV charging is as follows:

RE Source	RE (3rd Party Open access)	Solar (Capex) + Grid (NM)	Solar (RESCO) + Grid (NM)	Off Grid (RE+ BESS)	Grid green tariff
% load met	10%	10%	5%	0%	75%

The LCOE of public charging achieved based on the mix is as follows for different cities:

City	Bengaluru	Panaji	Kolkata
LCOE (INR/kWh)	13.84	13.68	16.18

The levelized cost of charging can be lowered using a mix of RE procurement routes. However, standalone LCOE from RE procurement routes require support from government stakeholders for initiating uptake.

3.1.4 Capex / Opex subsidy for EV chargers

The provisions concerning financial incentives for EV chargers is tabulated below:

Bengaluru	Capital subsidy is available on EV charging equipment[4]. Capital subsidy of 25% would be provided on the equipment /machinery subject to maximum of Rs 10,00,000 per station for the first 100 fast charging stations.
Panaji	The city provides a 20% capital subsidy for installation of solar-powered charging stations. Subsidy is also available for electrical infrastructure costs[5].
Kolkata	No provision for direct subsidies is available

Subsidies could also be defined for

1) different consumer categories viz. domestic, commercial, etc.
2) deployment of smart EV chargers
3) different charger types such as slow and fast
4) different types of chargers viz public, semi-public, etc.

3.1.5 Subsidies for RE based EV charging

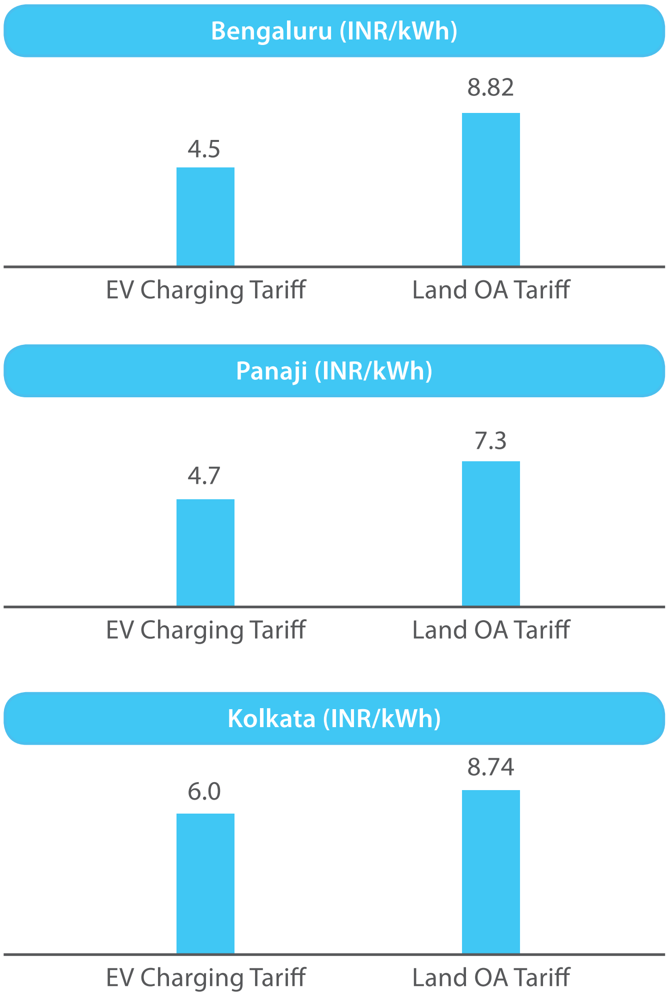
Subsidies for standalone RE or EV charging stations are present in some of the cities analyzed. However, when RE and EV charging are packaged together, specific subsidies are required to encourage uptake. The standing of the three cities on the subsidies front are tabulated below:

Bengaluru	❖ No special capital subsidy for solar based chargers is available. However, a rebate for EV charging has been proposed in the state's policy.
Panaji	❖ There is provision in the EV policy for 20% capital subsidy for installation of solar-powered charging stations. Subsidy is also available for electrical infrastructure costs[5].
	❖ Prosumers opting for batteries to store and supply power during peak hours will be compensated at 50 paise / kWh in addition to APPC Cost. This would enable such consumers to store excess RE in batteries, use them for EV charging or for supply to grid whenever possible.
Kolkata	❖ No special capital subsidy for solar based chargers is available.

Bengaluru and Kolkata could also provide subsidies for charging stations which are coupled with RE sources. This would naturally incentivize charging station operators to procure power from open access third party or captive route. In addition to capex incentives, subsidies could be rendered for installation of solar / RE based chargers.

3.1.6 Open access charges

Landed cost of electricity from open access constitutes of charges such as: generation cost, transmission and wheeling charges, cross subsidy surcharge, and additional surcharge. The landed cost RE RTC power vis-à-vis EV charging tariff in the three cities is showcased below:



Considering RE RTC generation cost of INR 6/kWh, applicable transmission, wheeling charges, transmission losses, CSS and AS for respective states from tariff orders.

The landed cost of power from the open access route is higher compared to the conventional tariff offered by the distribution companies.

Bengaluru	Procurement of RE through third-party route seems to be unattractive. This is because retail tariffs for EV charging are lower as compared to landed cost through third-party open access.
Panaji	Procurement of RE through third-party route seems to be unattractive. Open access charges drive the landed cost of electricity upwards of INR 7/kWh compared to ~INR 5/kWh offered by the Discom.

4. Government of Karnataka. Karnataka Electric Vehicle and Energy Storage Policy 2017 Karnataka Electric Vehicle and Energy Storage Policy 2017. Retrieved from https://startup.karnataka.gov.in/wp-content/uploads/2019/09/Karnataka-State-Electric-Vehicle-Energy-Storage-Policy-2017.pdf

5. Government of Goa. Goa Electric Mobility Promotion Policy 2021. Retrieved from http://www.indiaenvironmentportal.org.in/files/file/Goa%20EV%20policy%202021.pdf, Government of Goa. Goa EV Concessional Charging Infrastructure Policy-2021. Retrieved from https://www.goa.gov.in/wp-content/uploads/2021/12/Goa-EV-Charging-Infrastructure-Policy.pdf

Kolkata	Procurement of RE through third-party route seems to be unattractive. The landed cost of electricity through third party open access is ~45% higher compared to the Discom provided EV charging tariff.

Suitable relaxations on open access charges could be considered. This would make the landed cost of RE power through third-party route attractive against prevailing retail tariffs.

3.1.7 Tax incentives on purchasing/ installation of EV charging equipment

Bengaluru	No such incentive is available
Panaji	No such incentive is available
Kolkata	No such incentive is available

Internationally, tax benefits are provided for purchase and installation of EV charging equipment. The government of France provides ~INR 27,000 (EUR 300) tax credit on the purchase and installation of an EV charger for residential consumers. Netherlands had also introduced an Environmental Investment Allowance (MIA) in 2000), companies can receive an investment deduction of up to 36% of the amount invested in a charging point from the taxable profits. Similar measures may be considered.

3.1.8 Waiver of Demand Charges for EV charging

Utilization of EV charging infrastructure is a major driver for revenue realization. In the initial years of installation, utilization of public charging infrastructure can be sub-optimal in the range of 5 – 10% . Electricity chargers / demand charges form the major chunk of input cost for these projects and waivers during initial period of lower installations can enhance project viability. The aspects of such waivers in the cities is shown below:

Bengaluru	There is no provision of waivers on demand charges which are levied for electricity consumed by EV chargers. The demand charge levied by BESCOM as of 2023 is INR 375 (EUR 4.13) per KVA
Panaji	Demand charges are waived off for EV charging infrastructure
Kolkata	Demand charges are waived off for EV charging infrastructure

To increase financial attractiveness of RE based EV charging to charging station developers / operators, demand charge waiver may be considered in Bengaluru.

3.1.9 Provision for Green Zones

Green zones are a non-financial enabler for curbing the demand of ICE vehicles and incentivizing the movement of electric vehicles in certain regions. Areas with high traffic density and congestion are considered prime for designating as green zones. The position of analyzed cities on the green zone front are shown below:

Bengaluru	The city has no specific plans of creating green zones
Panaji	Specific areas have been mandated to move to 100% EVs by 2025
Kolkata	The city will have designated green zone (environment friendly lanes - Kolkata to Asansol and Kolkata – Digha) where plying of ICE vehicles would be banned in future[7].

Green zones will have major impact by forcing adoption of EVs. This is quite evident in Kolkata, where 60% charging stations are set up in NKDA area and has one of the highest penetrations of public EV chargers.

3.1.10 Provision for building EV charging infrastructure in parking

Majority of EV charging globally takes place at homes and depots. As per IEA, there were ~17.5 million home chargers in 2022 which is expected to increase to ~135 million in 2030[8]. Slow chargers are instated in such locations which includes parking spaces in buildings and workplaces where vehicles are stationery for longer durations. Provisions for EV charging infrastructure at parking places can foster the proliferation of chargers. The measures taken in the select cities are as follows:

Bengaluru	❖ The Karnataka Electric Vehicle and Energy Storage Policy 2017 laid down provisions for reserving 20% parking spots for EV charging in new buildings/ apartments. BBMP's draft building by-law of 2019 has also recognized the same[9].

6. As per industry inputs and primary consultations.
7. Government of West Bengal. Electric Vehicle Policy, 2021. Retrieved from https://wbpower.gov.in/wp-content/uploads/Electric%20Vehicle%20Policy%202021%20(Kolkata%20Gazette%20Notification).pdf
8. In the Stated Policies Scenario. IEA. Global EV Outlook 2023. Retrieved from https://iea.blob.core.windows.net/assets/dacf14d2-eabc-498a-8263-9f97fd5dc327/GEVO2023.pdf
9. Government of Karnataka. Karnataka Electric Vehicle and Energy Storage Policy 2017 Karnataka Electric Vehicle and Energy Storage Policy 2017. Retrieved from https://startup.karnataka.gov.in/wp-content/uploads/2019/09/Karnataka-State-Electric-Vehicle-Energy-Storage-Policy-2017.pdf

Bengaluru	❖ However, no rules are in place which can mandate spaces for installing RE sources in buildings.
Panaji	❖ Goa's Electric Mobility Promotion policy has mandated that all new and renovated buildings having more than 10 parking spots and being managed by Residential Welfare Associations must have minimum 20% EV readiness ECS spots[10].
	❖ However, no rules are in place which can mandate spaces for installing RE sources in buildings.
Kolkata	No specific Provisions for building EV charging infrastructure in parking

There are provisions for reserving parking spots for EV charging in new buildings/apartments in Bengaluru and Goa. There is no provision in Goa for building EV charging infrastructure in parking spaces. Incorporating such provisions in building byelaws would lead to compulsory implementation of such provisions in new buildings.

3.1.11 Energy charges for EV charging

Discoms have defined many consumer categories such as domestic, agricultural, commercial, industrial, etc. There are further sub-divisions in these categories in many states. Further, with the introduction of electric vehicles, Discoms have carved out a separate consumer category for Public EV Charging Stations. The MoP Guidelines for Charging Infrastructure for Electric Vehicle dated 14th January 2022[11] requires determination of a separate tariff for public EV charging stations. The energy charges for EV charging (if any) in the three cities are cited below:

Bengaluru	Applicable energy charges are Rs 4.5 / kWh[12] .		
	ToD Tariff for charging e-buses in depots of BMTC / KSRTC/ NEKRTC / NWKRTC		
	Time of Day	**From July to November (monsoon period)**	**From December to June in Rs. Per unit**
	06.00 Hrs to 10.00 hrs	0	0
	10.00 Hrs to 18.00 hrs	0	0
	18.00 Hrs to 22.00 hrs	0	(+)100 Paise
	22.00 Hrs to 06.00 hrs	0	(-)100 Paise
Panaji	Applicable energy charges are Rs 4.5 / KVAh for HT and Rs 4.7 / kVAh for LT[13] .		
Kolkata	Promotional ToD tariff is available for EV charging. Tariff is applicable at the rate of Rs 6.0 / kWh during the peak hours (17:00 hrs to 23:00 hours) and Rs. 5.50 / kWh during other than peak hours[14].		

There is absence of ToD tariffs in Panaji. ToD tariff is available for e-bus charging in Bengaluru and for all types of vehicles in Kolkata.

10. Government of Goa. Goa Electric Mobility Promotion Policy 2021. Retrieved from http://www.indiaenvironmentportal.org.in/files/file/Goa%20EV%20policy%202021.pdf, Government of Goa. Goa EV Concessional Charging Infrastructure Policy-2021. Retrieved from https://www.goa.gov.in/wp-content/uploads/2021/12/Goa-EV-Charging-Infrastructure-Policy.pdf
11. Ministry of Power. Charging infrastructure for electric vehicles (EVs) – the revised consolidated guidelines and standards regulation. Retrieved from https://powermin.gov.in/sites/default/files/webform/notices/Final_Consolidated_EVCI_Guidelines_January_2022_with_ANNEXURES.pdf
12. KERC. Tariff Order 2023 for BESCOM. Retrieved from https://kerc.karnataka.gov.in/uploads/42201683892826.pdf
13. JERC. Approval of Annual Performance Review of FY 2022-23, Aggregate Revenue Requirements (ARR) and Determination of Retail Tariff for FY 2023-24. Retrieved from https://jercuts.gov.in/writereaddata/UploadFile/edgoaorder_1066.pdf
14. WBERC. Gist of Tariff order dated 30.03.2023 for the year 2023-24 issued by WBERC in Case no. TP-98/22-23 in respect to WBSEDCL. Retrieved from https://www.wbsedcl.in/irj/go/km/docs/internet/new_website/pdf/Tariff_Volumn/Tariff_chart_dated_30.03.2023_for_the_year_2023-24_18_04.pdf

3.1.12 Provision for smart and bi-directional charging (V2G)

Smart and bi-directional charging enable the modulation of EV charging speeds depending on the availability of low cost power and flexibility services to the grid. EVs can act as a load and generating entity for the grid which can be leveraged to maintain grid stability. Steps taken to further the installation of smart and bidirectional chargers is mentioned below for the three cities:

Bengaluru	❖ Policies do not have any provision which allows authorities to explore smart and bi-directional charging in future.
	❖ No subsidies are specified for smart or bi-directional chargers
Panaji	❖ Policies do not have any provision which allows authorities to explore smart and bi-directional charging in future.
	❖ No subsidies are specified for smart or bi-directional chargers
Kolkata	❖ The policy mentions that the concerned authorities will evaluate technologies such as Vehicle-to-Grid[15] .

Smart chargers can modulate the EV charging speed in accordance with availability of low-cost power and prevailing demand-supply situation in the grid. Bi-directional chargers on the other hand can store surplus RE during off-peak hours and provide the same back to the system that they are connected to. Hence, both these types of chargers enable additional RE integration and its utilization for EV charging.

Internationally, many countries have provided subsidies for smart and bi-directional chargers. The same could be considered here as well.

3.1.13 Green Power Tariff

Electric vehicles shift the energy demand emanating from fossil fuels to electricity. The electrons used for charging should be from a green source to ensure the emissions are truly curbed rather than just being shifted. Discoms are the closest touchpoint for consumers either residential or C&I (commercial and industrial) in nature.

Discoms in many states allow consumers to procure green power through subscription to green tariffs. The onus of procuring commensurate green power resides with the distribution companies. Green tariffs provide operational ease to transition to RE based EV charging. The provisions for green tariffs across the three cities are mentioned below:

Bengaluru	Green tariff is available for HT industries and HT commercial consumers. For availing green tariff consumers must pay an additional 50 paise/ kWh over and above the normal retail tariff. This provides an additional avenue for industrial & commercial consumers to buy green power who may face higher open access charges[12].
Panaji	No provision for green power tariff is provided by the Discom[13].
Kolkata	The West Bengal Electricity Regulatory Commission notified the 'Green Tariff' of 50 paise per unit for all except domestic consumers. This would act as an addition to existing retail tariff and will be applicable only if 100 percent green power is consumed for at-least six months without interruption. Further, any EV charging station operator can apply for 100% green energy and pay the green tariff[14].

EV charging operators who wish to utilize green power can avail this mechanism. This mechanism can enable them to directly buy green power from Discom without availing open access.

3.1.14 Time based tariffs

Time based tariffs provide avenues for distribution companies to drive consumer behavior. For instance, higher tariffs at peak demand periods can shift demand towards non-peak hours through lower tariffs during those periods.

Bengaluru	ToD tariff is available for bus depots which would promote charging at off-peak hours12.
Panaji	No provision for ToD tariff is available[13].
Kolkata	Promotional ToD tariff is available for EV charging[14].

Bengaluru may consider offering ToD tariff for all vehicle categories. Internationally, many utilities provide EV specific time-of-use (TOU) rates to influence drivers to shift their EV loads to off-peak times of the day.

3.1.15 Green Open Access

Open access enables any consumers to procure electricity from sources other than the distribution company. General open access in India enables consumers with a load greater than 1 MW to buy power from the generator of its choice or the open market. However, the buyers have to compensate the distribution company through open access charges (transmission and wheeling charges, cross subsidy surcharge, and additional surcharge).

To accommodate a larger consumer based, green open access provisions in the select cities are mentioned below:

Bengaluru	Consumers with sanctioned load of 100 kW can opt for procuring power from RE sources through open access[16].
Panaji	No provision is available related to green open access. However, EV policy of the state highlights that the minimum contract demand requirement of 1 MW will be waived off for charging stations who wish to buy RE power[17].
Kolkata	Consumers with sanctioned load of 100 kW can opt for procuring power from RE sources through open access[18].

Green energy open access regulations have been specified for Kolkata and Bengaluru. Although Panaji has no such regulations, the EV policy has specified that certain relaxations can be offered for EV charging operators who procure RE power.

No waiver on open access charges is available for green power procurement in Panaji. However, Bengaluru and Kolkata both offer certain relaxations on open access charges for green power.

3.1.16 Banking of RE power under open access

Banking provision allows RE generators to bank / deposit surplus electricity and procure the same back whenever needed. This helps the generator to off-set its under-generation at certain periods and avoid paying penalties for deviation from schedules. For instance, a solar plant whose generation is higher during the daytime can bank surplus power. During the non-solar hours, when generation from solar plant reduces significantly, the banked power can be utilized for off-setting the deficit in its generation.

The provisions for banking in the three select cities are mentioned below:

Bengaluru	❖ Draft green energy open access regulation provides banking facility on a monthly basis. No banking charges are applicable as per Draft Green Open Access rules ❖ Un-utilized energy is compensated at 75% of the generic tariff determined by KERC for such RE source.
Panaji	❖ Banking of Energy is allowed up to 20% of the total energy generated by Renewable Energy Generating Station on monthly basis. ❖ Banking charges is levied at 5% ❖ Un-utilized energy at end of financial year, restricted to 20% of total RE generation, will be compensated at APPC or FiT, whichever is lower ❖ Provision allows energy banked during peak TOD slots to be drawn during off-peak TOD slots, but not vice-versa. ❖ Banking is also allowed for EV charging operators for a period of one year.
Kolkata	❖ No provision of Banking Energy of RE under open access is available.

Monthly banking may reduce the attractiveness of RE power since any surplus cannot be utilized in other billing periods. Moreover, the quantum of electricity left un-utilized post banking is not compensated properly.

Panaji restricts energy banked during off-peak TOD slots to be drawn during peak TOD slots which could be prohibitive.

Kolkata does not allow banking of RE power.

In addition, the compensation for surplus electricity in Bengaluru and Panaji is often lower than the tariff at which consumers (especially non-residential) buy power from the grid. This is also lower than the marginal cost / avoided cost of the utility. Hence, the compensation could be linked to the avoided cost.

16. Government of Karnataka. Karnataka Renewable Energy Policy 2022-2027. Retrieved from https://kredl.karnataka.gov.in/storage/pdf-files/Policy/Karnataka%20Renewable%20Energy%20Policy%202022-27%20Notification%20Copy.pdf
17. Government of Goa. Goa State Solar Policy 2017. Retrieved from https://www.goa.gov.in/wp-content/uploads/2019/08/Goa-State-Solar-Policy-2017.pdf, Amended Goa State Solar policy. Retrieved from https://www.goa.gov.in/wp-content/uploads/2020/08/Scheme-and-Policy-GEDA-gazette-for-solar-policy.pdf; Government of Goa. Scheme for promotion of grid-connected solar rooftop system with net-metering system. Retrieved from https://www.goa.gov.in/wp-content/uploads/2020/08/Scheme-and-Policy-GEDA-gazette-for-solar-policy.pdf
18. Department Of Power & Nonconventional Energy Sources, Government of West Bengal. Policy on Co-generation and Generation of electricity from Renewable sources of Energy 2012. Retrieved from https://wberc.gov.in/sites/default/files/policy-renewable-wb.pdf

3.1.17 Banking of RE power through net-metering regulations

Bengaluru[19]	Surplus energy, injected by the solar panel, is compensated at the generic tariff determined by Commission.
Panaji[20]	Surplus energy, injected by the solar panel, is compensated at the APPC / Feed-in-tariff
Kolkata	It is not explicitly clarified as to what is the rate at which the consumer would be compensated for the excess energy injected.

The compensation for surplus electricity is often lower than the tariff at which consumers (especially non-residential) buy power from the grid. This is also lower than the marginal cost / avoided cost of the utility. Hence, the compensation could be linked to the avoided cost.

3.1.18 Capacity for Net & gross metering

The energy transition efforts of any nation require conversion of consumers to prosumers who can provide electricity to the grid as and when required. Net metering and gross metering provisions enable it by providing compensation for the energy generated at consumer premises with varying contours for the payments.

In net metering, the user consumes the electricity generated by their generation systems (solar rooftop, etc.) and the excess electricity is injected into the grid. For any additional energy requirement, the consumer's load can be catered through the grid. At the end of the settlement period, consumer pays for the net energy imported by them.

In gross metering, the energy generated by the consumers' generation system is injected into the grid and the consumer imports electricity from the grid at predefined retail tariffs. At the end of settlement period, the consumer is paid for the energy injected by the generation system and the consumer pays for the energy imported.

The key difference between the two mechanisms is the settlement mechanism which can lead to varying payback periods for the consumers installing the systems like solar rooftop PV in their premises.

However, distribution companies have to ensure grid stability by outlining the solar rooftop capacity that a consumer can avail. These are mainly decided based on the existing network of the Discoms and load flow studies. The stated capacities in Bengaluru, Kolkata and Panaji are as follows:

Bengaluru[19]	Capacity of solar rooftop should not exceed 1 MW at one premise and not exceed the sanctioned load
Panaji[20]	Capacity of solar rooftop should not exceed 500 kWp at one premise and not exceed the sanctioned load
Kolkata	Policy restricts capacity of solar rooftop to not exceed 5 kW. Hence, Kolkata hence has the most restrictive size limits.

3.1.19 Restriction of capacity of solar installations at a Distribution Transformer

Distribution Transformers (DT) cater to the residential and commercial loads for a specific location for the utilities. Distribution Transformers carry a load, which varies from time to time during the day and night but generally capacity of these transformers are decided to cater for the maximum load during the day. However, often the average load on DT is far less than the peak load which occurs only for few hours in a day. Considering the same, distribution companies limit the installation of solar installations in the service area of a transformer.

Bengaluru19	The regulations provide that the total capacity of the existing and proposed SRTPV system on the distribution transformer (DT) should be limited to 80% of the rated capacity of the DT
Panaji20	Cumulative solar capacity allowed at a particular Distribution Transformer (DT) to not exceed 75% of the capacity of the Distribution Transformer. However, the same can be relaxed based on impact assessment studies / load flow studies
Kolkata18	The cumulative capacity of rooftop solar PV systems that can relate to a distribution transformer (DT) is up to 100% of DT capacity.

Kolkata has the most encouraging provision for allowable cumulative capacity of solar rooftop at a DT level.

19. KERC. Wheeling Charging and Banking Facility for RE projects. Retrieved from https://karunadu.karnataka.gov.in/kerc/Tariff%20Order%202021/Interim%20Order%20in%20the%20Matter%20of%20Wheeling%20Charges%20and%20Banking%20Facility%20for%20Renewable%20Power%20Projects.pdf
20. JERC. JERC For The State Of Goa And Union Territories (Connectivity And Open Access In Intra-State Transmission And Distribution) Regulations, 2017. Retrieved from http://jercuts.gov.in/writereaddata/UploadFile/DRAFT%20(Opan%20Access).pdf, JERC, First Amendment. Retrieved from http://jercuts.gov.in/writereaddata/UploadFile/First%20Amendment_1511.pdf, JERC, Second Amendment. Retrieved from http://jercuts.gov.in/writereaddata/UploadFile/235939_1349.pdf

3.1.20 Group & Virtual Net Metering

As mentioned in 3.1.18, net metering provisions proliferate prosumers. Historically, in the conventional model of net metering that was practiced, the consumer has to either utilize the generated solar power in the same premise or sell it to the distribution company. Consumers do not have an option to utilize the excess solar power of one location in another location. This gave rise to two innovative net metering models viz.

1) Utilize a modified form of net metering, called as group aggregate net metering wherein multiple service connections of one consumer are considered in aggregate for setting off of energy supplied from a solar power plant in a single location or

2) Utilize a modified form of net metering, called as virtual net metering wherein a large power plant is set up by a group of consumers, who then get offset energy from the solar power plant, usually in proportion to their ownership share in the plant or through some pre-defined adjustments.

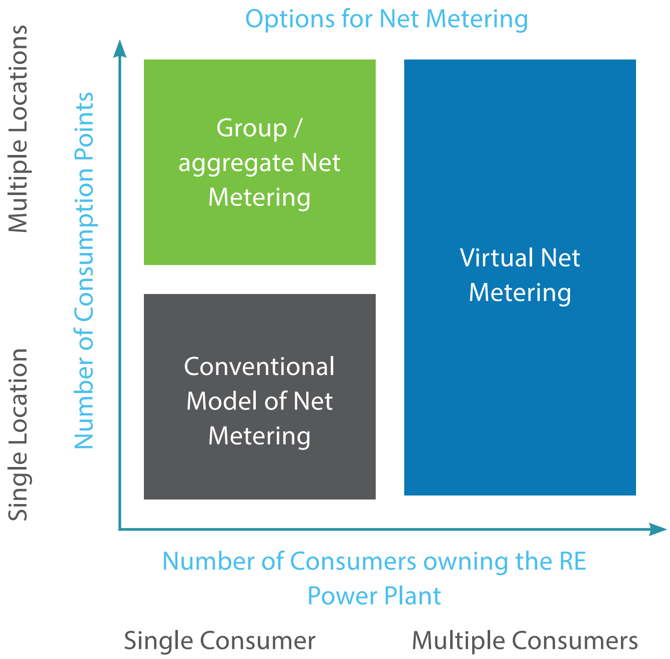


Figure 6: Options for net metering

Such innovative mechanisms allow proliferation of prosumers and the measures taken by the analyzed cities are shown below:

Bengaluru	No provision is available for Virtual Net Metering and Group Net Metering. These options are suitable for small size consumers who do not have captive space for installing rooftop solar PV systems.
Panaji[21]	Provision for group and virtual net metering is available.
Kolkata	No provision is available for Virtual Net Metering and Group Net Metering.

Virtual and group net-metering can enable solar energy generated at a different location to be credited to a user at another location. This can also allow small consumers to get renewable energy credits in case rooftop solar installations are not feasible at their premises.

3.1.21 Settlement of energy through net metering

Bengaluru[19]	The settlement of excess energy is on a monthly basis which restricts netting off of surplus in one month against the deficit in the other.
Panaji[20]	The settlement of excess energy is on an annual basis which allows netting off of surplus in one month against the deficit in the other.
Kolkata[18]	The settlement of excess energy is on an annual basis which allows netting off of surplus in one month against the deficit in the other.

Bengaluru offers a monthly settlement which could restrict a consumer to utilize surplus electricity from one month to the other. Longer settlement periods could be evaluated and explored.

3.1.22 Effect of 100% RE based EV charging on the levelized cost of charging for e-bus depots

E-buses in India are procured by State Transport Undertakings (STUs) through the GCC (Gross Cost Contracting) route. Competitive bidding is initiated between service providers in terms of the per kilometer cost they would charge the STUs to operate the e-buses. The multiple routes for RE procurement are mentioned in 3.1.3 and considering the same for the three cities, the levelized cost of charging in INR/km is measured. In effect, the cost escalation for operating buses is viewed through the lens of service operators in all the three cities analyzed. The levelized cost of charging in the city of Bengaluru is shown below:

21. JERC. Official Gazette Government of Goa. Retrieved from http://jercuts.gov.in/writereaddata/UploadFile/solar%20pv%20grid%20regulation_1355.pdf

LCOE charging in Bengaluru (INR/km)

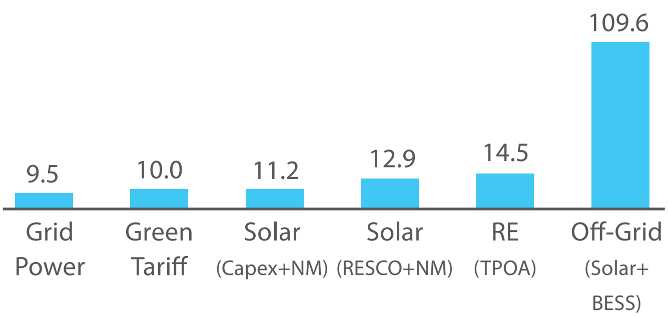


Figure 7: Levelized cost of e-bus charging in Bengaluru

The levelized cost of charging from different RE procurement routes in Kolkata is shown below:

LCOE charging in Kolkata (INR/km)

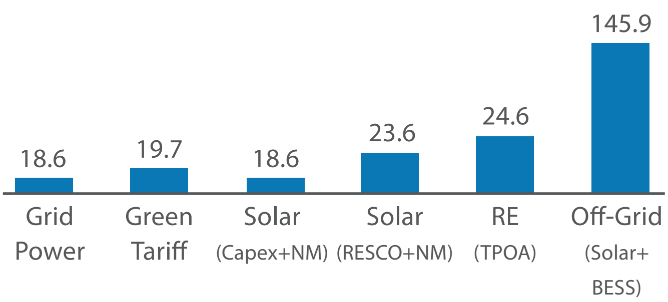


Figure 8: Levelized cost of e-bus charging in Kolkata

Similarly, the LCOE of public charging for Kolkata is as follows:

LCOE charging in Panaji (INR/km)

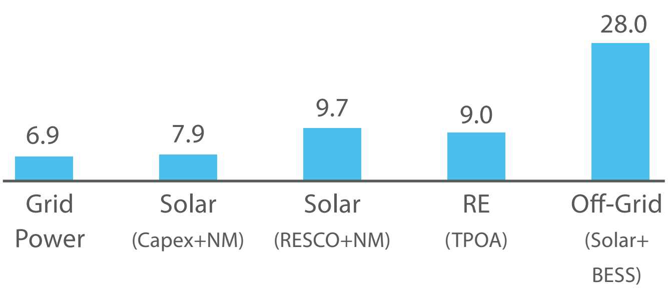


Figure 9: Levelized cost of e-bus charging in Panaji

E-bus operations are a social welfare aspect which experience an escalation in cost with RE procurement for EV charging. Holistic business models are necessitated to address the escalation without passing them on to passengers.

3.2 Key Challenges and open areas for stakeholders in adoption of RE for EV charging at national level

The previous section covers the key areas which the cities need to focus upon. However, it is understood that there are other challenges and issues which need to be addressed (at a country level) to manage the convergence of renewable energy and EV charging. For instance, issues in large-scale addition of RE will lead to limitation in the quantum of such clean energy being utilized for EV charging. Similarly, unless the barriers for deployment of EV charging infrastructure are addressed, large-scale demand for RE based EV charging will also not be witnessed.

In this backdrop, the following section highlights the challenges of renewable energy and EV charging and its implications on various stakeholders in the RE-EV ecosystem. These issues need to be addressed for a seamless mechanism for RE based EV charging.

Figure 10: Key challenges faced by multiple stakeholders in RE based EV charging ecosystem

3.2.1 Discoms

3.2.1.1 Managing bi-directional electricity flows

Traditionally, Discoms have designed their network to cater to one-way flow of power, i.e., from generating units to consumers. With the increase in penetration of distributed energy resources and their usage for EV charging, two-way power flow will be a common phenomenon when such resources would generate surplus electricity.

When the EVs will not get charged from solar PV systems, the electricity generated by such solar PV systems would be injected into the grid. To monitor two-way of power and manage the load and generation in real time efficiently, Discoms would need to adopt smart meters and other smart grid technologies. In case of large-scale solar rooftop installations, Discoms would also be required to strengthen the existing grid infrastructure. For instance, the distribution transformer capacity would need enhancement to integrate the additional RE at the distribution level.

There would be need for detailed grid-level studies to understand the technical impact of RE based EV charging. Discoms need to continuously undertake such studies.

3.2.1.2 Financial loss

The retail tariff charged by the Discom from the high paying commercial & industrial consumers is typically used to cross-subsidize the energy supply to the low paying consumers (such as the residential or agricultural category). In case those commercial & industrial consumers consume power from RE through open access, there is a substantial loss of revenue from these high paying consumers. This puts additional cross-subsidy burden on the Discom.

Furthermore, consumers can net off their electricity consumption from the grid by generating excess electricity during the day. At times, Discoms have to pay to the consumers in case the net electricity generation is more than the consumption at the end of settlement period. Because of this, Discoms may not encourage open access, given that their financial condition is not so encouraging.

Increasing the open access charges or offering no relaxation on such charges or introducing other charges (such as Telangana Discom introducing facilitation charges of Rs 20,000 per month for open access consumers[22]) could discourage RE based open access. Setting maximum installed capacity under net metering, restricting the capacity based on sanctioned load, non-existence of virtual / group net metering further reduces de-centralized rooftop proliferation.

There would be need for state governments to fund the loss incurred by Discoms in case such Discoms provide concessions for RE based EV charging.

3.2.1.3 Lack of availability of real-time generation data from solar rooftop PV systems

It is important for Discoms to account for anticipated

22. Telangana State Electricity Regulatory Commission. Retail supply tariffs &cross subsidy surcharge for FY 2022-23. Retrieved from https://tserc.gov.in/file_upload/uploads/Tariff%20Orders/Current%20Year%20Orders/2022/RST%20Order%20for%20FY%202022-23.pdf

generation from distributed & rooftop PV systems for day-ahead scheduling of power. If such data is available with Discoms, it can also help in managing the day-time peaks. The absence of information exchange in the real time basis causes hinderances in grid management at distribution level.

3.2.1.4 Overloading and over-voltage in distribution network

EVs are generally a floating load and EV owners can charge their vehicles at various locations. This makes it difficult for Discoms to predict the EV load. In case many EVs are getting charged at a location, especially by fast chargers, it would result into increase in load on the distribution grid infrastructure. This could contribute to overloading and stress on the distribution network assets like transformers, cables, etc. The overloading of distribution network assets can lead to unreliable power supply or load shedding for the end consumer. Frequent overloading can also lead to system breakdown such as transformer failures, which increases the operation and maintenance cost for the distribution companies.

In addition to the above, surplus generation by localized RE sources during periods of low EV charging demand could lead to over-voltage at the point where the RE is coupled with the network / chargers. Over-voltages can cause damages to the equipment connected to the distribution network. In addition, there could be reverse flow of electricity back to the grid.

There would be need for detailed grid-level studies to understand the technical impact of RE based EV charging. Discoms need to continuously undertake such studies.

3.2.2 Consumers / Prosumers

3.2.2.1 Banking of renewable energy-

Discoms in India allow banking of surplus electricity by open access consumers procuring renewable energy. However, certain measures taken by Discoms prohibit consumers to use this facility effectively. For instance, Karnataka has proposed to reduce annual banking to monthly banking which would restrict consumers to bank and utilize surplus electricity generated in one month to the other. Gujarat has introduced daily banking for solar energy[23].

Favourable banking provisions need to be allowed for EV charging stations with captive generation / storage.

3.2.2.2 Absence of group / virtual net-metering

Innovative arrangements such as group / virtual net-metering are absent. This restricts small-scale and distributed users who cannot install RE sources due to lack of rooftop area from utilizing the benefits of RE.

3.2.3 System Operator

3.2.3.1 Requirement of Flexible Resources

The primary responsibility of the power system operators is to maintain stability and reliability of the power system. With a large-scale integration of intermittent renewable energy into the grid, demand-supply imbalance would become more inherent. Thus, the system operator would require fast -acting flexible sources of power at its disposal to balance the grid.

Power generation from sources, viz gas-based plants, hydro power plants, battery energy storage systems, etc., are important resources for ensuring the grid balance and reliability. Because of the ability of these resources to respond within a short notice period, there is additional cost associated with maintain and operating such resources. System operators would be mandated to maintain sufficient reserves in case to ensure stable and reliable operations of the grid.

3.2.3.2 Shorter dispatch intervals

Presently, India has a 15-min scheduling and dispatch period in which generation and drawal schedules are prepared for every 15 mins time-blocks. In case of increased RE penetration, small dispatch interval such as a 5-min scheduling and dispatch system may be introduced in order to improve the grid reliability.

The management of ramping requirements in a 5-minute schedule is easier than with 15-minute schedule. This is because RE generation can tend to vary in shorter time scales which will require the need for modifying schedules of conventional plants to meet the demand. As the dispatch interval is longer in case of 15-minute dispatch, there is always possibility of over-scheduling or under-scheduling. This could result in large demand-supply imbalance in real time. Therefore, short despatch intervals would allow rapid adjustment of schedules to cater to these imbalances.

3.2.4 EV charging operators

3.2.4.1 Lack of Financial incentives

In some states, where the export of excess electricity is allowed, consumers are compensated at the lowest solar power tariff discovered through competitive bidding. This compensation is often lower than the tariff at which consumers (especially non-residential) buy power from the

23. KERC. Draft Karnataka Electricity Regulatory Commission (Terms and condition for Green Energy Open Access) Regulations, 2022. Retrieved from https://kerc.karnataka.gov.in/uploads/media_to_upload1660888724.pdf; GERC, Draft Gujarat Electricit Regulatory Commission (Terms and Conditions For Green Energy Open Access) Regulations, 2023, Retrieved from https://gercin.org/wp-content/uploads/2023/06/Final-Draft-regulationsGEOA-Regulations-2023-dated-23.06.pdf

grid. Such provisions may increase the pay-back period for investments made by the consumers on the solar PV system, thereby, discouraging consumer's initial high investment.

3.2.4.2 Capital Investment on solar coupled chargers

EV charging station operators need to commit to upfront capital investment associated with the solar PV system. In the absence of suitable subsidies, this may render the same as unattractive.

3.2.5 State/City transport corporations

3.2.5.1 Rooftop space

Availability of rooftop space is critical for installation of solar panel in depots. Some of the existing depots do not have adequate rooftop space where solar / wind energy sources can be installed. Visits conducted in the three cities of Kolkata, Panaji and Bengaluru suggests that the depot area may not be enough for 100% RE based e-bus charging. This means that even after adequate supporting structures are built to house on-site RE installations, the site still needs to procure RE through open access.

Innovative arrangements such as group / virtual net-metering can enable RE generated in another location to be credited to consumers who cannot install on-site RE. This allows small-scale and distributed users who cannot install RE sources due to lack of rooftop area to get the benefits of RE. In addition, Discoms can offer green tariff so that bus transport corporations can subscribe to such tariffs and ensure RE based e-bus charging.

3.2.5.2 Area for installation of chargers

While some depots have adequate space for installation of chargers, depots which have less ground area may not have adequate space for installation of chargers in future. This means that innovative ways of charging such as chargers mounted from ceilings need to be explored. These roof mounted chargers reduce the floor area required for installation of EV chargers. South Korea's LG Uplus Corp. and Hanwha Corporation/E&C have launched Forena EV Air Station which is a ceiling-mounted charging system. It is a significant breakthrough in addressing certain operational challenges and parking space shortages associated with traditional EV charging stations.

3.2.5.3 Resource availability

Availability of solar irradiation and adequate wind speed are major decision drivers for installation of RE sources. Absence of the same in certain locations could mean reduced energy generated by RE sources during the day-time. In such a case, the e-buses need to plan for back-up sources viz drawing electricity from grid, travelling to nearby locations for charging, etc.

3.2.5.4 Structural barriers in existing locations

In some of the bus depots there are sheds or rooftop spaces available for installation of rooftop solar PV systems. However, there are occasions where these rooftop spaces are blocked by structural obstructions such as a large building in the surroundings. This would lead to inadequate sunlight for generation of electricity from solar PV system.

3.3 Summary of gaps in existing landscape of RE based EV charging

Assessment of existing RE and EV landscape of three Indian cities viz. Bengaluru, Kolkata and Panaji highlighted their preparedness with respect to RE based EV charging. Following the assessment, it is understood that there are several challenges and issues which need to be addressed to promote large-scale deployment of RE based EV charging.

The following section summarizes the key challenges in RE based EV charging and its implications on various stakeholders in the RE-EV ecosystem.

Table 3: Key gaps in RE based EV charging landscape

Sl.	Key gaps
1.	Lack of mandating provisions through building codes for ensuring certain portion of demand from buildings is met from RE.
2.	Tariff structures such as time-of-day / time-of-use, green tariffs is yet to be implemented across most states in the country. Such tariff structures can enable EV charging from RE based sources.
3.	Small sized EV charging stations cannot avail of open access, and need additional avenues for buying green power.
4.	Certain provisions in net-metering regulations, such as settlement cycles, remuneration for surplus power, limited capacity of solar installations on rooftops, etc. may restrict attractiveness of distributed RE resources.

Sl.	Key gaps
5.	Lack of innovative arrangements such as group / virtual net-metering are absent. This restricts small-scale and distributed users who cannot install RE sources due to lack of rooftop area from utilizing the benefits of RE.
6.	Limited banking availability: Discoms in India allow banking of surplus electricity by open access consumers procuring renewable energy. However, certain measures taken by Discoms prohibit consumers to use this facility effectively. For instance, Karnataka has proposed to reduce annual banking to monthly banking which would restrict consumers to bank and utilize surplus electricity generated in one month to the other. Some states such as West Bengal do not allow banking at all. In addition, the compensation for surplus electricity in Bengaluru and Panaji is often lower than the tariff at which consumers (especially non-residential) buy power from the grid.
7.	There is lack of a regulation or mechanism to enable aggregation of demand-side / retail-side resources so that they can provide various services to the grid. Aggregators can enable resources such as EVs to be used in a way so as to correspond with the needs of the grid.
8.	There is lack of regulation on Demand Response. This can enable entities such as Discoms and third-party entities to control EV charging demand to correspond it with the needs of the grid.
9.	Procurement of 100% RE, whether through third-party open access or off-grid installations, is not cost-competitive when compared to grid-powered electric vehicle (EV) charging. There is a need to reduce the landed cost to make RE power attractive
10.	Absence of capital and operational subsidy for RE based EV charging makes the overall investment cost to increase. EV charging station operators need to commit to upfront capital investment associated with the solar PV system. Operational subsidies would incentivize charging station operators to procure power from open access third party or captive route.
11.	There is absence of capital subsidy for deployment of smart / bi-directional chargers
12.	There is absence of special incentives such as reduced demand charges for EV chargers in the initial years. Such incentives can enable charging operators to levy lesser service charges to EV users in case they face reduced charger utilization in the initial years of deployment.
13.	Providing waivers on open access charges could lead to financial loss for discoms and hence discoms might be wary of providing of open access.
14.	In some states, where the export of excess electricity is allowed, consumers are compensated at the lowest solar power tariff discovered through competitive bidding. This compensation is often lower than the tariff at which consumers (especially non-residential) buy power from the grid. Such provisions increase the pay-back period for investments made by the consumers on the solar PV system, thereby, discouraging consumer's initial high investment.
15.	There is lack of innovative pilot projects such as peer-to-peer trading, Virtual power plants, etc. which can demonstrate RE integrated EV charging.
16.	Lack of availability of real-time generation data from solar rooftop PV systems and retail-level platforms which can help retail-level trading of RE power
17.	EVs are generally a floating load, and EV owners can charge their vehicles at various locations. This makes it difficult for discoms to predict the EV load. In case many EV are getting charged at a location—especially by fast chargers—it would result into increase in load on the distribution grid infrastructure. There is a need to devise ways to manage this load effectively and enable it to coincide with the timing of RE generation.

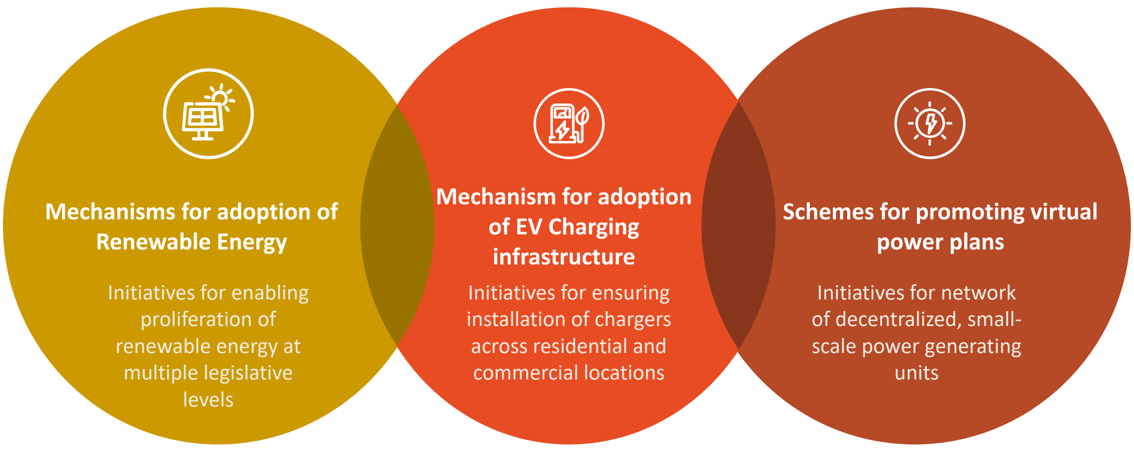
These issues require addressal for a seamless operation of RE based EV charging by taking reference from international best practices.

04 International best practices for enabling RE based EV charging

Countries around the world have taken multiple measures to promote renewable energy and EV charging in their aim to promote a greener future. There has been an array of policies and incentives in this regard. Various initiatives ranging from setting minimum targets for renewable procurement, tax incentives, feed-in-tariff, rebates on RE generation, subsidies on capital costs, soft loans, etc. have been provided by several governments to promote renewable energy. Similar initiatives have been widely adopted by various governments, at national level as well as city level, to promote the uptake of EV charging infrastructure. Specifying targets for EV charging, capital subsidy, tax rebates, installation subsidies, time-of-use tariff, etc. have all played key roles for uptake of EV charging infrastructure.

Focus has been provided to countries like USA, Germany, France, Netherlands, Norway, Austria, China and Japan for understanding how they have promoted renewable energy based EV charging. In RE based EV charging, RE and EV charging are significantly interwoven. Study of these countries helps in understanding key policy and regulatory interventions which have led to adoption in RE, EV charging infrastructure, and RE based EV charging.

In the sections that follow, each of the countries and their leading practices for promoting RE based EV charging have been captured in brief as per the buckets shown below. The same have been used as guiding pillars to address the gaps identified for India.



4.1 United States of America (USA)

USA has two levels of regulations and incentives. Some incentives/ regulations are at a federal level and some are at a State/ city level as tabulated below.

Table 4: List of initiatives in USA for enabling RE, EV charging, and virtual power plants

Mechanisms for adoption of RE	Mechanisms for adoption of EV charging infrastructure	Schemes for promoting virtual power plants
Solar Investment Tax Credit	Allowing utilities to apply for charging infrastructure	Regulations enabling aggregation
Production tax credits	Rate-basing of Make-ready infrastructure	FERC Order No. 2222 for Participation of DERs in the Energy and Ancillary Markets
Self-Generation Incentive Program (SGIP)	New Standards for National Electric Vehicle Charging Network	
Property Tax Exemption for Residential Renewable Energy, Colorado	PEPCO- reduced rates for EV charging	
Mandatory Solar Requirement for New Homes, Lancaster	PEPCO PIV Managed Charger Program	
Net-metering by Black hills energy	Providing time-of-use tariffs	
	Braintree Electric Light Department, Massachusetts	
	Dynamic and critical peak pricing (San Diego Gas & Electric Company and DTE Energy)	
	Salt River Project (SRP)- Business EV Charger Rebate	
	Tucson Electric Power - EV Chargers Rebate	
	Ameren Missouri- Electric Vehicle (EV) Charging Incentive Program for Business Customers	
	San Joaquin Air Pollution Control District- "Charge Up!" programme	
	California Green Building Standards Code, 2019	
	Denver, Colorado – City Level laws	
	Home Charging Rebates- Holland Board of Public Works (HBPW)- EV Level II charger rebate programme	

Some of these mechanisms are elaborated in the sections that follow.

4.1.1 Mechanisms for adoption of renewable energy

4.1.1.1 Federal level initiatives

- **The Solar Investment Tax Credit (ITC)**[24], introduced in 2006, was aimed at promoting solar technologies at both the distributed and utility-scale levels. In this mechanism, tax credits are provided to RE players which can be used to reduce income tax liabilities. At the beginning of the project, a credit of 12 – 30% of the investment is available. For 2020, the Joint Committee on Taxation (JCT) estimated the expenditures to be INR 566.14 billion (EUR 6.22 billion). Majority of these were provided for growth of solar technology INR 557.81 billion (EUR 6.13 billion). Between 2020 and 2024, the JCT has estimated that the expenditure would be INR 2955.58 billion (EUR 32.49 billion), out of which 2905.63 billion (EUR 31.94 billion) would be for solar[25].

- **Production tax credits**[26] is valid for 10 years after a RE projects comes into service. Incentives are provided in per kWh tax credits for the quantum of electricity generated and is adjusted annually for inflation. The PTC will be phased out for projects which commence construction in 2032 or when it has been established that there is a 75% or more reduction in annual GHG emissions from 2022.

4.1.1.2 State/ City level initiatives

- **Self-Generation Incentive Program (SGIP)**[27]**:** California Public Utility Commission (CPUC) offered rebates for installing energy storage technology at rooftops of residential and non-residential facilities. Residential and commercial consumers get a rebate of INR 20817/ kWh (EUR 229/ kWh) and INR 29144/ kWh (EUR 320/ kWh) respectively, which translates to ~25% and ~35% of the cost of energy storage system.

- **Property Tax Exemption for Residential Renewable Energy, Colorado**[28]: Property tax exemptions to community solar gardens for the percentage of capacity subscribed by residential and government subscribers or beneficiaries of property tax exemptions. This exemption was available from January 2015 and ended before January 2021.

- **Mandatory Solar Requirement for New Homes, Lancaster**[29]: Since December 2017, Lancaster mandated solar photovoltaics (PV) systems to be installed on new residential buildings having building permit issuance date of January 1, 2014, or later. The amount of photovoltaics (PV) to be installed depends on the building type and the zone where the residence is located.

24. Energy Efficiency & Renewable Energy. Federal Tax Credit for Solar Photovoltaics. Retrieved on 2nd Mar 2023. https://www.energy.gov/eere/solar/homeowners-guide-federal-tax-credit-solar-photovoltaics
25. Congressional Research Service. The Energy Credit or Energy Investment Tax Credit. Retrieved from https://crsreports.congress.gov/product/pdf/IF/IF10479
26. US Environmental Protection Agency. Renewable Electricity Production Tax Credit Information. Retrieved on 2nd Mar 2023. https://www.epa.gov/lmop/renewable-electricity-production-tax-credit-information
27. California Public Utilities Commission. Self-Generation Incentive Program (SGIP). Retrieved on 2nd Mar 2023. https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/self-generation-incentive-program
28. Colorado Department of Local Affairs. Renewable Energy. Retrieved on 2nd Mar 2023. https://cdola.colorado.gov/renewable-energy
29. DSIRE USA. City of Lancaster-Mandatory Solar Requirements for New Homes. Retrieved on 2nd Mar 2023. https://programs.dsireusa.org/system/program/detail/5624

- **Net-metering by Black hills energy**[30]: Program with two options viz. year-end cash-out or continuous rollover. In the continuous rollover, surplus electricity injected is carried over month to month as well as year after year. In the year-end cash-out mode, surplus energy at the end of the year is compensated at the utility's avoided cost rate.

4.1.2 Mechanisms for adoption of EV charging infrastructure

4.1.2.1 Federal level initiatives

At a federal level, Senate bill 350 mentions that respective state commissions would direct the utilities to file applications for investments in charging infrastructure[31]. The initiative has seen uptake from states viz. Washington, Minnesota, Florida, Oregon, and California where utilities have been encouraged to file applications for charging infrastructure[32].

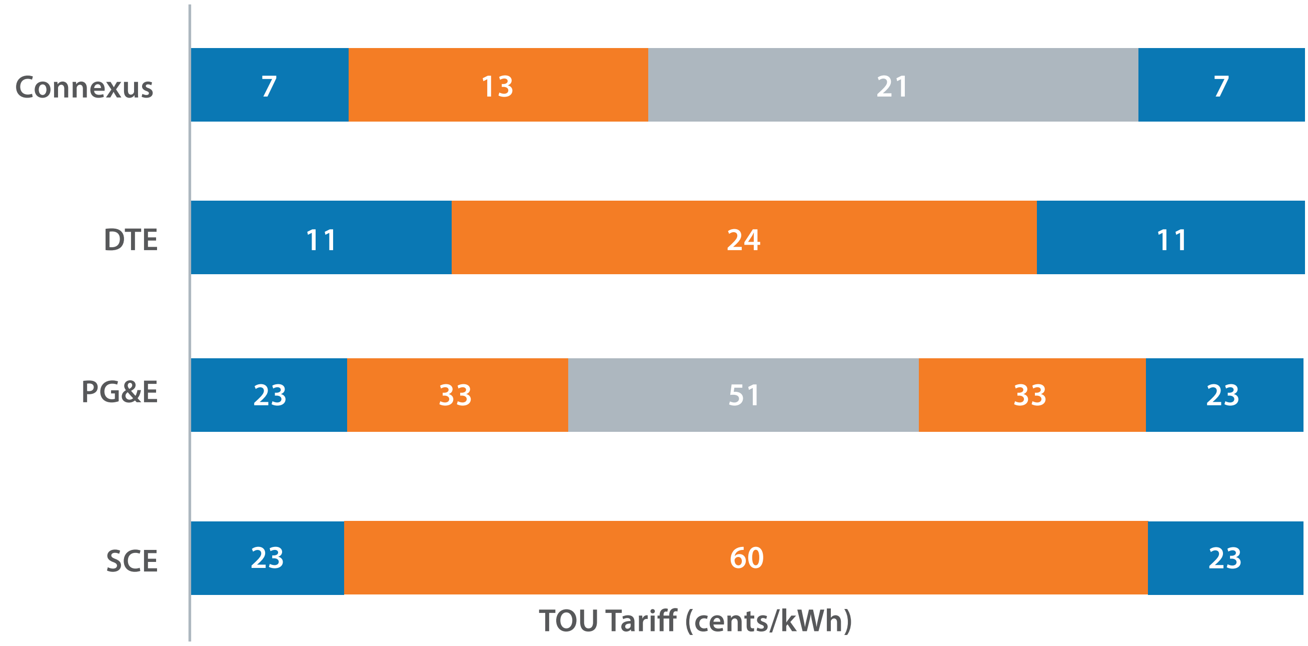
Utilities in the US invest in "make ready" infrastructure that includes the required transformer and transformer pads, service meter, service panel, conduits and wires and related Smart Grid Devices[32]. California Public Utilities Commission (CPUC) allows the utilities to invest and recover the expenses incurred in setting up of charging stations through its retail tariffs. This allows the utilities to actively participate in upgradation of network[33].

4.1.2.2 State/ city level initiatives

As shown in Table 4, in addition to federal initiatives, states and cities have brought out time of the day (ToD)/ time of use (ToU) tariffs, reduced EV charging rates, developed managed charging programs, dynamic pricing, rebates and funding for chargers, and mandates.

4.1.2.2.1 Time of the day/ time of use tariffs, dynamic pricing

Many utilities in the United States provide an EV specific time-of-use (TOU) rates. Such rates enable users to shift their charging periods to off-peak hours of the day. Examples of various power distribution entities offering TOU tariffs are highlighted below[34]:



30. Leaf Score. Colorado solar incentives for 2023. Retrieved on 2nd Mar 2023. https://www.leafscore.com/solar-guide/benefits-of-going-solar/solar-rebates-and-incentives/colorado/#:~:text=are%20also%20granted!-,State%20property%20tax%20exemptions%20in%20Colorado,not%20to%20the%20whole%20property.

    , Black Hills Energy Ready. Private on-site solar program. Retrieved on 2nd Mar 2023. https://www.blackhillsenergy.com/services/colorado-solar-program/private-site-solar-program
31. Leginfo. Senate Bill no .350. Retrieved on 2nd Mar 2023. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB350#
32. GeorgeTown Climate Center. Utility Investment in EV: Key Regulatory Considerations . Retrieved from https://www.georgetownclimate.org/files/report/GCC-MJBA_Utility-Investment-in-EV-Charging-Infrastructure.pdf
33. California Public Utilities Commission. Utility cost and Affordability of the grid of the future. Retrieved from https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/office-of-governmental-affairs-division/reports/2021/senate-bill-695-report-2021-and-en-banc-whitepaper_final_04302021.pdf
34. SCE. ToU -D-Prime Rates. Retrieved on 2nd Mar 2023. https://www.sce.com/residential/rates/electric-vehicle-plans

    , PG&E. Residential ToU rates EV-B rates. Retrieved from https://www.pge.com/tariffs/assets/pdf/tariffbook/ELEC_SCHEDS_EV%20(Sch).pdf

    , DTE. Electric Pricing ToU rates. Retrieved on 2nd Mar 2023. https://www.dteenergy.com/us/en/residential/service-request/pev/pev-res-rate-plans.html

    , Connexus Energy. EV Time-of-Day Rate. Retrieved on 2nd Mar 2023. https://www.connexusenergy.com/save-money-and-energy/programs-rebates/electric-vehicle/time-day-enrollment

Holland Board of Public Works (HBPW) offers EV TOU rates for residential and commercial chargers that have subscribed to rebates during installation. The EV TOU rate, consists of on, mid and off-peak timeframes (On-peak – 10 a.m. to 6 p.m where tariff is INR 9.99 (EUR 0.11) per kWh, Mid-peak – 8 a.m. to 10 a.m. and 6 p.m. to 10 p.m., and Off-peak – 10 p.m. to 8 a.m, weekend and holidays, where tariff is INR 2.50 (EUR 0.027) per kWh).

SDGG&E in California offered dynamic hourly pricing to its customers residing in societies and apartments. Dynamic Hourly pricing refers to prices fixed one day before in accordance with prices discovered in wholesale markets. Based on the prices, customers can use a phone app to enter their preferences for the maximum price which they are willing to pay and the maximum duration which they are willing to charge their vehicles[35].

4.1.2.2.2 Reduced EV charging rates and credits

PEPCO provided a rebate to its customers based on how much electricity is consumed to charge the EVs during the off-peak hours[36]. The rebate is calculated for each quarter. PEPCO calculates the rebate amount by subtracting any on-peak charging from total off-peak charging.

Braintree Electric Light Utility in Massachusetts provides an INR 665.93 (EUR 7.32) per month of electricity credit, for charging during off-peak hours. Advanced smart meters installed on EV chargers enable the utility to collect data on charging patterns and verify whether a particular consumer was actually charging during off-peak period or not.

4.1.2.2.3 Rebates and funding for chargers

Residential customers in Tucson, who purchase a Level 2 or DC Fast Charger, enabled with one-way or two-way communications, were given a rebate of up to INR 41,621 (EUR 457.26) by Tucson Electric Power. Such consumers are mandatorily required to adhere to a Time-of-Use (TOU) rate plan for a minimum of two years[37].

San Joaquin Air Pollution Control District- "Charge Up!" programme[38] was designed to offer funding for public agencies, businesses, and property owners of multi-unit dwellings in the San Joaquin Valley. The program offers INR 4,16,207.50 (EUR 4,572.63) for Level 2 single port, INR 4,99,449 (EUR 5,487.15) for Level 2 dual port and INR 20,81,037.50 (EUR 22,863.12) for DC Fast Chargers. There is a funding cap of INR 41,62,075 (EUR 45,726.25) annually per applicant/site.

Salt River Project (SRP)- offered rebate of INR 124761.75 (EUR 1372.09) for each networked EV charging port installed at a business location, or INR 332698 (EUR 3658.90) per port for government, non-profit and school customers. The scheme is applicable to a Level 2 EV charging station port. These rebates are limited to 75 charging ports per customer per program year.

4.1.2.2.4 Utility managed charging programs

PEPCO utility introduced a Managed Charger Program. This is a voluntary demand response program that allows consumers to shift their electric vehicle charging usage during peak periods. Consumers obtain a 50% discount on the cost of an eligible Level 2 charger[39] as well as 50% waiver on the costs of installation of EV charger. Under the program, PEPCO enrolled 101 participants and conducted seven DR events. It was observed that some participants reduced their charging successfully.

4.1.3 Schemes to promote development of virtual power plants

4.1.3.1 Regulations enabling aggregation

Multiple jurisdictions in US have regulatory frameworks for participation of distributed renewable energy resources in wholesale power markets.

- FERC Order 719, 2008 specified that "Each Commission-approved ISO* (Independent System Operator)[40] and regional transmission organization must accept bids from an aggregator of retail customers".

35. California Public Utilities Commission. Workshop on Dynamic Rates and Real Time pricing. Retrieved on 2nd Mar 2023. https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-rates/workshop-on-dynamic-rates-and-real-time-pricing

    , Public Utilities Commission. Dynamic Pricing Workshop Report. Retrieved from https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/electric-rates/rtp-workshop/workshop-report-filed-by-sdge.pdf

    , New Atlas. California to get utility owned EV charging station with Dynamic Pricing. Retrieved on 2nd Mar 2023. https://newatlas.com/california-electric-car-utility-charging/41585/#:~:text=SDG%26E%20will%20be%20building%20its,18%3A00%2C%20summer

36. PEPCO. Whole House Time of Use Rate (TOU). Retrieved on 2nd Mar 2023. https://www.pepco.com/SmartEnergy/InnovationTechnology/Pages/WholeHouseTimeOfUseRate.aspx,

    PEPCO. New Electric Rate Plan to Help You Save. Retrieved from https://www.pepco.com/SiteCollectionDocuments/SmartEnergy/Pepco_MD_Whole_House_TOU.pdf

37. TEP. EV Rebates. Retrieved on 2nd Mar 2023. https://www.tep.com/ev-rebates/

38. San Joaquin Valley Air Pollution Control District. Charge Up! Electric Vehicle Charger Incentive Program. Retrieved on 2nd Mar 2023. https://ww2.valleyair.org/grants/charge-up/

39. PEPCO. PIV Managed Charger Program. Retrieved on 2nd Mar 2023. https://www.pepco.com/SmartEnergy/InnovationTechnology/Pages/PIVManagedChargerProgram.aspx

40. *Independent System Operator in the US is responsible for operating the competitive wholesale power markets and is responsible for managing and controlling the regional transmission grid as well as its reliability

- MISO provisions specify that "An Aggregator of Retail Customers (ARC) is an MP [market participant] sponsoring one or more DRRs [demand response resources] or LMRs [load modifying resources] provided by customers. An ARC can, but need not, be an LSE [load serving entity] sponsoring a DRR or LMR that is the retail customer of another LSE4[1]. Traditionally, DR response aggregators have been more prevalent than DERs in the United States. However, in 2016, FERC recognized DER aggregations as a new type of market resource, similar to traditional generating facilities. Each ISO has specified different requirements, as given below, for an entity to become an aggregator.

NYISO	CAISO
Aggregation should consist of resources connected to the same transmission node.	For DER aggregation, DR and behind the meter resources will not qualify.
Demand response, generation, and storage can qualify for aggregation.	Combined capacity must be at least 0.5 MW / 20 MW if aggregations span single / multiple price nodes respectively.
Restriction has been placed on aggregations of less than 1 megawatt (MW) to participate in wholesale energy markets.	The aggregator needs to have an agreement with ISO specifying the list of DERs, notification to distribution utility etc.
	CAISO requires each DER to have provision for recording actual generation data.

4.1.3.2 FERC Order No. 2222 for Participation of DERs in the Energy and Ancillary Markets[42]

Federal Energy Regulatory Commission's (FERC) Order 2222 allows aggregators to compete in regional wholesale electricity markets. Aggregation is allowed for solar, wind, electric vehicles, battery storage, and other distributed energy resources (DERs). This order enables aggregated DERs to compete on the same level as traditional power plants and other grid resources in wholesale markets.

The minimum size requirement for DER aggregations is set at 100 kW. Any DER aggregation above 100 kW will be eligible to participate in the regional wholesale electricity markets.

A case-study of virtual power plant is given below.

JUMPSmartMaui project[43]

The JUMPSmartMaui project was launched in June 2011. The objective was to demonstrate smart grid technologies in Maui's electrical grid.

The Maui power grid is operated by the Maui Electric Company, which is a subsidiary of Hawaiian Electric Company. Maui Electric Company operated three (3) island power grids namely Maui, Lanai, and Molokai. The demonstration project comprised of (i) 64,500 customers (ii) Approximately 200 MW peak load and 90 MW minimum system load (iii) Two dual train combined cycle combustion turbines (iv) Four steam turbines (v) Fifteen internal combustion engines (vi) 30 MW wind farm (vii) Two 21 MW wind farms (viii) 69 MW customer-sited solar PV (ix) 0.5 MW hydroelectric plant.

The overall goal of this phase was to demonstrate the working of a "virtual power plant" by integrating distributed RE resources and EV batteries within the grid. The VPP utilizes EVs as batteries to absorb excess energy and to provide stability to the grid that has a large installed capacity of renewable energy.

Implementation mechanism of the project is highlighted below:

1. In Phase 1, the project enrolled more than 200 EV owners of Nissan Leaf and 30 homeowners. Thirteen fast charging stations were installed. Participants were offered the flexibility to charge their EVs, access to the fast-charging stations, level II chargers and smart energy monitoring devices at their homes. This phase focused on data collection to evaluate whether RE can be successfully integrated with EV charging.

41. MISO Energy. Aggregator. Retrieved on 2nd Mar 2023. https://cdn.misoenergy.org/Aggregator%20of%20Retail%20Customers%20(ARC)%20FAQ315124.pdf
42. FERC. FERC order no 2222 factsheet. Retrieved on 2nd Mar 2023. https://www.ferc.gov/media/ferc-order-no-2222-fact-sheet Hitachi Review. Island Smart Grid Model in Hawaii Incorporating EVs. Retrieved from https://www.hitachi.com/rev/pdf/2014/r2014_08_102.pdf
43. Hitachi Review. Island Smart Grid Model in Hawaii Incorporating EVs. Retrieved from https://www.hitachi.com/rev/pdf/2014/r2014_08_102.pdf

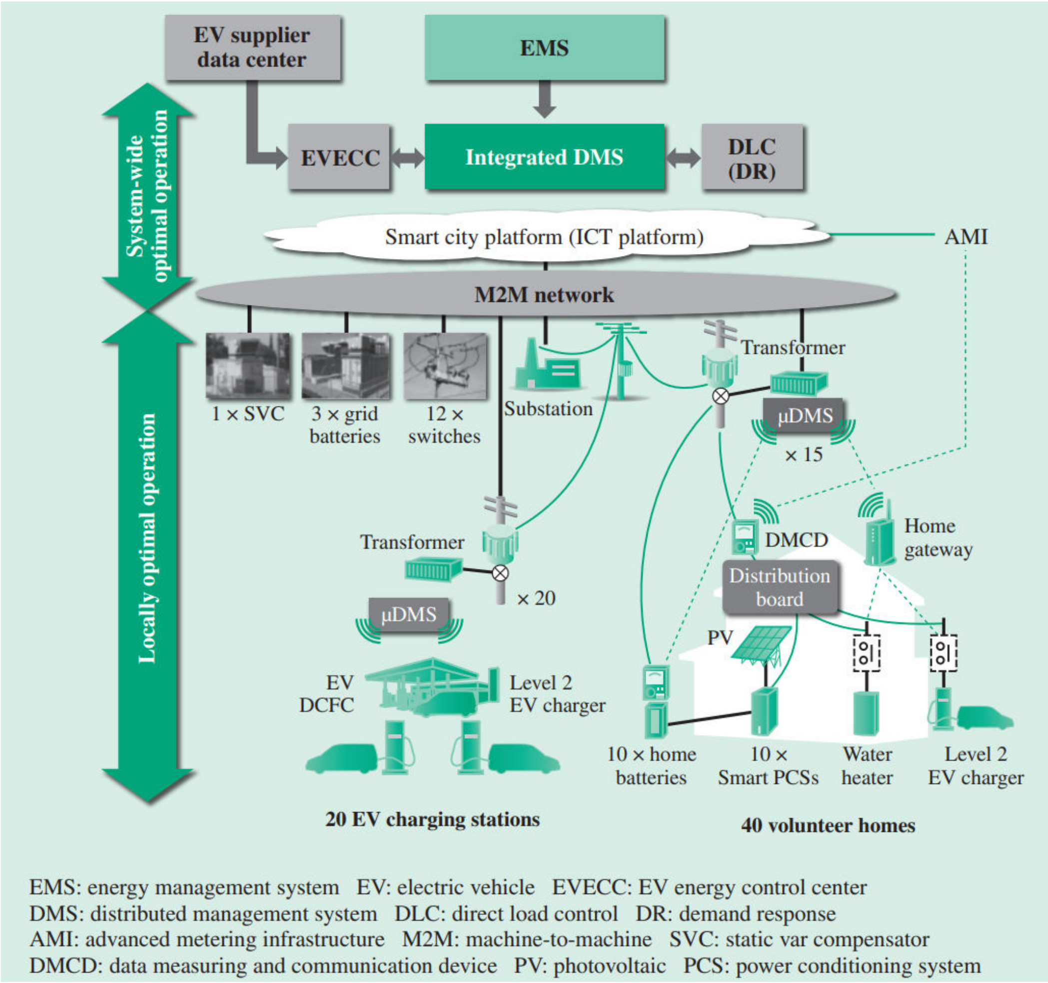


Figure 11 Overview: Island Smart Grid Model in Hawaii[44]

2. In Phase 2, 80 volunteers were provided with EV-Power Conditioning System (EV-PCS) units. The EV-PCS, developed by Hitachi, was used to intelligently charge the EV, and discharge the electricity to the home or business or to Maui Electric as per real-time requirements.

The EV Energy Control Center (EVECC) described alongside provides integrated energy management. It exchanges information with distributed management system (DMS) and energy management system (EMS) of Maui Electric. Hitachi supplied:

1. Variable-output EV DC fast chargers with ability to be directly controlled by the utility.
2. A charging management system that supports the EV DC Fast Chargers

The charging management system worked as per the following constraints:

1. Allocated a total charging capacity of 60 kW among the plugged-in vehicles. This is carried out through a preference for EVs which are connected earlier than others.
2. Minimized excessive disconnections to maintain supply and demand balance; and
3. Completed charging operations as per user preferences.

The charging management system collected information on availability of chargers and provides the same via web screens to EV users. Users can choose an appropriate time to charge their EVs accordingly.

The EVECC acquired information from the integrated DMS regarding the demand-supply position in the grid, and state of charge of the EVs from the EV supplier's data center. It was also equipped to undertake load shifting to balance the demand and supply in the grid.

1. The integrated DMS obtains information about the demand and supply situation, including availability of low-cost RE from the EMS.

44. Hitachi Review. Island Smart Grid Model in Hawaii Incorporating EVs. Retrieved from https://www.hitachi.com/rev/pdf/2014/r2014_08_102.pdf

2. The DMS uses this information to generate a schedule of when the low-cost RE would be available.
3. Next, the integrated DMS and EVECC exchange information about the demand-supply balance and EV charging preferences / schedules.
4. Finally, the EVECC sends signals to chargers to charge as per the availability of low-cost electricity.

Results of the project:

The JUMPSmartMaui project successfully demonstrated how RE can be utilized for charging EVs. The EVECC (EV energy control center) schedules charging based on the forecasted electricity demand and generation. It attempts to schedule more EV charging when there is more renewable generation. Also, the EVECC schedules charging of each vehicle as per consumer preferences. Shifting EV charging to off-peak time thus occurred as a result of accurate forecasting of demand-supply position.

4.2 Germany

Measures for enabling RE, charging infrastructure adoption and virtual power plants are tabulated below:

Table 5: List of initiatives in Germany for enabling RE, EV charging, and virtual power plants

Mechanisms for adoption of RE	Mechanisms for adoption of EV charging infrastructure	Schemes for promoting virtual power plants
German Feed-in-tariff -FiT (EEG)	Climate Action Program 2030	Energy Efficiency Directive 2012/27/EU
KfW Renewable Energy Programme Standard	Incentives for accelerating EV charging infrastructure adoption	Directive (EU) 2019/944 on common rules for the internal market for electricity
KfW Programme offshore wind energy	KfW grant	EU Directives
Tenant electricity surcharge	Act to Develop a Building-Integrated Charging and Connection Infrastructure for Electric Mobility (the "GEIG")	
	Directive of the European Parliament and of the Council on the Energy Performance of Buildings, 2021	
	Berlin Solar Act	
	Other legislations in Germany and incentives/State	

4.2.1 Mechanisms for adoption of renewable energy

Federal level initiatives such as feed-in-tariffs, low-interest loans, off-shore wind energy programmes, electricity surcharges have propelled RE share in overall installed capacity to reach 55% in 2021. Solar and Wind RE capacity has grown at a CAGR of ~10% from 2010 to 2021[45].

- **German Feed-in-tariff-FiT (EEG)**[46]: Through this mechanism, RE sources obtained priority access in the power grid. The scheme provided a fixed price for RE generators for every unit of electricity generated during a fixed period (generally 20 years). Tariffs are differentiated by source, size of the plant and the year of installation. The EEG amendment specified that feed-in tariffs will decrease by 1% every six months post 2024.
- **KfW Renewable Energy Programme Standard**[47]: Private individuals, not-for-profit organisations, self-employed professionals, farmers and select German and non-German enterprises were provided low

45. EIA. Electricity capacity. Retrieved from International - U.S. Energy Information Administration (EIA)
46. Renewable Energy Sources Act EEG 2017. Retrieved from https://www.bmwk.de/Redaktion/EN/Downloads/renewable-energy-sources-act-2017.pdf?__blob=publicationFile&v=3, EEG 2023. Retrieved from https://www.bmwk.de/Redaktion/DE/Downloads/Energie/04_EEG_2023.pdf?__blob=publicationFile&v=8
47. KfW. Energy and the environment. Retrieved on 2nd Mar 2023. https://www.kfw.de/inlandsfoerderung/Companies/Energy-and-the-environment/

interest loans for financing 100% of investment cost for installing solar energy (photovoltaics), biomass, wind energy, hydropower, and geothermal energy.

- **KfW Programme offshore wind energy**[47:] The program was devised to finance construction of offshore wind farms. Multiple loan options were provided which could be combined with a cost overrun loan. Option A: Up to INR 3636.8 Crores (EUR 400 million) and max. 50% of total project debt, Option B: Up to INR 6364.4 Crores (EUR 700 million) and max. of 70% of total project debt, and Option C: Up to INR 909.2 Crores (EUR 100 million) and max. of 50% of total cost overrun loan.

- **Tenant electricity surcharge**[48]: Owners of PV-plants (up to 100 kW) on residential buildings are supported through a surcharge, which is received for the electricity not injected into the grid and consumed in the same building. Compensation is linked to the statutory feed-in tariff set out as per the Renewable Energy Sources Act minus a deduction. In cases where tenants cannot utilize the entire electricity generated, the surplus electricity, injected into the grid, is compensated at the feed-in-tariff.

4.2.2 Mechanisms for adoption of EV charging infrastructure

- The Climate Action Program 2030 had set a target of making one-million charging stations available in Germany by 2030. Funding was earmarked for developing public chargers by 2025[49]. Funding was also earmarked for the expansion of private charging facilities. The Plan also directs all fuel (petrol) stations in Germany to have charging stations in their parking areas.

- Germany had set up a target to equip at least 25%, 50% and 75% of all pitstops with fast-charging infrastructure by the end of 2022, 2024 and 2026, respectively[50]. The incentive aims at boosting charging infrastructure, facilitating research in e-mobility and battery cell manufacturing. INR 227.3 billion (EUR 2.5 billion) fund has been dedicated to providing the incentives. The German Government pays a certain percentage of the cost incurred in setting up the infrastructure. To enable RE based EV charging, the country provides incentives for controllable non-public chargers.

- As part of the KfW grant, German Federal Ministry of Transport and Digital Infrastructure (BMVI) and KfW had launched a scheme for new charging stations developed in residential buildings. In this scheme, consumers can avail a grant of INR 81828 (EUR 900) for installing charging points. To avail the grant, 100% of the electricity used for the charging process should be from renewable sources[51].

- Act to Develop a Building-Integrated Charging and Connection Infrastructure for Electric Mobility (the "GEIG")[52]: GEIG, which is in force since March 2021, requires residential and non-residential buildings to install appropriate infrastructure for charging of EVs. This includes creation of electrical conduits and creation of charging infrastructure in the immediate vicinity of buildings[53].

- Directive of the European Parliament and of the Council on the Energy Performance of Buildings, 2021[54]: The Directive is applicable to all EU member countries. It mandates pre-cabling to be undertaken for all new buildings and buildings undergoing major renovation. The Directive provides that member states should enable smart and bidirectional charging.

- Berlin Solar Act[55] : Since July 2021, this Act mandated the installation of photovoltaic systems on all new buildings or conversions of older buildings in Berlin,

48. Federal Ministry for Economic Affairs and Climate Action. Landlord-to-tenant electricity supply: the energy transition in your own home. Retrieved on 2nd Mar 2023. https://www.bmwk.de/Redaktion/EN/Artikel/Energy/landlord-to-tenant-electricity-supply.html
49. The Federal Government. Climate Action Programme 2030. Retrieved on 2nd Mar 2023. https://www.bundesregierung.de/breg-en/issues/climate-action/klimaschutzprogramm-2030-1674080
50. European Commission. European Alternative Fuels Observatory. Retrieved on 2nd Mar 2023. https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/germany/incentives-legislations
51. KfW. Grant product to promote new charging stations for electric vehicles in residential buildings available from 24 November. Retrieved on 2nd Mar 2023. https://www.kfw.de/About-KfW/Newsroom/Latest-News/Pressemitteilungen-Details_618240.html
52. Federal Ministry for Economic Affairs and Energy. Building Electromobility Infrastructure Act (GEIG). Retrieved on 2nd Mar 2023. https://www.bmwk.de/Redaktion/DE/Artikel/Service/Gesetzesvorhaben/gebaeude-elektromobilitaetsinfrastruktur-gesetz.html
53. For new residential / non-residential buildings with more than five parking spaces, there must be a conduit at each / every 3rd parking space respectively; for existing residential / non-residential buildings which undergo a major renovation and which have more than ten parking spaces, each / every 5th parking space, respectively, should be equipped with conduits for electric cables; in the case of existing non-residential buildings with more than twenty parking spaces, the property owner must ensure that after 1 January 2025 a recharging point is set up, irrespective of any renovation.
54. European Commission, DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0802&qid=1641802763889
55. The Official Website of Berlin. Renewable Energy. Retrieved on 2nd Mar 2023. https://www.berlin.de/sen/energie/erneuerbare-energien/solargesetz-berlin/artikel.1053243.php

from 2023 onwards. The law is applicable to the buildings which have a usable area of more than 50 square meters. At-least 30% of the roof area should be covered with photovoltaic systems.

4.2.3 Schemes to promote development of virtual power plants

4.2.3.1 EU Directives

The EU Directives are valid for all the EU member states for promoting aggregation of Distributed Energy Resources and are enlisted below:

4.2.3.1.1 Energy Efficiency Directive 2012/27/EU[56]

Energy Efficiency Directive 2012/27/EU (EED) defines the term 'aggregator' as a "demand service provider that combines multiple short-duration consumer loads for sale or auction in organized energy markets". The definition, however, included only consumption of electricity and not the generation.

EED incorporates the aggregators as active participants in the energy market and defines them as demand service providers.

4.2.3.1.2 Directive (EU) 2019/944 on common rules for the internal market for electricity[57]:

These directives have provided for aggregation of Distributed Energy Resources and defines aggregation as a "function performed by a natural or legal person who combines multiple customer loads or generated electricity for sale, purchase or auction in any electricity market." It mentions that member states should allow customers to freely purchase and sell electricity services, including aggregation. This could be done independently from their electricity suppliers and from an electricity undertaking of their choice.

An example of VPP in Germany is highlighted below:

Table 6: VPP Case study in Germany

Next Kraftwerke and Jedlix Initiative, Germany [58]
Next Kraftwerke (VPP operator) and Jedlix (EV aggregator) launched a pilot project to deliver demand response services through batteries of EV. Jedlix's role was to provide a smart charging platform and an EV fleet. Next Kraftwerke provided an interface to the TSO and marketed the aggregated energy in TSO's ancillary markets.
Jedlix links its system to Next Kraftwerke's remote control unit. Next Kraftwerke then centrally controls the charging of the EV fleets. The EV fleets receive command signals from the remote-control unit and manage the power consumption of the fleet. Jedlix is responsible for obtaining user preferences on charging and data from the charging station to provide a continuous forecast of the available capacity. To balance the varying load of EVs, the EV charging sessions are coupled with wind and solar power generating plants, biogas plants and greenhouse CHP plants.
This project highlighted that a pool of electric vehicles can be coupled with renewable sources in the most optimal manner.

4.3 Netherlands

Netherlands has propelled towards 48% share of renewable energy in overall installed capacity in 2021. The installed capacity for RE has grown at a CAGR of 20% from 2010 to 2021. The country has also witnessed 96% share of solar and wind energy in overall RE capacity in 2021[59]. The set of initiatives taken in Netherlands are showcased below:

Table 7: List of initiatives in Netherlands for enabling RE, EV charging, and virtual power plants

Mechanisms for adoption of RE	Mechanisms for adoption of EV charging infrastructure
SDE++ Scheme	National Charging Infrastructure Agenda
Small Scale PV Net Metering	Tax benefits for businesses
Tax regulation mechanisms-I (Reduction of environmental protection tax)	Directive of the European Parliament and of the Council on the Energy Performance of Buildings, 2021
Energy Investment Allowance, EIA scheme	
Environmental Investment Allowance (MIA)	
Random depreciation of environmental investments – VAMIL	
Sustainable energy investment subsidy (ISDE)	
Exemption from sustainable energy surcharge	

The schemes to promote virtual power plants in Netherlands are similar to the ones deployed in Germany.

56. Official Journal of the European Union. Directive 2012/27/EU of THE EUROPEAN PARLIAMENT AND OF THE COUNCIL. Retrieved from https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:315:0001:0056:EN:PDF

57. Official Journal of the European Union. DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L0944

58. Next. Next Kraftwerke and Jedlix launch initiative to use electric car batteries for grid stability. Retrieved on 2nd Mar 2023. https://www.next-kraftwerke.com/news/next-kraftwerke-jedlix-launch-initiative-to-use-electric-car-batteries-for-grid-stability

59. IRENA. Energy Statistics 2022. Retrieved from https://www.irena.org/publications/2022/Jul/Renewable-Energy-Statistics-2022

4.3.1 Mechanisms for adoption of renewable energy

- **SDE++ Scheme**[60] (Stimulation of sustainable energy production and climate transition): Provided for an additional compensation to RE producers on top of the market price with focus on both large-scale deployment of RE technologies and other technologies that reduce CO2 emissions. Subsidy is provided to compensate for the difference between the wholesale price and the actual cost of electricity. The premium was designed to be paid for 15 years from the commissioning date of the plant. This provides a **guaranteed price** for RE generators and ensures their commercial viability.
- **Small scale PV net-metering**[61] **:** Excess generation fed into the grid is compensated at varying retail rates by various suppliers. A further value-based pricing is paid per kWh of PV generation when PV generation outpaces a consumer's annual total demand for power.
- **Tax regulation mechanisms-I (Reduction of environmental protection tax)**[62] **:** Environmental Protection Tax is not charged to a consumer who generates and consumes renewable energy. Technologies such as wind energy, solar energy, geothermal, biogas, hydropower and biomass are eligible under this programme. Such mechanisms incentivize adoption of RE sources by retail consumers.
- **Energy Investment Allowance, EIA scheme**[63] **:** Enabled businesses to write off investments in RE plants against tax. Solar PV systems connected to the grid can avail a maximum of INR 68190 (EUR 750) per kW. Solar PV systems not connected to grid can avail a maximum of INR 90920 (EUR 1,000) per kW. The amount of tax credit could be a maximum of 45.5% of the total investments made in RE technologies in addition to top of usual depreciation.
- **Environmental Investment Allowance (MIA)**[64]**, Random depreciation of environmental investments – VAMIL**[65] **:** MIA is applicable to green business assets with a specific investment cost. It offers option of reducing taxable profit by allowing the deduction of up to 45% of investment costs from Profit after tax (PAT) in addition to regular tax deductions. VAMIL scheme permits arbitrary depreciation up to 75%. The advantage of the VAMIL is that it accelerates the depreciation of company's assets, giving a liquidity (and interest) advantage.
- **Sustainable energy investment subsidy (ISDE)**[66] **:** Encouraged small and medium-scale businesses, and homeowners to install solar panels/ small-wind turbines for producing sustainable energy at their premises. The Dutch Government promotes investment in sustainable energy and partly compensates the initial investment cost. The budget for the incentive was INR 636.4 Crore (EUR 70 million)/year in 2016-17 and was further increased to INR 909.2 Crore (EUR 100 million)/ year in 2018-19. A budget of INR 2633.6 Crore (EUR 290 million) was allocated for ISDE in 2022.
- **Exemption from sustainable energy surcharge**[67] **:** Sustainable energy charge is a levy on the supply of energy to stimulate sustainable energy. The surcharge is paid per kWh of electricity consumed and is added to a consumer's annual energy bill. Companies which consumed self-generated sustainable energy and generated electricity from renewable sources, were exempted from payment of sustainable energy surcharge.

4.3.2 Mechanisms for adoption of EV charging infrastructure

Netherlands witnessed growth in EV stock from 2016 to 2021 at a CAGR of ~87% to reach 0.4 million. The nation had 4.7 EVs per charging point in 2021. The initiatives taken by the country for proliferating EV charging stations are highlighted below.

- **National Charging Infrastructure Agenda**[68] **:** Rolled out in 2019, the agenda stated measures for RE based EV charging like interoperability and open protocols, preparation of market models and regulations for smart charging, strengthening technical architecture and open standard protocols for smart charging. The agenda also stresses on the need of bi-directional charging.

60. Netherlands Enterprise Agency. *SDE++ 2022 Stimulation of sustainable energy production and climate transition.* Retrieved from https://english.rvo.nl/sites/default/files/2022/07/20220712-English-brochure-opening-round-2022_1.pdf
61. IEA. *The Netherlands 2020 Energy Policy Review.* Retrieved from https://iea.blob.core.windows.net/assets/93f03b36-64a9-4366-9d5f-0261d73d68b3/The_Netherlands_2020_Energy_Policy_Review.pdf
62. Netherlands Tax Authorities. *Energy tax and surcharge sustainable energy and climate transition.* Retrieved on 2nd Mar 2023. https://www.belastingdienst.nl/wps/wcm/connect/bldcontentnl/belastingdienst/zakelijk/overige_belastingen/belastingen_op_milieugrondslag/energiebelasting/
63 Netherlands Enterprise Agency. Energy Investment Allowance – EIA. Retrieved on 2nd Mar 2023. https://english.rvo.nl/subsidies-programmes/energy-investment-allowance-eia
64. Business.gov.nl. *Environmental investment allowance (MIA).* Retrieved on 2nd Mar 2023. https://business.gov.nl/subsidy/environmental-investment-allowance/
65. Netherlands Enterprise Agency. *MIA and VAMIL.* Retrieved on 2nd Mar 2023. https://english.rvo.nl/subsidies-programmes/mia-and-vamil
66. IEA. *Investment subsidies small renewable energy systems (ISDE).* Retrieved on 2nd Mar 2023. https://www.iea.org/policies/7728-investment-subsidies-small-renewable-energy-systems-isde
67. Business.gov.nl. *Energy Tax.* Retrieved on 2nd Mar 2023. https://business.gov.nl/regulation/energy-tax/#:~:text=and%20Customs%20Administration.-,Energy%20tax%20lowered%20for%202022,electricty%20bill%20will%20be%20raised.
68. *The National Charging Infrastructure Agenda*. Retrieved from https://english.rvo.nl/sites/default/files/2020/10/Factsheet%20The%20National%20Charging%20Infrastructure%20Agenda.pdf

- **Directive of the European Parliament and of the Council on the Energy Performance of Buildings, 2021:** The Directive is applicable to all EU member countries. It mandates pre-cabling to be undertaken for all new buildings and buildings undergoing major renovation. The Directive provides that member states should enable smart and bidirectional charging (as stated in Germany).
- Tax benefits for businesses: Using the Environmental Investment Allowance (MIA, introduced in 2000), companies can receive an investment deduction of up to 36% of the amount invested in a charging point from the taxable profits. Random depreciation of environmental investments (VAMIL, introduced in 1991) offers businesses and companies an opportunity to depreciate 75% of the investment costs of a charging point. This provides liquidity and interest benefits to the businesses.

4.4 Norway

Norway is a pioneer in renewable energy generation. Approximately 99 % of electricity generated was from renewable energy sources with hydropower being the major source[69] . Hydropower contributed to ~92% of the electricity generated from RE sources . The policy and initiatives undertaken in Norway are tabulated below:

Table 8: List of initiatives in Norway for enabling RE, EV charging, and virtual power plants

Mechanisms for adoption of RE	Mechanisms for adoption of EV charging infrastructure
Norway-Sweden Green Certificate Scheme for electricity production	Infrastructure Investments by Norwegian government
Enova Subsidy	Funding for fast chargers
	City level incentives

4.4.1 Mechanisms for adoption of renewable energy

- **Norway-Sweden Green Certificate Scheme for electricity production[71] :** It is a certificate trading system established in 2012. The system is a market-based support system for renewable electricity production, which permits trading in both Norwegian and Swedish certificates, and receiving certificates for RE in either country.
- **Enova Subsidy:** Enova granted aid for development of renewable energy projects. This scheme is not sector specific and is technology neutral. The subsidy is given for projects where the cost of producing RE electricity is higher than the cost of producing electricity from less environmentally friendly sources.

4.4.2 Mechanisms for adoption of EV charging infrastructure

- Infrastructure Investments by Norwegian government: Government of Norway came out with a support scheme in 2008 called as NOR1, for providing 100 percent installation cost for normal chargers or up to INR 2,41,556 (EUR 2662) per charging point. ***The scheme resulted in establishment of 1,800 charge points with total support amounting to INR 402.23 million (EUR 4.44 million)[72] .***
- **Funding for fast chargers[73] :** Transnova was established in 2009 to support research and test projects and provide for funding of EV charging infrastructure. It was funded through grants by the central government and was aimed at promoting projects which can demonstrate environmentally efficient transport technologies. Funds are provided to potential investors and private players who are desirous of setting up EV charging infrastructure. Additionally, Transnova also collaborates with industry players to support innovation in charging infrastructure. In 2015, the Government of Norway introduced a programme aimed to cover installation of one fast charging station for every 50 km. To facilitate the same, the government established Enova SF, which was previously named as Transnova.
- **City level initiatives:** Oslo's regulation mandated that the upcoming new building must have 50 percent parking area equipped with EV charging facilities. The facilities should be able to cater to minimum 3.6 kW of charging demand. Oslo also provides a grant for a maximum of 20% of the cost of EVSE purchase and installation cost. However, the grant is capped up to (INR 40,223 EUR 450) per charging point and INR 80,44,582 (EUR 88,666) per housing association[74]. Similar incentives are also provided by the City of Skedsmo and Asker.

69. IEA. Norway. Retrieved on 2nd Mar 2023. https://www.iea.org/countries/norway
70 IEA. Norway 2022 Energy Policy. Retrieved on 2nd Mar 2023. https://iea.blob.core.windows.net/assets/de28c6a6-8240-41d9-9082-a5dd65d9f3eb/NORWAY2022.pdf
71. Energy Facts Norway. Norwegian-Swedish electricity certificate scheme. Retrieved on 2nd Mar 2023. https://energifaktanorge.no/en/regulation-of-the-energy-sector/elsertifikater/
72. IBEX Publishing. Let's Learn from Norway: How Governments Can Accelerate EV's Road to the Mainstream. Retrieved on 2nd Mar 2023. https://ibexpub.media/lets-learn-from-norway-how-governments-can-accelerate-evs-road-to-the-mainstream/
73. European Commission. TRANSNOVA. Retrieved on 2nd Mar 2023. https://trimis.ec.europa.eu/programme/transnova
74. IEA. Building regulation EVSE Oslo. Retrieved on 2nd Mar 2023. https://www.iea.org/policies/8548-building-regulation-evse-oslo
, Oslo. Charging infrastructure for housing associations and condominiums. Retrieved on 2nd Mar 2023. https://klimatilskudd.no/ladeinfrastruktur-til-borettslag-og-sameier
, Asker Kommune. Charging of electric cars in housing associations in Asker municipality - grant for facilitation. Retrieved on 2nd Mar. https://www.asker.kommune.no/klima-og-miljo/tilskudd-til-lading-for-elbiler-i-boligselskap/
, Wall Box. Discover Norway's Unique EV And EV Chargers Perks. Retrieved on 2nd Mar. https://blog.wallbox.com/norway-ev-incentives/

4.5 France

In the period between 2010 and 2021, RE installed capacity in France increased from 32 GW to 60 GW. The share of RE in the overall installed capacity has also seen a significant rise from 25% in 2015 to 42% in 2021. Set of initiatives around RE, EV charging infrastructure, and virtual power plants have been captured below:

Table 9: List of initiatives in Netherlands for enabling RE, EV charging, and virtual power plants

Mechanisms for adoption of RE	Mechanisms for adoption of EV charging infrastructure
French support scheme for renewable electricity	Decree 2021153
Tax incentives France 2030 investment Plan"-Investment in renewable energy innovation	Advenir program
Tax incentives	Tax incentives
	Directive of the European Parliament and of the Council on the Energy Performance of Buildings, 2021
	Paris - subsidies for EV charging points

The schemes to promote virtual power plants in France are similar to the ones deployed in Germany.

4.5.1 Mechanisms for adoption of renewable energy

- **French support scheme for renewable electricity**[75] : France designed a support scheme for RE sources, which are awarded through tenders between 2021 to 2026. The support includes payment of a premium over and above the market price which such sources receive. The compensation would be paid for a maximum period of 20 years once new renewable project is connected to the grid. Such mechanism ensures guaranteed revenues for RE developers.
- **Tax incentives France 2030 investment Plan-Investment in renewable energy innovation**[76] : The French government earmarked INR 8,108 Cr (EUR 1 billion) to be invested for advancement of renewable energy. The goal is to install ten times as much renewable energy by 2050, or up to 100 GW. Among this, 40 GW of total installed capacity will come from offshore wind projects.

Tax incentives[77] : Consumers who install solar energy, wind energy or biomass-based plants at their residences are eligible for obtaining a tax credit on the investment cost. Such a mechanism would allow the growth of solar rooftop on buildings.

4.5.2 Mechanisms for adoption of EV charging infrastructure

- **Decree 2021**: Specified that a beneficiary could avail a subsidy of 30% of the investment for setting up of an EV charging station. An additional 10% subsidy would be given if the charging station is in select roads where profitability is expected to be low. An additional 10% of subsidy would be provided for the first 150 fast charging stations[78] .
- **Advenir Program**[79] : Launched in 2016, the program aims to provide funding for installation of private chargers for private buildings and companies. The programme has the target to finance 1,20,000 new charging points by 2025[80] .
- **Tax Incentives**[81] : The government of France provides INR 27,220 (EUR 300) tax credit on the purchase and installation of an EV charger for residential consumers. However, the tax credit cannot exceed 75% of the total costs.
- **Directive of the European Parliament and of the Council on the Energy Performance of Buildings, 2021**[82] : It mandated pre-cabling to be undertaken for all new buildings and buildings undergoing major renovation. The Directive also emphasizes on charging points in new and renovated office buildings. The Directive provides that member states should enable smart and bidirectional charging.

75. European Commission. State aid: Commission approves €30.5 billion French scheme to support production of electricity from renewable energy sourcesFrench support scheme for renewable electricity. Retrieved on 2nd Mar. https://ec.europa.eu/commission/presscorner/detail/en/ip_21_3922
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76. Republique Francais. France 2030 Investment Plan, Statement by Mr. Emmanuel Macron, President of the Republic, on energy policy, in Belfort on February 10, 2022. Ret Retrieved on 2nd Mar.https://www.vie-publique.fr/discours/283773-emmanuel-macron-10022022-politique-de-lenergie
77. Republique Francais. LegiFrance. Retrieved on 2nd Mar. https://www.legifrance.gouv.fr/codes/article_lc/LEGIARTI000042910306
, IEA. France 2021 Energy Review Policy. Retrieved from https://iea.blob.core.windows.net/assets/7b3b4b9d-6db3-4dcf-a0a5-a9993d7dd1d6/France2021.pdf
78. Republic France. Applicable National Law. Retrieved on 2nd Mar. https://www.legifrance.gouv.fr/loda/id/JORFARTI000043148060/#JORFARTI000043148060
79. Advenir. Aid amounts by type of premium. Retrieved on 2nd Mar. https://advenir.mobi/primes-et-montants-daides/
80. Advenir. Advenir, the financing program for charging stations for electric vehicles. Retrieved on 2nd Mar. https://advenir.mobi/programme-advenir/
81. Wallbox, How to Get An EV Subsidy In France. Retrieved on 2nd Mar. https://blog.wallbox.com/france-ev-incentives/
82. European Commission, DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0802&qid=1641802763889

❖ **Paris - subsidies for EV charging points:** Subsidies for EV charging in condominiums, car parks and taxi stands are provided.

i. **Subsidies for condominiums:** 50% of cost excluding tax, but capped up to EUR 500 per charging point and for four points for chargers

ii. **Subsidies for car parks and taxi standards:** 50% of the amount excluding tax, but capped up to EUR 4,000 for the electrical pre-equipment of a car park

4.6 Japan

Japan's installed renewable energy capacity has increased from 36 GW in 2010 to 111.85 GW in 2021. By 2030, the cumulative renewable capacity is expected to reach 165.3 GW, growing at a CAGR of 7.3% in this period[83] . The country aims to increase its renewable energy share energy mix to 36-38% by 2030.

Initiatives across renewable energy, EV charging infrastructure, and virtual power plants in Japan are tabulated below:

Table 10: List of initiatives in Japan for enabling RE, EV charging, and virtual power plants

Mechanisms for adoption of RE	Mechanisms for adoption of EV charging infrastructure
National Budget Solar PV Installation-2021	Next Generation Vehicle Charging Infrastructure Deployment Promotion Project
Feed-in-Tariffs	PHV, PHEV and EV Charging Infrastructure Assistance Project
Rebate Scheme	Tokyo metropolitan subsidy programme
	Tokyo metropolitan subsidy programme

4.6.1 Mechanisms for adoption of renewable energy

❖ **National Budget Solar PV Installation-2021**[84] : In 2021, the Japanese government allotted INR 2.87 billion (EUR 0.032 billion) for funding solar power installations. Subsidy amount for solar PV installations was fixed at (INR 22,932 to INR 34,398) INR/kW (EUR 252.37 to EUR 379.81) EUR/ kW while that of battery was fixed at INR 11,465 INR/kWh (EUR 126.3) EUR/kWh or INR 17,198 INR/kW (EUR 189.5) EUR/kW. The subsidy targets the private businesses mainly. This mechanism also supports the introduction of self-consumption of solar power by businesses.

❖ **Feed-in-tariffs**[85] : Starting in July 2012, in this mechanism the electricity generated from renewable energy sources was required to be purchased by electricity suppliers on a fixed-term, fixed-price contract. This is beneficial for solar PV systems installed on residential dwellings such as single-family houses, smaller apartment blocks, etc.

❖ **Rebate scheme**[86] : Launched in 2022, it provided a rebate on solar systems in farmland, water reservoirs, and waste disposal facilities. Developers were given a maximum reimbursement of INR 1,73,987 INR/kW EUR 1,915 EUR/kW for solar PV projects with a capacity of 10 kW to 50 kW. A rebate of INR 1,18,014 INR/kW EUR 1300 EUR/kW was provided for projects with more than 50 kW. The programme aimed to cover up to 50% of the project's cost. The grant is applicable on solar panels, batteries, and power electronics machinery.

4.6.2 Mechanisms for adoption of EV charging infrastructure

❖ **Next Generation Vehicle Charging Infrastructure Deployment Promotion Project**[87] : In 2013, METI launched this project where it provided subsidies for municipalities and expressway operating organizations in Japan to issue charger deployment plans. Subsidy to the tune of 100% of cost of chargers and 2/3rd of the installation costs was provided for the municipalities and organizations who intend to install public chargers. In addition, the project also subsidized cost of chargers and 50% of installation costs of public chargers which were not figured in government plans or were installed at MUDs and parking areas.

83. IRENA. Energy Statistics 2022. Retrieved from https://www.irena.org/publications/2022/Jul/Renewable-Energy-Statistics-2022

84. Ministry of Environment Government of Japan. Support project for conversion to a decarbonized society based on supply chain reform and return of production bases to Japan (collaboration project with Ministry of Economy, Trade and Industry).Retrieved from https://www.env.go.jp/guide/budget/r02/r0204-hos-gaiyo/005.pdf , IEA. National Budget 2021 - Solar PV installation. Retrieved on 2nd Mar. https://www.iea.org/policies/12636-national-budget-2021-solar-pv-installation

85. Ministry of Economy, Trade and Industry, Japan. Feed-in Tariff Scheme. Retrieved on 2nd March. https://www.meti.go.jp/english/policy/energy_environment/renewable/index.html

86. ETA. Public Offering Information. Retrieved on 2nd Mar. http://eta.or.jp/offering/22_08_shin2/220517.php , J-Net 21. Subsidy for installation of solar farmland: Ministry of the Environment. Retrieved on 2nd March. https://j-net21.smrj.go.jp/news/l357tf0000000ikj.html , PV magazine. Japan launches rebate program for solar on farmland, water reservoirs, waste sites. Retrieved on 2nd March. https://www.pv-magazine.com/2022/06/01

87. japan-launches-rebate-program-for-solar-on-farmland-water-reservoirs-waste-sites/ Japan's Initiatives for the diffusion of Next-Generation Vehicles . Retrieved from https://www.cev-pc.or.jp/event/event_pdf/okinawa20140207en_maruyama_03.pdf

- **PHV, PHEV and EV Charging Infrastructure Assistance Project**[88] : Joint project by the Toyota Motor Corporation, Nissan Motor Co., Ltd., Honda Motor Co., Ltd., and Mitsubishi Motors Corporation to provide additional subsidies to cover the costs remaining after subsidies were obtained from "Next Generation Vehicle Charging Infrastructure Deployment Promotion Project". A new entity was formed with additional funding and support from Development Bank of Japan Inc., Tokyo Electric Power Company, Inc., and Chubu Electric Power Co., Inc. in 2014. The entity compensated partly for the installation and maintenance costs, which were not fully provisioned through government subsidies.
- **Tokyo metropolitan subsidy programme**[89] : In 2018, Tokyo metropolitan government introduced subsidy for condominium owners, associations and developers for the purchase and installation of EV chargers. The programme also provided subsidy for installation of solar panel systems and battery systems if those were coupled with the installation of charging stations.
- **Tokyo metropolitan programme for utilizing ZEVs for energy management**[90] : Provided subsidies for installation of equipment which can utilize ZEVs as an energy infrastructure. The subsidies were provided for installing costs of chargers which can enable the ZEVs to feed electricity to home and standalone loads.

4.7 China

China is currently the world's largest producer of wind and solar energy with more than 1,000 GW of RE installed capacity in 2021[91] . The installed capacity of renewable energy increased from 233 GW to 1,020 GW between 2010 and 2021. Installed capacity of solar energy has grown from 4 GW in 2010 to 306 GW in 2021, at a CAGR of 48%. During the same period, installed capacity of wind energy has increased from 29 GW to 328 GW at a CAGR of 24%. The key initiatives around renewable energy, charging infrastructure in China are tabulated below.

Table 11: List of initiatives in China for enabling RE, EV charging, and virtual power plants

Mechanisms for adoption of RE	Mechanisms for adoption of EV charging infrastructure
BIPV subsidy program	Guidance on Accelerating the Construction of Electric Vehicle Charging Infrastructure
The Golden Sun Program	Active involvement by power utilities
Rebate Scheme	Incentives as a certain percentage of the total investment in EV charging infrastructure
	Incentives based on the power capacity of charging ports

4.7.1 Mechanisms for adoption of renewable energy

- **BIPV subsidy program**[92] : The BIPV (Building-integrated photovoltaics) subsidy program was launched in March 2009. BIPV refers to solar PV systems that can be installed on building's exteriors including windows, exterior walls, etc. An upfront subsidy of INR 237.2 INR/watt (EUR 2.58 EUR/watt) is provided for construction materials and components for BIPV projects. For roof-top and wall-based projects, a subsidy of INR 177.9 INR/watt (EUR 1.94 EUR/watt is provided.
- **The Golden Sun Program**[93] : The Ministry of Finance, the Ministry of Science and Technology (MOST) and the National Energy Administration (NEA) launched the Golden Sun Demonstration Program, in 2009. The aim of the program was to facilitate the growth of PV power generation industry in China. Under this program, the government provides a subsidy of 50% of investment for solar power projects as well as associated transmission systems. About 70% of investment is subsidized for solar PV projects located in remote regions that have no power supply.

88. TOYOTA. Toyota, Nissan, Honda and Mitsubishi Joint Development of Charging Infrastructure. Retrieved on 2nd Mar. https://global.toyota/en/detail/63045
89. Tokyo Metropolitan Environment Public Corporation. (FY2021) Project to promote the introduction of charging equipment (collective housing). Retrieved on 2nd Mar. https://www.tokyo-co2down.jp/subsidy/mansion-evcharge
, IEA. EVSE support Tokyo. Retrieved on 2nd Mar. https://www.iea.org/policies/6649-evse-support-tokyo
90. Tokyo ZEV promotion strategy. Retrieved from https://www.kankyo.metro.tokyo.lg.jp/en/about_us/zero_emission_tokyo/strategy.files/Full-ver.ZEV-strategy.pdf
91. IRENA. Energy Statistics 2022. Retrieved from https://www.irena.org/publications/2022/Jul/Renewable-Energy-Statistics-2022
92. China Policy in Focus. China's National Solar Subsidy Programs-BIPV. Retrieved on 2nd Mar. https://sites.google.com/site/chinapolicyinfocus/china-s-solar-subsidy-programs/china-s-solar-industry/china-s-national-solar-subsidy-programs
93. China Policy in Focus. China's National Solar Subsidy Programs-The Golden Sun Program. Retrieved on 2nd Mar. https://sites.google.com/site/chinapolicyinfocus/china-s-solar-subsidy-programs/china-s-solar-industry/china-s-national-solar-subsidy-programs

4.7.2 Mechanisms for adoption of EV charging infrastructure

- **Guidance on Accelerating the Construction of Electric Vehicle Charging Infrastructure**[94] : Established in 2015, the policy specified targets for 120,000 new charging stations and more than 4.8 million decentralized charging stations by 2020. The policy demarcates China into three categories of regions as per potential of EV infrastructure growth and urban density as well as proposes to develop a network of fast charging corridors.
- **Active involvement by power utilities**[95] : Two state-owned utilities in China – State Grid and China Southern Power Grid, have been frontrunners and have made large investments in electric vehicle charging infrastructure. These utilities were among the first to install charging infrastructure and provide electric vehicle charging services in China. They have also significantly invested in electricity grid upgrades to meet EV charging requirements.
- **Incentives as a certain percentage of the total investment in EV charging infrastructure**[96] : Beijing, Shanghai, Hainan, Wenzhou and Chengdu have provided up to 30% subsidy on the costs of construction of EV charging points. Hangzhou and Guiyang provide up to 25% and 10% subsidy on the costs of construction for EV charging points respectively. Jincheng province offers INR 35,772 (EUR 393.7) for AC charging points, INR 71,543 (EUR 787.4) for a fast-charging station, and 1.19 Cr (EUR 1,30,746) for public bus charging and battery swapping stations.
- **Incentives based on the power capacity of charging ports**[97] : Changzhou and Wuhan provided incentives up to INR 4,575 INR/kW (EUR 55 EUR/kW) for AC charging points, and INR 7,071 INR/kW (EUR 77.8 EUR/kW) for DC charging points. Wuxi also provides the same amounts for incentives but with a cap of the total incentive for a single charging station at INR 1.78 Cr (EUR 1,95,936). Nanjing and Suqian provide incentives of INR 7,071 INR/kW (EUR 77.8 EUR/kW) for AC charging points and INR 10,648 INR/kW (EUR 117.20 EUR/kW) for DC charging points. Xiamen provides incentives of INR 1,664 INR/kW (EUR 18.31 EUR/kW) for AC charging points and INR 5,823 INR/kW (EUR 64 EUR/kW) for DC charging points. Chongqing government offered a subsidy of INR 3,660 (EUR 40) per kilowatt to regular chargers and INR 7,320 (EUR 80.57) per kilowatt for fast chargers.

4.8 Key learnings from international policy and regulatory assessment

Following is a high-level summary of key initiatives which were taken by each country to promote RE based EV charging:

Table 12: Summary of key Initiatives for promoting Renewable Energy based Charging infrastructure

Intervention Areas	Key learnings and inferences
Incentives on capex and opex costs	Certain countries provide capital Incentives for EV chargers which are controllable. Such chargers enable control of charging speeds during high RE generation in the grid.
Incentives to enable RE consumption towards EV charging	Grants are provided for installation of charging points in residences which consume 100% of electricity from RE sources. Inntives are available on purchase and installation costs of EV chargers if the consumer produces and consumes RE at its own premises. Subsidies are provided for installation of solar panels and battery systems if the same are combined charging stations.
Incentives on Smart Chargers/Bidirectional-al Chargers	Countries provide policy directives for promotion of bi-directional charging which can enable large scale adoption of EVs coupled with storage. Subsidies are provided for bi-directional charging systems. This can enable utilization of RE / low-cost electricity. Surplus electricity in the batteries can be fed back as per requirement. Smart and intelligent energy solutions have been adopted in pilots and projects. These are key enablers for RE based EV charging.

94. Future Bridge. Impact of Policy Landscape on Future of EV Charging Infrastructure. Retrieved on 2nd March. https://www.futurebridge.com/industry/perspectives-energy/impact-of-policy-landscape-on-future-of-ev-charging-infrastructure/
, IEA. Guidelines for the development of electric vehicles charging infrastructure. Retrieved on 2nd March. https://www.iea.org/policies/2695-guidelines-for-the-development-of-electric-vehicles-charging-infrastructure

95. Electrive. Largest utilities in China invest in charging infrastructure. Retrieved on 2nd March. https://www.electrive.com/2020/04/15/utilities-in-china-invest-in-charging-infrastructure/

96. NRDC. Scaling Up EV Infrastructure. Retrieved from https://www.nrdc.org/sites/default/files/charging-infrastructure-best-parctices-202007.pdf

97. ibid

Intervention Areas	Key learnings and inferences
Suitable tariff designs and information availability	Information availability on periods of time when RE generation is high enables users to schedule their charging needs appropriately. Real-time pricing, critical peak pricing, dynamic day-ahead pricing, etc. provides clarity to users on suitable time periods for charging. In some countries, EV chargers are provided subsidies only when they demonstrate that such information is disseminated. Provision for Time-of-use tariffs enables users to charge during high RE hours.
Technical interventions	Deployment of Energy management systems is vital for enabling RE based EV charging. RE based EV charging requires coordination among fleet managers, aggregators, solar PV developers, vehicle OEMs, charging solution providers, etc. IT enabled systems are important for users to set their charging preferences.
Regulatory interventions	Demand response programmes allow modulation of charging speed in response to demand-supply situation and availability of low-cost power. Aggregation of DERs and Virtual Power Plants enables optimal utilization of Distributed Energy Resources such as RE and EV sources. Regulatory directives are given towards enabling aggregation and demand response. Development of business models & regulations and bi-directional charging are recognized as key enablers. National level directives are formulated to promote smart and bidirectional charging.

05 Key policy and regulatory recommendations

The gaps in the ecosystem hindering the development of RE based EV charging in India are elaborated in Section 3.3. The gaps are bucketed as shown below.

Regulatory aspects	Commercial aspects	Technical aspects
R1. Mandates for meeting demand from RE in buildings R2. Lack of tariffs structures such as time-of-day / time-of-use, green tariffs which can enable EV charging from RE based sources R3. Unavailability of avenues to buy green power for small sized EV charging stations R4. Prohibitive provisions in net metering (settlement cycles, remunerations, limiting capacities, etc.) R5. Lack of innovative arrangements viz. group/ virtual net metering R6. Limited energy banking availability R7. Lack of regulations to enable aggregation of demand-side / retail-side resources R8. Lack of regulation on Demand Response R9. Unavailability of banking provisions in certain states	C1. Need to reduce landed cost of RE power through third party open access and off-grid installations C2. Absence of capex and opex subsidies for RE based EV charging C3. Absence of capital subsidy for deployment of smart / bi-directional chargers C4. High open access charges in certain Discom jurisdictions C5. Lower remuneration for excess electricity exports from rooftop solar systems	T1. Lack of innovative pilot projects viz. P2P trading, etc. T2. Lack of real time generation data from rooftop solar PV and retail level platforms T3. Absence of ways to manage EV charging loads effectively

Note: The ID (Rx/ Cx/ Tx) provided to the gaps are referenced in the subsequent sections in the chapter.

Not all the stated gaps are applicable to all the cities or jurisdictions but on an aggregated country level, these gaps require unified recommendations which can be implemented by specific stakeholders.

With electricity being a concurrent subject in India, certain recommendations would be applicable to central stakeholders (CERC, etc.) and some would be applicable for state level stakeholders (Discoms, Renewable energy development agencies, transport undertakings, etc.). Some of the recommendations can be executed immediately with the current regulatory landscape whereas some would be dependent on other measures.

Each of the recommendation covered in this chapter will have specified action items for individual stakeholders, the implementation timeframe (short-/ medium-/ long-term), and dependent measures, if any. Short term measures have been categorized as the ones to be taken up for implementation in the next 2 years till 2025. Similarly, medium term measures are specified for the period of 2026 – 2028, and anything beyond 2028 is categorized long term.

Among the three cities studied i.e., Bengaluru, Kolkata, and Panaji, to which city the recommendations are applicable have also been mentioned. It is expected that the mentioned steps for the city would serve as a ready reckoner for other cities preparing themselves for RE based EV charging.

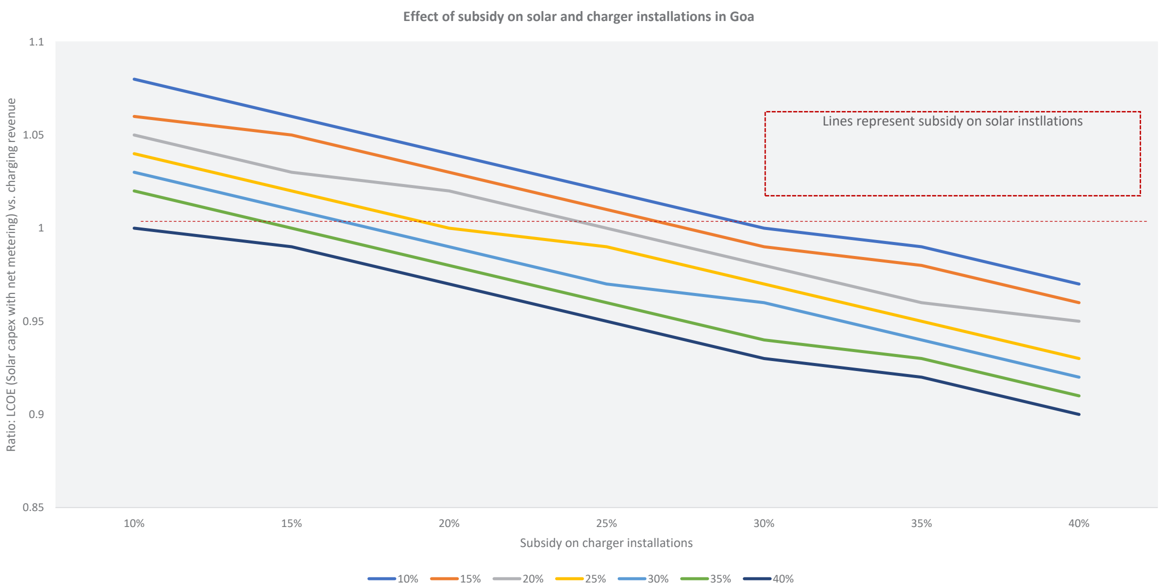
5.1 Recommendations

5.1.1 Incentives for RE installations dedicated towards EV charging

Stakeholders	State renewable energy development agency, finance department, Distribution companies	**Timeframe**	Short-term
Gaps addressed	C2 - Absence of capex and opex subsidies for RE based EV charging	**Applicable to**	Bengaluru, Kolkata, other states (w/o incentives)

Incentives (in the form of upfront subsidy, tax rebate) could be given for deployment of RE source dedicated for EV charging. Subsidies can be provided for installation of solar panels and battery systems if they are combined with charging stations. Subsidies can also be provided if the RE is generated and consumed at the consumer's own premises (off-grid installations).

Panaji provides 20% capital subsidy for installation of solar-powered charging stations which has been extended to electrical infrastructure costs. A feasibility analysis for levelized cost of electricity[98] (LCOE) highlighted that the subsidy is sufficient in present tariff setting to ensure parity between onsite solar capex based installations and the charging cost levied to the consumers[99] . This is shown in the figure below



Note: Considering a charging station with 6 chargers and applicable tariffs from JERC, Goa

98. Conducted as part of feasibility assessment for 100% RE based EV charging

99. Considered INR 15/kWh

Similar subsidies can be made available for charging stations in Bengaluru and Kolkata. The steps involved in developing the subsidy provisions are mentioned below:

Sl.	Action item	Responsibility
1.	Preliminary study to assess subsidy required to ensure parity between onsite RE based and grid electricity based EV charging	State RE development agency (SREDA)
2.	Forward proposal for dedicated fund creation to accommodate subsidies to state finance department	State RE development agency
3.	Creation of dedicated fund for providing subsidies on RE installations	State finance department
4.	Develop subsidy application process for EV charging station operators (directly through SREDA for off-grid installations and through Discom for grid connected infrastructure)	State RE development agency, Distribution company
5.	Disburse subsidies from dedicated fund to applicants	State RE development agency, Distribution company

5.1.2 Incentives on Smart Chargers/ Bidirectional Chargers / RE based EV chargers

Stakeholders	State finance department, Distribution companies	**Timeframe**	Short-term
Gaps addressed	C3 - Absence of capital subsidy for deployment of smart / bi-directional chargers	**Applicable to**	Bengaluru, Kolkata, Panaji & other states (w/o incentives)

Smart & bi-directional charging facilitates utilization of RE for EV charging. Incentives could be provided for fast charger (level 2 & DC fast charger) installations which have such features. Grants/ subsidies could also be provided to consumers for installing charging points which demonstrate 100% of electricity consumption from RE sources.

Among the three cities analyzed, Kolkata has a policy mentioning possible evaluation of V2G solutions which could lead to pilots and demonstration projects. In Tucson, USA, residential consumers are provided a rebate of USD 500 for installing DC chargers enabled with one- or two-way communication. The rebate is provided under the condition that consumers are required to adhere to Time of use rate plans for 2 years.

The steps involved in developing the incentive program are mentioned below:

Sl.	Action item	Responsibility
1.	Develop program proposal for smart/ bi-directional charger installation in jurisdiction (covering eligibility, funding requirements)	Distribution company
2.	Approach state finance department/ renewable energy development agency for funding support	Distribution company
3.	Launch program basis approval and contours agreed by funding authority	Distribution company

Standalone subsidies on smart/ bi-directional charging would not reap the intended benefits without time of use/ time of day tariffs. Distribution companies should also develop such tariff mechanisms and ensure consumers provided with subsidies are subscribed to time of use tariffs. With such mechanisms, distribution companies can emphasize on demand response programs.

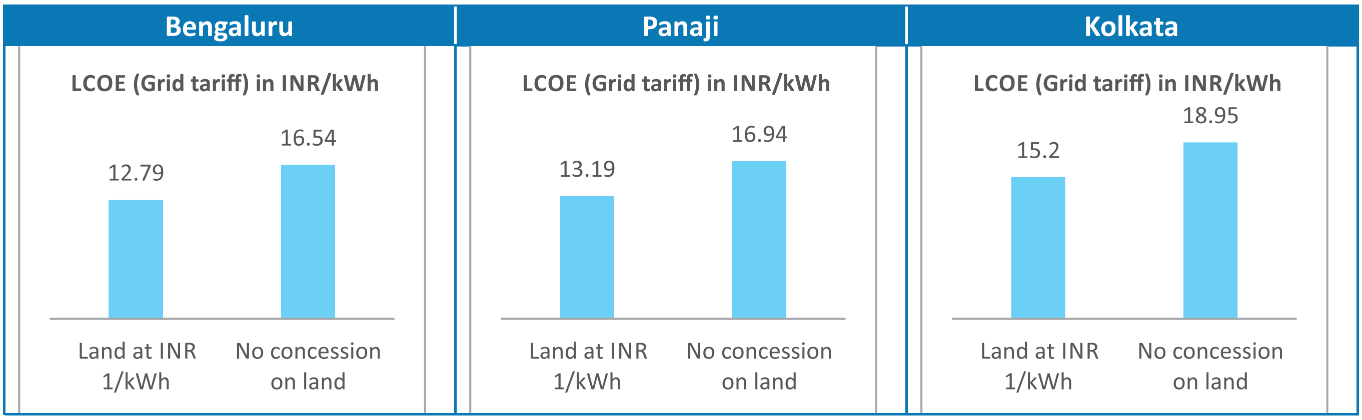
5.1.3 Concessional land for EV charging stations

Stakeholders	State Nodal agency for EV charging infrastructure	**Timeframe**	Short-term
Gaps addressed	C2 - Absence of capex and opex subsidies for RE based EV charging	**Applicable to**	Cities and states across India

EV charging stations are placed in high traffic locations to ensure higher utilization. As per Guidelines & Standards for Charging Infrastructure for Electric Vehicles (EV)[100] , in revenue sharing models, government and public entities can receive land at concessional rate of INR 1/kWh. However, private entities installing charging stations at public owned land have to undergo bidding with floor price of INR 1/kWh for land.

Municipal corporations and state nodal agencies may consider giving demarcated land at concessional rates/minimum lease (INR 1/kWh) to Charge point operators. This will help in deploying charging stations on minimum lease rentals. Such locations would comprise primarily of public parking spaces. It helps in reducing the operational cost of the CPO.

The effect of such a concession on the levelized cost of electricity for EV charging for electricity procured at grid tariff rates is shown below for the cities of Bengaluru, Panaji, and Kolkata:



Note: Considering 6 EV chargers (2 CCS fast chargers, 2 CHAdeMO fast chargers, and 2 Bharat DC-001 chargers) located at high traffic corporate locations; Utilization going up to 40% in last year of operation and respective city's EV charging tariff; lease of INR 50,000 per month is considered for 3 chargers installed at a particular location

There is a reduction of ~25 – 30% in the LCOE of EV charging with a concessional fee on land in place of lease taken by the charging point operator. Direction from the state nodal agency for EV charging infrastructure can enable this recommendation.

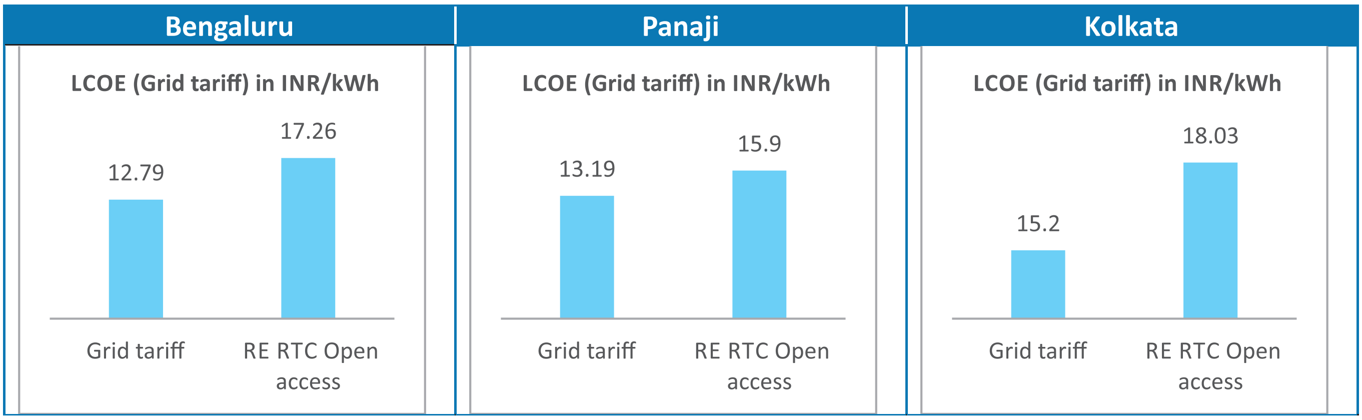
5.1.4 Incentives for reduction of open access charges

Stakeholders	Distribution companies, State finance department, SREDA	**Timeframe**	Short-term
Gaps addressed	C1 - Need to reduce landed cost of RE power through third party open access and off-grid installations C4 - High open access charges in certain Discom jurisdictions	**Applicable to**	Cities and states across India

Renewable energy in a RTC (round the clock) scenario can be obtained through open access route. Through this route, the consumers are subjected to open access charges which escalate the landed cost of electricity compared to conventional grid tariff. In West Bengal, 25% reduction in open access charges is provided however, it is not allowed for hybrid installations. RE RTC power is usually provided through hybrid installations.

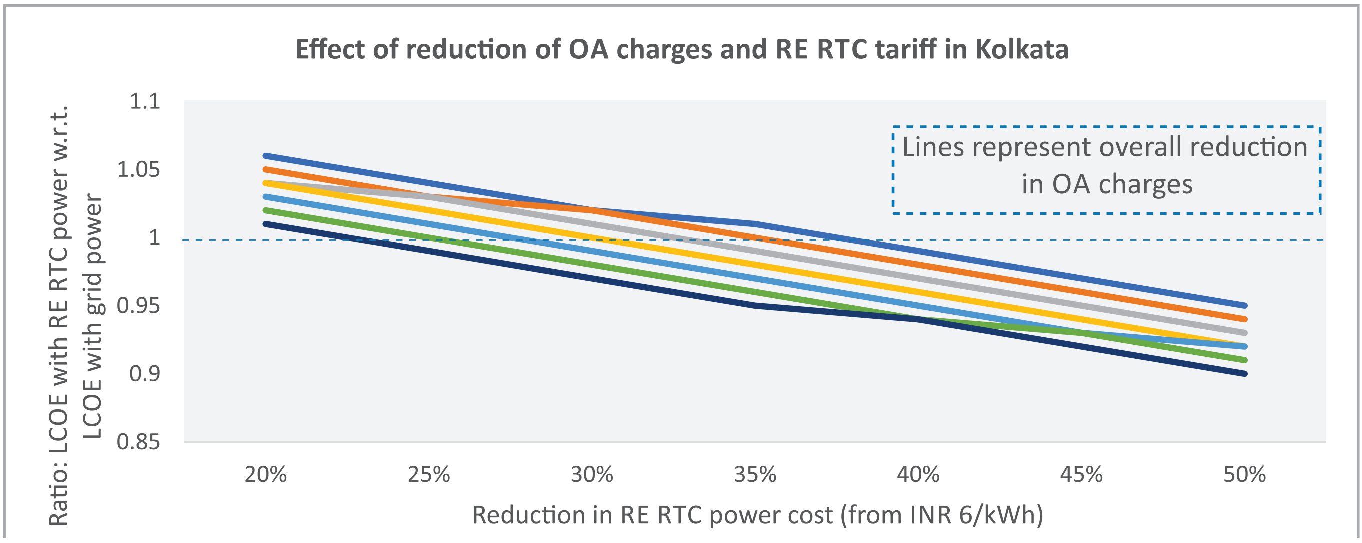
100. PIB. Revised Consolidated Guidelines & Standards for Charging Infrastructure for Electric Vehicles (EV) Promulgated) Promulgated by Ministry of Power. Retrieved on 16th Nov 2022. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1790136#:~:text=Land%20available%20with%20the%20Government,Owning%20Agency%20from%20such%20PCS

A comparative view of the increase in landed cost of power is provided below:



Note: Considering 6 EV chargers (2 CCS fast chargers, 2 CHAdeMO fast chargers, and 2 Bharat DC-001 chargers) located at high traffic corporate locations; Utilization going up to 40% in last year of operation and respective city's EV charging tariff; RE RTC tariff of INR 6/kWh is considered

Reduction of open access charges can enable charging stations to obtain parity between the LCOE realized from RE RTC power (through open access route) and conventional grid electricity. The effect of the concessions for the city of Kolkata is shown below:



Thus, the reduction of open access charges can enable RE based EV charging in cities having high open access charges which escalate the landed cost of RE RTC power. The steps involved in developing such incentives is showcased below:

Sl.	Action item	Responsibility
1.	Finalization of subsidies/ incentives for reducing open access charges and effect on distribution company finances	SREDA, Distribution company
2.	Proposal to finance department for approving funds for the initiative	SREDA, Distribution company
3.	Acceptance of proposal and development of fund	State finance department
4.	Development of application process and disbursement of funds	SREDA, Distribution company

5.1.5 State level fund for RE based EV charging stations

Stakeholders	State Nodal agency for EV charging infrastructure, State finance department	**Timeframe**	Short-term/ Medium-term
Gaps addressed	C2 - Absence of capex and opex subsidies for RE based EV charging C3 - Absence of capital subsidy for deployment of smart / bi-directional chargers C4 - High open access charges in certain Discom jurisdictions	**Applicable to**	Cities across India

Dedicated state level funds should be created to provide capital subsidies for EV charging stations that incorporate solar and BESS installations. Additionally, it should serve to reduce **open access charges.**

The effect of the concessions have been highlighted in the prior recommendations. However, a state level fund with defined time period of applications and incentive ceiling could be institutionalized in the states. The steps involved in developing the same are shown below:

Sl.	Action item	Responsibility
1.	Finalization of subsidies/ incentives for RE, charger installations and reduction in open access charges at a state level	SREDA, Distribution company
2.	Proposal to finance department for development of fund	SREDA, Distribution company
3.	Acceptance of proposal and development of fund	State finance department
4.	Development of application process and disbursement of funds	SREDA, Distribution company

5.1.6 Formulate green tariffs to provide additional avenues for green power procurement

Stakeholders	Distribution company, SERC	**Timeframe**	Short-term
Gaps addressed	R2 - Lack of tariffs structures such as time-of-day / time-of-use, green tariffs which can enable EV charging from RE based sources R3 - Unavailability of avenues to buy green power for small sized EV charging stations	**Applicable to**	Cities across India (excluding Discoms already having green tariffs)

Green tariffs could be designed by Discoms that will provide consumers an additional avenue for green power procurement. These would enable all consumers especially small CPOs/ EV users (with demand < 100 kW, who are outside the purview of green open access) to procure RE for EV charging.

Out of the three cities analyzed, green tariffs were absent in Panaji. Green tariffs provide significant ease of operation to the charging point operators as neither they have to take the burden of on-site installations nor they would need to enter into agreements with third-party RE developers. Green tariffs for EV charging stations could be developed by Discoms annually in their ARR (Annual Revenue Requirement) exercise.

The steps involved in developing the same are shown below:

Sl.	Action item	Responsibility
1.	Determine cost of procuring RE from IPPs	Distribution company
2.	Determine premium to be charged in retail tariffs in line with the cost of procuring RE from IPPs	Distribution company
3.	Propose green tariffs in annual tariff filing exercises	Distribution company
4.	Review and approval of green tariff	SERC

5.1.7 Formulating Green Energy Open Access (GEOA) regulations

Stakeholders	Distribution company, SERC	**Timeframe**	Short-term
Gaps addressed	R3 - Unavailability of avenues to buy green power for small sized EV charging stations	**Applicable to**	Cities across India (excl. Discoms already having green energy open access)

Green Energy Open Access (GEOA) regulations could be formulated to enable consumers (with demand > 100 kW) to procure green energy through Open Access. Certain states have GEOA regulations and other states may follow suit. Concessions on green open access charges will reduce the landed cost of RE power for consumers such as EV users.

Several states including Karnataka, Haryana, Madhya Pradesh, Punjab, and West Bengal have adopted Green open access regulations[101] . However, to enable EV charging through RE in open access route, state electricity regulatory commissions could form green energy open access regulations.

The steps involved in developing the same are shown below:

Sl.	Action item	Responsibility
1.	Undertake stakeholder consultations on various provisions to open access regulations	SERC
2.	Formulate draft GEOA regulations	SERC
3.	Receive comments on draft regulations	SERC
4.	Incorporate suggestions and finalize regulations and explanatory memorandum	SERC

5.1.8 Formulating innovative Net-metering (NM) provisions

Stakeholders	State Electricity Regulatory Commission, Distribution companies	**Timeframe**	Medium-term
Gaps addressed	R5 - Lack of innovative arrangements viz. group/ virtual net metering	**Applicable to**	Cities across India

Innovative Net-metering (NM) arrangements such as virtual net-metering and group net-metering could be encouraged. This would enable small consumers (CPOs, EV owners) who have space constraints to use RE for EV charging. Such arrangements would enable growth of decentralized RE sources and their utilization at different locations.

101. As of June 2023

At present, net metering with RE + battery installations is not allowed by Distribution utilities in India[102] . Discoms are unable to assess the net injection/ drawal by the entities without installing additional meters. Guidelines around rooftop solar and battery installations are required to enable RE based EV charging with net metering.

Panaji has provisions for group and virtual net metering which could be mirrored in other cities and states in India. With such an arrangement, bus depots in a city can aggregate their demand and use rooftop installations to avail credits on electricity bills.

The steps involved in developing the same are shown below:

Sl.	Action item	Responsibility
1.	Conduct technical evaluation of various options and feasibility of innovative mechanisms	Discoms and SERC
2.	Formulate draft amendments to existing regulations	Discoms and SERC
3.	Undertake stakeholder consultations and receive comments	SERC
4.	Incorporate suggestions and finalize regulations and explanatory memorandum	SERC

5.1.9 Relaxing maximum installed rooftop solar capacity

Stakeholders	State Electricity Regulatory Commission, Distribution companies	**Timeframe**	Medium-term
Gaps addressed	R4 - Prohibitive provisions in net metering (settlement cycles, remunerations, limiting capacities, etc.)	**Applicable to**	Cities across India

Regulations could allow consumers to have solar capacity as per sanctioned load. In some states, it is capped to certain capacity or sanctioned load whichever is lesser. Technical studies could be carried out to understand if such limit could be reviewed.

In the three cities analyzed, Kolkata allows installations up to 100% of the DT capacity contrary to 80% and 75% in Bengaluru and Panaji respectively. Based on load flow studies, the maximum allowable renewable energy capacity installations could be updated in the jurisdictions of respective distribution companies.

The steps involved in developing the same are shown below:

Sl.	Action item	Responsibility
1.	Conduct technical studies to understand maximum permissible limits	Discoms
2.	Propose changes to existing regulations	Discoms
3.	Formulate draft amendments to existing regulations	SERC
4.	Undertake stakeholder consultations and receive comments	SERC
5.	Incorporate suggestions and finalize regulations and explanatory memorandum	SERC

102. Based on primary consultations with discoms and private players

5.1.10 Changes to net-metering regulations

Stakeholders	State Electricity Regulatory Commission, Distribution companies	**Timeframe**	Medium-term
Gaps addressed	R4 - Prohibitive provisions in net metering (settlement cycles, remunerations, limiting capacities, etc.) R5 - Lack of innovative arrangements viz. group/ virtual net metering R9 - Unavailability of banking provisions in certain states	**Applicable to**	Cities across India

The following changes can be brought to the current net metering regulations in multiple states:

1. Compensation for surplus electricity injected into the grid through net-metering could be linked to avoided cost / marginal cost of utility if found suitable instead of APPC / PPA tariff.
2. Reducing / waiving off banking charges
3. Allowing longer settlement period for settling surplus energy injected to grid under net-metering scheme. This would enable consumers to utilize surplus electricity generated in one month to be utilized in subsequent months

SERC of respective states would be privy to such decisions which require consultations with distribution companies. In the case of Kolkata, WBERC could allow banking of RE power for enabling innovative net metering mechanisms.

The steps involved in developing the same are shown below:

Sl.	Action item	Responsibility
1.	Undertake discussions to understand changes required in existing regulations	Discoms and SERC
2.	Propose changes to existing regulations	Discoms and SERC
3.	Formulate draft amendments to existing regulations	SERC
4.	Undertake stakeholder consultations and receive comments	SERC
5.	Incorporate suggestions and finalize regulations and explanatory memorandum	SERC

5.1.11 Formulation of directives to ensure distributed RE installation

Stakeholders	State Electricity Regulatory Commission, Distribution companies	**Timeframe**	Short-term
Gaps addressed	R1. Mandates for meeting demand from RE in buildings R3. Unavailability of avenues to buy green power for small sized EV charging stations	**Applicable to**	Cities across India

Directives could be formulated mandating certain level of electricity demand for buildings / public EV parking spaces to be met from RE sources. The provision already existing in certain cities and could be extended to others.

In Lancaster, USA, it is mandated for new residential buildings to install solar PV systems depending on the building type and zone in which it is located. In India, State building codes / byelaws could be reviewed to ensure there are provisions to mandate solar PV installation on new residences/buildings.

Mandating deployment of rooftop solar PV systems along with EV charging points could be the next step taken by states through the Building Bye-laws.

The steps involved in developing the same are shown below:

Sl.	Action item	Responsibility
1.	Undertake discussions to understand changes required in existing building bye-laws of the state	Discoms, SERC, State Housing department
2.	Propose changes to existing bye-laws	Discoms, SERC, State Housing department
3.	Formulate draft amendments to existing bye-laws	State Housing department
4.	Undertake stakeholder consultations and receive comments	State Housing department
5.	Incorporate suggestions and finalize bye-laws	State Housing department

5.1.12 Remuneration for excess generation by solar rooftop installed in consumer premises

Stakeholders	State Electricity Regulatory Commission, Distribution companies	Timeframe	Medium-term
Gaps addressed	R5 - Lack of innovative arrangements viz. group/ virtual net metering, C5 - Lower remuneration for excess electricity exports from rooftop solar systems	Applicable to	Cities across India

A major challenge for consumers installing rooftop solar PV system is the extent of remuneration that they get for the excess electricity generation. Discoms usually pay the prosumer for the excess generation at lower rates. A few Discoms have also restricted a certain limit up to which the excess quantum will be compensated.

Linking the remuneration to avoided cost of utility, for excess RE generation, could increase the attractiveness for de-centralized growth of RE. This basically means that the excess electricity injected by the solar PV is remunerated at the cost which the utility would have incurred to arrange for the same quantum of power at that period of time. This would incentivize consumers to store excess solar during times of high RE generation, in batteries for self-use at a later period of time.

The steps involved in developing the same are shown below:

Sl.	Action item	Responsibility
1.	Undertake discussions to understand changes required in existing regulations	Discoms and SERC
2.	Propose changes to existing regulations	Discoms and SERC
3.	Formulate draft amendments to existing regulations	SERC
4.	Undertake stakeholder consultations and receive comments	SERC
5.	Incorporate suggestions and finalize regulations and explanatory memorandum	SERC

5.1.13 Regulations for enabling aggregation of DERs

Stakeholders	CERC	Timeframe	Medium-term
Gaps addressed	R7. Lack of regulations to enable aggregation of demand-side / retail-side resources	Applicable to	Cities across India

Suitable regulations should be framed for enabling aggregation of DERs. Aggregation would enable resources such as distributed RE, battery storage and EVs to earn additional revenues by participating in the electricity market.

The steps involved in developing the same are shown below:

Sl.	Action item	Responsibility
1.	Undertake review of international best practices to understand provisions required to enable aggregation of DERs	CERC, Forum of Regulators
2.	Draft discussion paper and release for public comments	CERC, Forum of Regulators
3.	Undertake stakeholder consultation	CERC, Forum of Regulators
4.	Prepare draft regulations and statement of reasons	CERC, Forum of Regulators
5.	Receive comments	CERC, Forum of Regulators
6.	Prepare final regulations and explanatory memorandum	CERC, Forum of Regulators
7.	Formulate Model template document for interactions between Aggregators and DERs to ensure uniformity in interactions and consumer interest	CERC, Forum of Regulators

In USA, MISO has provisions for **"An Aggregator of Retail Customers"** which can participate in the market sponsoring more than one demand response resources. Similarly in Europe, Energy Efficiency Directive 2012/27/EU (EED) defines the term 'aggregator' as a "demand service provider that combines multiple short-duration consumer loads for sale or auction in organized energy markets".

Aggregators can also enable small-size customers to buy RE power through exchanges by combining multiple such consumers to meet the load criteria for open access. Charging station loads across cities can be aggregated to participate in markets like GDAM and GTAM to procure green power.

5.1.14 Establishment of virtual power plant (VPP) technology through demonstration programs

Stakeholders	CERC, SERCs, Discoms	**Timeframe**	Long-term
Gaps addressed	T1. Lack of innovative pilot projects viz. P2P trading, etc. T3. Absence of ways to manage EV charging loads effectively	**Applicable to**	Cities across India

The forum of central and state level stakeholders should actively undertake demonstrations through pilot programs to demonstrate VPPs. A virtual power plant can enable participation of distributed energy resources. A VPP requires an intelligent energy management system to connect various stakeholders.

Hence, proper infrastructure should be in place for enabling smooth functioning of the system. The concept of VPPs is yet to commence in India. If the results of such pilots showcase the feasibility and benefit, CEA / CERC can come with relevant regulations for the same. The steps involved in this exercise are as follows:

Sl.	Action item	Responsibility
1.	Development of forum of central and state level stakeholders	CERC, SERCs, Discoms
2.	Outlining contours of pilot program for virtual power plant demonstration	SERCs, Discoms
3.	Conducting pilot program and capturing learnings	Discoms
4.	Developing a report on learnings and establishing virtual power plants	Discoms

5.1.15 Adoption of latest version of communication protocols

Stakeholders	CEA, BIS	**Timeframe**	Short to Medium-term
Gaps addressed	T3. Absence of ways to manage EV charging loads effectively	**Applicable to**	Cities across India

The latest version of communication protocols which enable RE based EV charging should be adopted. Protocols such as OSCP (Open Smart Charging Protocol), OpenADR (Open Automated Demand Response), Open Charge Point Interface protocol (OCPI), Open Charge Point Protocol (OCPP), ISO 15118 are required for better management of EV load and implementation of smart charging. For rooftop solar PV systems, protocols such as IEEE 2030.5, IEEE 1815, are required for enabling RE based EV charging.

Sl.	Action item	Responsibility
1.	Identification of latest version of communication protocols which enable RE based EV charging	CEA, BIS
2.	Propose changes to existing communication protocols	CEA, BIS
3.	Undertake stakeholder consultations with EV and EVSE OEMs and receive feedback	CEA, BIS
4.	Incorporate suggestions and adopt latest versions of the communication protocols	CEA, BIS

5.1.16 Formulating innovative tariff mechanism

Stakeholders	SERCs, Discoms	**Timeframe**	Short to Medium-term
Gaps addressed	R2. Lack of tariffs structures such as time-of-day / time-of-use, green tariffs which can enable EV charging from RE based sources	**Applicable to**	Cities across India

Formulating innovative tariff mechanisms such as time of day charges (ToD), time-of-use (TOU) rates, etc. will allow EV end users and CPOs to avail low-cost energy and reduce strain on grid. TOD and TOU tariffs are available for C&I consumers (including charging infrastructure) in multiple states however, they are unavailable for residential consumers. It also enables the set of RE based EV charging system to participate in Demand Response.

The steps involved in developing the same are shown below:

Sl.	Action item	Responsibility
1.	Undertake study on load profile for various consumers	Distribution company
2.	Analyze extent of load shifting possible with various levels of off-peak tariffs	Distribution company
3.	Formulate off-peak tariffs in line with cost of RE generation and peak tariffs in line with cost of peak power	Distribution company
4.	Prepare tariff proposals for review	Distribution company
5.	Review and approval of tariff structures	SERC

5.1.17 Benchmarking pilots to establish value streams emerging from EV charging

Stakeholders	CERC, SERCs, Discoms	Timeframe	Medium-term
Gaps addressed	T3. Absence of ways to manage EV charging loads effectively	Applicable to	Cities across India

Funding should be provided to conduct pilots (with public as well as private players) on RE based EV charging and smart EV charging. The steps involved are as follows:

Sl.	Action item	Responsibility
1.	Development of forum of central and state level stakeholders to conduct pilot programs	CERC, SERCs, Discoms
2.	Outlining contours of pilot program for RE based and smart EV charging	SERCs, Discoms
3.	Conducting pilot program and capturing learnings	Discoms
4.	Developing a report on learnings	Discoms

5.1.18 Formulation of Demand Response (DR) regulations

Stakeholders	CERC, Forum of regulators	Timeframe	Long-term
Gaps addressed	R8. Lack of regulation on Demand Response	Applicable to	Cities across India

Regulators should formulate Demand Response (DR) regulations enabling Discoms to undertake active management of loads.

The steps involved in developing the same are shown below:

Sl.	Action item	Responsibility
1.	Undertake review of international best practices to understand provisions required to enable demand response	CERC, Forum of Regulators
2.	Undertake stakeholder consultation	CERC, Forum of Regulators
3.	Prepare draft regulations and statement of reasons	CERC, Forum of Regulators
4.	Receive comments	CERC, Forum of Regulators
5.	Prepare final regulations and explanatory memorandum	CERC, Forum of Regulators

5.1.19 Participation of utilities in load control and demand response programmes

Stakeholders	Discoms, SERC, CEA	Timeframe	Long-term
Gaps addressed	R7. Lack of regulations to enable aggregation of demand-side / retail-side resources R8. Lack of regulation on Demand Response	Applicable to	Cities across India

Utilities should participate in active load control and demand response programmes. This enables the utilities to remotely modulate the charging rate and time to correspond with grid conditions and surplus renewable generation time.

Demand response programs enable Discoms to provide flexibility to the grid and manage their peak loads effectively. Such programmes allow consumers to provide flexibility to discom during peak demand hours and to store low-cost electricity during off-peak hours and reduce consumption during peak hours.

Passive control mechanisms such as time-of-day (TOD), time of use (TOU), dynamic pricing, and real-time pricing can be employed to shift EV charging loads to periods of low demand when surplus renewable energy generation is available. This approach will optimize the use of RE and helps minimize grid stress during peak demand hours

Implementation of such measures would require investments in communication infrastructure at the premises of utilities.

Sl.	Action item	Responsibility
1.	Prepare guidelines for load control and demand response programmes	CEA
2.	Propose time-of-day (TOD), time of use (TOU) for RE based EV charging for different consumer categories to SERC	DISCOMs
3.	Approval of time-of-day (TOD), time of use (TOU) tariffs for RE based EV charging by SERC	SERC
4.	Include time-of-day (TOD), time of use (TOU) tariffs for RE based EV charging in tariff orders	SERC
5.	Launch demand response and load control programmes	DISCOMs

5.1.19 Participation of utilities in load control and demand response programmes

Stakeholders	CEA	Timeframe	Short to Medium-term
Gaps addressed	-	Applicable to	Cities across India

CEA could formulate guidelines for conducting technical readiness assessment of distribution grid for DERs, on a rolling basis. This would enable discoms to understand hosting capacity assessment of grid for EVs and DERs.

Sl.	Action item	Responsibility
1.	Establish a framework to evaluate the grid readiness assessment of distribution grid for DERs	CEA
2.	Consult with DISCOMs to further understand the Volume of flexible-charging EV load and flexibility demand of the grid	CEA, DISCOMs
3.	Formulate and launch guidelines for conducting technical readiness assessment of distribution grid for DERs	CEA

5.1.21 Creation of EV load and RE generation forecasting guidelines

Stakeholders	CEA	Timeframe	Medium-term
Gaps addressed	T2. Lack of real time generation data from rooftop solar PV and retail level platforms T3. Absence of ways to manage EV charging loads effectively	Applicable to	Cities across India

CEA should provide standard guidelines for accurate EV load profile and RE generation profile forecasting which will help DISCOMs to plan their power systems accordingly.

The steps involved in developing the same are shown below:

Sl.	Action item	Responsibility
1.	Undertake review of international best practices on RE and EV load forecasting	CEA
2.	Undertake stakeholder consultation with discoms	CEA
3.	Prepare guidelines on RE and EV load forecasting	CEA

5.1.22 Creation of a forum for development of RE EV ecosystem

Stakeholders	State nodal agency for EV charging infrastructure	Timeframe	Short-term
Gaps addressed	-	Applicable to	Cities and states across India

A forum comprising stakeholders such as EV OEMs, RE IPPs, aggregators, fleet managers, charging solution providers and utilities can be formulated. The forum needs to take up innovative pilot projects such as EV charging coupled with rooftop solar, to generate learnings from the same.

Sl.	Action item	Responsibility
1.	Mandate creation of EV cells in every state – Delhi has set up a dedicate EV cell	State Transport Infrastructure Development Corporation
2.	Launch guidelines stating the roles and responsibilities of EV cells	Niti Aayog
3.	Facilitate adoption of RE based EV charging in every state using dedicated EV cells	Niti Aayog

5.1.23 Conduct pilots on use of bidirectional chargers

Stakeholders	Discoms, aggregators	Timeframe	Long-term
Gaps addressed	T1. Lack of innovative pilot projects viz. P2P trading, etc.	Applicable to	Cities and states across India

Pilots should be carried out to demonstrate how smart / bi-directional charging can enable modulation of EV charging demand to match with the timing and quantum of RE generation. A key enabler necessary for pilots is the availability of aggregators. Aggregators provide scale to the pilot program which is essential for learnings.

Sl.	Action item	Responsibility
1.	Adoption of latest version of communication protocols to allow bidirectional charging of EVs viz. ISO-15118-20:2022	CEA
2.	Promoting studies on Battery state-of-health considerations for V2G cycling	CEA
3.	Enabling platforms for decentralized power trading and promoting aggregators	CEA

5.1.24 Enabling virtual PPAs and P2P trading

Stakeholders	CERC, SERC, Discoms	**Timeframe**	Long-term
Gaps addressed	T1. Lack of innovative pilot projects viz. P2P trading, etc.	**Applicable to**	Across India

Alternative avenues for RE procurement for EV charging such as virtual PPAs and P2P trading should be explored. Cleantech Solar has commissioned a virtual PPA driven solar plant in India[103] . VPPAs provide a hedge against volatile electricity prices through a contract for differences (CFD) mechanism.

The renewable energy policy of Karnataka envisages promotion of P2P trading which would promote growth of de-centralized solar rooftop installations in the city. Similar provisions could be mirrored in the renewable energy policies of other states.

Sl.	Action item	Responsibility
1.	Launching P2P trading platforms across States – Uttar Pradesh has launched India's first Blockchain enabled P2P trading platform for rooftop solar	State DISCOMS
2.	Preparing guidelines and regulations for virtual PPAs	CEA
3.	State RE policies can further promote P2P trading to promote growth of decentralized solar rooftop installations.	State Electricity Regulatory Commissions

103. PV Magazine. Cleantech Solar commissions virtual PPA-driven solar plant in India. Retrieved on 16th Nov 2023. https://www.pv-magazine-india.com/2023/09/12/cleantech-solar-commissions-virtual-ppa-driven-solar-plant-in-india/

06 Conclusion

A summary view of the recommendations is provided in the table below. The applicability of the recommendations based on the current landscape of regulations in Bengaluru, Kolkata, and Panaji is highlighted along with the timeframe of implementation.

Short term measures have been categorized as the ones to be taken up for implementation in the next 2 years till 2025. Similarly, medium term measures are specified for the period of 2026 – 2028, and anything beyond 2028 is categorized as long term.

Table 13: Recommendations for enabling RE based EV charging

Sl.	Recommendation	Applicability		Implementation timeframe and Remarks
		State-level	National level	
1.	Provide incentives for RE installations dedicated towards EV charging **Stakeholders**: *State renewable energy development agency, finance department, Distribution companies*	✓		***Short*** Subsidies can be clubbed together for onsite RE installations and chargers to develop incentive programs to proliferate RE based EV charging.
2.	Provide incentives on smart/ bi-directional chargers / RE based EV chargers **Stakeholders**: *State finance department, Distribution companies*	✓		***Short*** Installation of advanced chargers supporting smart charging are precursors to demand response programs and V2G operations.
3.	Provide land at concessional rates for EV chargers **Stakeholders**: *State Nodal agency for EV charging infrastructure*	✓		***Short*** MoP guidelines allowing concessional land lease at INR 1/kWh for public entities should be extended to private entities considering RE based EV charging. LCOE reduction of 25 – 30% envisaged.
4.	Provide incentives to reduce open access charges for RE based EV charging stations **Stakeholders**: *Distribution companies, State finance department, SREDA*	✓		***Short*** Open access charges waivers limited to single type of RE source in some states can be extended to hybrid installations which are prevalent for RE RTC power.
5.	Development of state level fund for RE based EV charging stations **Stakeholders**: *State Nodal agency for EV charging infrastructure, State finance department*	✓		***Short to medium*** Multiple concessions and incentives to enable RE based EV charging require dedicated funds. States based on their status quo can develop funds upon aggregating the requirements from multiple schemes/ programs.

Sl.	Recommendation	Applicability		Implementation timeframe and Remarks
		State-level	National level	
6.	Formulate green tariffs to provide additional avenue for green power procurement **Stakeholders**: *Distribution company, SERC*	✓		***Short*** Green tariffs from distribution companies provide operational ease with minimal impact on LCOE of charging for 100% RE based EV charging compared to other modes of RE procurement.
7.	Formulate green energy open access (GEOA) regulations **Stakeholders**: *Distribution company, SERC*	✓		***Short to medium*** Provides opportunity for consumers (with demand> 100 kW) to procure green energy through Open Access. Applicable to all state except Karnataka, Haryana, Madhya Pradesh, Punjab, and West Bengal.
8.	Formulate innovative net-metering (NM) provisions **Stakeholders**: *State Electricity Regulatory Commission, Distribution companies*	✓		***Medium*** Enables small consumers (CPOs, EV owners) which have space constraints to use RE for EV charging and growth of decentralized RE sources and their utilization at different locations.
9.	Provide relaxation on maximum installed rooftop solar capacity **Stakeholders**: *State Electricity Regulatory Commission, Distribution companies*	✓		***Medium*** Necessary technical studies must be undertaken prior to enhance the maximum installed capacity provisions.
10.	Undertake changes in the net-metering regulations. **Stakeholders**: *State Electricity Regulatory Commission, Distribution companies*	✓		***Medium*** Compensation for surplus injection can be linked to avoided cost / marginal cost of utility if found suitable instead of APPC / PPA tariff. Banking should be allowed followed by waivers on banking charges. Longer settlement periods allow for higher benefits to consumers.
11.	Formulation of directives to ensure distributed RE installations **Stakeholders**: *State Electricity Regulatory Commission, Distribution companies*	✓		***Short*** Mandating certain level of demand for buildings / public EV parking spaces to be met from RE sources can fuel RE installations and procurement.
12.	Enhance remuneration for excess generation by solar rooftop installed in consumer premises **Stakeholders**: *State Electricity Regulatory Commission, Distribution companies*	✓		***Medium*** The payback period for consumers can be reduced by attractive remunerations from discoms. Decentralized RE growth attained hence can be leveraged to proliferate RE based EV charging.

Sl.	Recommendation	Applicability		Implementation timeframe and Remarks
		State-level	National level	
13.	Outline regulations for enabling aggregation of DERs **Stakeholders**: *CERC*		✓	***Long*** Aggregation would enable resources such as distributed RE, battery storage and EVs to earn additional revenues by participating in the electricity market.
14.	Establishment of virtual power plants (VPP) technology through demonstration programs. **Stakeholders**: *CERC, SERCs, Discoms*	✓	✓	***Long*** A virtual power plant can enable participation of distributed energy resources. It requires an intelligent energy management system to connect various stakeholders. If the results pilots showcase feasibility, benefit, CEA / CERC can develop relevant regulations.
15.	Adoption of latest communication protocols for RE based EV charging (for chargers and solar installations) **Stakeholders**: *CEA, BIS*		✓	***Short to medium*** Protocols such as OSCP, OpenADR, OCPI, OCPP, ISO 15118, IEEE 2030.5, IEEE 1815 should be adopted.
16.	Formulate innovative tariff mechanisms for consumers **Stakeholders**: *SERCs, Discoms*	✓		Mechanisms such as time of day charges (ToD), time-of-use (TOU) rates, etc. will allow EV end users and CPOs to avail low-cost energy and reduce strain on grid.
17.	Benchmarking pilots to establish value streams emerging from EV charging **Stakeholders**: *CERC, SERCs, Discoms*	✓	✓	***Medium*** Fundings should be directed towards pilots on RE based EV charging and smart EV charging.
18.	Formulation of Demand Response (DR) regulations **Stakeholders**: *CERC, Forum of regulators*		✓	***Long*** Demand response programs can open up revenue opportunities for RE based EV charging stations. However, aggregation of stations would be critical to maximize revenue potential.
19.	Encourage participation of utilities in load control programmes **Stakeholders**: *Distribution companies*	✓	✓	***Long*** Enables utilities to remotely modulate the charging rate and time to correspond with grid conditions and surplus renewable generation time.

Sl.	Recommendation	Applicability		Implementation timeframe and Remarks
		State-level	National level	
20.	Active participation in demand response by utilities **Stakeholders**: *Distribution companies*	✓	✓	***Long*** Enables Discoms to provide flexibility to the grid and manage their peak loads effectively.
21.	Conduct grid readiness assessment **Stakeholders**: *CEA*	✓	✓	***Short to medium*** Readiness assessment would help Discoms assess their hosting capacity for EVs and DERs on a rolling basis.
22.	Creation of EV load and RE generation forecasting guidelines **Stakeholders**: *CEA*		✓	***Medium*** Standard guidelines for accurate EV load profile and RE generation profile forecasting will help DISCOMs to plan their power systems accordingly.
23.	Creation of a forum for development of RE EV ecosystem **Stakeholders**: *State nodal agency for EV charging infrastructure*	✓		***Short*** Stakeholders such as EV OEMs, RE IPPs, aggregators, fleet managers, charging solution providers and utilities can be formulated to initiate innovative pilot projects.
24.	Conduct pilots on use of bi-directional chargers **Stakeholders**: *Discoms, aggregators*	✓		***Long*** Pilots to demonstrate how smart / bi-directional charging can enable modulation of EV charging demand to match with the timing and quantum of RE generation.
25.	Enabling virtual PPAs and P2P trading **Stakeholders**: *CERC, SERC, Discoms*	✓	✓	***Long*** VPPAs provide a hedge against volatile electricity prices through a contract for differences (CFD) mechanism. Regulations should encourage VPPAs and P2P trading to provide viable avenues for RE based EV charging stations.

With promulgation of a greener future through EVs, a staggered approach towards implementing RE based EV charging is crucial to integrate renewable energy and EV charging. International best practices with suitable customizations for the Indian regulatory and consumer landscape would pave the way for addressing pain points of stakeholders in the value chain viz Discoms, prosumers, system operators, EV charging operators, State/ City transport corporations and e-bus service operators.

Coordinated approach by both state and central entities would ensure the uptake of RE based EV charging. The approach would vary from city to city with considerations of state regulations, RE availability, and the EV landscape in general. The recommendations mentioned in Table 13 can serve as a ready reckoner for public authorities to bridge the gaps in their state/ city and enable RE based EV charging.

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