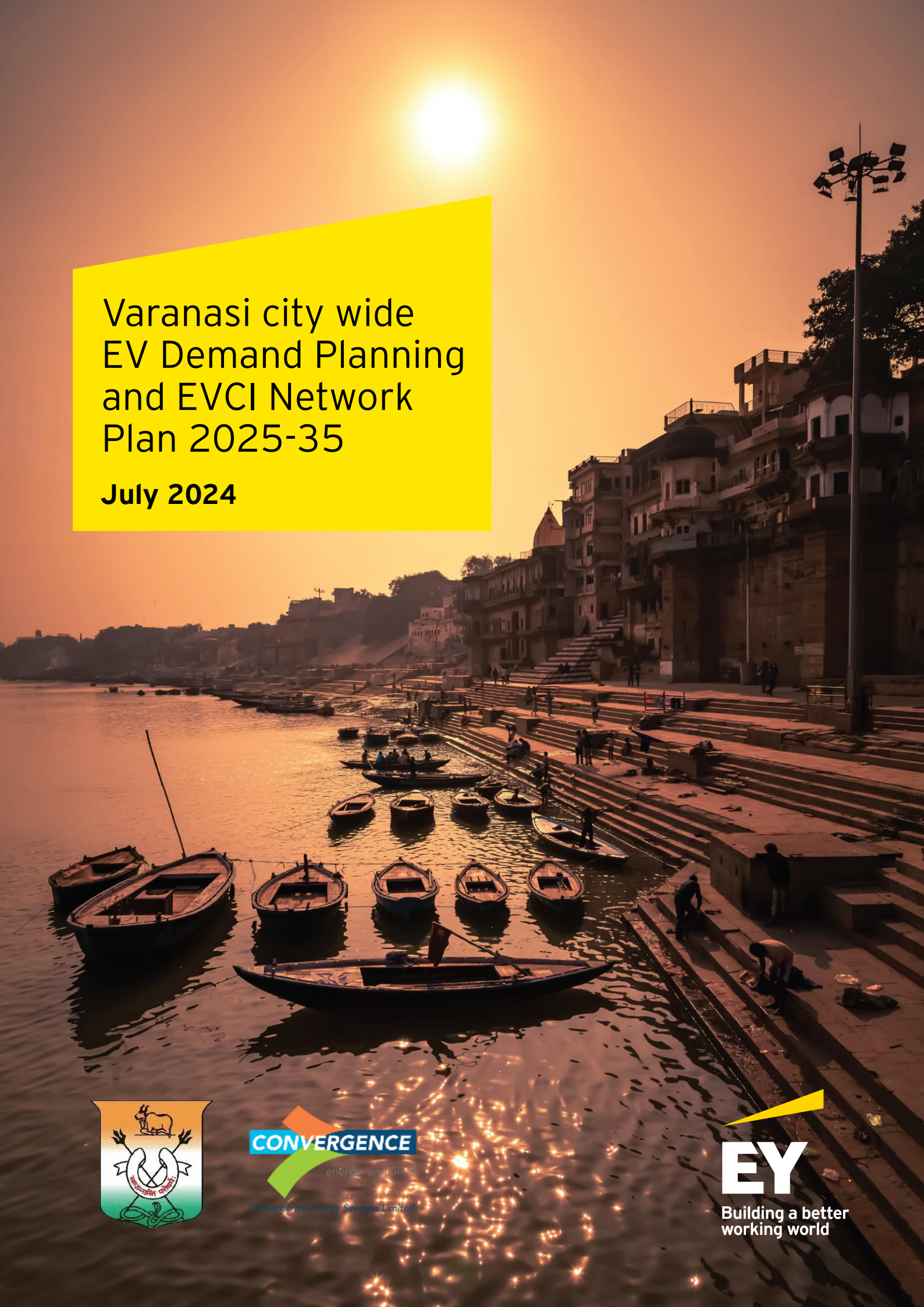
Varanasi city wide EV Demand Planning and EVCI Network Plan 2025-35

July 2024



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Acknowledgement

We express our deepest gratitude to all those who have contributed to the fruition of this project, which aims to catalyse the integration and expansion of Electric Vehicles (EVs) and Electric Vehicle Charging Infrastructure (EVCI) across select cities in India. This endeavour has been made possible through the collaborative efforts of Convergence Energy Services Limited (CESL) and Ernst & Young LLP supported by Asian Development Bank (ADB).

Special thanks are extended to Shri. Akshat Verma (IAS), Municipal Commissioner, and Shri. Gaurav Verma, Regional General Manager, Varanasi City Transport Services Limited (VCTSL), for their invaluable support and guidance throughout the project. Their vision and leadership have been instrumental in shaping the direction of this initiative.

From CESL, our heartfelt thanks go to Shri. Rajneesh Rana, Shri. Amit Sood, and Shri. N. Mohan for their unwavering support and expertise. Furthermore, we would like to acknowledge the efforts of the EY team comprising Shri. Somesh Kumar, Shri. Sandeep Narang, Shri. Shobhit Saxena, Shri. Ranjan Verma, and Ms. Kiran Singh, for encapsulating the findings of this report.

Lastly, we extend our gratitude to all the stakeholders, partners, and participants involved in this endeavour. Your collaboration and commitment have been indispensable in conducting a thorough analysis and charting a course towards a sustainable future for electric mobility in the Varanasi city.

Office of Municipal Commissioner, Varanasi

As India makes significant commitments to combat climate change during COP26, Varanasi's unique blend of rich cultural heritage and vibrant spirit positions as a pioneer in Uttar Pradesh, spearheading the transition towards sustainable transportation. At the forefront of this movement is Varanasi Nagar Nigam (VNN), playing a crucial role in inspiring other cities to follow suit.

Through meticulous planning and collaborative efforts with various stakeholders, VNN is paving the way for a transportation landscape that is more environmentally friendly and sustainable. One of our ambitious initiatives involves the establishment of public Electric Vehicle Charging Infrastructure (EVCI), aimed at addressing critical challenge such as range anxiety which will encourage adoption of electric vehicles in Varanasi. Given Varanasi's unique geographical and demographic characteristics, it serves as an ideal implementing ground for EV infrastructure, showcasing how modern technology can seamlessly integrate with the city's timeless allure.

The transition to electric mobility not only helps in reducing emissions and combating pollution but also lays the groundwork for a brighter and more sustainable future for generations to come. I am hopeful that VNN's comprehensive initiative will promote electric mobility in Varanasi. Through meticulous analysis, proactive measures, and unwavering dedication, we lay the groundwork for a transportation revolution that will benefit our city and beyond. Together, let us embark on this journey towards a cleaner, greener tomorrow.

With regards,

(Akshat Verma)
Municipal Commissioner

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Abbreviations

2W	**Two-wheeler**
3W	Three-wheeler
4W	Four-wheeler
AC	Alternating Current
ACC	Advanced Chemistry Cell
ACoS	Average Cost of Supply
ADB	Asian Development Bank
AFC	Automated Fare Collection
BC	Before Christ
BCE	Before the Common Era
BEE	Bureau of Energy Efficiency
BEV	Battery Electric Vehicles
BHU	Banaras Hindu University
BSS	Battery Swapping Station
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditures
CCS	Combined Charging System
CDM	Clean Development Mechanism
CEA	Central Electricity Authority
CESL	Convergence Energy Services Limited
CNA	City Nodal Agencies
CNG	Compressed Natural Gas
CO2	Carbon dioxide
COP	Conference of the Parties
CPO	Charge Point Operators
DC	Direct Current
DHI	Department of Heavy Industries
DISCOMS	Distribution Companies
E2W	Electric 2-Wheeler
E3W	Electric 3-Wheeler
E4W	Electric 4-Wheeler
E-Bus	Electric Bus
EESL	Energy Efficiency Services Limited
E-LCV	Electric - Light Commercial Vehicle
EoI	Expression of Interest
ETP	Effluent Treatment Plant
EV	Electric Vehicles
EVCI	Electric Vehicles Charging Infrastructure
EVMM	Uttar Pradesh Electric Vehicle Manufacturing and Mobility
EVSE	Electric Vehicle Supply Equipment
EWCD	Elderly, Women, Children, and Disabled
FAME	Faster Adoption and Manufacturing of Electric Vehicles
FI	Financial Institutions
FY	Financial Year
GCC	Gross Cost Contract
GDP	Gross Domestic Product
GHG	Greenhouse gas
GIS	Geographic Information Systems
GoI	Government of India
ha	Hectare
HOHO	Hop-on Hop-off
ICE	Internal Combustion Engine
IFI	International Financial Institutions
IOCL	Indian Oil Corporation Limited
IT	Information Technology
JnNURM	Jawaharlal Nehru National Urban Renewal Mission
kms	Kilometres
kW	Kilo-Watt
kWh	Kilo-Watt Hours
LLP	Limited Liability Party
LoA	Land Owning Agency
m	metres
MHI&PE	Ministry of Heavy Industries and Public Enterprises
MIS	Management Information System
mm	Millimetre
MMTS	Multi-Modal Transport System
MNRE	Ministry of New and Renewable Energy
MoEF&CC	Ministry of Environment, Forest, and Climate Change
MOEFCC	Ministry of Environment, Forest, and Climate Change
MoF	Ministry of Finance
MoHI&PE	Ministry of Heavy Industries and Public Enterprises
MoHUA	Ministry of Housing and Urban Affairs
MOP	Ministry of Power
MoPNG	Ministry of Petroleum and Natural Gas
MoRTH	Ministry of Road Transport & Highways
MoST	Ministry of Science & Technology
MoU	Memorandum of Understanding
MSME	Ministry of Micro, Small & Medium Enterprises
MW	Mega Watt
MWh	Mega-Watt hours
NBEM	National Board for Electric Mobility
NBFC	Non-Banking Financial Companies
NCEM	National Council for Electric Mobility
NEMMP	National Electric Mobility Mission Plan
NH	National Highway
NHAI	National Highway Authority of India
NHPC	National Hydroelectric Power Corporation
NITI Aayog	National Institution for Transforming India
OEM	Original Equipment Manufacturer
OMC	Oil Marketing Companies
PBS	Public Bicycle Sharing System
PCS	Public Charging Stations
PCU	Passenger Car Unit
PLI	Production Linked Incentive
PM	Particulate Matter
PPP	Public-Private Partnership
PSU	Public Sector Undertaking

PuVNNL	Purvanchal Vidyut Vitaran Nigam Limited
R&D	Research & Development
R&M	Repair and Maintenance
RCC	Reinforced Cement Concrete
RDAs/UDAs	Regional/Urban Development Authorities
RE	Renewable Energy
ROI	Return on Investments
RTO	Regional Transport Office
RWA	Resident Welfare Association
SCM	Smart City Mission
SECI	Solar Energy Corporation of India Limited
SGST	State Goods and Services Tax
SNA	State Nodal Agencies
sq.km.	Square Kilometre
STU - P	State Transmission Utility
STU - T	State Transport Undertaking (Transport)
SWM	Solid Waste Management
TCO	Total Cost of Ownership
tCO2	Total Carbon dioxide
THDC	Tehri Hydro Development Corporation Limited
TPDDL	Tata Power Delhi Distribution Limited
UAs	Urban Agglomerations
UK	United Kingdom
ULBs	Urban Local Bodies
UNESCO	United Nations Educational, Scientific and Cultural Organization
UP	Uttar Pradesh
UPERC	Uttar Pradesh Electricity Regulatory Commission
UPPCL	Uttar Pradesh Power Corporation Limited
UPSRTC	Uttar Pradesh State Road Transport Corporation
US	Unitest States
UT	Union Territory
V2G	Vehicle-to-Grid
VAHAN	Vehicle in Sanskrit
VNN	Varanasi Nagar Nigam
VSCL	Varanasi Smart City Limited
('000)	in thousands
(E)	Estimated
°C	degree Celsius
°F	Degree Fahrenheit

Executive summary

During the COP26 climate summit, India, as one of the 42 participating leaders, supported the UK's Glasgow commitments and took on the role of co-convener for the Glasgow breakthrough on road transport, alongside the UK and the US. India made pledges to achieve net-zero emissions by 2070 and to decrease emission intensity by 45% from 2005 levels by 2030.

With India ranking as the fifth largest vehicle market globally, there are substantial opportunities for the adoption of electric vehicles (EVs). The establishment of public electric vehicle charging infrastructure (EVCI) is crucial in advancing Uttar Pradesh's (UP) shift towards sustainable transportation. A well-developed public charging network addresses concerns regarding range anxiety, a primary obstacle to EV uptake, by offering convenient and accessible charging facilities for EV owners.

As UP implements policies to encourage EVs, Varanasi can emerge as a leading city, inspiring other urban centres in the state to follow its example. Varanasi holds significant importance in Uttar Pradesh's transition towards sustainable transportation for several reasons. Being one of the oldest and culturally significant cities globally, Varanasi symbolizes the embrace of modern technologies while preserving heritage and tradition. By leading the way in the adoption of electric vehicles (EVs), Varanasi can demonstrate the seamless integration of sustainable practices with historical allure.

Varanasi's distinctive geography and demographics make it an ideal location for testing EV infrastructure. Its relatively compact size facilitates the establishment of an efficient public charging network, addressing concerns about range anxiety and promoting EV adoption. Additionally, Varanasi's status as a pilgrimage site attracts a diverse array of visitors, providing an opportunity to showcase the convenience and accessibility of EV charging facilities to a broad cross-section of the population.

Varanasi Nagar Nigam (VNN) is taking a proactive stance in addressing the pressing challenges confronting the city's transportation sector. With escalating pollution levels, growing energy demands, and the urgent need to combat climate change, EVs offer a promising avenue for cleaner mobility.

VNN is spearheading a comprehensive initiative aimed at overcoming these barriers. Through meticulous market segmentation, sizing, and feasibility analysis, this initiative seeks to identify promising markets and assess the viability of EV deployment within VNN's jurisdiction.

Furthermore, by evaluating the city's charging infrastructure requirements, VNN is laying the groundwork for the seamless integration of EVs into Varanasi's transportation ecosystem. Through collaboration with key stakeholders and leveraging its resources and expertise, VNN is driving meaningful change towards a greener and more sustainable transportation landscape in the city.

Demographics:

Varanasi, situated in eastern Uttar Pradesh, holds immense historical and cultural significance as a hub for trade, commerce, and spirituality along the Ganga River. Its administrative structure, comprising five zones and 90 wards, ensures systematic development and efficient governance.

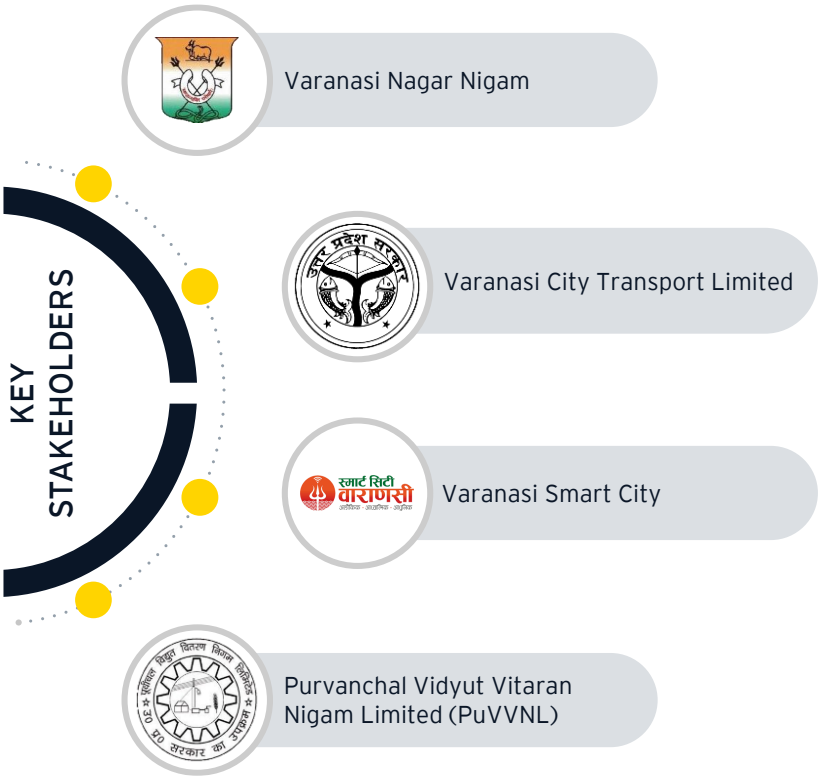
The city's economy, driven by its historical ties to the Silk Road and a thriving textile industry, now relies heavily on the tertiary sector, notably trade and transportation. Tourism, drawn to Varanasi's iconic riverfront and ghats, further bolsters its economy.

Yet, Varanasi grapples with challenges like rapid urbanization, population growth, and changing land use patterns. Urban sprawl and conversion of agricultural land pose hurdles to sustainable development and urban management.

The municipal area spans 82.1 sq.km. and has a municipal area population of ~1.2 million according to the Census of 2011, The projected population for Varanasi city and adjacent areas is expected to reach 2.27 million by 2035.

Despite these obstacles, Varanasi remains vibrant, with the potential to lead in sustainable development and inclusive growth. By addressing urban complexities and leveraging its cultural heritage, Varanasi can emerge as a model city in the region.

Key government stakeholders:



The city will have to strategically implement citywide EV charging stations and develop infrastructure for electric vehicles, enhancing accessibility and viability for electric transportation. Policy advocacy efforts will be bolstered through partnerships to offer incentives and regulations for EV adoption, while public awareness campaigns and educational initiatives will highlight the environmental and economic benefits of e-mobility. Fleet electrification, partnership collaborations, and monitoring mechanisms will further propel the city towards its goal. Integration of technology, pilot projects. Varanasi's commitment to safety, compliance, and grid integration ensures a robust and sustainable e-mobility ecosystem, positioning the city as a model for sustainable urban transportation in the region.

Existing Transportation in Varanasi City:

During the period spanning from FY2015 to FY2023, the Compounded Annual Growth Rate (CAGR) of Internal Combustion Engine (ICE) vehicles progressed at a rate of 0.3%, contrasted sharply by the remarkable surge of 120% witnessed in Electric Vehicles (EVs). As a result, EVs captured approximately 13% of the market share in Varanasi transport by FY2023. This data highlights a notable transition towards electric mobility, even as ICE vehicles continue to retain dominance.

Policy Framework:

The adoption of e-mobility as a sustainable transportation alternative is gaining momentum worldwide, prompting governments to develop frameworks and regulations. In India, the Ministry of Power (MoP) and the Department of Heavy Industries (DHI) are central to this transition, focusing on establishing widespread charging infrastructure and incentive programs. Designation of the Bureau of Energy Efficiency (BEE) as the Central Nodal Agency (CNA) underscores India's commitment to EV adoption. State Nodal Agencies (SNA) are also engaged in establishing supportive ecosystems. Various governmental bodies are formulating and implementing policies to promote EV proliferation, reflecting a collective determination to steer transportation towards sustainability and mitigate climate change impacts.

The Uttar Pradesh Electric Vehicle Manufacturing and Mobility (EVMM) Policy 2022 has undergone a comprehensive revision to adapt to the evolving EV landscape. Flexible in approach, the policy charts a course for the next five years, allowing adjustments as needed. It encompasses various aspects of the EV ecosystem, addressing manufacturing and mobility infrastructure, overseen by the Infrastructure and Industrial Development Department of Uttar Pradesh. The policy promotes the EV industry through three pillars and offers incentives in three categories, including charging infrastructure and demand incentives for buyers, along with multiple benefits for manufacturers. These measures aim to drive EV sector growth in Uttar Pradesh while promoting sustainability.

Market Assessment:

EV sales projections:

Vehicle category	EV penetration rate		EV Sales ('000)	
	FY 2030 (E)	FY 2035 (E)	FY 2030 (E)	FY 2035 (E)
e-2W	28% - 30%	48% - 50%	18 - 20	35 - 38
e-rickshaw	100%	100%	12 - 14	18 - 20
e-3W	65% - 70%	90% - 100%	4 - 5	8 - 9
e-4W (private)	5% - 10%	20% - 25%	1.0 - 1.5	4 - 5
e-4W (commercial)	10% - 15%	35% - 40%	0.1 - 0.2	0.6 - 0.7
e-bus	100%	100%	0.06 - 0.07	0.02 - 0.03
SWM vehicles	25% - 30%	45% - 50%	0.06 - 0.08	0.1 - 0.3

Power Projections:

Vehicle category	Volume ('000)		Total Power Demand (MW)	
	FY 2030 (E)	FY 2035 (E)	FY 2030 (E)	FY 2035 (E)
e-2W	80 - 83	225 - 232	50 - 55	150 -152
e-rickshaw	66 - 68	143 - 145	130 - 136	290 - 294
e-3W	17 - 19	54 - 56	80 - 85	242 - 244
e-4W (private)	3 - 4	17 - 19	12 - 14	60 - 62
e-4W (commercial)	0.3 - 0.5	2 - 3	3 - 5	27 - 29
e-bus	0.21 - 0.22	0.24 - 0.25	43 - 44	48 - 50
SWM	0.1 - 0.3	0.6 - 0.8	0.3 - 0.5	0.8 - 1.0
Total	**174 - 175**	**453 - 454**	**340 - 341**	**832 - 833**

Additional power demand due to tourist four-wheeler (commercial) vehicles and electrification of Solid Waste Management vehicles

Vehicle category	Numbers in '000		Total Power Demand (MW)	
	FY 2030 (E)	FY 2035 (E)	FY 2030 (E)	FY 2035 (E)
Tourist cabs (EV influx)	116 - 118	296 - 298	18 - 20	45 - 47
SWM vehicles (EV volume)	0.2 - 0.4	0.6 - 0.8	0.2 - 0.4	0.7 - 0.9

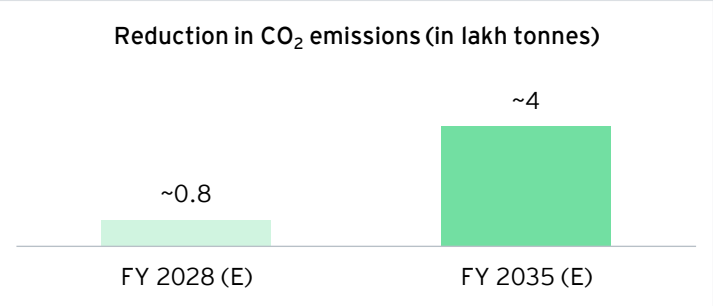
Total number of charger required by 2030 and 2035

Charger Rated Capacity	kW	Total Number of charger required by 2030	Total Number of charger required by 2035
LEV AC	10 (3*3.3)	2,949	6,762
IS 17017-2-6	7.7	310	881
Type-II AC	11	167	456

CCS II	30	48	227
CCS II	180	44	50
Total		3,518	8,376

Impact on GHG emissions

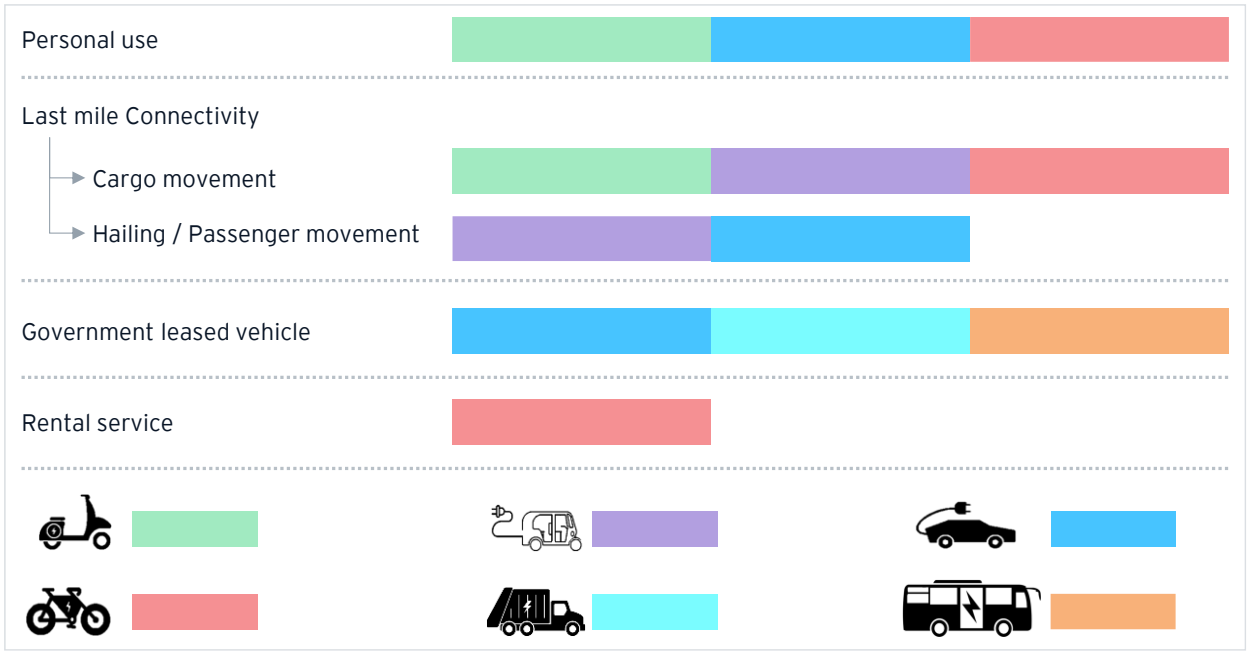
The shift from ICE vehicles to EVs in Varanasi could lead to a reduction of 0.8 to 1 lakh tonnes of emissions by FY 2028, with estimates projecting a notable decrease of 4 to 4.5 lakh tonnes by FY 2035, illustrating the significant potential for decarbonization.



Primary consultation with city level EV stakeholders:

The analysis of fleet drivers in Varanasi indicates that while 70% primarily operate small vehicles covering an average of 140 km per day, 90% express uncertainty about switching to electric vehicles (EVs) in the near future. Concerns such as range anxiety and charging infrastructure availability pose significant barriers. Fleet operators, managing an average fleet size of 10 vehicles, show openness to transitioning to EVs, but cite cost and charging infrastructure availability as primary hurdles. In fleet dealerships, there's a sales disparity between ICE and electric vehicles in four-wheeler dealerships, while electric two-wheelers see greater acceptance, possibly due to lower operating costs and environmental concerns.

Use cases of different vehicle segments:



Role of STU in fleet electrification for intracity bus movement:

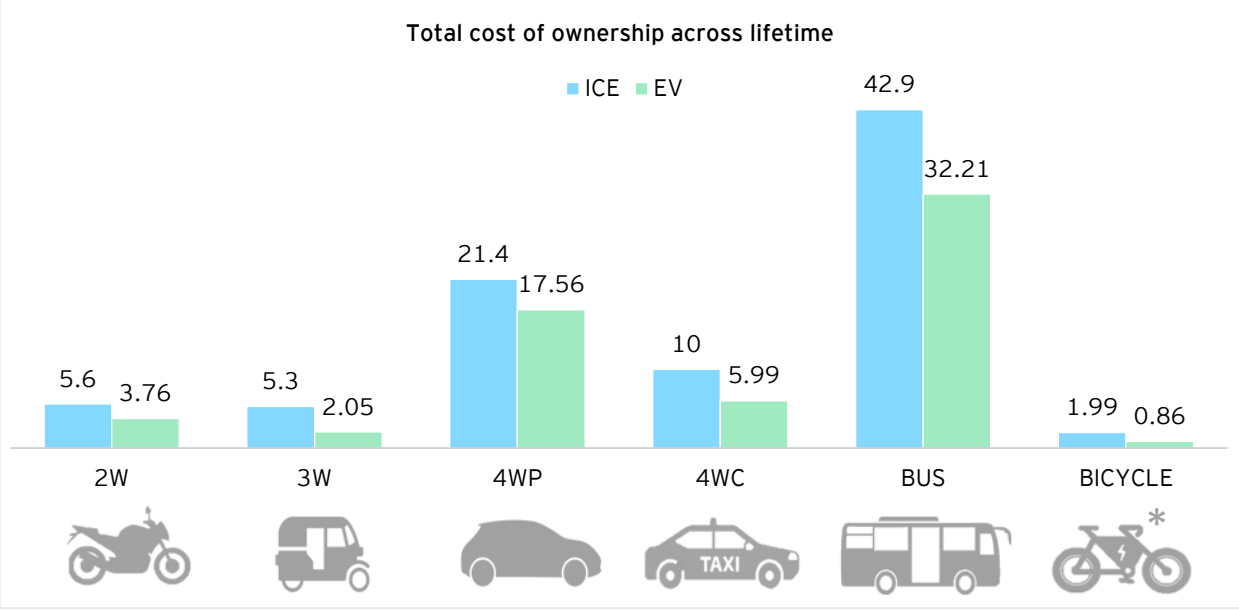
Varanasi's bus network comprises 180 buses, with ICE buses procured during 2009-2010 and electric buses acquired in 2021 under the FAME-II initiative. Presently, 28% of the city's transportation network consists of electric vehicles (EVs), with plans for future expansions aimed at increasing eco-friendly travel. The city transport department aims to transition its entire bus fleet to electric by 2028, reflecting a commitment to a cleaner, greener transportation system. However, challenges exist with a significant portion of the ICE bus fleet nearing end of life, indicating potential maintenance and infrastructure issues. The operational cost comparison between ICE and electric buses reveals financial implications and operational differences, underscoring the need for strategic planning and investment in modernizing the fleet. Presently, electric buses are charged at the Varanasi Cantt depot with fast chargers, enabling efficient service with an operational range of ~200 kilometres per day.

Business Model Analysis:

This section explores a range of innovative business models aimed at revolutionizing urban mobility in Varanasi. From the installation of Public Bicycle Sharing (PBS) systems to the electrification of government fleets through Energy Efficiency Services Limited (EESL). Simultaneously, EESL's initiative to transition government fleets to electric vehicles underscores a commitment to reducing emissions and fostering a greener transport ecosystem. Moreover, Varanasi is exploring diverse procurement strategies for electric buses, emphasizing reliability, cost-effectiveness. Additionally, the proposed Hop-On Hop-Off (HOHO) bus service promises to offer tourists a convenient and flexible mode of transportation to explore the city's cultural treasures. Integrating this service with the PBS system further enhances connectivity and promotes sustainable tourism practices. These initiatives collectively signify Varanasi's dedication to redefining urban mobility while preserving its rich cultural heritage and advancing environmental sustainability.

Estimating Total Cost of Ownership:

The Total Cost of Ownership (TCO) of a vehicle encompasses all expenses from purchase to disposal, including purchase price, depreciation, fuel costs, maintenance, insurance, and financing fees. It guides decision-making by analysing factors such as purchase price, depreciation, fuel efficiency, maintenance, insurance premiums, and financing costs. Electric vehicles are cost effective in all segments of vehicle category, as demonstrated below.



**ICE 2W (scooter) considered for TCO comparison*

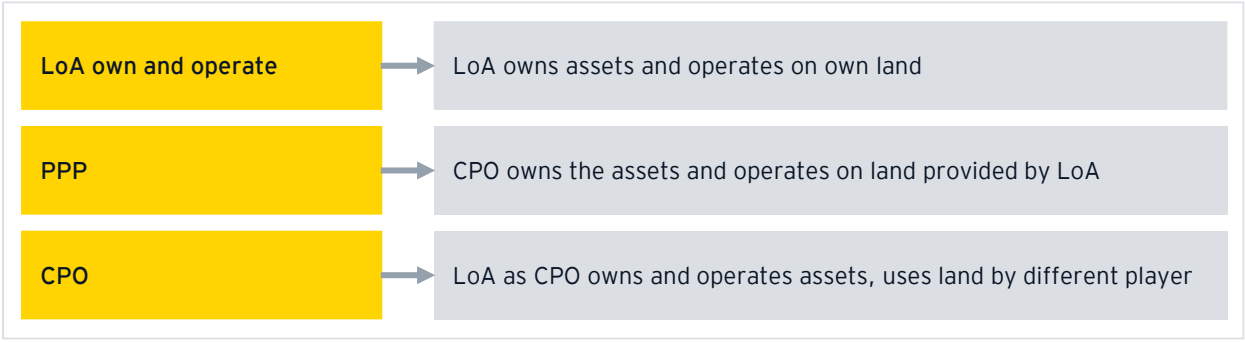
EV Charging Infrastructure:

In Uttar Pradesh, EV adoption is bolstered by dedicated policies, including tariffs for EV charging set by the UPERC, fostering sustainable transportation. Collaborating with UPERC ensures accessible charging, with incentives like subsidies and open access, mandating charging, and swapping stations in each district. Varanasi's Smart City Mission advances e-charging with plans for 100 stations at heritage sites and 200 more at tourist spots, including a comprehensive Electric Bus Charging Station project costing 12.30 Cr, featuring amenities for efficient operations and sustainability.

Mapping existing EV charging infrastructure in Varanasi involves a systematic four-step process. Firstly, the city's boundary is delineated, dividing it into 1km x 1km grid squares to establish the geographical scope. Next, major points of interest are identified, including government buildings, key stakeholders' facilities, and existing EV charging stations, ensuring comprehensive coverage. These initial steps provide valuable insights into the current EV charging landscape and enable projections for future infrastructure requirements based on demand and availability trends. Subsequently, heat maps representing demand areas for Electric Vehicle Charging Infrastructure (EVCI) installation are generated, followed by the identification of potential implementation locations. This methodical approach facilitates the strategic placement of EV charging infrastructure to meet the city's evolving needs while promoting widespread accessibility and adoption of electric vehicles.

Potential Business Model for development of EVCI for fleet adoption:

Public charging infrastructure is essential for widespread electric mobility adoption. To promote EV awareness and alleviate range anxiety, affordable and accessible charging networks are crucial. In Varanasi, the Land-owning Agency (LoA), such as Varanasi Nagar Nigam (VNN) or Varanasi Smart City Limited, plays a pivotal role in deploying Electric Vehicle Charging Infrastructure (EVCI). Various government bodies can serve as the LoA. Different implementation models, including capital expenditure for charging equipment and land provision, are utilized for setting up public charging infrastructure.



Renewable energy integration:

The integration of Renewable Energy (RE) with Electric Vehicle (EV) charging infrastructure is vital for sustainable transportation. Combining clean energy sources like solar and wind power with EV charging systems addresses environmental concerns and reduces carbon emissions. In Varanasi, this integration offers environmental sustainability and long-term energy cost savings. Uttar Pradesh's proactive approach to renewable energy, including initiatives like the Har Ghar Solar Abhiyan and solar subsidy programs, demonstrates the state's commitment to promoting solar adoption and achieving renewable energy targets. Through collaboration and innovative financing, Uttar Pradesh is paving the way for a greener, more sustainable energy future.

Government initiatives are pivotal in facilitating the successful integration of renewable energy (RE) with EV charging infrastructure. Establishing comprehensive incentive programs, supportive regulations, and fostering public-private partnerships are key recommendations. Additionally, investing in research and development, promoting

standardization, and enhancing awareness through education campaigns are essential steps. For the private sector, initiatives such as investment in renewable energy infrastructure, collaboration with renewable energy companies, and development of smart charging infrastructure are recommended. Private entities should also engage in community education, offer incentives for sustainable practices, and participate in government initiatives. DISCOMs, as critical stakeholders, should collaborate with renewable energy developers, implement net metering policies, and introduce time-of-use tariffs to optimize grid usage. Moreover, grid modernization, dynamic pricing models, and educational campaigns for consumers are vital for DISCOMs to support the integration of RE with EV charging. Through collaborative efforts and strategic initiatives, government, private sector, and DISCOMs can accelerate the adoption of renewable energy-integrated EV charging infrastructure, contributing to a sustainable energy ecosystem.

Benefits of integrating EWCD friendly features:

Integrating EV Charging Infrastructure with services tailored to Elderly, Women, Children, and Disabled (EWCD) populations offers a range of benefits, promoting inclusivity, sustainability, and accessibility. By ensuring that transportation solutions are designed with diverse users in mind, barriers to mobility faced by EWCD populations can be addressed, fostering a more inclusive society. Key advantages include reducing greenhouse gas emissions, enhancing safety and security, and aiding services tailored to specific needs. Implementation measures include selecting accessible locations, providing well-lit and secure charging stations, and offering charging assistance services. Clear signage, child-proof features, and convenient parking configurations further enhance safety and usability. By prioritizing accessibility and safety considerations, EV charging infrastructure can become more inclusive and welcoming to all members of the community.

Recommendations:

Embracing modernity, Varanasi recognizes the importance of robust EV charging infrastructure to facilitate this transition smoothly. To integrate EVs into the city's bustling streets, strategic planning and collaboration among stakeholders are paramount, with Varanasi Nagar Nigam and PuVNNL taking the lead. Leveraging the city's accessible landmarks, the provision of public charging stations not only enhances convenience but also promotes sustainable mobility, harmonizing tradition with technology.

Currently, Charging Point Operators (CPOs) face challenges in setting up stations, yet simplifying regulations and offering incentives can encourage their involvement, thus fostering the growth of EV charging networks. Moreover, to ensure the economic viability of charging businesses, innovative strategies such as flexible pricing and local partnerships can maximize charger usage. The shift towards electric mobility in Varanasi signifies more than just embracing innovation; it's about preserving heritage, fostering inclusivity, and building a sustainable future for generations to come. Through strategic planning, collaboration, and innovation, Varanasi can lead the charge towards a greener and more vibrant tomorrow.

Recommendations for the adoption of e-Mobility in Varanasi encompass strategic planning, collaboration, technology integration, regular policy review, and public-private partnerships, among others, ensuring a comprehensive and sustainable approach to electric mobility integration in the city.

Background

The project focuses on conducting a comprehensive analysis to facilitate the induction and scale-up of EVs within various vehicle segments across critically selected 5 cities in India.

In collaboration with the Asian Development Bank (ADB), Energy Efficiency Services Limited (EESL), and Convergence Energy Services Limited (CESL), the initiative aims to identify promising markets and assess the feasibility of EV deployment.

Out of the five selected city, one of the cities is Varanasi, which is selected based on criteria such as Uttar Pradesh's readiness for e-mobility solutions, existing EV deployment success, and private sector participation, in close consultation with key stakeholders.

Subsequently, a detailed market assessment is being conducted, covering passenger and cargo applications across various vehicle segments, with a focus on understanding demand and supply dynamics, policy frameworks, and business models. This analysis involves evaluating fleet use cases, assessing market size, and projecting demand until 2030, alongside an examination of EV key players, industry barriers, and policy implications.

Moreover, the project delves into charging infrastructure requirements, considering factors like location, grid impact, and integration of renewable energy options.

The findings are encapsulated in this report, providing insights into market assessment, charging network plans, and business models.

Need

The need for this report arises from the urgent imperative to address several critical challenges facing the transportation sector in India. As the country grapples with escalating pollution levels, burgeoning energy demand, and the pressing need to mitigate climate change, transitioning to sustainable modes of transportation is imperative. EVs present a promising solution to these challenges, offering a cleaner, more efficient alternative to traditional fossil fuel-powered vehicles. However, the widespread adoption of EVs in commercial fleets faces several barriers, including limited infrastructure, policy constraints, and market uncertainties.

By conducting a comprehensive market segmentation, sizing, and feasibility analysis, this project seeks to address these barriers and unlock the full potential of EVs in India's transportation landscape. The project aims to identify promising markets and assess the feasibility of EV deployment.

Furthermore, by conducting detailed market assessments and feasibility analyses, the report provides invaluable insights into demand and supply dynamics, policy frameworks, and business models, essential for informed decision-making. This analysis enables stakeholders to understand the market landscape better, identify potential barriers, and devise strategies to overcome them. Additionally, by evaluating charging infrastructure requirements and proposing sustainable business models, the report lays the groundwork for the seamless integration of EVs into commercial fleets.

Overall, the need for this report is underscored by the urgency to accelerate the transition to sustainable transportation solutions in Varanasi. By leveraging the expertise and resources of key stakeholders, the report aims to drive meaningful change, fostering a cleaner, more sustainable future for the transportation sector in Varanasi.

Approach and methodology

EV Sales, power demand and EV charger estimates calculation

Methodology for estimating EV sales of 2W, E-rickshaw, 3W, 4W (private) and 4W (commercial)

A bottom-up approach is used to understand the trajectory of electric vehicles penetration, the power demand required for the EV charging, estimation on the number of chargers required and capital investment for deploying the required number of chargers till FY 2035.

The assessment starts with understanding the present demand of various vehicle segments such as 2W, e-rickshaw, 3W, 4W (private), 4W (commercial). To understand segment wise demand, the number of ICE vehicles registered from FY 2015 to FY 2023 are taken into consideration and then the number of ICE vehicles are projected till FY 2035 based on the previous year's CAGR.

To assess the EV projections till FY 2035, the present EV penetration is observed for various vehicle segments such as e-2W, e-3W, e-4W (private) and e-4W (commercial). Based on the growth rate of present EV penetration rate and government targets, assumptions are for future EV penetration. Based on the projected number of ICE vehicles are future EV penetration, the number of EVs are projected till FY 2035.

Methodology for estimating EV sales and number of charger required by buses operated by government for intracity movement

The assessment of electric buses in this report is for government operated intracity movement buses only.

Based on primary consultation, by 2026, all 130 ICE buses will be scrapped, and 100 new electric buses will be procured under the PM e-bus Sewa scheme, achieving 100% electrification of the city's bus fleet. Current trends indicate that each e-bus serves an average of 6,000 people. Maintaining this trend, we have estimated the number of additional electric buses required by 2030 and 2035 to meet future transportation needs.

Additionally, the charger-to-bus ratio has been maintained at the current trend of 1:5 to ensure efficient and reliable charging infrastructure.

Once the projected number of EVs are obtained, based on the daily power requirement and daily distance travelled by each EV segment, daily power requirement for EV charging is evaluated. This assessment of daily power requirement will form the basis for estimating the number of chargers required to support the EV charging. Based on the rated capacity of chargers available in the market and their percentage utilization, the total number of chargers are evaluated. And further, based on the cost of each charger, the total capital expenditure for deploying the chargers is also evaluated.

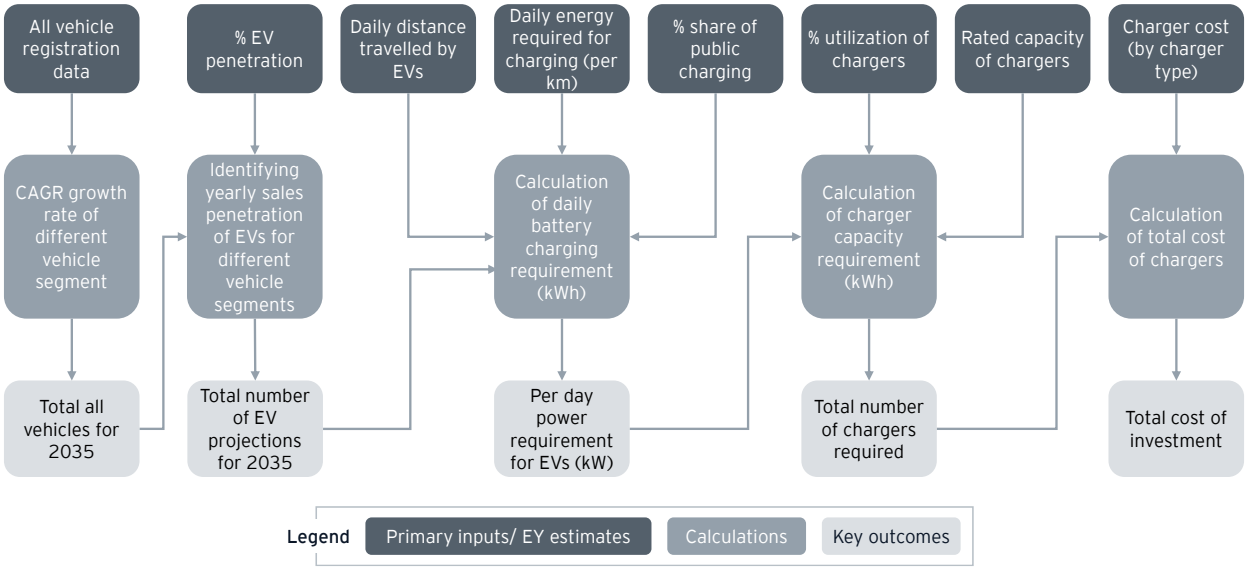
Table 1: Assumption for Public Charging share by vehicle segment

Charging type	e-2W	e-3W	e-4W (private)	e-4W (commercial)	e-Bus	e-rickshaw
Public Charging Share	10%	20%	30%	10%		50%
Home charging	80%	30%	10%	80%		50%
Captive charging		50%	60%		100%	
Workplace charging	10%			10%		

Charging type	e-2W	e-rickshaw	e-3W	e-4W (private)	e-4W (commercial)	e-Bus
Public Charging Share	10%	50%	20%	10%	30%	
Home charging	80%	50%	30%	80%	10%	
Captive charging			50%		60%	100%
Workplace charging	10%			10%		

The process flow for the assessment of EV sales projections, power demand from EVCI and cost estimation for deployment of projected number of EV chargers is presented below:

Figure 1: EV Charging Infrastructure Model



Power demand due to EV charging

Charging infrastructure is the backbone of any electric mobility implementation. The provision of an adequate, affordable, accessible, and reliable charging network is a prerequisite for the mass adoption of EVs. The provision of robust charging infrastructure solutions is key to promoting awareness and confidence in vehicle range among prospective EV users.

For an ambitious shift towards sustainable transportation, a comprehensive and easily accessible network of electric vehicle (EV) charging infrastructure is imperative. Infrastructure is a prerequisite to match up the pace of EV adoption as seen in the projections in the previous section. The Government has an important role to play in the planning and implementation of public charging infrastructure.

The power demand will increase in the future in tandem with more urbanization and an increase in the number of consumers. With an increase in EV penetration, the overall power demand will further rise due to the charging requirements of different segments of EVs. The significant rise in EV charging power demand will come from the e-bus segment. **It has been estimated that e-buses with battery capacity in the range of 200 kWh – 240 kWh consume around 200 to 240 units while charging. This is equivalent to 100 to 120 household Air Conditioners (ACs) running for 1 hour[1].**

To understand the power requirement for charging of projected number of EVs in the years to come, certain assumptions are taken to assess the power demand. The percentage utilization of chargers is assumed to be 40% for FY 2028 which would increase to approximately 60% by FY 2035. Assumptions considered for estimating power demand due to EV charging by 2035 is mentioned below:

1https://www.hindustantimes.com/cities/delhi-news/dtc-to-launch-pilot-project-for-smart-charging-system-for-electric-buses-with-ai-software-to-reduce-grid-load-and-costs-101685729415393.html

Table 2: Assumptions considered for estimating power demand due to EV charging by 2035

Assumptions[2]	e-2W	e-rickshaw	e-3W	e-4W (private)	e-4W (commercial)	e-Bus[3]
Average Daily run (in kms)	20	60	120	30	140	200
Battery capacity (kWh)	2.98	3.7	7.4	28.6	26	151
Daily battery charge requirement (kWh)	0.66	2.04	6.2	3.18	15.4	201.3

Projections for EV Charging infrastructure and estimated capital expenditure required to deploy EV chargers

Different EV models and segments have different charging requirements. It is usually recommended to have a good mix of different charger types that can cater to existing and future demand. It is equally important to determine the quantity of chargers to be installed. Installing too many chargers will increase the cost and installing fewer chargers will create scheduling and access issues and will create a discouraging impact on the existing EV users and upcoming potential EV buyers.

The number of installed EV chargers in a charging station should aim to serve existing EVs as well as additional demand in the future. Several research papers suggest that fast charging a vehicle's battery on continuous basis depletes the battery life. Therefore, it is recommended to keep this factor in mind and choose a combination chargers to maximise the life of the battery of the vehicles. For the purpose of projecting the number of chargers to cater the EV charging power demand as per the projections in the previous section, the type of chargers is assumed in this report as provided below:

Table 3: Charger types for different vehicle segments & estimated cost

Type of charger	kW rating	e-2W	e-rickshaw	e-3W	e-4W (private and commercial)	Estimated cost of charger (In INR.)
LEV AC	3.3	40%	100%	60%	-	37,000
Type-II AC	11	-		40%	-	45,000
IS-17017-2-6	7	60%			-	45,000
CCS II	30	-		-	100%	14,00,000

Reduction in CO_2 emissions

E-mobility plays a critical role in decarbonization of transport sector. The concerning levels of vehicular emissions underscore the pressing need to address and mitigate the adverse environmental impacts posed by the ICE vehicles. A transition to electric mobility has the potential to reduce the impact of vehicular emissions by road transport sector and it will help reduce oil imports as well.

To assess the impact of additional CO_2 emissions reduction due to future penetration of EVs are estimated based on EV stock volume, which is the cumulative value of the year-on-year addition of EVs. The following assumptions are considered as provided in the table below.

[2] National Automotive Board (NAB) (heavyindustries.gov.in)
[3] https://www.buses.tatamotors.com/products/brands/starbus/tata-ultra-9-9m-ac-electric-bus/

Table 4: Assumptions for CO_2 emissions calculations

ICE Vehicle type	Daily run (In kms)	Average mileage (In kms)	Emission norms[4] (Grams CO_2/km)
2W	20	80	28.58
3W	120	40	77.89
4W - Private	30	17	139.52
4W – Commercial	140	19	139.52
Bus	200	7	787.72

While adoption of electric vehicles (EVs) can help in reducing the impact of tailpipe emissions within the city, it is also important to recognize that certain level emissions are also present at the point of electricity generation that fulfil the EV charging demand. Presently, a significant portion of electricity generation is derived from non-renewable sources like coal based thermal power. Therefore, the actual reduction in carbon emissions due to EV adoption is projected by taking into consideration, the impact of carbon emissions due to electricity generation as well. The assumptions for daily power requirement for each EV segment is provided in the Table 2.

CEA Clean Development Mechanism

Based on the data of Central Electricity Authority (CEA) for Clean Development Mechanism (CDM), the weighted average emission factor for CO_2 based on power generation from grid connected power plants in India including Renewable Energy generation are:

Table 5: Weighted average emission factor for CO_2 based on power generation from grid connected power plants

FY	Carbon Emission factor of Grid Electricity (including RE) (tCO_2/MWh)[5]
2017-18	0.754
2018-19	0.744
2019-20	0.713
2020-21	0.703
2021-22	0.715

The above table shows the weighted average emission factor over the period from FY 2017-18 to FY 2021-22. The weighted average emission factor has been reducing by a factor of around 2% to 4% except for FY 2021-22 where it has increased slightly due to increase in total generation, where coal-based generation is increased compared to gas & hydro based generation as per the CEA emissions report.

However, with Clean Development Mechanism (CDM), generation of power will be more efficient with higher efficient technologies such as supercritical technology, integrated gasification combined cycle, renovation and modernisation of old thermal power plants and co-generation along with renewable energy sources. Therefore, it can be assumed that the weighted average emission factor will reduce slightly each year. The assumed weighted average emission factor for FY 2024 to FY 2035 is mentioned below assuming yearly reduction of 2%:

[4] Appraisal guidelines for Metro rail projects proposals, Ministry of Housing & Urban Affairs, Government of India, September 2017
[5] https://cea.nic.in/wp-content/uploads/baseline/2023/01/Approved_report_emission__2021_22.pdf

Table 6: Assumed weighted average emission factor for FY 2024 to FY 2035 Reduction in CO_2 emission

FY	Carbon Emission factor of Grid Electricity (including RE) (tCO_2/MWh)[6]
2023-24	0.701
2024-25	0.687
2025-26	0.673
2026-27	0.659
2027-28	0.646
2028-29	0.633
2029-30	0.621
2030-31	0.608
2031-32	0.596
2032-33	0.584
2033-34	0.573
2034-35	0.561

Heat map of all Point of Interests (PoI)

Step 1: The city of Varanasi is partitioned into a grid measuring 1km x 1km to facilitate analysis and visualization.

Step 2: Identification of key points of interest (PoI), including railway stations, airports, bus stands, hospitals, existing EV charging stations, commercial malls, government buildings, public parking lots, major 5-star hotels, e-rickshaw stands and potential parking lots.

Step 3: Assignment of weightage to each PoI based on various factors such as the type of charging it supports, charger type, and expected time spent at the charging station. Weightage values are defined in tables representing charger type, charging type, and time spent intervals.

Table 7: Assumed weightages for assigning weightages to PoI

Charging type	weightage
PCS	3
Captive	2
Private	1

Charger Type	weightage
Fast	3
Moderate	2
Slow	1

Time spent (In minutes)	weightage
0 - 30	4
30 - 60	3
60 - 90	2
> 90	1

Step 4: Normalization of weightage values to ensure uniformity and prevent data discrepancies.

Step 5: Visualization of the normalized weightage data as kernel density heatmap, providing insights into the distribution and significance of PoIs across Varanasi.

[6] https://cea.nic.in/wp-content/uploads/baseline/2023/01/Approved_report_emission__2021_22.pdf

Approach and methodology for tourist and SWM vehicle calculation

Tourist vehicles:

Between 2016 and 2023, Varanasi experienced a notable increase in tourist arrivals, reflecting the city's growing popularity as a travel destination.

To gain a deeper understanding of this surge, we can analyse the data by converting the total number of tourists into Passenger Car Units (PCUs), considering the typical occupancy of cars, which is approximately 5 people per vehicle. This conversion allows us to quantify the impact of tourism on the city's transportation infrastructure more effectively.

Moreover, assuming that 10% of these vehicles were intercity tourist cars while the remaining portion comprised buses and other transportation modes.

As a next step, we can delve into projecting the total influx of electric tourist cars expected in Varanasi for the years 2030 and 2035. By forecasting the growth of electric tourist cars over the years, we can better understand the infrastructure requirement for Varanasi.

SWM vehicles:

The Varanasi Nagar Nigam provided data on the total count of Solid Waste Management (SWM) vehicles in 2023, serving as a foundational dataset for analysing future trends and striving for a Compound Annual Growth Rate (CAGR). To gain insights into the trajectory of SWM infrastructure, a meticulous process of backtracking vehicles was initiated, correlating their numbers with the households each vehicle served. This detailed analysis facilitated the projection of the total influx of electric SWM vehicles expected in Varanasi by the years 2030 and 2035.

1 Demographics of Varanasi City

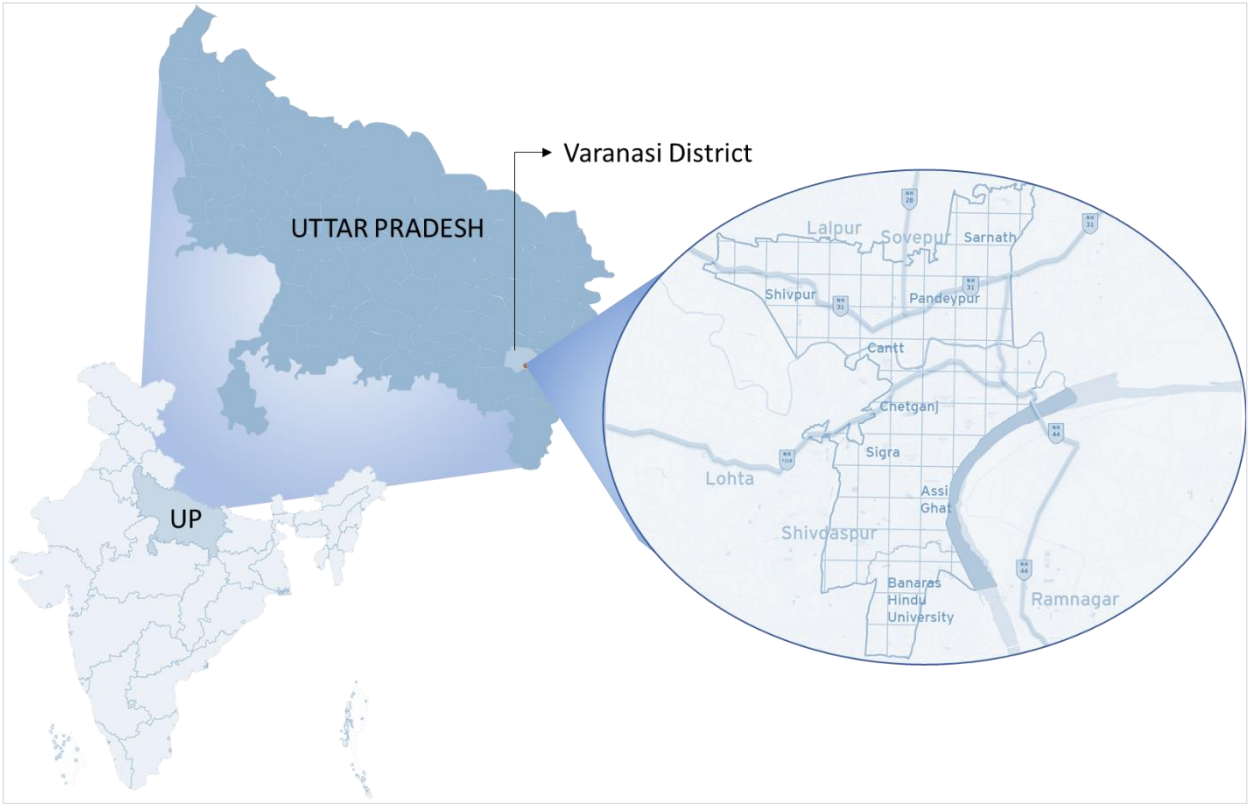
1.1. City Background

1.1.1. Geographical placement of Varanasi city:

1. Varanasi is located in the central part (between 25.3176° N & 82.9739° E, Ganga River and Ram Nagar lie to the east, while Chandauli is located to the east, Jaunpur Road to the west, Azamgarh Road to the north, and Chunar Road to the south[7]) of the Gangetic Plain in eastern Uttar Pradesh.
2. Positioned at a distance of 293 km from Lucknow and 820 km from New Delhi, the city is situated along a crescent-shaped curve of the Ganga River, following its course towards the Bay of Bengal. Nestled within a fertile agricultural region that cultivates various crops, Varanasi shares its borders with the districts of Chandauli and Mirzapur[8].

Varanasi is administratively divided into a comprehensive structure consisting of **five zones, each further subdivided into 14 sub-zones, and a total of 90 wards.** This hierarchical division facilitates the efficient management and governance of the city, ensuring that various aspects such as infrastructure development, public services, and civic amenities can be organized and implemented systematically across different geographical areas. The zoning and ward system also enable local authorities to address the specific needs and concerns of residents in different parts of Varanasi, thereby enhancing the overall quality of life and urban environment in the city[9].

Figure 2: Geographical positioning of Varanasi city



[7] https://nnvns.org.in:449/nnvns/images/SWM-plan-24th-march-2019.pdf
[8] https://www.varanasionline.in/city-guide/about-varanasi
[9] https://nnvns.org.in:449/nnvns/images/SWM-plan-24th-march-2019.pdf

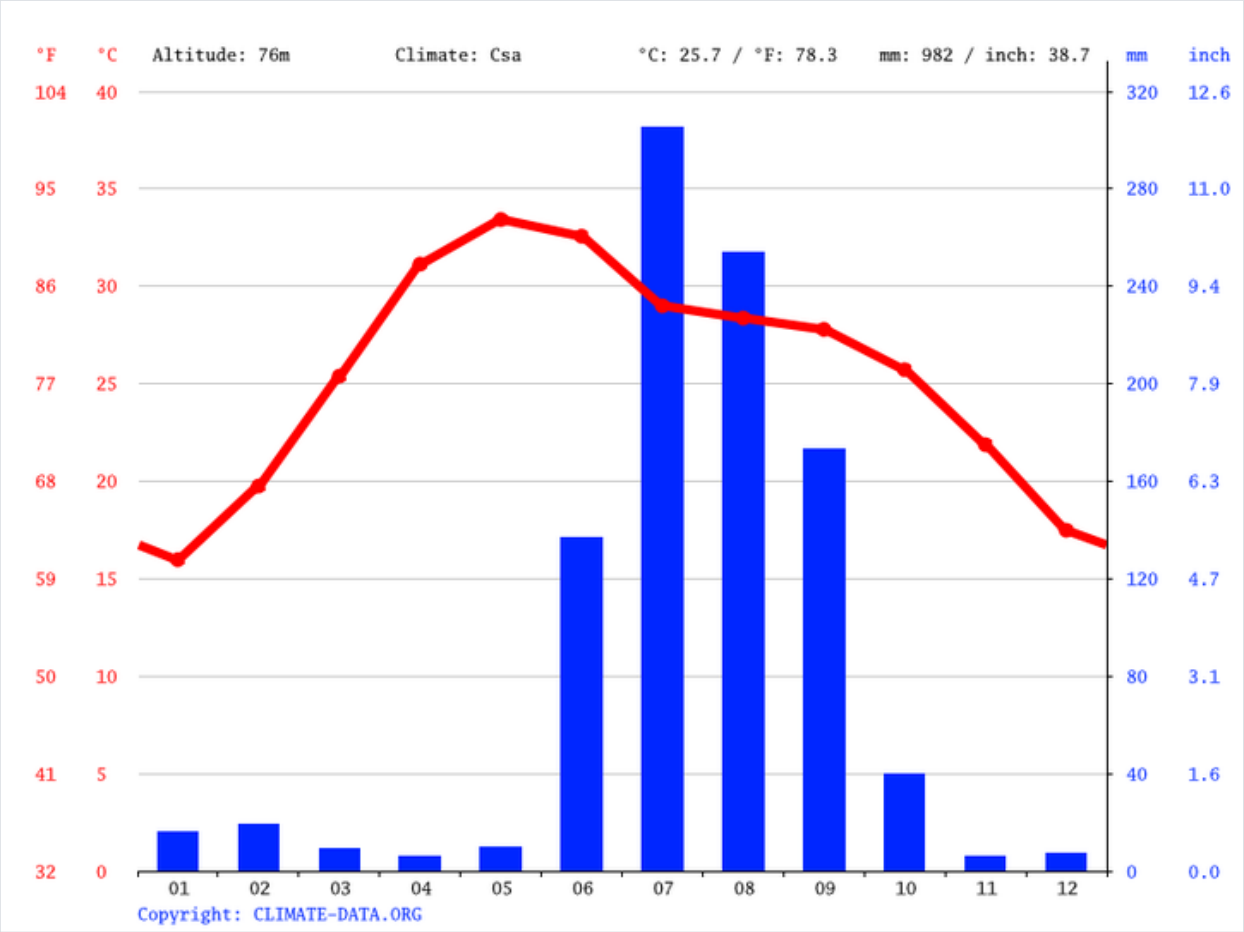
1.1.2. History

Varanasi's archaeological evidence dates human settlement to the 11th or 12th century BC[10], establishing it as one of the oldest continuously inhabited cities. By the 2nd millennium BCE, it emerged as a key urban centre for Vedic religion and philosophy, and later flourished as a hub for commerce and industry, producing renowned goods like muslin, silk, perfumes, ivory crafts, and sculptures[11]. Historically, Varanasi served as a pivotal point along ancient trade routes, connecting Taxila to Pataliputra and bridging western and eastern India. It also lay on Sher Shah Suri's route linking Peshawar to Kolkata[12].

1.1.3. Climate

Varanasi experiences a humid subtropical climate with notable differences between summer and winter temperatures. **Summers, from April to June, are dry and hot, with May being the hottest month, reaching an average of 33.4°C (92.2°F). Winters are cooler, with January averaging 16.0°C (60.8°F)** [13]. The monsoon season, lasting from July to October, brings the majority of the annual rainfall, with July receiving the highest amount at 305 mm (12.0 inches) [14]. October receives about 5% of the total rainfall, while the remaining months collectively receive only 8%[15]. Approximately eighty percent of the precipitation occurs during the monsoon months, leading to fluctuations in the flow patterns of the river[16].

Graph 1: Climatic condition of Varanasi



[10] https://www.varanasihamstp.in/overview-of-the-city/
[11] https://www.britannica.com/place/Varanasi
[12] https://www.varanasionline.in/city-guide/about-varanasi
[13] https://en.climate-data.org/asia/india/uttar-pradesh/varanasi-3554/#climate-graph
[14] https://en.climate-data.org/asia/india/uttar-pradesh/varanasi-3554/#climate-graph
[15] https://www.varanasihamstp.in/overview-of-the-city/
[16] https://www.varanasihamstp.in/overview-of-the-city/

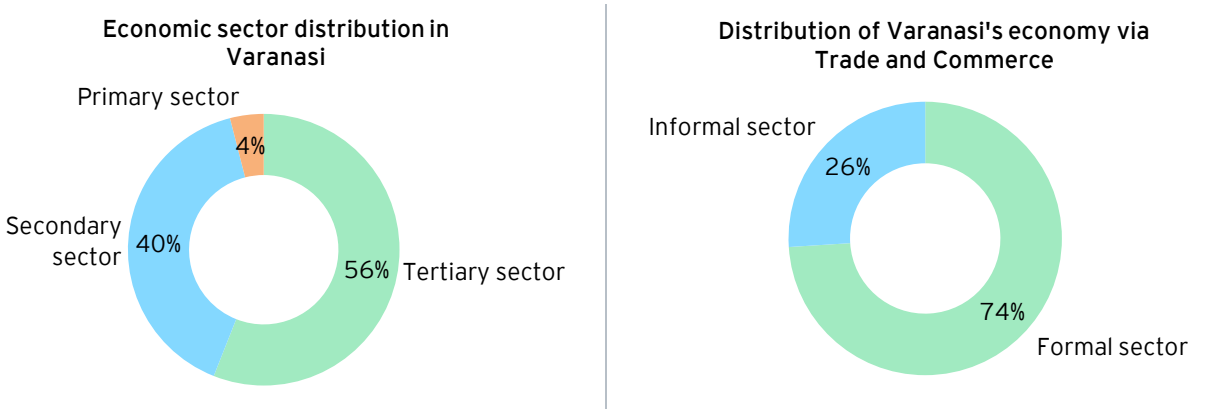
1.1.4. Economy, Trade, and commerce

Varanasi's connection to the Silk Road has shaped its economy and culture for centuries, attracting traders and travellers. Its renowned textile industry, especially silk weaving, remains a symbol of its prosperous past. Today, the city's vibrant cultural scene and handloom industry continue to reflect its rich heritage[17]. With an estimated GDP per capita of $5.9 thousand and a labour force of 1.2 million, Varanasi's Trade and Transportation sector employs nearly half of its workforce[18]. The city hosts over 5,000 industrial units, primarily located in peripheral areas.

Formal sector: The formal sector comprises businesses and economic activities that are under the supervision of the government.

Informal sector: The informal sector consists of workers and enterprises that do not come under the regulation of the government.

Graph 2: Economic sector distribution in Varanasi and Distribution of Varanasi's economy via Trade and Commerce



Primary sector: This sector is responsible for providing raw materials and base products for goods and services, it is an unorganised sector. Examples of primary sectors are agriculture, forestry, and mining.

Secondary sector: This industry manufactures natural products in various usable forms, it is an organised sector. Examples of the secondary sector are manufacturing units, small-scale units, large firms, and multinational corporations.

Tertiary sector: This sector provides services to both the primary and secondary sectors; it is an organised sector. Examples of tertiary sectors are Banking, communication, and trade.

In Varanasi, the tertiary sector dominates the economy, comprising 56% of formal employment, followed by the secondary sector at 40% and the primary sector at 4%. Manufacturing and trade are significant contributors to employment, with trade and commerce alone accounting for 36% of formal employment within the tertiary sector. The industrial sector serves as a primary source of livelihood for many Varanasi residents[19]. **The city's average annual per capita income is INR 1,93,616, surpassing the national average of INR 68,747[20].**

[17] https://varanasipedia.com/transportation/varanasis-connection-with-the-silk-road-tracing-the-citys-international-trade-links/
[18] https://metroverse.cid.harvard.edu/city/8463/economic-composition
[19] https://niua.in/intranet/sites/default/files/189.pdf
[20] https://niua.in/intranet/sites/default/files/189.pdf

1.1.5. Tourism

Tourism thrives in Varanasi, particularly along the riverfront and ghats, which constitute the city's primary heritage zone. Varanasi welcomed over 233 million tourists as of October 2021, surpassing the city's native population by over 56 times.

Figure 3: Tourist spots in Varanasi


Namo Ghat


Dashashwamedh Ghat


Assi Ghat


Banaras Hindu University (BHU)

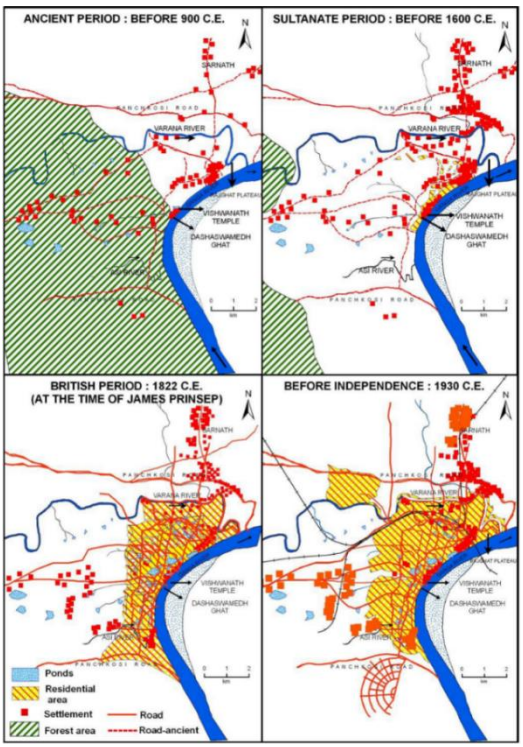

Kashi Vishwanath Temple


Ramnagar Fort

1.1.6. Spatial Extent and features

Before independence, Varanasi's historical and spiritual significance attracted migrants seeking religious fulfilment, economic opportunities, or education, driving centuries of population growth. However, the rapid influx outpaced the capacities of urban planning and governance. Limited infrastructure and deficient services pushed development to the outskirts, contributing to haphazard settlements. Despite economic vibrancy drawing industries and informal enterprises, the expansion of informal settlements exacerbated sprawl. Rural-urban migration and land use changes also played a role, converting agricultural land to residential and commercial zones, further expanding the city's footprint. Cultural and social dynamics influenced housing choices, with traditional settlement patterns shaping neighbourhood formations. As families sought affordable housing, sprawl extended into the peripheries, posing challenges for sustainable development and urban management before independence.

Figure 4: Spatial growth of Varanasi

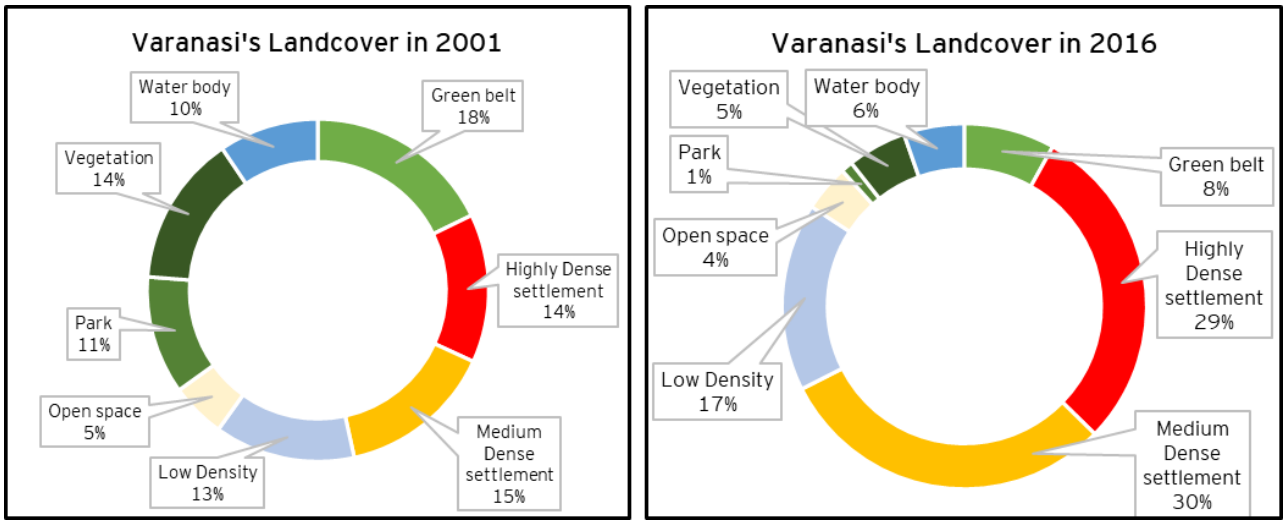


1.2. Area and land use

The Municipal Corporation governs an area of 82.1 sq. km., while the urban agglomerations span 793 sq. km[21]

The land cover analysis of Varanasi from 2001 to 2016 reveals a significant rise in high-density and medium-density settlements, indicating rapid urbanization. Conversely, there has been a notable decline in green belts, vegetation, parks, and open spaces during the same period[22].

Graph 3: Varanasi land cover in 2001 and 2016

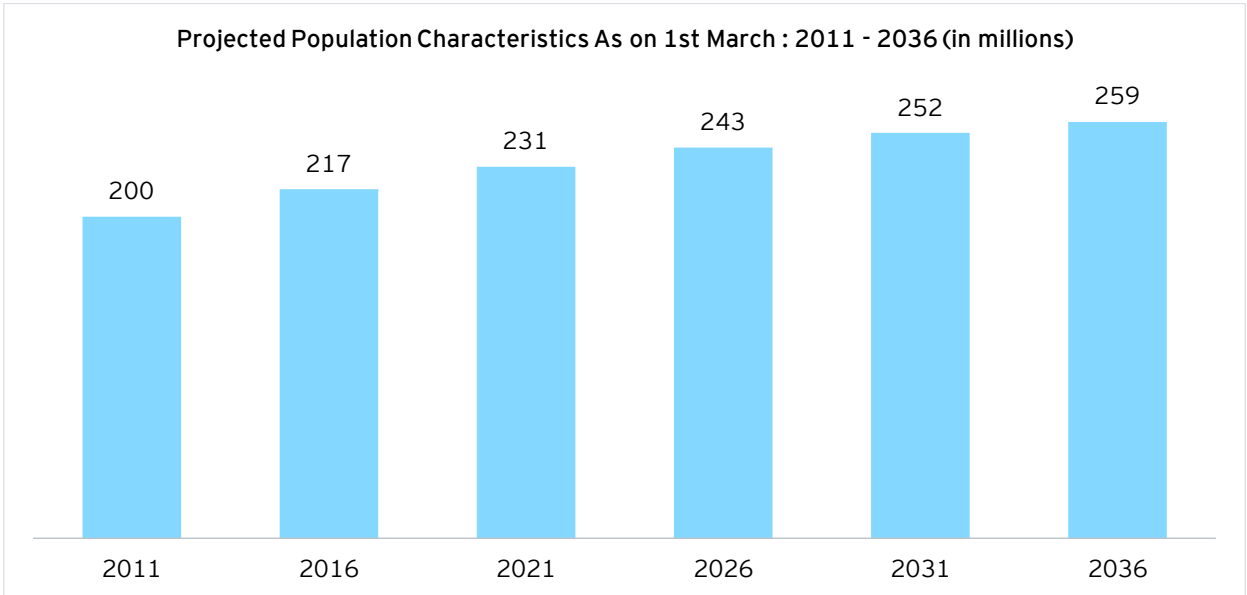


1.3. Population and Population density

1.3.1. Population

Uttar Pradesh's Population[23]

Graph 4: Population of Uttar Pradesh 2011 - 2036



[21] https://niua.in/intranet/sites/default/files/189.pdf
[22] https://www.ngji.in/index.php/ngji/article/view/85/72
[23] https://main.mohfw.gov.in/sites/default/files/Population%20Projection%20Report%202011-2036%20-%20upload_compressed_0.pdf

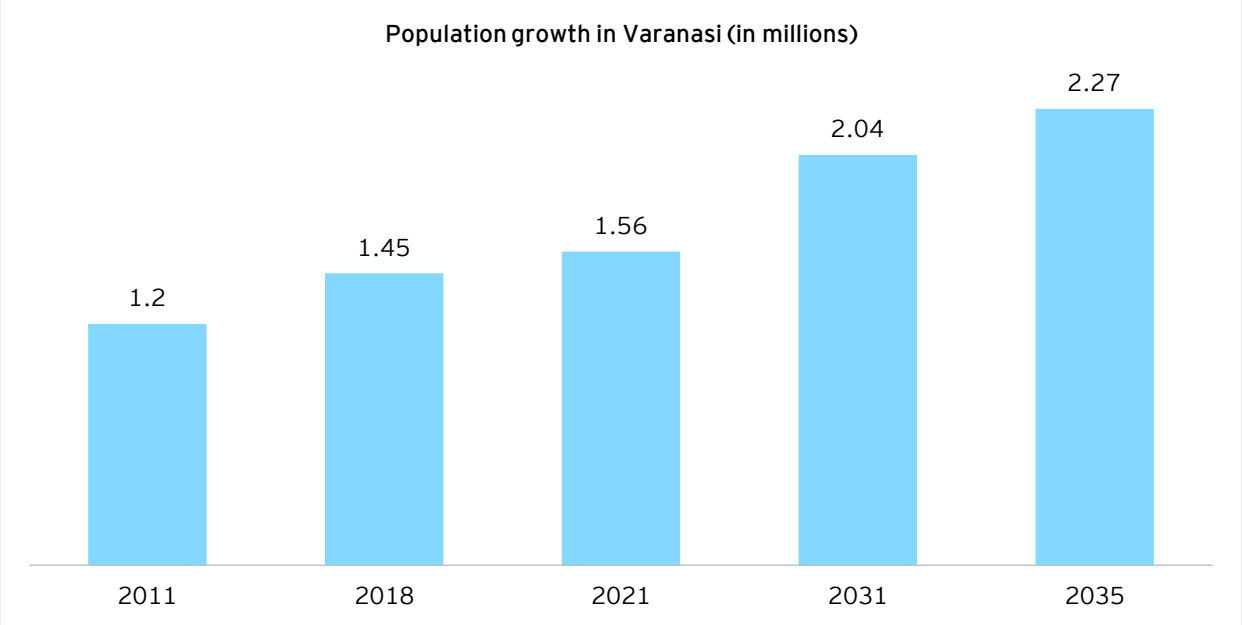
The top 6 most populous cities of Uttar Pradesh are:

1. Kanpur – 28,17,105
2. Lucknow – 27,67,348
3. Ghaziabad – 17,29,000
4. Agra – 15,85,704
5. Meerut - 12,26,709
6. Varanasi – 11,98,491

Varanasi ranks as the sixth most populous city in the state of Uttar Pradesh. Classified as a Class-II city, it has a municipal area population of ~1.2 million according to the Census of 2011. The total population within the Urban Agglomeration reaches ~1.4 million[24].

As per the analysis of Nagar Nigam Varanasi, the population of the city experienced a compounded annual growth rate of 2.74% from 2011 to 2018, and a rate of 2.47% from 2018 to 2021[25]. The projected population for Varanasi city and adjacent areas is expected to reach 2.27 million by 2035[26].

Graph 5: Population of Varanasi (in million)



1.3.2. Population Density

Varanasi's population density stands at 15,170 persons per square kilometre, showcasing significant variations across the city's wards, ranging from 16 persons/ha to 1,991 persons/ha[27].

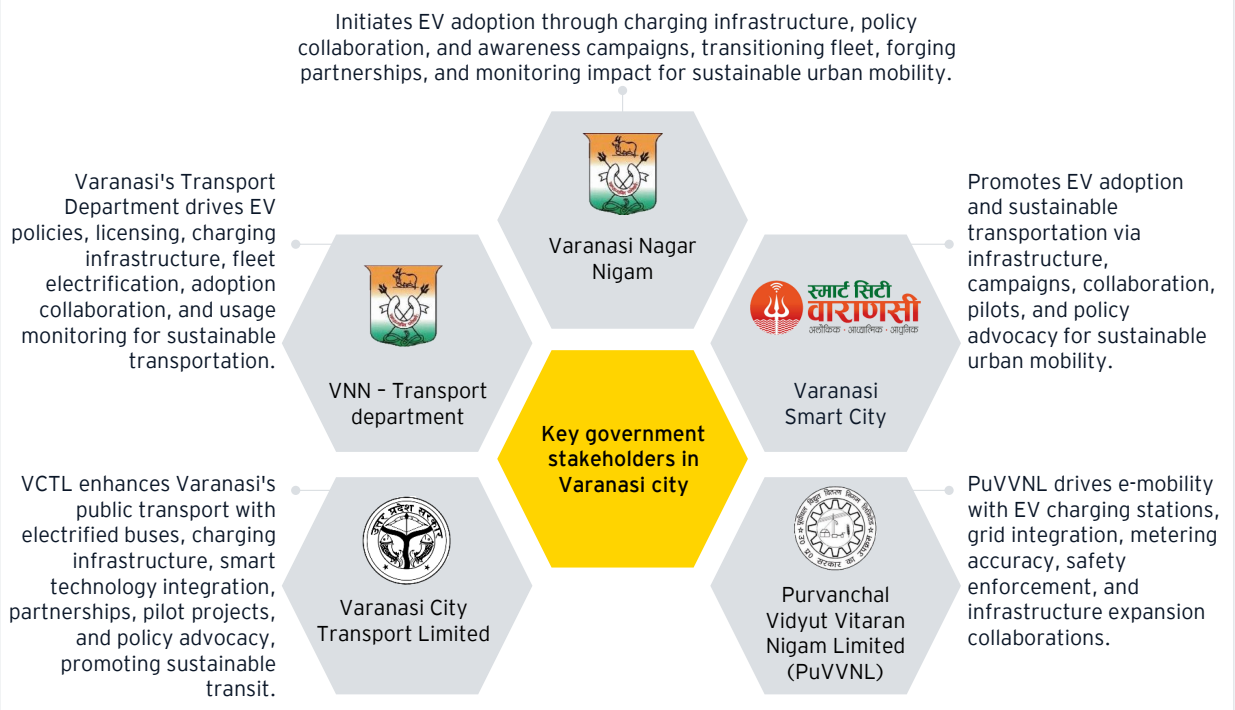
[24] https://niua.in/intranet/sites/default/files/189.pdf
25 https://nnvns.org.in:449/nnvns/images/SWM-plan-24th-march-2019.pdf
[26] https://worldpopulationreview.com/world-cities/varanasi-population
[27] https://niua.in/intranet/sites/default/files/189.pdf

2

Key Government Stakeholders

in Varanasi City

2.1. Key government Stakeholders in Varanasi City



2.1.1. Varanasi Nagar Nigam

The Municipal Corporation of Varanasi, known as the Varanasi Nagar Nigam (VNN), was formally established on January 24, 1959, by the Government of Uttar Pradesh under the Municipal Corporation Act of 1959, initially designated as a Nagar Mahapalika. However, under the U.P. Government Act-2 in 1994, it reverted to its Nagar Nigam status.

Governed by the Municipal Corporation Act of 1959, this municipal body holds significant responsibility in delivering civic services to both rural and urban areas, including tasks like colony relocation, road construction, water supply, public transportation, sanitation, solid waste management, and more.

The Nagar Nigam consists of democratically elected representatives, including a mayor, the municipal corporation is responsible for overseeing the city's infrastructure and public amenities. Elected officials from prominent political parties within the state occupy positions within the corporation. Both the Mayor and councillors are elected for five-year terms. The Varanasi Municipal Corporation is responsible for the planning, development, and upkeep of the city and the delivery of civic services to its citizens[28].

[28] https://nnvns.org.in:449/nnvns/index.php?option=com_content&view=article&id=3&Itemid=121&lang=en

Varanasi Nagar Nigam administers 90 wards[29].

The primary goal of VNN is to transform Varanasi into a dynamic, lively, aesthetically pleasing, self-sufficient, and sustainable city, equipped with essential amenities, aiming to enhance the quality of life for its residents. VNN fulfils both mandatory and discretionary functions in alignment with this mission.

As provider

- Potable Water Supply
- Underground Sewage system
- All-weather Roads
- Efficient and sustainable Solid Waste Management
- Health coverage to all focused more on the poor
- Primary education to the needy & Library facility for all
- Up-gradation of the amenities in the existing slums and alternative accommodation
- Clean, Green, and Pollution-free environment
- Facilities to the Visiting Pilgrims and Tourists

As facilitator

- Trade and commerce
- Health services
- Higher Education and Research
- Cultural activities
- Sports and Games
- Recreation and Entertainment
- Development of Local Industries, Handicrafts, and Artifacts

Varanasi Nagar Nigam departments

Accounts and Finance	Administrator	Audit	Computer Cell	Advertisement
Council	DUDA	Encroachment	Engineering	Establishment
Garden	Health	Jal kal - JKV	Revenue	RTI
Sanitation	Streetlight	Transport	Veterinary	

[29] https://www.varanasi.org.in/nagar-nigam-varanasi

2.1.2. Varanasi Smart City:

The Varanasi Smart City Limited (VSCL) is a Special Purpose Vehicle (SPV) established on 29.10.2016 as per directives from the Ministry of Housing and Urban Affairs (MoHUA), Government of India, to implement the SMART CITY MISSION (SCM) in Varanasi.

VSCL is tasked with designing and managing IT and Non-IT projects under the Smart City Mission, with a primary focus on enhancing citizen welfare, upgrading city infrastructure, and improving living standards while preserving Varanasi's cultural heritage[30]. The vision statement of Varanasi Smart city is:

Vision

To rejuvenate the oldest Indian living city of Varanasi as a great place to live and visit by conserving and showcasing its enriched heritage, culture, spirituality and traditions through innovative social and financial inclusion solutions.

VSCL is overseen by the Divisional Commissioner of Varanasi Division, Uttar Pradesh, collaborates closely with the Municipal Corporation of Varanasi to implement the Smart City Mission in Varanasi, aiming for its successful execution[31].

The 6 pillars of Varanasi Smart City are:

Suramya Kashi	Nirmal Kashi	Surakshit Kashi	Samunnat Kashi	Ekikrit Kashi	Sanyojit
Area based development	Area based development	Area based development	Area based development	Pan-city initiative	Pan-city initiative
The goal is to revitalize ancient temples and riverfront ghats in Varanasi, providing visitors with an immersive experience of the city's vibrant cultural heritage. This initiative aims to leverage Varanasi's recognition as a UNESCO City of Music to create a meaningful platform for visitors to engage with its cultural offerings.	The objectives include revitalizing sacred water bodies and parks, implementing efficient and transparent solid waste management systems, and promoting eco-friendly practices like green rooftops and rainwater harvesting.	The aims are to utilize analytics-based surveillance to decrease infractions, enhance emergency response capabilities, and enhance interactions between the police force and citizens.	The goals include setting up a Skill Development Centre, promoting local artifacts, supporting street vendors, incentivizing research, integrating smart technologies, and improving health facilities for the community.	The aims are to offer transparent information and quality services to all citizens, introduce a One-stop-shop smart card system, provide easy access to information through a mobile app, and enhance the effectiveness of grievance redressal mechanisms.	The objectives include establishing multi-modal transportation hubs, integrating traffic management with CCTV surveillance, implementing multi-level smart parking to reduce congestion, introducing e-rickshaws for clean last-mile connectivity, and developing waterways as an alternate transport option.

[30] https://nnvns.org.in:449/nnvns/images/Smart-City-Project-Overview.pdf

[31] https://www.efkonindia.com/case-study-varanasi-smart-city-project.php?CaseStudies&VSC

2.1.3. Varanasi Nagar Nigam - Transport Department:

The Varanasi Municipal Corporation's Traffic Department is committed to fulfilling its responsibility by managing traffic engineering aspects to regulate and control the city's traffic. Its mission is to ensure the overall regulation and control of vehicle and pedestrian traffic and transportation, thus ensuring citizens safe and timely travel[32].

The main functions carried out by the cell are listed below:

- Conducting traffic and transportation surveys.
- Installing and maintaining traffic signals at road junctions.
- Erecting channelisers at road junctions.
- Building road dividers using either R.C.C. pardi or guard stones, with provision for plantations.
- Installing automatic night blinkers at critical curves, vehicular gaps, accident-prone points, etc., and ensuring their maintenance.
- Constructing traffic islands (rotaries) at road junctions.
- Placing traffic sign boards (cautionary, mandatory, informative, etc.), and installing signboards indicating the names of new streets and squares.
- Constructing speed breakers in coordination with the traffic police department.
- Implementing road markings such as zebra crossings, stop Lines, junction markings, centre lines, lane lines, etc., and affixing cat eyes on dark roads along the canter line for better visibility.
- Conducting maintenance of islands, channelisers, and road dividers by conducting minor repairs and painting them annually.
- Designating spots for rickshaw stands, bus stands, and other traffic-related structures.

2.1.4. Varanasi City Transport Limited

Varanasi City Transport Service Ltd. functions as a municipal transportation service within the framework of the JnNURM initiative launched by the Government of India, with its primary focus on serving Varanasi city.

Vision

As per the facilities of organisation, benefits are to be given to passengers and to make the organisation successful.

Mission

For the betterment of passengers, better facilities, services as per specified time-table and other necessities are to be provided to passengers.

It provides extensive coverage throughout the entire city and serves as the primary transportation choice for daily commuters. The fleet operated by Varanasi city transport service Ltd. comprises A/c and non-A/c low-floor Marcoplo Buses, Tata, and Kamal body, all aimed at providing environmentally friendly, convenient, and comfortable transportation options for various demographics including office-goers, students, senior citizens, and women.

[32] https://nnvns.org.in:449/nnvns/index.php?option=com_content&view=article&id=6:departments&catid=2&Itemid=101&lang=en

In November 2009, the responsibility for public services was transferred to UPSRTC, Varanasi, as part of the JNNURM Company initiative. The company was officially incorporated on June 15, 2010, under the Companies Act 1956[33].

Table 8: Bus fleet in Varanasi

City	Total number of buses	Floor Height			
Varanasi		Low Floor 400MM A/C	Low Floor 400MM NON-A/C	Normal 830+/-100 MM	Mini
CNG	130	0	10	50	70
Electric	50	-	-	-	-

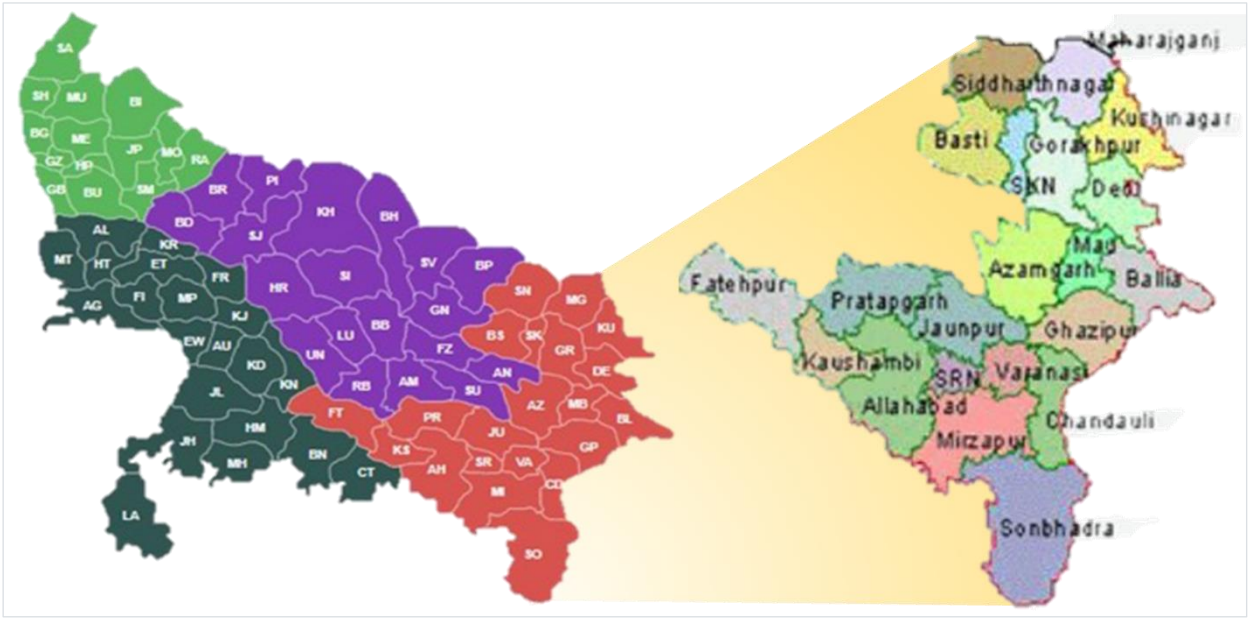
2.1.5. Purvanchal Vidyut Vitaran Nigam Limited (PuVVNL)

Purvanchal Vidyut Vitaran Nigam Limited, headquartered in Varanasi, is a successor entity of Uttar Pradesh Power Corporation Limited (UPPCL), with a focus on distributing Electric Power in the Eastern region of Uttar Pradesh.

It was established on July 5, 2003, PuVVNL has significantly expanded its services to cater to approximately 33 lakh consumers in Eastern U.P.

PuVVNL's operational domain encompasses Varanasi, Ghazipur, Chandauli, Jaunpur, Sant Rabidas Nagar (Bhadohi), Mirzapur, Sonbhadra, Mau, Azamgarh, Ballia, Deoria, Kushi Nagar, Gorakhpur, Maharajganj, Sant Kabir Nagar, Basti, Sidharth Nagar, Allahabad, Pratapgarh, Fatehpur, and Kaushambi districts. Purvanchal Vidyut Vitaran Nigam Limited is dedicated to enhancing consumer service, increasing revenue realization, and ensuring the delivery of high-quality electricity[34].

Figure 5: PuVVNL's operational domain



[33] https://uputd.gov.in/varanasictsl

[34] https://puvvnl.up.nic.in/about_us.asp

2.2. Role of government Stakeholders for facilitating e-mobility in Varanasi city

Table 9: Role of key government stakeholders for facilitating e-mobility in Varanasi city

S. No.	Role in facilitating e-mobility in Varanasi		Probable responsible stakeholder
1	Infrastructure	▶ Implement citywide EV charging stations strategically for convenient access. ▶ Develop charging infrastructure for electric buses at depots and along routes. ▶ Enhance accessibility and viability of electric vehicles in Varanasi for sustainable transportation.	▶ Varanasi Nagar Nigam ▶ Varanasi Smart city ▶ VNN Transport department ▶ Varanasi City Transport Limited ▶ Purvanchal Vidyut Vitaran Nigam Limited
2	Policy advocacy support and regulation	▶ Partnering with stakeholders to offer incentives and regulations for EV adoption. ▶ Formulating transportation policies with EV guidelines and adoption incentives.	▶ Varanasi Nagar Nigam ▶ Varanasi Smart city ▶ VNN Transport department ▶ Varanasi City Transport Limited ▶ Purvanchal Vidyut Vitaran Nigam Limited
3	Public awareness	▶ Conduct campaigns highlighting environmental and economic advantages. ▶ Organize workshops and community events to educate citizens on e-mobility benefits, emphasizing environmental sustainability and electric transportation significance.	▶ Varanasi Nagar Nigam ▶ Varanasi Smart city
4	Fleet electrification	▶ Advocate for transitioning office fleet to electric vehicles. ▶ Encourage converting city public transport bus fleet to electric.	▶ Varanasi Nagar Nigam ▶ Varanasi City Transport Limited ▶ Purvanchal Vidyut Vitaran Nigam Limited
5	Partnership and collaboration	▶ Departments should collaborate with government agencies, private firms, and research institutions to accelerate e-mobility adoption including charging infrastructure. ▶ Partnering with stakeholders like EV manufacturers and infrastructure providers drives adoption and innovation, facilitating electric bus adoption and infrastructure development.	▶ Varanasi Nagar Nigam ▶ Varanasi Smart city ▶ VNN Transport department ▶ Varanasi City Transport Limited ▶ Purvanchal Vidyut Vitaran Nigam Limited
6	Monitoring and evaluation	▶ Continuously assess the impact of transitioning to electric vehicles. ▶ Track EV registrations, charging station usage, and emission reductions to gauge initiative effectiveness accurately.	▶ Varanasi Nagar Nigam ▶ VNN Transport department ▶ Regional Transport Office (RTO)
7	Integration of technology	▶ Implement smart charging solutions and mobile apps for streamlined EV charging. ▶ Enhance accessibility for residents and visitors, ensuring smoother operations and greater convenience for electric vehicle users to bolster e-mobility initiatives.	▶ Varanasi Smart city ▶ Varanasi City Transport Limited
8	Pilot projects and demonstrations	▶ Launch pilot projects in specific areas to assess e-mobility solutions.	▶ Varanasi Smart city

S. No.	Role in facilitating e-mobility in Varanasi		Probable responsible stakeholder
		► Implement pilot projects on select routes to demonstrate electric bus feasibility. ► Gather insights for future expansion and improvements, ensuring effective implementation and scalability of e-mobility initiatives. ► Creation of EV zones within city to promote EV adoption	► Varanasi City Transport Limited ► Varanasi Nagar Nigam
9	Licensing and registration	Overseeing the licensing and registration of EVs in Varanasi.	Regional Transport Office (RTO)
10	Safety and compliance	Ensures charging infrastructure meets safety standards through inspections and audits.	Purvanchal Vidyut Vitaran Nigam Limited
11	Grid integration	Integrating charging infrastructure with the electrical grid.	
12	Metering and billing	Metering electricity usage at charging stations and accurately bills EV owners.	

3 Existing Transportation in Varanasi City

The city boasts a comprehensive transportation network, including rail, air, and road connections[35].

3.1. Air transport:

Air transport in Varanasi plays a crucial role in connecting the city with major domestic destinations and facilitating tourism, business, and pilgrimage travel. Lal Bahadur Shastri International Airport serves as Varanasi's primary air gateway, offering both domestic and international flights. **It is situated approximately 24 km from the city centre**.

Airlines operating at Lal Bahadur Shastri International Airport connect Varanasi with major cities across India such as Delhi, Mumbai, Kolkata, Bengaluru, and Hyderabad. Additionally, international flights to destinations in Southeast Asia and the Middle East further enhance connectivity and contribute to Varanasi's global outreach.

Figure 6: Lal Bahadur Shastri Airport

3.2. Rail Transport:

Rail transport in Varanasi is an integral part of the city's transportation network, serving as a vital link to connect Varanasi with various parts of India. Varanasi Junction, also known as Varanasi Cantt Railway Station, is one of the busiest railway stations in Uttar Pradesh and a major hub for both passenger and freight trains. **Varanasi lies along the Delhi-Kolkata railway route, with three primary rail lines connecting the city to Lucknow, Bhadoi, and Prayagraj**.

Varanasi Junction is equipped with modern amenities and facilities to cater to the needs of passengers, including waiting halls, food stalls, ticket counters, and restroom facilities. The station has multiple platforms to handle a high volume of train traffic efficiently.

In addition to passenger services, rail transport in Varanasi also plays a crucial role in freight transportation. The railway network enables the movement of goods, commodities, and raw materials to and from Varanasi, supporting trade and commerce in the region.

[35] https://niua.in/intranet/sites/default/files/189.pdf

Figure 7: Varanasi Junction

3.3. Road transport:

Varanasi boasts a well-developed road network comprising of 3 national highways, arterial roads, and local streets.

- **National Highway 28 (NH 28)** intersects NH31 in Pandeypur and the intersection is named as Pandeypur chowraha. This road stretches in the north till Naugarh and passes through Azamgarh.
- **National Highway 31 (NH 31):** NH 31 is another important national highway that passes through Varanasi. It connects the city with places like Gorakhpur, Muzaffarpur, and Barauni. NH 31 plays a crucial role in regional connectivity and serves as a key transportation corridor for both passenger and freight traffic.
- **National Highway 44 (NH 44):** NH 44 is an extension of GT road which connects with NH31 in the north and NH 19 on the south, this road is on the opposite side of Varanasi city and plays an important role in reaching the city.

3.3.1. Local transportation:

Local transportation within Varanasi primarily relies on a variety of vehicles, including auto-rickshaws, cycle-rickshaws, taxis, buses, and private cars. **Auto-rickshaws and e-rickshaws are a popular mode of transport** for short distances, offering flexibility and convenience for travellers navigating through the narrow lanes and crowded streets of the city.

Figure 8: Local transportation modes in Varanasi

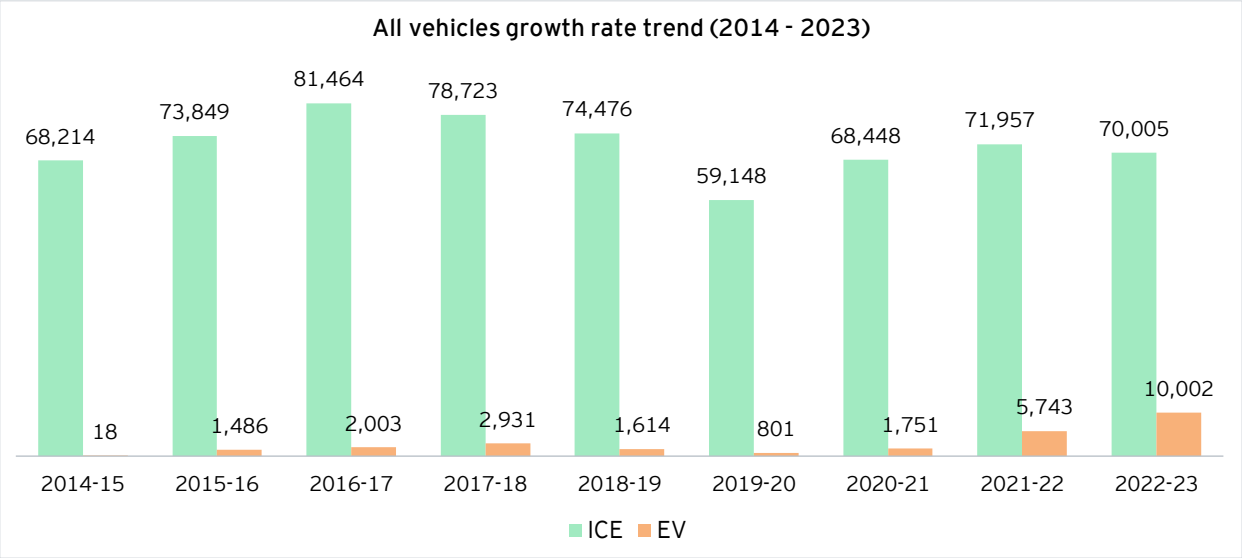
Issues in road transportation:

- Varanasi grapples with challenges such as irregular parking and encroachments, which occupy 50% of the carriageway capacity in its central area.
- The city's road network covers only 11% to 15% of its land, with less than 50% accessible by paved roads.
- Additionally, the organic growth pattern of the city, gaps in citizen awareness, and non-operational traffic signals contribute to traffic congestion in Varanasi.

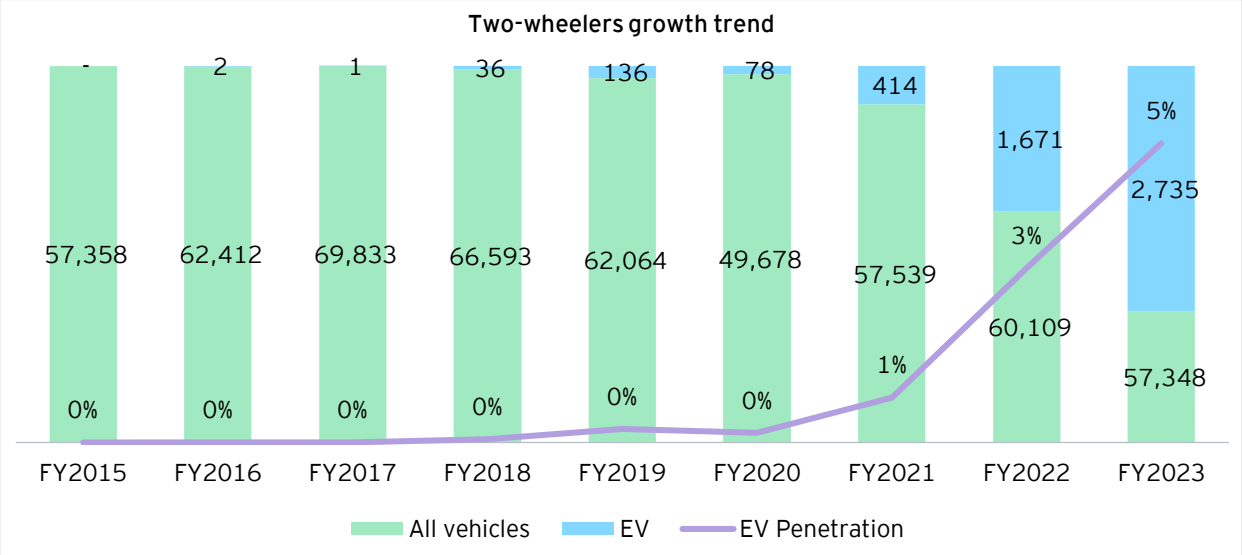
3.3.2. Vehicle Sales growth in Varanasi:

Between FY2015 and FY2023, the Compounded Annual Growth Rate (CAGR) of ICE vehicles crawled at 0.3%, while EVs surged by an astounding 120%. This led to EVs accounting for ~13% of the market share Varanasi transport in FY2023. This data underscores a significant shift towards electric mobility, despite ICE vehicles maintaining dominance.

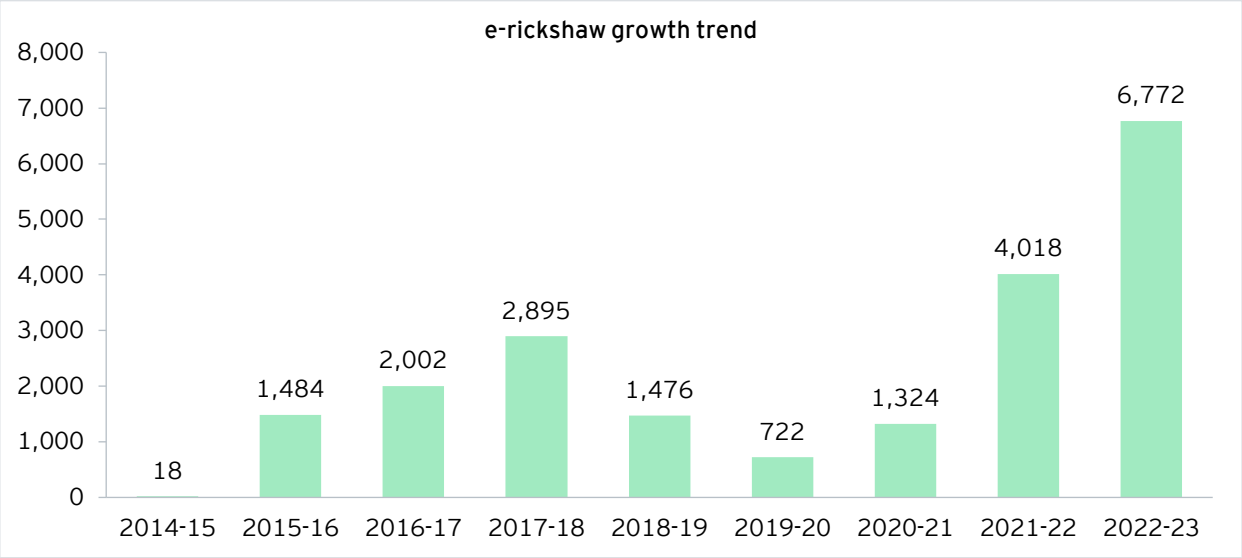
Graph 6: All vehicle growth trend 2014-2023



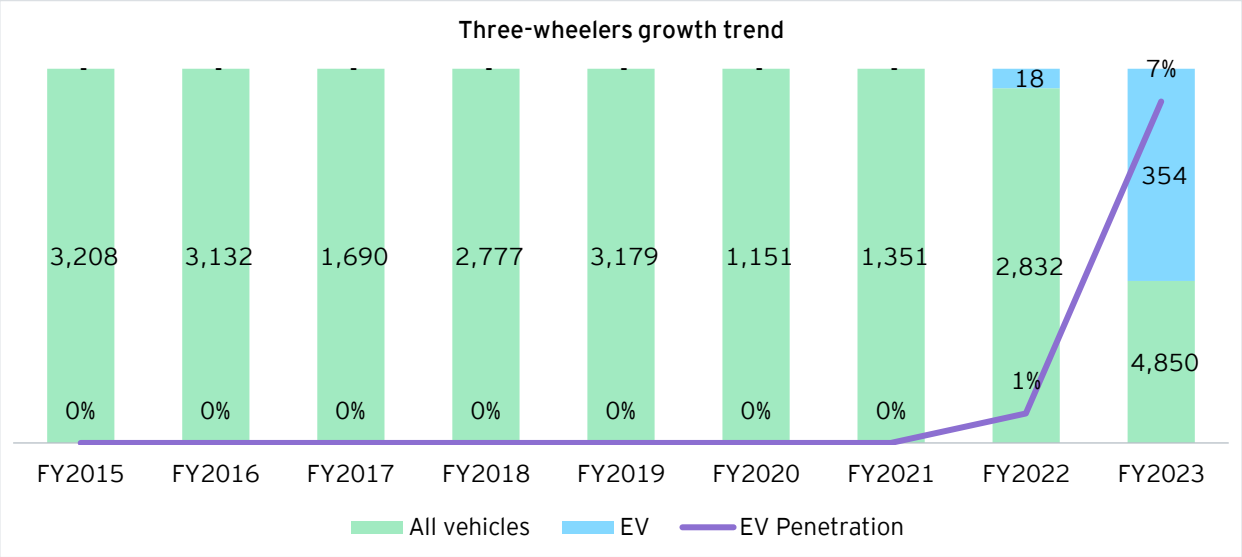
Graph 7: Two-wheelers growth rate trend (2014 - 2023)



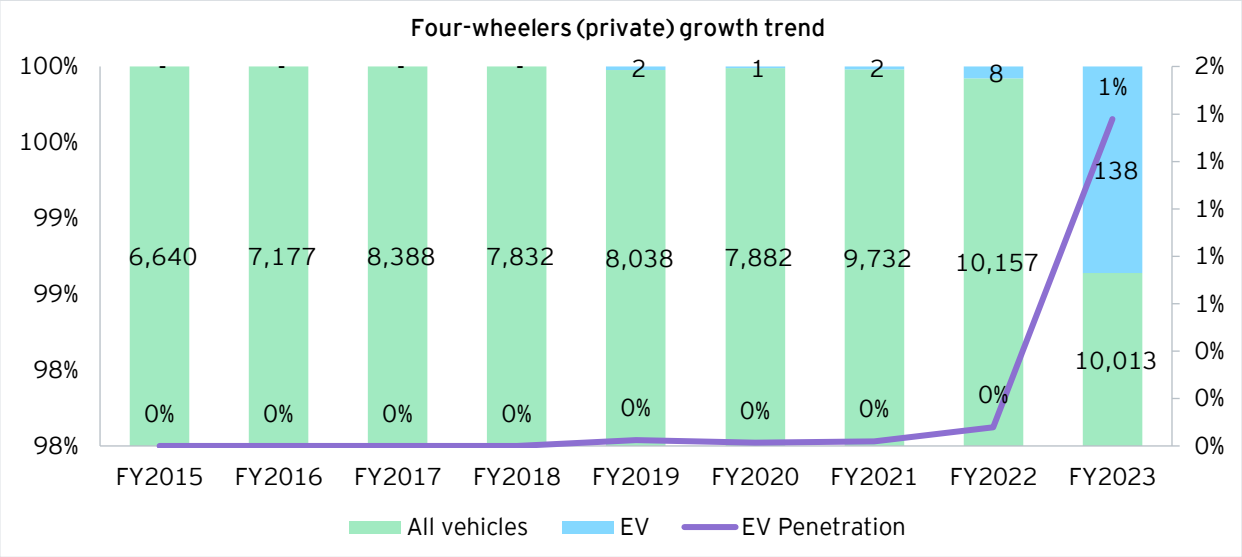
Graph 8: e-rickshaw growth rate trend (2014 - 2023)



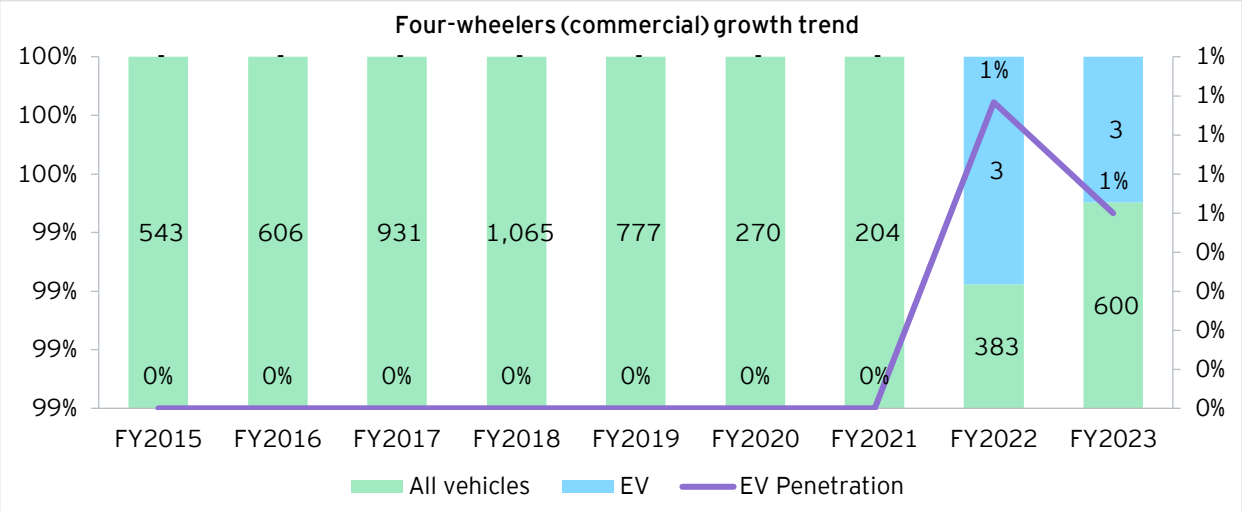
Graph 9: three-wheelers (passenger) growth rate trend (2014 - 2023)



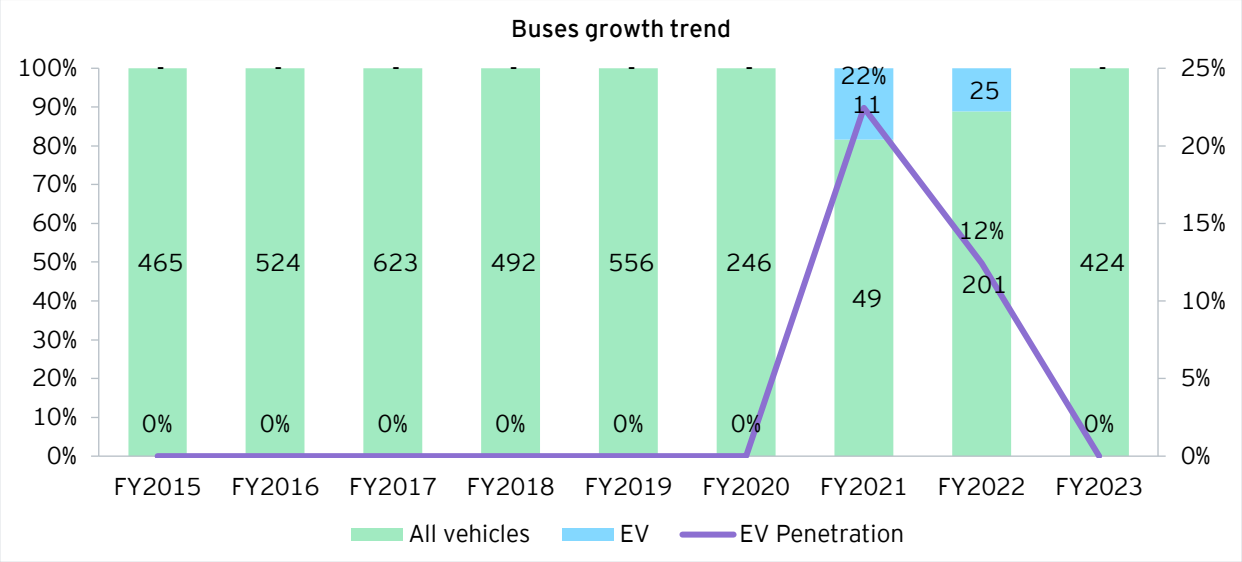
Graph 10: Four-wheelers (private) growth rate trend (2014 - 2023)



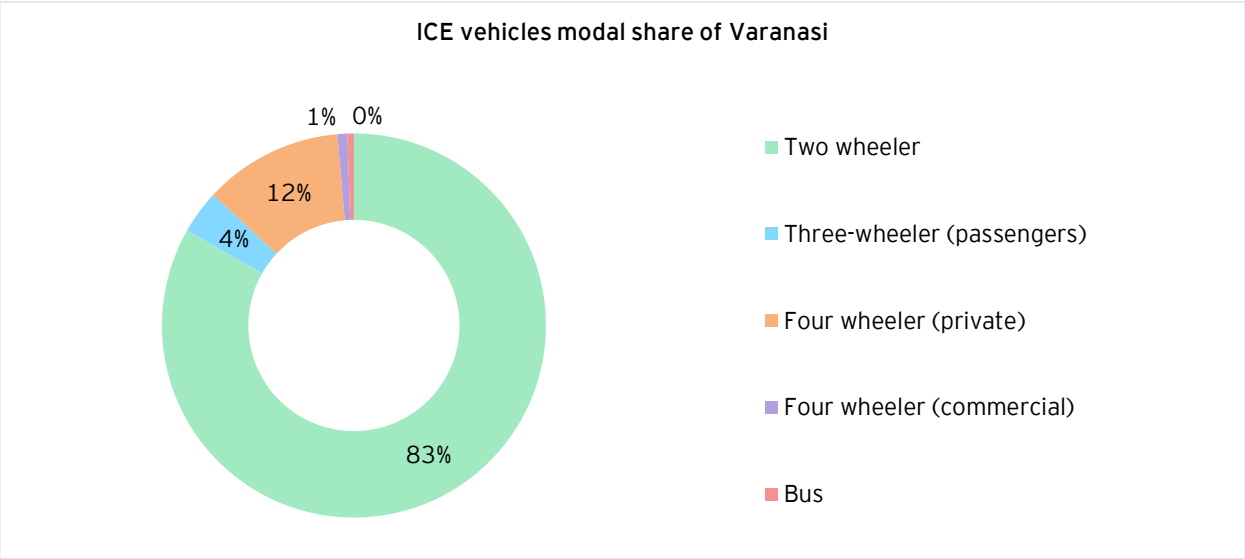
Graph 11: Four-wheelers (commercial) growth rate trend (2014 - 2023)



Graph 12: Buses growth rate trend (2014 - 2023)



Graph 13: Modal share of Varanasi



Growth rate of different ICE vehicle segments:

To assess the growth rates of various vehicle segments, the Compounded Annual Growth Rate (CAGR) from the year 2015 to 2019 has been calculated for two-wheelers, four-wheelers (private), four-wheelers (commercial) and buses segment as the data for year 2020 and 2021 seems to be impacted by the effect of COVID-19, due to which the actual growth rate is compromised. For e-rickshaw the CAGR is calculated for the years FY 2018 to FY 2022, and for three-wheelers segment CAGR is calculated from FY2015 to FY2023. Below are the segment-wise CAGR figures:

Table 10: Vehicle segment wise growth rate

Vehicle category	Growth rate
	1.99%
	8.54%
	5.30%
	4.89%
	9.37%
	3.31%

EV penetration status of different vehicle segments:

Table 11: EV penetration status of different vehicle segments

Vehicle category	EV penetration rate in FY 2023
	4.77%
	100%
	7.30%
	1.38%
	0.64%
	28%*

*Based on 50 e-buses procured in 2021

4 Policy framework

The pressing need to address climate change has sparked a significant shift in global climate policy, driving nations worldwide to embrace the transition toward a low-carbon economy as a vital step in mitigating the detrimental effects of environmental degradation. During the recent COP 26 summit, India reaffirmed its commitment by pledging substantial reductions, aiming to decrease the emissions intensity of its GDP by 45 percent by 2030 compared to 2005 levels. Simultaneously, India aims to achieve an admirable milestone of 50 percent cumulative electric power installed capacity from non-fossil fuel-based energy sources by the same year.

On the international stage, the momentum to tackle climate change has catalysed policies and governmental incentives geared towards accelerating the adoption of e-mobility as a sustainable alternative for both freight and passenger transportation. This concerted effort has prompted Central and State Governments worldwide to develop comprehensive frameworks and regulations to facilitate the transition to electric vehicles (EVs). **In India, the Ministry of Power (MoP) has assumed a central role in orchestrating this transition, while the Department of Heavy Industries (DHI) has been tasked with establishing widespread charging infrastructure across the nation, leveraging various incentive programs.**

The MoP's designation of the Bureau of Energy Efficiency (BEE) as the Central Nodal Agency (CNA) for Public EV charging infrastructure underscores India's commitment to creating an enabling environment for EV adoption. Additionally, State Nodal Agencies (SNA) are actively engaged in establishing supportive ecosystems at the state level to streamline the transition to EVs.

Furthermore, beyond national endeavours, various governmental bodies, including the Ministry of Road Transport and Highways (MoRTH), Ministry of Housing and Urban Affairs (MoHUA), Ministry of Finance (MoF), Ministry of Science & Technology (MoST), and Ministry of Environment, Forest, and Climate Change (MoEF&CC), are actively formulating and implementing policies conducive to the proliferation of EVs. Together, these coordinated efforts reflect a collective determination to steer transportation toward sustainable solutions and mitigate the adverse impacts of climate change on a global scale.

The key central stakeholders in the E-Mobility sector are:

Figure 9: Timeline of e-mobility initiatives in India

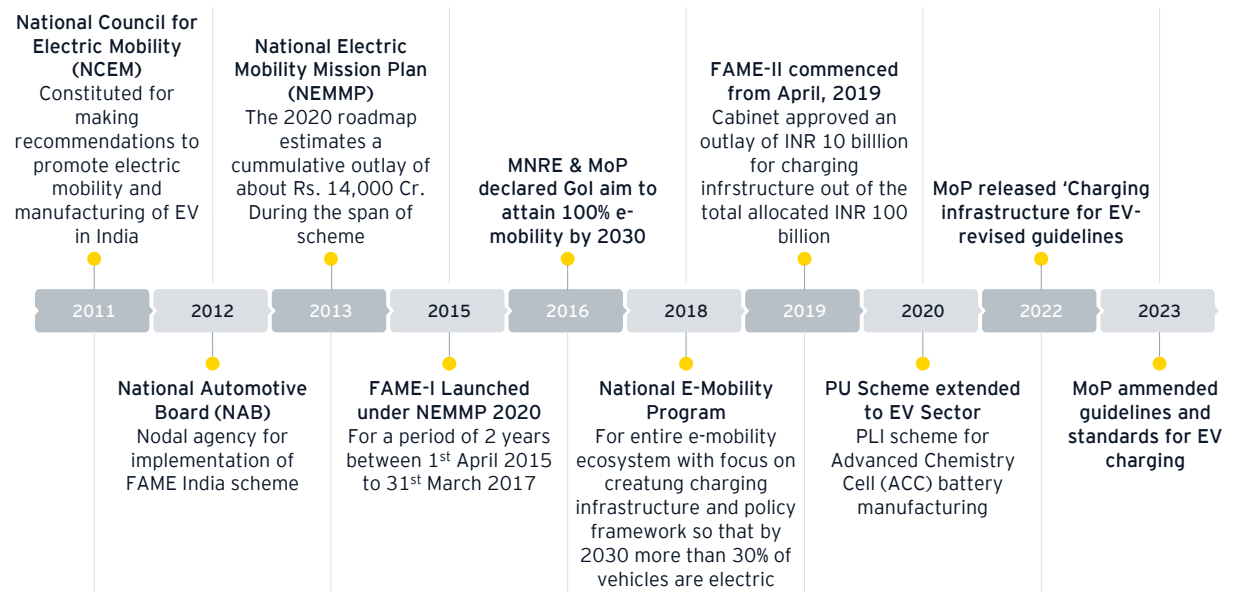
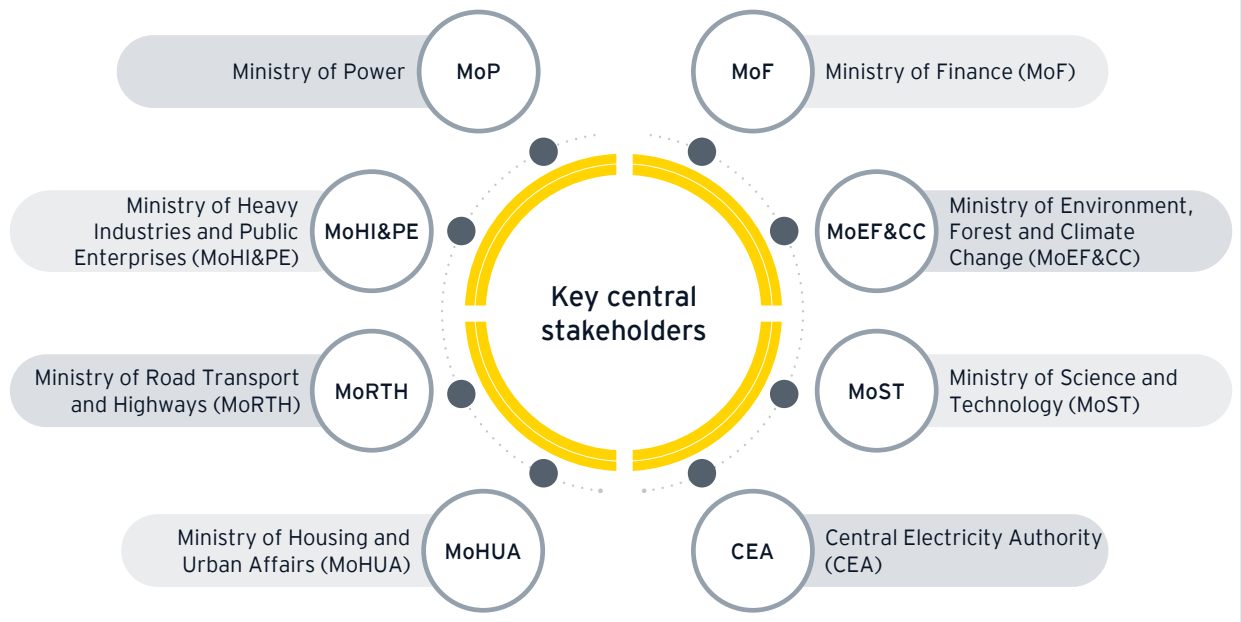


Figure 10: Key Central stakeholders in e-mobility sector



1. Ministry of Power

The Ministry of Power (MoP) formulates policies and oversees power projects. In 2018, it issued guidelines for Electric Vehicle Charging Infrastructure, updated in 2022. The MoP appointed the Bureau of Energy Efficiency (BEE) as the Central Nodal Agency (CNA) for national charging infrastructure.

2. Ministry of Heavy Industries and Public Enterprises (MoHI&PE)

Electric mobility initiatives in India, led by the Ministry of Heavy Industries and Public Enterprises (MoHI&PE), began with the National Electric Mobility Mission Plan (NEMMP) in 2013, followed by the Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles in India (FAME India) scheme in 2015. Phase-II of FAME India, introduced in 2019, built upon the insights from FAME-I. The Department of Heavy Industry (DHI) under MoHI&PE manages policy formulation and implementation to drive EV adoption in India.

The Ministry of Heavy Industries is launching the INR 500 Cr Electric Mobility Promotion Scheme 2024 (EMPS 2024) to boost EV adoption nationwide. Under EMPS 2024, subsidies up to INR 10,000 for two-wheelers and INR 25,000 for small three-wheelers will be provided. Large three-wheelers will receive up to INR 50,000. The scheme, active from April 1 to July 31, 2024, aims to accelerate the adoption of electric vehicles and promote advanced battery technology. It also implements the Phased Manufacturing Programme to strengthen the EV manufacturing sector, fostering a sustainable transportation future in India.

3. Ministry of Road Transport and Highways (MoRTH)

The Ministry of Road Transport and Highways (MoRTH) is tasked with developing policies and regulations related to road transport. It contributes to the promotion of electric vehicles (EVs) by designing nonfinancial incentives, such as facilitating parking infrastructure and providing priority lane access.

4. Ministry of Housing and Urban Affairs (MoHUA)

The Ministry of Housing and Urban Affairs (MoHUA) has been instrumental in revising building by-laws to accelerate the installation of charging facilities in commercial and residential complexes. It has also updated the 'Urban and Regional Development Plans Formulation and Implementation Guidelines– 2014' to encompass the establishment of norms and standards for charging infrastructure within city planning frameworks. These guidelines will serve as a reference for State Governments and Union Territories to integrate Electric Vehicle Charging Infrastructure standards into their building by-laws.

5. Ministry of Finance (MoF)

The Ministry of Finance has been pivotal in driving the adoption of electric mobility in India. In 2019, it streamlined customs duties for vehicles, battery packs, and cells across all categories to bolster the Make in India initiative.

6. Ministry of Environment, Forest, and Climate Change (MoEF&CC)

The Ministry of Environment, Forest, and Climate Change (MoEF&CC) is the principal union ministry involved in the 'National Electric Mobility Mission Plan 2020' initiative. Additionally, the ministry introduced the Battery Waste Management Rules, 2022, to enhance the system for managing and disposing of batteries throughout India. These rules aim to establish a robust mechanism for battery disposal while prioritizing public safety. They also seek to ensure accountability across the entire value chain, including central and state authorities.

7. Ministry of Science and Technology (MoST)

The Department of Heavy Industry (DHI) and the Department of Science & Technology (DST) under the Ministry of Science & Technology (MoST) have collaborated to establish the 'Technology Platform for Electric Mobility (TPEM)' aimed at bolstering research and development (R&D) efforts and technological advancements in electric mobility.

8. Central Electricity Authority (CEA)

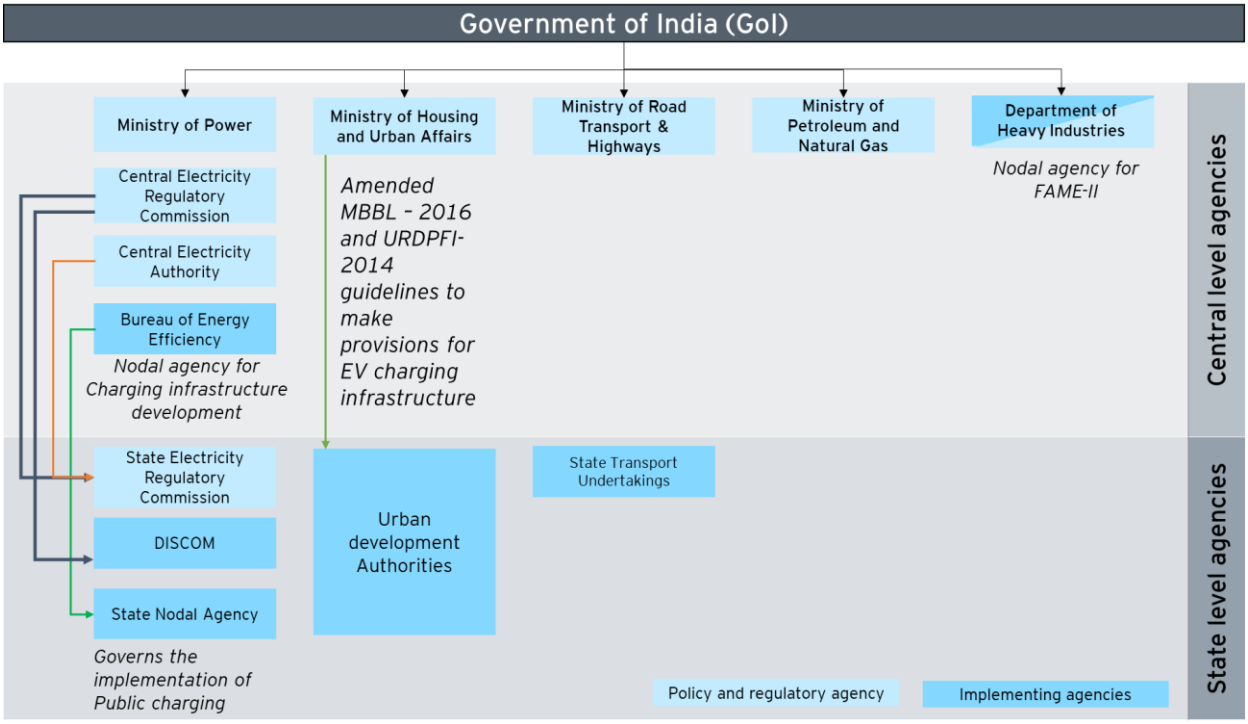
The Central Electricity Authority (CEA) plays a crucial role in setting and enforcing technical standards across the power sector. It ensures safety and reliability in power grid infrastructure by establishing stringent guidelines for equipment and operational practices. Additionally, the CEA collaborates with stakeholders to promote efficient energy transmission, integrate renewable sources, and adopt emerging technologies. By upholding these standards, the CEA enhances the reliability, resilience, and sustainability of the nation's power infrastructure, ensuring uninterrupted electricity supply to industries, businesses, and households nationwide.

9. Bureau of Energy Efficiency (BEE)

The Bureau of Energy Efficiency (BEE) plays a crucial role in promoting e-mobility. As an agency focused on enhancing energy efficiency and sustainability, BEE is actively involved in developing policies, standards, and initiatives to support the adoption of electric vehicles (EVs) and charging infrastructure. BEE works closely with government agencies, industry stakeholders, and research institutions to implement measures that encourage the use of electric vehicles, improve charging infrastructure, and reduce greenhouse gas emissions from the transportation sector. Through its various programs and initiatives, BEE aims to accelerate the transition to e-mobility and contribute to India's energy security and environmental sustainability goals.

4.1. Overarching framework:

Figure 11: Overarching framework



4.2. Uttar Pradesh State EV Policy

The "Uttar Pradesh Electric Vehicle Manufacturing and Mobility (EVMM) Policy 2022" represents a strategic initiative spearheaded by the Uttar Pradesh government. Originally introduced in 2019, the EVMM Policy has recently undergone comprehensive revision to adapt to the evolving landscape of electric vehicle technology and mobility trends. Designed to chart a course for the next five years from the date of notification, the policy framework remains flexible, allowing the state government to make necessary adjustments and amendments as the sector progresses.

Vision

The policy aims to promote adoption of sustainable and clean mobility solutions and infrastructure in Uttar Pradesh and become one of India's leading state for electric vehicles adoption. It also envisions to emerge as one of the India's preferred investment destination for EV ecosystem globally

Mission

The policy aims to stimulate the demand side by promoting rapid transition in the transportation system and faster adoption of non-ICE vehicles. The policy shall also stimulate the supply side by encouraging the manufacturing landscape for EVs which includes Electric Vehicles (EVs), EV components, EV Batteries / Fuel Cells and other EV Supply Equipment (EVSE).

Also, the policy aims at supporting measures to ensure adequate infrastructure and ecosystem for EV Industry, which primarily includes creation of charging facilities, followed by R&D, innovations, and skill development.

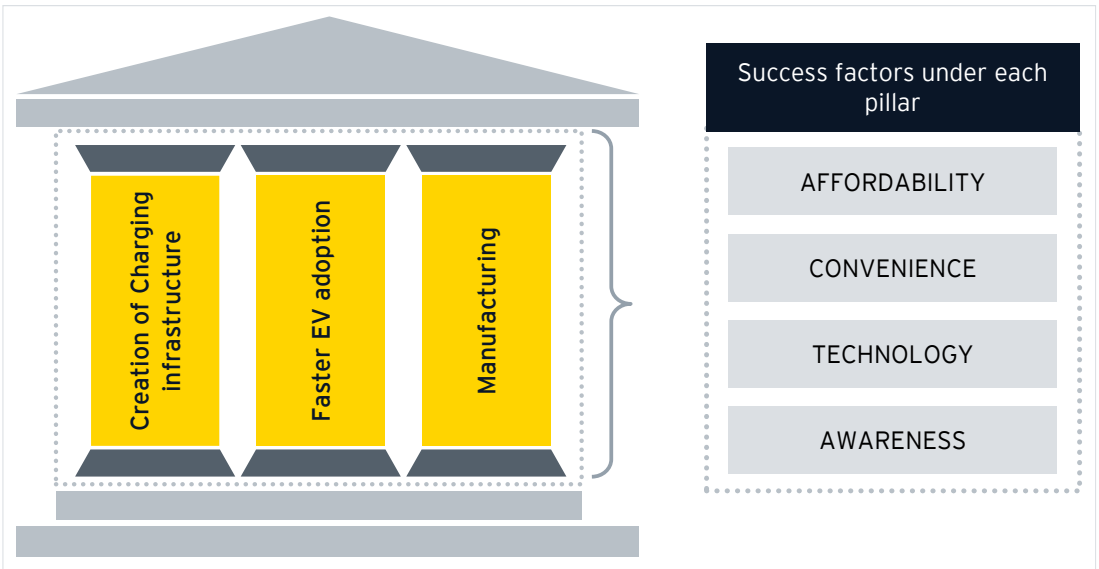
Encompassing a broad spectrum of areas within the electric vehicle ecosystem, the policy addresses not only the manufacturing aspects but also the mobility infrastructure essential for their adoption. It extends its purview to cover electric vehicles (EVs), their various components, batteries, and the indispensable charging and battery equipment required for their operation and maintenance.

Underlining the government's commitment to effective implementation, the Infrastructure and Industrial Development Department of the Uttar Pradesh government has been designated as the "Nodal department" entrusted with overseeing the policy's execution. This decision highlights the significance attached to fostering a conducive environment for electric vehicle manufacturing, deployment, and mobility solutions across the state. Through collaborative efforts and strategic partnerships, the Uttar Pradesh government aims to propel the growth of the electric vehicle sector while simultaneously addressing environmental concerns and promoting sustainable development agendas.

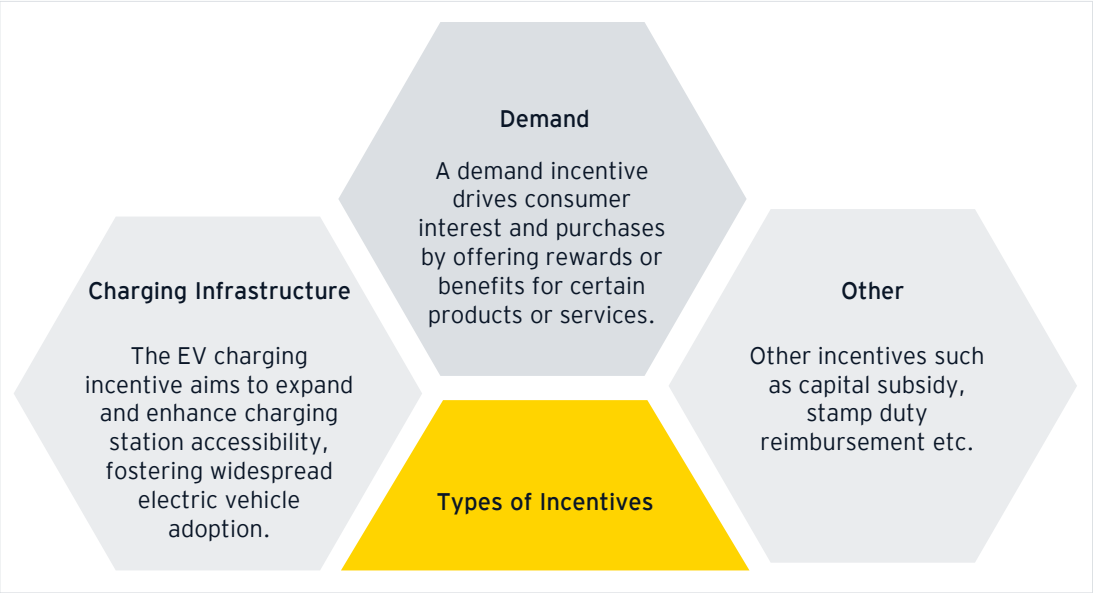
4.2.1. Objectives of the UP EV Policy:

Lead e-mobility	To make UP a global hub for electric mobility development and manufacturing
Fleet electrification	To enable transition to eco-friendly transportation system particularly in cities
Facilitating investments	To enable investments for development of charging/ battery swapping infrastructure
Setting up manufacturing units	To attract manufacturers across the EV ecosystem to the state to setup their manufacturing units and supply to a global market
Research & Innovation	To promote research and innovations in non-ICE based automobiles, battery technology, fuel cell technologies and EV electronics

In order to above envisioned, the state government of Uttar Pradesh shall focus on 3-pillars for promoting the EV industry in the state, which are:



The Uttar Pradesh Electric Vehicle Manufacturing and Mobility (EVMM) Policy 2022 offers incentives in three categories which are:



4.2.2. Charging infrastructure related incentives:

The Uttar Pradesh Electricity Regulatory Commission (UPERC) has established a special tariff category for EV charging, with the state government committed to coordinating regularly with UPERC to adjust tariff rates for EV charging in the state. Additionally, the state government will permit "open access" at charging/swapping stations or swapping kiosks with a contracted cumulative demand of 1MW and above. The policy aims to attract investment for installing a minimum of 20 charging stations and 5 swapping stations per district during its tenure. In addition to offering land at subsidized rates, the policy will provide the following incentives:

Capital subsidy to service provides:

1. The first 2000 charging stations in the state will receive a one-time capital subsidy of 20% on eligible fixed capital investments for service providers, capped at INR 10 lakh per unit.
2. The first 1000 swapping stations will be eligible for a one-time capital subsidy of 20% on eligible fixed capital investments for service providers, up to a maximum of INR 5 lakh per unit.

4.2.3. Demand Incentives:

1. Registration fees and road tax exemptions for buyers in Uttar Pradesh include:
    a. A 100% exemption on any EV purchased and registered in UP within 3 years of policy notification.
    b. A 100% exemption on any EV manufactured, purchased, and registered in UP during the 4th and 5th years of the policy period.
2. An early bird purchase subsidy incentive will be extended to buyers through dealers for a one-year duration starting from the date of notification, exclusively allocated for this subsidy scheme, at specified rates across defined segments.
    a. For 2-Wheelers EVs, the subsidy will be provided at 15% of the ex-factory cost, up to Rs. 5000 per vehicle, with a maximum budget allocation of Rs. 100 Crore, applicable to a maximum of 200,000 EVs.
    b. For 3-Wheelers (3W), the subsidy will be provided at 15% of the ex-factory cost, up to Rs. 12,000 per vehicle, with a maximum budget allocation of Rs. 60 Crore, applicable to a maximum of 50,000 EVs.
    c. For 4-Wheelers (4W), the subsidy will be provided at 15% of the ex-factory cost, up to Rs. 1 lakh per vehicle, with a maximum budget allocation of Rs. 250 Crore, applicable to a maximum of 25,000 EVs.
    d. For E-buses (non-government: schools, ambulances, etc.), the subsidy will be granted at a rate of 15% of the ex-factory cost, up to Rs. 20 lakh per vehicle, with a maximum budget allocation of Rs. 80 Crore, applicable to a maximum of 400 e-buses.
    e. For E-goods carriers, the subsidy will be provided at a rate of 10% of the ex-factory cost, up to Rs. 1 lakh per vehicle, with a

maximum budget allocation of Rs. 10 crore, applicable to a maximum of 1000 e-goods carriers.

4.2.4. Other incentives:

1. Fixed capital investment for EV and battery projects may receive a capital subsidy of up to 30%.
2. Manufacturers could be eligible for stamp duty reimbursement.
3. Reimbursement for quality certification chargers can be availed at 50% of fees paid, up to INR 10 lakh per unit, for both large and MSME EV/Battery projects.
4. Patent registration fees reimbursement is available at 75% of the incurred cost, up to a maximum of INR 50,000 for domestic patents and INR 2 lakh for international patents, for large and MSME EV/Battery projects.
5. Skill development incentives offer one-time reimbursement of stipends at Rs. 5,000 per employee per year for the first 50 employees in all defined manufacturing projects.

5 Market Assessment

5.1. EV Sales projections

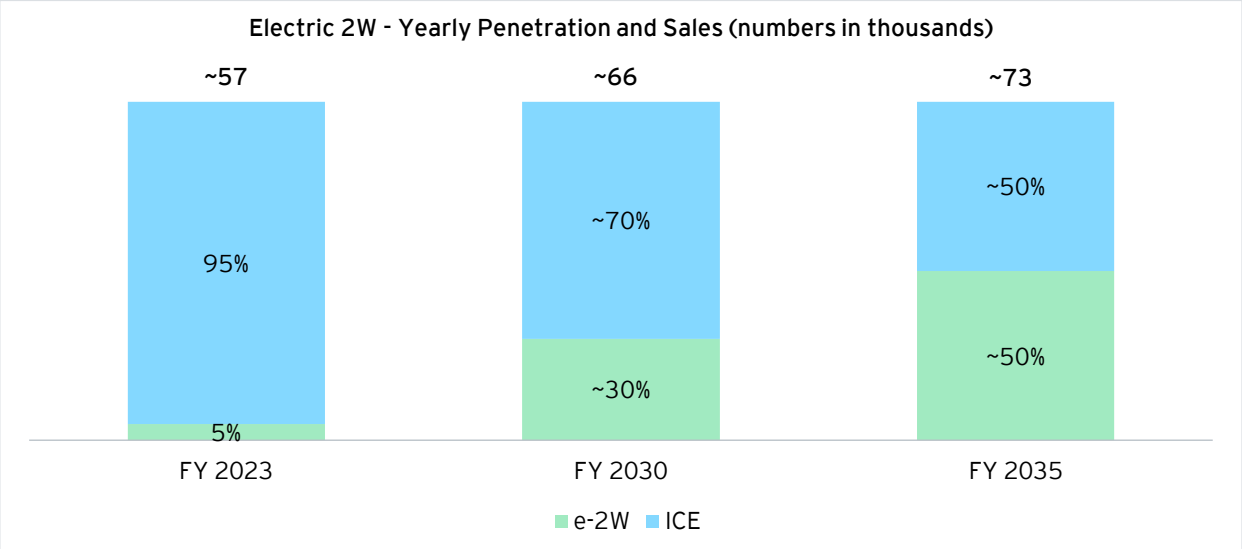
Table 12: EV Sales projections

Vehicle category	EV penetration rate		EV Sales ('000)	
	FY 2030 (E)	FY 2035 (E)	FY 2030 (E)	FY 2035 (E)
e-2W	28% - 30%	48% - 50%	18 - 20	35 - 38
e-rickshaw	100%	100%	12 - 14	18 - 20
e-3W	65% - 70%	90% - 100%	4 - 5	8 - 9
e-4W (private)	5% - 10%	20% - 25%	1.0 - 1.5	4 - 5
e-4W (commercial)	10% - 15%	35% - 40%	0.1 - 0.2	0.6 - 0.7
e-bus (govt intracity)	100%	100%	0.04 - 0.05	0.07 - 0.08
SWM vehicles	25% - 30%	45% - 50%	0.1 - 0.3	0.6 - 0.8

Electric Two-wheelers:

Traffic congestion is a significant issue in Varanasi, especially in the central areas and around popular landmarks such as the ghats and temples. Narrow roads, mixed traffic, and a lack of efficient traffic management systems contribute to congestion and delays, particularly during peak tourism seasons, hence for easy manoeuvrability electric two-wheeler can be an optimal solution in private vehicle segment.

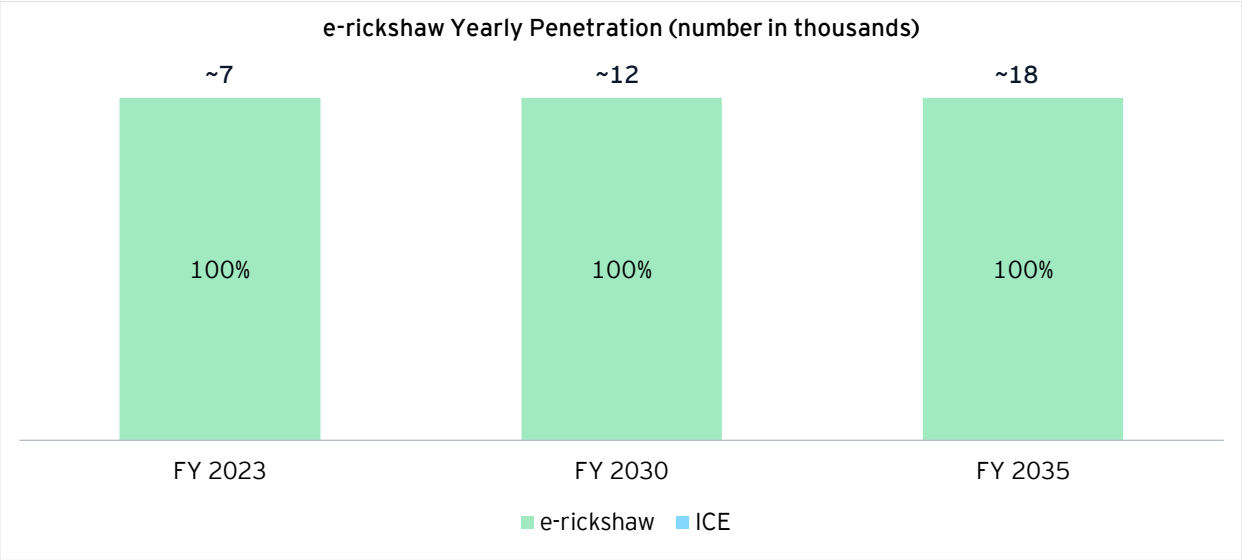
Graph 14: Electric two-wheeler yearly sales



Electric rickshaw:

E-rickshaws thrive in Varanasi due to their eco-friendly nature, and their manoeuvrability through narrow lanes, perfectly suited for the city's bustling streets.

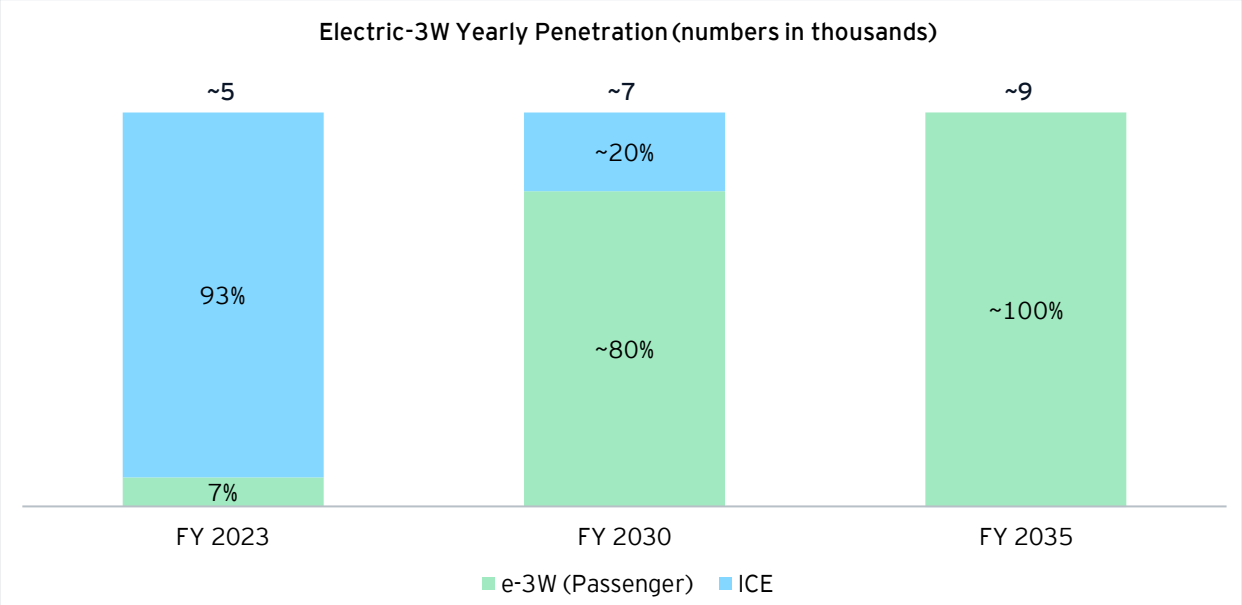
Figure 12: Electric rikshaw yearly sales



Electric Three-wheeler:

Auto-rickshaws serve as the primary mode of public transport in Varanasi, catering to both residents and tourists. Their accessibility and flexibility make them ideal for navigating the city's narrow lanes and congested streets, providing access to destinations where larger vehicles may struggle. Regulated fares ensure affordability for most passengers, and auto-rickshaws play a vital role in last-mile connectivity, bridging transportation hubs with neighbourhoods and tourist attractions. The city currently has 7% electric three-wheelers. It is anticipated that the penetration will reach 100% by 2035.

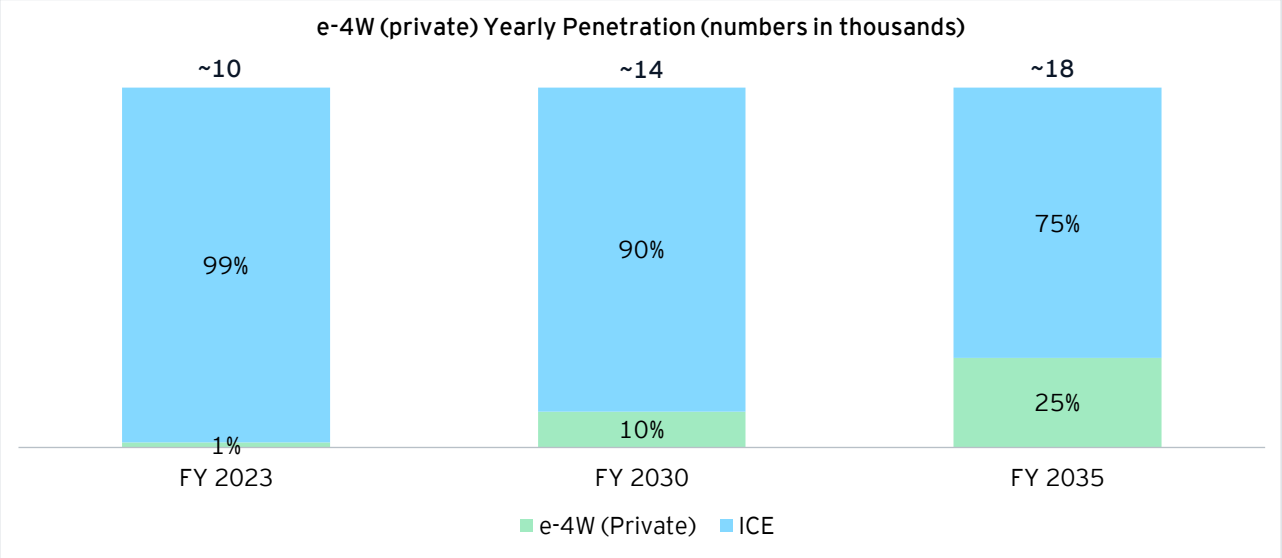
Graph 15: Electric three-wheeler yearly sales



Electric Four-wheeler (Private):

Private cars in Varanasi provide residents with flexible mobility for daily commuting, errands, and leisure activities, particularly when public transport options are limited. They offer comfort, shelter, and privacy. However, the increasing number of cars has led to traffic congestion, parking challenges, and environmental concerns. To mitigate these issues, Varanasi's authorities are focusing to encourage a shift towards electric cars by charging infrastructure development. However due to issues parking space availability, it can be said that the overall penetration of electric cars will be lower as compared to commercial vehicles and private two-wheeler.

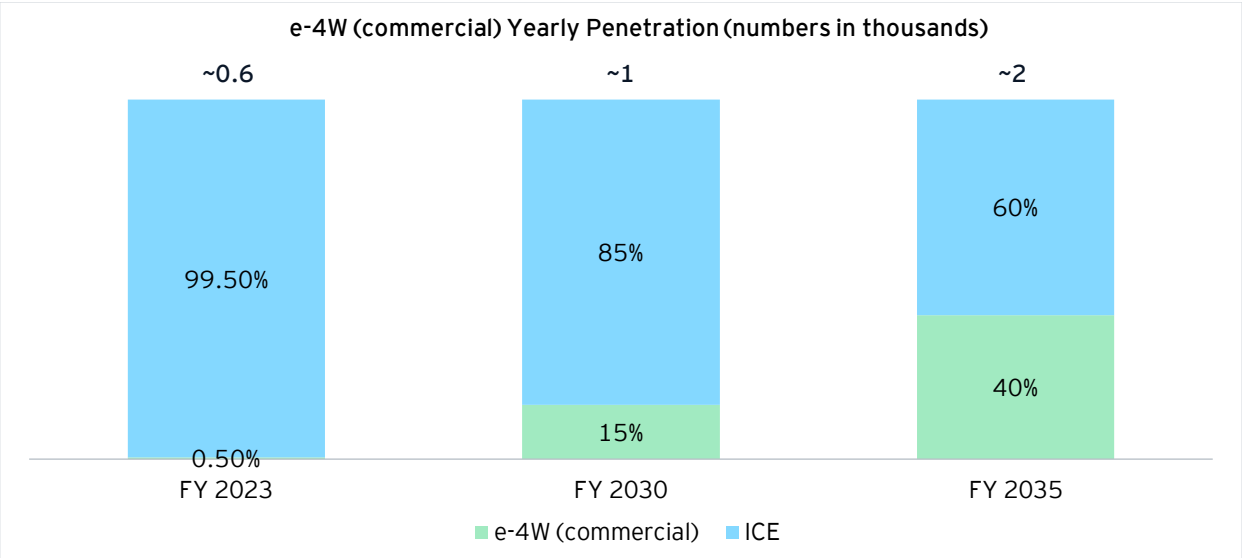
Graph 16: Electric four-wheeler (private) yearly sales



Electric Four-wheeler (Commercial):

Taxis in Varanasi offer convenient accessibility, operating at key transportation hubs and tourist areas. They provide a diverse range of options, from standard sedans to larger vehicles, catering to different preferences and budgets. Known for comfort and door-to-door service, taxis are popular for sightseeing trips and exploring Varanasi's attractions. Despite competition from ride-hailing services, taxis remain favoured for their personalized service and reliability. Safety is paramount, with passengers advised to choose licensed operators for a secure travel experience. Hence, it can be said that commercial four-wheelers will adopt electric vehicles in coming years due to the TCO benefits.

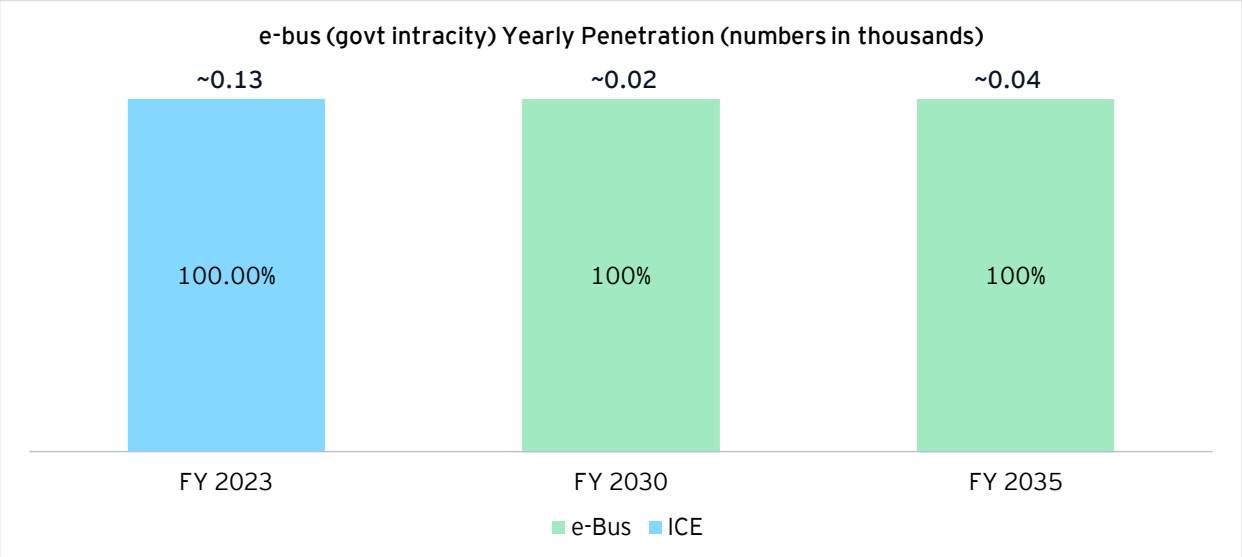
Graph 17: Electric four-wheeler (commercial) yearly sales



Electric bus:

Buses form the backbone of Varanasi's public transport, linking neighbourhoods and major hubs, serving diverse passengers including commuters, students, and tourists. The extensive network covers residential, commercial, and tourist areas, offering affordable fares for daily commuting and errands. Varanasi's bus fleet includes various vehicles for short and long-distance travel. The city government aims to electrify 100% of their intracity bus fleet to electric.

Graph 18: Electric bus yearly sales



5.2. Projection of power demand for different vehicle segment

Considering the overall stock of different segments of electric vehicles, the power requirements for charging electric vehicles is mentioned below table:

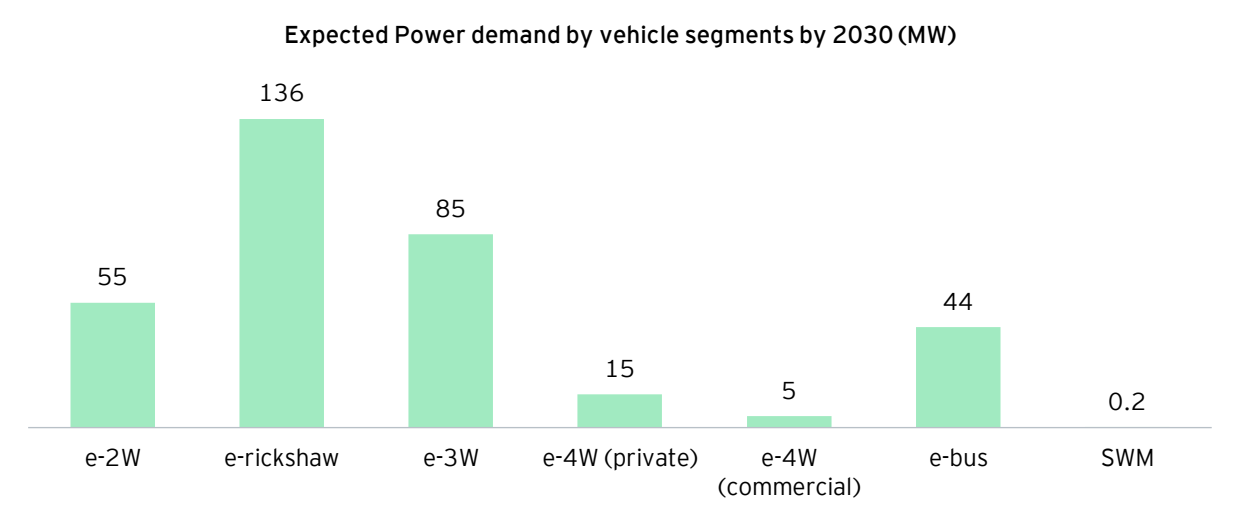
Table 13: EV stock volume & total power demand of Varanasi in FY2028 and FY2035

Vehicle category	Volume ('000)		Total Power Demand (MW)	
	FY 2030 (E)	FY 2035 (E)	FY 2030 (E)	FY 2035 (E)
e-2W	80 - 83	225 - 232	50 - 55	150 -152
e-rickshaw	66 - 68	143 - 145	130 - 136	290 - 294
e-3W	17 - 19	54 - 56	120 - 125	345 - 350
e-4W (private)	3 - 4	17 - 19	12 - 14	60 - 62
e-4W (commercial)	0.1 - 0.2	2 - 3	7 - 9	40 - 42
e-bus	0.2 - 0.25	0.25 - 0.3	40 - 42	57 - 59
SWM	0.1 - 0.3	0.6 - 0.8	0.2 - 0.3	0.6 - 0.8
Total	**174 - 175**	**453 - 454**	**375 - 380**	**955 - 960**

The share of public charging, home charging, captive charging and workplace charging are as follows:

Table 14: Charging type wise power demand in FY 2030

Power demand in 2030 (in MW)								
Vehicle category	Public charging share	Power demand from public charging stations	Home charging share	Power demand from home charging	Captive charging share	Power demand from captive charging	Workplace charging share	Power demand from workplace charging (2030)
e-2W	10%	5.5	80%	44	-	-	10%	5.5
e-rickshaw	50%	68	50%	68	-	-	-	-
e-3W	20%	24	30%	37	50%	61	-	-
e-4W (private)	10%	1.5	80%	12	-	-	10%	1.5
e-4W (commercial)	30%	2	10%	1	60%	4	-	
e-bus	-	-	-	-	100%	41	-	-
SWM					100%	0.2		
Total		**~101**		**~162**		**~106**		**~7**



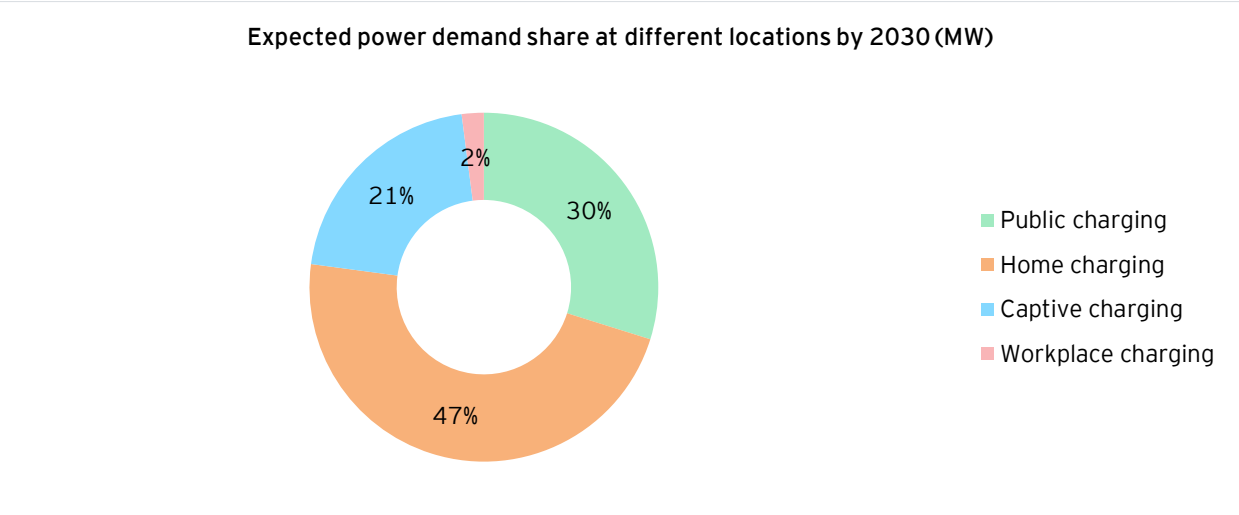
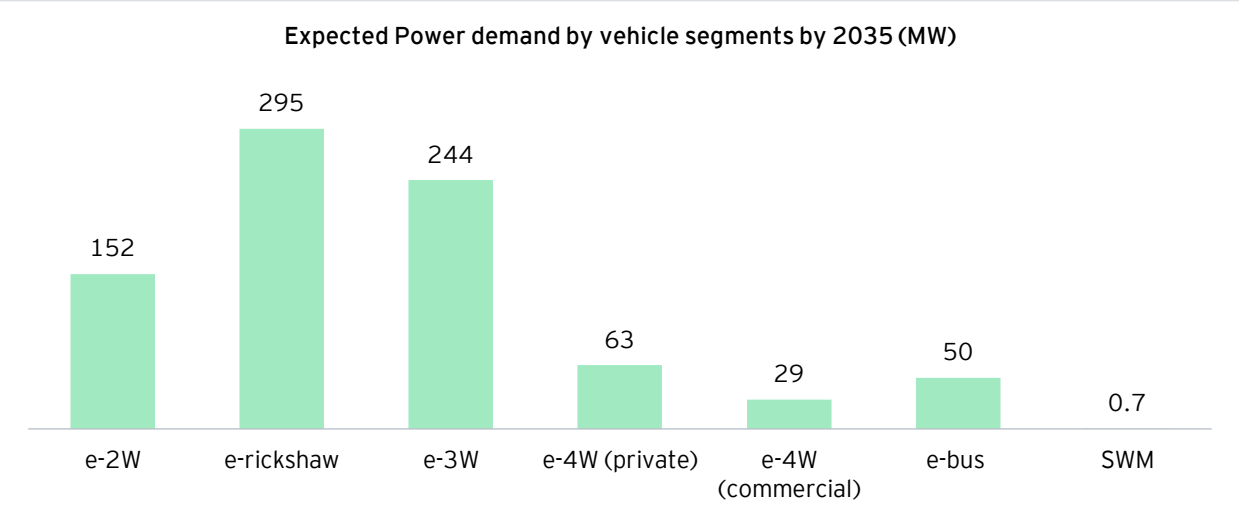
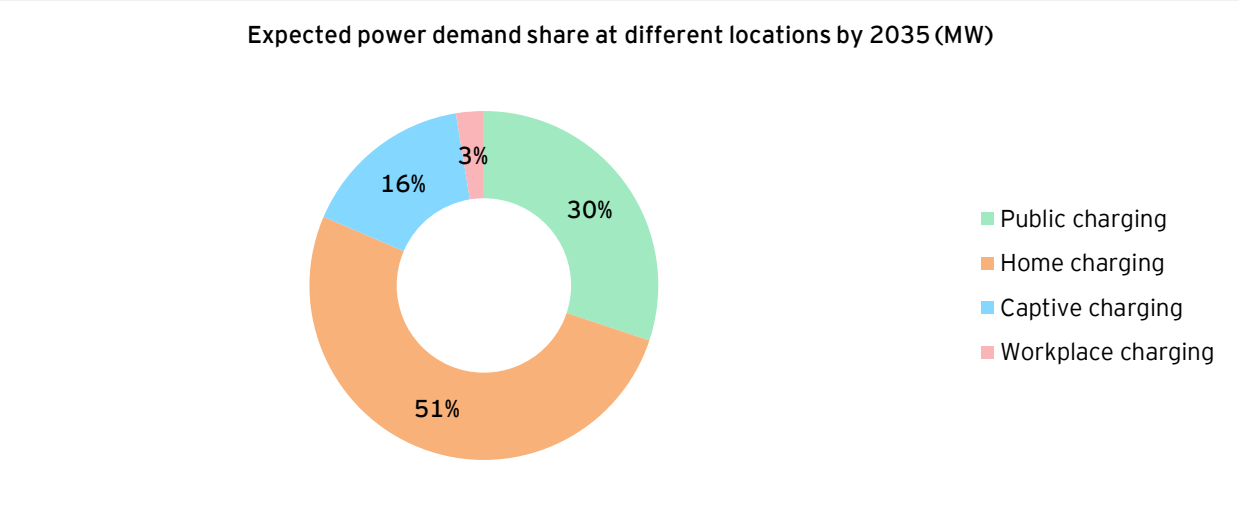


Table 15: Charging type wise power demand in FY 2035

Power demand in 2035 (in MW)								
Vehicle category	Public charging share	Public charging stations	Home charging share	Home charging	Captive charging share	Captive charging	Workplace charging share	Workplace charging (2035)
e-2W	10%	15	80%	122	-	-	10%	15
e-rickshaw	50%	147	50%	148	-	-	-	-
e-3W	20%	70	30%	104	50%	175	-	-
e-4W (private)	10%	6	80%	50	-	-	10%	7
e-4W (commercial)	30%	12	10%	4	60%	25	-	-
e-bus (govt intracity)	-	-	-	-	100%	57	-	-
SWM	-	-	-	-	100%	0.7		
Total		**~250**		**~428**		**~257**		**~22**





Additional power demand due to tourist four-wheeler (commercial) vehicles and electrification of Solid Waste Management vehicles

As Varanasi continues to flourish as a prime tourist destination, the city anticipates a surge in intercity tourist vehicles, consequently leading to heightened demands on its power infrastructure. With the increasing global emphasis on sustainability, there's a notable shift towards electric vehicles (EVs). As a consequence, the introduction of EV cabs to cater to the tourist population.

However, this transition to EVs brings about additional power demands for charging infrastructure within the city. Thus, Varanasi's evolution into a tourist hub necessitates proactive measures to augment its power infrastructure to accommodate the growing demand spurred by the integration of EV cabs into its transportation network.

Vehicle category	Numbers in '000		Total Power Demand (MW)	
	FY 2030 (E)	FY 2035 (E)	FY 2030 (E)	FY 2035 (E)
Tourist cabs (EV influx)	116 - 118	296 - 298	18 - 20	45 - 47
SWM vehicles (EV volume)	0.2 – 0.4	0.6 – 0.8	0.2 – 0.4	0.7 – 0.9

5.2.1. Power demand due to EV in Varanasi:

The total energy requirement forecast for Varanasi is projected to reach ~3600 MW[36], excluding the demand from electric vehicles (EVs). With the inclusion of EVs, this requirement is expected to increase to ~4000 MW, representing about 8.8% of the total energy demand.

By 2035, the forecasted energy requirement is estimated to be ~4770 MW[37]. When factoring in the power demand from EVs, this number is expected to rise to ~5700 MW, with the EV power demand accounting for about 16.5% of the total energy requirement[38].

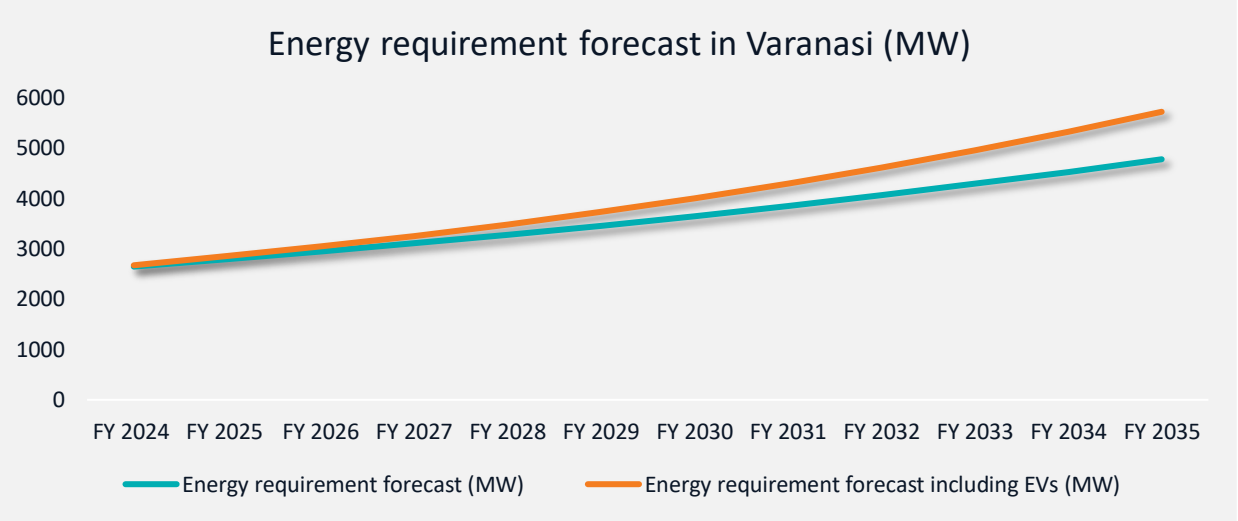


Figure 13: Energy requirement forecast in Varanasi (MW)

5.3. Projection of EV Charging infrastructure and cost

The number of chargers required is projected on the basis of total power demand required for charging electric vehicles and assumed utilization rate.

36 https://cea.nic.in/old/reports/others/planning/pslf/19th_EPS_Mega%20City_Part%20II.pdf

37 https://cea.nic.in/old/reports/others/planning/pslf/19th_EPS_Mega%20City_Part%20II.pdf

38 The impacts of solar rooftop have not been considered exclusively. It is generally assumed that their impact would be negligible, as solar rooftop installations have not yet gained significant traction.

Accordingly, the numbers of chargers projected is around 7,000 by FY 2030 which would further increase to around 19,500 EV chargers by FY 2035.

The projected number of chargers for deployment is mentioned in the table below:

Table 16: Projected number of chargers required for public charging stations and bus depots by 2030

Total number of chargers required for public charging stations and bus depots by 2030								
Charger Rated Capacity	**kW**	e-2W	e-rickshaw	e-3W (P)	e-4W (Pvt)	e-4W (Com)	e-Bus	Total
LEV AC	10 (3*3.3)	80	2,358	511				2,949
Type-II AC	11			310				310
IS-17017-2-6	7	167						167
CCS II	30				20	28		48
CCS II	180						41	41
Total		**247**	**2,358**	**821**	**20**	**28**	**44**	**3,518**

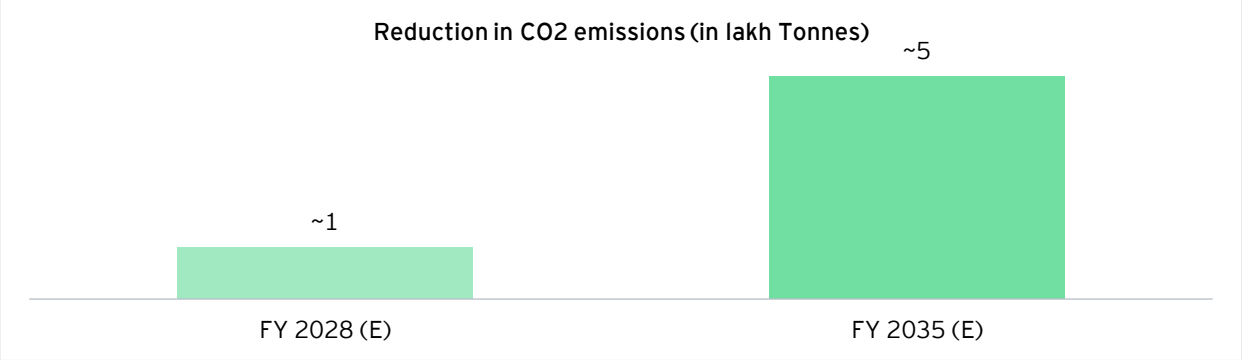
Table 17: Projected number of chargers required for public charging stations and bus depots by 2035

Total number of chargers required for public charging stations and bus depots by 2035								
Charger Rated Capacity	**kW**	e-2W	e-rickshaw	e-3W (P)	e-4W (Pvt)	e-4W (Com)	e-Bus	Total
LEV AC	10 (3*3.3)	216	5,093	1,453				6,762
Type-II AC	11			881				881
IS-17017-2-6	7	456						456
CCS II	30				78	149		227
CCS II	120						57	57
Total		672	5,093	2,334	78	149	41	8,383

5.4. Impact on GHG emissions

The link between decarbonization and the evolving vehicle landscape in Varanasi is clear and significant. Projections indicate that the transition from Internal Combustion Engine (ICE) vehicles to Electric Vehicles (EVs) could lead to a reduction in emissions ranging from 0.9 to 1.2 lakh tonnes by FY 2028. This noteworthy estimate is poised to experience a significant upsurge by FY 2035, culminating in a remarkable reduction in CO_2 emissions spanning from 4.75 lakh to 5 lakh tonnes.

Graph 19: Reduction in CO_2 emissions

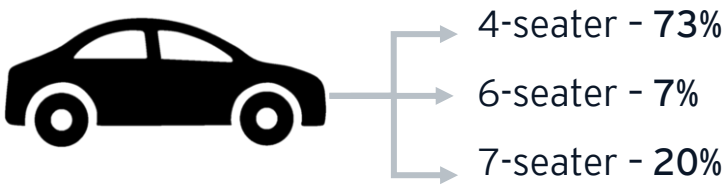


6

Primary Consultation with EV stakeholders in Varanasi

6.1. Fleet drivers

After the initial consultation, it was determined that the drivers in the fleet use traditional vehicles for ride-hailing purposes. The analysis reveals that ~70% of the drivers predominantly operate small vehicles with a seating capacity of 4. The breakdown of vehicle distribution based on their seating capacity is as follows:



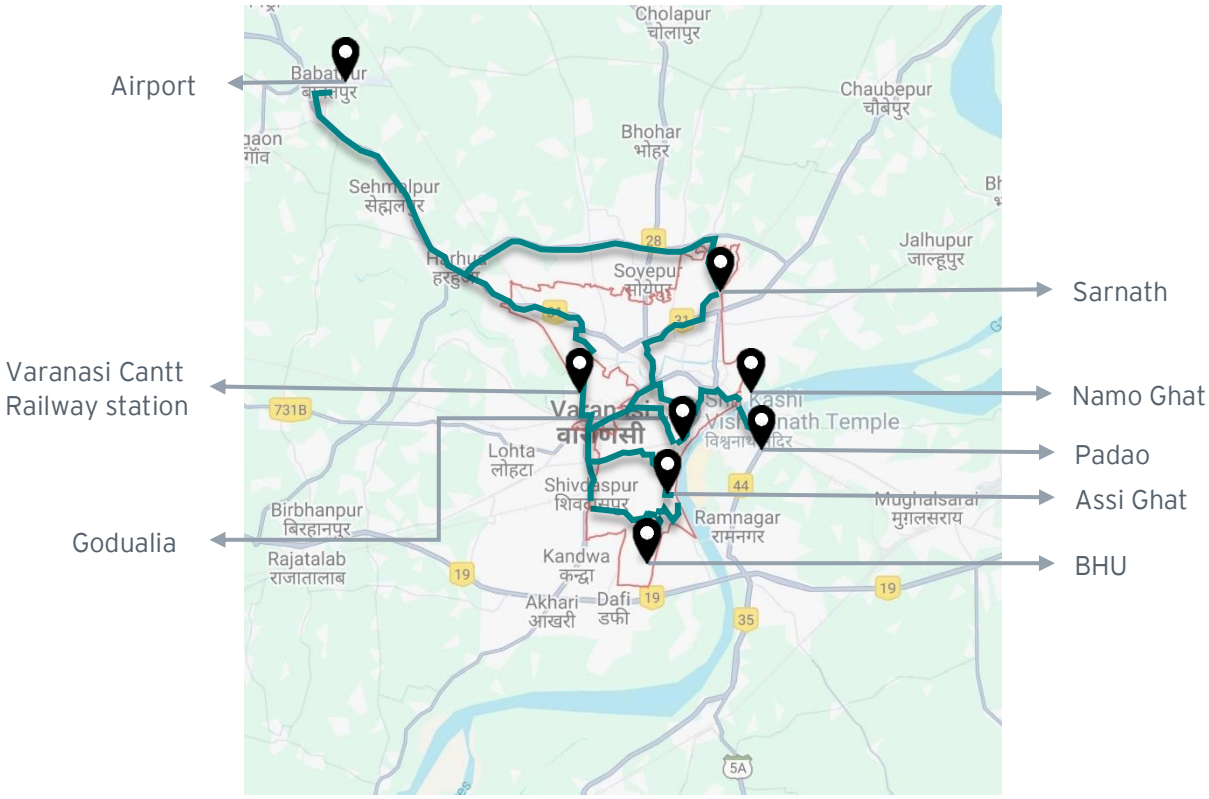
Number of operational days in a year: The average number of working days is about 350.

Average distance travelled per day: The average distance travelled per day is approximately 140 km.

Number of airport drops: The average number of airport drops per year by fleet drivers is 70, which is approximately 6 airport trips in a month.

Major pick up / drop off points in Varanasi

Figure 14: Major pick up / drop off points in Varanasi

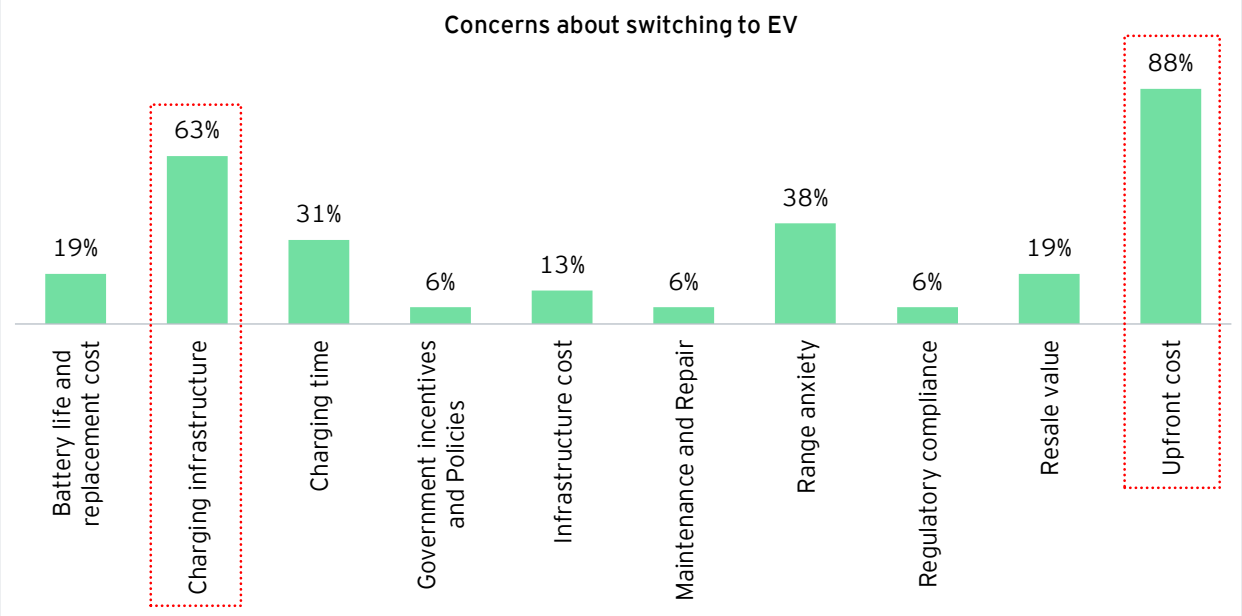


How likely are drivers to switch to EVs:

> Approximately 90% of drivers were not sure and responded with a "Maybe" when asked about the likelihood of switching to electric vehicles within the next 1-2 years.

Concerns about switching to EV:

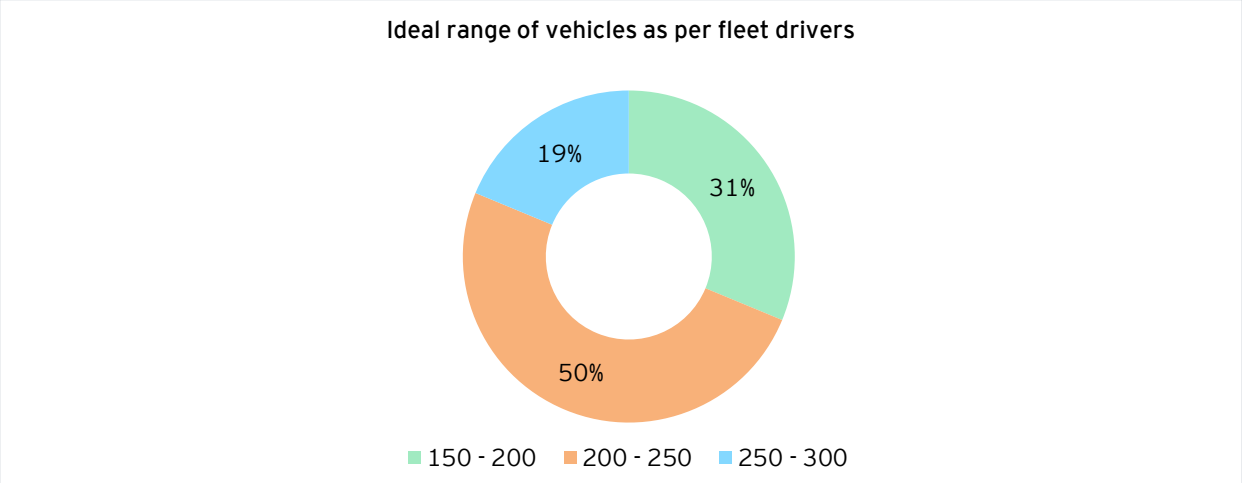
Graph 20: Fleet drivers concerns about switching to EV



Acceptable range of vehicle run per charge as per fleet drivers:

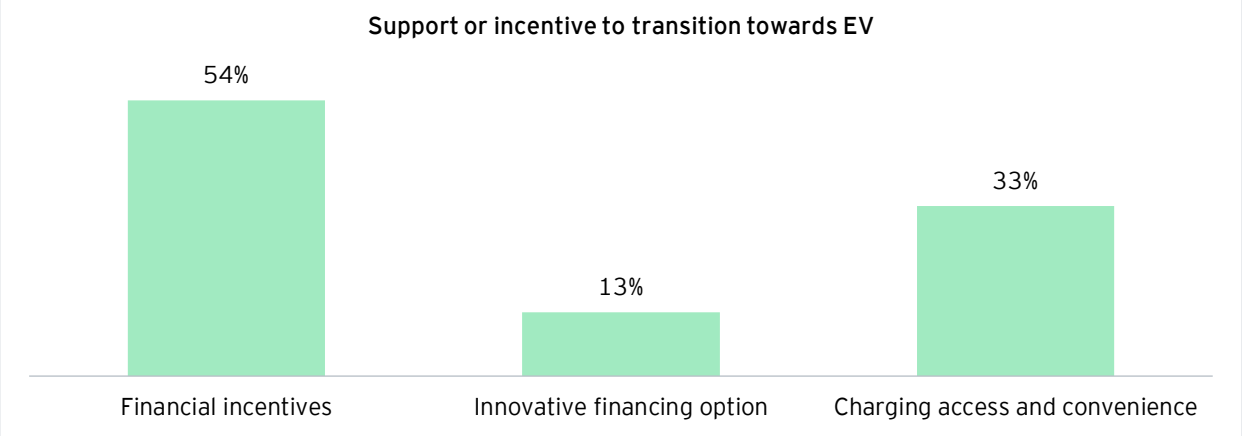
The current average daily distance covered by vehicles stands at ~140 km. Nevertheless, the anticipated optimal range for electric vehicles as per the drivers falls within the span of 200 to 250 km. Given that 38% of drivers express range anxiety as a significant concern, availability of adequate EV charging infrastructure will play a pivotal role in addressing this barrier to adoption of electric vehicles by fleet owners.

Graph 21: Ideal range of vehicles as per fleet drivers



Support or incentive to transition towards EV

Graph 22: Support or incentive to transition towards EV



6.2. Fleet operators

On average, fleet operators manage a fleet size of 10 vehicles, all falling within the 4W segment. Half of these operators have incorporated electric vehicles (EVs) into their fleets. Among these, all fleet owners possess 4-seater vehicles, with 25% having a combination of 7-seater and 4-seater vehicles.

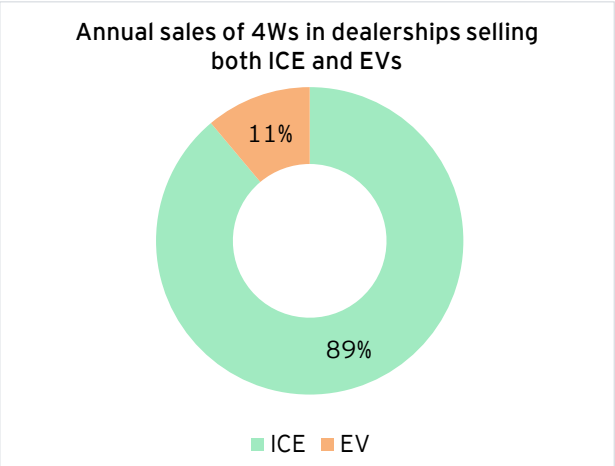
For local commuting, the average daily distance covered is 140 km, while outstation trips span an average distance of 310 km. The general tariff hovers around Rs. 4000 per day. Three-fourths of the operators have dedicated private parking spaces for their vehicles.

When it comes to transitioning to electric fleets, 75% of operators are open to the idea ("May be"), while the remaining 25% are resolute about converting their fleets to electric. The primary hurdles faced by operators are the costs associated with the switch and the availability of charging infrastructure.

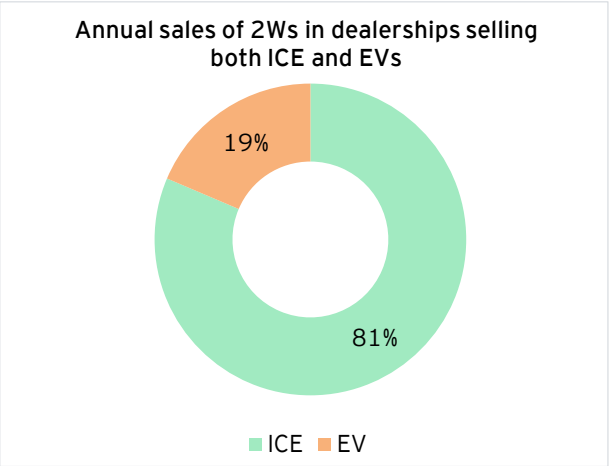
6.3. Fleet dealers

Annual sales:

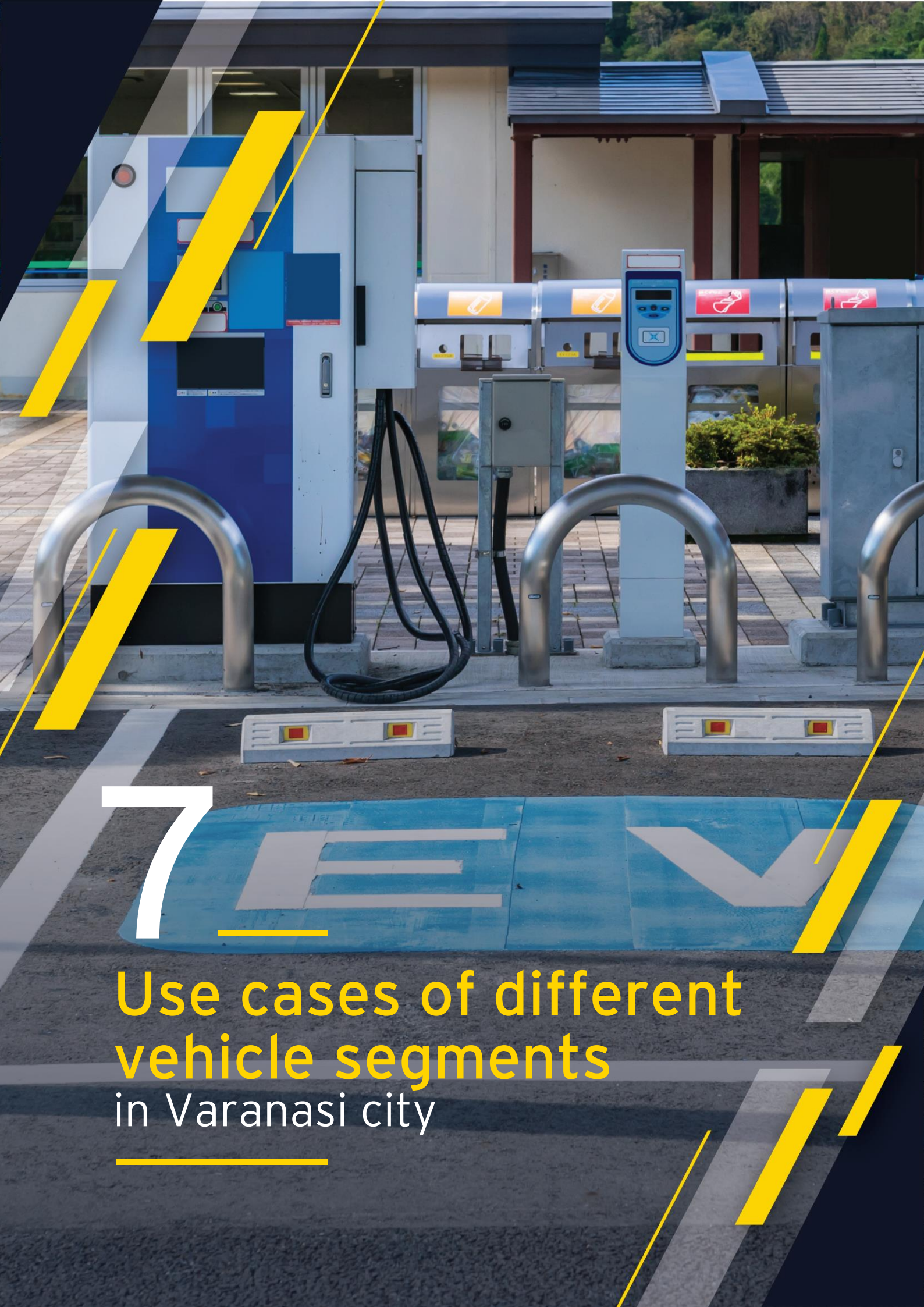
1. **Sales Disparity Between ICE and Electric Vehicles in Four-Wheeler Dealerships:**



2. **Sales Ratio in Two-Wheeler Dealerships:**

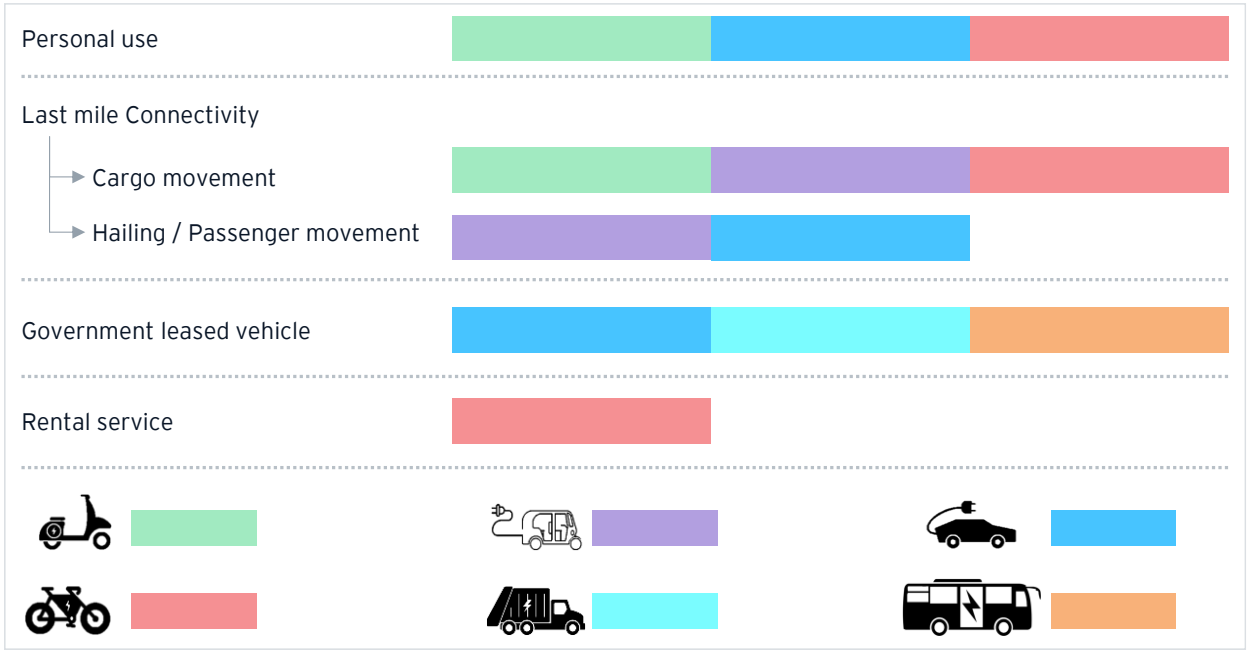


This indicates a greater acceptance of electric two-wheelers among consumers, possibly due to factors such as lower operating costs, environmental concerns, and advancements in electric vehicle technology.



7

Use cases of different vehicle segments in Varanasi city



Mapping of different fleet use cases:

7.1. Personal use:

Two-wheeler:

Two-wheelers, including motorcycles and scooters, are popular choices of transportation for several reasons:

Two-wheelers are highly manoeuvrable vehicles, allowing riders to navigate through traffic congestion and narrow streets more easily compared to larger vehicles like cars.

Two-wheelers require much less space to park than four-wheelers. This makes them convenient for urban areas where parking space is limited and expensive.

Generally, two-wheelers tend to be more fuel-efficient compared to cars, which means they offer a cost-effective mode of transportation for short to medium distances.

In many cases, the initial cost of purchasing a two-wheeler is lower than that of purchasing a car. Additionally, maintenance and operating costs are usually lower for two-wheelers.

Two-wheelers come in various types and sizes, catering to different needs and preferences. From small scooters for local commuting to powerful motorcycles for longer trips, there is a wide range of options available to suit different lifestyles.

Why two–wheelers should be electrified:

Two-wheelers achieve cost parity with the lowest utilization among all vehicle segments due to several factors:

Sr. No.	Particulars	Details
1	**Operational Cost Savings**	Despite their minimal usage, two-wheelers offer substantial operational cost savings. The average round trip commute for office workers falls within the range of 30-40 kilometres. With a daily usage of around 30 kilometres, operational cost savings can exceed INR 25,000 annually when compared to traditional vehicles.
2	**Sufficient Range**	Two-wheelers typically offer ranges of 70-100 kilometres per charge, which is more than adequate for fulfilling daily personal transportation needs, including commuting to offices and schools. This range ensures that users can complete their daily trips without worrying about running out of charge.
3	**Consistent Commuting Patterns**	While personal usage of two-wheelers may vary, commuting to offices and schools remains consistently high over time. This consistent demand for transportation to and from key locations ensures that two-wheelers remain a practical and reliable mode of travel.
4	**Convenient Charging**	Charging electric two-wheelers at home is convenient and straightforward, requiring only a standard 15A power socket for their portable charger. Additionally, some models feature removable batteries, making indoor charging even more accessible and convenient for users.
5	**Minimal Parking Space**	Two-wheelers have a compact size that occupies minimal parking space, making them suitable for urban environments where parking is limited. This compact size also simplifies workplace charging setups, as they require less space for charging infrastructure installation.
6	**Enhanced EV Visibility**	Two-wheelers constitute the largest vehicle segment in many cities, and their electrification could significantly boost the visibility of electric vehicles (EVs) in urban environments. Increased visibility promotes awareness and acceptance of EVs among the general public.
7	**Word of Mouth Influence**	Word of mouth is highly effective in encouraging the adoption of unfamiliar technology such as electric vehicles. A single user of electric two-wheelers can serve as a positive example and motivate their co-workers and family members to consider electric vehicles as well, further contributing to the adoption of sustainable transportation options.

Steps to electrify personal two-wheeler segment

The Ministry of Housing and Urban Affairs (MoHUA) has issued guidelines regarding EV charging infrastructure, allowing individuals to use their residential power supply for charging electric vehicles via a standard 230V/15A socket. Workplaces can also set up similar charging points in their parking areas and construct standalone sheds for charging removable batteries. Safety guidelines include placing sockets in shielded areas, installing them as independent units with safety mechanisms, keeping fire extinguishers nearby, and ensuring installation by certified electricians. Prefabricated charging points with integrated safety features and app-based tracking are available, like the Bharat AC-001 chargers that can accommodate three vehicles simultaneously at 3.3 kW power. Government employees can offset initial EV costs using measures like the UP EV Policy (2022), allowing Group C employees to use their Vehicle Advance of INR 30,000 with lower interest rates.

Four-wheeler:

Four-wheelers, are popular choices of transportation for several reasons:

Cars generally provide better protection to occupants in the event of a crash compared to two-wheelers. They are equipped with safety features such as seat belts, airbags, and crumple zones designed to minimize the impact of collisions.

Cars offer more comfort and amenities compared to two-wheelers. They provide protection from weather conditions, noise, and pollution, and often come equipped with features like air conditioning, entertainment systems, and comfortable seating.

Cars typically offer more storage space than two-wheelers. They have trunks where passengers can store groceries, luggage, and other belongings securely, making them more practical for transporting goods and larger items.

Cars can accommodate multiple passengers comfortably, making them suitable for families and group travel. They offer seating for several people, along with ample legroom and headroom.

They can be locked securely, and many modern cars come equipped with advanced security features such as anti-theft systems and GPS tracking.

Cars are well-suited for long-distance travel, offering greater range and endurance compared to two-wheelers. They can travel extended distances without the need for frequent refuelling or recharging.

Steps to electrify personal four-wheelers:

- **Research and Choose an Electric Vehicle**: Research various electric car models available in the market. Factors such as range, charging infrastructure, pricing, and incentives to be assessed.
- **Evaluate Charging Infrastructure**: Assess the availability of public charging stations in area. Determine installation process of home charging station.
- **Financial Planning and Incentives:** financial options for purchasing, tax credits, rebates, and incentives offered by local and national governments to support electric vehicle adoption.
- **Charging Procedures:** Understanding the different charging levels (Level 1, Level 2, DC fast charging) and the time required for each type of charger.
- **Maintenance and Service**: Electric vehicles have different maintenance requirements compared to internal combustion engine vehicles, which typically involve fewer components and less frequent maintenance intervals.
- **Dispose of Old Vehicle**: selling it to a dealership or recycling it through a certified facility.

e-Bicycles:

Micro-mobility solutions like electric bicycles offer a promising alternative for urban transportation, combining convenience, environmental friendliness, and popularity in cities worldwide.

E-bicycles, under the Central Motor Vehicle (5th Amendment) Rules, 2014, must meet specific criteria: equipped with an electric motor of less than 250W, with a maximum speed of under 25km/hr, fitted with suitable brakes and retro-reflective devices, and an unladen weight (excluding battery) not exceeding 60kg. Consequently, they are not classified as motor vehicles, exempting them from transport regulations such as licensing, registration, insurance, and taxes.

States like Tamil Nadu and Punjab, along with Union territories such as Chandigarh and Delhi, have included provisions in their policies for e-bicycles. They offer fiscal incentives ranging from 20% to 25% for passenger e-bicycles and up to 33% for e-cargo bicycles.

Steps to promote usage of e-bicycles:

Subsidies and Incentives: Introduce subsidies or tax incentives for purchasing e-bicycles to make them more affordable for the general public.

- **Rental Programs:** Establish e-bicycle rental docks at popular tourist destinations and transportation hubs. This allows visitors and residents to easily access e-bicycles for short-term use, promoting their adoption.
- **Integration with Public Transport:** Integrate e-bicycles with existing public transportation systems by establishing designated e-bicycle stations near bus stops and railway stations.
- **Awareness Campaigns:** Launch comprehensive awareness campaigns to educate the public about the benefits of e-bicycles, including environmental benefits, cost savings, and health advantages.
- **Infrastructure Development:** Improve cycling infrastructure by creating dedicated lanes for bicycles and installing secure parking facilities for e-bikes at key locations such as transit hubs, markets, and educational institutions.

Partnerships with Educational Institutions: Collaborate with schools and universities; example Banaras Hindu University (BHU), to promote e-bicycle usage among students and faculty members. Organize events such as workshops to encourage participation and generate interest.

7.2. Last mile connectivity: Vehicle segment – Two-wheelers, Three-wheelers and e-bicycles and four-wheelers

7.2.1. Cargo movement: Vehicle segment – Three-wheelers, two-wheelers and e-bicycles

Last-mile cargo movement refers to the final stage of the logistics process, where goods and products are transported from a distribution centre or hub to the end destination, typically the customer's doorstep or a retail location. This stage of delivery is often considered the most crucial and challenging part of the supply chain, as it involves navigating through urban or suburban areas to reach individual customers or small businesses.

Two and three-wheeler vehicles are particularly well-suited for urban deliveries due to their compact size and agility. They can navigate through narrow streets, congested traffic, and tight alleyways, reaching destinations that might be inaccessible to larger vehicles. This makes them ideal for last-mile deliveries, where goods need to be transported from distribution centres to final destinations.

Compared to larger trucks and vans, two and three-wheeler vehicles are more affordable to purchase, operate, and maintain. They consume less fuel, require fewer maintenance costs, and often have lower insurance premiums. This cost-effectiveness makes them a preferred choice for small businesses, independent contractors, and delivery services looking to optimize their operational expenses.

Many two and three-wheeler vehicles run on alternative fuels such as electricity or compressed natural gas (CNG), reducing their environmental impact compared to traditional gasoline-powered vehicles. Electric two and three-wheelers, in particular, produce zero tailpipe emissions, contributing to improved air quality and reduced carbon footprint, especially in densely populated urban areas.

Advancements in technology, including GPS navigation, route optimization software, and telematics systems, have enhanced the efficiency and productivity of cargo movement using two and three-wheeler vehicles. These technologies help drivers optimize delivery routes, track shipments in real-time, and improve overall fleet management, leading to faster deliveries and enhanced customer satisfaction.

Key features and aspects of last-mile cargo services include:

- **Customer-Centric Focus**: Last-mile delivery is focused on meeting the specific needs and expectations of customers. It aims to provide timely, reliable, and convenient delivery options that enhance the overall customer experience.
- **Efficiency and Timeliness**: Last-mile delivery services prioritize speed and efficiency to ensure that packages reach their destination within the shortest possible time frame. This often involves optimizing delivery routes, utilizing technology for route planning and tracking, and employing efficient delivery methods.
- **Flexibility and Adaptability**: Last-mile delivery services must be adaptable to various delivery scenarios and customer preferences. This includes offering multiple delivery options such as same-day or next-day delivery, flexible delivery time slots, and the ability to reroute packages in real-time based on customer requests or changes in delivery instructions.
- **Technology Integration**: Technology plays a significant role in last-mile delivery services, enabling route optimization, real-time tracking, electronic proof of delivery, and communication between delivery personnel and customers.
- **Cost-Effectiveness**: Last-mile delivery services strive to optimize costs while maintaining service quality. This includes minimizing fuel consumption, reducing delivery times, maximizing vehicle capacity utilization.
- **Sustainability**: With increasing concerns about environmental impact, last-mile delivery services

are increasingly focused on adopting sustainable practices. This may include using electric vehicles, optimizing delivery routes to minimize emissions, implementing eco-friendly packaging solutions, and exploring alternative delivery methods such as bicycle or pedestrian couriers.

- **Collaboration and Partnerships**: Last-mile delivery services often involve collaboration and partnerships between logistics companies, retailers, e-commerce platforms, third-party delivery providers, and technology companies. These partnerships help streamline operations, expand delivery networks, and improve service offerings.

Three distinct delivery modes are employed to fulfil the diverse delivery requirements of businesses, either in isolation or in conjunction with each other:

- **Business-Owned**: In this model, vehicles are acquired and managed directly by the delivery platform, store, or e-commerce entity. This approach necessitates a substantial initial investment and is most suitable for entities experiencing consistent demand and maintaining high utilization rates for each vehicle.
- **Service Contracts**: Under this arrangement, vehicles are owned by service providers contracted to manage deliveries. It's a lighter asset approach with ongoing payments, either time-based or performance based. This model is adaptable for businesses of all sizes as they can delegate operational intricacies to service providers and adjust service utilization based on actual demand.
- **Driver-Owned**: In this model, vehicles are owned and managed by drivers themselves, who are contracted by businesses. This primarily encompasses smaller vehicles, as private ownership of larger delivery vehicles is uncommon. Typically, gig workers without long-term contracts with the business opt for this model, offering maximum flexibility to match demand. Although it's a lighter asset model for businesses, it entails significant investment and risk for drivers, including vehicle wear and tear, increased insurance premiums, and accident risks. Additionally, drivers may lack the training and operational efficiency needed for delivery services, necessitating guidance from businesses to operate effectively.

Steps to electrify Last-mile cargo vehicles:

- **Upfront Costs and Funding Accessibility**: The initial expenses play a critical role for both companies and electric vehicle (EV) service providers. Subsidies and incentives associated with programs like FAME II and the state EV Policy provides indispensable support in this regard. It is essential to raise awareness about the available benefits and streamline the application process. Financial institutions, often cautious about investing in new technologies, require education on the proven operational advantages of electric vehicles. Government encouragement can motivate these institutions to offer loans, with publicly owned banks leading by example through specialized financial assistance for EV purchases.
- **Range and Reliability**: Businesses need to carefully analyse their delivery patterns to identify areas of high utilization where EVs can be introduced initially. This allows for first-hand evaluation of their reliability. EV service

providers should actively showcase their capabilities and be ready to offer vehicles for trial periods. Contracts with EV service providers should include provisions for minimum payment guarantees to mitigate adverse effects during low utilization periods. However, since EVs offer maximum savings in high-utilization scenarios, businesses inherently aim to minimize instances of low utilization.

- **Fragmented Service Landscape**: As time progresses, EV service providers will expand their operations. To accelerate this growth, businesses should nurture deeper partnerships with service providers and support their expansion through investments and long-term contracts. This collaborative approach fosters the development of large service providers proficient in meeting partner companies' specific needs, even as they expand into new territories. Such partnerships also position businesses as pioneers in zero-emission delivery, expediting the attainment of economies of scale.

7.2.2. Hailing service: Vehicle segment – Four-wheelers and Three-wheelers

Taxis, autorickshaws and e-rickshaws play a crucial role in modern transportation systems and offer several benefits that make them important for individuals, communities, and economies. Here are some reasons why taxis are considered essential:

- **Accessibility and Convenience**: Hailing vehicles provide accessible transportation options for individuals who may not own a vehicle or have access to public transit systems. They offer door-to-door service, making it convenient for passengers to travel directly to their desired destinations without the need for transfers or additional transportation modes.
- **Flexibility and On-Demand Service**: They operate on an on-demand basis, allowing passengers to request a ride whenever and wherever they need it. This flexibility is particularly valuable in situations where public transportation options are limited, or when individuals require immediate transportation for urgent matters or emergencies.
- **Efficiency and Time Savings**: They offer efficient and time-saving transportation solutions, especially for short-distance trips or travel within urban areas with heavy traffic congestion. Three-wheelers can navigate through traffic and take alternative routes to minimize travel time, helping passengers reach their destinations quickly and efficiently.
- **Accessibility for Tourists and Visitors**: They play a vital role in catering to the transportation needs of tourists and visitors in cities and tourist destinations worldwide.
- **Support for Local Economies**: This industry creates employment opportunities for drivers, dispatchers, maintenance personnel, and other support staff, contributing to local economies and livelihoods. Additionally, these services generate revenue through fares, taxes, and licensing fees, which support public infrastructure and services.
- **Accessibility for Individuals with Mobility Challenges**: They serve as an important transportation option for individuals with mobility challenges or disabilities who may require assistance or accommodations when traveling.

Affordability: Three-wheelers are typically more affordable to purchase and operate compared to four-wheelers. Their lower initial cost and maintenance expenses make them an economically viable option for last-mile connectivity solutions, especially in regions with limited financial resources.

7.3. Government leased vehicle: Vehicle segment – Four-wheelers, Solid waste management (SWM) vehicles and buses

Four Wheelers:

Leasing allows government agencies to access vehicles without the significant upfront costs associated with outright purchase. Lease agreements typically involve fixed monthly payments, making budgeting and financial planning more predictable for government departments.

Leasing provides flexibility in fleet management, allowing agencies to adjust the size and composition of their vehicle fleets according to changing needs. Government agencies can lease a variety of vehicles, including sedans, SUVs, vans, and specialty vehicles, to accommodate diverse operational requirements.

Leasing enables government agencies to access newer vehicle models equipped with advanced safety features, improved fuel efficiency, and enhanced technology. By leasing vehicles on a rotational basis, agencies can ensure that their fleets remain up-to-date and compliant with evolving regulatory standards.

Many lease agreements include maintenance and service packages, relieving government agencies of the burden of managing vehicle upkeep. Maintenance contracts may cover routine servicing, repairs, and roadside assistance, ensuring optimal vehicle performance and reliability.

Leasing simplifies administrative tasks associated with vehicle ownership, such as registration, insurance, and compliance with regulatory requirements. Government agencies can streamline administrative processes and focus on core responsibilities without the administrative complexities of vehicle ownership.

Leasing helps mitigate the risks associated with vehicle depreciation, resale value fluctuations, and technological obsolescence. Lease agreements may include provisions for vehicle disposal at the end of the lease term, transferring residual value risk to the leasing company.

Leased vehicles for government agencies offer a flexible and cost-effective solution for meeting transportation needs while minimizing upfront capital investment.

There are currently 2 widespread models for leasing of government vehicles, which are dry lease and wet lease:

- **Dry lease:** It is a contractual agreement where the government entity leases vehicles for utility work or for their staff from another party without additional services included. In this arrangement, the entity would solely receive the vehicles and be responsible for deploying their own staff or manpower to operate and maintain the vehicles.
- **Wet lease:** This type of model entails a more comprehensive arrangement. In this case, the government entity not only procure the vehicles on a lease but also avail additional services of drivers. This model grants the leasing company greater control over the entire operation of the vehicles, including personnel management and maintenance schedules.

Solid waste Management vehicle

SWM vehicle door-to-door collection is a systematic method used by municipalities to collect household waste directly from residences, aiming to streamline waste collection, enhance efficiency, and improve community sanitation. This involves dedicated vehicles equipped for waste segregation, operated by trained personnel along designated routes and schedules. Key components include waste segregation at the source, scheduled collections, segregated transportation, and promoting compliance and awareness among residents. Benefits encompass improved sanitation, environmental sustainability through recycling, and protection of public health by preventing disease spread.

WHY electrify SWM vehicles?

- **High emissions**
  - Diesel fleet
  - Low fuel efficiency
  - Increasing waste generation
- **High cost**
  - High fuel cost
  - High maintenance cost
  - Low vehicle life

Potential to electrify

- Fixed origin and destinations (routes)
- Fleet ownership level
- Major stakeholder is ULB

Potential barriers in electrification

- Overloading
- Usage tracking
- Gradient of roads
- Trained drivers

Solid waste Management (SWM) vehicle electrification case:

Vijayawada:

In 2017, Vijayawada, a city in the Indian state of Andhra Pradesh, emerged as a pioneer in the adoption of electric three-wheelers. This move marked a significant shift towards sustainable transportation solutions. The decision to introduce electric three-wheelers was likely influenced by the growing concerns over pollution, particularly in urban areas where traditional fossil fuel vehicles contribute significantly to air and noise pollution.

Following Vijayawada's lead, Coimbatore, another city in India, took a step towards embracing eco-friendly transportation by integrating 50 electric three-wheelers into its fleet in 2019. This adoption demonstrates a broader trend across various Indian cities towards embracing cleaner modes of transportation.

The commitment made by the Andhra Pradesh government to purchase 7500 electric three-wheelers for garbage collection further underscores the state's commitment to environmental sustainability. By opting for electric vehicles for garbage collection, the government aims to reduce carbon emissions and promote cleaner streets and neighbourhoods. The timeline set by the Andhra Pradesh government to procure electric three-wheelers for garbage collection by December 2019 highlights a sense of urgency and determination to transition towards greener alternatives rapidly.

Pune:

PMC possesses approximately 1,400 vehicles, comprising both three and four-wheelers as well as heavy-duty vehicles, dedicated to garbage collection and transportation. Among these, about 750 vehicles are heavy-duty, primarily utilized for the purpose of collecting and transporting solid waste.

The Pune Municipal Corporation procured 10 electric tipper trucks from Eka Mobility for the purpose of collecting garbage throughout the city.

The price of each vehicle amounts to approximately ₹17 lakh, equipped with a 30-kilowatt battery. The company asserts a mileage of 180 kilometres on a full battery charge.

Charging station is established within the premises of sewage treatment plant on Sinhagad Road. Currently, the plan is to deploy these vehicles in the Sinhagad Road area for the collection and transportation of solid waste.

Steps to electrify SWM vehicles:

1. **Mandated Replacement of ICE Vehicles:**
   - Emphasis on replacing ICE vehicles.
   - Focus on ICE 3-wheelers and mini-trucks approaching end of life to expedite EV adoption.
   - Minimum replacement rate of 10% annually targets oldest and least efficient ICE vehicles for gradual transition to EVs.
2. **Procurement Strategies:**
   - Bulk purchases and tendering processes to address EV acquisition costs.
   - UP-EV Policy (2022) allows state departments to procure EVs directly from **EESL, reducing costs and streamlining procurement.**
3. **Training Program Development:**
   - Feedback-driven training program ensures proficient EV operation, maintenance, and longevity.
   - Enhances operational efficiency and sustainability of expanding EV fleet.
4. **Charging Infrastructure Expansion:**
   - Overnight charging at depots and parking lots aligns with practical EV operational needs.
5. **Maintenance Contracts and OEM Partnerships:**
   - Crucial for securing technical support and spare parts for growing EV fleet.
   - Encourages OEMs to develop tailored models addressing specific market demands.

Buses

Electric buses are sustainable public transportation vehicles powered by electricity instead of fossil fuels. They offer benefits like reduced emissions, lower operational costs, and quieter operation.

Advancements in battery technology and charging infrastructure support their feasibility. Governments worldwide are investing in electric buses to promote sustainability, offering incentives and subsidies. Challenges include the need for charging infrastructure and higher upfront costs.

Steps to electrify Buses:

- **Feasibility Study**: Conduct a feasibility study to assess the viability of electrifying STU buses. Factors such as budget, infrastructure requirements, route characteristics, and operational considerations to be assessed.
- **Policy and Regulatory Framework**: Policies and regulations to support the electrification of STU buses. This may include incentives, subsidies, and mandates to encourage the adoption of electric buses and support the development of charging infrastructure.
- **Procurement Process**: This involves issuing requests for proposals (RFPs) or tenders to select manufacturers or suppliers of electric buses. Factors such as bus specifications, range, charging capabilities, warranty, and after-sales support to be considered.
- **Charging Infrastructure**: Assess the charging infrastructure requirements for electric buses. Determination of the locations for installing charging stations, considering factors such as bus depots, terminals, and route endpoints. Selection of appropriate charging technologies, such as slow chargers, fast chargers, or opportunity chargers, based on operational needs.
- **Infrastructure Development**: Development of the necessary infrastructure to support electric bus operations. This includes installing charging stations, upgrading electrical systems, and implementing smart grid technologies to manage energy consumption and optimize charging schedules.
- **Training and Capacity Building**: Provide training and capacity building programs for STU staff, drivers, and maintenance personnel. Ensuring that personnel are equipped with the necessary skills and knowledge to operate, maintain, and troubleshoot electric buses and charging infrastructure effectively.
- **Pilot Testing and Evaluation**: Conduct pilot testing of electric buses to evaluate their performance, reliability, and suitability for STU operations. Gather feedback from drivers,

passengers, and stakeholders to identify areas for improvement and optimization.

- **Deployment and Integration**: Deploy electric buses into STU fleets and integrate them into existing operations. Develop plans for phased deployment to minimize disruptions and ensure a smooth transition from conventional buses to electric buses.
- **Monitoring and Evaluation**: Establish monitoring and evaluation mechanisms to track the performance and impact of electric buses. Monitor key performance indicators such as energy consumption, emissions reduction, operational efficiency, and passenger satisfaction.

7.4. Rental service: Vehicle segment – e-bicycles

Vehicle rental services offer individuals and businesses the flexibility of temporary access to vehicles without the long-term commitment and financial burden of ownership. Here's an overview of e-bicycle rental services, including their features, benefits, and popular applications:

- **Flexibility and Convenience:** e-bicycle rental services provide customers with the flexibility to rent a vehicle for short-term needs, without the constraints of ownership.
- **Ease of Access:** these e-bicycles on rent are readily available at numerous rental locations, including airports, train stations, urban centres, and commercial hubs, ensuring convenient access for customers across various regions. Many e-PBS rental companies offer online booking platforms and mobile apps, allowing customers to easily reserve vehicles, manage bookings, and make payments from the comfort of their homes or offices.
- **Short-Term Commitment:** It eliminates the need for long-term commitments associated with vehicle ownership, making them ideal for individuals or businesses with temporary transportation needs or fluctuating demand. Customers can rent vehicles for specific durations, ranging from a few hours to several weeks.
- **Cost-Effectiveness:** Renting a e-bicycle for short-term use can be cost effective, especially for occasional travellers or individuals with short distance needs.
- **On-Demand Accessibility:** Vehicle rental services offer on-demand access to vehicles, enabling customers to rent a vehicle at short notice.

8

Role of STU
in fleet electrification for intracity bus movement

8.1. Uttar Pradesh State Road Transport Corporation profile

Passenger road transport services in the state of Uttar Pradesh commenced on May 15, 1947, with the introduction of bus operations along the Lucknow - Barabanki route by the then U.P. Government Roadways. Subsequently, during the fourth Five Year Plan, the entity was rebranded as the Uttar Pradesh State Road Transport Corporation (UPSRTC) on June 1, 1972, in accordance with the provisions of the Road Transport Act, 1950. The objectives driving this renaming were threefold:

- To foster the development of the road transport sector in alignment with the overall expansion of trade and industry.
- To synchronize road transport services with other modes of transportation.
- To ensure the provision of adequate, cost-effective, and efficiently coordinated road transport services for the residents of the state.

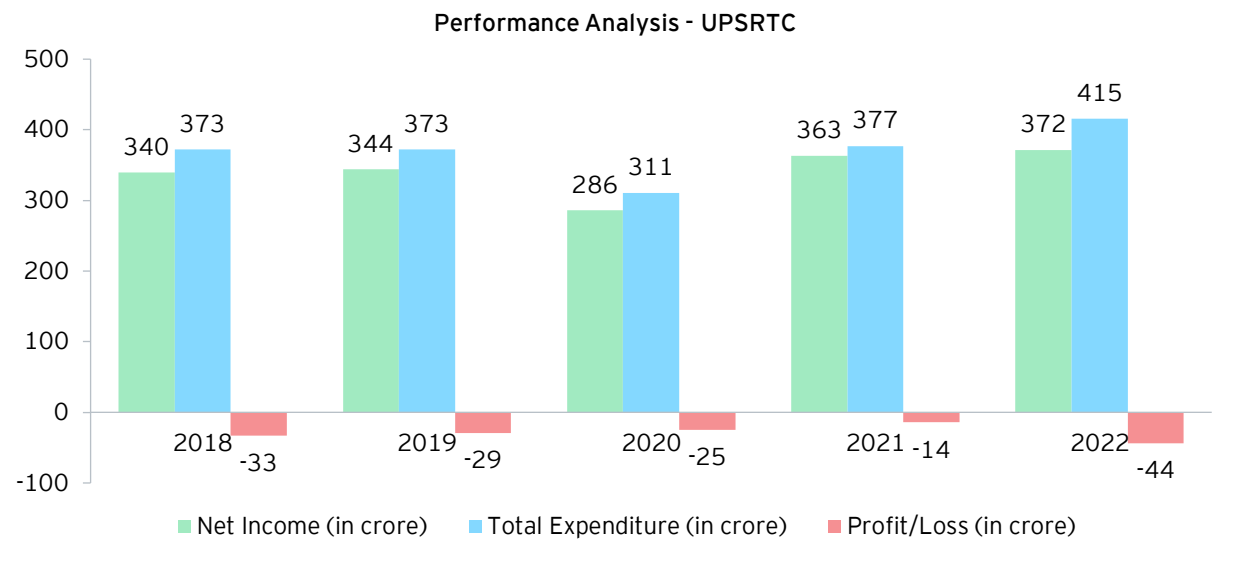
The Corporation functions as an autonomous body corporate, with the overall supervision, direction, and management of its affairs vested in a Board of Directors.

These buses collectively cover over **3.51 million kilometres**, meeting the travel requirements of more than **1.41 million individuals** and generating revenues exceeding Rs. **137.70 million daily**.

- The corporate headquarters of the corporation is based in Lucknow.
- On October 30, 2003, the Corporation underwent reorganization, leading to the establishment of a separate entity to manage services in the state of Uttaranchal.
- In order to streamline operations and bolster efficiency, the corporation is divided into 20 regions. Among these, one region is specifically dedicated to managing urban and suburban services.
- Within each region, a regional workshop is established to undertake significant repair, maintenance, and assembly reconditioning tasks.
- Furthermore, each region is subdivided into operational units known as depots.
- Presently, the corporation oversees a total of 115 depots, inclusive of car sections.
- Each depot is outfitted with a workshop to deliver essential maintenance support services.

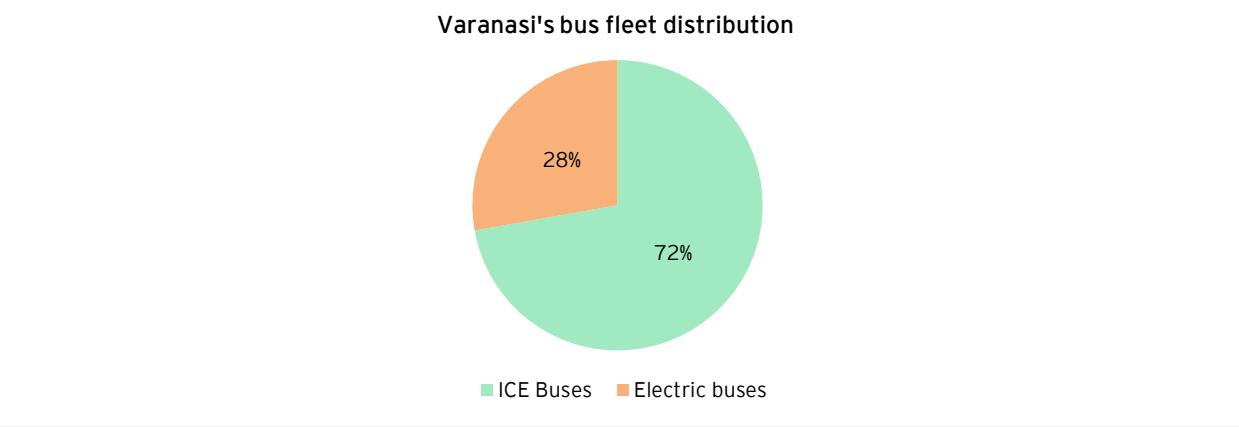
8.2. Financial health of overall UPSRTC buses operating in Uttar Pradesh

Graph 23: Financial health of UPSRTC



Varanasi boasts a robust bus network comprising a total fleet size of 180 buses. The distribution of these buses is as follows:

Graph 24: Varanasi's bus fleet distribution



The ICE (Internal Combustion Engine) bus fleet, consisting of 130 buses, was procured during the 2009-2010 period. Presently, 30 of these buses are not in operational condition. Conversely, the electric buses, acquired on lease in 2021 under the FAME-II initiative, follow a GCC (Gross Cost Contract) model.

Table 18: ICE and EV bus fleet in Varanasi

Vehicle OEM	Bus type	Seaters	Number of buses
Marcopolo	ICE	34	10
Kamal body	ICE	38	50
Minibuses (Tata Mini)	ICE	28	70
PMI electro	EV	31	50

8.3. Analysing percentage share of EV fleet deployment and plans for future expansion

Currently, 28% of the city's transportation network consists of electric vehicles (EVs), showing progress toward eco-friendly travel. Future expansions would be planned from the Lucknow head office, focusing on increasing the use of electric transportation in different areas.

As per the primary consultation it was understood that the city transport department is planning to switch its current fleet of buses to electric by 2028 through careful planning. This initiative reflects their dedication to creating a cleaner, greener transportation system for both current and future generations.

8.4. Identifying number of ICE buses nearing end of life

Out of the total fleet of 130 buses, a notable portion comprising 30 buses is currently inactive due to their deteriorated condition. These buses belong to the ICE (Internal Combustion Engine) bus fleet, which was procured during the period of 2009-2010. The presence of such a significant number of inactive buses indicates potential challenges related to maintenance or aging infrastructure within the fleet.

The fact that these buses were acquired over a decade ago implies that they may have reached a stage where they require substantial repairs or maintenance to ensure their safe and efficient operation. Additionally, it suggests that these buses might be nearing the end of their permitted operational lifespan, as vehicles typically have a lifespan of 12-15 years, hence during this duration they can legally ply on roads without significant upgrades or renewals.

The implications of having a considerable portion of the ICE bus fleet inactive are multifaceted. Firstly, it underscores the importance of regular maintenance and upkeep to prolong the operational lifespan of vehicles and ensure passenger safety. Secondly, it highlights the need for strategic planning and investment in modernizing the fleet to enhance efficiency and reliability.

8.5. Operational cost of buses nearing end of life and financial impact on STUs for replacing it with electric buses

- **Running losses of ICE and Electric buses**: ICE buses are facing running losses which is estimated to incur losses of Rs. 40-50 lakh per year. These losses are currently covered by Lucknow Parivahan Nideshalay, which suggests financial challenges in the operation of these buses.
- **Varanasi Transport providing conductors and AFC services for Electric buses:** Varanasi Transport plays a pivotal role in the operation of Electric buses by providing conductors and Automated Fare Collection (AFC) services. This collaboration ensures smooth operations and efficient fare collection processes, contributing to the overall effectiveness of the electric bus service.
- **Payment for Electric bus operation:** Varanasi city transport pays Lucknow Nideshalay Rs. 62.75 per kilometre for the operation of Electric buses. This payment structure indicates the financial arrangement between the involved parties and highlights the cost implications associated with operating Electric buses.
- **Daily coverage and standby of Electric and ICE buses:** The comparison between electric and ICE buses highlights significant differences in their daily operational capacity and utilization within the transportation network. Electric buses, with a fleet of 50, cover approximately 10,000 kilometres per day collectively, averaging 200 kilometres per bus. In contrast, ICE buses cover a distance, ranging from 17,000 to 18,000 kilometres daily, considering the operational status of around 130 buses, some of which are kept on standby as reserves in specific cases. This comparison underscores several key points:
  - It emphasizes the efficiency and reliability of electric buses, which despite their smaller fleet size, cover a considerable distance per day.
  - It indicates the higher overall capacity and utilization of ICE buses due to their larger fleet size and longer operational distances.
  - It suggests that while electric buses make a valuable contribution to the transportation network, they may not yet match the scale of operations achieved by ICE buses.

Furthermore, this comparison highlights the potential for growth and improvement in electric bus technology and infrastructure. As advancements are made in battery technology, charging infrastructure, and fleet management systems, the operational capacity of electric buses is expected to increase, potentially narrowing the gap with ICE buses in terms of daily kilometres covered.

8.6. Charging infrastructure for electric buses

Presently, the 50 electric buses that have been procured are being charged at the Varanasi Cantt depot, which is equipped with 10 fast chargers installed for this purpose. These buses undergo overnight charging and can operate for ~120 kilometres before returning to the depot for a brief top-up charge of 1 hour. This additional charge enables the buses to extend their operational range to ~200 kilometres per day, ensuring efficient and reliable service throughout their daily routes.

Figure 15: e-bus charging station at depot in Varanasi-1

Figure 16: e-bus charging station at depot in Varanasi-2

Figure 17: e-bus charging station at depot in Varanasi-3

Specification of Charger deployed at the depot for charging electric buses:

Table 19: Depot e-bus charger specifications

Model	DH-DC1800SG43
Number of equipment	DHDC1800SG43-E
Input voltage	380Vac ± 15%
Output voltage	200Vdc - 1000Vdc
Output current rate	DC 180A
Output current maximum	DC 250A for each connector
Use environment	Use outside (IP54)
Power rate	180kW
Number of product	SN2108070702
Product date	August 2021
THD	<5%
Power factor	0.98
Phase number	3P+N+PE

9

Business model
Analysis

9.1. Public Bicycle Sharing (PBS) system

Ministry of Housing and Urban Affairs (MoHUA) defines PBS as "a high-quality bicycle based public transport system in which bicycles, stored in a closely spaced network of stations, are made available for short-term use."

The adoption of public bicycle sharing systems has gained momentum across numerous cities in India.

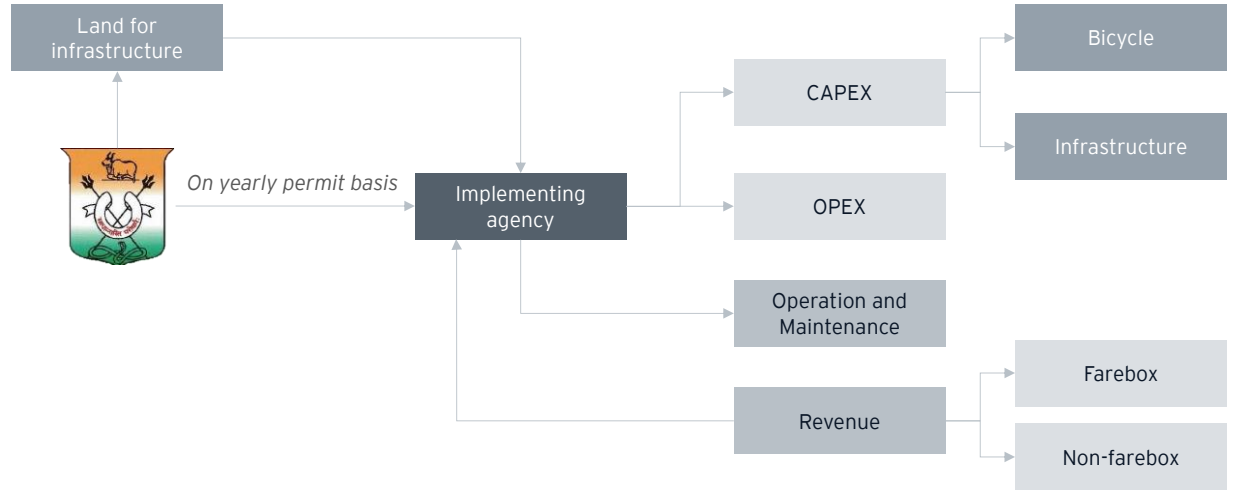
Recent technological advancements have introduced electric bicycles with pedal assistance, revolutionizing the landscape of urban transportation. This innovative leap facilitates a more widespread adoption of bicycles, primarily owing to their enhanced ease of use and accessibility. Therefore, promoting an e-bicycle public sharing system in Varanasi will enhance tourist mobility.

Farebox revenue refers to the income generated directly from ticket sales or fares collected from passengers using public transportation systems, sustaining operations and maintenance. Non-farebox revenue encompasses income derived from sources other than passenger fares, such as advertising, rental of commercial space within transit stations, or partnerships.

Business Model:

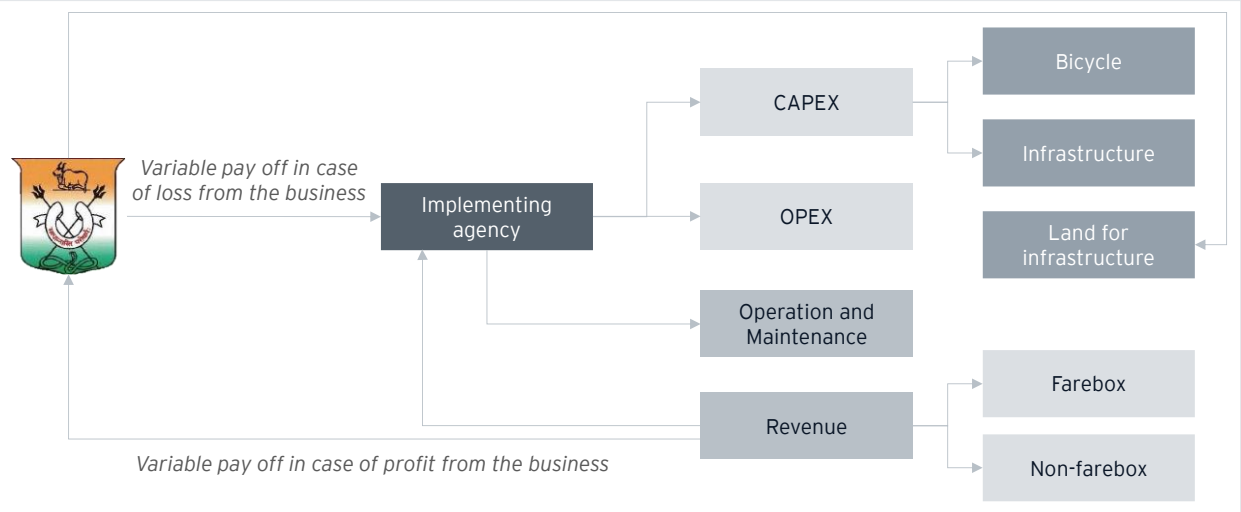
Varanasi Nagar Nigam can engage one or multiple entities for PBS installation, with contracts being on yearly permit basis. Capex covers bicycles, e-PBS infrastructure, and land acquisition. The implementing agency manages Opex and Capex for bicycles and infrastructure, with land provided by Varanasi Nagar Nigam. The implementing agency handles operation, maintenance, and revenue collection.

Figure 18: Business model for PBS

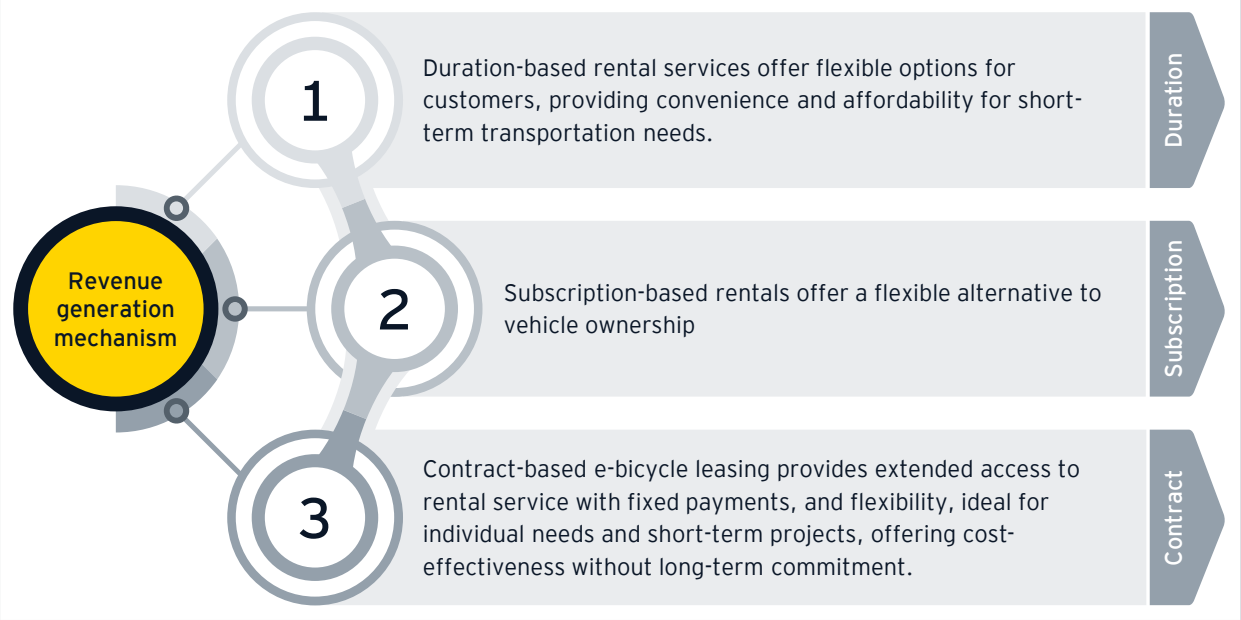


Varanasi Nagar Nigam will onboard an implementing agency for PBS installation and would offer a variable pay off in case of loss from the business. Capex covers bicycles, e-PBS infrastructure, and land acquisition. The implementing agency manages Opex and Capex for bicycles and infrastructure, with land provided by Varanasi Nagar Nigam. The implementing agency handles operation, maintenance, and revenue collection, and would share revenue with Shimla Municipal Corporation in case of profit.

Figure 19: Business model for PBS 2



Farebox revenue generation mechanism:



Case study:

To combat traffic issues in Mysuru, authorities introduced Trin Trin, an eco-friendly PBS transit program, in June 2017, initially with 430 conventional bicycles. Expanded in 2023 to include e-bicycles, it's supported by the Karnataka government and the World Bank's GEF Grant, serving over 17,000 subscribers to meet the rising demand for sustainable urban transport.

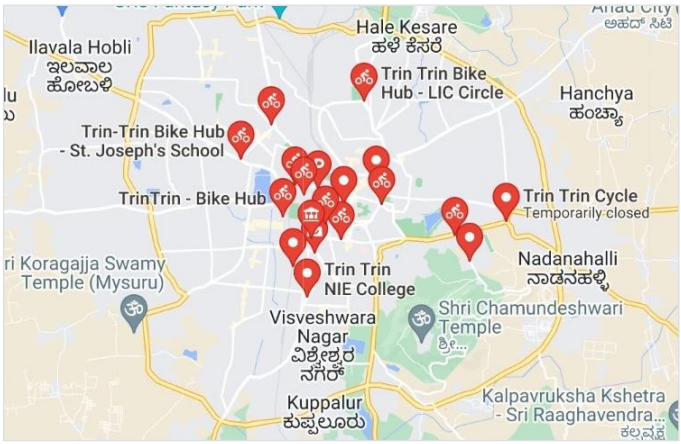


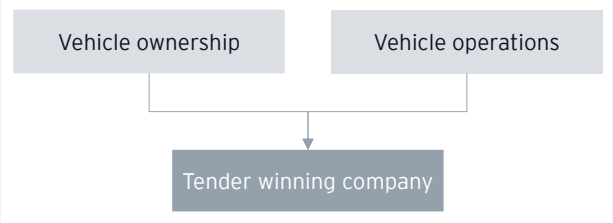
Table 20: Mysuru PBS case study

Parameters	Details
PBS Operator	Trin Trin
Launch year	2017
Fleet size	450
No. of docking stations	48
City Area Covered	28 sq.km.
Users	> 14,000
Fare structure[39]	First half-hour free; minimum fare INR 5 (30–60 min), increasing gradually up to INR 245 for over 12 hours. Users register online via the Trin Trin app, designated centres, or Mysuru One centres, paying INR 360 including a refundable INR 250 deposit and INR 50 processing fee, accepting both cash and cards.

9.2. Government leased vehicles – Vehicle segment – Four-wheelers, Solid waste management vehicles

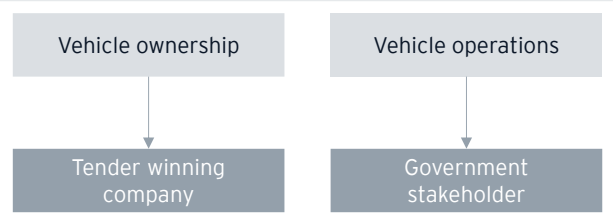
Procurement Model 1: Wet Lease

This type of model entails a more comprehensive arrangement. In this case, the winning company of the tender not only provides the vehicles but also offers additional services such as hiring and managing staff, maintenance, and possibly other operational aspects. This model grants the leasing company greater control over the entire operation of the vehicles, including personnel management and maintenance schedules.



Procurement Model 2: Dry Lease

This type of tender refers to a contractual agreement where the government entity, typically the urban local bodies, leases vehicles for utility work or for their staff from another party without additional services included. In this arrangement, the ULBs would solely receive the vehicles and be responsible for deploying their own staff or manpower to operate and maintain the vehicles.



Role of EESL in converting existing government fleet to electric

The National E-Mobility Programme, initiated by the Ministry of New and Renewable Energy (MNRE) on March 7th, 2018, represents a strategic effort to drive the adoption of electric vehicles (EVs) throughout India. The primary objective of the program is to transition towards sustainable and environmentally friendly modes of transportation while reducing dependency on traditional fossil fuel-powered vehicles.

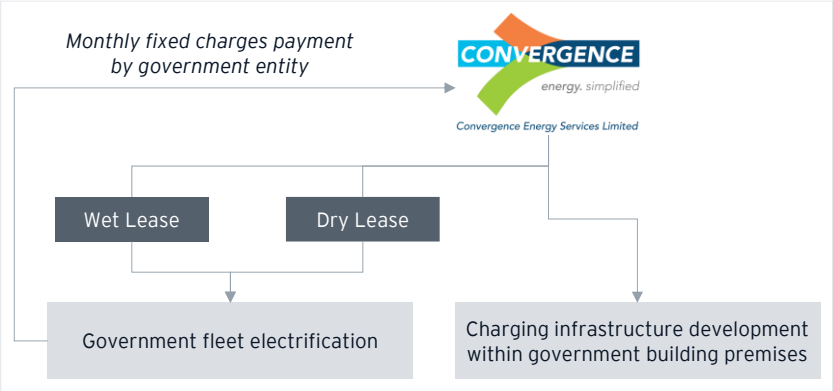
Central to the program is the role of the Energy Efficiency Services Limited (EESL), which acts as a key facilitator in implementing various initiatives aimed at promoting e-mobility. One of the core strategies employed by EESL involves the aggregation of demand for electric vehicles by

[39] https://wri-india.org/sites/default/files/FINAL_Public%20Bicycle%20Sharing%20India_WP_3July.pdf

procuring them in bulk. By purchasing a large number of EVs at once, EESL leverages economies of scale to make the adoption of electric vehicles more financially viable for government agencies and other stakeholders.

As part of the procurement process, EESL issued a tender for the acquisition of 10,000 electric cars. These vehicles were intended to replace existing petrol and diesel vehicles used by various government departments and agencies across the country. By transitioning to electric vehicles, these entities not only contribute to reducing greenhouse gas emissions and air pollution but also set an example for sustainable transportation practices.

Furthermore, the deployment of electric vehicles is complemented by the establishment of a robust charging infrastructure. EESL, in collaboration with other stakeholders, has installed 256 public chargers in strategic locations across 42 cities. This infrastructure development is crucial for addressing range anxiety among EV users and ensuring the seamless integration of electric vehicles into the existing transportation network.

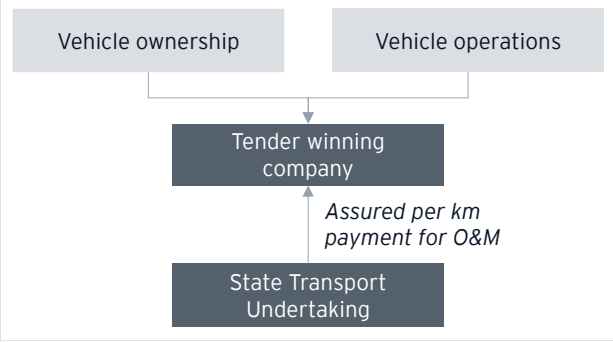


9.3. Government leased vehicles – Vehicle segment – Buses

9.3.1. City transport bus

Procurement Model: Gross Cost Contract Model

The gross cost contract model for buses is a procurement and operational approach used in public transportation systems. Under this model, a contracting authority pays a fixed amount to a private operator to provide specified bus services for a defined period. The operator manages all aspects of the service, including fleet operation, maintenance, and scheduling, while adhering to service specifications outlined in the contract. The operator may retain revenue from fares, and the contracting authority monitors performance to ensure compliance with service standards. The model offers flexibility, risk transfer to the operator, and aims to deliver reliable, cost-effective bus services that meet the needs of communities.



PM e-bus Sewa

PM e-bus Sewa is a central government initiative designed to revolutionize urban transportation by integrating electric buses into city networks. The program operates with the primary objective of curbing air pollution and decreasing reliance on fossil fuels. The scheme, estimated at Rs. 57,613 crore, with Rs. 20,000 crore support from the Central government, will operate for 10 years. It targets cities with a population of over three lakh as per the 2011 census, including all Union Territory capitals, the North-eastern Region, and Hill States, with priority given to those lacking organized bus services. Expected to generate 45,000 to 55,000 direct jobs.

The scheme consists of two segments:

- Segment A focuses on augmenting city bus services in 169 cities
- Segment B emphasizes Green Urban Mobility Initiatives (GUMI) in 181 cities.

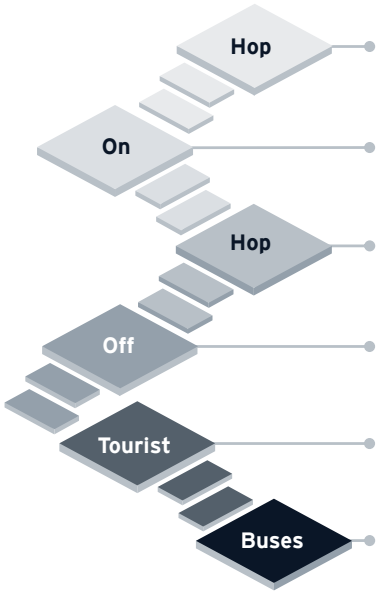
The scheme aims to promote e-mobility, improve infrastructure, and reduce pollution by supporting bus priority infrastructure, charging infrastructure development, and adoption of electric buses.

9.3.2. Hop on – Hop off bus

Hop-on-hop-off bus services, commonly referred to as HOHO buses, have gained popularity as convenient transportation options for tourists

globally. Operating on looped routes that encompass major attractions, these buses enable passengers to explore destinations at their own pace. By purchasing tickets for specified durations, travellers benefit from unlimited boarding and disembarking privileges, allowing them to customize their sightseeing experience according to their preferences. These services prioritize passenger convenience by offering informative commentary, often available in multiple languages, to provide insights into the landmarks and points of interest along the route.

Additionally, HOHO buses are equipped with comfortable amenities, such as air conditioning and comfortable seating, ensuring a pleasant and enjoyable journey for passengers. HOHO buses are particularly advantageous for first-time visitors and those with limited time, as they offer a hassle-free way to discover key attractions without the need for navigation or scheduling individual transportation. Moreover, by encouraging tourists to utilize public transportation, HOHO buses contribute to reducing traffic congestion and promoting sustainable tourism practices in popular destinations.



Hop on	Passengers board the bus at designated stops along a pre-defined route, typically located near popular tourist attractions and landmarks.
Hop off	At any desired destination, passengers can disembark the bus to explore the area. The bus remains at each stop for a predetermined duration, allowing passengers to sightsee at their own pace.
Frequency	HOHO buses operate on a regular schedule, with buses arriving at each stop at specified intervals. This allows passengers to plan their journey according to their preferences and time constraints.
Ticketing	Passengers purchase tickets either in advance or on board the bus. These tickets usually grant unlimited access to the bus for a specified period, such as 24 or 48 hours.
Informative commentary	While on board, passengers are often provided with informative commentary or audio guides in multiple languages, offering insights into the attractions and landmarks along the route.
Continuous loop	The bus follows a continuous loop along the designated route, ensuring that passengers can easily return to their starting point or continue their journey to additional destinations.

Delhi's HOHO Buses

The Hop-On Hop-Off (HOHO) bus service in Delhi was started in 2010 by the Delhi Tourism Development Corporation (DTDC) to provide tourists with a convenient and flexible way to explore the city's attractions.

The Hop-On Hop-Off (HOHO) bus service in Delhi offers tourists a flexible way to explore the city's landmarks. Operating on a circular route, it covers major attractions like India Gate, Qutub Minar, and Red Fort. Passengers can hop on and off at designated stops, enjoying audio guides and panoramic views from the upper deck. With amenities like Wi-Fi and refreshments, the service eliminates navigation challenges and traffic hassles. Tickets are available online or on board, and passengers can tailor their itinerary to suit their interests. The HOHO bus provides a convenient and enjoyable way for visitors to experience Delhi's rich cultural heritage and vibrant atmosphere.

revenue generated by such services includes ticket sales, partnerships with tour operators or hotels, advertising on the buses, and other ancillary revenue streams. The revenue generated by the HOHO bus service would depend on factors such as the number of passengers, ticket prices, operational costs.

Significance of HOHO Buses in Varanasi:

Procuring HOHO (Hop-On Hop-Off) buses in Varanasi holds significant promise for the city's tourism and overall development. Varanasi, renowned for its cultural heritage and spiritual significance, attracts a large number of visitors annually. HOHO buses provide a convenient and organized mode of transportation for tourists, allowing them to explore the city's myriad attractions at their own pace. This initiative not only enhances the tourist experience but also addresses traffic congestion and pollution issues plaguing the city. By encouraging tourists to utilize HOHO buses instead of individual vehicles, Varanasi can mitigate traffic congestion and reduce carbon emissions, contributing to environmental sustainability.

Integration of Public Bicycle Sharing system with Hop on – Hop out buses:

Integrating public bicycle sharing with HOHO buses offers a range of benefits. It enhances last-mile connectivity by providing bicycles at bus stops, reducing congestion, and promoting environmental sustainability by encouraging cycling over motor vehicles. Additionally, it improves health and fitness, saves costs, and offers flexibility and convenience to commuters. This integration also promotes multimodal transportation, improves public transit accessibility, and benefits tourism and recreation. Overall, it provides a holistic and sustainable approach to urban mobility, benefiting commuters, the environment, and the community.

Importance of integration of Hop on – Hop off buses with PBS:

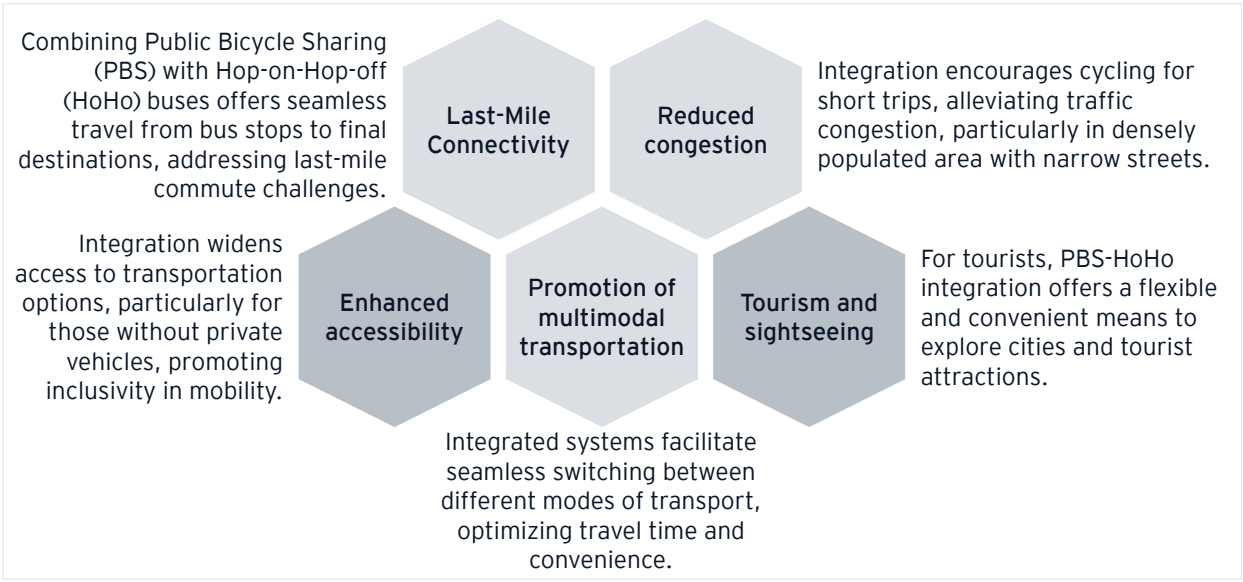
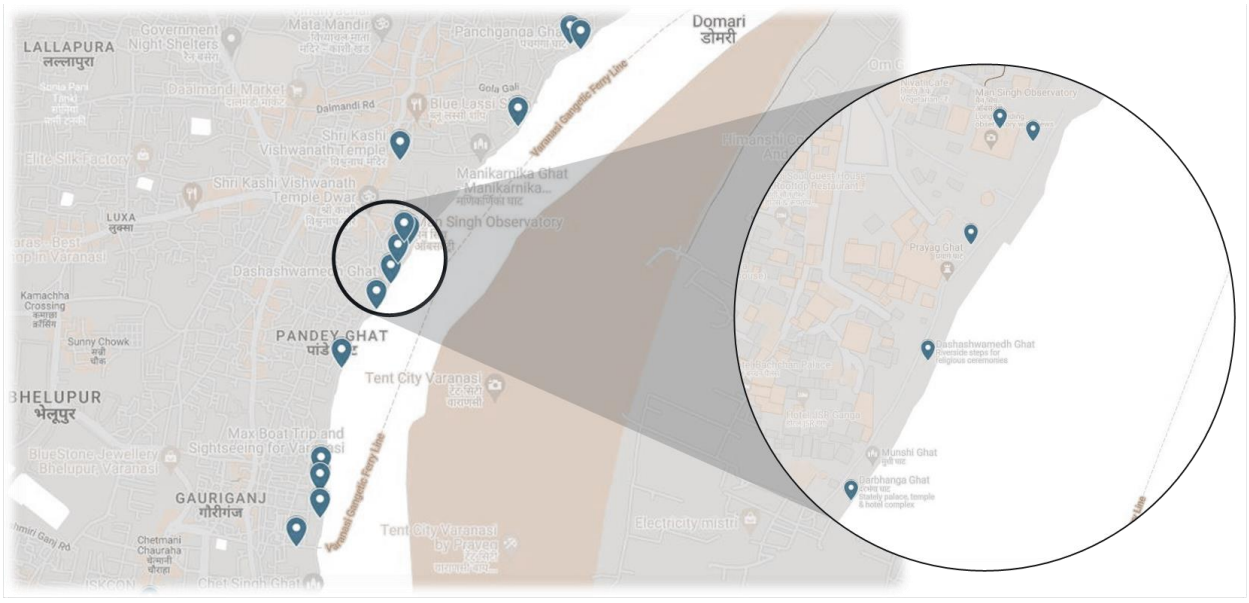


Figure 20: Assi Ghat



Varanasi, renowned for its cultural and spiritual significance, is adorned with various clusters of tourist attractions that draw visitors from across the globe. Assi Ghat, captured in the image below, stands as a prime example of one such cluster.

However, navigating through these clusters can be a challenge, primarily due to the narrow, winding streets that characterize the city's ancient layout. These alleys, while adding to the city's charm, pose logistical hurdles for vehicles, especially in providing efficient last-mile connectivity to these tourist hubs.

Recognizing this challenge, integrating Public Bicycle Sharing (PBS) with the Hop-On Hop-Off (HOHO) bus service emerges as a practical solution. PBS systems provide visitors with convenient access to bicycles stationed at various points throughout the city. Tourists can then easily hop on a bike and traverse the narrow streets, reaching their desired destinations with ease.

Figure 21: Concept design of PBS and HOHO Bus integration

Proposed PBS docking stock in Banaras Hindu University (BHU) complex

Integrating PBS with BHU is essential for several reasons. Firstly, BHU hosts a large community of students, faculty, and staff who frequently need to move around the campus and its vicinity. By incorporating PBS within BHU, it provides an eco-friendly and convenient transportation option for this population, reducing the reliance on motor vehicles and promoting sustainability. Secondly, BHU serves as a significant hub of activity within Varanasi, attracting visitors, scholars, and tourists. Integrating PBS with BHU ensures that these individuals have access to efficient and sustainable transportation options while exploring the university campus and surrounding areas.

The selected PBS locations are easily accessible to both the general public and residents of BHU, including students and staff members.

Figure 22: Proposed location for PBS station at BHU

10

Estimating Total Cost of Ownership

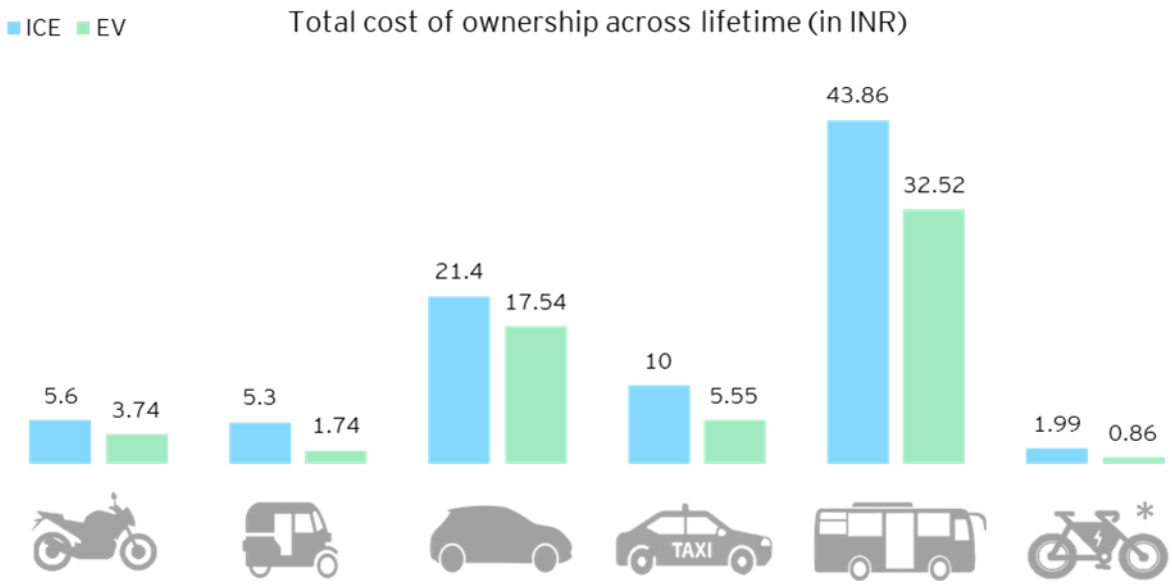
The total cost of ownership (TCO) of a vehicle encapsulates both present and future expenses associated with owning and operating it over its lifespan. This comprehensive analysis relies on carefully chosen assumptions to forecast the vehicle's usage patterns and its corresponding costs. Key components of TCO include capital expenditure, operational costs, and maintenance expenses. Operational costs entail fuel expenses, while maintenance costs cover repair and maintenance (R&M) expenditures. The salvage value of the vehicle at the conclusion of its life cycle is determined by assessing its depreciation over time due to usage and market inflation.

The parameters are comprehensively explained below:

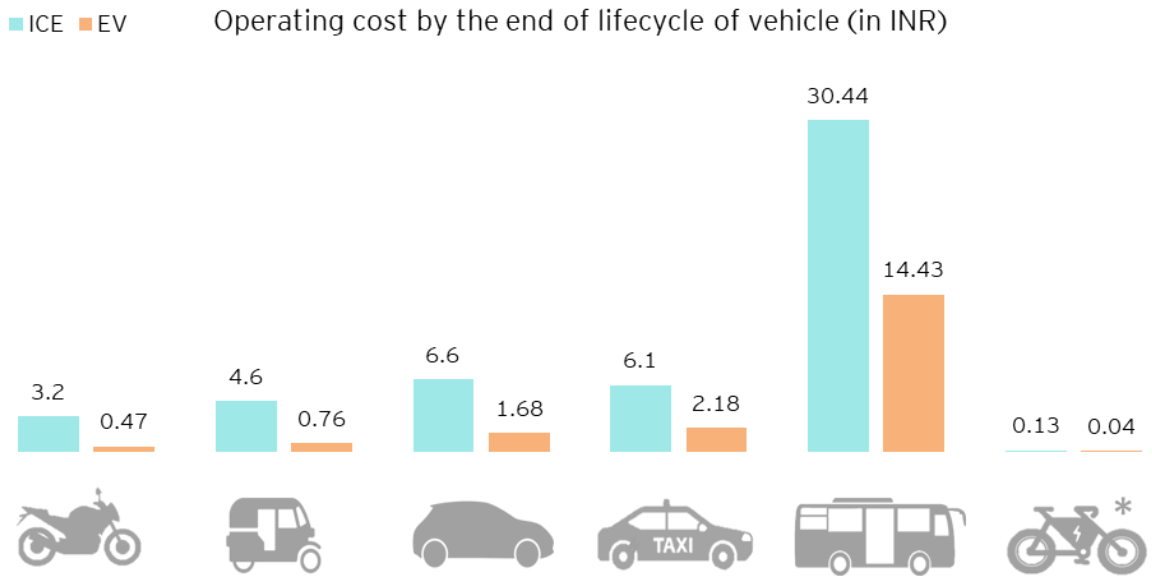
1. **Purchase Price**: This is the initial cost of buying the vehicle, which includes the negotiated price, taxes, registration fees, and any additional charges.
2. **Depreciation:** Depreciation represents the decrease in the vehicle's value over time due to factors such as age, mileage, wear and tear, and market conditions. It is one of the most significant costs of vehicle ownership.
3. **Fuel Costs:** The amount spent on fuel over the vehicle's lifetime depends on its fuel efficiency, the distance driven, and fuel prices.
4. **Maintenance and Repairs:** Regular maintenance such as oil changes, tire rotations, brake replacements, and repairs for wear and tear are ongoing costs associated with vehicle ownership.
5. **Insurance:** Insurance premiums vary depending on factors such as the vehicle's make and model, the driver's age and driving record, location, coverage options, and deductibles.
6. **Financing Costs:** If the vehicle is financed through a loan, the interest payments and any financing fees are part of the TCO.

Vehicle segment wise total cost of ownership across lifetime:

Table 21: TCO of various vehicle segments



**ICE 2W (scooter) considered for TCO comparison. The lifecycle comparison for e-bicycles have been taken for a 5-year period.*



**ICE 2W (scooter) considered for operating cost comparison. The lifecycle comparison for e-bicycles have been taken for a 5-year period.*

11

EV Charging Infrastructure and Location assessment

11.1. EV charging introduction

In Uttar Pradesh, progressive policies are driving the adoption of EVs and the development of EV infrastructure. **The Uttar Pradesh Electricity Regulatory Commission (UPERC) has established a dedicated tariff category for EV charging, signalling the state's commitment to sustainable transportation.** The government collaborates closely with UPERC to ensure affordable and accessible EV charging, including through "open access" at charging and swapping stations. **The state mandates a minimum of 20 charging stations and 5 swapping stations per district**, offering incentives such as subsidized land and capital subsidies for service providers. These subsidies, up to INR 10 lakh per unit for charging stations and INR 5 lakh per unit for swapping stations, encourage investment and infrastructure expansion. Overall, Uttar Pradesh's EV charging policy fosters sustainability and economic growth by incentivizing investment, promoting open access, and prioritizing affordability.

11.2. Initiatives taken by Varanasi for developing EV charging network

In a significant advancement for the Smart City Mission, eight cities in Uttar Pradesh have been selected to receive e-charging facilities for two, three, and four-wheelers. As per a recent proposal, the implementation of e-charging facilities through the smart city projects is set to commence simultaneously. Additionally, around 100 stations will be established at heritage sites, with approximately 200 more at prominent tourist destinations.

The Electric Bus Charging Station project entails a comprehensive setup with a total cost of 12.30 Cr. It encompasses various features essential for efficient operations, including charging solutions for up to 50 electrical buses, an office, and driver's rest area for personnel comfort and management facilities like an electric substation, pump room, and a 25 KL R.C.C. overhead tank for water storage. Additionally, the station comprises amenities such as a washing bay with a compressor room, workshop block, and rainwater harvesting system for sustainability. Furthermore, it includes provisions for horticulture and landscaping, a mild steel entrance gate for security, and an engineered steel structure shed tailored to accommodate buses, ensuring a comprehensive and functional infrastructure setup[40].

[40] https://varanasismartcity.gov.in/about/completedproject

11.3. Need for location assessment for setting up of EVCI

Assessing the location for setting up an Electric Vehicle (EV) charging station is crucial for several reasons:

Accessibility and Convenience: The location should be easily accessible. It should be strategically placed along commonly used routes or near major point of interests. This accessibility encourages more EV adoption and ensures drivers can charge their vehicles conveniently during their daily activities.

Infrastructure Compatibility: Assessing the location involves considering the existing infrastructure such as electrical grids and utility connections. Ensuring that the location can support the power demands of charging stations without overloading the grid or requiring extensive upgrades is essential for the station's efficient operation.

Parking Availability: Availability of parking space is critical for EV charging stations, especially for longer charging sessions. Locations with ample parking space or dedicated EV parking spots are preferable to accommodate EV drivers.

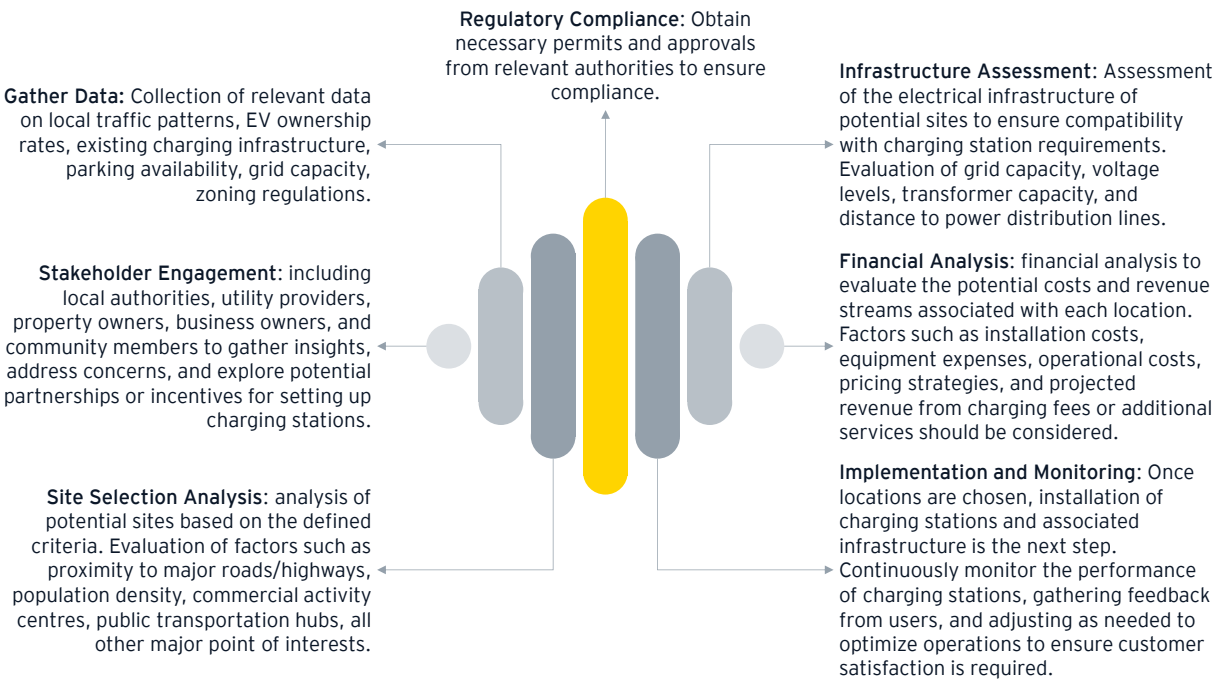
Safety and Security: The safety and security the charging station and EV owners is critical. Assessing the location involves considering factors such as adequate lighting, visibility, and proximity to emergency services to ensure a safe charging experience for users.

Regulatory Compliance and Permits: Assessing the location involves obtaining necessary permits and ensuring compliance with local regulations.

Business Viability: For public charging stations, assessing the location includes evaluating the potential for generating revenue and achieving profitability. Factors such as nearby amenities, expected footfall, and competitive landscape play a crucial role in determining the station's business viability.

11.4. Approach for location assessment for setting up EVCI

To systematically assess locations for setting up Electric Vehicle (EV) charging stations, the following approach can be employed:

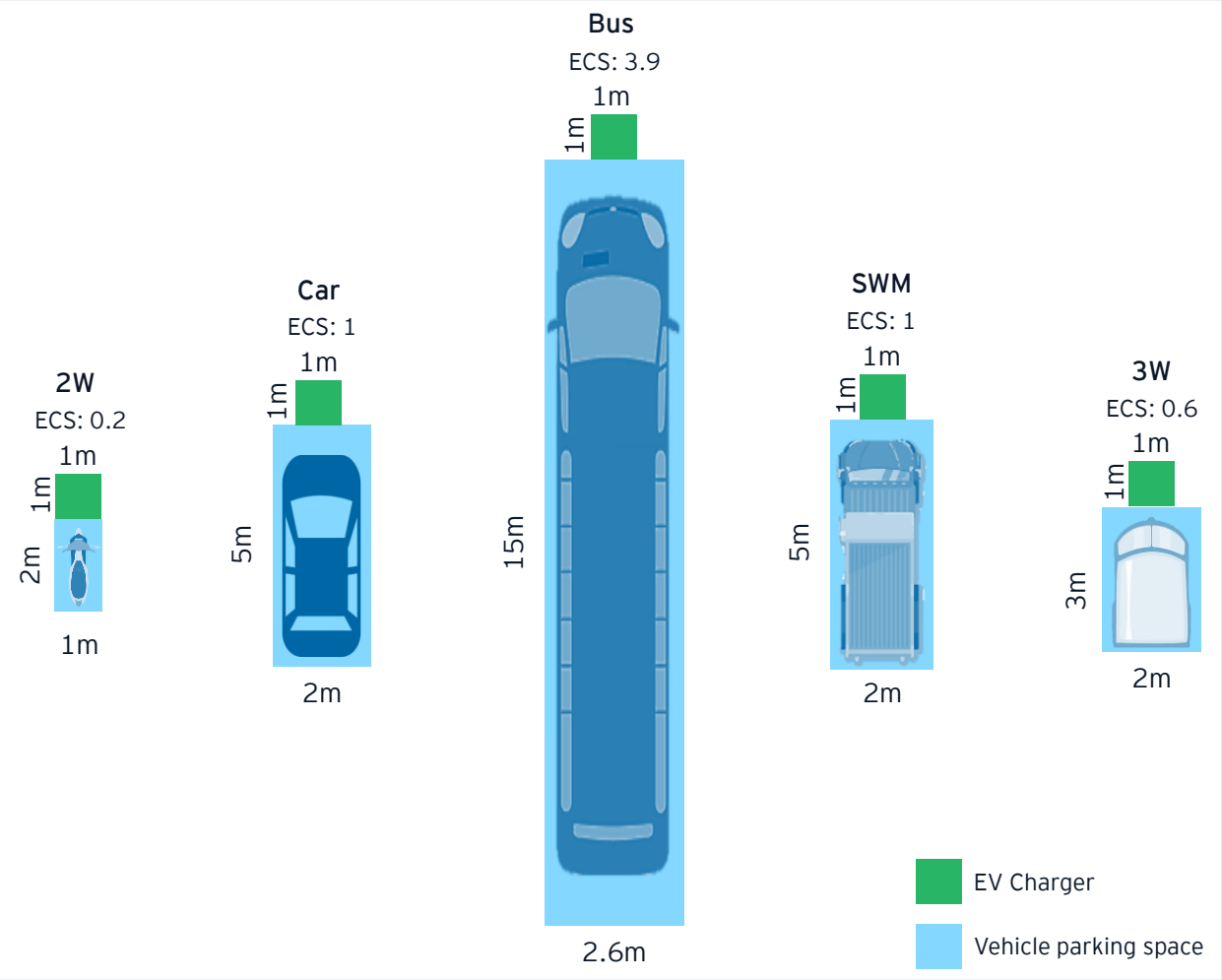


11.5. EV ready Parking space requirements

EV parking spaces are specially designated areas in parking lots or garages equipped with electric vehicle charging stations. These spaces provide convenient and accessible locations for EV owners to charge their vehicles while they shop, work, or reside. By offering dedicated charging infrastructure, EV parking spaces support the growing adoption of electric vehicles. Furthermore, these spaces often come with features like reserved parking and proximity to building entrances, enhancing the overall convenience and appeal for EV drivers.

- **Clearance:** Additional clearance around the vehicle may be required to ensure that the charging cable can be easily connected and to allow for accessibility features such as wheelchair access. This might mean an extra 3 to 4 feet (about 1 meter) of space.
- **Height:** For covered parking, a minimum height clearance of about 8 to 10 feet (2.4 to 3 meters) is usually sufficient to accommodate most electric vehicles and charging infrastructure.
- **Signage and Markings:** Clear signage and ground markings should indicate that the space is reserved for EV charging. This helps in preventing misuse by non-EV vehicles and ensures that EV drivers can easily locate the charging spots.

The below figure visualises the space required by each vehicle segment for an EV ready parking.



11.6. Location assessment for mapping potential EVCI locations

The process of mapping existing EV charging infrastructure involves four steps:

- **Step 1 - City Boundary Mapping:** Delineate Varanasi's city boundary to establish the geographical scope. The city is divided into a grid of 1km x 1km squares.
- **Step 2 - Identification of Key Points of Interest:** Identify and mark major points of interest, including significant government buildings and key stakeholders' facilities and existing EV charging station, to ensure comprehensive coverage.

> By executing the first two steps, valuable insights into the current EV charging infrastructure landscape can be gained. Moreover, this comprehensive mapping approach enables to project future requirements for EV charging infrastructure based on demand and availability trends.

- Step 3 – Heat map representing the demand areas for EVCI installation
- Step 4 – Identify potential EV charging infrastructure implementation locations

Step 1: City Boundary mapping

The Municipal Corporation administers an 82.1 square kilometer area, with significant highways including NH31, NH28, NH44, and NH731B traversing through and surrounding the city.

Figure 23: City boundary map of Varanasi

Step 2: Identification of Key Points of Interest

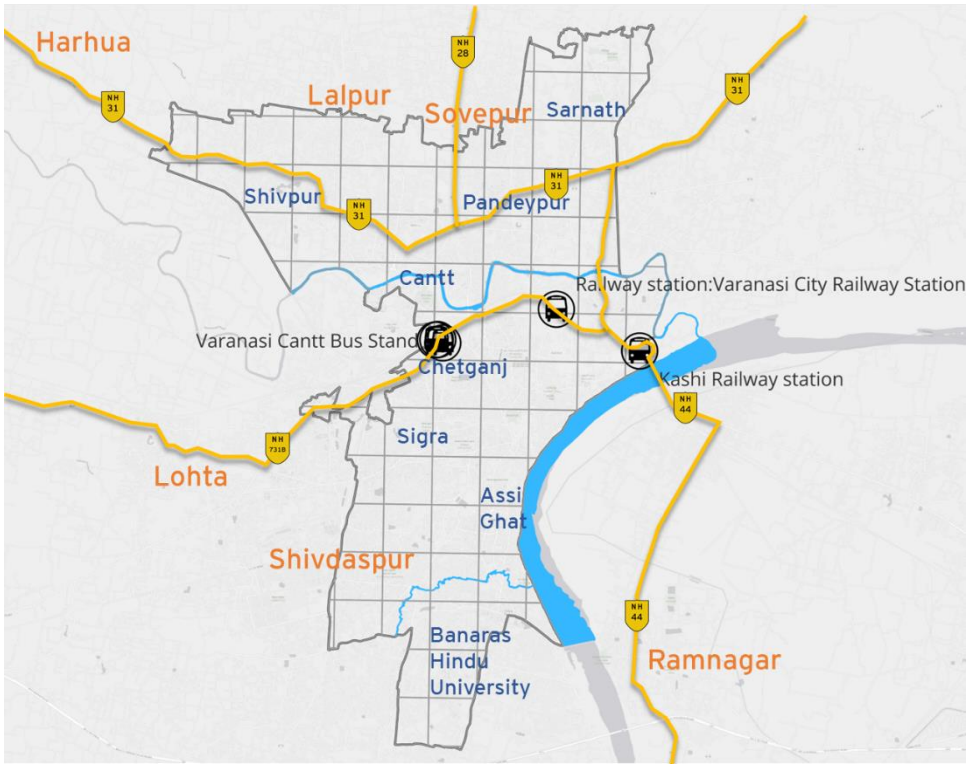
Major Government offices:

Aayakar Bhawan		U P Jal Nigam	
Civil Court Varanasi		Pollution Control Board in Varanasi	
Food Corporation of India		Varanasi Development Authority	
India Tourism Office (Ministry Of Tourism)		Irrigation Department	
Varanasi Smart City		Transport office	
UP Government Tourist Office		Varanasi new RTO office	
Varanasi Nagar Nigam		Varanasi RTO	
		Varanasi RTO extension	

Figure 24: Major Government offices in Varanasi

Transport hubs in Varanasi:

Figure 25: Transport hubs in Varanasi

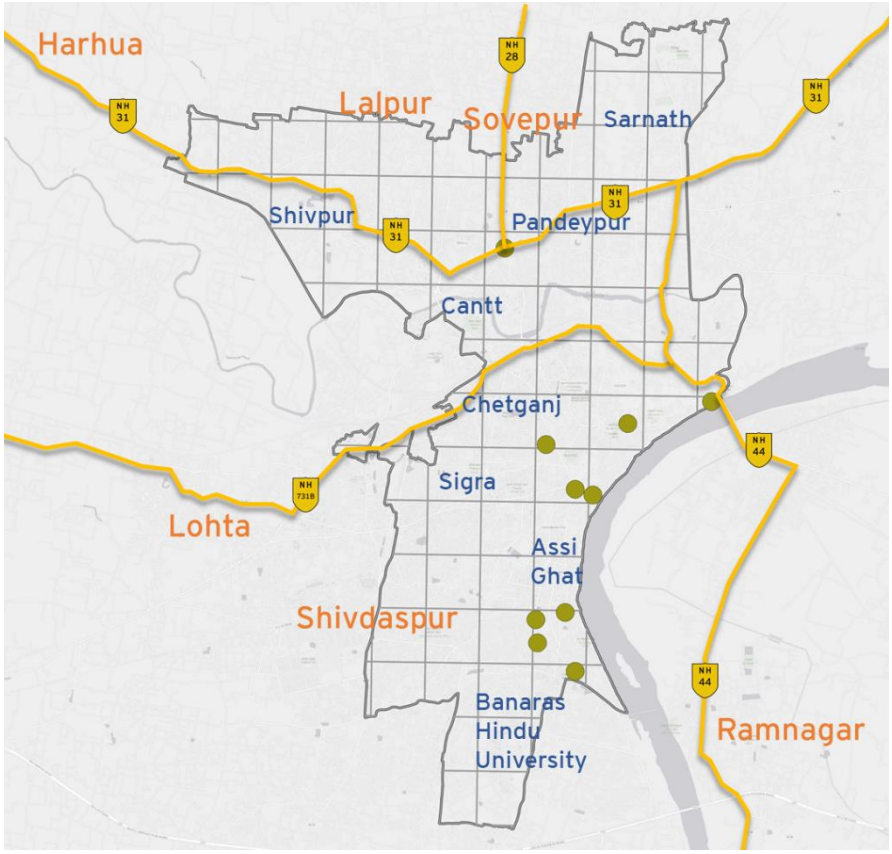


Malls in Varanasi:

Figure 26: Malls in Varanasi

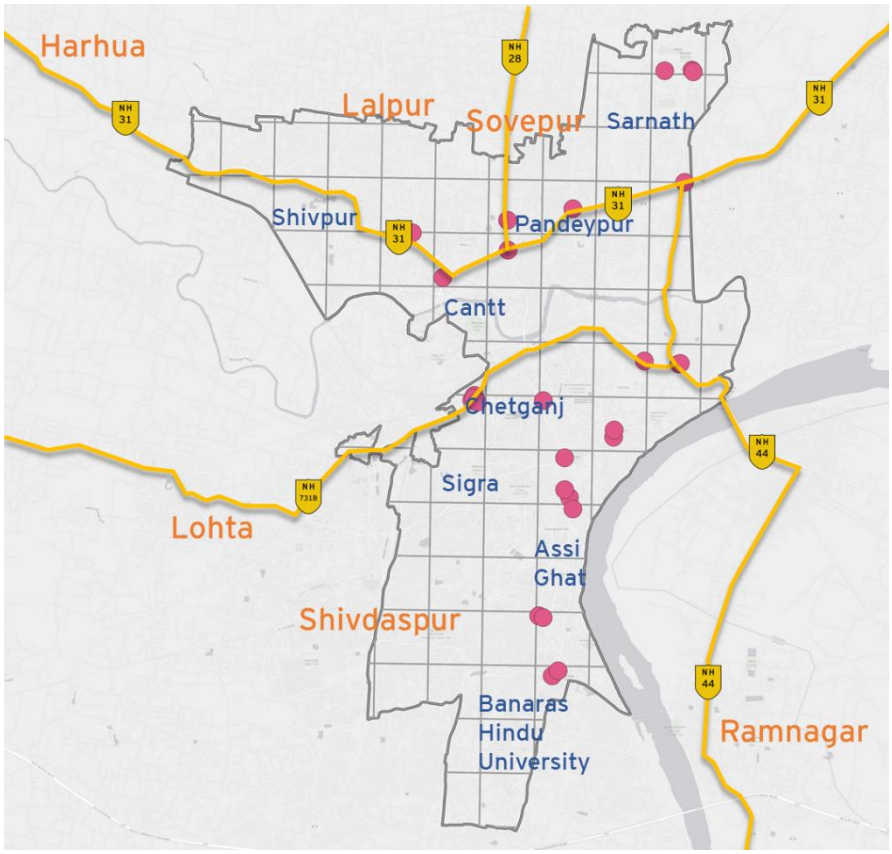
Public Parking lots in Varanasi:

Figure 27: Public Parking lots in Varanasi



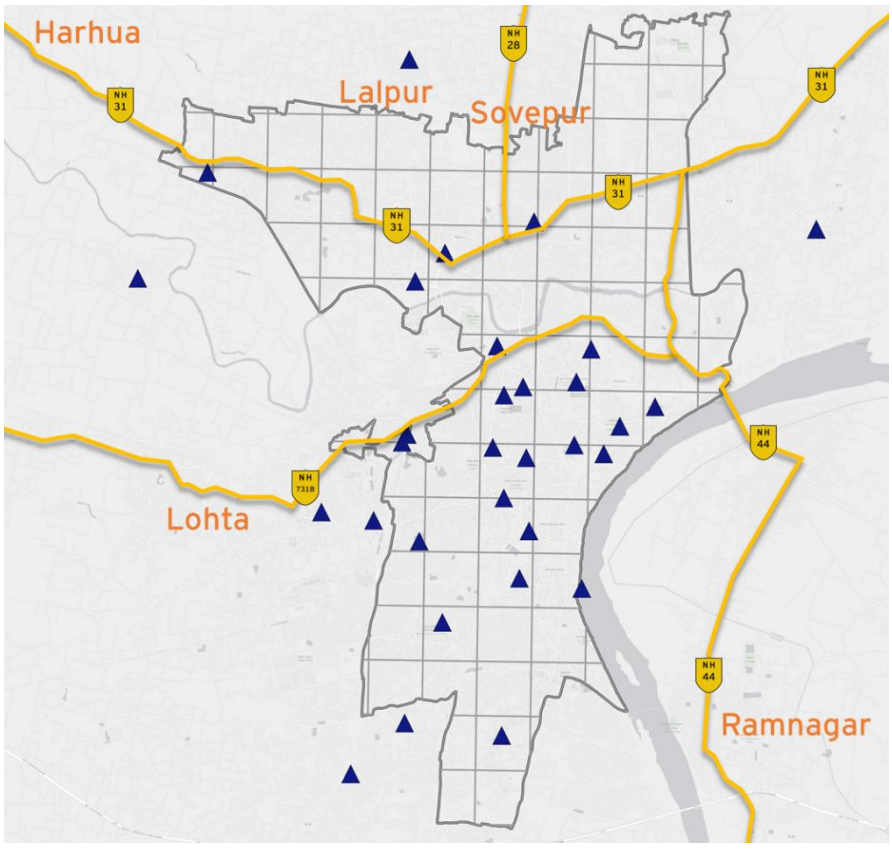
E-autorickshaw stands in Varanasi:

Figure 28: E-autorickshaw stands in Varanasi



33/11kV substations in Varanasi (Detailed list attached in Annexure):

Figure 29: 33/11kV substations in Varanasi

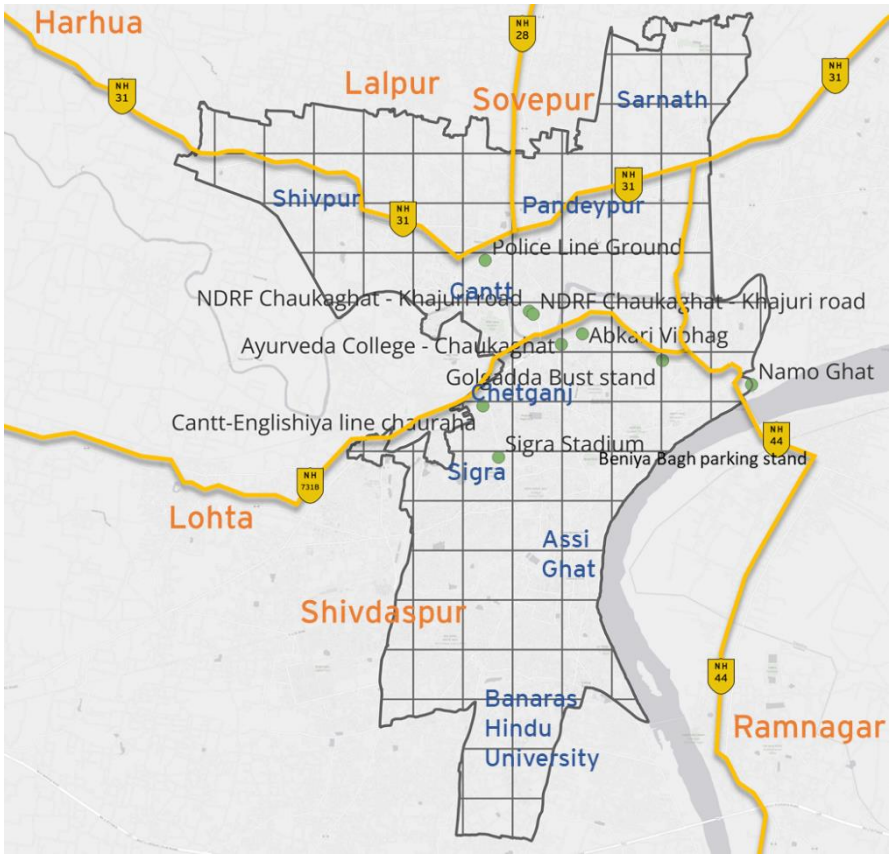


5 Star hotels in Varanasi:

Figure 30: 5 Star hotels in Varanasi

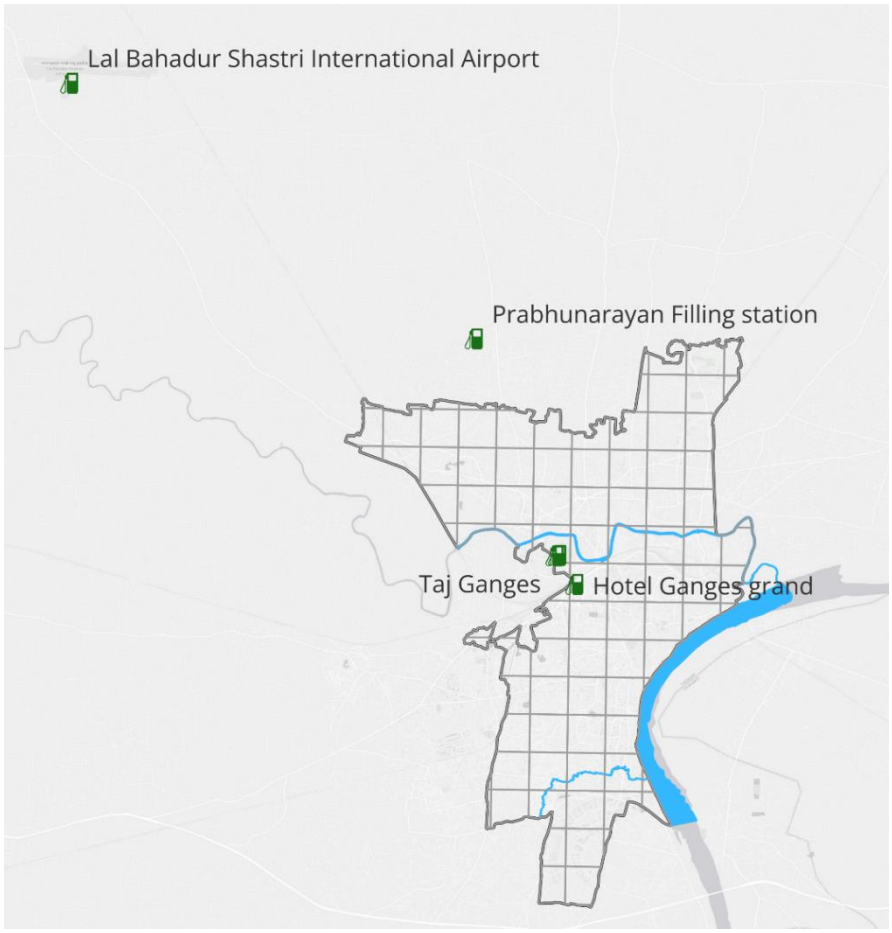
Existing Bus shelters in Varanasi:

Figure 31: Existing Bus shelters in Varanasi



Existing Public EV Charging stations in Varanasi:

Figure 32: Existing Public EV Charging stations in Varanasi



11.7. Analysing existing usage, charging pattern and power demand of existing charging stations (on sampling basis)

Lal Bahadur Shastri International Airport

Sr. No.	CPO	Charger type	Charger rating (kW)	Number of Chargers	Service charge (in INR/kWh)	Remark
1	Tata Power	AC 001	7.4	1	21	Installed & Operational, uses through Telio EV app
2	Tata Power	DC 001	15	1	21	

Figure 33: Lal Bahadur Shastri International Airport EV charging station

Hotel Ganges Grand

Sr. No.	CPO	Charger type	Charger rating (kW)	Number of Chargers	Service charge per kWh (in INR inclusive of GST)	Remark
1	Tata Power	Type II AC	7.4	1	21	Installed but chargers are not usable because of internet connectivity issues
2	Tata Power	CCS II	25	1	21	

Figure 34: Hotel Ganges Grand EV charging station

Hotel Tridev Grand

Sr. No.	CPO	Charger type	Charger rating (kW)	Number of Chargers	Service charge per kWh (in INR inclusive of GST)	Remark
1	Tata Power	Type II AC	7.4	1	21	Installed & operational, approx. 40-50 number of 4W vehicles are getting charged in a month, Payment through Charger mobile app.
2	Tata Power	CCS II	25	1	21	

Figure 35: Hotel Tridev Grand EV charging station

Neelkanth Kisan Sewa Kendra

Sr. No.	CPO	Charger type	Charger rating (kW)	Number of Chargers	Service charge	Remark
1	IOCL	AC 001	3.3	1	NA	3.3kW charger installed, not operational

Figure 36: Neelkanth Kisan Sewa Kendra EV charging station

Prabhunarayan Filling Station

Sr. No.	CPO	Charger type	Charger rating (kW)	Number of Chargers	Service charge	Remark
1	IOCL	AC 001	3.3	1	NA	3.3kW charger installed, not operational

Figure 37: Prabhunarayan Filling Station EV charging station

Taj Ganges

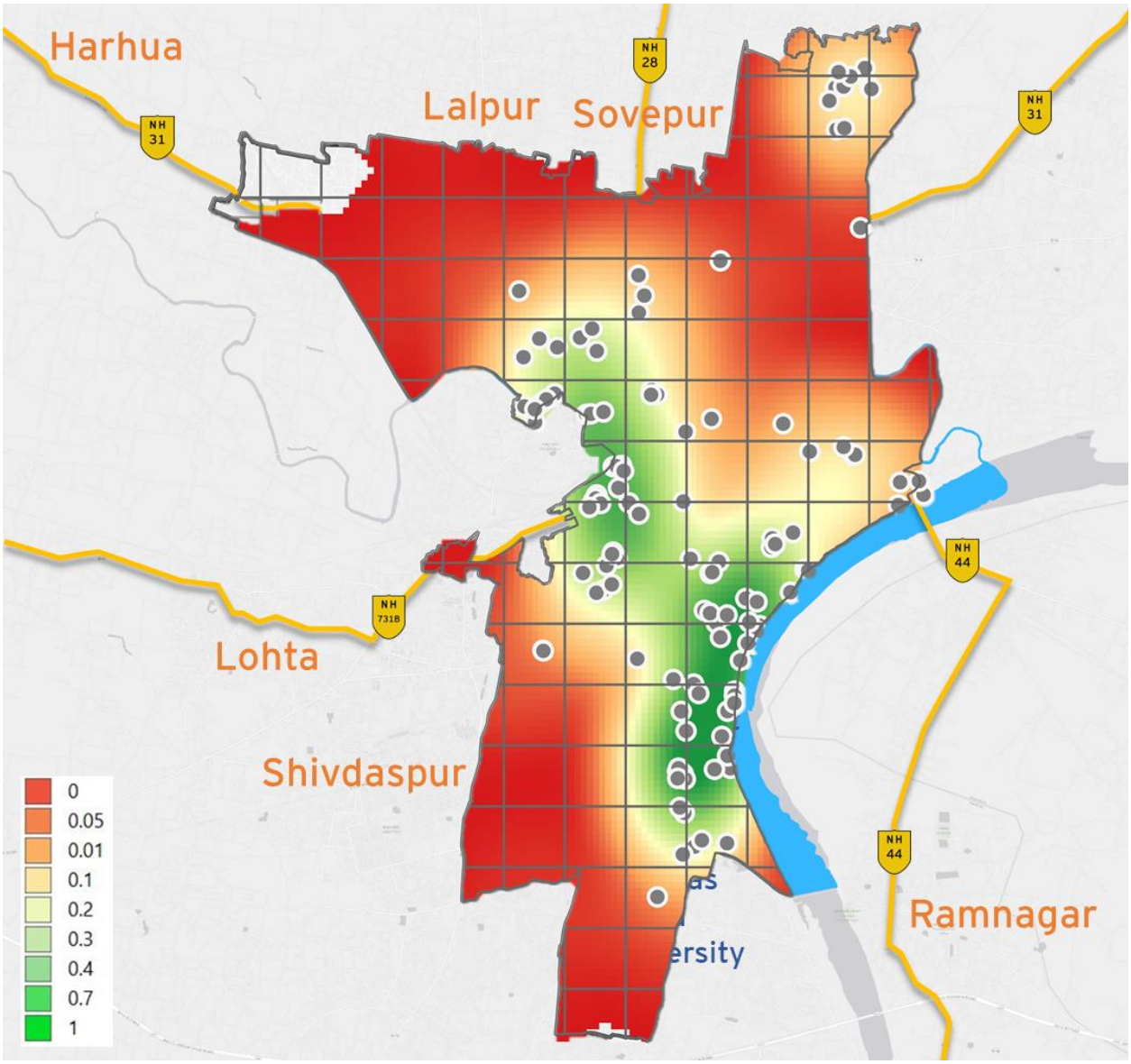
Sr. No.	CPO	Charger type	Charger rating (kW)	Number of Chargers	Service charge	Remark
1	Tata Power	CCS II	30	2	21	Installed & Operational, Approx 250-300 number of 4W vehicles are getting charged in a month, payment through charger mobile app.
2	Tata Power	Type-II AC	7.4	2	21	

Figure 38: Taj Ganges EV charging station

Step 3: Heatmap of all Point of Interests (PoI)

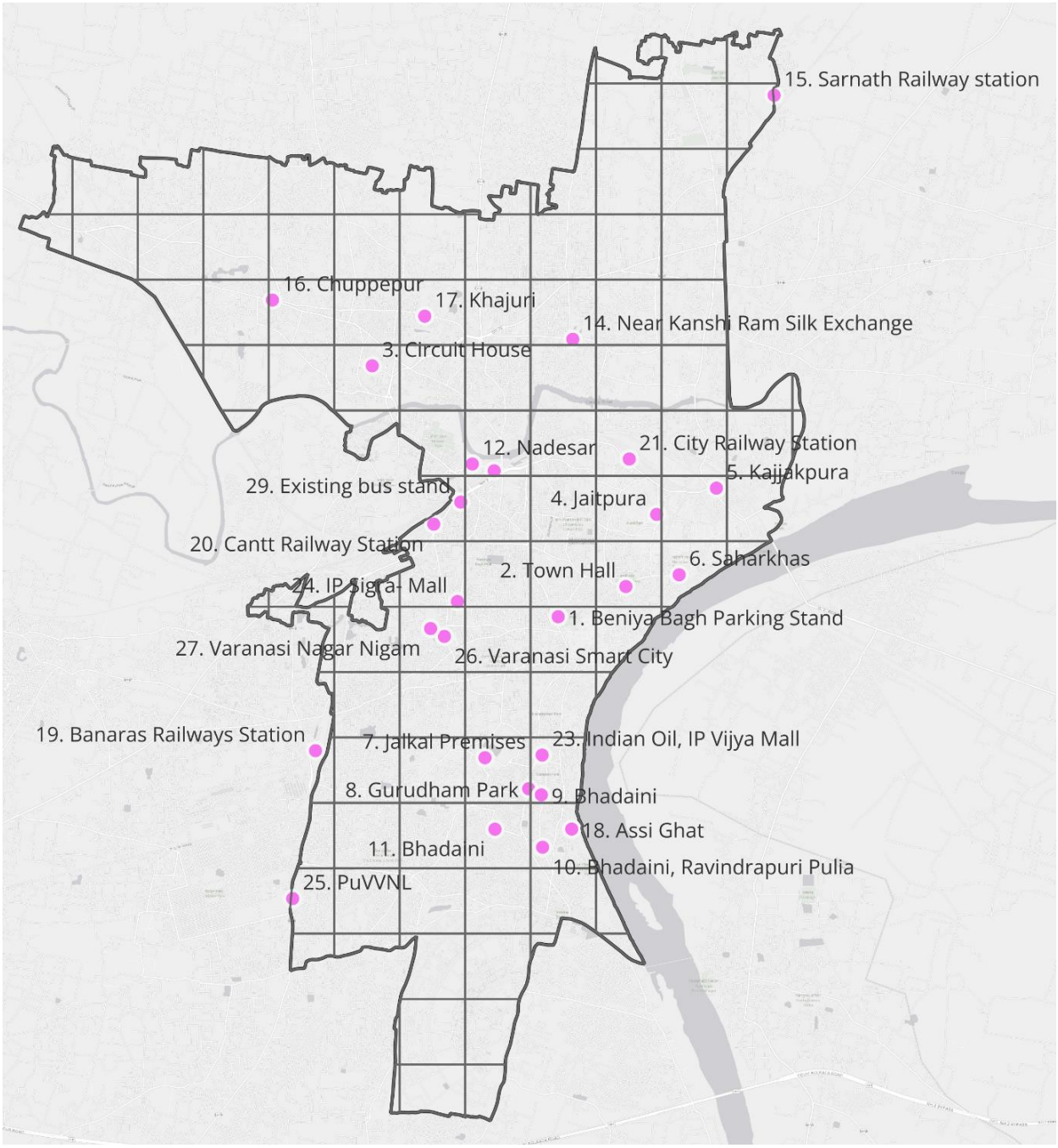
This heatmap provides a visual representation of the concentration of points of interest across a grid with dimensions of 1km x 1km. Each point of interest is assigned a normalized weight, indicating its significance or frequency within the dataset, ranging from 0 to 1. The color scale employed in the heatmap ranges from red to green which is based on proximity of each point of interest of 1km, with varying shades representing different weight values. Red hues signify areas with lower weightage or fewer points of interest, gradually transitioning to green, which indicates higher weightage or a denser concentration of points.

Figure 39: Heatmap of all Point of Interests



Step 4: Potential locations for setting up E charging infrastructure for different vehicle segment

A comprehensive site assessment was conducted, and 27 potential locations deemed suitable for the installation of EV charging stations. These locations have been meticulously analysed and selected based on various factors such as accessibility, demand, infrastructure, and feasibility to ensure optimal placement and effectiveness of the charging stations in facilitating the transition towards sustainable transportation.



PROPOSED PUBLIC CHARGING STATION LOCATIONS

Existing Major Public Parking Stands

1. Beniya Bagh Parking Stand

Name	**Beniya Bagh Parking Stand**
Site location address	Beniya Bagh Parking Stand near Beniya bagh
Latitude	25.314806
Longitude	83.004088
Visibility of EV charging station	Underground Parking
Type of parking (free parking or paid parking operated by parking concessionaire)	Paid Parking, Private contractor by Smart city
Whether the location is open to public (24x7) or restricted operating hours.	Open
Floor type (concrete, tiles, mud etc.) at the proposed location	Concrete
Visibility from Road/Highway	Visible
Distance from Road/Highway	0 metres
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	No
Ownership of the land and its maintenance agency.	Smart City / Nagar Nigam Varanasi
Total no. of parking capacity in parking area	
4W	600
3W	50
2W	250

2. Town Hall

Name	**Town Hall**
Site location address	Town Hall, Maidagin
Latitude	25.31856
Longitude	83.013376
Visibility of EV charging station	Underground Parking
Type of parking (free parking or paid parking operated by parking concessionaire)	Paid Parking, Private contractor by Smart city
Whether the location is open to public (24x7) or restricted operating hours.	Open
Floor type (concrete, tiles, mud etc.) at the proposed location	Concrete
Visibility from Road/Highway	Visible
Distance from Road/Highway	0 metres
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	No
Ownership of the land and its maintenance agency.	Smart City / Nagar Nigam Varanasi
Total no. of parking capacity in parking area	
4W	170
3W	20
2W	70

3. Circuit House

Name	**Circuit House**
Site location address	Circuit House, Kachahri, Maidagin
Latitude	25.345958
Longitude	82.978562
Visibility of EV charging station	Underground Parking
Type of parking (free parking or paid parking operated by parking concessionaire)	Paid Parking, Private contractor by Smart city
Whether the location is open to public (24x7) or restricted operating hours.	Open
Floor type (concrete, tiles, mud etc.) at the proposed location	Concrete
Visibility from Road/Highway	Visible
Distance from Road/Highway	0 metres
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	No
Ownership of the land and its maintenance agency.	Smart City / Nagar Nigam Varanasi
Total no. of parking capacity in parking area	
4W	100
3W	30
2W	1000

4. Jaitpura

Name	**Jaitpura**
Site location address	Jaitpura, Araji no. 4731 (Near petrol pump)
Latitude	25.327505
Longitude	83.017603
Visibility of EV charging station	Not visible
Type of parking (free parking or paid parking operated by parking concessionaire)	No parking
Whether the location is open to public (24x7) or restricted operating hours.	Open
Floor type (concrete, tiles, mud etc.) at the proposed location	Mud
Visibility from Road/Highway	Visible
Distance from Road/Highway	0 metres
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	Yes
Ownership of the land and its maintenance agency.	Nagar Nigam Varanasi
Total no. of parking capacity in parking area	
4W	5
3W	5
2W	20

5. Kajjakpura

Name	**Kajjakpura**
Site location address	Kajjakpura, IDH Colony, Aaraji no. 301
Latitude	25.330768
Longitude	83.025801
Visibility of EV charging station	Not visible
Type of parking (free parking or paid parking operated by parking concessionaire)	No parking
Whether the location is open to public (24x7) or restricted operating hours.	Open
Floor type (concrete, tiles, mud etc.) at the proposed location	Mud
Visibility from Road/Highway	No
Distance from Road/Highway	100 metres
Advertisement potential (high/low)	Low
Suitability for solar installation (canopy structures)	Yes
Ownership of the land and its maintenance agency.	Nagar Nigam Varanasi
Total no. of parking capacity in parking area	
4W	5
3W	5
2W	20

6. Saharkhas

Name	**Saharkhas**
Site location address	Saharkhas, Machhodari Park
Latitude	25.320016
Longitude	83.02069
Visibility of EV charging station	Not visible
Type of parking (free parking or paid parking operated by parking concessionaire)	No Parking
Whether the location is open to public (24x7) or restricted operating hours.	Open
Floor type (concrete, tiles, mud etc.) at the proposed location	Mud
Visibility from Road/Highway	no (boundary wall)
Distance from Road/Highway	0 metres
Advertisement potential (high/low)	Low
Suitability for solar installation (canopy structures)	no
Ownership of the land and its maintenance agency.	Nagar Nigam Varanasi
Total no. of parking capacity in parking area	
4W	5
3W	5
2W	10
Existing Sanctioned Load	Transformer is working on overload.
Transformer Supply (name and rating)	400 kVA
Feeder name and Capacity	Gayghat feeder
Substation Name	Machhodari s/s
Existing load availability on transformer	Transformer is working on overload. 11 kV line available at 100 metres distance from proposed site.
Other information if any	Installation of transformer of appropriate size & capacity for EV Charging connection is required

7. Jalkal Premises

Name	**Jalkal Premises**
Site location address	Jalkal Premises, Jolha, Varanasi
Latitude	25.297299
Longitude	82.994035
Visibility of EV charging station	Visible
Type of parking (free parking or paid parking operated by parking concessionaire)	No Parking
Whether the location is open to public (24x7) or restricted operating hours.	Restricted
Floor type (concrete, tiles, mud etc.) at the proposed location	Concrete
Visibility from Road/Highway	Yes
Distance from Road/Highway	0 metres
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	No
Ownership of the land and its maintenance agency.	Nagar Nigam Varanasi

8. Gurudham Park

Name	**Gurudham Park**
Site location address	Gurudham Park, Durgakund, Varanasi
Latitude	25.29345
Longitude	83.000026
Visibility of EV charging station	Visible
Type of parking (free parking or paid parking operated by parking concessionaire)	No Parking
Whether the location is open to public (24x7) or restricted operating hours.	Open
Floor type (concrete, tiles, mud etc.) at the proposed location	Mud
Visibility from Road/Highway	Visible
Distance from Road/Highway	0
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	No
Ownership of the land and its maintenance agency.	Nagar Nigam Varanasi
Total no. of parking capacity in parking area	
4W	5

9. Bhadaini

Name	**Bhadaini**
Site location address	Bhadaini, Ramchandra sukla Chawraha
Latitude	25.292687
Longitude	83.001772
Visibility of EV charging station	Visible
Type of parking (free parking or paid parking operated by parking concessionaire)	No Parking
Whether the location is open to public (24x7) or restricted operating hours.	Open
Floor type (concrete, tiles, mud etc.) at the proposed location	Mud
Visibility from Road/Highway	Visible
Distance from Road/Highway	0 metres
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	Yes
Ownership of the land and its maintenance agency.	Nagar Nigam Varanasi
Total no. of parking capacity in parking area	
4W	4
3W	3
2W	5
Existing Sanctioned Load	300 KVA
Transformer Supply (name and rating)	400 KVA
Feeder name and Capacity	Ravindrapuri
Substation Name	Bhadaini
Existing load availability on transformer	50 KW Connection can be given for proposed EV charging station.
Other information if any	near site (50-60 metres cable required)

10. Bhadaini, Ravindrapuri Pulia

Name	**Bhadaini, Ravindrapuri Pulia**
Site location address	Bhadaini, Ravindrapuri Pulia (near park)
Latitude	25.28618
Longitude	83.001941
Visibility of EV charging station	Visible
Type of parking (free parking or paid parking operated by parking concessionaire)	No Parking
Whether the location is open to public (24x7) or restricted operating hours.	Open
Floor type (concrete, tiles, mud etc.) at the proposed location	Concrete
Visibility from Road/Highway	Visible
Distance from Road/Highway	0 metres
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	No
Ownership of the land and its maintenance agency.	Nagar Nigam Varanasi
Total no. of parking capacity in parking area	
4W	5
3W	5
2W	10
Existing Sanctioned Load	270 KVA
Transformer Supply (name and rating)	400 KVA (PUMP)
Feeder name and Capacity	Ravindrapuri Extension
Substation Name	Bhadaini
Existing load availability on transformer	Available for Supply to EV Charging station
Other information if any	Cables of appropriate size needs to be placed (~ 60-100metres) for connection to EV Charging station.

11. Bhadaini

Site location address	Bhadaini, Near Kabir Nagar Park
Latitude	25.288423
Longitude	82.995408
Visibility of EV charging station	Visible
Type of parking (free parking or paid parking operated by parking concessionaire)	No Parking
Whether the location is open to public (24x7) or restricted operating hours.	Open
Floor type (concrete, tiles, mud etc.) at the proposed location	Bricks
Visibility from Road/Highway	Visible
Distance from Road/Highway	0 metres
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	Yes
Ownership of the land and its maintenance agency.	Nagar Nigam Varanasi
Total no. of parking capacity in parking area	
2W	3

12. Nadesar

Name	**Nadesar**
Site location address	Nadesar Araji No 440
Latitude	25.333773
Longitude	82.992297
Visibility of EV charging station	Not visible
Type of parking (free parking or paid parking operated by parking concessionaire)	No parking
Whether the location is open to public (24x7) or restricted operating hours.	Open
Floor type (concrete, tiles, mud etc.) at the proposed location	Mud
Visibility from Road/Highway	Visible
Distance from Road/Highway	0-10 metres
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	No
Ownership of the land and its maintenance agency.	Nagar Nigam Varanasi
Total no. of parking capacity in parking area	
4W	5
Existing Sanctioned Load	400 KVA
Transformer Supply (name and rating)	630 kVA
Feeder name and Capacity	Nadesar feeder
Substation Name	Ordaly Bazar s/s
Existing load availability on transformer	Connection for EV Charging can be given.
Other information if any	LT Line is near site, 20-30 metres cable for appropriate size will be required.

13. Near Sunrise Mall Near

Name	**Near Sunrise Mall**
Site location address	Ghausabad, Near Sunrise Mall
Latitude	25.33292
Longitude	82.995298
Visibility of EV charging station	Visible
Type of parking (free parking or paid parking operated by parking concessionaire)	No Parking
Whether the location is open to public (24x7) or restricted operating hours.	Open
Floor type (concrete, tiles, mud etc.) at the proposed location	Mud
Visibility from Road/Highway	Visible
Distance from Road/Highway	50-100 metres
Advertisement potential (high/low)	Low
Suitability for solar installation (canopy structures)	Yes
Ownership of the land and its maintenance agency.	Nagar Nigam Varanasi
Total no. of parking capacity in parking area	
4W	6
Existing Sanctioned Load	150 KVA
Transformer Supply (name and rating)	250 KVA
Substation Name	Nadesar
Existing load availability on transformer	150 KVA approx
Other information if any	20-25 metres cable required for EV Charging connection.

14. Kanshi Ram Silk Exchange

Name	**Near Kanshi Ram Silk Exchange**
Site location address	Hall, Near Kanshi Ram Silk Exchange
Latitude	25.349259
Longitude	83.00609
Visibility of EV charging station	Visible
Type of parking (free parking or paid parking operated by parking concessionaire)	No Parking
Whether the location is open to public (24x7) or restricted operating hours.	Open
Floor type (concrete, tiles, mud etc.) at the proposed location	Mud
Visibility from Road/Highway	Visible
Distance from Road/Highway	0 metres
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	No
Ownership of the land and its maintenance agency.	Nagar Nigam Varanasi
Total no. of parking capacity in parking area	
3W	4

15. Near Sarnath Railway station

Name	**Near Sarnath Railway station**
Site location address	Near Sarnath Railway station
Latitude	25.379538
Longitude	83.033721
Visibility of EV charging station	Visible
Type of parking (free parking or paid parking operated by parking concessionaire)	No Parking
Whether the location is open to public (24x7) or restricted operating hours.	Open
Floor type (concrete, tiles, mud etc.) at the proposed location	Mud
Visibility from Road/Highway	Visible
Distance from Road/Highway	10-100 metres from road
Advertisement potential (high/low)	Low
Suitability for solar installation (canopy structures)	Yes
Ownership of the land and its maintenance agency.	Nagar Nigam Varanasi
Total no. of parking capacity in parking area	
4W	6

Sufficient land is available for setting up of **new depot for electric buses within Varanasi** City.

16. Chuppepur

Name	**Chuppepur**
Site location address	Chuppepur, Araji No 99, Shivpur.
Latitude	25.354123
Longitude	82.964859
Visibility of EV charging station	Visible
Type of parking (free parking or paid parking operated by parking concessionaire)	No Parking
Whether the location is open to public (24x7) or restricted operating hours.	Open
Floor type (concrete, tiles, mud etc.) at the proposed location	Mud
Visibility from Road/Highway	Visible
Distance from Road/Highway	50-100 metres
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	Yes
Ownership of the land and its maintenance agency.	Nagar Nigam Varanasi
Total no. of parking capacity in parking area	
4W	6
Existing Sanctioned Load	350 KVA (Overload)
Transformer Supply (name and rating)	250 KVA
Substation Name	Koilaha
Existing load availability on transformer	350 KVA, working on overload.
Other information if any	20-25 kW load can be sanctioned for EV Charging station.

17. Khajuri

Name	**Khajuri**
Site location address	Khajuri, Araji No 05 near ESIC hospital
Latitude	25.352118
Longitude	82.985774
Visibility of EV charging station	Visible
Type of parking (free parking or paid parking operated by parking concessionaire)	No Parking
Whether the location is open to public (24x7) or restricted operating hours.	Open
Floor type (concrete, tiles, mud etc.) at the proposed location	Mud
Visibility from Road/Highway	Visible
Distance from Road/Highway	0 metres
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	No
Ownership of the land and its maintenance agency.	Nagar Nigam Varanasi
Total no. of parking capacity in parking area	
4W	2
3W	2
2W	5
Existing Sanctioned Load	60-100 KVA
Transformer Supply (name and rating)	100 KVA
Feeder name and Capacity	Khajuri Feeder
Substation Name	Khajuri
Existing load availability on transformer	Transformer is working at full load.
Other information if any	11 kV HT line is available above the proposed site. Need to install appropriate transformer for EV Charging station.

18. Assi Ghat parking

Name	**Assi Ghat**
Site location address	Assi Ghat
Latitude	25.288434
Longitude	83.005938
Visibility of EV charging station	Visible
Type of parking (free parking or paid parking operated by parking concessionaire)	Private Parking / Paid
Whether the location is open to public (24x7) or restricted operating hours.	Open
Floor type (concrete, tiles, mud etc.) at the proposed location	Mud
Visibility from Road/Highway	No
Distance from Road/Highway	50-100 metres
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	Yes
Ownership of the land and its maintenance agency.	Private Parking
Total no. of parking capacity in parking area	
4W	15

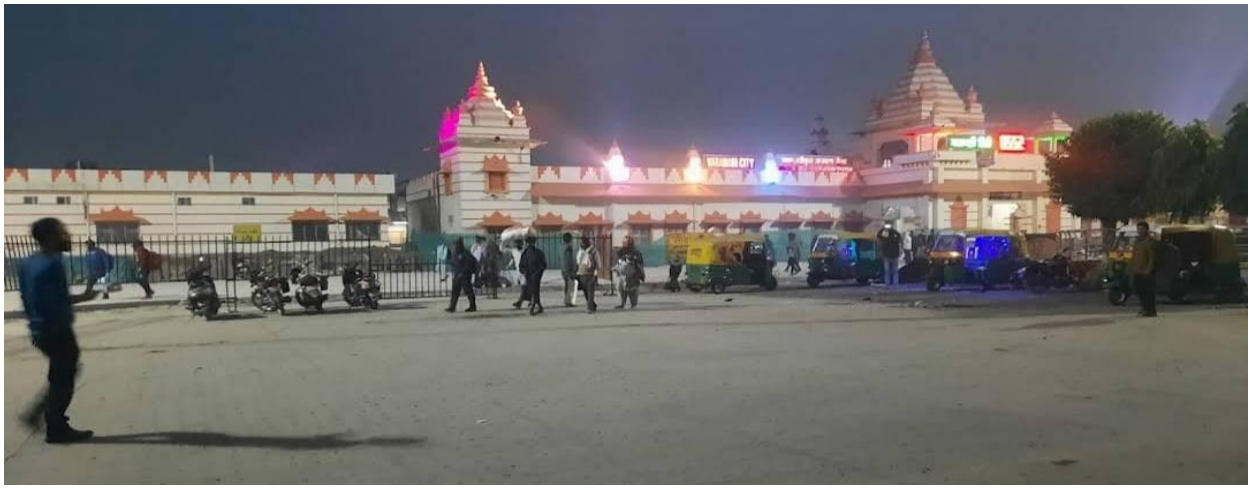
19. Banaras Railway Station

Name	Banaras Railways Station
Site location address	Banaras Railways Station (Manduadih)
Latitude	25.298176
Longitude	82.97078
Visibility of EV charging station	Yes
Type of parking (free parking or paid parking operated by parking concessionaire)	Railway paid parking
Whether the location is open to public (24x7) or restricted operating hours.	Yes
Floor type (concrete, tiles, mud etc.) at the proposed location	Tiles
Visibility from Road/Highway	yes
Distance from Road/Highway	50 metres
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	Yes
Ownership of the land and its maintenance agency.	Railway
Total no. of parking capacity in parking area	
4W	35

20. Cantt Railway Station

Name	Cantt Railway Station
Site location address	Cantt Railway Station, 4W & 3W Parking stand
Latitude	25.326302
Longitude	82.987004
Visibility of EV charging station	Yes
Type of parking (free parking or paid parking operated by parking concessionaire)	Railway Parking (Paid)
Whether the location is open to public (24x7) or restricted operating hours.	Yes
Floor type (concrete, tiles, mud etc.) at the proposed location	Concrete
Visibility from Road/Highway	Yes
Distance from Road/Highway	0 Metres
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	Yes
Ownership of the land and its maintenance agency.	Railway
Total no. of parking capacity in parking area	
4W	100

21. City Railway Station

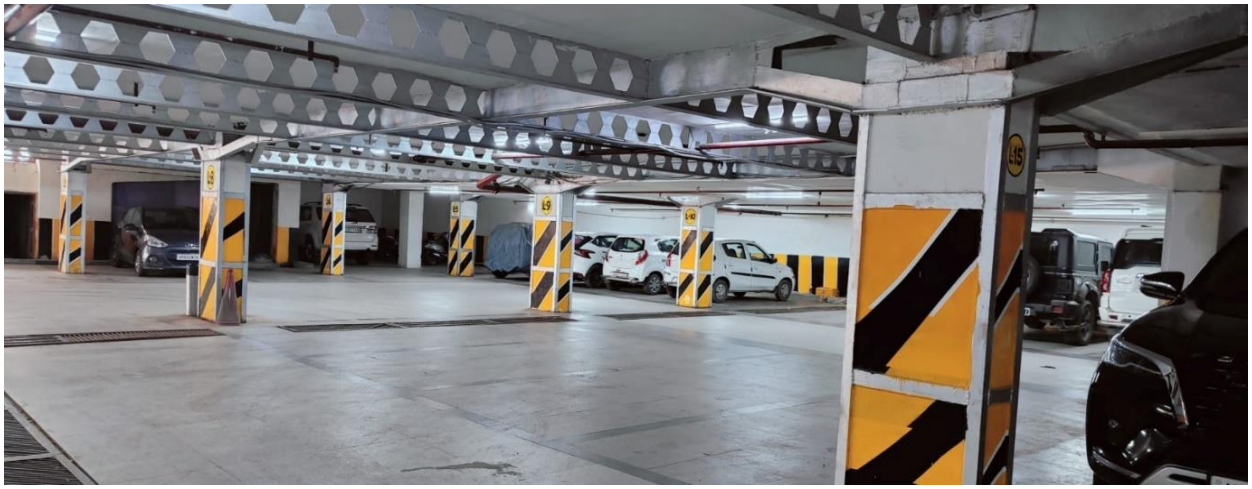


Name	City Railway Station, 4W & 3W Parking stand
Site location address	City Railway Station
Latitude	25.334388
Longitude	83.013842
Visibility of EV charging station	Yes
Type of parking (free parking or paid parking operated by parking concessionaire)	Railway Parking (Paid)
Whether the location is open to public (24x7) or restricted operating hours.	Open
Floor type (concrete, tiles, mud etc.) at the proposed location	Concrete
Visibility from Road/Highway	Yes
Distance from Road/Highway	0 Metres
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	Yes
Ownership of the land and its maintenance agency.	Railway
Total no. of parking capacity in parking area	
4W	100

22. JHV Mall

Name	**JHV Mall**
Site location address	JHV Mall
Latitude	25.336018
Longitude	83.977126
Visibility of EV charging station	No (Under Ground Parking)
Type of parking (free parking or paid parking operated by parking concessionaire)	Private Parking / Paid
Whether the location is open to public (24x7) or restricted operating hours.	No restricted for working hrs
Floor type (concrete, tiles, mud etc.) at the proposed location	Concrete
Visibility from Road/Highway	No
Distance from Road/Highway	50-100 metres
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	Yes
Ownership of the land and its maintenance agency.	Private Parking

23. IP Sigra- Mall



Name	**IP Sigra- Mall**
Site location address	Sigra
Latitude	25.316686
Longitude	82.990257
Visibility of EV charging station	No (Under Ground Parking)
Type of parking (free parking or paid parking operated by parking concessionaire)	Private Paid Parking
Whether the location is open to public (24x7) or restricted operating hours.	Restricted for mall opening hrs.
Floor type (concrete, tiles, mud etc.) at the proposed location	Concrete
Visibility from Road/Highway	No
Distance from Road/Highway	0
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	No
Ownership of the land and its maintenance agency.	Mall owner
Total no. of parking capacity in parking area	
4W	50

24. Indian Oil, IP Vijya Mall

Name	**Indian Oil, IP Vijya Mall**
Site location address	Indian Oil, IP Vijya Mall
Latitude	25.297631
Longitude	83.001877
Visibility of EV charging station	Visible
Type of parking (free parking or paid parking operated by parking concessionaire)	No parking, Petrol & CNG pump
Whether the location is open to public (24x7) or restricted operating hours.	Open
Floor type (concrete, tiles, mud etc.) at the proposed location	Concrete
Visibility from Road/Highway	Visible
Distance from Road/Highway	0 Metres
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	Yes
Ownership of the land and its maintenance agency.	Petrol pump owner

WORKPLACE CHARGING STATIONS LOCATIONS

25. Purvanchal Vidyut Vitaran Nigam Limited

Name	**PuVVNL**
Site location address	MD office, PuVVNL, Bhikharipur, Varanasi
Latitude	25.279806
Longitude	82.967646
Visibility of EV charging station	No (inside premises of PuVVNL)
Type of parking (free parking or paid parking operated by parking concessionaire)	PuVVNL official parking
Whether the location is open to public (24x7) or restricted operating hours.	No restricted for working hrs
Floor type (concrete, tiles, mud etc.) at the proposed location	Concrete
Visibility from Road/Highway	Visible
Distance from Road/Highway	50 metres
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	Yes
Ownership of the land and its maintenance agency.	PuVVNL
Total no. of parking capacity in parking area	
4W	20

26. Varanasi Smart City

Name	**Varanasi Smart City**
Site location address	Smart City Parking, Sigra
Latitude	25.312364
Longitude	82.988459
Visibility of EV charging station	Yes
Type of parking (free parking or paid parking operated by parking concessionaire)	Free parking for Smart city officials
Whether the location is open to public (24x7) or restricted operating hours.	restricted by Smart city office
Floor type (concrete, tiles, mud etc.) at the proposed location	Concrete
Visibility from Road/Highway	yes
Distance from Road/Highway	0 metres
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	Yes
Ownership of the land and its maintenance agency.	Smart City / Nagar Nigam Varanasi
Total no. of parking capacity in parking area	
4W	10
2W	70

27. Varanasi Nagar Nigam

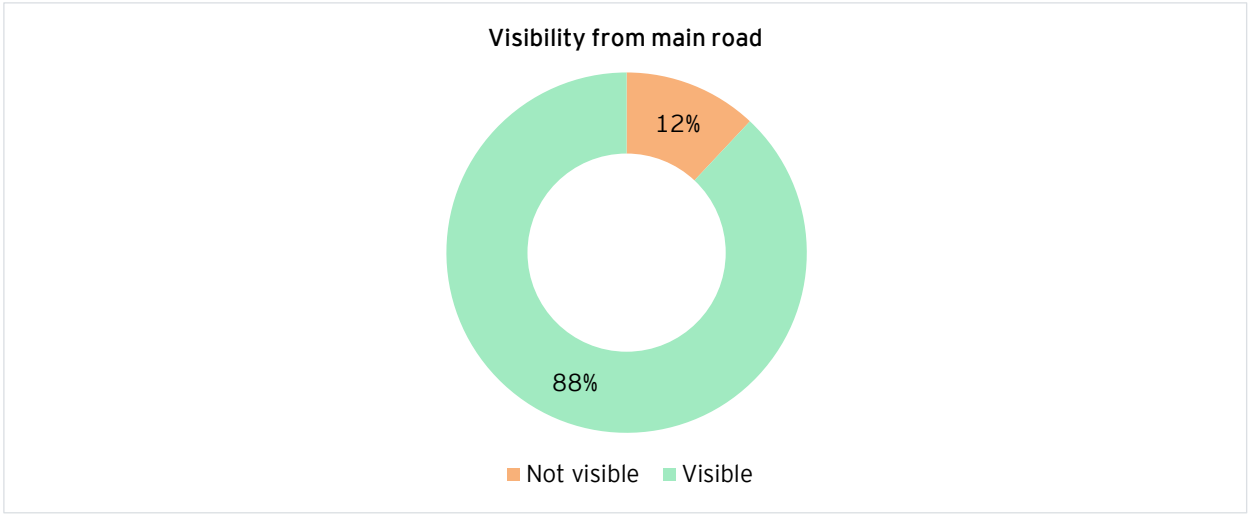
Name	**Varanasi Nagar Nigam**
Site location address	Varanasi Nagar Nigam
Latitude	25.313335
Longitude	82.986575
Visibility of EV charging station	Visible
Type of parking (free parking or paid parking operated by parking concessionaire)	Free parking for Nagar Nigam officials
Whether the location is open to public (24x7) or restricted operating hours.	Restricted for officials
Floor type (concrete, tiles, mud etc.) at the proposed location	Concrete
Visibility from Road/Highway	Visible
Distance from Road/Highway	0
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	Yes
Ownership of the land and its maintenance agency.	Nagar Nigam
Total no. of parking capacity in parking area	
4W	10

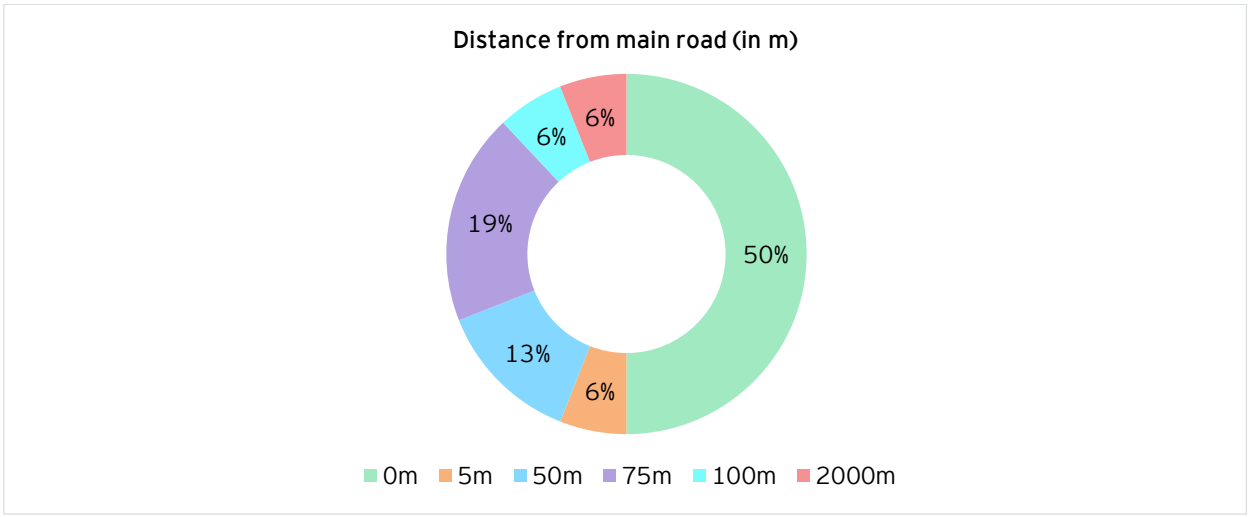
28. New RTO Office

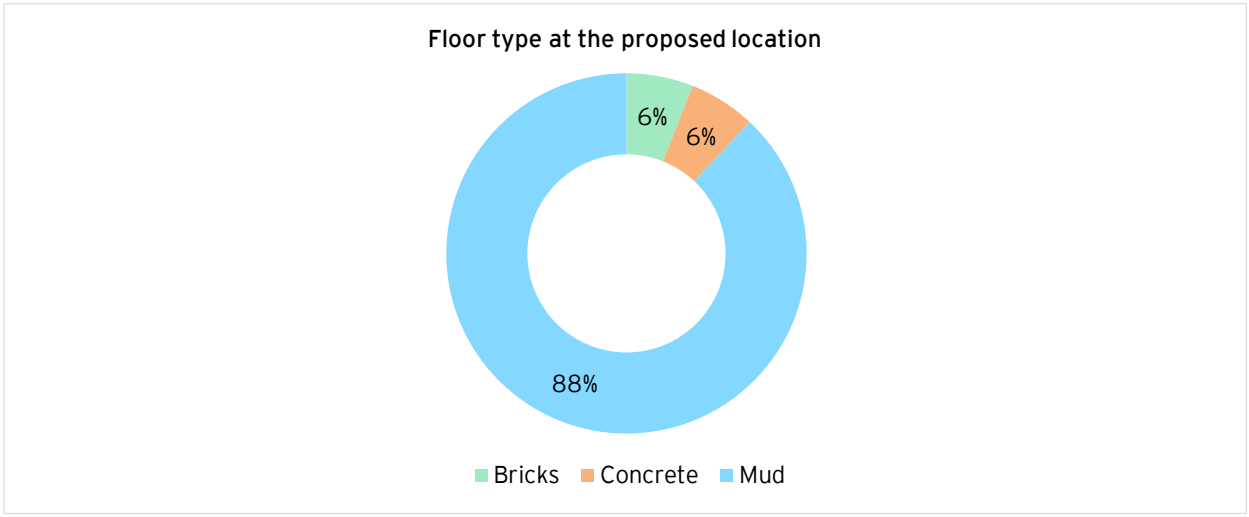
Name	RTO office Babatpur, Varanasi
Latitude	25.422816
Longitude	82.876014
Visibility of EV charging station	Not visible
Type of parking (free parking or paid parking operated by parking concessionaire)	Parking stand only for RTO officials
Whether the location is open to public (24x7) or restricted operating hours.	Restricted upto working hours
Floor type (concrete, tiles, mud etc.) at the proposed location	Mud
Visibility from Road/Highway	Visible
Distance from Road/Highway	50-100 metres from Lucknow -Jaunpur - Varanasi Highway
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	No
Ownership of the land and its maintenance agency.	RTO Varanasi
Total no. of parking capacity in parking area	
4W	15

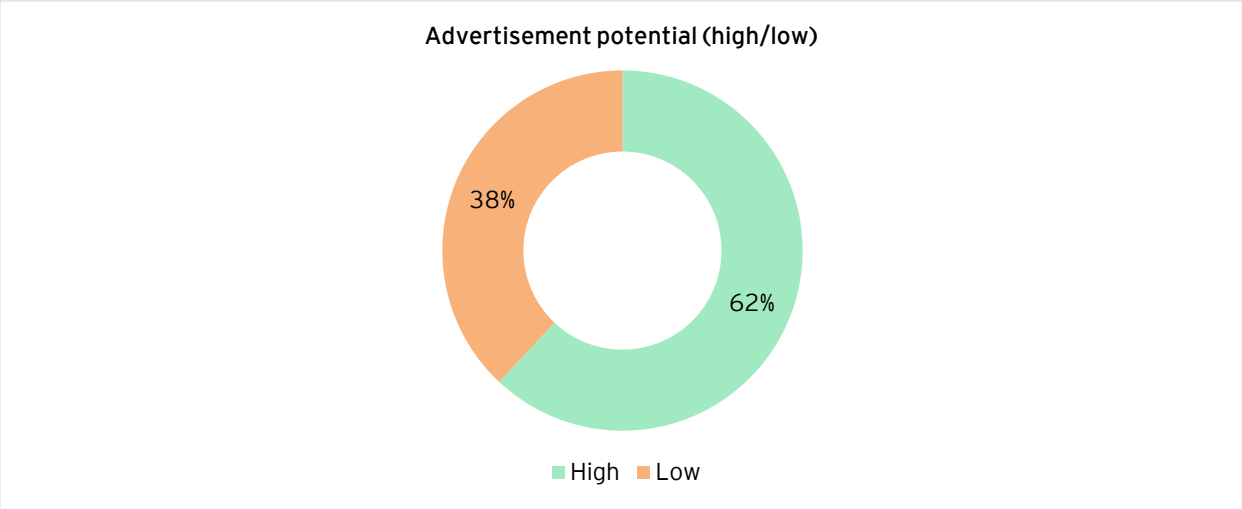
29. Bus charging facility at exiting bus stand, Varanasi

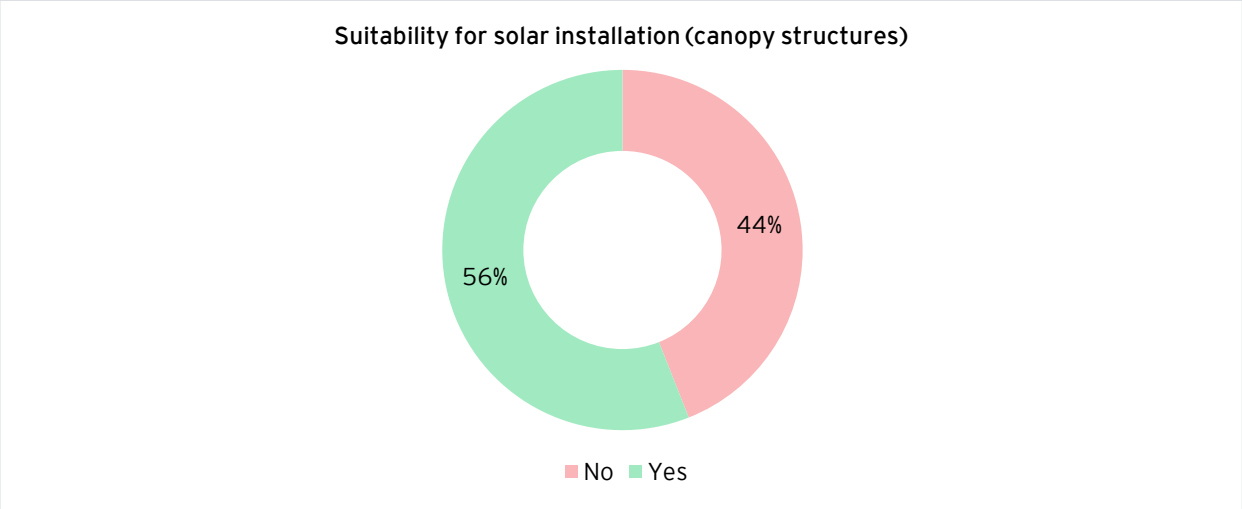
Name	Old Bus stand
Latitude	25.329041
Longitude	82.990713
Visibility of EV charging station	Visible
Type of parking (free parking or paid parking operated by parking concessionaire)	Bus depot
Whether the location is open to public (24x7) or restricted operating hours.	Open to public
Floor type (concrete, tiles, mud etc.) at the proposed location	Bricks
Visibility from Road/Highway	Visible
Distance from Road/Highway	0 metres
Advertisement potential (high/low)	High
Suitability for solar installation (canopy structures)	Yes
Ownership of the land and its maintenance agency.	UPSRTC
Total no. of parking capacity in parking area	
4W	


Visibility from main road
12%
88%
Not visible
Visible

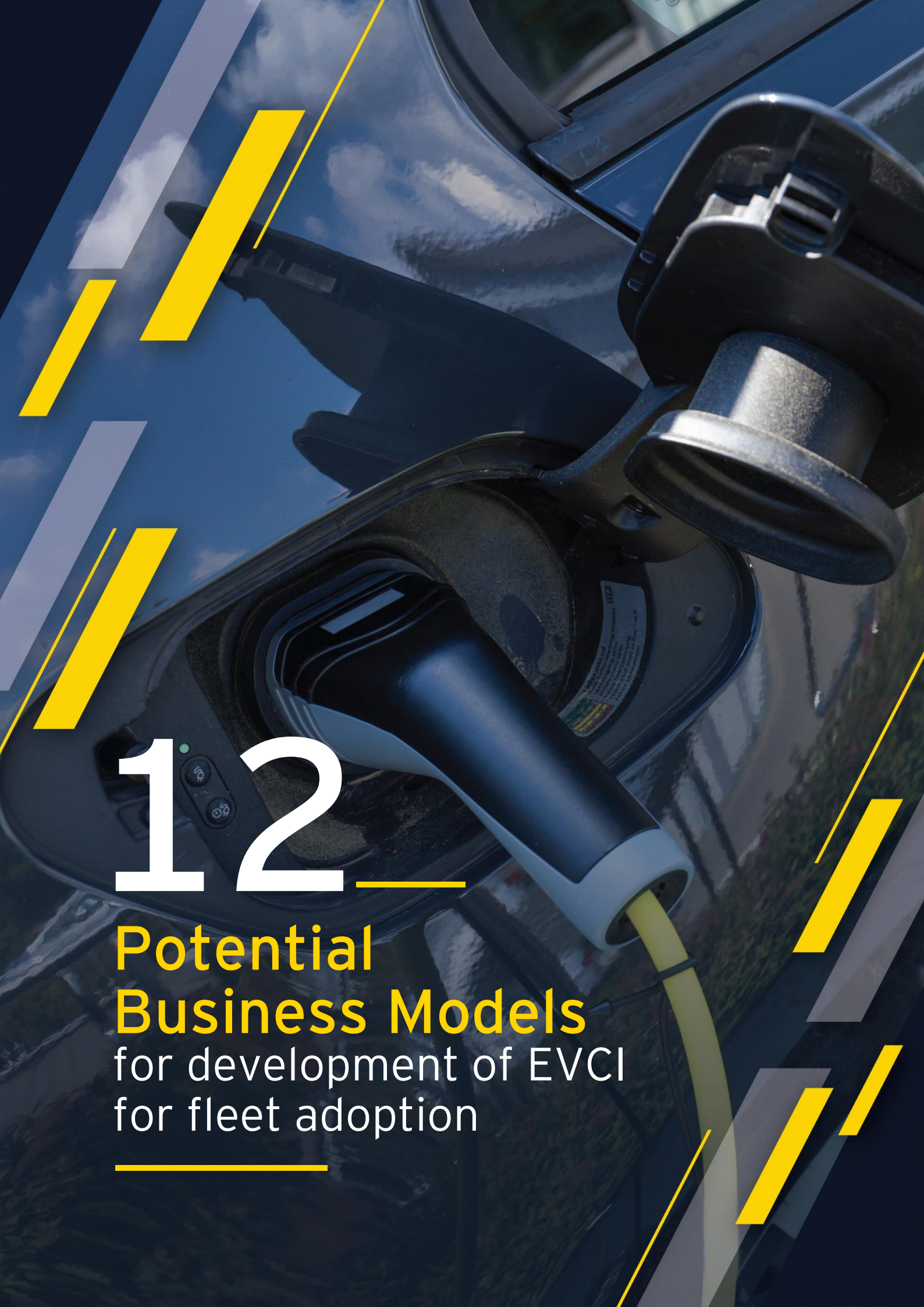

Distance from main road (in m)
6%
6%
19%
50%
13%
6%
0m
5m
50m
75m
100m
2000m


Floor type at the proposed location
6%
6%
88%
Bricks
Concrete
Mud





The initial identification of Electric vehicle Charging Station locations was facilitated by the analysis of this heat map complemented by satellite images. The virtual visual aids provided valuable insights into the distribution and concentration of potential sites across the targeted area. Subsequently, to ensure the accuracy and suitability of these identified locations, on-site reconnaissance Survey was conducted. The surveys involved physically visiting each site to assess various factors such as accessibility, parking availability, proximity to power sources, and any potential logistical challenges.



12

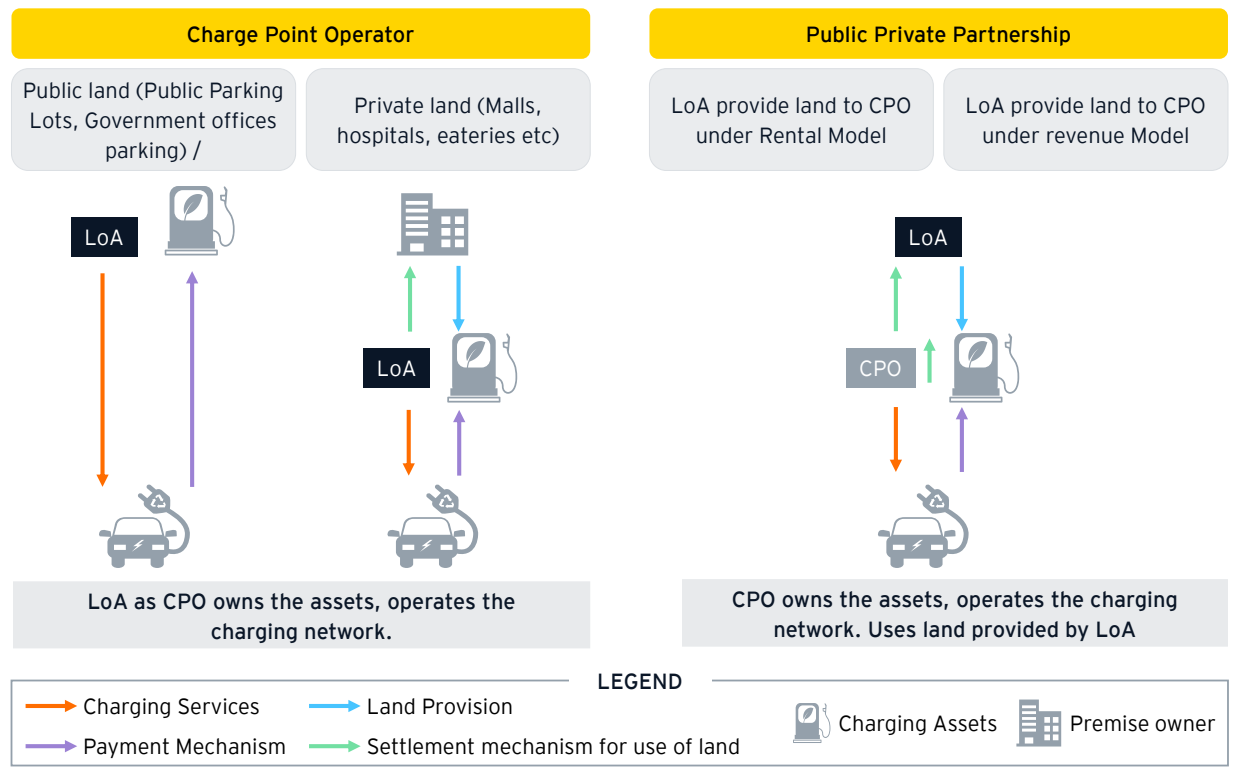
Potential Business Models

for development of EVCI for fleet adoption

Public charging infrastructure is the backbone of any electric mobility implementation. The provision of adequate, affordable, accessible, and reliable charging networks is a prerequisite for mass EV adoption and could help promote awareness and reduce range anxiety among potential EV users. To facilitate a sustainable electric mobility ecosystem in India, the role of Land-owning Agency (LoA) will be a leading one, especially in deploying EVCI within Varanasi city.

The Land-owning Agency in case of Varanasi can be any suitable government stakeholder such as Varanasi Nagar Nigam (VNN), Varanasi Smart City Limited, PuVVNL (DISCOM), Varanasi City Transport Limited (VCTL) or any other potential government body.

Different types of implementation models may be used to set up and scale public charging infrastructure. A typical charging infrastructure implementation model comprises of multiple components, including the capital expenditure for charging equipment, provision of land, supply of electricity, and the day-to-day operations and maintenance of facilities and services. The different types of EV charging business models are:

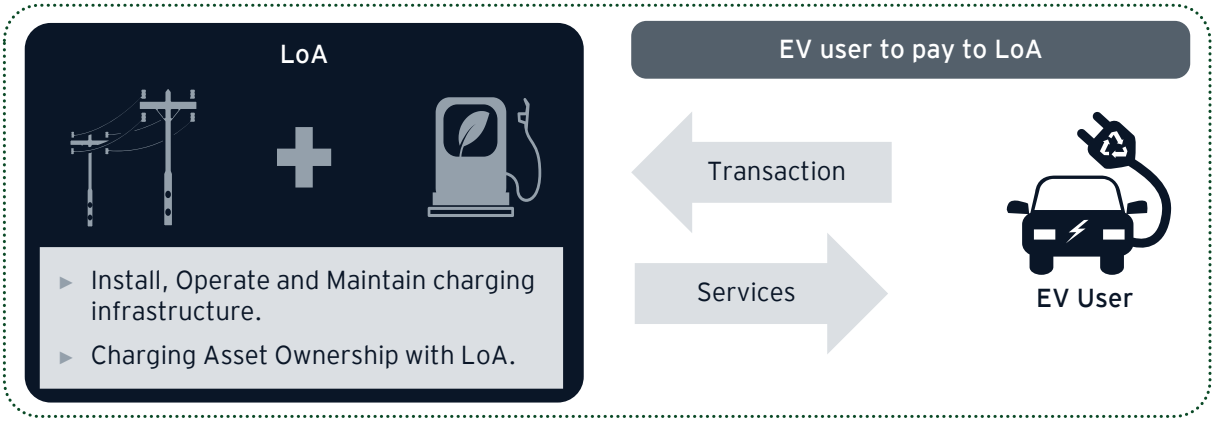


In regard to the investment required for setting up a public charging station, there are various cost components such as installation costs for procuring and installing EV charging equipment, cost incurred for making provision of land to set up the charging station, costs incurred in maintaining and operating the charging station, costs of manpower that will be required to efficiently oversee the daily operations of the charging station etc.

In terms of revenue generation through the EV charging business, there are certain direct methods such as charging user fees to customers for energy use either on a per-user basis or a subscription basis. Further, there are certain additional factors that will improve the financial viability of EV charging such as revenue from advertisement at the charging station and retail co-location by setting up EV charging stations alongside pre-existing retail stores. This will increase the visibility of a charging station which will result in achieving better utilization of the charging stations. The different types of business models are discussed below:

Business Model 1a: LoA own and operate public charging station on public land

To establish an EV charging business, provision of land is one of the key requirements and from the perspective of lighthouse cities, availability of affordable land is very low. In this scenario, Land owning Agency (LoA) can play a leading role in setting up public charging stations at their premises itself. The ULB owns the EVSE and operate the public charging station.



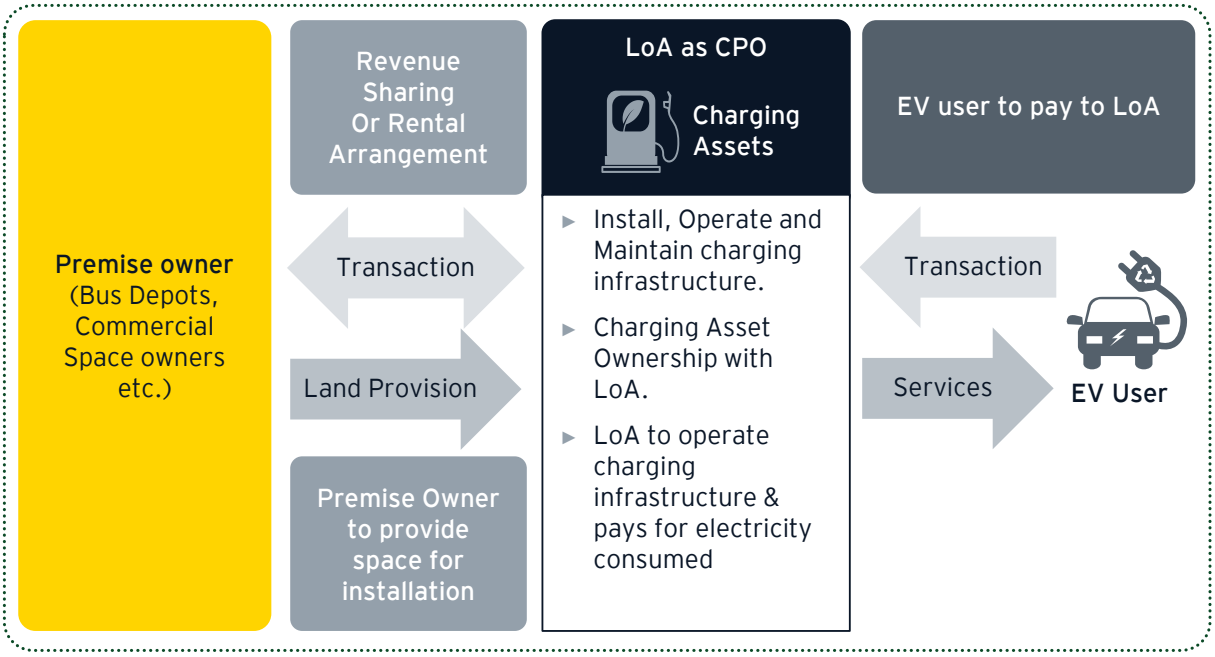
Pros	Cons
► More control of LoA over pricing policy and type/make/capacity of chargers deployed ► Option for enhancing revenue through advertisements by using available space	► Demand risk lies with LoA ► Requires LoA to invest ► ULB may lack prior expertise in running EV charging business

Business Model 1b: LoA own and operate public charging station on private land

The LoA can act as a Charge Point Operator and can either collaborate with other city stakeholders such as municipal corporation, state transport utility (bus depots) etc to install, own and operate the public charging stations as a CPO.

The LoA can also form a partnership with commercial establishments, such as malls, office spaces, IT parks, etc to setup and operate public charging stations at their premises. Both the rental arrangement and revenue sharing can be worked out depending upon the mutual agreement of both parties.

LoA acting as a CPO can also set up charging stations at bus depots. The LoA in collaboration with DISCOMs could also provide their expertise and electricity infrastructure required to set up the charging station. These stations would primarily meet the charging demand of public transport, thus resolving the utilisation issue and providing a win-win situation to both entities.



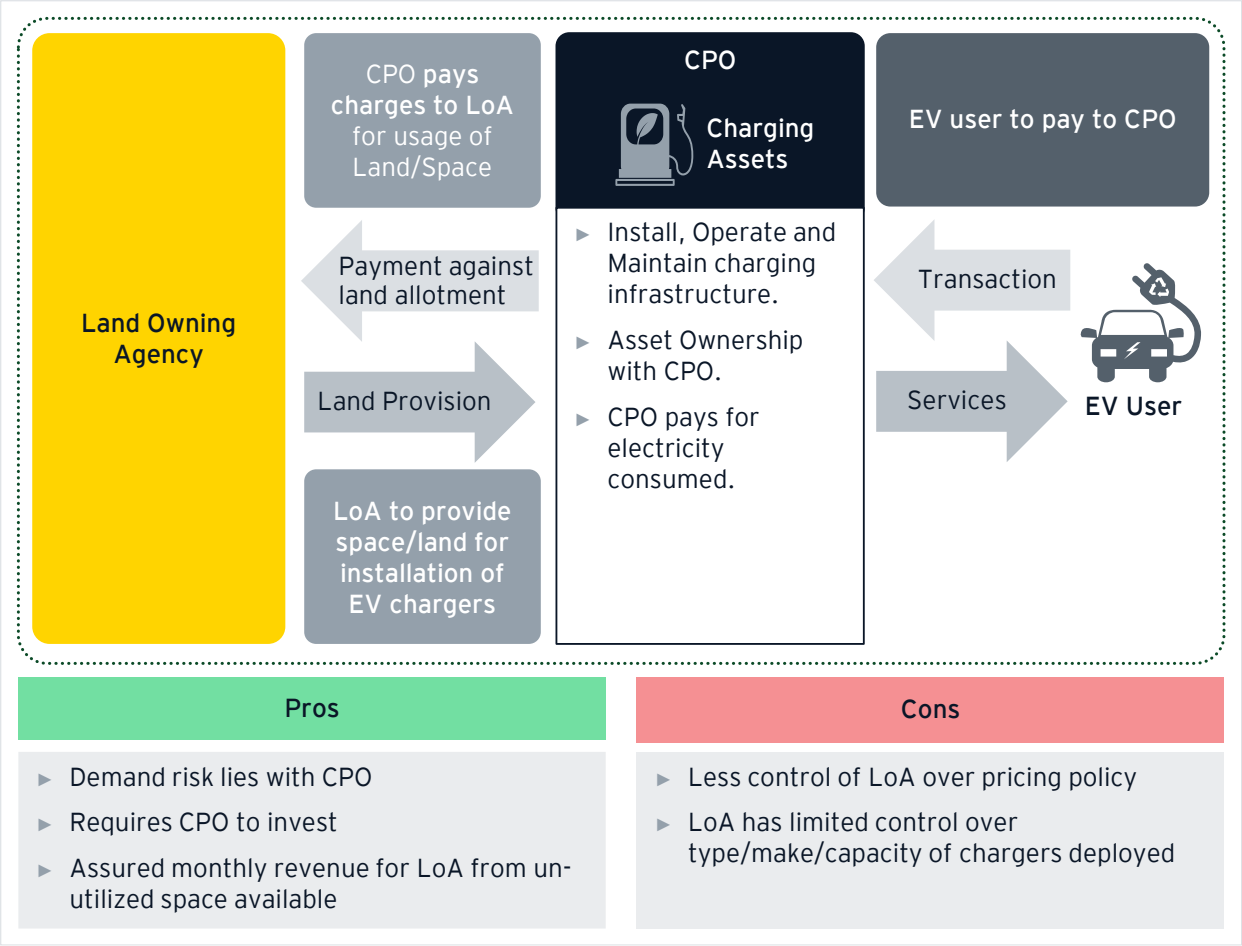
Pros	Cons
▸ More control of LoA over pricing policy ▸ LoA has more control over type/make/capacity of chargers deployed ▸ Ownership of assets lies with LoA	▸ Demand risk lies with LoA ▸ LoA required to invest ▸ LoA not having prior expertise in running EV charging business

Business Model 2: Land-Owning Agency

The government body can act as a Land-Owning Agency (LoA) and can provide the land to Charge Point Operator (CPO) to install and operate public charging stations within its license area after suitable locational planning. There can be multiple ways to implement this type of business model. ULB can either provide land to CPO on **rental basis** or ULB can enter into a **revenue sharing** agreement with CPO.

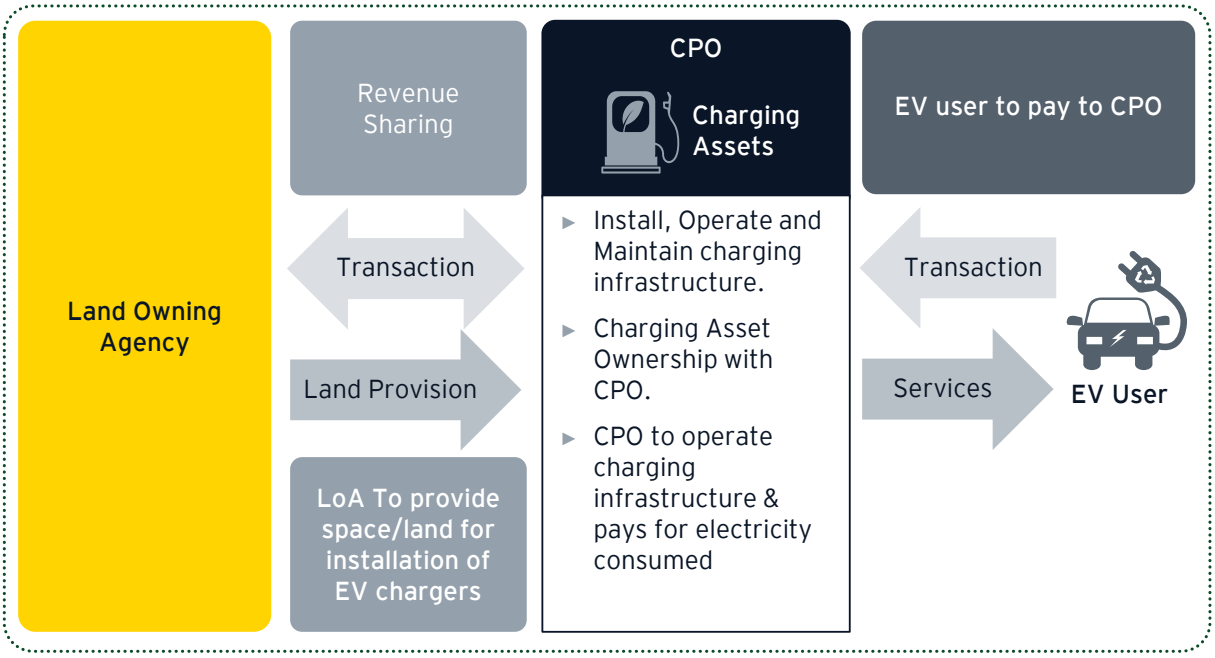
➔ Business Model 2: LoA - CPO Rental Arrangement Model

In urban areas, the cost of land is high and buying separate land to set up public charging stations significantly reduces the business viability. Arranging land on a rental basis is a better option where the land required for establishing the charging station is provided by the Land-Owning Agency (LoA). The Charge Point Operator (CPO) engages in a rental arrangement with the LoA, securing permission to utilize the land for charging infrastructure deployment. By the established terms of this agreement, the CPO disburses rental payments to the v. The CPO's role is installation, operation, and maintenance of the charging infrastructure, and retains full ownership of the charging station. Moreover, the CPO takes up the financial responsibility of covering the costs incurred by electricity consumption.

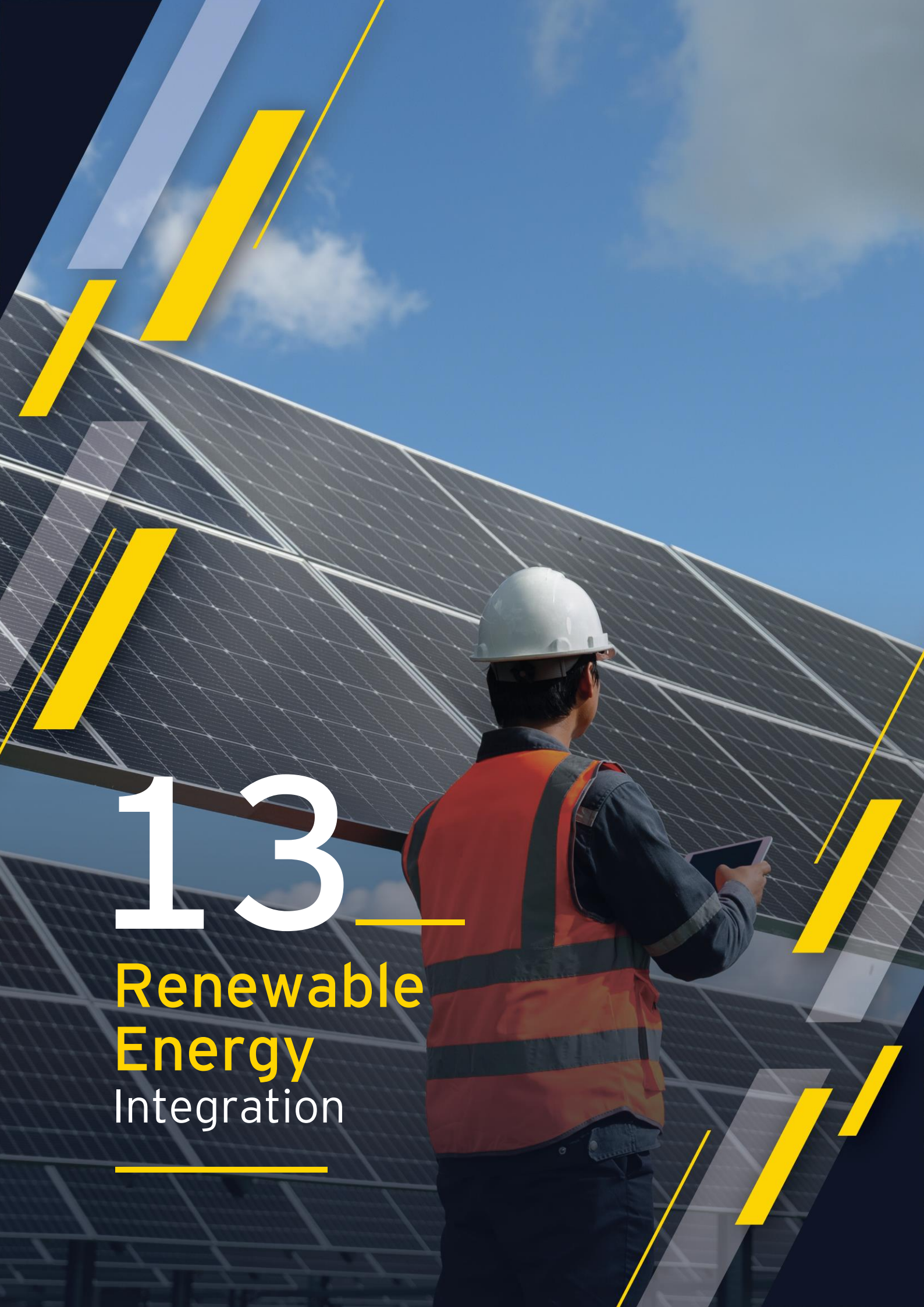


➔ Business Model 2b: LoA - CPO Revenue Sharing Arrangement

A business model which is widely used for its financial benefits to both, the LoA and the CPO is a revenue-sharing business model. In this scenario, the ULB extends the use of their land to the CPO for the installation of a charging station. A mutually agreed upon revenue sharing agreement is established between the LoA and the CPO, wherein a specified percentage of the revenue generated from service charges, paid by EV users for their charging requirements, is passed on to the LoA. Remaining consistent, the CPO takes on the responsibilities of installation, operation, and maintenance of the charging infrastructure while retaining ownership of the assets. The CPO remains accountable for covering the electricity expenses incurred by the charging station. As before, EV users directly remit their payments to the CPO for the charging services they utilize.



Pros	Cons
► Requires CPO to invest ► LoA has control over pricing policy and type/make/capacity of chargers deployed ► Generate revenue for LoA from un-utilized space available	► Demand risk shared by LoA & CPO both



13

Renewable Energy Integration

13.1. Introduction

The integration of Renewable Energy (RE) with Electric Vehicle (EV) charging infrastructure represents a pivotal stride towards sustainable and eco-friendly transportation solutions. In response to global environmental concerns and a collective commitment to reduce carbon emissions, the amalgamation of clean, renewable energy sources such as solar and wind power with EV charging systems has emerged as a transformative strategy. This synergistic approach not only aligns with India's pursuit of a low-carbon future but also addresses critical challenges related to energy security, air pollution, and grid management. In this context, the integration of RE with EV charging infrastructure becomes a linchpin, fostering a harmonious convergence of transportation and energy sectors for a cleaner, greener tomorrow.

At the global level, governments are implementing programs to transition away from traditional energy sources and towards clean energy to power EVs. Many utilities are introducing new pilot programs that enable EV users to utilize renewable energy for their charging needs. Integrating renewable energy with electric vehicle (EV) charging infrastructure in Varanasi holds significant importance for several reasons such as environmental sustainability, reduced carbon footprint, and long-term energy cost savings. By harnessing renewable energy sources, the electric vehicle charging ecosystem becomes more sustainable and aligns with the overall goals of transitioning to clean energy.

> For India, a country with abundant sunlight and increasing emphasis on sustainability, the integration of renewable energy into EV charging infrastructure can play a pivotal role in shaping a cleaner and more resilient energy future.

13.1.1. Benefits of Integrating RE with EV charging

Implementing renewable energy integration in EV charging infrastructure can contribute to:

1. **Environmental Benefits**: India, like many other countries, aims to reduce its carbon footprint to combat climate change. The integration of renewable energy sources, such as solar and wind power, with EV charging can significantly reduce carbon emissions associated with transportation. This is particularly crucial since the power sector is one of the largest contributors to carbon emissions.
2. **Energy Security**: India heavily relies on imported fossil fuels to meet its energy needs. The integration of renewable energy sources for EV charging can enhance energy security by reducing dependence on imported fossil fuels. This, in turn, helps mitigate the risks associated with price volatility and geopolitical tensions.
3. **Air Quality Improvement**: India grapples with severe air pollution issues in numerous cities, largely stemming from vehicular emissions. Shifting to electric vehicles charged with renewable energy holds the potential to enhance air quality by eliminating tailpipe emissions, which are major contributors to respiratory illnesses and other health concerns.
4. **Grid Stability and Peak Demand Management**: The integration of EV charging infrastructure has the potential to exert stress on the electricity grid, especially during peak demand hours. By incorporating renewable energy sources into EV charging systems, grid load management becomes more effective, allowing a reduction in peak demand. Furthermore, the implementation of smart charging systems enables the scheduling of charging activities during off-peak hours or periods of abundant renewable energy generation.
5. **Promoting Renewable Energy Investments**: The integration of renewable energy with EV charging infrastructure can establish synergies between the transportation and energy sectors, fostering investments in renewable energy projects. This has the potential to expedite the deployment of renewable energy projects in India, aligning with the country's sustainability targets and generating employment opportunities.
6. **Technological Innovation and Economic Growth**: The integration of renewable energy with EV charging necessitates technological advancements, including smart grids, energy storage solutions, and vehicle-to-grid (V2G) systems. These innovations can catalyse economic growth by stimulating investments in research and development, nurturing entrepreneurship, and generating job opportunities in emerging industries.
7. **Utilization of Solar Energy Surplus**: India has significant solar energy potential, particularly with its abundant sunlight throughout the year. However, solar power generation typically peaks during the daytime when electricity demand is relatively low. By coupling EV charging stations with solar installations, surplus solar energy can be effectively utilized to charge electric vehicles, maximizing the use of solar infrastructure, and reducing curtailment.
8. **Cost Savings**: Solar energy is becoming increasingly cost-competitive with conventional sources of electricity generation in India. Leveraging solar power for EV charging presents an opportunity for vehicle owners and charging station operators to potentially reduce their electricity costs over the long term. By relying less on grid electricity, especially during daylight hours when solar generation is plentiful, they can achieve greater cost-effectiveness.
9. **Scalability and Flexibility**: Solar-powered EV charging infrastructure exhibits a remarkable versatility, accommodating various scales ranging from residential installations to expansive public charging stations. This adaptability facilitates the widespread expansion of EV charging infrastructure, encompassing urban areas, highways, and even remote locations with limited grid connectivity. This, in turn, contributes significantly to the nationwide promotion of EV adoption.

13.2. Solar Energy adoption in Uttar Pradesh

Uttar Pradesh ranks 9th in clean energy production. As of March 2022, Uttar Pradesh's total installed energy capacity stood at 30,769 MW, with solar energy production reaching 2,567 MW by December 31, 2023[41].

Uttar Pradesh has left an indelible mark in the realm of solar energy. Over the past seven years, the state has achieved significant strides in this critical sector, serving as a guiding light for the entire nation. **During this period, Uttar Pradesh has successfully added approximately 2,300 MW of solar energy capacity**. This remarkable feat owes its success to the unwavering commitment of the state government, complemented by policies like the **UP Solar Energy Policy 2022, Solar Cities and Har Ghar Solar Yojana**. These policies not only paved the way for new investment opportunities but also delivered substantial benefits to both investors and the public.

The state government has set a target of generating 22,000 MW of solar power by 2026-27. This bold objective includes a proposal to **deploy 6,000 MW through solar rooftop systems in residential, governmental, organizational, and industrial buildings**. To achieve this, Uttar Pradesh is embracing innovative strategies and initiatives.

Additionally, Uttar Pradesh recognizes the necessity of a robust transmission system for power evacuation. To address this, a Green Energy Corridor with a capacity for evacuating **4,000 MW of power is coming up under construction in Bundelkhand Region**. The first phase, with a **capacity of 2,000 MW, is targeted for completion by 2026**. Despite technological advancements in renewable energy, challenges persist, particularly in economics, storage, and infrastructure. To encourage the adoption of renewable energy, Uttar Pradesh offers various subsidies and fiscal incentives. For instance, the state provides **a subsidy of Rs 30,000 per consumer, in addition to central subsidies, for installing solar rooftop systems**.

Uttar Pradesh's proactive approach to renewable energy extends beyond policies. The state is actively exploring innovative financing models to make solar installations more accessible to lower- middle-class populations. **Collaboration with financial institutions and the adoption of EMI schemes are among the strategies being considered.**

UP's Notable Achievements

Utility Scale Solar Power Projects:

The government, in collaboration with central PSUs such as THDC, NHPC, and SECI, is poised to install **4,000 MW of capacity within the next two years**. In addition to this, **private developers are set to add around 1400 MW in the** same period for selling power to Industries and for captive use.

[41] Invest UP

Rooftop Solar Power Projects:

Uttar Pradesh has successfully commissioned a **cumulative capacity of 345 MW in rooftop solar installations, benefiting 16,000 residential consumers.** Solar rooftop plants have also been established in ~1,550 buildings belonging to social institutions, educational institutions, universities, medical institutions, government and semi-government bodies, industrial, and commercial entities.

Varanasi have approximately 3.26 lakh electricity connections and 2.25 lakh households. **Varanasi boasts 664 rooftop consumers (588 of them residential) with connected load of 27 MW**. To promote the usage of solar rooftops, The Uttar Pradesh government will start a campaign to **install solar rooftops on 25,000 households in Varanasi city in next two months**[42]. The central and the state governments will provide subsidy of Rs 150 crores and Rs. 75 crores respectively to 25,000 households that purchase solar panels.

The 25,000-household rooftop installation target in Varanasi city in two months has been strategized by keeping a target of solarising around 250 houses in each 100 wards of the city using Geospatial technology with the Remote Sensing Application to find houses having substantial space and shadow free area.

UPNEDA has also finalised 100 solar panel vendors, 25 manufacturers and distributors, five invertors manufacturers, two net meter manufacturers that will set up their offices in Varanasi city to install solar rooftops.

Har Ghar Solar Abhiyan:

The **Uttar Pradesh government has launched 'Har Ghar Solar Abhiyan' in Lucknow and Varanasi** to promote solar adoption across the state. Through this initiative, the state government aims to **bolster solar capacity and achieve the 6 GW solar target set forth in UP's Solar Energy Policy 2022**[43]**.** As part of the Har Ghar Solar Abhiyan, the UP government will conduct camps state-wide, **providing detailed information on rooftop solar plant installation, application procedures, and net metering facilities**.

Uttar Pradesh is steadily advancing towards enhancing its solar energy capacity and embracing clean energy alternatives. The state offers a dedicated solar subsidy for residential consumers, in addition to financial assistance provided by the state to promote rooftop solar installations.

[42] https://www.hindustantimes.com/cities/lucknow-news/up-govt-to-install-solar-rooftops-on-25k-varanasi-households-in-just-two-months-101704652796190.html

[43] Invest UP

13.3. Approach for integrating Renewable Energy within EV Charging

Globally, governments are spearheading initiatives to shift from conventional energy sources to cleaner alternatives to power Electric Vehicles (EVs). In tandem with this, numerous utilities are launching pilot programs to facilitate EV users in utilizing renewable energy for their charging needs. The integration of renewable energy with EV charging has been approached through various strategies across the globe as mentioned below:

Renewable Energy Certificates (RECs)	On-Site Solar Installations	Green Tariffs and Time-of-Use Rates
Community Renewable Energy Programs	Smart Charging Infrastructure	Incentives and Subsidies

Approach for integrating RE with EV Charging

EV Charging with On-Site Renewables	EV charging is paired with an on-site renewable energy generation, most commonly by co-locating EVs with on-site solar energy systems.
Network charging	Network charging approach allow EV users to use electricity exclusively from Renewable sources to charge their EVs at the charging stations.
Shift Charging	EV charging is encouraged during off-peak periods or when renewable energy generation is high.
Managed Charging	Utilities and consumers can control the timing of EV charging to align with renewable energy availability and requirements of the electricity grid.
Time of Use based EV Charging with Renewables	Utilities provide discounted rates encourage customers to charge EVs when excess renewables are on the grid. Customer cannot claim the renewables.

These diverse approaches highlight the global commitment to transitioning towards cleaner energy sources for powering EVs, fostering a sustainable and eco-friendly mobility ecosystem.

Solar power, with its abundant availability and the feasibility of on-site installation, has emerged as an increasingly popular and suitable form of renewable energy for integrating with Electric Vehicle (EV) charging stations. This preference for solar energy extends beyond the charging infrastructure to homes and businesses, driven by a desire to reduce carbon footprints and achieve energy cost savings.

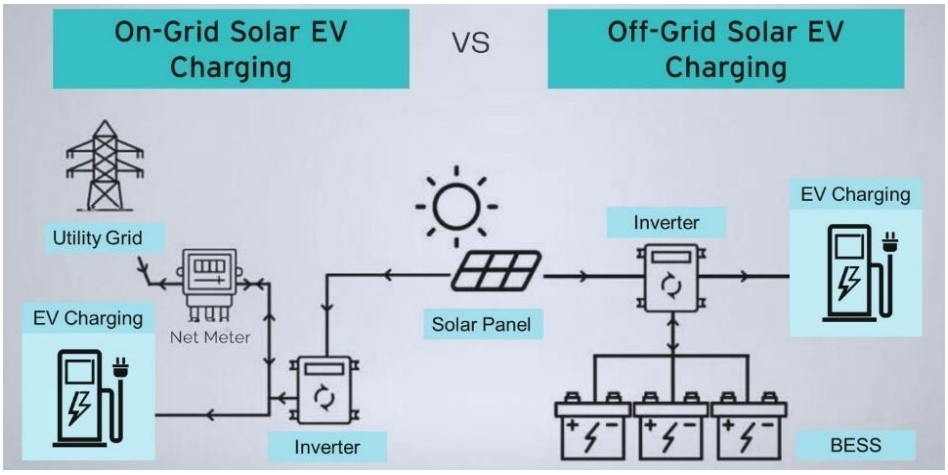
There are two primary categories of on-site solar power systems, each offering distinct advantages:

1. On-Grid Solar Power Systems:

On-grid solutions augment the electricity supply obtained from the utility grid by integrating solar power. Solar panels installed at the EV charging station feed excess energy back into the grid, contributing to the overall grid capacity. This approach ensures a continuous and reliable power supply, with any surplus energy being utilized beyond the charging station's requirements.

2. Off-Grid Solar Power Systems:

Off-grid solutions operate independently of the utility grid, relying on battery storage to store excess solar energy. These systems are self-sufficient and do not draw power from the grid. Off-grid solar power is particularly advantageous in remote locations or areas with unreliable grid connectivity, providing autonomy and resilience.



Parameter	On-Grid Solar System	Off-Grid Solar System
Connection to the Grid	Are connected to the electricity grid. They generate power during the day and give excess power back into the grid. When the solar panels are not generating electricity, the system takes power from the grid	Are connected to the electricity grid. They generate power during the day and give excess power back into the grid. When the solar panels are not generating electricity, the system takes power from the grid
Energy Storage	Do not require batteries to store excess energy for use during cloudy days or at night	Require batteries to store excess energy for use during cloudy days or at night
Maintenance	Maintenance for on-grid systems is generally simpler, as they do not require battery maintenance	Requires more maintenance
Assurance of Energy & Cost	When the grid is operating properly, it has a high degree of reliability. They could, however, experience power disruptions if the grid fails. Less expensive than off-grid.	Offers reliable energy, even during grid outages, making them suitable where grid access is unreliable. More expensive due to the cost of batteries & associated equipment.

The choice between the two depends on factors such as location, grid accessibility, energy requirements, and the level of desired autonomy, with each system presenting unique advantages and considerations.

Moreover, both on-grid and off-grid solar systems incorporate an EV Charging system. The EV charging system typically includes three main types of charging: DC charging, AC charging, and battery swapping. The system comprises charging guns, a power distribution controller, and protective appliances. In the battery swapping mode, the battery can be replaced using automatic or semi-automatic mechanical equipment, with replacement times typically ranging from 2 to 10 minutes.

13.4. Recommendations

The successful integration of renewable energy with EV charging in India requires a collaborative effort among both government and private stakeholders to establish an economically self-sustaining RE-integrated EV charging business. Key stakeholders include state and local governments, utilities, property owners/managers overseeing workplace charging and public parking, as well as participants from the solar and EV charging industries.

13.4.1. Recommendations for Government Sector

The government can play a crucial role by setting supportive policies and regulatory frameworks is key to fostering the successful integration of renewable energy with EV charging.

Sr. No.	Initiatives	Description
1	**Incentive Programs**	Establish comprehensive incentive programs to encourage the installation of renewable energy-integrated EV charging infrastructure. This could include tax credits, grants, or subsidies for businesses and individuals adopting these systems.
2	**Regulatory Support**	Develop and implement supportive regulations to streamline the permitting and approval processes for renewable energy and EV charging projects. Clear and efficient regulations can accelerate project timelines
3	**Public-Private Partnerships**	Foster collaborations between the government and private sector entities. Public-private partnerships can leverage resources, expertise, and funding for large-scale deployment of renewable energy-integrated EV charging stations.
4	**R&D Investments**	Allocate funds for research and development initiatives focused on advancing technologies related to renewable energy and EV charging. This could include improving energy storage solutions, enhancing charging efficiency, and reducing costs.
5	**Standardization**	Establish industry standards for the integration of renewable energy sources with EV charging infrastructure. Standardization can promote interoperability, ensuring that different systems work seamlessly together.
6	**Education and Awareness**	Implement awareness campaigns to educate the public about the benefits of renewable energy-integrated EV charging. This can drive adoption and create a positive perception of sustainable transportation solutions
7	**Grid Modernization**	Invest in upgrading the electricity grid to accommodate the increased demand from EV charging stations. Grid modernization efforts can enhance reliability and flexibility in managing renewable energy inputs
8	**Demonstration Projects**	Initiate pilot projects or demonstrations to showcase the feasibility and benefits of renewable energy-integrated EV charging. These projects can serve as models for future deployments
9	**Financing Programs**	Develop financing programs to support the deployment of renewable energy-integrated EV charging infrastructure. This could involve low-interest loans or financial instruments to make investments more attractive.
10	**Policy Alignment**	Ensure that existing policies related to renewable energy and electric vehicles align with the goal of integration. Identify and address any regulatory barriers that might hinder progress.

13.4.2. Recommendations for Private Sector

For the private sector to actively participate and contribute to the successful integration of renewable energy with EV charging, several strategic actions and initiatives can be undertaken. The private sector actors (solar and EV industries in particular)) can create initiatives to capture RE+EV value in its products and services. The private players can create suitable RE+EV market products to enhance the value-added opportunity of pairing the two technologies.

Sr. No.	Initiatives	Description
1	**Investment in Renewable Energy Infrastructure**	▸ Private businesses should consider investing in on-site renewable energy infrastructure, such as solar panels or wind turbines, to power their EV charging stations. ▸ Explore partnerships with renewable energy providers or developers to facilitate the integration of green energy sources.
2	**Green Certifications and Labels**	▸ Obtain and showcase green certifications or labels for EV charging stations powered by renewable energy. ▸ Communicate the commitment to sustainability and environmental responsibility to attract environmentally conscious consumers
3	**Collaboration with Renewable Energy Companies**	▸ Form partnerships with renewable energy companies to procure green energy for EV charging operations. ▸ Explore power purchase agreements (PPAs) or other collaborative models to ensure a reliable and sustainable energy supply.
4	**Development of Smart Charging Infrastructure**	▸ Invest in smart charging technologies that optimize charging schedules based on renewable energy availability and grid demand. ▸ Implement advanced energy management systems to enhance the efficiency of renewable energy usage.
5	**Community Engagement and Education**	▸ Engage with local communities to raise awareness about the benefits of renewable energy-integrated EV charging stations. ▸ Conduct educational campaigns to inform customers about the environmental impact of choosing renewable-powered charging options
6	**Incentive Programs for Employees and Customers**	▸ Create incentive programs for employees and customers who choose to charge their EVs using renewable energy sources. ▸ Offer discounts, loyalty rewards, or other perks to encourage sustainable charging practices
7	**Participation in Government Initiatives**	▸ Participate actively in government-led initiatives that promote the integration of renewable energy with EV charging. ▸ Advocate for supportive policies and incentives that benefit both private businesses and the broader renewable energy ecosystem
8	**Adoption of Energy Storage Solutions**	▸ Consider the integration of energy storage solutions, such as batteries, to store excess renewable energy for later use. ▸ Explore opportunities for peak shaving and grid support through the deployment of energy storage systems
9	**Demonstration Projects and Pilots**	▸ Undertake demonstration projects or pilot initiatives to showcase the viability and benefits of renewable energy-integrated EV charging. ▸ Share results and best practices with industry peers and stakeholders.
10	**Green Financing and Grants**	▸ Seek green financing options or grants that support renewable energy projects for EV charging infrastructure. ▸ Leverage available financial instruments to reduce the upfront costs associated with incorporating green energy sources.
11	**Monitoring and Reporting**	▸ Implement robust monitoring and reporting systems to track and transparently communicate the renewable energy performance of EV charging stations. ▸ Share data on energy usage, carbon savings, and other relevant metrics to build trust and credibility.

13.4.3. Recommendations for DISCOMs

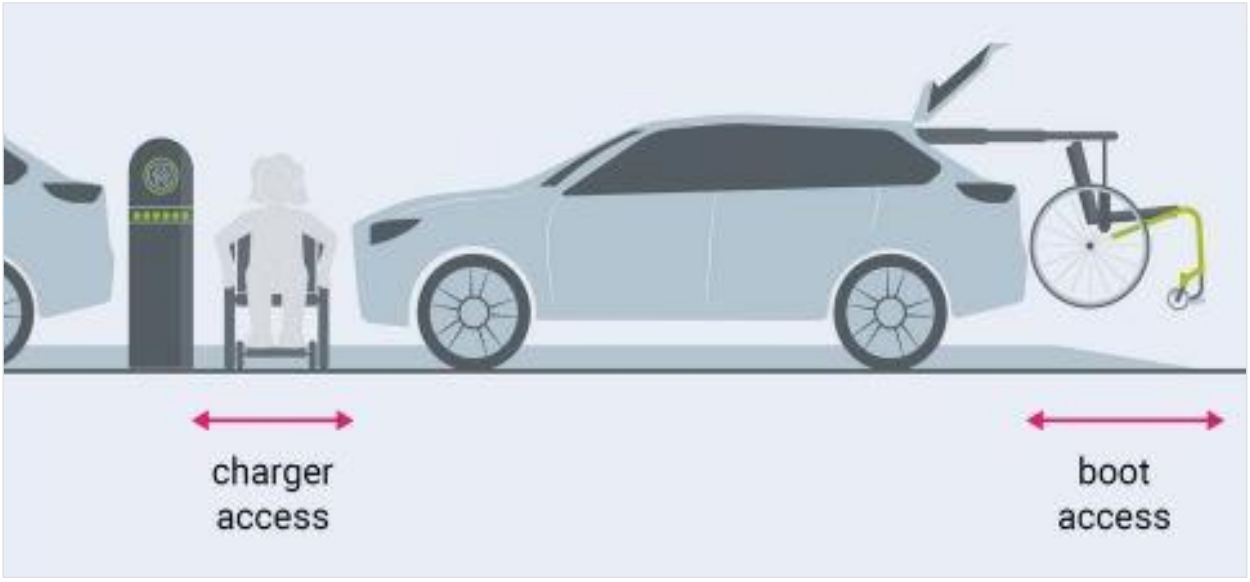
DISCOMs being the most critical stakeholders for the power supply system have a crucial role to play in supporting integration of RE with EV charging. DISCOMs must design supportive EV charging utility rates and incentives that enable potential demand charge savings, grid benefits, and bulk power benefits.

Sr. No.	Initiatives	Description
1	**Collaboration with Renewable Energy Developers**	▸ Form partnerships with renewable energy developers to facilitate the installation of solar or wind power projects that can directly supply energy to EV charging stations.
2	**Net Metering Policies**	▸ Implement and streamline net metering policies that allow EV charging stations to feed excess renewable energy back into the grid. ▸ Provide clear guidelines and incentives for entities contributing to the grid through renewable energy generation
3	**Time-of-Use Tariffs**	▸ Introduce time-of-use tariffs that encourage EV charging during periods of high renewable energy availability, thereby optimizing grid usage and promoting sustainable practices.
4	**Demand Response Programs**	▸ Develop demand response programs that incentivize EV charging stations to adjust their energy consumption based on grid conditions and renewable energy availability
5	**Grid Modernization**	▸ Invest in grid modernization initiatives to enhance the capacity and flexibility of the grid to accommodate the increased demand from EV charging stations powered by renewable energy.
6	**Dynamic Pricing Models**	▸ Implement dynamic pricing models that reflect real-time changes in electricity costs, encouraging EV charging during periods of lower demand or higher renewable energy production
7	**Interconnection Standards**	▸ Establish clear interconnection standards and procedures for integrating renewable energy sources with EV charging infrastructure. ▸ Streamline the process for obtaining grid connection approvals, ensuring a seamless integration process.
8	**Educational Campaigns for Consumers**	▸ Conduct educational campaigns to inform consumers about the benefits of using renewable energy for EV charging and how it contributes to a sustainable energy ecosystem
9	**Incentives for Renewable-Powered Charging Stations**	▸ Offer financial incentives or reduced tariffs for EV charging stations that derive a significant portion of their energy from renewable sources. ▸ Create tiered incentive structures based on the percentage of renewable energy used.
10	**Collaboration with Government Initiatives**	▸ Collaborate with government initiatives promoting the integration of renewable energy with EV charging stations. ▸ Provide input and feedback to policymakers to shape supportive regulations and incentive programs.
11	**Data Sharing and Monitoring**	▸ Implement data-sharing mechanisms to monitor the performance and impact of renewable energy-integrated EV charging stations on the grid. ▸ Use collected data to optimize grid operations and plan for future renewable energy integration.
12	**Development of Charging Hubs**	▸ Identify strategic locations for developing charging hubs powered by renewable energy. ▸ Prioritize areas where the integration of renewable energy and EV charging aligns with broader urban planning and sustainability goals
13	**Community Engagement**	▸ Engage with local communities to address concerns and build support for the integration of renewable energy with EV charging infrastructure.

14

Benefits of integrating EWCD friendly features **while planning EVCI**

Integrating Electric Vehicle (EV) Charging Infrastructure with services tailored to Elderly, Women, Children, and Disabled (EWCD) populations offers a range of benefits that cater to their specific needs and contribute to a more inclusive and accessible transportation system. Here are some key advantages:



1. **Inclusivity:** Integration promotes inclusivity by ensuring that transportation solutions, including EV charging infrastructure, are designed with diverse users in mind. This helps to address barriers to mobility and transportation faced by EWCD populations, thereby fostering a more inclusive society.
2. **Sustainability:** Encouraging the use of electric vehicles through integration with EWCD services aligns with broader sustainability goals by reducing greenhouse gas emissions and reliance on fossil fuels. This benefits not only current but also future generations, including children and vulnerable populations, by mitigating the impacts of climate change.

Integration of EV Charging infrastructure can be done by the following measures:

1. Opting for a location with a paved surface is advisable to guarantee accessibility regardless of weather conditions and to facilitate the delineation of buffer zones.
2. Selecting a parking spot adjacent to open space is highly recommended as it enhances accessibility and manoeuvrability.
3. **Accessibility:** EWCD integration ensures that EV charging infrastructure is accessible to all members of the community, including the elderly, women, children, and individuals with disabilities. This can include features such as designated parking spaces with easy access to charging stations and facilities that accommodate mobility aids.
4. **Safety and Security:** Providing well-lit, easily accessible EV charging stations with enhanced security features ensures a safe environment, particularly for vulnerable groups like the elderly and children.
5. **Assistance Services:** Helping services such as on-site personnel or digital support for charging assistance can be particularly beneficial for elderly individuals or those with disabilities who may require help navigating the charging process or handling charging equipment.
6. **Clear Indication of Compatibility:** In situations where multiple chargers are available, it's crucial to ensure that users can easily identify which charging point is suitable for their specific vehicle or equipment. By prominently displaying notices at each charging point, clearly indicating

compatibility with AC or DC charging, users can quickly determine the appropriate charging station to use, reducing confusion and streamlining the charging process.

7. **Distinct Differentiation of Rapid Charging Points:** Rapid charging points, operating at 500V DC, pose unique hazards compared to conventional charging points. Therefore, it's essential to distinctly differentiate them to prevent accidental misuse and ensure user safety. Implementing measures such as unique signage and physical barriers can effectively communicate the differences and prevent potential accidents.
8. **Positioning for Flood Resilience:** Electric vehicle charging points should be strategically positioned to mitigate the risk of water damage, especially in flood-prone areas. Ensuring that the socket-outlet of supply is at least 800 millimetres above the Highest Flood level helps safeguard the infrastructure against water ingress, minimizing the risk of electrical hazards and infrastructure damage during flooding events.
9. **Convenient Parking and Charging:** Electric vehicle parking spaces should be designed to optimize convenience for users during the charging process. By positioning the parking space within a five-meter radius of the charging point, users can easily access the charging infrastructure without needing to navigate significant distances, enhancing user experience, and promoting widespread adoption of electric vehicles.
10. **Safety Considerations for Children:** To ensure the safety of children, charging points should incorporate child-proof features and be situated away from designated play areas. By implementing safety measures such as child-proof enclosures and positioning charging points away from areas frequented by children, the risk of accidents or injuries can be significantly reduced, promoting a safer environment for all users.
11. **Prominent Signage and Markings:** Clear signage and markings are essential for guiding users to the charging bays and ensuring efficient use of the infrastructure. By prominently displaying signage and markings on the ground, users can easily locate and navigate towards the charging points, minimizing congestion and facilitating a smooth charging experience. Additionally, ensuring that charging cables are of sufficient length helps prevent damage and ensures compatibility with various types of vehicles and equipment, further enhancing user satisfaction and usability of the charging infrastructure.
12. For universal access, perpendicular charging bays should be 4.8m by 7.2m with 1.2m access zones on all sides, extendable to 1.5m near charging stations. Side-by-side bays need 1.5-1.8m between them.
13. For universal access, parallel on-street charging bays should be 3.6m by 7.2m with 1.2m access zones in front, back, and along the roadside. If 3.6m width isn't feasible, provide level access along the pavement. Consider extending the access zone to 1.5m where space permits.
14. The public charging station requires installation on a flat, stable surface with good traction. Surrounding surfaces should vary to indicate orientation and obstacles.
15. Whenever feasible, charging stations should align with road level for straightforward access. In cases of unavoidable height variations, ensure disabled access features like kerb drops and ramps adhere to existing regulations. Additionally, drainage infrastructure should be positioned to avoid obstructing access to the charging station.

15 Recommendations

In Varanasi, where history and spirituality converge, the shift towards electric vehicles aligns with the city's rich cultural tapestry. As Varanasi embraces modernity, the need for robust EV charging infrastructure becomes increasingly important. To seamlessly integrate EVs into Varanasi's busy streets, stakeholders must prioritize strategic planning and collaboration, with Varanasi Nagar Nigam and PuVNNL leading the way.

Varanasi's charm lies in its accessible spots brimming with cultural significance. Provision of public charging stations near the landmarks not only enhances convenience but also promotes sustainable mobility, blending tradition with technology.

Currently, CPOs encounter barriers in setting up charging stations. By simplifying regulations and offering incentives their involvement can be encouraged, fuelling the growth of EV charging networks. Also, over the years boosting charger usage is vital for the economic viability of EV charging businesses, hence, innovative strategies like flexible pricing and local partnerships can maximize charger usage, improving financial prospects for CPOs.

The shift towards electric mobility is not just about embracing innovation; it's about preserving heritage, fostering inclusivity, and building a sustainable future for generations to come. Through strategic planning, collaboration, and innovation, Varanasi can lead the charge towards a greener and more vibrant tomorrow.

Recommendations for adoption of e-Mobility in Varanasi:

Recommendations priority

1 Short term

- Location assessment
- Collaboration and Partnerships
- Creation of EV accelerator Cell and single window system
- Awareness Campaigns
- Identification of CPO for deployment of EVCI
- Integration with Development Plans
- Innovative Financing Mechanisms
- Integration with Public Transit
- Capacity building
- Dynamic pricing model

0 – 12 months

2 Medium term

- Regular Review and Policy Adaptation
- Implementing HOHO bus services
- Electric Public Bicycle Sharing (PBS)
- Introduction of electric water taxi/ferry
- Integration with Renewable Energy
- Incentivizing Workplace Charging
- E-rickshaw prohibited zones:
- Setting up of EVCI on fuel stations

12- 18 months

3 Long term

- Accessibility for All
- Data Collection and Analysis
- Green Parking Initiatives
- Zero emission zones

18 – 24 months

Short term Priority recommendations:

1. **Location assessment:** Varanasi needs to strategically plan the deployment of public charging infrastructure by considering factors such as accessibility, footfall, parking availability, and future development plans.
2. **Collaboration and Partnerships:** Collaboration between stakeholders, including Varanasi Nagar Nigam, land-owning agencies, and Charging Point Operators (CPOs), is crucial. Partnerships can be fostered through concessional land offerings and revenue-sharing mechanisms.
3. **Creation of EV accelerator Cell and single window system:** Establishing an EV accelerator cell focusing upon strategizing growth of electric mobility and charging infrastructure in Varanasi. Example, capacity-building efforts, creation of single window system for obtaining necessary permits and approvals.
4. **Awareness Campaigns:** Comprehensive awareness campaigns are vital for promoting understanding and adoption of EV charging infrastructure among residents. Varanasi can employ diverse communication channels and community engagement strategies to foster a culture of sustainable mobility.
5. **Identification of CPO for deployment of EVCI:** it can be conducted through a competitive tendering process by floating a Request for Proposal (RFP) with Additions, to ensure public safety at charging stations, measures like adequate lighting, security cameras, and emergency call boxes are implemented, ensuring the safety and security of EV owners and the infrastructure.
6. **Integration with Development Plans:** Integrating public EV charging infrastructure planning with overall development plans ensures alignment with urban mobility strategies and sustainability goals.
7. **Innovative Financing Mechanisms:** Explore innovative financing mechanisms, such as public-private partnerships, or green bonds, to mobilize investment capital for the deployment of EV charging infrastructure in Varanasi.
8. **Integration with Public Transit:** Integrate EV charging infrastructure with existing public transit systems, such as bus terminals, to encourage multi-modal transportation and provide EV owners with convenient charging options while utilizing other modes of transit.
9. **Capacity building:** Provide training programs and educational resources for EV owners, charging station operators, and maintenance personnel to ensure safe and efficient operation of EV charging infrastructure and promote user awareness and confidence.
10. **Dynamic Pricing Models**: Implement dynamic pricing models for EV charging, such as time-of-use or demand-based pricing, to incentivize off-peak charging and optimize resource utilization, thereby reducing strain on the electrical grid during peak hours.

Medium term Priority recommendations:

1. **Regular Review and Policy Adaptation:** Regular review processes and the introduction of city policy are integral to maintaining effectiveness and relevance. Varanasi should evaluate EV policy targets, incorporate public feedback, and adapt to changing dynamics and technological advancements.

2. **Implementing HOHO bus services** in Varanasi would enhance tourism, improve connectivity, reduce traffic congestion, promote environmental sustainability, boost the local economy, foster cultural exchange, and enhance accessibility, making it a valuable addition to the city's transportation infrastructure. An electric HOHO bus will enhance the city's image as a forward-thinking tourist destination.

3. **Electric Public Bicycle Sharing (PBS)** in Varanasi offers sustainable mobility by reducing emissions, enhancing connectivity, promoting physical activity, reducing congestion, and enriching tourism. Integrating electric HOHO buses and PBS provides a seamless, sustainable mobility solution, improving travel for residents and tourists while contributing to a cleaner transportation system. Implementing electric PBS at Banaras Hindu University (BHU) will offer convenient, eco-friendly transportation for students, faculty, staff, and visitors, aligning with BHU's commitment to sustainability and reducing congestion.

4. **Introduction of electric water taxi/ferry:** Introducing electric water taxis/ferries in Varanasi is crucial for easing traffic congestion and pollution while enhancing tourism. These zero-emission vessels offer a sustainable alternative for transportation along the Ganges River, reducing carbon emissions and traffic pressure. Additionally, they provide tourists with a scenic way to explore the city's cultural landmarks, supporting local businesses and showcasing Varanasi's commitment to sustainability.

5. **Integration with Renewable Energy:** Explore opportunities to integrate EV charging infrastructure with renewable energy sources, such as solar panels or wind turbines, to reduce carbon emissions and enhance sustainability.

6. **Incentivizing Workplace Charging:** Encourage businesses and employers to install EV charging stations at workplace parking facilities through incentives, subsidies, or tax benefits, promoting EV adoption among employees and reducing emissions from commuter vehicles.

7. **E-rickshaw prohibited zones:** To address congestion caused by the growing number of slow-moving e-rickshaws, certain zones in the city can be designated as e-rickshaw restricted areas. This measure aims to manage traffic flow more effectively as e-rickshaw sales are expected to continue rising in the future.

8. **Setting up of EVCI on fuel stations:** It is recommended that the Ministry of Petroleum and Natural Gas (MoPNG) conduct a feasibility study to assess the potential for installing EV chargers at fuel stations in high-demand zones.

Long term Priority recommendations:

1. **Accessibility for All:** Ensure that EV charging infrastructure is accessible to all segments of the population, including individuals with disabilities, elderly and women, by incorporating accessible design features and providing designated parking spaces with charging facilities. Also, designed in a way that it is child proof and away from children's play area.
2. **Data Collection and Analysis:** Implement systems for collecting and analysing data on EV charging usage, user demographics, and trends, real time monitoring dashboard for enabling informed decision-making.
3. **Green Parking Initiatives**: Introduce green parking initiatives that incentivize EV owners with preferential parking spots, discounted parking fees, or extended parking durations at locations equipped with EV charging stations, encouraging EV adoption and utilization of charging infrastructure.
4. **Zero emission zones:** Zero emission zones (ZEZs) are designated areas where only vehicles producing no tailpipe emissions, such as electric or hydrogen-powered vehicles, are permitted to operate. These zones can be in a proximity of 2km radius of major tourist spots, wherein on electric vehicles and active transportation can operate. These zones aim to reduce air pollution, improve public health, and combat climate change by encouraging the adoption of cleaner transportation technologies.

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Annexures

Annexure I

ICE vehicle segment and their specifications:

Table 22: ICE vehicle segments and their specifications for TCO calculation

Parameters	2W	3W	4W (private)	4W (Commercial)	Bus
Fuel type	Petrol	Diesel	Petrol	Petrol	Diesel
Vehicle Model	Honda activa 125	Piaggio Ape auto DX-Diesel	Swift Dzire ZXI Plus	Swift Dzire ZXI Plus	Tata star bus LPO 7.5
Vehicle Cost	91,233	3,54,000	10,16,000	10,16,000	30,00,000
Range in full tank	243.8	315	829	829	540
Max. speed (kmph)	93	60	165	165	80
Engine capacity (cc)	124	597.7	1197	1197	3300
Kerb weight	110	480	985	985	8,500
tank Capacity (ltr.)	5.3	10.5	37	37	120
Mileage	46	30	22.41	22.41	4.5
Fuel Consumption/ 100KM (Ltr)	2.17	3.33	4.46	4.46	22.2
Fuel consumption/ KM (Ltr)	0.02	0.03	0.044	0.044	0.22

Electric vehicle segment and their specifications:

Table 23: Electric vehicle segment and their specifications for TCO calculation

Parameters	e-2W	e-3W	e-4 (private)	e-4W (commercial)	e-Bus	e-Bicycle	e-scooters
Vehicle Model	Ola s1	Ape E- City FX NE MAX	Tata Nexon EV XM	Tata tigor EV XE	PMI Regio-9m	Hero Lectro C4+	Ola S1 X
Vehicle Cost	130000	326000	1449000	1374000	10000000	30000	108000
Range	141	181	312	314	150	30	91
Max. speed (kmph)	75.3	41.6	80	116.5	80	-	
Acceleration (m/s2)	1.32	0.68	1.7	1.4		-	
Kerb weight	125	125	1235	1235		-	
Battery Capacity (kWh)	2.98	8	30.2	26	151	0.21	2
Battery type	Nickel Manganese Cobalt Oxide	Lithium	Lithium-ion Iron Phosphate	Lithium-ion Iron Phosphate	Adv Lithium ion	-	Lithium Ion
Energy Consumption/ 100KM (kWh)	3.3	5.17	10.6	11	100.67	-	2.2
Energy Consumption/KM (kWh)	0.033	0.0517	0.106	0.11	1.01	0.007	0.022

Assumptions for calculation of TCO:

Table 24: Assumptions for calculation of TCO

Parameter		Unit	e-2W	e-3W	e-4W (private)	e-4W (commercial)	Bus	E-scooters
General	Lifecycle of Vehicle	years	10	10	10	10	10	
	Lifecycle of Battery	years	5	5	5	5	5	
	Cost of Battery	$/kWh	133	133	133	133	133	
	Dollar to INR	Rs.	83.4	83.4	83.4	83.4	83.4	
Financial	Loan Tenure	years	5	5	5	5	5	5
	Rate of Interest	pa	19.50%	13%	9.30%	9.30%	9.30%	19.50%
	Equity		30.00%	30%	30%	30%	30%	100%
	Debt		70.00%	70%	70%	70%	70%	0%
	Insurance Amount Annually- ICE	PA	1.30%	1.30%	1.30%	1.30%	1.30%	
	Insurance Amount Annually- EV	PA	1.30%	1.30%	1.30%	1.30%	1.30%	5.30%
	Maintenance Cost ICE + repairs	INR/PA	4800	18200	24000			2808
	Maintenance Cost EV + repairs	INR/PA	2000	7200	8200			
	Maintenance Cost ICE + repairs	INR/km				2.075	10.02	
	Maintenance Cost EV + repairs	INR/km				0.83	4.43	
	Depreciation of Vehicles	PA	10%	10%	10%	10%	10%	20%
	YoY escalation on maintenance		5%	5%	5%	5%	5%	2%
Operational	Operational Days in a year	days	312	350	312	350	350	312
	Months in a Year	months	12	12	12	12	12	12
	Distance travelled per day	kms	20	120	30	140	200	60
	Home Charging/ EV Tariff	INR/kWh	9	9	9	9	-	
	Workplace charging	INR/kWh	15		15			
	Captive charging	INR/kWh		15		15		
	Public charging / Depot Charging for buses	INR/kWh	12.21	20.42	20.42	20.42	9	
	YoY escalation		5%	5%	5%	5%	5%	
	Cost of Diesel	INR/Litre	94.84	87.99	94.84	87.99	90.08	
	YoY escalation		5%	5%	5%	5%	5%	
	GST on ICE		28%	28%	28%	28%	28%	
	GST on EV		5%	5%	5%	5%	5%	

Annexure II: Detailed list of existing EV charging stations in Varanasi

Table 25: Detailed list of existing EV charging stations in Varanasi

Owner/ Vendor	Location	Latitude	Longitude	Types of chargers installed / Connector	Charger Rating	Number of Charger
Indian Oil Corporation Ltd (IOCL)	Neelkanth Kisan Sewa Kendra,Village Lacchirampur Pargana Pandah Tehsil Pindra	25.30081	82.80588	Bharat AC-001	3.3	1
Indian Oil Corporation Ltd (IOCL)	Neelkanth Kisan Sewa Kendra,Village Lacchirampur Pargana Pandah Tehsil Pindra	25.30081	82.80588	Type-II AC	7.4	1
Indian Oil Corporation Ltd (IOCL)	Prabhunarayan Filling Station,Vill-Dandoopur Taluka-Sadardistt-Varanasi Up	25.38673	82.95888	Bharat AC-001	3.3	1
Indian Oil Corporation Ltd (IOCL)	Prabhunarayan Filling Station,Vill-Dandoopur Taluka-Sadardistt-Varanasi Up	25.38673	82.95888	Type-II AC	7.4	1
Indian Oil Corporation Ltd (IOCL)	T.S.Filling Ksk,Village Lerhupur Taluka Sadar Distt Varanasi	25.35762	83.04477	Bharat AC-001	3.3	1
Indian Oil Corporation Ltd (IOCL)	T.S.Filling Ksk,Village Lerhupur Taluka Sadar Distt Varanasi	25.35762	83.04477	Type-II AC	7.4	1
National Thermal Power Corporation	Ms Hsd Sanhetana Sambharan Kendra,Babaptpur , Varanasi	25.43510	82.85550	Bharat DC-001	15	1
National Thermal Power Corporation	Hp Petrol Pump Sankatmochan,Hp58,Lanka Durgakund Marg Sankat Mochan Varanasi-221001	25.28543	83.00017	Bharat DC-001	15	1
Tata Power	Hotel Ganges grand, Godowlia, D-37/47, 47-A ,47A-1, Hotel Ganges Grand, Godowlia, Dashashwamedh, Uttar Pradesh,221010	25.30961	83.00735	CCS-II	25	1
Tata Power	Hotel Ganges grand, Godowlia, D-37/47, 47-A ,47A-1, Hotel Ganges Grand, Godowlia, Dashashwamedh, Uttar Pradesh,221010	25.30961	83.00735	Type-II AC	7.4	1
Tata Power	Hotel Ganges grand, Godowlia, D-37/47, 47-A ,47A-1, Hotel Ganges Grand, Godowlia, Dashashwamedh, Uttar Pradesh,221010	25.30961	83.00735	Type-II AC	7.4	1
Tata Power	Hotel Tridev Grand, Durgakund, B-36/10, Tridev Mandir, Durgakund, Varanasi 221005	25.28651	82.99978	CCS-II	25	1
Tata Power	Hotel Tridev Grand, Durgakund, B-36/10,	25.28651	82.99978	Type-II AC	7.4	1

Owner/ Vendor	Location	Latitude	Longitude	Types of chargers installed / Connector	Charger Rating	Number of Charger
	Tridev Mandir, Durgakund, Varanasi 221005					
Tata Power	Taj Ganges, Nadesar Palace Grounds, Nadesar Palace Grounds, Varanasi - 221002	25.33593	82.98550	CCS-II	30	1
Tata Power	Taj Ganges, Nadesar Palace Grounds, Nadesar Palace Grounds, Varanasi - 221002	25.33593	82.98550	CCS-II	30	1
Tata Power	Nadesar, Chaukaghat, Varanasi, Uttar Pradesh 221002	25.33586	82.98551	Type-II AC	7.4	1
Tata Power	Nadesar, Chaukaghat, Varanasi, Uttar Pradesh 221002	25.33586	82.98551	Type-II AC	7.4	1
Bharat Petroleum Corporation Ltd (BPCL)	Khajuri,Varanasi,Dst Varan, Varanasi, Uttar Pradesh 221104	25.27570	82.80924	CCS-II	30	1
Airport Authority of India, Delta make	Babatpur Airport Parking, Varanasi, Uttar Pradesh	25.4484	82.8572	DC 001	15	1
Airport Authority of India, Delta make	Babatpur Airport Parking, Varanasi, Uttar Pradesh	25.4484	82.8572	AC 001	7.4	1

Annexure III: Detailed list of 33/11kV substations in Varanasi

Table 26: Detailed list of 33/11kV substations in Varanasi

Sr. no.	33/11 kV Upkendra name	Latitude	Longitude
1	33/11 kV substation Laksa, Varanasi city	25.31765	82.97391
2	33/11 kV substation Rathyatra, Varanasi city	25.30709	82.99165
3	33/11 kV substation Belpur, Varanasi city	25.31765	82.97391
4	33/11 kV substation Khojva, Varanasi city	25.29378	82.9945
5	33/11 kV substation Gaudalia, Varanasi city	25.31765	82.97391
6	33/11 kV substation Pandey Haveli, Varanasi city	25.31377	82.99576
7	33/11 kV substation Shivala Assi, Varanasi city	25.29211	83.00592
8	33/11 kV substation Birdopur, Varanasi city	25.30163	82.99626
9	33/11 kV substation Dashashmedh, Varanasi city	25.31765	82.97391
10	33/11 kV substation Maldahiya, Varanasi city	25.3255	82.99518
11	33/11 kV substation Nati Imli, Varanasi city	25.32631	83.00495
12	33/11 kV substation Beniya, Varanasi city	25.31765	82.97391
13	33/11 kV substation Chetganj, Varanasi city	25.32414	82.99168
14	33/11 kV substation Shastri Nagar, Varanasi city	25.31547	82.98963
15	33/11 kV substation Badshah Bagh, Varanasi city	25.31765	82.97391
16	33/11 kV substation Singra, Varanasi city	24.49998	89.14292
17	33/11 kV substation Chittpur, Varanasi city	25.31765	82.97391
18	33/11 kV substation Nagar Nigam, Varanasi city	25.31588	83.00456
19	33/11 kV substation BHU, Varanasi city	25.26772	82.99126
20	33/11 kV substation Nagva upkendra, Varanasi city	25.31765	82.97391
21	33/11 kV substation Kabirnagar Upkendra, Varanasi city	25.31765	82.97391
22	33/11 kV substation Kandwa upendra, Varanasi city	25.26136	82.9636
23	33/11 kV substation Karondi Upkendra, Varanasi city	25.26979	82.97348
24	33/11 kV substation Ramnagar upkendra, Varanasi city	25.31765	82.97391
25	33/11 kV substation Dafi upkendra, Varanasi city	25.24444	82.97972
26	33/11 kV substation New Ramnagar upkendra, Varanasi city	25.31765	82.97391
27	33/11 kV substation Lohta (industrial estate), Varanasi city	25.30476	82.95824
28	33/11 kV substation Bhatti, Varanasi city	25.31765	82.97391
29	33/11 kV substation Kotwa, Varanasi city	25.34349	82.92461
30	33/11 kV substation Fulwariya, Varanasi city	25.31765	82.97391
31	33/11 kV substation Ranipur, Varanasi city	25.29992	82.97616
32	33/11 kV substation Maduadih, Varanasi city	25.30338	82.9678
33	33/11 kV substation Brij enclave, Varanasi city	25.28648	82.9804
34	33/11 kV substation DPH, Varanasi city	25.31765	82.97391
35	33/11 kV substation Lahartara, Varanasi city	25.31634	82.97301
36	33/11 kV substation Maidagin, Varanasi city	25.31898	83.01291
37	33/11 kV substation Machodari, Varanasi city	25.32222	83.01935
38	33/11 kV substation Maidagin, Varanasi city	25.31898	83.01291

Sr. no.	33/11 kV Upkendra name	Latitude	Longitude
39	33/11 kV substation Chowk, Varanasi city	25.31441	83.00995
40	33/11 kV substation Tunnel house, Varanasi city	25.31765	82.97391
41	33/11 kV substation Ardali Bazar and MIS, Varanasi city	25.34769	82.98089
42	33/11 kV substation Sanskritik school, Varanasi city	25.31765	82.97391
43	33/11 kV substation Panna lal park, Varanasi city	25.343	82.97542
44	33/11 kV substation New Badalalpur, Varanasi city	25.37976	82.97435
45	33/11 kV substation Badalalpur, Varanasi city	25.37976	82.97435
46	33/11 kV substation Pandeypur, Varanasi city	25.35285	82.99719
47	33/11 kV substation Tarna, Varanasi city	25.36105	82.93738
48	33/11 kV substation Koilahwa, Varanasi city	25.31765	82.97391
49	33/11 kV substation Pandeypur and Sanskritik School, Varanasi city	25.35285	82.99719
50	33/11 kV substation Purana Daulatpur, Varanasi city	25.31765	82.97391
51	33/11 kV substation Udaipur and Goithawa, Varanasi city	24.58545	73.71248
52	33/11 kV substation Udaipur, Varanasi city	24.58545	73.71248
53	33/11 kV substation Shaktipith, Varanasi city	25.31765	82.97391
54	33/11 kV substation Ledhupur, Varanasi city	25.35162	83.04889
55	33/11 kV substation Naya Daulatpur, Varanasi city	25.31765	82.97391
56	33/11 kV substation Ledhupur, Varanasi city	25.35162	83.04889
57	33/11 kV substation Kashi, Varanasi city	25.31765	82.97391
58	33/11 kV substation IDH Colony, Varanasi city	25.31765	82.97391
59	33/11 kV substation Chowkaghat, Varanasi city	25.33229	82.99043
60	33/11 kV substation Alaipur, Varanasi city	25.33174	83.00764

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Varanasi Nagar Nigam

Varanasi Nagar Nigam, also known as Varanasi Municipal Corporation, is responsible for the civic administration and infrastructure development of Varanasi city. It provides essential services like waste management, water supply, road maintenance, and public health. Committed to enhancing the quality of life for its residents, the corporation aims to make Varanasi a clean, green, and sustainable city.

Convergence Energy Services Limited

Convergence Energy Services Limited (CESL), a subsidiary of EESL, focuses on renewable energy, electric mobility, and climate change. CESL delivers renewable energy solutions for agricultural pumps, lighting, and cooking appliances in rural India. It also promotes battery-powered electric mobility and infrastructure to boost electric vehicle adoption. CESL is also the implementing agency for ADB GEF7 program.

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