SHAKTI SUSTAINABLE ENERGY FOUNDATION

MP ENSYSTEMS

ELECTRIC VEHICLE CHARGING INFRASTRUCTURE SITING STUDY TO SUPPORT FREIGHT ELECTRIFICATION

DECEMBER 2022

MP ENSYSTEMS

About Shakti Sustainable Energy Foundation

Shakti Sustainable Energy Foundation seeks to facilitate India's transition to a sustainable energy future by aiding the design and implementation of policies in the following areas: clean power, energy efficiency, sustainable urban transport, climate change mitigation and clean energy finance. The views/analysis expressed in this report/document do not necessarily reflect the views of Shakti Sustainable Energy Foundation. The Foundation also does not guarantee the accuracy of any data included in this publication nor does it accept any responsibility for the consequences of its use.

About MP Ensystems Advisory Pvt. Ltd.

MP Ensystems is a research-driven private consulting firm set up in 2012 actively supporting equitable energy and resource efficiency measures. The MP Ensystems team for this project comprised: Dr Mahesh Patankar, Meenal Sutaria, Ira Athale Prem, Dr Anoop Kulkarni, Dr MT Arvind, Prajkta Adhikari, Asmita Ekawade, Hrishabh Chandra, Kaustubh Arekar, Smitha Lobo and Rutal Deshmukh (intern). Our project partners include Sanket Sarang and team from Blobcity, Mumbai.

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We would like to thank all the individuals and institutions representing policy makers, public, private sector for meeting with us, responding to surveys, participating in training sessions and providing data and insights on freight EVCI. This document reflects the views of the authors and not that of any other parties.

About this document

MP Ensystems has developed a deep understanding of EVCI requirements based on user convenience, grid impact and revenue maximisation. The model developed in 2021 was used for developing EVCI sites in the state of Goa, Municipal Corporations at Pune and Pimpri-Chinchwad; and the corridor connecting Pune and Pimpri Chinchwad. This tool is available at evci.in

In 2022, in partnership with the Electric Mobility Initiative at Shakti Sustainable Energy Foundation, MP Ensystems developed a model to specifically explore EVCI siting for freight transit systems, investment opportunities in specific corridors and policy, finance, social and technical recommendations for stakeholders.

The report “Electric Vehicle Charging Infrastructure Siting Study to Support Freight Electrification” consists of a Summary that captures the activities and findings of the project. Each following section deals with a specific aspect of developing freight EVCI- including a User Guide for the siting tool, stakeholder inputs on siting requirements, recommendations for EVCI investments, and recommendations to planners. Each section contains relevant chapters and annexures and can be read as a stand-alone document.

If you wish to use any of the material in this report, please use the citation below or contact the authors (listed in About MP Ensystems).

Citation for this document

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EXECUTIVE SUMMARY

Around 71% of India's freight is transported by road, generating negative externalities including inflation, reduced productivity, lower job creation, air pollution and contribution to climate change

Systematic study and support in the creation of EV charging infrastructure (EVCI) would benefit the commodity haulage services while optimising electricity grid impact and revenue maximisation.

Currently, electric vehicles (EVs) in the freight sector are less than

1%

of the total fleet.

MP Ensystems has developed an intelligent geo-spatial model for siting EVCI along economic corridors. The model considers traffic demand management, public parking spaces, electricity grid networks and charging requirements as key inputs to develop EVCI locations. The model is available for stakeholders such as city or state governments on the website https://www.evci.in .

The model was applied to 32 freight corridors of over 100km length each, to generate potential sites for EVCI. Ground truthing of the proposed EVCI locations was conducted through in person visits and site surveys. Of these 32 corridors, planners, financial institutions, investors, Charge Point Operators (CPOs) and Original Equipment Manufacturers (OEMs) selected 10 corridors, where MP Ensystems conducted in-depth meetings with stakeholders to determine the roadmap for planning, financing and installing EVCI. The 10 selected corridors are:

From	To	Distance, Km
Shimla	Chandigarh	110
Chandigarh	Karnal	125
Karnal	Delhi	120
Mumbai	Vapi	175
Mumbai	Pune	148
Mumbai	Nashik	167
Bangalore	Vellore	211
Vellore	Chennai	138
Chennai	Puducherry	151
Madurai	Kanyakumari	243

The table below shows the cost of setting up EVCI for freight along the 10 corridors.

Costs	Units	Costs
EVCI Equipment	INR	40,00,000
Installation and commissioning	INR	10,00,000
Operating Costs for 1 station	INR/year	5,20,000
Total cost for setting up EVCI at 1 location	INR	55,20,000
No of EVCI sites on 10 corridors	Units	131
Total cost for setting up EVCI along 10 corridors	INR crore	72.3

MP Ensystems met with investors, financing entities and implementing agencies. Feedback received included

- For individuals or small businesses, investment in EVCI could be promoted by including EVs and EVCI in **priority sector lending** and providing **interest rate subventions**
- Financing freight businesses for charging along corridors could be promoted through a **risk-sharing mechanism** led by the fleet operator
- Governments and multilateral institutions and climate finance can develop **risk-sharing mechanisms** for banks and FIs, that cover potential losses from financing EVCI

The key findings from discussions with freight EV and EVCI OEMs, CPOs and logistics and trucking companies are in the table below:

Policy	Technology	Implementation	Financing
• Need for clear policies at national and state level for freight EVs and EVCI	• Range anxiety remains an important concern for freight • As per the EVCI consolidated guidelines published on 14th January, 2022, for HDVs there shall be at least one FCS (Fast charging station) every 100km on either side of the highways / road	• At present there is no standardisation pertaining to EV supply equipment (EVSE), which makes it increasingly difficult to set up an integrated charging ecosystem • CPOs and OEMs have to create a network of FCS intracity and intercity to facilitate long range EVs	• Small businesses want to set up EVCI, and may require bank loans • Greater awareness on EVCI business models and expected revenue is needed among banks and business owners • CPOs and OEMs will need innovative financing models to make FCS operations economically viable, especially for long range

MP Ensystems has developed the following recommendations to key stakeholders on siting EVCI for freight vehicles:

Recommendations to planners	Recommendations to grid operators	Recommendations to businesses
• Cohesive approach to land-use planning among multiple governing institutions • Clear guidelines to earn rental revenue • All future development plans should include specific land allocations for freight EVCI • To promote interoperability, a single charging protocol to be promoted and Government-led forum to improve coordination • For cyber security, develop best practices for end to end cyber security in EVCI and integrate them into the standards; promote local manufacture of key components and build cyber security awareness	• Include EVCI load as a resource to balance supply-demand positions, frequency, voltage regulations, on-site and remote renewable energy integration • Promote smart charging • Onsite and remote renewable energy assets linked and integrated with freight EVCI spots • Specific tariffs and policies to maximise capacity utilisation factors of renewable assets • Integration of RE in national power mix and development of energy storage systems	• CPOs, OEMs, freight operators, land-use planners and grid companies to create larger ecosystems through partnerships • Home-grown technologies can benefit substantively through make-in-India initiatives • For interoperability, CPOs to adopt a common, widely accepted protocol, share relevant data with discoms • Smart charging and integration of energy storage devices with DC fast chargers • For cyber security, co-design hardware and software to ensure end to end security, remediation of vulnerabilities through updates; and use of AI and blockchain to secure communication

SECTION 1

RESULTS, LEARNINGS AND RECOMMENDATIONS FROM FREIGHT EVCI SITING STUDIES

1. PROJECT RESULTS

MP Ensystems has worked on a project to determine the gaps and opportunities in developing charging infrastructure for India's freight fleet. The project's outputs include

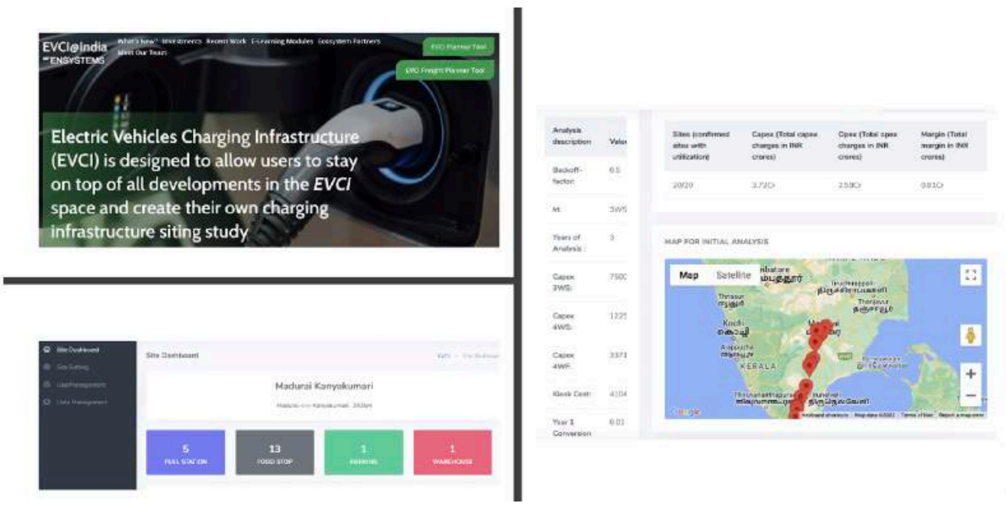
- A geo-spatial model for siting EVCI along economic corridors
- Training stakeholders on using the tool to optimise EVCI siting
- Selecting appropriate highway corridors for investment
- Engaging with stakeholders to gather their inputs on financing and implementation
- Providing recommendations to planners, grid operators and EVCI businesses

1. EVCI Geo spatial tool

An Intelligent Geospatial EVCI (IG-EVCI) modelling tool was developed as a flexible, scalable tool that can accept assumptions, user inputs and continuously refined based on field data and clearer understanding. The model considers traffic demand management, public parking spaces, electricity grid networks and charging requirements as key inputs to develop EVCI locations. The model is designed as a living document to be used periodically. This framework is available for stakeholders such as city or state governments on the website https://www.evci.in . The model was run for 32 freight corridors in India. The results of the model were verified by discussions with planning authorities, grid operators, EVCI Original Equipment Manufacturers (OEMs) and Charging Point Operators (CPOs), financial institutions and researchers.

The screenshots below show the user interface and results of using the EVCI freight planner tool for the Madurai Kanyakumari corridor.

Figure 1. EVCI planner tool snapshots



Source: MP Ensystems Research 2022

Functionalities of the tool include:

- **The tool provides already populated user data for 32 freight corridors**
- **A new user can create a login and run any of the pre-specified corridors to get results of EVCI sites on these corridors**
- **The user can download the template files, and populate them for other corridors in India and upload them to conduct analysis**
- **The user-created analysis can be kept private or shared with all users**

The results of the tool were physically validated through site visits.

The team has created an EVCI Tool User Manual to document the working of the planner tool.

The team also conducted demonstrations and training sessions hands-on learning. The institutions where training was conducted are below:

Table 1. Stakeholders provided training/ demo on EVCI planner tool

Government agencies, PSUs	Electricity sector	Private sector	Think tanks, educational Institutes
• Atal Bihari Vajpayee Institute of Good Governance and Policy Analysis • Chandigarh Renewal Energy and Science & Technology Promotion Society (CREST) • Energy Efficiency Services Limited (EESL) • Gujarat Energy Research and Management Institute (GERMI) • Haryana Renewable Energy Development Agency (HAREDA) • Himachal Road Transport Corporation (HRTC) • Maharashtra State Road Development Corporation (MSRDC) • Mahatma Phule Renewable Energy & Infrastructure Technology Limited (MAHAPREIT) • Punjab Energy Development Agency (PEDA)	• Bangalore Electricity Supply Company (BESCOM) • Chamundeshwari Electricity Supply Corporation Ltd. (CESCOM) • Dakshin Gujarat Vij Company Ltd (DGVCL) • Gujarat Electricity Regulatory Commission (GERC) • Madhya Gujarat Vij company Ltd. • Madhya Pradesh Paschim Kshetra Vidyut Vitran Company Ltd. (MPPKVVCL) • Madhya Pradesh Urja Vikas Nigam Limited (MPUVNL) • Maharashtra State Electricity Distribution Company (MSEDCL • Maharashtra Electricity Regulatory Commission (MERC)	• EVage Ventures Pvt Ltd • Kazam • MetroRide • PHD Chamber of Commerce and Industry • Renew Power • Sema Connect • Statiq • The Energy Company (TEC)	• Citizen Consumer and Civic Action Group (CAG) • cKers finance • Climate Collective • Council on Energy Environment and Water (CEEW) • IIT Indore • IIT Bombay • International Council on Clean Transportation (ICCT) • National Institute of Urban Affairs (NIUA) • Smt. K L Tiwari College of Architecture • The Climate Group • USAID South Asia Regional Energy Partnership (SAREP) • VES College of Architecture • World Resources Institute (WR()

Source: MP Ensystems Research 2022

2. Selecting 10 corridors for investment

Initial analysis and discussions with stakeholders led to the selection of 32 corridors where freight EVCI could be installed. The map below shows these 32 corridors.

For these 32 corridors, the team collected GIS and other data, applied the EVCI model to generate potential sites for EVCI and conducted ground truthing of the proposed EVCI locations through in person visits and site surveys.

Shortlisting the 10 corridors:

Based on an analysis of freight data, government policies, and a survey of stakeholders, the following 10 corridors have been selected for investment.

Figure 2. Initial list of 32 corridors

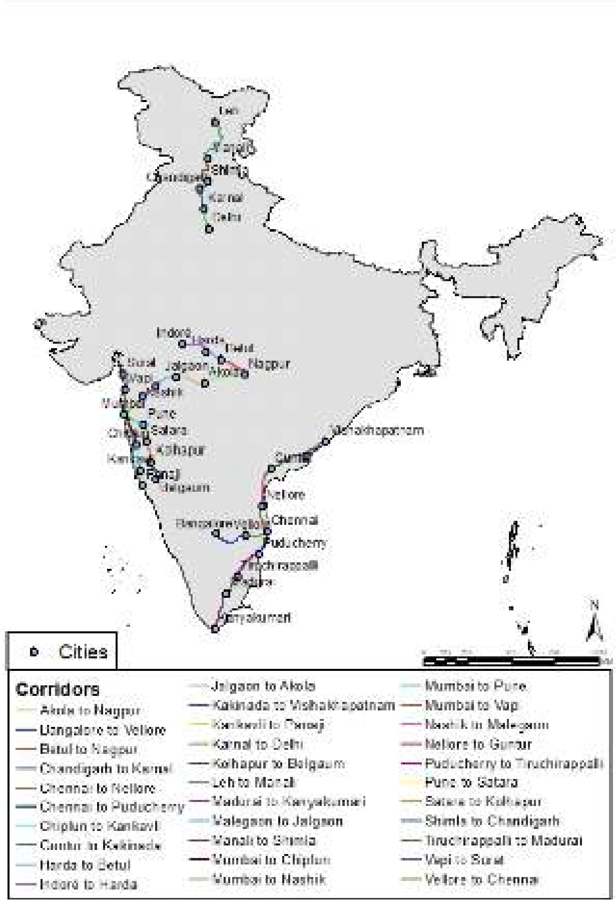
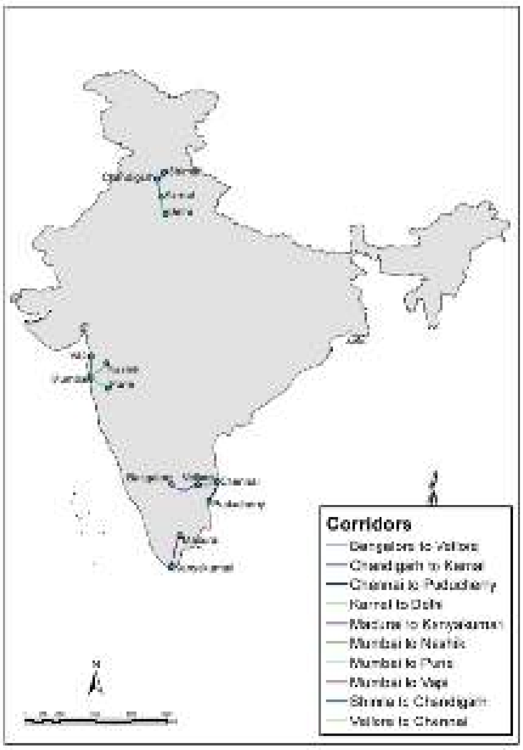


Figure 3. Shortlisted corridors



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Bangalore	Vellore	211
Vellore	Chennai	138
Chennai	Puducherry	151
Madurai	Kanyakumari	243

Source: MP Ensystems Research 2022

While the team has visited and validated most potential EVCI sites along the 32 corridors, in the case of the shortlisted 10 corridors, we additionally carried out in-depth meetings with stakeholders to determine the roadmap for planning, financing and installing EVCI. A summary of the feedback and proposed plans for EVCI at some of the selected 10 corridors is below:

a. Himachal Pradesh

Road transport in Himachal Pradesh, with a well-built road network and active bus services is key for the major sectors including tourism and goods transport (for products ranging from apples to cement). However, the CPOs believe that introduction of a state EV policy would help in the roll-out of charging infrastructure.

During discussions with the MP Ensystems team, state policy makers recognised the need for the roll out of EVCI. The HP Government stated in a press release on 20th Dec, 2022 that the adoption of electric vehicles shall be promoted by the Secretariat and thereafter EV use will be increased in public transport. The electric charging vehicle infrastructure will be provided by the government institutions including Secretariat, Himachal Sadan and others.

b. Gujarat

A meeting at Gujarat Energy Research and Management Institute (GERMI) revealed that they have proposed an MOU with Gujarat Electricity Regulatory Commission (GERC) to support capacity building in all energy areas as needed. The focus areas for GERMI are E Mobility, Solar Rooftop and Solar Pumping system, Battery Storage and Battery Management systems, new technologies like Green Hydrogen, BIPVs etc.

GERMI will undertake a rigorous effort on preparing a decarbonisation plan for the Government of Gujarat for the coming year including Transport Sector and Energy Sectors. As per the EV policy of Gujarat, GERMI is recognised by the Government of Gujarat as the state nodal department for research, training, innovation and incubation and capacity building activities for all the stakeholders within the state, which is also a mandated area of work for them. GERMI is about to establish an Electric Vehicles Center of Excellence which includes an EV testing facility.

Gujarat State Ports and Transport Department, is responsible for planning implementation and review of EV policy. They released the Gujarat state EV policy in June 2021. The Energy and Petrochemicals department is the nodal agency for charging station infrastructure.

c. Maharashtra

With a fast growing population in the Mumbai Metropolitan Region the need for goods and services will remain high for years to come. It is also home to two significant ports of India i.e Mumbai Port (MbPT) and Jawaharlal Nehru Port Trust (JNPT) which is the largest cargo handling port of the country. Both the ports are overseeing huge expansion activities and hence are likely to experience greater freight transport movement in the near future. Major warehousing clusters in the MMR region include

- The Bhiwandi warehousing cluster, which is located strategically at the junction of Mumbai, Navi Mumbai and Thane and
- Panvel warehousing cluster, located in the proximity of JNPT - the largest port of India. It is well connected to some of the major freight transportation corridors of the country, including Virar-Alibaug Multi-modal Corridor, Delhi-Mumbai Industrial Corridor (DMIC), Delhi-Mumbai Expressway and Mumbai-Nagpur Expressway.

Thus, the economic potential of the MMR area is huge and it is a well-established fact that decarbonising freight is the need of the hour and should be taken up on an urgent basis. A proposal for the development of a net zero freight corridor policy has been submitted to MMRDA and is presently under consideration.

3. Estimating investment in setting up freight EVCI

The table below shows the estimated investment for setting up charging stations along these 10 freight corridors for 131 charging stations is approximately INR 72.3 crores. The estimated investment for all 32 corridors, at 409 locations is INR 226 crores. These estimates do not include any incentives provided by state or central governments.

The move from Internal Combustion Engine (ICE) freight vehicles to EVs covering 1 million freight kms is expected to reduce greenhouse gas emissions by

85,000 tonnes

annually.

Table 2. Investment for EVCI along selected freight corridors

Costs	Units	Costs
EVCI Equipment	INR	40,00,000
Installation and commissioning	INR	10,00,000
Operating Costs for 1 station	INR/year	5,20,000
Total cost for setting up EVCI at 1 location	INR	55,20,000
No of EVCI sites on 10 corridors	Units	131
Total cost for setting up EVCI along 10 corridors	INR crore	72.3

Source: MP Ensystems Research 2022

The investment calculations and details are in Section 4: Recommendations on EVCI investment.

2. RECOMMENDATIONS

A summary of the recommendations to key stakeholders- planners, grid operators and businesses is in the table below:

Table 3. Recommendations for EVCI stakeholders

Recommendations to planners	Recommendations to grid operators	Recommendations to businesses
• Cohesive approach to land-use planning among multiple governing institutions • Clear guidelines to earn rental revenue • Urban development departments can create supportive policies for additional floor space index or allowances in housing societies to facilitate freight charging points in addition to passenger vehicles • All future development plans should include specific land allocations for EVCI, with a clear emphasis on charging infrastructure for freight vehicles • Recommendations related to interoperability of EVCI include mandating a single charging protocol and setting up a Government-led forum on EV charging for better coordination • Recommendations related to cyber security of EVCI include building on existing work in cybersecurity to develop best practices for end to end cyber security in EVCI and integrating them into the standards at an early stage; promoting local manufacture of key components and engaging with stakeholders to build cyber security awareness	• Include EVCI load as a resource to balance supply-demand positions, frequency, voltage regulations, on-site and remote renewable energy integration • Promote smart charging where the grid can use EV loads for ramping up during periods of excess generation, with higher renewables in the system and low-cost options available from the grid • Onsite and remote renewable energy assets linked and integrated with freight EVCI spots located at multiple locations in the grid network offer deeper decarbonisation • EVCI should promote higher renewables to be absorbed and specific tariffs and policies to maximise capacity utilisation factors of renewable assets should be taken up on priority • Integration of RE in national power mix and development of energy storage systems can help in reducing the gap between EV charging demand and variable RE generation, which will enable maximum potential of EVs for decarbonizing transport	• Charging point operators (CPOs), original equipment manufacturers (OEMs) of charging infrastructure, freight EV manufacturers, freight operators, land-use planners and grid companies need to create larger ecosystems through partnerships. Joint partnerships and memoranda of undertaking are recommended • Home-grown technologies can benefit substantively through make-in-India initiatives • Recommendations related to interoperability include CPOs adopting a common, widely accepted protocol for their own EV systems; sharing relevant data with discoms • Smart charging and integration of energy storage devices with DC fast chargers can help in reducing the impact of high-power charging load on grid • Recommendations related to cyber security of EVCI include co-designing hardware and software to ensure end to end security, remediation of vulnerabilities through updates; and use of AI and blockchain to secure communication

Source: MP Ensystems Research 2022

3. LEARNINGS

The learnings from the project activities have been listed below in the categories of freight segment, policy, finance, technology and implementation.

Freight segment

- Several OEMs, either are ready or are soon producing e-truck models for the Indian market. They include companies like TATA Motors, IPLTech Electric, Volvo Eicher, Triton EV, Omega Seiki Mobility and Olectra Greentech Ltd. Currently the EV designs seem to be focusing on L5 chassis sites.
- OEMs (Tata Motors and Omega Seiki Mobility) are currently focusing on light commercial vehicles ranging from 1 to 3.5 tonnage. They have plans to launch medium-density vehicles ranging up to 6.5 tonnes soon in the market. Price sensitivity stands as an issue for the customers. Volvo Eicher as an industry leader is planning specific product launched that are likely to be announced in early part of 2023.
- OEMs such as EVage and Ashok Leyland have electric trucks in the advanced prototype stage; including advanced battery chemistry that would be useful in enhancing the trucking performance.
- PMI Electro Mobility is currently working on a portfolio of 15 commercial vehicles across the light to heavy vehicles category.
- OEMs suggest the need for pilots to understand the performance of battery-operated e-HDVs; while some of them are directly involved in intense internal testing and homologation.
- E-commerce companies such as Amazon India, Flipkart, Zomato, Delhivery are focusing on decarbonising the middle mile and last mile.
- Partners have highlighted the need for an integrated battery charging system that is a combination of destination charging and opportunity charging networks, which is being widely discussed by OEMs and PSUs.
- To increase uptake in the freight segment, (LDVs, MDVs, HDVs), the government can intervene in the following manner:

    * Formulate mandates in the form of policies
    * Announce incentive programs as a market-making activity focusing on freight
    * Formulate certification programs and standards
    * Carry out homologation of the new vehicles to be launched, including safety audits, road worthiness (suitable for Indian driving conditions), crash testing and grid to vehicle interfaces
    - Monitor vehicle and technology performance to develop better designs for Indian driving cycles

* Develop adequate charging infrastructure that supports fast and slow-charging; and also bring-in additional benefits to the table through interactivity with the electricity load balancing opportunities
* Create fast charging mechanisms, intervening in the battery cells configuration and thermal management

Policy

The central and state governments have focussed on passenger e-mobility and it is imperative for them to focus on freight. Since the investment needed is high and the risk is substantial, the freight segment needs to be addressed comprehensively in policy making and implementation.

- A few states such as Delhi and Union Territories such as Chandigarh have created single-window approval system for EVCI. Pan-India, such a system can be operationalised for quicker penetration of charging infrastructure.
- Government of Himachal Pradesh apprised that they have introduced electric buses on all the major routes in the state. Himachal is also developing 4 model cities to demonstrate excellence in the field of Electric Vehicle in the state. The state government is collaborating with EESL to promote charging infrastructure in the state.
- UT Chandigarh mentioned the UT Administration is offering zero rentals from charging point operators in the city for first two years under the EV policy of Chandigarh. The UT administration is about to launch tenders for the battery swapping system in the city.
- Haryana Government has notified the EV policy in the state and is offering electricity to charging point operators at subsidized rates.
- Punjab Renewable Energy Development Agency (PEDA) mentioned that Government is offering subsidy to the tune of Rs 30,000 to Rs 50,000 per electric vehicle in the state and is targeting 45% increase in sales from last year.
- Ministry of Micro Small and Medium Enterprises Development Institute (MSME DI) stated that the Indian Government while pushing the agenda of Aatma Nirbhar Bharat has rolled out a number of schemes to promote Electric Vehicles in the states. Maruti Suzuki is coming up with a unit for Electric Vehicles in Haryana and is exploring vendors to supply parts which is a big opportunity to new entrepreneurs, and Ministry of MSME is supporting the budding entrepreneurs in a big way.
- Freight EVCI will need higher capacity of service connections; this will need careful planning as several states charge a normative number for fixed cost towards developing such an infrastructure and a few states also have the provision to recover the cost of service connections from the users.
- Co-located charging infrastructure with the existing high tension connections is a viable option and users such as petrol pumps, warehouses and large restaurants have a clear opportunity to develop such an infrastructure.
- The Ministry of Road Transport & Highways has defined the life of petrol and diesel vehicles. Defining the life corresponding to roadworthiness of the EVs, including LCVs, MCVs will be useful for buyers.

- Charging of LCVs and MCVs would need substantial space allocations. Land-use planners and roads/highways authorities need to carry out an exercise to define users in their prospective land-use planning.
- While we wait to have advanced chemistry battery cells rolled-out; standards-setting related to the battery technologies and battery management systems is essential and should be developed further.
- A mechanism to create battery testing facilities is essential for the purpose of adherence to the testing protocols.
- Battery swapping is still at a nascent stage in India but is gaining ground among fleet operators. Niti Aayog's draft battery swapping policy, 2022 recommends interoperability, financial support, institutional support and reuse of EV batteries.

Finance

Feasibility for freight charging lies in last mile, first mile, intra city and short intercity carriageways and the economics of scale for freight lies in fast charging and battery swapping. It is important that appropriate measures are taken at policy levels to strengthen the above so as to strengthen the business models for freight charging and ensure sustenance.

- One of the most significant stakeholders in the economics of freight charging are discoms that are directly impacted. Innovative business models need to be supported through policies, tariff design, subsidies etc to ensure proactive readiness from the discoms to support the roll out of charging infrastructure.
- A positive financial proposition for discoms can also be developed from the TOU (time of use) strategy as well as flexible demand strategy.
- The upfront investment in heavy vehicles is substantial and hence government policies and subsidies need to be looked at to embed economic viability for OEMs, fleet operators and CPOs. Most investors are wary of lending due to high asset risk (technology, resale and infrastructure risk) and business model risk (operation, maintenance, performance and customer loan) . These led to limited financing options, low loan to value ratios and high interest on loans leading to high insurance rates.
- Commercial banks are not positive about EVCI start-ups and the government process should encourage setting up of priority sector lending requirements and import substitution facilitated by start-ups needs to be encouraged.
- Training bankers on the EV space is essential and revenue guarantee or debt servicing mechanisms can be built.
- Specialised funds that are investing in start-ups seem to be interested in the EV charging space. A definitive effort to attract additional investments also backed by the patenting opportunities is essential.
- Banks and non-banking financing companies (NBFCs) such as Axis Bank, SBI, HDFC, Bajaj Finserv, Mahindra Finance, L&T Financial Services are providing debt financing for EVs and EVCI.

Technology

- Technologies related to freight electrification including slow, fast and battery swapping systems are available in the Indian context; specific support by way of technology demonstrations is needed in this context.
- Data analytics is a key to set-up an integrated interoperable charging point locator service. Such a platform that is industry-driven, industry-developed and managed would be useful.
- Smart charging infrastructure hasn't been tried in India so far. As it is likely to bring load balancing benefits to discoms too, it is essential to begin developing such a process. Specific modelling opportunities should be explored by partnering with the distribution companies.

Implementation

- A key challenge faced by charging point operators (CPOs) is the delay in obtaining permission from the government and public institutions to facilitate their investments
- While start-up CPOs are technically capable of setting up charging points, the public sector procurement process requires higher level of prequalification criteria that is a deterrent to market creation
- A unified mechanism to facilitate passing on of central and state government subsidies is necessary to ease infrastructure development
- Charging points established on the outskirts of cities have been attracting good revenue due to scarce infrastructure. This also implies that in the freight charging point category, charging points established on the corridors and on the fringes of cities would be useful; specifically in the area of last-mile/logistics connectivity associated with warehousing
- Public-private partnerships in co-located charging sites with risks assumed by both the participants has not been explored much beyond land-leasing. Such newer business models would be useful
- IOCL is promoting green energy and has undertaken a target to install 1000 EV chargers in 3 years and 2700 Electric Vehicle charges have been installed in first year. IOCL is also promoting battery swapping, and is already doing 100- 120 battery swaps a day as on date
- Freight OEMs require fast charging and ultra-fast Charging networks. States of Punjab, Chandigarh and Himachal Pradesh have identified the deployment for fast chargers along several road networks
- Most policies are not focussed specifically towards commercial EVs and this area may need some attention

4. WAY FORWARD FOR FREIGHT

Multiple stakeholder consultations and bilateral meetings and emerging research have revealed that electrification of freight by 2030 could be effective in saving approximately 43% emissions from the overall emissions of the transportation sector. Hence targeting freight electrification in the immediate future would be a strong strategy

Need for coordinated action with a unified and systematic approach

India is primed to lead the electrification of freight globally. Leaders from government, industry, technology and research and financing institutions must align deliberately to enable and enact near term market creation and policy interventions.

There is a need to develop, adopt and modify policy interventions to promote and support the emerging EV market. Setting definite targets and defining clear pathways for adoption of freight electrification is essential for development and sustenance of the EV ecosystem.

The immediate need will be to focus on demand side policy development and subsidies on purchase to sustain the demand and thus encouraging the manufacturing sector. A simultaneous effort has to be made to prioritize the development of charging infrastructure at source and enroute, to increase the market confidence that these vehicles can meet their operational needs.

Next would be to strengthen supply side policies for scaled manufacturing for adequate supply for greater adoption for scalability. Scaled market developments backed by banking and tailored loans can finally trigger growth and sustainability.

Governments, State nodal agencies and Urban local bodies could consider some of the following recommendations towards a short term and long term plan for EV adoption for freight:

- **It would also be useful if state nodal agencies (SNAs) initiate discussions and mechanisms for freight friendly tariffs, an actual plan for most effective locations for charging infrastructure from a grid interactivity point of view to strengthen the business models.**
- **The central and state governments should look at extending subsidies for freight vehicles.**
- **While long haul freight charging infrastructure is being sited along freight corridors, it is important the first and last mile delivery charging stations are identified within the cities in its overall planning.**
- **The HP Government had expressed interest in signing MOUs with OEMs and CPOs to set up charging infrastructure in the state for passenger and freight once the state EV policy is in place. EV committees could be suggested to be formed so as to enable a well-rounded EV policy and its systematic implementation.**
- **The Gujarat government has recognised GERMI as the state nodal department for research, training, innovation and incubation and capacity building activities for all the stakeholders within the state, which is also a mandated area of work for them. GERMI is proposing to sign an MOU with GERC to carry out continuous capacity building programs for all state departments and their officials within the electric mobility space.**
- **Chandigarh Renewable Energy, Science & Technology Promotion Society (CREST) has initiated discussions with MP Ensystems to hold training for their officials, in the area of siting of electric charging infrastructure within the city and in its outskirts.**
- **While some work on freight electrification has begun along the freight highways within the country to address local and national logistics, it is now important to also look at the corridors connecting major ports and cities for international freight logistics and develop and zero emission plan for the same.**
- **Ports are major trade and business houses in EXIM trade. It is important to understand the impact of present policies for decarbonisation and electrification of freight for this sector, identify the gaps, and provide insights for accelerated decarbonisation and electrification.**

Way forward for triggering market development through financing freight EVCI

It is realised that along with policy support it is market forces that are going to be drivers or scale and ecosystem development. By developing a stable policy environment, having interest subvention schemes and risk sharing mechanisms will help trigger market development. Some market strategies that could be initialised could be:

- **Local supply should be supported through manufacturing mandates and adequate government support should be provided. This could reduce the overall cost of the vehicles and make the Total Cost of Ownership more competitive.**
- **Banks lack the expertise in lending in the EV market. They need to be better trained to bridge the gap between perceived risk and actual risk.**
- **Demand aggregation may also prove to be effective to enhance the lending.**

- **Likewise EV service and cell technology should be supported to be developed by financial market mechanisms which are very critical to address safety, range anxiety and battery life issues so as to be able to have a clearer picture on the ROI for investors.**
- **Thus it is important to develop tailored lending products for lowering the cost of borrowing and increasing the debt financing.**
- **Vehicle and battery leasing programs may also be developed as well as increased performance guarantees be demanded.**

Supportive ambitious policies for planning, implementation and financing at national, state and city level will support development of charging infrastructure, enable demand creation, ensure supply sustenance and scaled growth for the adoption of freight electric vehicles. This could lead to a long term economic win for the country establishing India as one of the global leaders in freight electrification

SECTION 2

EVCI PLANNER TOOL USER GUIDE

1. INTRODUCTION

1.1 What is the EVCI planner tool?

1.1.1 Objective

The EVCI application is designed to aid in identifying potential locations for setting up EV charging stations for cities and freight corridors across India. Data is classified into logical blocks, called sites. A site can correspond to either a city or a corridor type of requirement. A software system is created whereby given the right amount of data input, the software can help quickly run customised analytics on the sites to assist in the identification of ideal locations for setting up new EV charging stations. A cost-benefit analysis is also provided based on the projected revenue the charging station would get at the recommended location.

1.1.2 EVCI description

The term “EVCI” stands for Electric Vehicle Charging Infrastructure. EVCI Planner is a tool designed to aid in budgeting and planning for setting up charging stations on road networks. Given the right data, the tool provides insights on potential locations for the setup of charging stations where the cost of setup may be the minimum and operational profitability the highest.

1.1.3 Target audience

The target audience for the EVCI tool is state electricity utilities (DISCOMs, TRANSCOs), state and regional transport authorities, central or nodal government agencies involved in implementation of Electric Vehicle Charging Infrastructure (Ministry of Power, Bureau of Energy Efficiency, Central Electricity Authority etc.), urban development authorities, Charge Point Operators (CPOs), Original Equipment Manufacturers (OEMs), logistic companies, fuel station operators and financing institutions.

2. ACCESS AND USER PROFILE

In this section we will talk about how users can register and use the EVCI tool. Let's get started by first setting up an account and then running a new analysis.

2.1. User registration

2.1.1 Login to your account

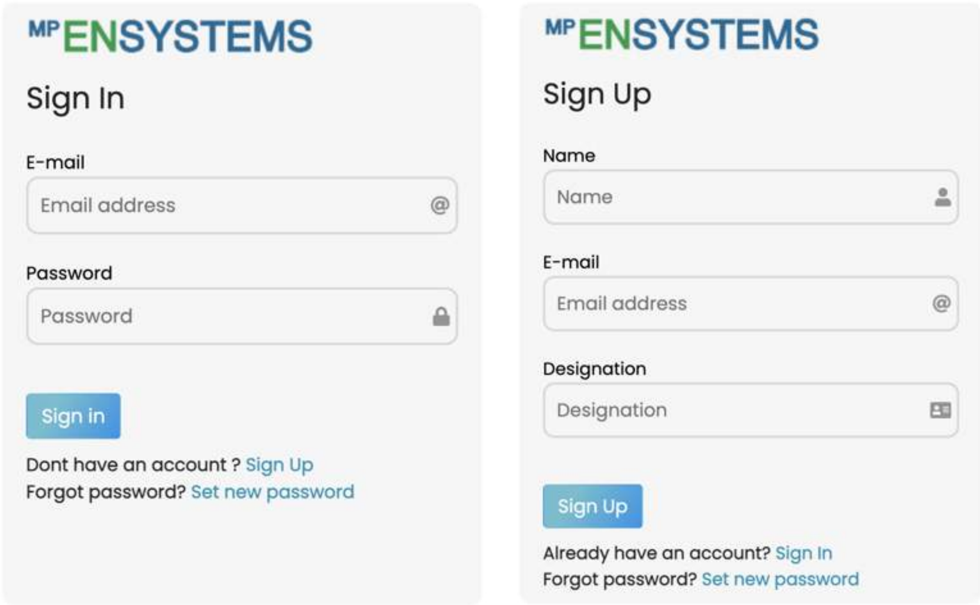
The registration and login process are seamlessly integrated within the EVCI application as a Single Sign-On Below are the steps to register and log in:

Visit https://evci.in and hit the button labelled (1) you see at the top right, called "EVCI Freight Planner Tool".

You will be redirected to a login page. If you are not a registered user, choose the "Sign Up" option to set up a new account.

2.1.2 New user registration

Register for a new account from the login page using the "Don't have an account, Sign Up" option shown on the login page. The registration is powered by MP Ensystems Single Sign-On. Once you register, you will be able to use the registration across any website that accepts a login with MP Ensystems.

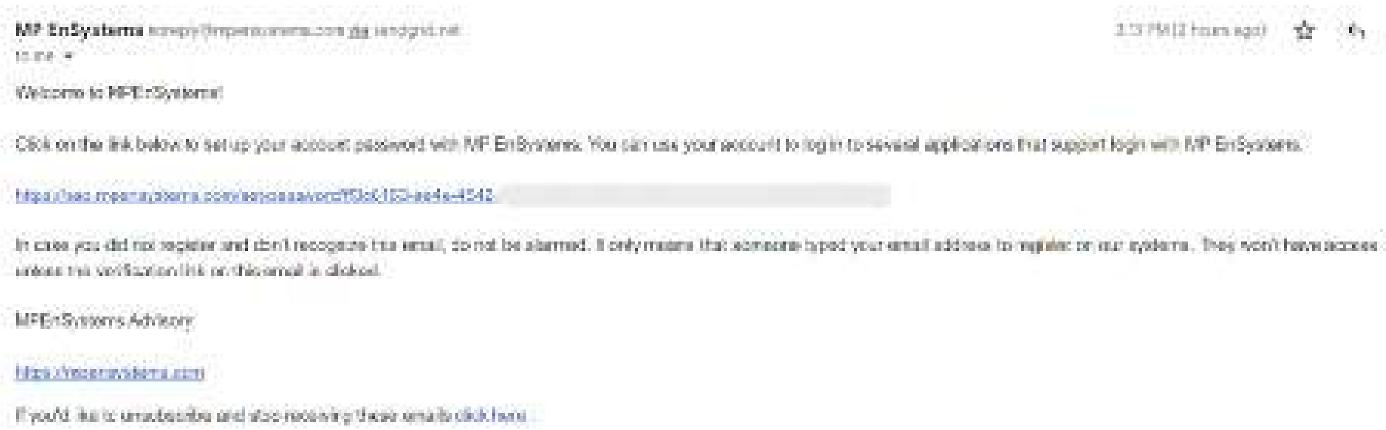


Use your email address to sign up for a new account with MP Ensystems. If your email has already been registered on any MP Ensystems portal before, you will not be able to set up a fresh registration. You must then log in, even though you may have never registered or logged into the EVCI application per se before.

If you are proceeding with setting up a new user account, you must enter your Full Name, a valid email address, and your current designation. Your email will be verified before your account is set up. If you are currently a student, please write your designation as “Student”. We capture your designation only for internal analytics and getting to know our users better can help us improve our systems to offer you a better experience.

Email verification for new registrants

Once you successfully fill up the sign-up form, you should receive an email from noreply@ mpensystems.com with a link to verify your email.



When you click on the verification link, your email will stand verified, and you will now be directed to setup a password for your account. Complete the password setup process before you close the browser to complete the sign up process.

Once you successfully setup your password, you can now proceed to login. You must login with your newly created account. The system does not auto login on setting up your password.

Diagnosing issues with registration email

If you do not receive an email, please check your spam and junk folders. It is possible you received the email, but your email provider incorrectly classified the email as spam/junk. If you are a Gmail user and you do not see your email in the Inbox then please check the Promotions tab as well. We have noticed that Gmail occasionally places our emails in the Promotions folder.

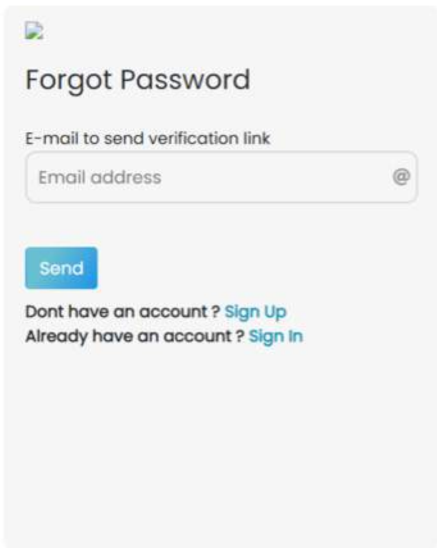
If you are still unable to locate your registration email, please contact MP Ensystems by sending an email to evci@mpensystems.com .

Issues with verification link not working

The verification link you receive in an email is only valid for 24 hours. Occasionally we may invalidate links in less than 24 hours if we consider them to be a security risk of any sort. If your link is not working, then it likely means that we have cancelled your current registration attempt. You can try by beginning a fresh registration with the same email address. If you continue to face issues, send an email to evci@mpensystems.com, along with a reasonable description of the problem you are facing.

2.1.3 Resetting your password

You can set new passwords by clicking on Forgot password? If your email is registered, you will receive an email with instructions to reset your password.



2.1.4 Understanding MP Ensystems single sign-on

All users are required to log in to use the EVCI application. No functionality is open without a verified email address. Authorisation to the EVCI application is backed by MP Ensystems Single Sign-On (SSO). The SSO module is owned by MP Ensystems and used to authorise several applications backed by MP Ensystems. A user must register onto the SSO module and log in with their credentials into the EVCI tool. After logging in, you will see the EVCI portal.

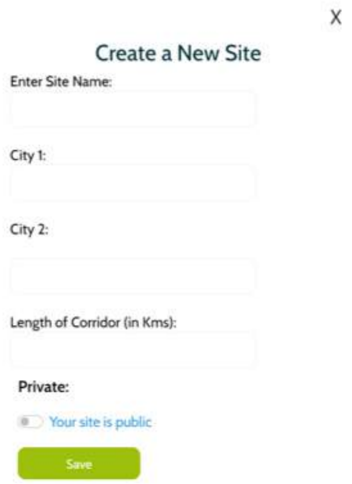
2.2 Sites & analysis

2.2.1 Navigating sites

The registration and login process are seamlessly integrated within the EVCI application as a Single Sign-On Below are the steps to register and log in:

- **Post login, you should see your list of sites on the first screen. You must choose and go to a specific site to perform an analysis. You can analyse only one site at a time.**
- **The site selection screen is bifurcated into a "Discover" and "My Sites" section.**
- **The "Discover" section shows you a list of all public sites. These could be sites created by EVCI tool administrators, government bodies, and other fellow users who have opted to make their sites public.**
- **The section "My Sites", when selected, shows a list of sites that are private but shared with you. This is the same place where private sites created by you will show.**
- **You can create a new site by clicking on "Create a New Site". It will open a dialog for you to create a new site of your own. As a user who is creating the site, you will automatically become an owner of the site.**

We will cover more details of user roles and permissions in later sections.



A site is nothing but a corridor that is being analysed. It is called a site for a logical bifurcation within the system. Enter the name that you would like to site to be known by along with names of the two cities that the corridor maps. Also mention the length of the corridor for display purposes. You can enter a value of 0 for the length if the same is not known. All fields entered while creating a site can be changed once the site is created. While creating a site, you get the option to make your site either public or private.

If you mark the new site as public then it will be accessible by all registered users. You should mark your site as Private by default unless you intend to make it public. You will later have the option to invite other users into your private side for a team to collectively work together on the site.

2.2.2 User interface

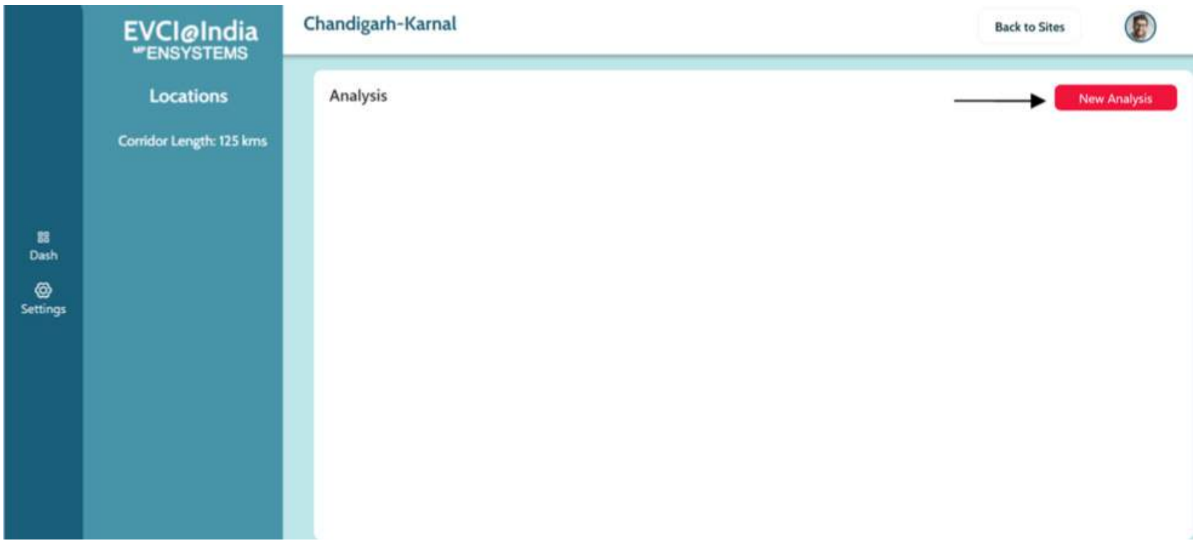
Selecting any of the sites from the Discover or My Sites section, navigates you to within the site. Everything you now do will be within the site you selected. You will always see the name of the selected site on the top navigation bar of the website.

This page displays the following:

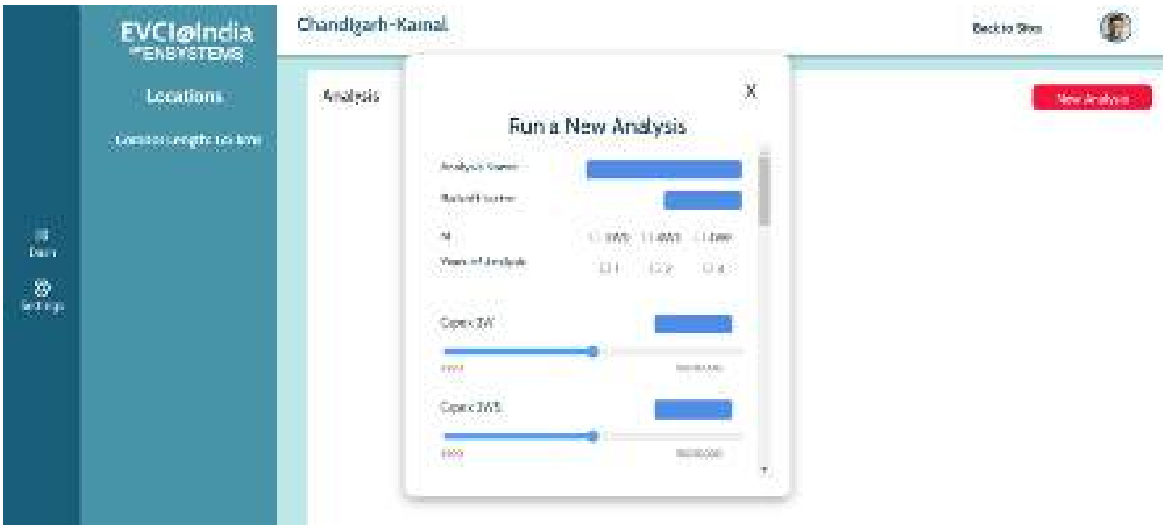
- **Shows the name of the site**
- **Takes you back to the site selection page. Use to jump out of this site and select another site.**
- **This is the current page, that shows the site specific dashboard**
- **Takes you to the settings page corresponding to this site**
- **Shows the count of potential charging station points, based on data uploaded by the administrator**
- **Shows the length of the corridor. This is as entered by the site administrator, and is changeable**
- **Use the button to begin a new analysis**
- **Shows the list of analysis that have already been run**

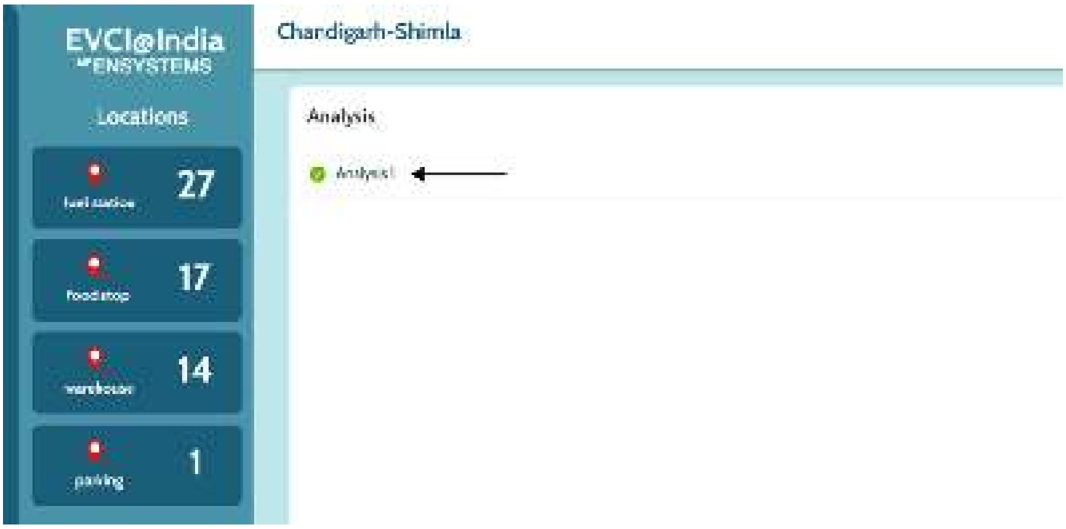
On the left-hand side, you will see the setting, dash (referring to the Dashboard), and location points between the cities.

After creating a new site you will see a page where you can start analysing your site data. You can start analysing your data by clicking on "New analysis". Analysis cannot be private. Any analysis you run is accessible to other users who have access to the site. Other users will be able to view your inputs and outputs. We currently do not support privately run analyses by any individual. If you want to go back to sites, click on "Back to Sites" by clicking on it, you will be directed to the sites page.



If it is a new site, then you have to upload data from the Data Management section before starting the analysis. The data management section is located within the Settings tab. After uploading the data you can start the analysis by clicking on "New analysis". After you have filled in the required details for the analysis and saved it, a new analysis will be created. After creating the new analysis you will see a screen where you can find all the analysis list and map of the sites for which the analysis has been created.





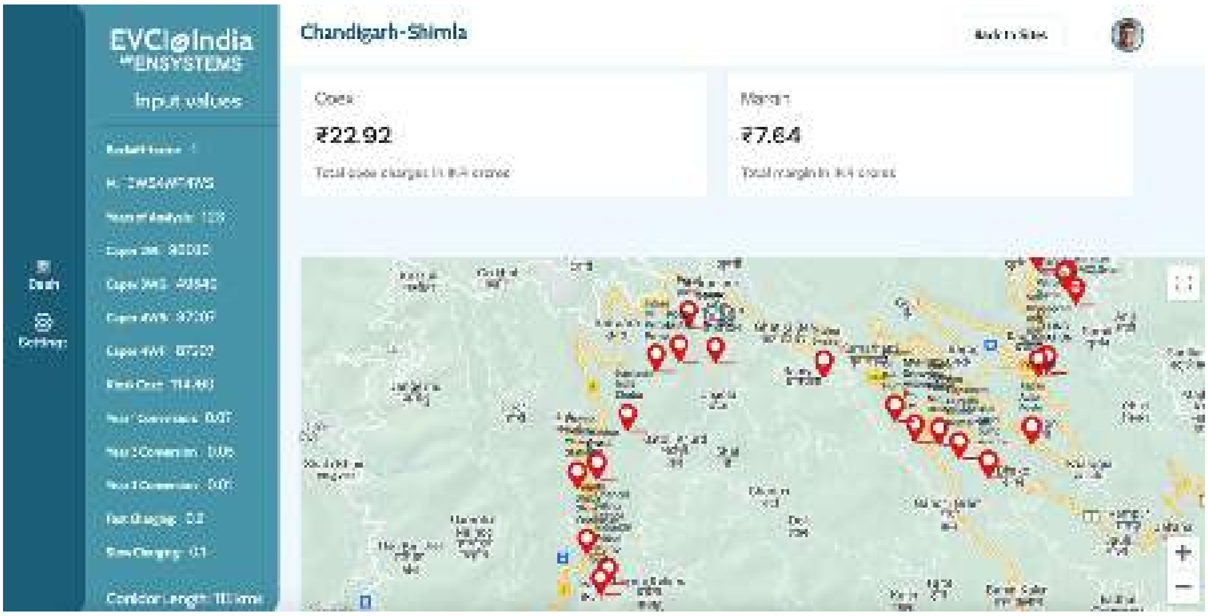
When you click on the analysis, you will see an analysis of the site as per the given input. On the left-hand side, you will see all the given inputs by you while creating the analysis and on the right-hand side, you will see the reports.

There are two types of reports you see, first Initial Analysis and second Cluster Analysis. You can download the reports separately by clicking on “Download Report”. You can delete the analysis by clicking on the button “Delete Analysis”.

In the Initial Analysis report, you will see sites, Capex, Opex, and Margin. In the Initial report, you will see all the initial values i.e. approximate cost required, the margin of the analysis which you have requested, etc. In the Initial Analysis, you will see two types of graphs, the first Initials Utilisation Histogram, and the second Initial Unserviced Histogram. Initial utilisation and unserviced are computed for all the sites listed in sites.xlsx taking into account their proximity to one another. The site list can be rationalised by eliminating lower utilisation sites while maintaining the distance constraints for charger placement.

The analysis output also includes a map that marks out the potential locations where an electric charging station can be setup. The name of the place along with the latitude and longitude are appropriate marked.

The map is interactive, and you can zoom in to view all the pin drops in detail. An example of a zoom in view is shown below.



2.3 Settings

Site settings allow site owners and admins to manage their sites. There are 3 primary management sections for every site.

2.3.1 Site setting

You can change site settings i.e. Name, City, Length of Corridor(km). You can change the site to private if it is public, or public if it is private.

2.3.2 User management

The user management section shows the list of users who have access to the site. The section is accessible by all users who have access to the site, but is editable by only Site Owners and Admins.

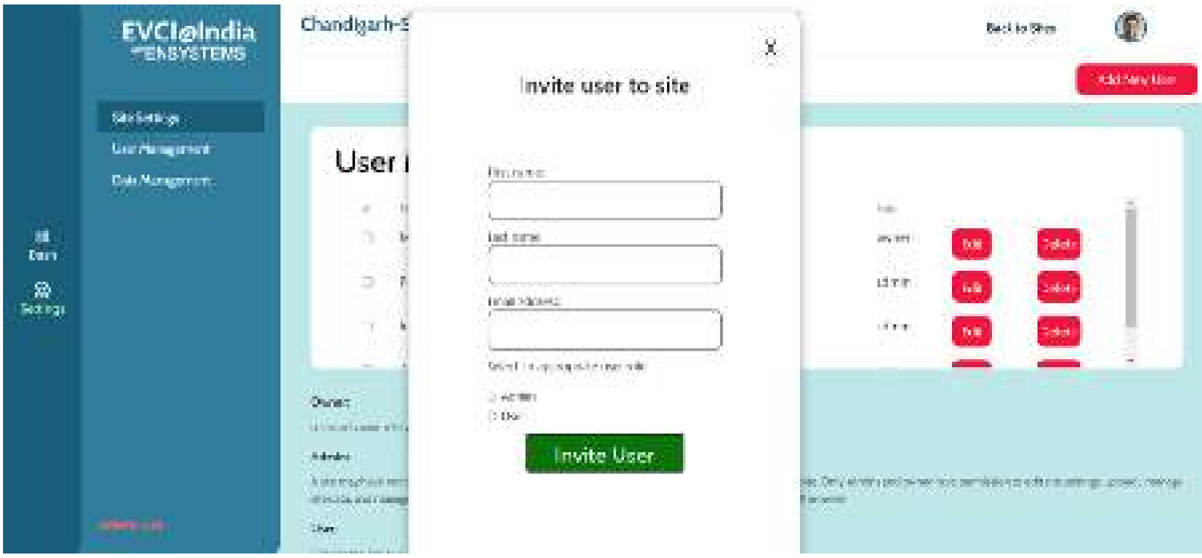
If you are a Site Owner, or Site Admin, you will have the option to invite new users to the site. You can add new users by clicking on “Add New User”. Only the owner can add a new user. The owner can assign roles to the new users i.e. either Admin or just User role.

Sites primarily have 3 types of users. A user can be any one of “Owner”, “Admin” or “User”. The differences between these roles are explained in the table below.

Owner	• By default assigned to the user who created the site. Only the Owner role has permission to delete a site. • A site may have only a single owner. The owner has permission to transfer ownership privileges to another member of the site. • An owner is like a super user and has full/maximum permissions to carry out any on all operations on the site.
Admin	• A site may have multiple administrators. An admin has full access permissions to the site. An admin can perform all operations except for deleting a site and assigning a new owner. • Admins have permission to manage the site data and site settings. • An admin may appoint other admins.
Users	• A user is the lowest level role on a site. Users can access the site, and view all content, including viewing the identity of the site owner, admins, and other users. A user can use the site to carry out an analysis. They can also download site data that is uploaded by admins, but they cannot change any of the site data.

The “User” role is not available to public sites. A public site may have only an Owner & Admin role.

You can edit the information of the user and delete the user as well. You can edit the First name, Last name. Email id cannot be changed or edited. You can delete the users as well. Deleting the user does not delete the users account, but removes them from site. Edit and Delete operations can only be carried out by an Owner or Admin.



2.3.3 Data management:

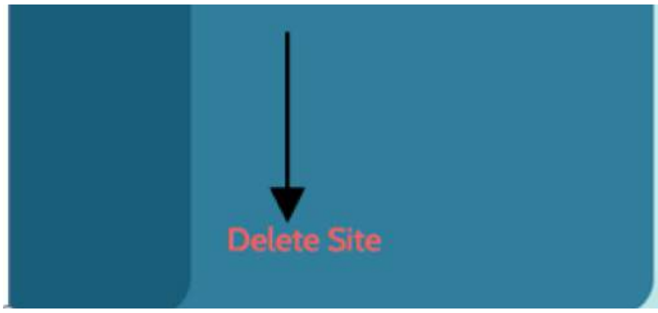
You can upload the data from data management to analysis it. There are three Excel files that must be uploaded before any analysis can be run on the site. The names of the files are:

1. grid.xlsx
2. sites.xlsx
3. traffic.xlsx

The contents of each of the 3 files are explained in detail in the later parts of the document. A sample file containing the file format is provided. You can download a sample file by using the "Download Sample" option visible next to each of the upload boxes.

Deleting a site

If you are a site Owner you will see the option to delete a site at the bottom left of the screen. Deleting a site is a non-reversible operation. Once the site is deleted, all data is permanently lost. All users will lose access to the site, and will also lose the analysis they have run on it.



Sharing your results

Users can share their sites with other users. Any user who has access to a site has the ability to view all the analyses run on the site. Completed analysis shows all users with site access, irrespective of their access role. Clicking on the analysis allows the user to see the results. The site dashboard provides the name of the user who ran the analysis, and when the analysis was run.

Data privacy

EVCI application data is currently stored on Google Cloud, within India regions (Mumbai and Delhi). The application does not capture any critical PII (Personally Identifiable Information) data, apart from the names and emails of registered users. Site-specific data is stored on encrypted storage with minimum security measures. Source code is scanned monthly to check for known vulnerabilities from the CVE (Common Vulnerabilities and Exposures) registry, and compatible libraries are updated monthly to keep security exposures to the minimum.

3. QUICK INFORMATION

The core functionality of the EVCI tool is a design and analysis engine that implements an EV siting model. The model implements EV charging infrastructure for a specified freight corridor. This model suggests most likely and/or preferred locations for EV charging sites along the route based on the following information:

a. Generic model parameters

b. Initial list of sites

c. Typical traffic profile of vehicles (both current and projected)

d. List of grid substations on the route

The analysis can be performed by specifying the policy period or duration of the policy (default: 3 years).

3.1 Definitions, links, and site layer selection

3.1.1. Input file checklist

The ultimate goal of the EVCI tool is to compute the "utilisation" of a site and number of unserviced vehicles depending upon its infrastructure and expected traffic profile. Utilisation is expressed in percentage or as a number between 0 and 1, where 0 means the site will never be utilised and 1 means the site will have charging vehicles available at all times. The goal is to maximise the utilisation for a site and also to select those sites. Towards achieving these objectives, the model works with the following excel sheets:

a. model.xlsx – provided and maintained by the tool

b. sites.xlsx – user contributed

c. traffic.xlsx – user contributed

d. grid.xlsx – used contributed

The aforementioned files are available for few corridors already specified by the tool for the users to interact with. However, if the user intends to input data about another corridor of their interest, then it is recommended that they download the sites.xlsx, traffic.xlsx and grid.xlsx files and update them accordingly.

The following sections describe the form and contents of each of these excel workbooks. For the model to work satisfactorily, it is mandatory, that the users contributing their own corridor data conform to the file specifications. Specifically, it is recommended that the file name, worksheet name and column names MUST NOT be modified.

a. model.xlsx

This file captures the generic parameters required by the model and is maintained by the tool. The file has the following worksheets and columns therein:

1. charger_specific: this worksheet captures charger specific information. In particular the following information is used:

- Vehicle types
- Charger types
- Capex for 3-wheeler (3W) vehicles and 4-wheeler (4W) vehicles. The 4W capex is accounted differently for slow and fast charger type.
- Capex per charger type
- Required KW per charger
- Required space per charger
- Annual maintenance per charger
- Charging time for charger types -
  Number of evaluation slots for charger types
- Grid weightage factor for year k (default 1.0 to compare different grids)
- Number of chargers per type
- Charger point degradation (number between 0 and 1)
- Battery swap feasibility

2. battery_specific: this worksheet captures battery specific information.

- Battery swap option (yes or no)
- Battery types
- Battery ratings
- Battery charging efficiency
- Battery charging times
- Battery swap time
- Battery lease price
- Capex required for battery infrastructure

others: this worksheet captures other important information that is applicable across all corridors:

- Policy duration (3 years default)
- Fraction of vehicles converted to EV during year 1 (0-1)
- Fraction of vehicles converted to EV during year 2 (0-1)
- Fraction of vehicles converted to EV during year 3 (0-1)
- Slow charger margin
- Fast charger margin
- Battery margin
- Cabling cost per running km

b. sites.xlsx

This file captures site specific information and is corridor specific. The file has the following worksheet and columns therein:

1. sites

    - Name
    - Address
    - Longitude
    - Latitude
    - Traffic congestion
    - Year for Site recommendation
    - Hoarding/Kiosk (1 is yes & 0 is no)
    - Hoarding margin
    - Kiosk margin
    - Available area
    - Upfront cost per sqm (land)
    - Yearly cost per sqm (land)
    - Upfront cost per sqm (kiosk)
    - Yearly cost per sqm (kiosk)
    - Upfront cost per sqm (hoarding)
    - Yearly cost per sqm (hoarding)
    - Battery swap available

c. traffic.xlsx

This file captures corridor specific traffic profile. The file has the following worksheet and columns therein:

1. profile: this worksheet contains hourly information of number of vehicles passing through the corridor.

- name: This worksheet has many rows. Data corresponding to each row needs to be updated in the ‘vehicles’ column as described below.
- Vehicles: This column needs to be user updated.

    * **24 rows numbered 1 to 24 corresponding the hours in a typical day from midnight to midnight. Against each hour, typical number of vehicles passing through the corridor are indicated here.**
    * **holiday_percentage: this is a number between 0 and 1 which indicates if there is a difference in traffic profile through the corridor during week day vs holidays.**
    * **fast_charging: Number indicating what fraction of the vehicles passing through will opt for fast charging.**
    * **slow_charging: Number indicating what fraction of the vehicles passing through will opt for slow charging.**
    * **Battery swapping: Number indicating what fraction of the vehicles passing through will opt for battery swapping.**

d. grid.xlsx

This file captures corridor specific grid substation information. The file has the following worksheet and columns therein:

1. grid: this worksheet contains optional information related to grid substations along the corridor

    - Name of transformer
    - Address
    - Longitude
    - Latitude
    - Tariff
    - Power Outage
    - Available load

3.1.2 Selection of corridors of interest

Under this project, 32 corridors across India are selected for evaluation of EVCI appropriate location mapping. The Planner tool will help further identification of 10 shortlisted corridors based on the model simulations and also interests from CPOs, investors, utilities, logistics companies and highway authorities to facilitate the installation of EVCI.

3.2 Definitions of terms, acronyms

The following definitions are frequently used in subsequent sections while discussing the analysis and performance of the sites.

1. Utilisation: The model computes per site utilisation, which is the key metric for tracking and ranking of sites. It is defined as a number between 0 (no utilisation) and 1 (full utilisation) and indicates percentage time the EVCI at the site will be utilised for charging of vehicles.
2. Unserviced vehicles: Depending upon the charging infrastructure at a site and assumed traffic profile, there may be number of vehicles that cannot be serviced by that site, owing to waiting time etc. It is a complementary metric to utilisation and the two together indicate the usefulness of a site location for charging.
3. Capex: Capital expenditure incurred (INR) over the duration of policy to get the site functional.
4. Opex: Operating expenditure incurred (INR) by the site for maintenance and running.
5. Margin: Margins generated by the site (INR) after factoring in the capex and opex.

4. USING EVCI PLANNER TOOL

TIn this section we will talk about how users can register and use the EVCI tool. Let's get started by first setting up an account and then running a new analysis.

4.1 Analysis

4.1.1 Site layer selection

The tool readily provides already populated user data for many corridors. The user can run any of the pre-specified corridors to get acquainted with the tool. The user can then download the template files and populate them as required before uploading. If there are no errors during file creation, a new analysis will be performed by the tool for the corridor data specified by the user.

Analysis begins with an initial list of sites provided by the user for the corridor under investigation. This is provided with the sites.xlsx excel file.

Typical analysis is performed in following stages:

1. Initial analysis: Initial analysis computes the utilisation for each site.
2. Analysis with clustering: Analysis with clustering involves finding a revised and pruned list of sites. The pruning is done using clustering threshold. The analysis is performed again on the shortened list of sites, thereby improving overall utilisation of all candidate sites.

4.1.2 Interpretation of graphs and results

The following section describes the generated analysis and how it can be interpreted.

Initial analysis

This analysis will output the following textual output (example only) and an associated histogram. Both are shown here for example purposes only.

Number of sites: 244/244

Total capex charges = INR Cr 45.68

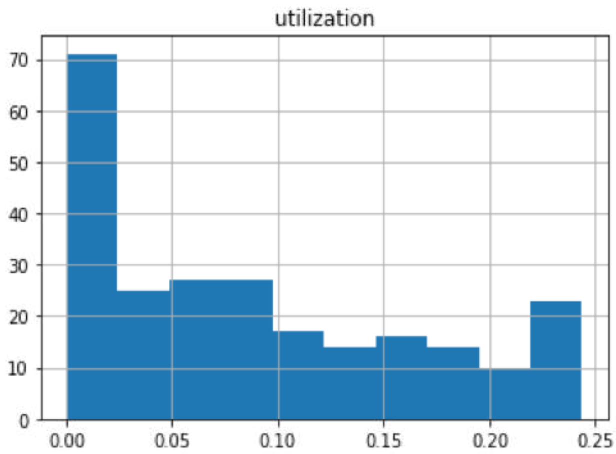
Total opex charges = INR Cr 94.01

Total Margin = INR Cr 34.47

Confirmed sites with utilisation > 20%: 31

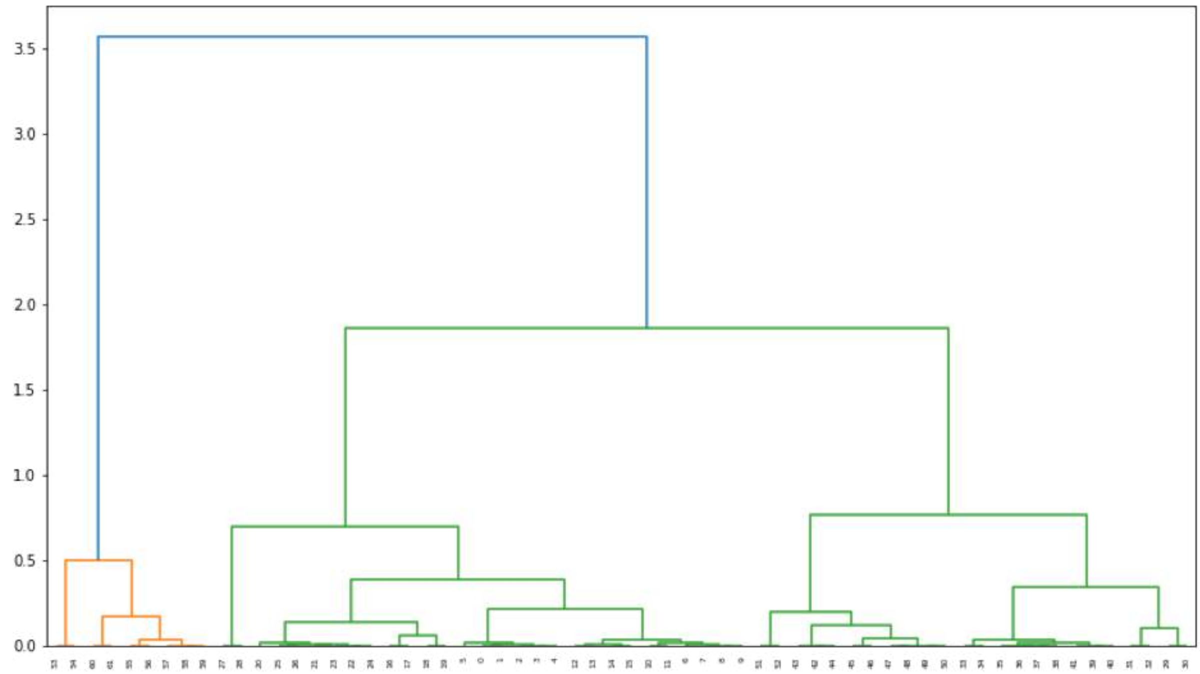
The analysis indicates that the site.xlsx provided a list of 244 sites and all 244 (244/244) were analysed for their utilisation potential. At the end of the policy duration, total capex incurred by the site was 45 Cr with 94Cr opex and 34Cr margin.

From the utilisation histogram, it can be seen that 213 out of 244 sites have utilisation < 20%. All these can be candidates for clustering reducing the list of sites to 31.



Analysis with clustering

Reducing the list of sites from 244 to 31 seems rather drastic. Hence, the clustering threshold parameter comes handy. From the left panel, user can select, say a threshold of 2% utilisation. This can be decided by looking at the dendrogram.



From the above dendrogram it can be seen that using a threshold of around 2-3% would retain many sites and yet merge a few together compared to utilisation value of 0.2. This is because many of the sites have very low utilisation. With this threshold, when user runs clustered analysis, following analysis is presented, which indicates that the total sites were reduced from 244 to 205.

Clustered analysis

Number of sites: 205/205

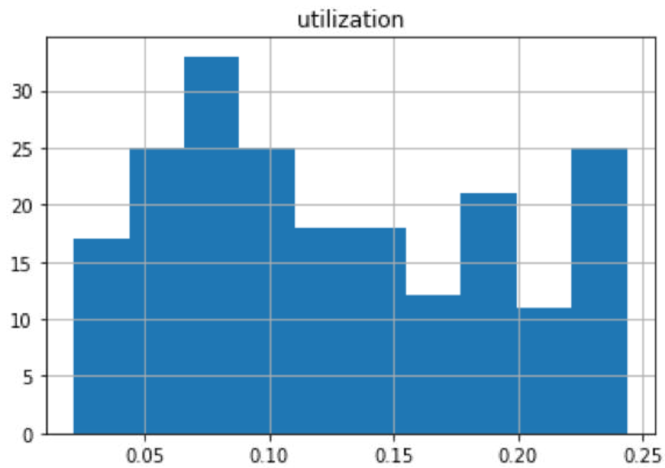
Total capex charges = INR Cr 38.38

Total opex charges = INR Cr 82.27

Total Margin = INR Cr 29.47

This shows affected numbers of capex, opex and margins accumulated for all the sites (corridor

As can be seen from the histogram (compared to the one in the initial analysis) that the utlisation is rather improved for all sites and many will be better utilised compared to before clustering, where a major chunk would hardly get utilised.



4.1.3 Download analysis

The analysis can be downloaded as an excel sheet and it contains the information in following columns

1. Name
2. Latitude
3. Longitude
4. Traffic congestion
5. year 1 kiosk
6. hoarding
7. hoarding margin
8. utilisation
9. unserviced
10. capex
11. opex
12. margin
13. max vehicles
14. estimated vehicles

The output excel can be used by the user to further their analysis and presentation using Excel tools.

5. EVCI TOOL FRAMEWORK

5.1 User inputs and assumptions

After the user inputs the required files for a new corridor analysis or chooses an existing corridor for analysis, the user is required to configure the following parameters in the left panel for performing the analysis. Please note that all parameters are provided a default value, so technically, no change is required run the analysis, however, the user is free to use sliders and buttons to modify any or all of the following parameters.

1. backoff_factor: This number is used in computing utilisation to increase / decrease the region of interest around the site. If the traffic density is higher, then it may help in increasing this number. However, “1” works in most cases.
2. M: Pull-down list of charger/vehicle types
3. years_of_analysis: Number of years for evaluation (policy duration)
4. capex_3WS: 112000 (capex for installing 3W charger)
5. capex_4WS: 250000 (capex for installing 4W slow charger)
6. capex_4WF: 1500000 (capex for installing 4W fast charger)
7. hoarding cost: 900000 (Hoarding/ advertisement boards cost)
8. kiosk_cost: 180000 (Kiosk cost)
9. year1_conversion: 0.02 (Fraction of vehicles converted to EV in year 1)
10. year2_conversion: 0.05 (Fraction of vehicles converted to EV in year 2)
11. year3_conversion: 0.1 (Fraction of vehicles converted to EV in year 3)
12. holiday_percentage: 0.3 (Fraction of vehicles on a holiday)
13. fast_charging: 0.3 (Fraction of vehicles using fast charging)
14. slow_charging: 0.15 (Fraction of vehicles using slow charging)
15. cluster: True: A button to indicate if user would like to cluster and reduce list of sites further to improve utilisation
16. cluster_th: A threshold value indicating that vehicles with utilisation below this number will be considered candidates for clustering and merging to improve over-all utilisation
17. plot_dendrogram: A button indicating if user would like to plot the dendrogram. This plot can be used to optimally identify the clustering threshold.
18. use_defaults: A button indicating if default (or assumed) values are to be used for missing values. This is useful when users may not have all the data but would like to still conduct an analysis in presence of missing values

5.2 Analysis framework

The analysis framework comprises of following two main blocks:

1. Analysis – This block analyses specified list of sites for their utilisation potential. The goal of EVCI tool is to ensure that sufficient sites are installed (assuming a certain traffic profile) and as many of them are utilised well to be financially viable for the site owner.
2. Once, the utilisation, capex, opex and margin are computed for all initial list of sites, a new derived site list can be generated using the clustering block.
3. Clustering – This block takes the initial list of sites with their computed utilisation numbers and then uses an optimal threshold value of utilisation that can be used to cluster/ merge a few sites together. The rationale is to improve utilisation numbers of as many sites as possible. A reduced set of well-placed sites has been observed to improve utilisation numbers.

It should also be noted that it is not mandatory to carry out clustering. It is hence an optional block. It is possible that the initial list of sites provides good utilisation numbers for all sites, and hence warrants no further pruning. In such a case, clustering phase can be bypassed.

a. Model platform

The model platform is built using Python v3. The user login credentials were managed using the MPEN Single Sign-On (SSO) module. The tool is hosted on a platform running instance of Python supported with following libraries.

1. fiona – for reading and writing spatial data files
2. rtree – for handing Python GIS spatial index files
3. pandas – for data manipulation and analysis
4. geopandas – for using geographic Pandas extensions
5. numpy – for array processing of numbers, strings, records and objects
6. matplotlib – python plotting package
7. shapely – for geometric objects, predicates and operations
8. scipy – optimised scientific functions writing in C and C++ for Python
9. openpyxl – for reading and writing Excel (xlsx/xlsm) files

SECTION 3

STAKEHOLDER DISCUSSION ON APPROPRIATE EVCI SITING REQUIREMENTS

1. INTRODUCTION

India has

7,59,182

registered plug-in electric vehicles, and estimates it will need

400 million

more EV customers on its road by 2030 to meet its greenhouse gas emission goals and envisaged EV penetration.

In response to the expected growth in the adoption of electric vehicles, over 25 states and UTs have notified or drafted state EV policies. The central Government has gradually given the impetus necessary to decarbonise passenger transport both public and private. However, the freight segment in India, which contributes ~45% of the transport CO_2 emissions, has been neglected to date.

As a result, there is an urgent need to decarbonise the freight sector to reduce CO_2 emissions. Converting the freight fleet from Internal Combustion Engine (ICE) to EV will mean new charging demand, and freight corridors, highways, and cities will need sufficient charging with a combination of slow, fast and option for battery swapping stations to serve freight EV users.

Data from the IEA suggests that road freight contributes more than

35%

of transport-related carbon dioxide (CO_2) emissions, and around

7%

of total energy-related CO_2 emissions.

MP Ensystems in association with Shakti Sustainable Energy Foundation's Electric Mobility Initiative has developed a publicly available mapping and forecasting EVCI planner tool. It will provide key locations and information such as network impact and revenue information about charging infrastructure across the locations identified within the freight corridor. To do so, MP Ensystems is establishing an open-source software planner tool with data and sources that are available and relevant to the tool's development. Based on interactions with stakeholders, including Government, utilities, Charge Point Operators (CPOs), freight and logistics companies, vehicle manufacturers, financing institutes, civil society and academia, the team has shortlisted 10 corridors where freight EVCI can be implemented.

This section is organised as follows: chapter 2 assesses the EVCI stakeholder landscape based on their intrinsic functions: policy, technology, implementation and finance. The chapter also covers stakeholder feedback obtained through meetings, a roundtable and an online survey.

Chapter 3 contains the methodology for selecting corridors for implementing EVCI, using criteria related to Government priorities, grid access, ease of logistics and stakeholder feedback. The chapter also contains the top 10 corridors selected on the basis of these criteria.

The final chapter contains recommendations, based on stakeholder interactions, which will facilitate implementation of freight EVCI along the selected corridors.

2. ASSESSMENT OF EVCI STAKE-HOLDERS IN FREIGHT SEGMENT

2.1 EVCI stakeholders' landscape

Stakeholder mapping is important in the evolution of this project, in identifying, analysing and understanding the interrelations between stakeholders. It provides a systematic means by which stakeholders can be analysed with their strengths and interests to influence the sector development.

The e-mobility ecosystem is composed of multiple vertically and horizontally integrated stakeholders that are responsible for facilitating investment, encouraging adoption, and ensuring the fair functioning of the industry. We conducted meetings and interactions with key stakeholders and characterised them by mapping them to their intrinsic functions.

- **Policy makers:** Freight EVCI needs support from central, state and local governments; involves multiple infrastructure development institutions in the road, highways and power sector development that span across interstate and intrastate efforts; transportation departments, environment departments setting EV targets across categories.

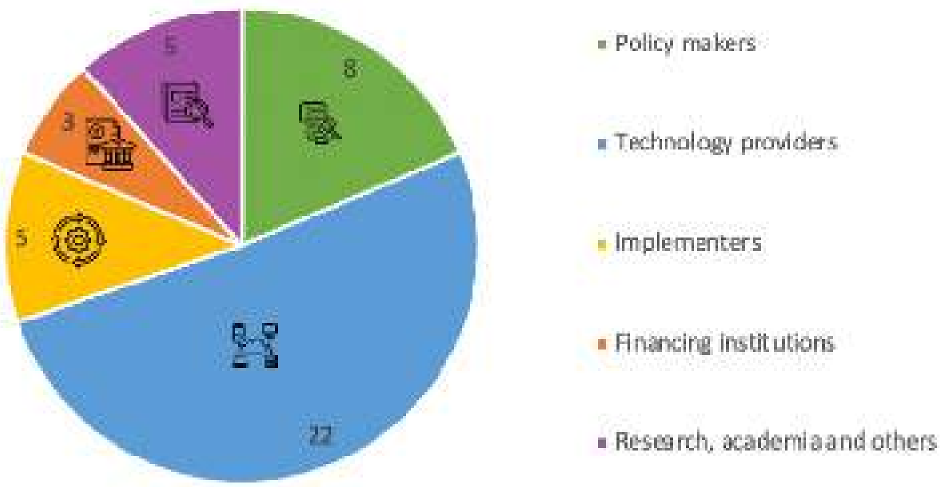
- **Technology providers:** This is an important stakeholder group in the freight electrification specifically involving charging point operators, electricity utilities, smart charging infrastructure providers, interoperability aspects and grid-interactivity related to slow, fast charging and battery swapping opportunities.

- **Implementers:** Several models of implementation are emerging in the space of faster and quicker implementation opportunities. These include publicly-funded/subsidised (DHI as an example), private ventures and public-private partnerships supporting such efforts. We have identified several central and state government supported public institutions developing business models and creating business value.

- **Financing institutions:** In order to meet the aggressive transportation electrification targets being set-forth by the central, state and city governments; substantive public and provide equity and debt investments are necessary. As such, the financing institutions, venture debt providers, venture capital providers all are important.

The pie chart shows the diverse range of 43 institutions (over 50 stakeholders) whose responses have been recorded.

Figure 1. Stakeholders Participating in Discussions



A list of stakeholders that we met is in Annexure I.

2.2 EVCI stakeholders survey tools

In order to get inputs from stakeholders across industries and across the country, we used hybrid surveying techniques including online meetings, in-person meetings, a stakeholder consultation roundtable and an online response platform.

This section includes the questions posed to stakeholders during meetings (2.2.1) and via an online platform (2.2.2).

2.2.1 Questions for stakeholder meetings

We developed a standard protocol for capturing responses from stakeholders. Specific questions that we administered during the meetings and interviews are listed below.

Questions to policy-makers:

1. Is a single-point approval process from all government departments possible, for EV freight charging point operators to create the required infrastructure?
2. Are you considering battery swapping stations and the consolidated loads as a grid support system?
3. Are you focusing on freight charging points or you are limiting to 2W and passenger vehicles at this stage?
4. As a land-use planning entity, do you have a clear picture of the specific users that can be identified as co-locations of freight EV charging infrastructure?

Questions to technology providers:

1. As a power utility, do you encounter any barriers in creating last-mile connections to the charging points meant for all types of EVs?
2. As a distribution company, do you encounter any barriers in investing in the transformation capacities required for freight electrification?
3. As a part of EVCI development, are you focusing on freight charging points or you are limiting to 2W and passenger vehicles at this stage?
4. Do you have access to enhanced technologies to create battery swapping stations for freight transit?

Questions to implementers:

1. What are the barriers and the lead times for getting all the sanctions in place from the competent authorities for you to set-up the EVCI for your investment decisions?
2. Do you have a clear mandate from the highway authorities, electricity utilities and land-use planners to set-up EVCI, specifically for freight?
3. Do you estimate enough market potential for freight EVCI?
4. What are your priorities to set-up EVCI – on the intersection of last-mile delivery and warehousing or on long-corridors or both?
5. Do you experience any barriers in raising equity and/or working capital/debt for your operations? What are your suggestions to create enough capital flow in the freight EVCI segments?

Questions to financing institutions:

1. Amongst the private equity funding opportunities that exist, do you see EVCI, as a priority sector?
2. As the EVCI space is evolving and has enough policy-push from the central government and several state governments, do you treat this sector as a sunrise sector with low-risk but higher rewards?
3. Is there a mandate to include EVCI debt and working capital requirements as a priority sector for lending? Would a clear mandate from the regulators such as the Reserve Bank of India be useful for you as a commercial bank to explore this possibility?
4. Do we see enough foreign direct investments and technology play in the EVCI space; do you see an opportunity to finance interoperability/app-based systems and data analytics around that?
5. Would you as an equity or a debt financier focus on service providers or technology developers/provider or both?

2.2.2 Online survey tool

In addition to the structured interview questions developed above to capture subjective and qualitative responses from the stakeholders, we also developed an online survey that we shared with several stakeholders. The simple survey to capture responses as a rating on a scale of 1-5 was also used during a multiple stakeholder roundtable conducted by us on 9th September 2022.

The questions in the survey instrument are below:

Topic	Units
Questions related to policies:	
1. Do we have clear policies from central or state governments that articulate importance of freight electrification?	1: low or no clear policies 5: clear policies
2. Do you face any barriers in securing approvals for EVCI set-up from land-use authorities, highway authorities?	1: high barriers 5: no barriers
3. Does Indian EV space have technical standards for EVCI?	1: absence of standards 5: very clear standards
Questions related to technologies:	
4. Do you see an opportunity and need to collaborate amongst EVCI and CPOs to create interoperability (for app-based systems) amongst their platforms as well the government-run platforms?	1: not desirable 5: highly desirable
5. Do we have enough charging points technology providers or access to technologies in India?	1: lack of technology providers 5: sufficient presence of technology providers
Questions related to implementation	
6. Do the electricity distribution companies take up investments to provide service connections to EVCI on priority or are delays experienced?	1: slow process 5: expedited process
7. Do you see enough scope of freight EVs on interstate or intra-state corridors for 3W, 4W and multi-axel EVs?	1: low scope 5: high scope
8. Do you see enough scope for freight EVs on intersections of highways and cities/towns for 3W, 4W and multi-axel EVs?	1: low scope 5: high scope
9. Would co-locating freight charging points with passenger and 2W charging points be useful?	1: Freight and Private co-location not useful 5: Co-location useful
10. Do you see any scope for battery swapping systems for 3W or 4W freight vehicles, based on the availability of swapping technology?	1: low scope 5: high scope
Questions related to financing:	
11. Are there enough financing conduits for the charging point operators to access equity capital? Is there enough interest from private equity players in this sector?	1: access to equity capital is low 5: access to equity capital is high
12. Is the ecosystem to access debt and working capital for the charging operators robust? What's the level of access to debt/working capital finance?	1: access to debt/working capital is low 5: access to debt/working capital is high

The survey was shared through the MP Ensystems website, EVCI website, Linked In, Twitter, email, and during the stakeholder roundtable.

2.3 Summary of responses from EVCI stakeholders

2.3.1 Stakeholder responses at meetings

The responses received from stakeholders at meetings and the roundtable have been detailed below, keeping the respondents' affiliations anonymous.

Insights from policy makers

- A few states such as Delhi and Union Territories such as Chandigarh have created single-window approval system for EVCI. Pan-India, such a system can be operationalised for quicker penetration of charging infrastructure.
- Government of Himachal Pradesh apprised that they have introduced electric buses on all the major routes in the state. Himachal is also developing 4 model cities to demonstrate excellence in the field of Electric Vehicle in the state. The state government is collaborating with EESL to promote charging infrastructure in the state.
- UT Chandigarh mentioned the UT Administration is offering zero rentals from charging point operators in the city for first two years under the EV policy of Chandigarh. The UT administration is about to launch tenders for the battery swapping system in the city.
- Haryana Government has notified the EV policy in the state and is offering electricity to charging point operators at subsidised rates.
- Punjab Renewable Energy Development Agency (PEDA) mentioned that Government is offering subsidy to the tune of Rs 30000 to Rs 50000 per electric vehicle in the state and is targeting 45% increase in sales from last year.
- Ministry of Micro Small and Medium Enterprises Development Institute (MSME DI) stated that the Indian Government while pushing the agenda of Aatma Nirbhar Bharat has rolled out a number of schemes to promote Electric Vehicles in the states. Maruti Suzuki is coming up with a unit for Electric Vehicles in Haryana and is exploring vendors to supply parts which is a big opportunity to new entrepreneurs, and Ministry of MSME is supporting the budding entrepreneurs in a big way.
- Freight EVCI will need higher capacity of service connections; this will need careful planning as several states charge a normative number for fixed cost towards developing such an infrastructure and a few states also have the provision to recover the cost of service connections from the users.
- Co-located charging infrastructure with the existing high tension connections is a viable option and users such as petrol pumps, warehouses and large restaurants have a clear opportunity to develop such an infrastructure.

- The Ministry of Road Transport & Highways has defined the life of petrol and diesel vehicles. Defining the life corresponding to roadworthiness of the EVs, including LCVs, MCVs will be useful for buyers.
- Charging of LCVs and MCVs would need substantial space allocations. Land-use planners and roads/highways authorities need to carry out an exercise to define users in their prospective land-use planning.
- While we wait to have advanced chemistry battery cells rolled-out; standards-setting related to the battery technologies and battery management systems is essential and should be developed further.
- A mechanism to create battery testing facilities is essential for the purpose of adherence to the testing protocols.
- Battery swapping is still at a nascent stage in India and certain exemplars can emerge should an institution such as the Ministry of Power develop specific opportunities through discom involvement.

Insights from technology providers

- Technologies related to freight electrification including slow, fast and battery swapping systems are available in the Indian context; specific support by way of technology demonstrations is needed in this context.
- Data analytics is a key to set-up an integrated interoperable charging point locator service. Such a platform that is industry-driven, industry-developed and managed would be useful.
- Smart charging infrastructure hasn't been tried in India so far. As it is likely to bring load balancing benefits to discoms too, it is essential to begin developing such a process. Specific modelling opportunities should be explored by partnering with the distribution companies.

Insights from implementers

- A key challenge faced by charging point operators is the delay in obtaining permission from the government and public institutions to facilitate their investments.

- While charging point operators, who are start-ups, are technically capable of setting up charging points, the public sector procurement process requires higher level of prequalification criteria that is a deterrent to market creation.
- A unified mechanism to facilitate passing on of central and state government subsidies is necessary to ease infrastructure development.
- Charging points established on the outskirts of cities have been attracting good revenue due to scarce infrastructure. This also implies that in the freight charging point category, charging points established on the corridors and on the fringes of cities would be useful; specifically in the area of last-mile/logistics connectivity associated with warehousing.
- Public-private partnerships in co-located charging sites with risks assumed by both the participants has not been explored much beyond land-leasing. Such newer business models would be useful.
- IOCL is promoting green energy in a big way and has undertaken a target to install 1000 EV chargers in 3 years and 2700 Electric Vehicle charges have been installed in first year. IOCL is also promoting battery swapping, and is already doing 100- 120 battery swaps a day as on date.
- Freight OEMs require fast charging and ultra-fast Charging networks. States of Punjab, Chandigarh and Himachal Pradesh have identified the deployment for fast chargers along several road networks.

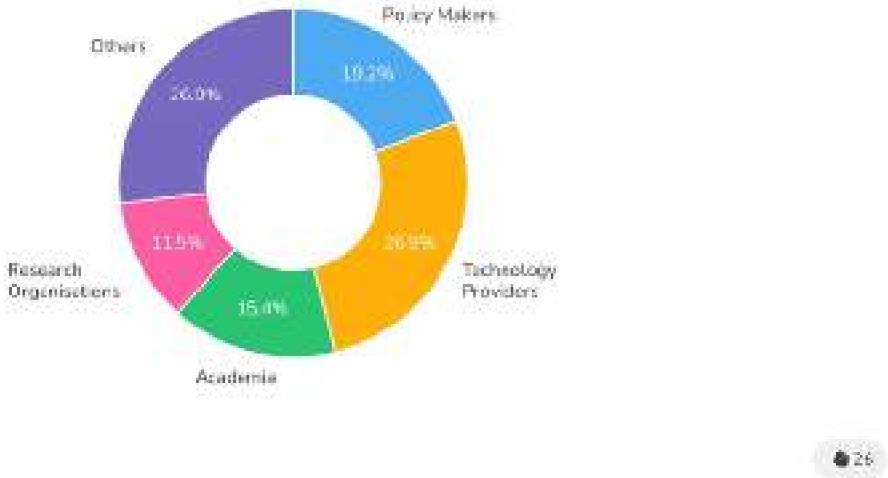
Insights from financing institutions

- Commercial banks are not positive about EVCI start-ups and the government process should encourage setting up of priority sector lending requirements and import substitution facilitated by start-ups needs to be encouraged.
- Training bankers on the EV space is essential and revenue guarantee or debt servicing mechanisms can be built.
- Specialised funds that are investing in start-ups seem to be interested in the EV charging space. A definitive effort to attract additional investments also backed by the patenting opportunities is essential.

2.3.2 Summary of responses from EVCI stakeholder surveys

We have categorised the responses captured on a scale of 1 to 5 related to four sets of questions, namely clear policies, availability of technology, ease of implementation and availability of financing. Respondents scored each question from 1-5, with 1 indicating barriers and 5 indicating favourable environment. The pie-chart below shows the distribution of participants. The responses were anonymised to enable them to freely share their opinions. The total sample size of the responses is 26.

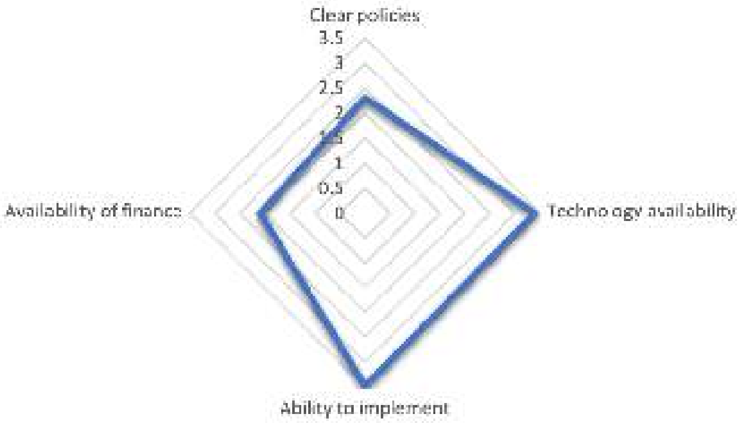
Figure 2. Participants of Survey, Chandigarh



Source: MP Ensystems Research 2022

The figure below shows the average response to the questions.

Figure 3. Stakeholder Perceptions on Freight EVCI



Source: MP Ensystems Research 2022

The questions asked stakeholders their perspectives on clarity of policies and standards, accessibility of technology, investment in service connections by electricity suppliers, scope for freight EVs along inter-city corridors, scope for battery swapping and availability of finance for working capital and equity.

The score indicates that the stakeholders surveyed believe that financing and policy interventions are two important factors required to expand freight EVCI.

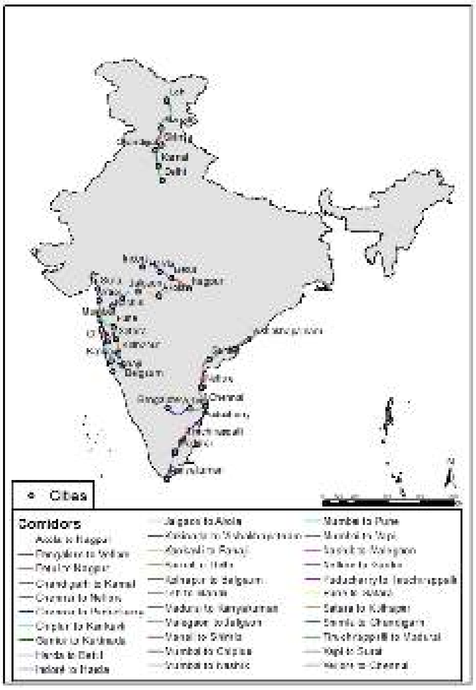
3. SELECTING CORRIDORS FOR PROPOSED IMPLEMENTATION

3.1 Corridor selection methodology

The EVCI project proposes a systematic approach to determine suitable criteria to select corridors. The team at MP Ensystems initiated the modelling exercise, by identifying where LCV, MCV, and fleet operators are likely to halt to charge their vehicles, which required identifying the most likely adopters and sizable occupancy of charging to maximise the operator's revenue. To encourage owners in the logistics and freight segment to make the transition to EVCI, finding the optimum locations along the corridors is crucial. Mapping EVCI is helpful to stakeholders to understand where and how many chargers and its types will be required to service freight EV drivers in each corridor area.

Under this project, 32 corridors across India were selected for evaluation of EVCI appropriate location mapping. We are running simulations for these corridors on the EVCI planner tool to determine suitable sites for locating EVCI.

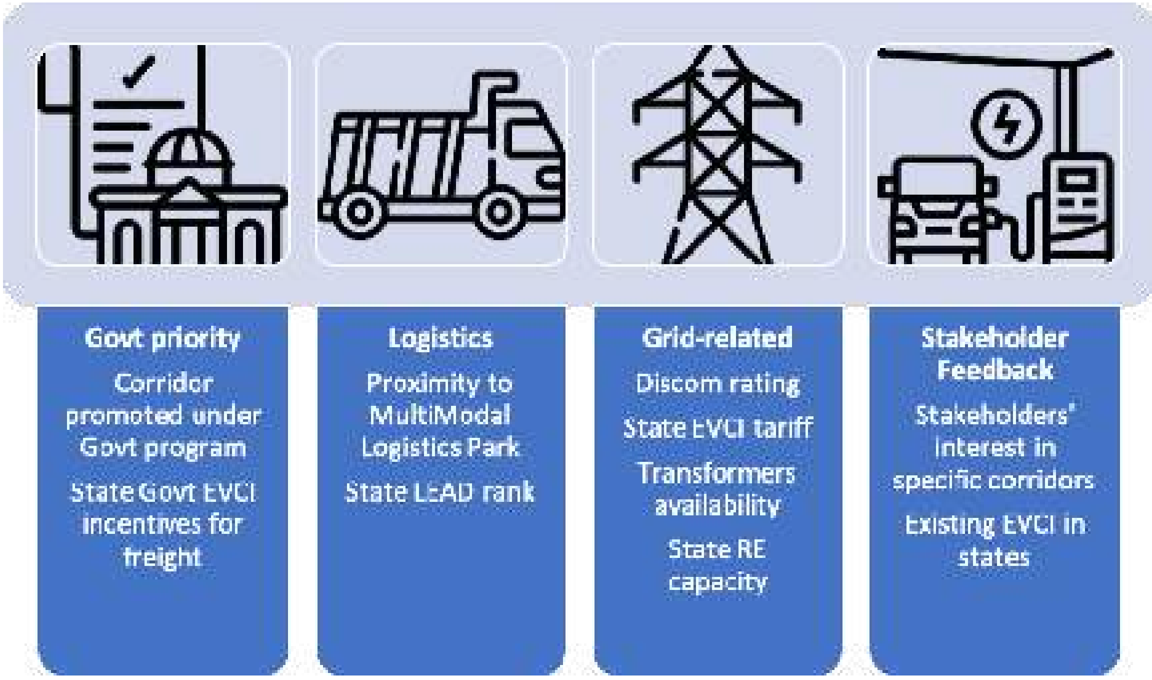
Figure 4. 32 Freight corridors in India



Source: MP Ensystems Research 2022

One of the aims of the project is to select corridors where CPOs, investors, utilities, logistics companies and highway authorities can facilitate the installation of EVCI. In order to select 10 corridors out of the above 32 corridors, we have listed four criterias under which there are 10 indicators for evaluating corridors, as seen in the figure below.

Figure 4. 32 Freight Corridors in India



Source: MP Ensystems Research, 2022

The table below shows the methodology followed for capturing information on the indicator and converting qualitative and quantitative data into a score from 0-10.

Table 1. Methodology for ranking corridors

Topic	Units	Scoring
Highway promoted under Govt program	Whether the corridor is part of Bharatmala, or one of the cities on it is a hub for a Bharatmala corridor	If corridor is part of Bharatmala Pariyojana: 10 If part of corridor is a hub on Bharatmala: 5
Incentives for freight EVCI	Does the state EVCI Policy have specific incentives for freight	State has EVCI policy AND incentives or target for freight: 10 EV policy, but no freight incentives: 2 No incentives and no policy: 0
Proximity to Logistics Parks	Multi Modal Logistics Parks lie along the corridor	For 1 or more MMLP: 10 No MMLP: 0
LEAD rank	Government logistics performance ranking Logistics Ease Across Different States (LEAD)	For more that 1 state, consider lowest rated state LEAD ranked in top 5 rank: 10 Ranked 6-10: 8 Ranked 11-20: 5 Unranked: 0

Tariff score	State or UT HT tariff for EV charging	For more than 1 state, take average tariff Tariff from Re 1 to Rs 5.9: 8 Tariff above Rs 6: 5 No tariff: 0
Grid availability	Distribution Transformers in proximity to corridors	Yes: 10 Yes for part of the route: 5 Data NA: 2 No: 0 Here, Yes refers to data provided to us or data available in the public domain
RE Capacity	Share of RE as a total of state’s installed capacity	RE greater than 10%: 9 5-10%: 8; 1-5%: 5 0-1%: 2
EVCI	Existing EVCI in the state	50+ charging stations: 8 11-50 charging stations: 5 0-10 charging stations: 2
Stakeholders Ranking	Interest in setting up EVCI for freight along the corridor	Top 10 corridors selected by stakeholders surveyed (mainly the responses captured during roundtable at Chandigarh) Top 10 corridors: 10 Other corridors: 0 To eliminate regional bias in selecting corridors at the roundtable, participants were asked to select 2-3 corridors from each region of India
Overall Score		Weighted average of the scores above Stakeholders’ feedback was given 50% weight, and all the other criteria were given 50% weight

The purpose of these indicators is to assess corridors that are most likely to be first movers in implementing EVCI, with basic infrastructure, policy support and private sector in place.

3.2 Shortlisted 10 corridors

We rated the corridors against the criteria described above. The final scores and ranks of the 32 corridors are in the table below:

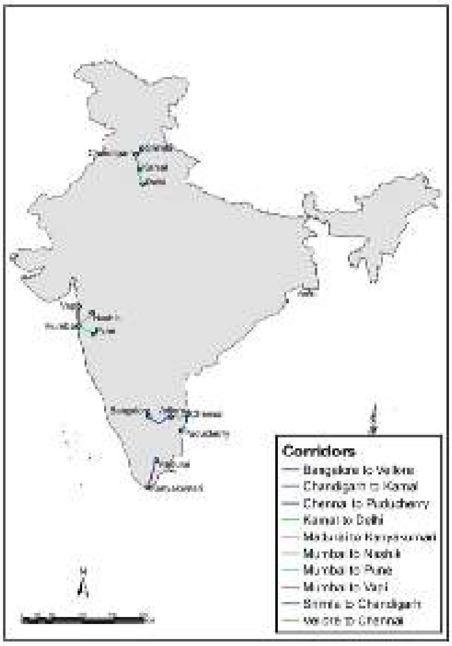
Table 2. 32 Corridors Scores

Nr	From	To	Distance	Part of Bharatmala	Proximity to Logistics Parks	LEAD Rank	Govt. Incentives for Freight EVs	Score of Utility	Grid Availability	Corridor Avg Tariff	PoD	State RE capacity	Stakeholder score	Overall Score
1	Mumbai	Nashik	167	10	10	10	10	8	10	4.1	8	8	10	8.9
2	Mumbai	Pune	148	10	10	10	10	8	10	4.1	8	8	10	8.9
3	Madurai	Kanyakumari	243	10	10	10	10	2	2	5.2	5	9	10	8.2
4	Mumbai	Vapi	175	5	10	10	10	8	5	4.1	2	8	10	8.1
5	Vellore	Chennai	138	10	10	10	10	2	2	5.2	5	8	10	8.1
6	Karnal	Delhi	120	5	10	15	10	8	2	4.8	5	2	10	8.1
7	Bangalore	Vellore	211	10	8	8	10	2	2	5.2	5	9	10	8.0
8	Chandigarh	Karnal	125	0	10	10	10	8	2	5.8	2	2	10	7.5
9	Chennai	Puducherry	151	10	0	3	10	2	2	5.2	5	2	10	6.8
10	Shimla	Chandigarh	110	0	0	10	2	8	2	5.8	2	2	10	6.0
11	Nashik	Malegaon	108	10	10	10	10	8	10	4.1	8	8	0	3.9
12	Akola	Nagpur	250	10	10	10	10	8	10	4.1	8	8	0	3.9
13	Mumbai	Chiplun	246	10	10	10	10	8	10	4.1	8	8	0	3.9
14	Pune	Satara	113	5	10	10	10	8	10	4.1	8	8	0	3.7
15	Vapi	Surat	117	5	10	10	10	10	5	4.1	8	9	0	3.6
16	Malegaon	Jalgaon	145	10	0	10	10	8	10	4.1	8	8	0	3.4
17	Jalgaon	Akola	191	10	0	10	10	8	10	4.1	8	8	0	3.4
18	Chiplun	Kankavli	182	10	0	10	10	8	10	4.1	8	8	0	3.4
19	Satara	Kolhapur	121	0	10	10	10	8	10	4.1	8	8	0	3.4
20	Kolhapur	Belgaum	112	0	10	10	10	5	10	4.5	8	8	0	3.3
21	Tiruchirappalli	Madurai	138	10	10	10	10	2	2	5.2	5	9	0	3.2
22	Guntur	Kakinada	250	10	8	3	10	2	2	6.7	8	9	0	3.1
23	Kakinada	Vishakhapatnam	155	10	8	3	10	2	2	6.7	8	9	0	3.1
24	Nellore	Guntur	245	10	8	4	10	2	2	6.7	8	8	0	3.0
25	Chennai	Nellore	176	10	8	8	10	2	2	5.9	5	8	0	2.9
26	Indore	Harda	154	10	10	5	10	2	2	6.5	5	8	0	2.9
27	Betul	Nagpur	175	10	10	5	10	2	2	5.2	2	8	0	2.7
28	Kankavli	Panaji	110	10	0	5	10	8	5	4.1	5	2	0	2.5
29	Harda	Betul	126	10	0	5	10	2	2	6.2	5	8	0	2.4
30	Puducherry	Tiruchirappalli	265	10	0	3	10	2	2	5.2	5	2	0	1.8
31	Manali	Shimla	290	0	0	6	2	8	2	6.7	2	6	0	1.8
32	Leh	Manali	427	0	0	3	0	5	0	0.0	2	2	0	0.5

Source: MP Ensystems Research, 2022

The 10 shortlisted corridors are in the map and list below.

Table 3. 32 Corridors Scores



From	To	Distance, Km
Shimla	Chandigarh	110
Chandigarh	Karnal	125
Karnal	Delhi	120
Mumbai	Vapi	175
Mumbai	Pune	148
Mumbai	Nashik	167
Bangalore	Vellore	211
Vellore	Chennai	138
Chennai	Puducherry	151
Madurai	Kanyakumari	243

Source: MP Ensystems Research, 2022

The selected corridors scored highest across categories- i.e. the states had policies in place for freight EV, there are major logistics hubs along the corridors, EVCI tariffs are low and data on the grid is available. These corridors were also selected by surveyed stakeholders.

4. RECOMMENDATIONS

Based on our interactions with over 100 respondents through in-person and virtual meetings and their perspectives, we present the following recommendations for each part of the freight EVCI ecosystem.

Recommendations relevant to policies

- Unified policies from multiple government departments at the central, state and urban local bodies to approve investment decisions by public and private sector charging point operators would help expedite the infrastructure development.
- A quicker effort to standardise the battery and battery management system; specifically related to the battery swapping requirements would support creation of better battery swapping infrastructure and looking at smart charging.
- More specificity to be embedded in policy from Commercial Electric Vehicles point of view
- Interventions by Ministry of Power and/or the Central Electricity Authority to create value to be captured through smart charging (selective TOU) and battery stacks in a battery swapping techniques would be useful.

Recommendations relevant to technologies

- Smart charging, unified app-based charging point locators and associated technology demonstrations supported by the public institutions would help.
- Application of data analytics to create value-proposition to charging point operators from the grid-operation and support would help.

Recommendations relevant to implementation

- Encouraging technology-driven start-ups supporting infrastructure development through easing of bidding norms in the public tenders as much as allowed by law will support the new entrants.
- Public-private partnerships with risks allocated to the participants can be tried out on key corridors and the intersections of highways and city road infrastructure.

- Charging point operators needs to focus on additional value-capture through ancillary services, smart charging and grid support (related to battery stacking/swapping services).
- Co-location of services and charging infrastructure should be favoured such that charging happens as a part of the journey.

Recommendations relevant to financing institutions

- Banking regulators including EVCI investments in the priority sector lending would be useful for the start-ups, to access debt finance and working capital, which will be a positive step forward.
- Public sector entities joining the start-up community to assure the private equity funds on revenue realisation from the charging infrastructure would help.

ANNEXURE 1: LIST OF STAKEHOLDERS

The team received the views of individuals at the following organisations, through hybrid surveying techniques including online meetings, in-person meetings, stakeholder consultation roundtable and an online response platform.

No.	Organisation	Institution Type	Location
1	Central Electricity Authority (CEA)	Policy makers	Delhi
2	Department of Science and Technology	Policy makers	Delhi
3	Bureau of Energy Efficiency (BEE)	Policy makers	Delhi
4	Maharashtra Electricity Regulatory Commission (MERC)	Policy makers	Mumbai
5	Madhya Pradesh Electricity Regulatory Commission (MPERC)	Policy makers	Bhopal
6	Gujarat Electricity Regulatory Commission (GERC)	Policy makers	Gandhinagar
7	Ministry of Micro Small and Medium Enterprises	Policy makers	Delhi
8	Chandigarh Renewable Energy and Science & Technology Promotion Society (CREST)	Policy makers	Chandigarh
9	Madhya Gujarat Vij Company Ltd. (MGVCL)	Technology providers	Gujarat
10	Dakshin Gujarat Vij Company Ltd. (DGVCL)	Technology providers	Gujarat
11	Madhya Pradesh Paschim Kshetra Vidyut Vitaran Company Limited (MPPKVVL)	Technology providers	Indore
12	The Calcutta Electric Supply Corporation (CESC)	Technology providers	Mysore
13	Statiq	Technology providers	Gurgaon
14	BRPL	Technology providers	Delhi
15	Magenta	Technology providers	Mumbai
16	Volttic	Technology providers	Lucknow
17	EVage	Technology providers	Chandigarh
18	BSES Yamuna Power Limited (BYPL)	Technology providers	Delhi
19	Tata Power	Technology providers	Mumbai
20	Convergence Energy Services Limited (CESL)	Technology providers	Mumbai, Delhi
21	Adani Power	Technology providers	Mumbai

22	Maharashtra State Electricity Distribution Company Limited (MSEDCL)	Technology providers	Mumbai
23	Tata Motors	Technology providers	Mumbai
24	ASHRAE	Technology providers	Chandigarh
25	Evage Automobile Pvt Ltd	Technology providers	Delhi
26	Fortum India	Technology providers	Delhi
27	Vijnata private limited	Technology providers	Delhi
28	Genesis BCW	Technology providers	Delhi
29	Global power Solution	Technology providers	Chandigarh
30	Punjab State Power Corporation Ltd (PSPCL)	Technology providers	Patiala
31	Statiq	Technology providers	Gurgaon
32	Erisha Emobiliy Pvt Ltd	Technology providers	Delhi
33	ZEV Point E-Mobility	Technology providers	Chandigarh
34	The Maharashtra State Road Development Corporation Limited (MSRDC)	Implementers	Mumbai
35	Mahatma Phule Renewable Energy & Infrastructure Technology Ltd (Mahapreit)	Implementers	Mumbai
36	Punjab Energy Development Agency (PEDA)	Implementers	Chandigarh
37	Indian Oil Corporation (IOC)	Implementers	Chandigarh
38	Haryana Renewable Energy Development Agency (HAREDA)	Implementers	Chandigarh
39	CKers Finance	Financing institutes	Mumbai
40	State Bank of India (SBI)	Financing institutes	Mumbai
41	Bank of India (BoI)	Financing institutes	Mumbai
42	Indian Institute of Technology Bombay (IIT Bombay)	Research, academia and others	Mumbai
43	German Agency for International Cooperation (GIZ) India	Research, academia and others	Delhi
44	International Council on Clean Transportation (ICCT) India	Research, academia and others	Delhi
45	Centre for Innovation & Incubation	Research, academia and others	Mahendragarh
46	Indian School of Business	Research, academia and others	Mohali

SECTION 4

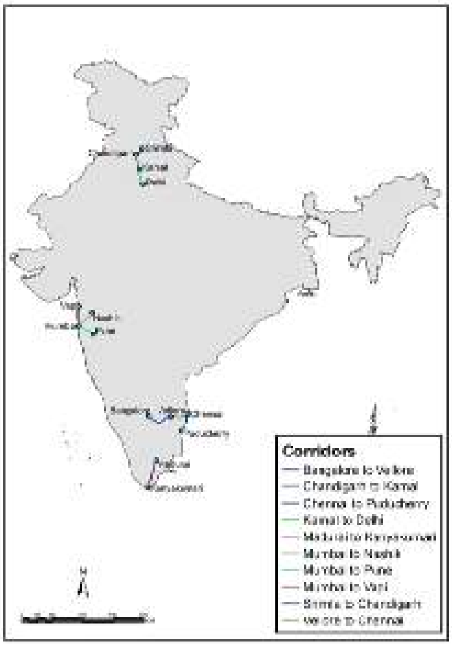
RECOMMENDATIONS ON EVCI INVESTMENTS

1. INTRODUCTION

MP Ensystems is working to determine the gaps and opportunities in developing charging infrastructure for India's freight fleet. The purpose of this report is to estimate the investment required to set up EVCI along 10 selected corridors, as well as summarise the MP Ensystems team's interaction with EV manufacturers, investors and other stakeholders in the period September- November 2022.

Using the EVCI siting tool https://www.evci.in, the following 10 corridors have been selected for investment.

Figure 1. 10 Selected freight corridors for investment



From	To	Distance, Km
Shimla	Chandigarh	110
Chandigarh	Karnal	125
Karnal	Delhi	120
Mumbai	Vapi	175
Mumbai	Pune	148
Mumbai	Nashik	167
Bangalore	Vellore	211
Vellore	Chennai	138
Chennai	Puducherry	151
Madurai	Kanyakumari	243

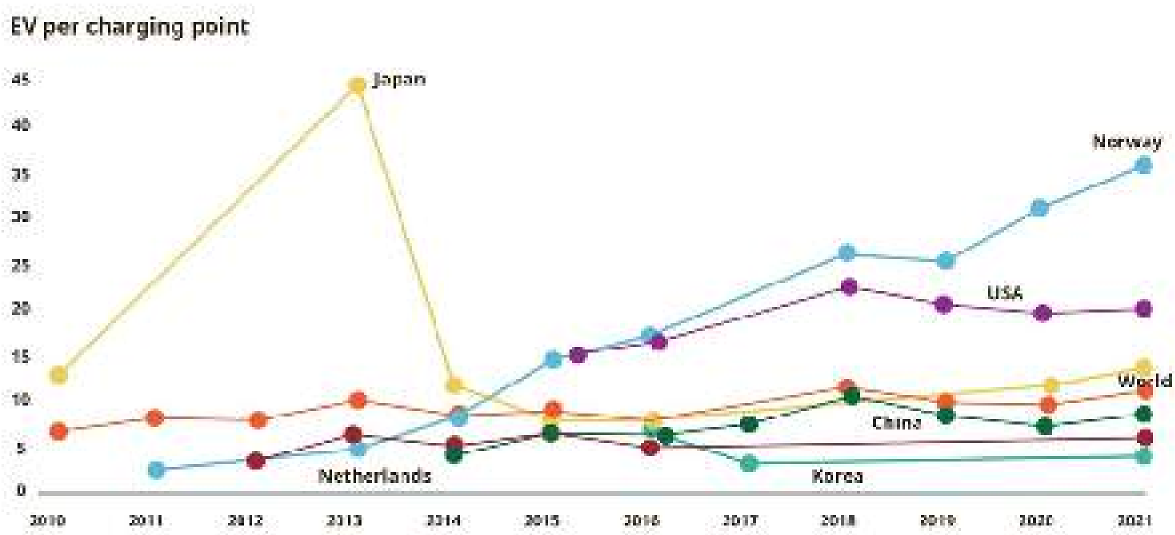
Source: MP Ensystems Research, 2022

2. ESTIMATES OF INVESTMENT FOR FREIGHT EVCI

India currently has approximately 2,800 public charging stations, as of August 2022, with approximately 1 public charger for every 135 EVs. The worldwide average in 2021 was 10 EVs per charger, with China having a ratio of 7 EVs per charger, about 30% of these are estimated to be fast chargers.

Looking specifically at the freight sector, the chart below shows the number of LDVs (Light Duty Vehicles) per charging point in selected countries.

Figure 2. Electric LDVs per charging point in selected countries



Source: IEA, 2020

Box 1: Investment in EVCI along highways

The central government has already sanctioned funding for 1,576 charging stations across 9 Expressways and 16 Highways under Phase II of the FAME India Scheme, to be funded from the INR 1,000 crore allocation for EVCI.

There is no one-size-fits-all recommended ratio of EVs to charging stations, with factors such as location of warehouses, driving pattern, vehicle mix all determining the required number of charging stations. However, India plans to install 46,000 EV chargers across the country by 2030, for which an investment of INR 14,000 crores will be needed from public and private sectors. Box 1 contains an estimate of central government funds for EVCI along highways.

In order to estimate the investment required for setting up EVCI along the 10 selected freight corridors, the following heads have been used to calculate the consolidated cost for each charging station:

Capital expenditure	Operating expenditure
EVCI equipment	Land lease
Installation and commissioning	Salaries
	Maintenance

The cost of land has not been considered a capital expenditure, since most CPOs or investors are not looking to purchase land to set up EVCI. In most cases, EVCI for freight is being set up on or leased land.

Owned land

In this case, CPOs are petrol pumps, restaurants, logistics parks and other businesses already established along highways.

Land under lease

CPOs may lease land from National Highway Authority of India (NHAI), the government or private owners. NHAI is accepting bids from concessionaires for 700 locations to set up EVCI and other facilities on 2-4 hectare plots along highways. Some state governments are providing public land to CPOs at no charge, but require CPOs to share revenue.

The table below shows the estimated investment for setting up charging stations along the 10 freight corridors for 131 charging stations is approximately 72.3 crores. This estimate does not include any incentives provided by state or central governments

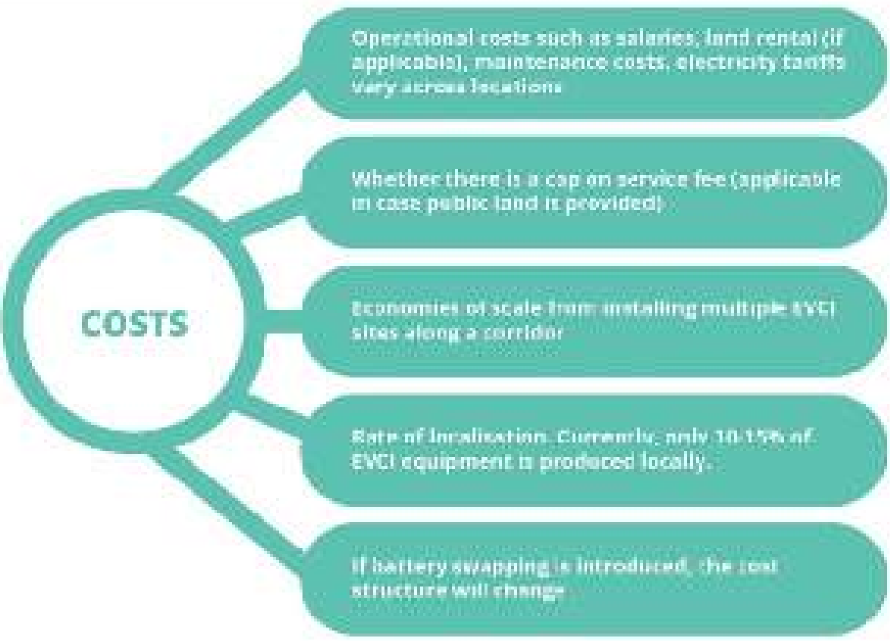
Table 1. Investment for EVCI along 10 freight corridors

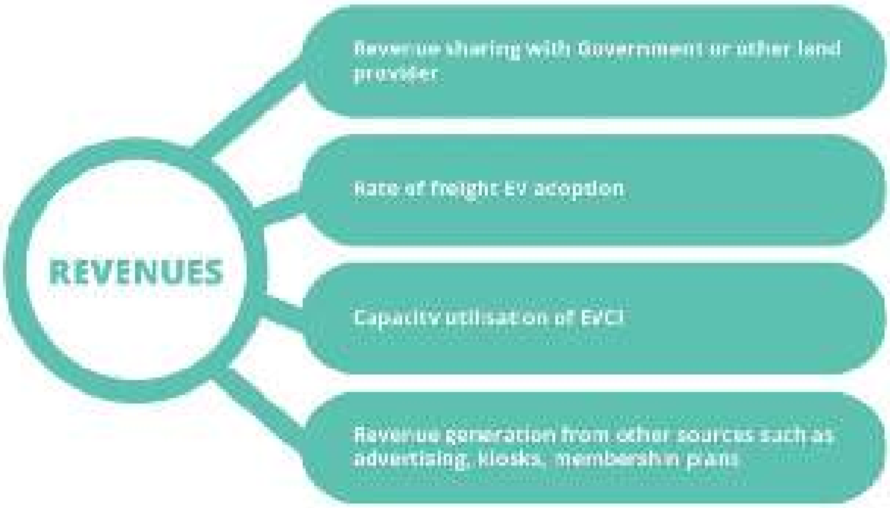
Costs	Units	Costs
Equipment	INR	40,00,000
Installation and commissioning	INR	10,00,000
Operating Costs for 1 station	INR/year	5,20,000
Total cost for setting up EVCI at 1 location	INR	55,20,000
Nr of EVCI sites on 10 corridors	Units	131
Total cost for setting up EVCI along 10 corridors	INR crore	72.3

Source: MP Ensystems Research, 2022

The estimated investment for all 32 corridors, at 409 locations is INR 226 crores. The assumptions for these estimates are in Annexure 1. An excel-based tool to calculate investment in freight EVCI for a charging station or for several charging stations along a corridor is available at https://www.evci.in.

While the investment has been calculated pan-India, the return on investment in freight EVCI will vary greatly depending on some of the factors below:





3. KEY FINDINGS FROM STAKE-HOLDER DISCUSSIONS

This section contains a summary of findings from discussions held with freight EVCI stakeholders.

3.1 OEMs

The MP Ensystems team met five EV and EVCI OEMs (at their request, the responses have been kept anonymous), their responses on policy, technology, implementation and finance are below:

Policy

- Targets for freight EVs/HDVs are needed at a national and state level
- Rules of registration and road tax differ in different states, which affects consumer adoption

Technology and Implementation

- There is a need for developing additional charging infrastructure, strengthening the local and national supply chain, and creating consumer awareness and bringing behavioural change.
- Range anxiety still remains one of the topmost concerns and even with the present battery technologies it is not feasible to travel longer distances without charge. This becomes an important concern for freight.
- Cost of battery is single determining factor along with power electronics which constitute upto 2/3rd the cost of an EV. India is still dependant on imports and uneconomical low volumes, gaps in supply chains which also contribute to the high cost of EVs.
- Supply chain problems and gaps especially related to Lithium ion batteries, which are still heavily imported. Also much research is needed in robust technology that can be made local so as to reduce import dependency and vulnerability of the supply chain.
- EVSE (Electric Vehicle supply equipment) needs to be installed at appropriate places such that long range journeys can be undertaken. Also availability of service that could cater to a vehicle breakdown on roads is almost negligible.
- Addressing issues around multiple standards is needed to ensure wider coverage of charging infrastructure. At present there is no standardisation pertaining to EVSE, every company has its own charging port which makes it increasingly difficult to set up an integrated charging ecosystem.

- Temperature affects the performance of EV batteries and OEMs are struggling with either too hot or too cold temperature settings and performance of EVs in those settings.

Financing

- The upfront cost of buying an EV is still almost 50% more than the cost of an ICE vehicle, which affects EV demand in a price-sensitive market like India.
- For manufacturers, there is a significant upfront investment, which affects the ROI
- Low interest loans and financial incentives for manufacturers and consumers both need to be introduced and enhanced
- For entrepreneurs wanting to run EVCI, bank loans may be required. Greater awareness on EVCI business model and expected revenue is needed among banks and business owners

3.3 Investment from financing and implementing entities

3.3.1 Financing freight EVCI

The following table includes the major sources, recipients and terms of financing EVCI

Table 2. Sources and recipients and financing

Implementer	Requirement	Financing terms	Investor/ lender
Individuals or small businesses	Setting up EVCI as a standalone business, or in addition to retail business	• Business loans of INR 5 to 75 lakh • Loan tenures of 12 to 36 months • Unsecured loans • Interest rates at 15% and above	Banks and financial institutions such as SBI, Axis Bank, Tata Capital
Logistics or freight company	Setting up captive EVCI, or EVCI along corridor for own- and third-party vehicles	• Most investments in this space are equity placements in start-ups with expectation of hurdle rates above 25% • Other conventional businesses access finance through lending institutions and banks at a token of 8% to 12%, based on business relationships	Banks and financial institutions such as SBI, Axis Bank, cKers Finance, Tata Cleantech Capital, equity investors
CPOs	Setting up EVCI for freight vehicles along corridors	• This space is split between emerging CPOs backed by global private equity (PE) funds and large Indian PSUs (such as EESL and IOCL) • Terms of finance vary, with hurdle rates upwards of 25% and internal capital recovery expectations of 16% for PSUs	Banks, financial institutions, equity investors, multilateral aid agencies, global PE funds
Government agencies	Setting up EVCI for freight vehicles along corridors	• Long term loan tenures • Low interest rates	Banks, infrastructure funds, climate finance, multilateral aid agencies, green bonds

Source: MP Ensystems Research, 2022

3.3.2 Promoting investment in EVCI

Based on research and discussions with financial sector stakeholders, some measures that could promote EVCI investment are below:

- For individuals or small businesses: While the costs of setting up the business are well known, the expected revenue is hard to predict. Investment in EVCI by these businesses could be promoted by including EVs and EVCI in Priority Sector Lending. Interest rate subventions are another tool to promote lending to small businesses.
- Financing freight businesses for charging along corridors- In the case of logistics firms, fleet operators and last-mile delivery, investment in EVCI could be promoted through a risk-sharing mechanism led by the fleet operator. Fleet operators and logistics companies can use their own funds, or leverage their relationships with banks to provide partial credit guarantees to businesses that set up EVCI along corridors and at the periphery of cities.
- Government, multilateral institutions, climate finance can develop risk-sharing mechanisms for banks and FIs, that cover potential losses from financing EVCI. The aim will be to spread out the risk and build lender confidence in the sector.

ANNEXURE 1: INVESTMENT IN FREIGHT EVCI

The number of charging stations along the 10 corridors was determined by running the EVCI tool and using the clustering function to reduce the number of charging stations near each other, to maximise CPO revenue.

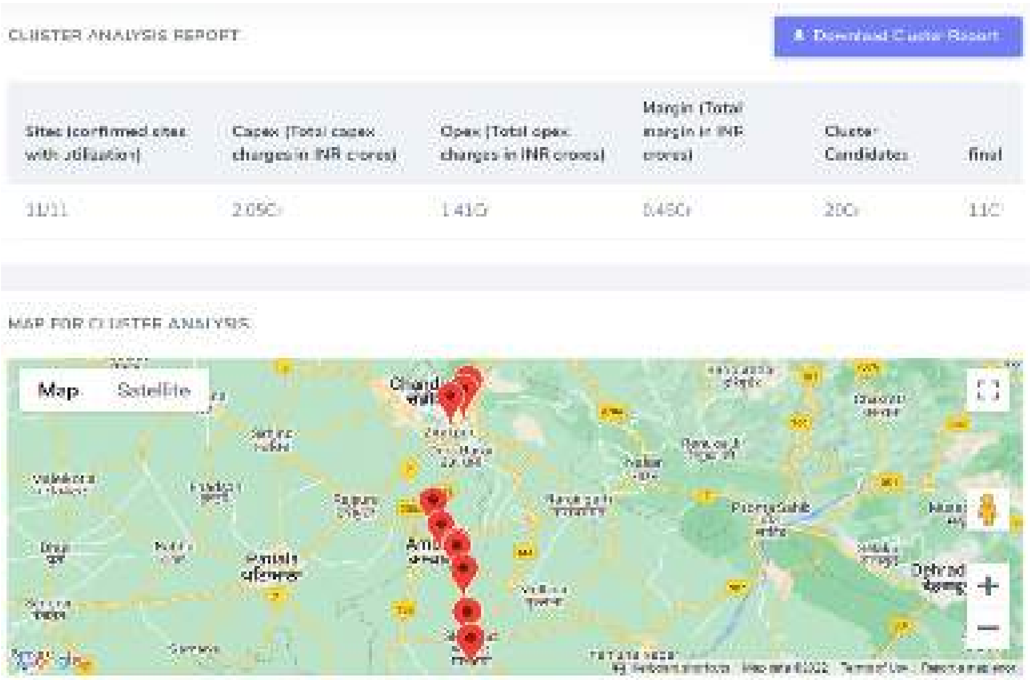
See below the number of charging stations along the corridors, along with a snapshot of the output for the Delhi to Karnal corridor.

Charging stations for each corridor

S. No.	Corridor	Length of Corridor, km	No. of Sites after clustering
1	Chandigarh to Karnal	125	11
2	Karnal to Delhi	120	9
3	Betul to Nagpur	173	16
4	Mumbai to Nashik	167	12
5	Akola to Nagpur	250	9
6	Kankavli to Panaji	110	15
7	Mumbai to Pune	148	14
8	Kolhapur to Belgaum	113	13
9	Vellore to Chennai	138	17
10	Chennai to Puducherry	151	15
		1495	131

Source: MP Ensystems Research, 2022

Snapshot of Delhi Karnal EVCI locations after clustering analysis



Other assumptions for Freight EVCI investment:

Infrastructure Costs	Units	Cost/quantity
Land Costs	Rs/sq m	0
Electricity connection, transformers, and energy meters	Rs	7,50,000
Civil Works	Rs	2,50,000
Type of Charger		
Bharat AC – 001	Rs	65,000
Bharat DC – 001	Rs	2,47,000
Type 2 AC	Rs	2,00,000
CCS	Rs	18,00,000
Charging Station layout		
Space for 1 freight vehicle & charger	Sq m	20
Number of charging stations in 1 location	No.	4
No of fast chargers	No.	2
No of slow chargers	No.	2
Other Costs		
Network Integration with CPO server	Rs/year	50,000
Brand promotion and Marketing	Rs/year	50,000

No of technicians	No.	
Technician salary	Rs/year	2,40,000
No of personnel manning the station	No.	1

Based on the assumptions, the costs are in the table below:

Fixed Costs	Units	Cost/quantity
Electricity connection, transformers, and energy meters	Rs	7,50,000
Civil Works	Rs	2,50,000
Total Infrastructure Costs	Rs	10,00,000
Cost of Equipment		
No. of fast chargers		2
No. of slow chargers		2
Cost of fast charger/unit	Rs	18,00,000
Cost of slow charger/unit	Rs	2,00,000
Cost of installing fast chargers	Rs	3600000
Cost of installing slow chargers	Rs	400000
Total cost of installation of equipment	Rs	40,00,000

Operating Costs	Unit	Year 1
Network Integration with CPO server	Rs/year	50,000
Brand promotion and Marketing	Rs/year	50,000
Personnel salaries manning the station	Rs/year	1,80,000
Backend staff and management salaries	Rs/year	2,40,000
Total operating Costs for 1 station	Rs/year	5,20,000

Total Costs	Unit	Costs
Total Cost of Initial Installation of 1 station	INR	50,00,000
Total operating Costs for 1 station	INR/year	5,20,000
Total cost for setting up EVCI at 1 location	INR	55,20,000
Nr of EVCI sites on 10 corridors		131
Total cost for setting up EVCI along 10 corridors	INR crore	72.3
Nr of EVCI sites on 32 corridors		409
Total cost for setting up EVCI along 32 corridors	INR crore	225.768

SECTION 5

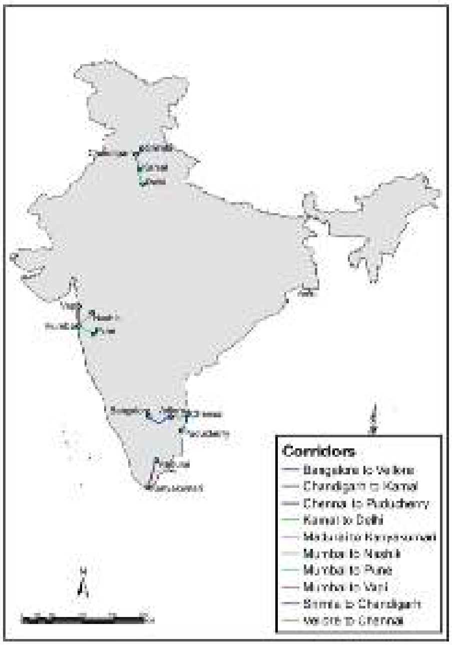
RECOMMENDATIONS ON EVCI PLANNING

1. INTRODUCTION

Widespread adoption of electric freight vehicles can drastically cut the country's GHG emissions, improve air quality and reduce overall costs associated with maintenance and fuel. While there has been a focus on improving charging infrastructure for private vehicles, there is a need to systematically study the location, grid impact, convenience and profitability of freight EVCI.

MP Ensystems developed a publicly available mapping and forecasting EVCI planner tool that provides key charging locations and information such as network impact and revenue within the freight corridor. To do so, MP Ensystems established an open-source software planner tool with data and sources that are available and relevant to the tool's development. Based on interactions with stakeholders, including Government, utilities, Charge Point Operators (CPOs), freight and logistics companies, vehicle manufacturers, financing institutes, civil society and academia, the team has shortlisted 10 corridors where freight EVCI can be implemented. These 10 corridors form a part of the 30 corridors studied so far. The list of selected corridors is below:

Figure 1. Shortlisted Freight Corridors



From	To	Distance, Km
Shimla	Chandigarh	110
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Mumbai	Vapi	175
Mumbai	Pune	148
Mumbai	Nashik	167
Bangalore	Vellore	211
Vellore	Chennai	138
Chennai	Puducherry	151
Madurai	Kanyakumari	243

We have estimated the consolidated investment (capital expenditure and operational expenditure for the first year) for setting up 131 charging stations along the 10 freight corridors is approximately INR 72.3 crores.

This section is organised as follows: Chapter 1 contains recommendations to EVCI planning authorities, including state and central governments, National Highways Authority of India (NHAI), Regional Development Agencies (RDAs) and Urban Local Bodies (ULBs). Chapter 2 contains recommendations to grid operators, including electricity distribution and transmission companies, and the central and state electricity regulators. Chapter 3 contains recommendations to EVCI businesses, including Charge Point Operators (CPOs), Original Equipment Manufacturers (OEMs) of EVCI equipment and freight EVs, logistics companies and charging management software (CMS) companies.

2. RECOMMENDATIONS FOR PLANNERS

During the current phase of the project, the MP Ensystems team interacted with planning authorities across multiple regions of interest in the country, including the state and district governance networks that span across the 32 corridors. Some of the important planning and policy agencies in the freight EVCI sector are in the figure below.

Highway authorities (NHAI, State Road Transport authorities)	City and regional planners (MMRDA, DDA, BMRDA etc)	Ministry of Power, Central Electricity Authority
Ministry of Road Transport and Highways	Bureau of Energy Efficiency, Department for Science and Technology	Ministry of Heavy Industries

The following are recommendations for strengthening and improving freight EVCI in India, based on interactions with stakeholders and an analysis of the gaps and opportunities. We have covered land-use planning, revenue maximisation, supporting standardisation and interoperability.

- One of the key challenges likely to be faced in EV charging infrastructure development is land allocation. Freight electrification spans across revenue boundaries of several urban local bodies, city governments and state governments. As an example, a freight corridor linking Panchkula, Chandigarh and Mohali runs across various municipal and state boundaries. As such, some cohesive approach to land-use planning is important as a collaborative step amongst multiple governing institutions.

- Clear guidelines to earn rental revenues would be useful for the government and quasi-government institutions as well. Government Resolutions notified by the energy and transportation departments will allow a better land-use approach.

- Housing societies and large private complexes have the potential to facilitate freight charging points in addition to the passenger vehicles. The urban development departments can facilitate the process of creating enabling policies to support additional floor space index or allowances in the open area requirements under the development plans.

- All future development plans should include specific land allocations for the charging infrastructure for all electrified vehicles; with a clear emphasis on the charging infrastructure for freight vehicles.

- Revenue-sharing in the electric vehicles charging infrastructure is an important attribute of creating a business case. As such, clear guidelines in any bidding document from the government would be of greater importance.

- Several state and city-specific standards related to the open spaces etc. exist and specific efforts should be made to create a uniform standardisation process.

- Recommendations related to the interoperability were explored during our analysis. Specific aspects of interoperability are listed below.

  * Mandating Open Charge Point Protocol (OCPP) can be one of the first steps towards harmonisation of communication protocols across the country, as many of the platforms are already using it and the indigenous Bharat standard chargers are compatible with it
  * Planners must conduct outreach towards CPOs in order to explain the benefits of interoperability so that they share their data willingly
  * Creation of databases should be taken up on a priority basis
  * Bureau of Energy Efficiency (BEE) has been mandated for creation of an aggregate platform, this effort should be expedited
  * In our conversations with CPOs, they showed a willingness to be part of an aggregator platform where all the CPOs share their data transparently. Trust and transparency can be best maintained if this platform is created and updated by a government entity
  * In cases where government entities are funding the installation of chargers, they should share data related to utilisation patterns in EV charging transparently with discoms in order to enable them to improve EV load forecasts
  * With rapid developments in EV charging technology, there is a need for integration of smart grid infrastructure of discoms with ICT (Information and Communications Technology) infrastructure in charging stations which should be pushed by the regulators
  * Data security must be clearly specified, in order to generate trust among CPOs that their data would not be used by competitors

- Recommendations related to cyber security are presented below:

  * Indian planning agencies need to build on existing work in cybersecurity to develop best practices for end to end cyber security in EVCI and integrate them into the standards at an early stage
  * Engage with stakeholders to build cyber security awareness and test preparedness against cyber attacks

3. RECOMMENDATIONS FOR GRID OPERATORS

Availability of the grid network at the places where the freight charging infrastructure is being proposed is important. Unlike passenger EVCI, freight EVCI has higher connected loads and hence is of importance from the point of view of grid availability.

Related to the 32 corridors, we have estimated a total load of approximately 192 MW. As we create other opportunities for freight EVCI siting requirements, the recommendations below can inform grid operators on the facilitative role they can play.

- Grid operators can include EVCI loads as resources to balance the supply-demand positions, frequency/voltage regulations, on-site and remote renewable energy integration
- Grid operators can promote smart charging where the grid can use EV loads to ramp up during periods of excess generation, higher renewables in the system and low-cost options available from the grid side
- Onsite and remote renewable energy assets linked and integrated with the freight EVCI spots that are located at multiple locations in the grid network offer deeper decarbonisation
- Interconnection points of EVCI need to comply with the safety and grid integrity/ autonomy standards issued by the Central Electricity Authority (CEA)
- Tariffs for the EVCI category has been issued by several state regulators. Specifically, the Maharashtra electricity regulator has developed time-of-use/time-of-day tariffs for the EVCI category, setting the trend of encouraging off-peak charging. EVCI should necessarily promote higher renewables to be absorbed and as such, specific policies to maximise capacity utilisation factors of the renewables assets should be taken up on priority.
- Specific recommendations related to reducing the grid impact of EVCI and incorporating RE in charging infrastructure:

  * Smart charging and integration of energy storage devices with DC fast charger can help in reducing the impact of high-power charging load on grid. For fast charging, to some extent local peaks and grid congestion issues can be mitigated by limiting the power demand in case of peak demand in network
  * Smart charging strategies are more common for slow charging due to flexibility offered by the slow charging approaches; their utility for freight charging is limited
  * Appropriate modelling of EV power demand and sizing of energy storage system is crucial for optimising RE based EV charging stations
  * Integration of RE in the national power mix and development in energy storage systems can help in reducing the gaps between EV charging demand and variable RE generation, which will enable maximum potential of EVs for decarbonising transport

4. RECOMMENDATIONS FOR EVCI BUSINESSES

EVCI business such as OEMs, CPOs, app developers, freight and logistics companies play an important role in the higher penetration of freight electrification. EVCI businesses have an excellent opportunity to benefit from a variety of sources that are available towards profits maximisation

- Recommendations related to creating partnerships

  * Charging point operators, original equipment manufacturers of charging infrastructure, EV manufacturers (freight manufacturers in this case), freight operators, land-use planners and grid companies need to create a larger ecosystems through partnerships. Specific joint partnerships and memorandum of undertaking are recommended efforts towards creating larger ecosystem that if formalised.
  * Industry bodies need to come together with specific product development and innovation processes to create significant leadership in this space. Specifically, in the Indian context, home-grown technologies can benefit substantively through make-in-India initiatives and contribute to the local, regional and global businesses.

- Recommendations related to interoperability

  * CPOs should adopt OCPP for their own EVSE as it is one of the most common protocols in India, which has been emphasised by the government regulators in different instances
  * CPOs should plan their business operations in such a way that they can maximise the utilisation of their charging stations once the government aggregator platform goes live
  * CPOs should share relevant data with discoms, as this data can help with demand forecasting and help maintain grid stability
  * There have been attempts such as Statiq to aggregate EV charging stations on their platform, but it is largely confined to their own stations, EVCI developed by customers using their white-label apps and stations installed by oil marketing companies (OMCs) and government entities such as EESL. The participation of other private CPOs in such an initiative would result in this being a truly representative platform
  * In cases where CPOs and Government agencies are promoting interoperability, they need to ensure that there is granularity of data. There is a need for live, or near-real time data, with information on types of chargers, current status (operational, out of operation, busy, free) and tariff.

- Recommendations related to reducing the grid impact of EVCI and incorporating RE in charging infrastructure:

  * There is currently limited scope for installing captive solar PV system in EV charging stations as the area required for solar PV installation will be significantly higher (i.e., 250 m2 for generating maximum of 50 kW power). However, any renewable capacity developed on site would be useful to cater to auxiliary loads
  * Communication and coordination with grid operators and EV drivers to ensure that charging absorbs excess renewable energy production, thereby reducing overall emissions and impact on the grid

- Cyber security recommendations for CPOs, EV and EVCI OEMs include:

  * Co-design hardware- software to ensure security, remediation of vulnerabilities through updates
  * Research, develop and demonstrate a resilient AC input for fast charging stations (>350kW) that will be likely to be set up for freight

ANNEXURE 1: INTEROPERABILITY OF EVCI

What is interoperability in EVCI?

Interoperability refers to the compatibility of key system components in the EV ecosystem – hardware and software – allowing all components to work seamlessly together (Electric Power Research Institution, 2019). Introduction of standardisation in all components of EV charging ecosystem is an essential step for enabling interoperability. Through standard technical protocols, all components involved in charging can conform to the same standards, thus enabling universal access.

Interoperability in the EV ecosystem involves the following activities:

- User authentication
- Communicate the maximum allowable charging current
- Control start/end of charging session
- Billing, smart charging
- Provision of roaming facilities

The main forms of interoperability in EVCI charging are:

- Between charging stations
- Charging station to network
- Physical charging interface
- Vehicle to grid

The main actors involved in implementing interoperability are:

- Charge point operators (CPOs)
- Mobility service providers/ aggregators
- Roaming platforms
- EVSEs (Electric vehicle supply equipment)
- OEMs (Original Equipment Manufacturers)
- Discoms (Electricity distribution companies)

Regulations promoting interoperability in India

Currently in India, Open Charge point protocol (OCPP) version 1.5 and above is primarily implemented for communication between EVSE and the charge point operator. It was introduced by Open Charge Alliance in 2016. OCPP, being an open-source protocol enables easy usage and implementation.

It does not depend on the charging techniques and works for EVSEs regardless of their charging protocols, e.g.; CHAdeMO, CCS or Bharat Standards. Some of the major platforms that use the OCPP platform in India include Tata Power EZ Charge app, ElectreeFi and Pulse Energy, an app which claims to aggregate electric chargers of Tata Power, Zeon, KSEB, BESCOM, EESL, ChargeGrid, Ather Grid, Hero Electric on its app. Statiq is in the process of achieving OCPP compliance.

The OCPP protocol, although not mandated by the government authorities, has also been suggested in the following regulations:

- Bharat EV charger specifications namely, AC001 and DC001 were released in 2017 by the Department of Heavy Industry (DHI). The communication protocol between the public metered AC outlet (PMAO) and the central management system was defined to be open charge point protocol (OCPP) 1.5.
- Ministry of Power (MoP) released the “Charging Infrastructure for Electric Vehicles (EV) – the revised consolidated Guidelines and Standards” in January 2022. It stated that to obtain the availability of chargers and to activate the feature of reservation of chargers, OCPP 1.5 or above communication protocol is necessary and the EV chargers must be compatible with this protocol.
- Ministry of Power’s 2019 guidelines mandate the Central Electricity Authority (CEA) with the responsibility to create and maintain the database of all public charging stations (PCS) in the country. CEA also formulated the format to collect the information from the distribution companies (discoms) on PCS, which requested data including the location of the charger, operation time, type of connector, type and number of chargers, connection voltage and the DC output from the charger, in addition to data on total number of charging stations, number of EVs charged and the total electricity consumption.
- The Final Consolidated EVCI Guidelines released by MoP in 2022 mandate the Bureau of Energy Efficiency (BEE) to create and maintain an online database of all charging stations in consultation with state nodal agencies. They mandate the BEE to create a web-portal/ software/ mobile app for this database which should be updated on a weekly basis.

Indian CPOs and Interoperability

Interoperability among CPOs in India is currently through the following means:

1. Interoperability through listing

- Some third-party apps, Government portals (e.g. Delhi Government) and Google maps are listing different EVCI locations.

2. Interoperability through aggregation

- Companies such as Statiq, Kazam and others develop a white-label EVCI app, charging management software (CMS) and charging hardware and sell it to businesses. The business can rebrand the EVCI and pays a development fee and an ongoing service fee to the EVCI developer. The business' EVCI is listed on the EVCI developer's app, even though it may be branded differently. This integration is relatively simple, since both companies use the same platform.

3. True Interoperability

- In this scenario, EV owners can look up different apps and find all EVCI locations in a region, and availability for charging at each site in real-time. Until all CPOs in India adopt a uniform protocol and agree to share data, this form of interoperability will not be achieved.

Delhi Government's initiative

The Delhi government launched the Switch Delhi initiative to aggregate all EV Charging stations and swap facilities on one platform, which currently provides directions for reaching charging stations and number of charging spots currently vacant. Future additions can include providing an option to book charging spot online.

Prominent EVCI players leading interoperability efforts

EV Charging App	Tata Power EZ Charge	Statiq	ElectreeFi
App installations	100K+	10K+	10K+
App Features	Type and no of chargers, charger availability status visible, slot booking and payments	Type and no of chargers, charger availability status visible, slot booking and payments, trip planner	Type and no of chargers, charger availability status visible, slot booking and payments
Extent of Interoperability	Shows quite a large number of charging stations in addition to its own stations. Other stations mostly include stations installed by OMCs, EESL and other govt bodies	Predominantly list its own chargers in addition to some other charging stations	Shows its own chargers in addition to chargers set up by public entities like EESL, BRPL, BYPL, et al
No of charging stations	1000+	200+	NA
Geographical coverage	40+ cities across India	Major cities pan India	Major cities like Delhi, Jaipur, Lucknow, Mumbai, et al
Comments	Uses OCPP protocol	Developing OCPP compliance	Uses OCPP protocol

Requirements of EVCI App Interoperability

Between Charging Stations	Charging Station to Network
• Charge Point Operators (CPOs) operate their charging networks like islands, without communication or interaction with other networks. • Interoperability between charging networks or "e-roaming" means EV owners can access public EVCI from any CPO over a common platform and/ or single subscription.	• Charging stations communicate with their supporting networks: When a CPO puts in a proprietary protocol, consumers get locked in to a closed-network provider. • Instead, an open standards-based allows CPOs to switch between network service providers without installing new equipment.

Communication Protocols

There are various open-source communication protocols for smart charging infrastructure, but four protocols are majorly adopted for EV roaming and used primarily in Europe:

1. **Open clearing house protocol (OCHP)**
   - It is an open roaming protocol used to exchanging charging transaction data, authorisation and charging station information between the charge point operator provider. It serves functions such as roaming, authentication, billing, providing charge point information, providing real-time data access, et al. and the mobility service

2. **Open charge point interface protocol (OCPI)**

   - OICP is a protocol for charging point information exchange between CPO and MSP. It is the most used roaming protocol in Europe. It provides roaming, authentication, reservation and billing, and providing charging point information, real-time and charging session information.

3. **Open intercharge protocol (OICP)**

   - It is a roaming protocol formed by Dutch CPOs and MSPs. It provides roaming, authentication, reservation and billing, providing charging point information, real-time and charging session information and smart charging

4. **E-Mobility interoperation protocol (eMIP)**

   - It is developed with an objective of allowing open access to all charging stations. It is mainly adopted in France. It provides roaming, authentication, reservation and billing, and providing charging point information, real-time and charging session information and also checks connectivity of CPO, MSP and data aggregators.

5. **Open charge point protocol (OCPP)**

   - It is an independent protocol with interoperability among EVSE and software system provider, and communication between the EVSE and the central controller. It provides billing data, energy meter data, and status information. OCPP 2.0 supports additional features of plug and charge and smart charging, interactive communication with secure authentication and complete information of tariff and estimated charging bill.

Benefits of Interoperability

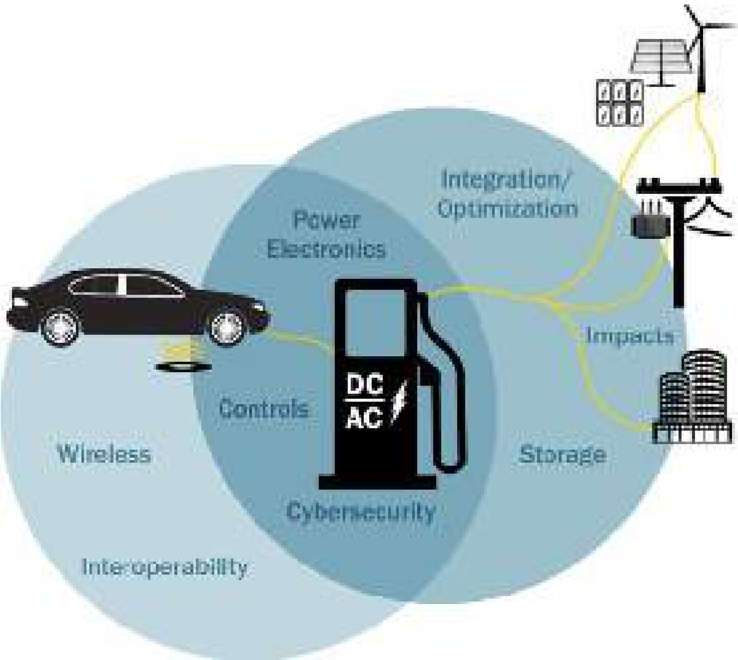
- Interoperability enhances the convenience of users in terms of availability of multiple services on a single platform, including the ability to discover and use charging stations of any CPO, paying for charging, et al.
- It removes the need for availing a subscription from each CPO if the user wishes to use their charging station.
- Interoperability enhances consumer confidence as the availability of all charging stations on a single platform helps better plan travel routes and stoppages in case of long-term travel.
- It provides an easy comparison of charger availability and charges across charging stations of different CPOs at a single place.
- Recording of all charging sessions and payments on a single platform also enhances user experience in terms of consolidated billing for cumulative charging sessions, charging budget for a month and vehicle performance.
- CPOs benefit by increased utilisation due to greater visibility of their charging stations on a common platform which would see much better usage as compared to multiple platforms in which case the user traffic would be divided.

- Interoperability would also increase operational flexibility to add new services, expand operations in new areas and easy technical integration with other stakeholders.
- Interoperability would help generate better and more reliable data on electricity demand patterns, which in turn would help DISCOMs understand the impact of EV charging on grid stability better and manage their power procurement plans accordingly.
- Interoperability can help induct new technologies to enhance user experience e.g. smart charging.
- Interoperability has been a major driver for reducing costs and enabling mass adoption in the telecom sector - both with wired and wireless. EVCI Interoperability will enable healthy competition (eg. stations close to each other will compete on charging price to attract customers) and benefit the consumer.

ANNEXURE 2: CYBER SECURITY OF EVCI

Cyber security of EVCI is a growing area of concern as charging stations communicate with the grid, payment gateways, other vendors and vehicles. The cyber security of EVCI needs to be assessed in the context of ensuring interoperability and incorporating distributed energy resources.

Figure 1. EVCI Cyber security



Source: US Department of Energy, 2019

Potential Impacts of cyber threats to EVCI

Interoperability enhances the convenience of users in terms of availability of multiPotential High Consequence Events (HCE) due to cyber attacks on EVCI are in the table below

Prominent EVCI players leading interoperability efforts

Attack on	Impact
Grid	Utility power disruption Pathway to utility back-office Feeder equipment damage
EVCI	Hazards due to thermal cooling system manipulation Electromagnetic field public exposure Charger not working
EV	Vehicle system hijacked, affecting controls, safety, route
Credit card	Financial data stolen

Source: US Department of Energy, 2019

Risk factors

Some of the risk factors that affect cyber security of EVCI are:

Increased system complexity due to number of stakeholders, multiple communication protocols, and advanced control systems (for improving performance, energy management and autonomous operation)

Internet-connected EVCI may allow cyber attacks against single EVCI stations as well as against integrated critical infrastructure, e.g. power grid

Risks can be magnified by poorly implemented EVSE including no comprehensive cybersecurity approach, incomplete industry understanding of attach surface, interconnected assets, and unsecured interfaces

In the case of freight charging. cyberattacks risks are magnified by higher charging power. The target may not just be vehicles, but also infrastructure sectors such as

Sources: Sandia National Laboratory, 2022 , US Department of Energy 2019,

EVCI cyber security standards

Currently, there are no comprehensive EVCI cyber security standards in India, or globally. The current status of standards and regulations is below:

- Cyber security best practices documents have been developed for EVs (not EVCI). The automobile industry's Automotive Information Sharing and Analysis Center (Auto-ISAC) provides guidance on Automotive Cybersecurity Best Practices . The US Department of Transportation has developed cyber security best practices for modern vehicles, mainly targeting EVs .
- The ISO 15118 standard covers digital communication between an electric vehicle and charging station. The aim of this standard (Plug and Charge) is to allow EVs to plug into EVCI and automatically begin charging, with financial transactions occurring seamlessly and securely in the cloud. In terms of cyber security, some automakers have objected to the ISO standard's prescribed method of handling security certificates between vehicles, CPOs and mobility operators . However, this standard is primarily for the vehicle's charging communication and not cyber security.

Way forward

Currently, there is no comprehensive EVSE cybersecurity approach or system in place. However, there are a number of studies focusing on vulnerability assessment, threat model development, investigating consequences of cyber attacks, creating a risk matrix and prioritising mitigation. These studies are being carried out on multiple EVCI firmware, management systems, communication protocols. Some proposed best practices for Indian planners and operators are:

- Study current status of cybersecurity standards across the EV and EVSE ecosystem and identify opportunities for harmonisation
- Co-design hardware- software to ensure security, remediation of vulnerabilities through updates
- Use Artificial Intelligence (AI) and blockchain technologies to ensure encryption in communication
- Engage with stakeholders to build cyber security awareness

Indian planners need to build on existing work in cybersecurity to develop best practices for end to end cyber security in EVCI and integrate them into existing EVCI standards at an early stage.

ANNEXURE 3: EVCI GRID IMPACT AND POTENTIAL FOR RE

Charging of electric freight vehicles requires high charging power, because of two major constraints of time availability for charging and large size of battery. Fast charging of electric vehicles has different characteristics as compared to overnight slow charging. Fast charging requires high charging power with centralised load, also the fluctuations in load are high due to shorter charging time and high-power demand.

1. Impact of EV fast charging on grid

In the case of a high EV penetration scenario, forecasting of EV charging demand will become challenging and deviations can lead to global phenomena of grid stability issues such as frequency instability. High centralised load of EV fast charging and power electronics conversion of AC power will lead to local grid quality issues such as voltage fluctuation, harmonic stability and harmonic emission.

1.1 Voltage profile

The impact of a DC fast charging station on the voltage profile is studied by NREL and the impact of domestic EV charging load on distribution network is studied by the Forum of Regulators (FOR) . The location of the charging station is critical, as can be seen in Figure 1. For case 1, case 2 and case 3, charging station locations are different. The EVCI location in case 3 has the maximum impact of EV charging on voltage profile.

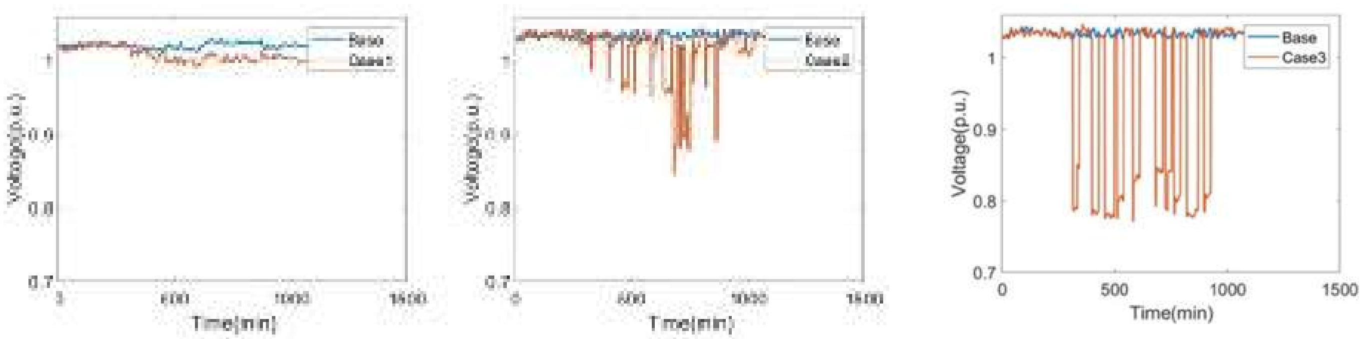


Figure 1. Voltage profile after charging station is connected

1.2 Current harmonics

An EV DC fast charger also injects current harmonics into the grid. For a 50 kW 3 Phase charger, the harmonics content in input current have been estimated . For 11 kW charging power, 13th harmonic dominates, and in the case of 50 kW charging, power maximum amount of 7th harmonics are observed.

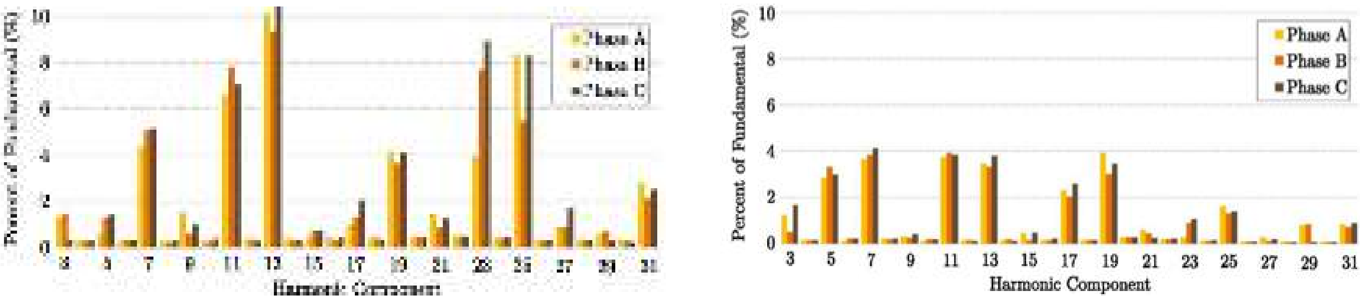


Figure 2. Input current harming (a) when input power is 11 kW, (b) when input power is 50

1.3 Supraharmonics

Supraharmonics are current and voltage waveform distortions in the range of 2 kHz to 150 kHz . Electrical vehicle charger is a high power load as compared to other household equipment and can affect a low voltage network significantly. EV charging has high chance of supraharmonic disturbances, which can lead to different grid impacts on the grid and connected loads such as high voltage distortion in network, which can propagate additional supraharmonic current, exposing more components and devices to it.

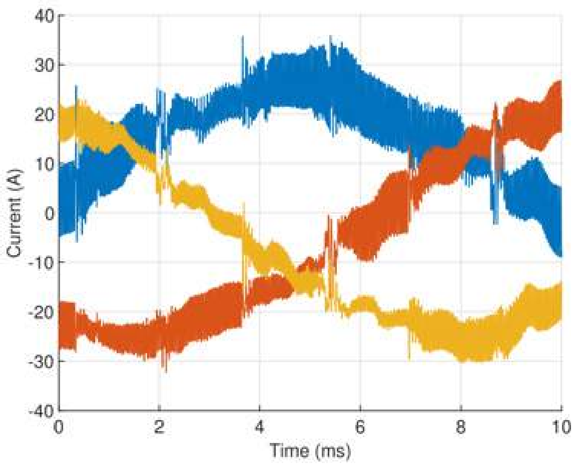


Figure 3. Supraharmonics in 3 phase input current of DC fast charger

2. Mitigation measures

Smart charging and integration of energy storage devices with DC fast chargers can help in reducing the impact of high-power charging load on the grid. Smart charging strategies are more common for slow charging, due to flexibility offered by the slow charging approaches. For fast charging to some extent local peaks and grid congestion issues can be mitigated by limiting the power demand in case of peak demand in the network.

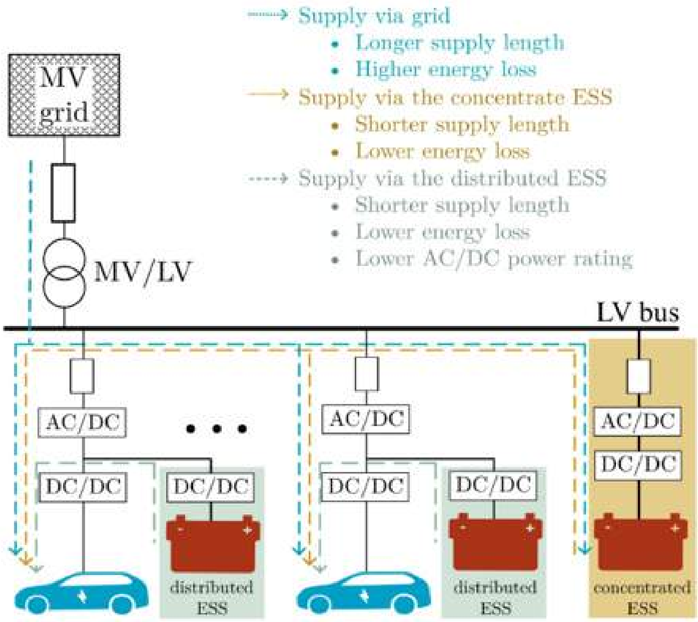
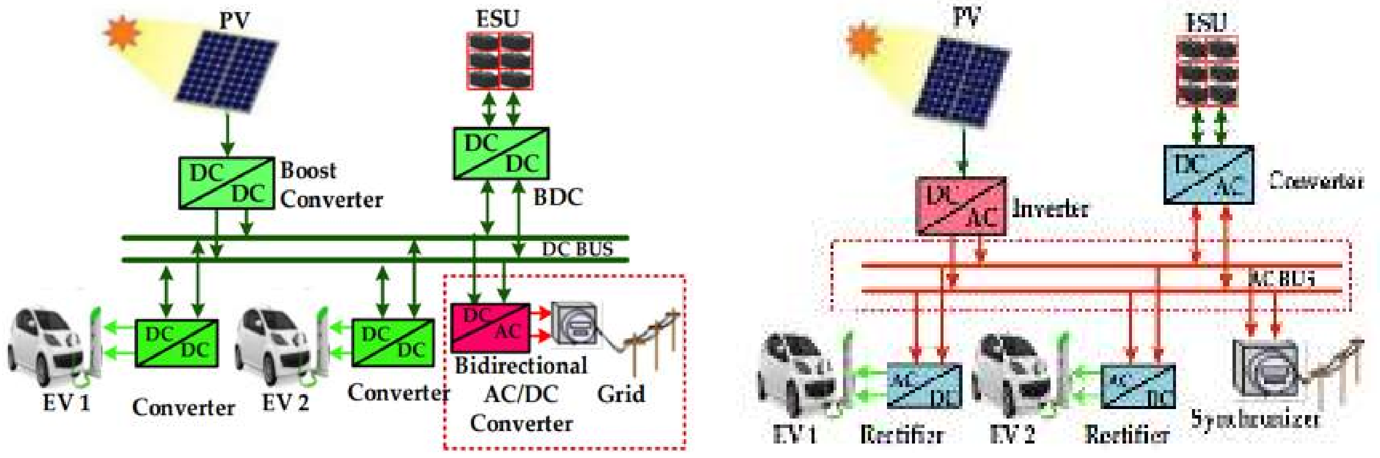


Figure 4. Energy storage integrated EV charging station

On the other hand, integration of battery storage with EV charging station as shown in figure 4 , can mitigate the issues arising from large fluctuating load of EV charging. The high pulsating demand can be supplied by energy storage systems, while the relatively smaller base load demand can be met by the transformer, this will also reduce the cost of transformer and cables.

3. Renewable energy for EV charging

Electrification of transport is one of the key strategies identified for decarbonising the transport sector. EVs do not emit tailpipe emission, but the net emissions from EVs depends on the primary fuel used for production of electricity. As per the current scenario, the Indian power sector depends significantly on thermal power plants for electricity production. Considering the emissions in electricity production, net emissions from EVs are lower compared to ICE vehicle counterparts. With a greener energy mix in electricity, the net emissions from EVs will further reduce. Efforts are on to develop the best strategies to enable efficient integration of RE power for EV charging demand.



a

b

Figure 4. Renewable energy integrated Electric vehicle charging station (a) DC bus coupled, (b) AC bus coupled

The figure shows the DC coupled and AC coupled architecture of an RE based EV charging station system. DC coupled architecture allows the solar PV and energy storage to work in parallel. The charging power is supplied by the solar PV or energy storage as per the power demand and availability of solar power, in case of high solar generation and low EV charging demand, the access of solar generation is used to charge the energy storage. The main advantage of this architecture is power conversion losses are minimum as DC-AC and AC-DC conversion of power is avoided. An AC coupled system also works on a similar principle, only the conversion of power from AC-DC and DC-AC is required at each node increasing the losses in the system. The main advantage of AC coupled architecture is it allows the independent sizing of different system components.

As the power density of solar PV is low, there is limited scope for installing captive solar PV system in EV charging station as the area required for solar PV installation will be significantly higher (i.e., 250 m2 for generating maximum of 50 kW power). That said, any capacity developed on site would be useful to cater to auxiliary loads as well.

The variability in RE power generation and uncertainty in load demand makes the power balancing problem challenging. Appropriate modelling of EV power demand and sizing of energy storage system is crucial for optimising the cost of charging energy in RE based EV charging station.

Integration of RE in national power mix and development in energy storage systems can help in reducing the gaps between EV charging demand and variable RE generation, which will enable maximum potential of EVs for decarbonising transport.

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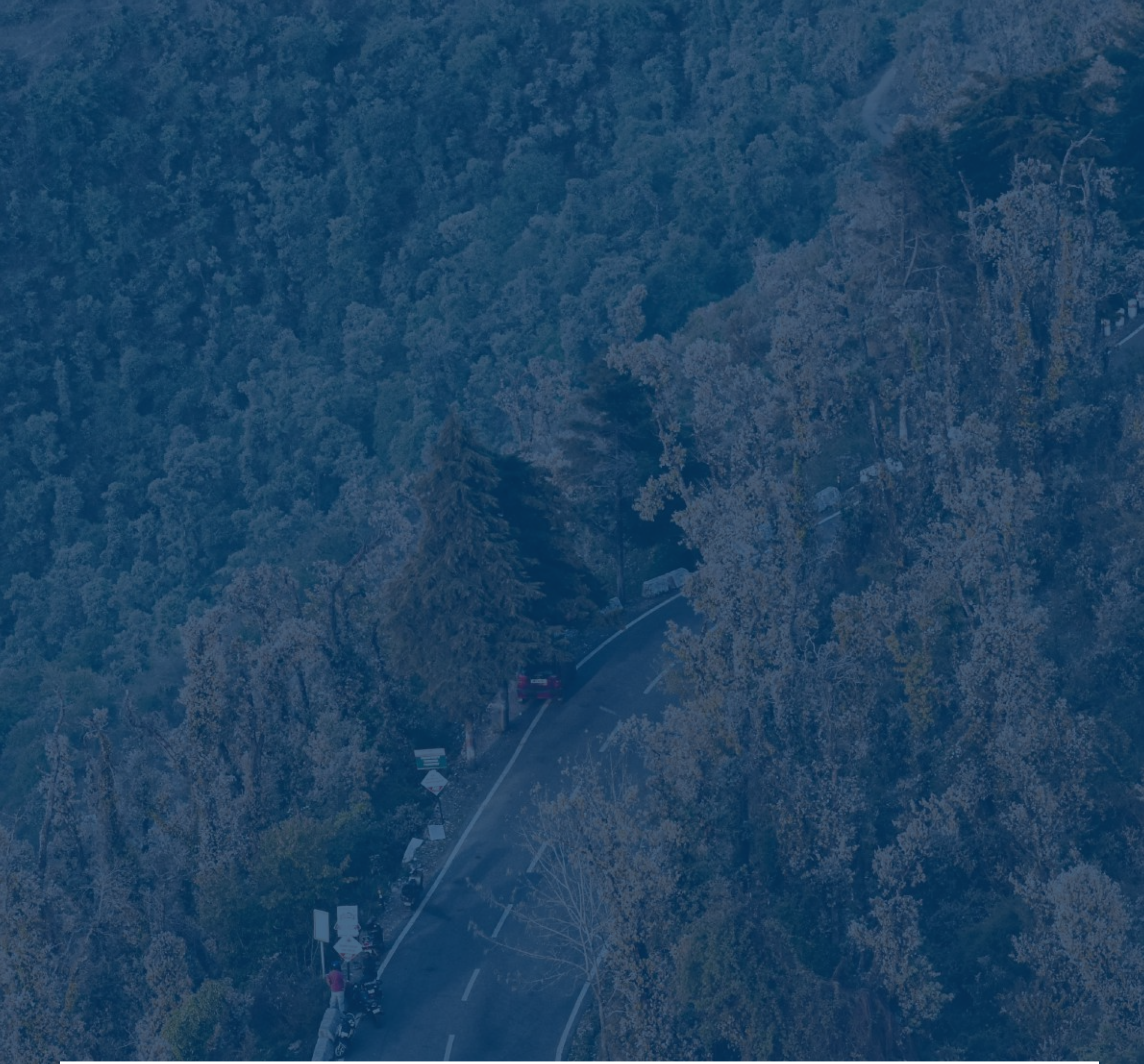

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