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Readiness and Capacity Needs Assessment for Electric Vehicle Adoption in Indian Cities

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Contents

List of Tables

List of Figures

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Executive Summary

Electric Vehicles in the Context of India

In India, the electric vehicle (EV) transition is one of the key elements for realisation of a sustainable transportation future. The nation's target of 30% EV penetration by 2030 would be a vital step towards India's major sustainability goals. So far, EV adoption has been slow, however, there is tremendous potential for electrification due to the country's rapidly increasing demand for transportation. As India continues to grow and urbanise, accelerating the rate of EV diffusion is becoming increasingly important for the nation's vision of a sustainable future.

Purpose

As cities work closely with electricity utilities, transportation planners, vehicle manufacturers, and other key players in the EV ecosystem, city-level interventions may be able to kickstart EV deployment in India. However, city-level interventions in India have been under-explored through both policy and research. Therefore, the purpose of this report is twofold:

1. To understand the current status and rank the readiness of Indian cities for EV planning and adoption.
2. To identify the capabilities and roadblocks for future EV planning and deployment in Indian cities.

Profiles of Selected Cities

Four Indian cities with varied transportation landscapes were selected for an in-depth EV readiness and capacity needs analysis. To conduct this study, insights from stakeholders involved with various areas of the EV transition were gathered to understand the key factors influencing EV deployment at the city level. After designing a multi-criteria city selection framework, the team interviewed and surveyed stakeholders from the following cities:

1. **New Delhi:** New Delhi is high-population megacity that leads India in the EV transition. Additionally, as the nation's capital city, New Delhi has a unique government and institutional structure.
2. **Bengaluru***:* Like New Delhi, Bengaluru too is a highly populous city that has shown a willingness to be an innovator in the EV space. Karnataka was the first state to pass a dedicated policy to promote EV growth.
3. **Guwahati:** Guwahati is a medium-population city and a major industrial hub with a high percentage of commercial vehicles.
4. **Panaji:** Panaji is a low-population city with a high density of tourist vehicles and highly seasonal transportation patterns. Additionally, a uniquely high share of bus service is provided by private operators.

Findings

On the basis of the interviews conducted and gathered data via surveys, we reviewed each city, in terms of the following seven key criteria to determine overall readiness score for EV.

1. **Institutional:** While each of the selected cities does not have any local EV policy, their belonging states have an EV policy in place that influences the EV landscape in the city. Bengaluru and New Delhi's EV policies have been active for years and are at latter stages of implementation than Panaji and Guwahati's as introduction of EV policy in these cities is of recent origin. New Delhi emerged as the clear leader amongst the four cities with reference to institutional EV readiness.
2. **Infrastructure:** Stakeholders consistently identified charging infrastructure as one of the prerequisites for the successful EV deployment. The need extends to all phases of EV charging points installation, from the charging model to location planning of charging points to the number of charging stations. Our analysis found that Bengaluru and New Delhi lead the way in this respect.
3. **Technology:** Across our selected cities, the availability of reliable and sufficient electricity was the key technological development challenge impacting EV diffusion. While New Delhi once again emerged as the leader, Guwahati scored extremely low, as mass EV adoption would likely overwhelm the city's electricity grid.
4. **Economic:** Higher capital costs of EVs remain the greatest economic challenge to mass EV adoption in the selected cities as buyers are either unaware of the reduced cost of ownership or unable to afford the higher up-front cost. Market penetration of EVs was the greatest in Delhi, while Panaji's share of EVs lagged behind the remaining three cities.
5. **Social:** Some experts saw social willingness to accept EVs as an underrated element of EV readiness. It seems that the government's support of EVs through subsidies has been a major factor in increasing the public trust in EVs as a safe and reliable transportation option. With the highest EV sales growth rate among the selected cities, Bengaluru leads this study, in terms of shifting public opinion in favour of EV.
6. **Environmental:** EVs are positioned as a key to improve environmental outcomes like air quality and pollution in cities. As one of the most polluted cities, New Delhi set itself apart from the target cities by instituting the Air Quality Monitoring Committee that explicitly incorporates EV deployment in its plan of action. Meanwhile the remaining three cities lack comparable environmental action plans suitable for EV adoption.
7. **Innovation:** Innovation emerged as the key for constructing a local self-sustaining EV environment. To promote EV deployment, city governments may collaborate with private players to co-develop models for EV growth. Alternatively, they may lead by example by actively implementing EVs in government fleets. This can be a growth area for each city, although Bengaluru and New Delhi scored markedly higher than Guwahati and Panaji.

Overall City-level Electric Vehicle Readiness Assessment

The final overall readiness scores from our readiness and capacity needs assessment were led by New Delhi with a score of 72.3/100 points, followed by Bengaluru (57.1/100), Guwahati (30.5/100), and Panaji (30.0/100). Despite all of them being capital cities, substantial variations in the EV readiness is reflected in the analysis. The study indicated that New Delhi is already much ahead in the EV planning and deployment, with its strong areas being institutional/policy, infrastructure and economic capacities. The cities of Panaji and Guwahati are in the early stages of EV adoption and have large scope in exploring innovative actions for accelerated EV adoption. A key observation that was seen in the case of all cities was the interdependency of one criterion on the other, prompting a holistic approach towards EV planning and deployment. Overall, key capacity areas, such as fiscal incentives, more local level interventions, EV awareness campaigns, learning from international best practices, etc. were also identified in order to implement innovative and targeted interventions for EV adoption.

1 Introduction

1.1 Background and Context Setting

Global dependence on fossil fuels in the transport sector has been a key driver of climate change and air pollution for decades (IEA, 2020). Despite major concerns about the sustainability of a fossil fuel-dependent transport sector, projections suggest that a whopping 88% of the global sector will still run-on fossil fuels in 2040 (IEA, 2016). With road vehicles accounting for almost 75% of the global transportation greenhouse gas (GHG) emissions (IEA, 2020), a sustainable future requires a paradigm shift away from internal combustion engines (ICE) in favour of cleaner propulsion systems for road vehicles (Shah, *et al.*, 2021). Electric vehicles (EVs) are positioned to be a significant part of this shift, as they produce zero on-road emissions while performing at a level competitive to internal combustion vehicles (Dominković, *et al*., 2018).

In response to sustainable transport concerns, India has set an aggressive initial target of 30% adoption of EVs by 2030. This would have a material impact on the nation's progress towards general sustainability objectives, including Nationally Determined Contributions (NDCs) related to emissions intensity and Sustainable Development Goals (SDGs) in the areas of public health, energy, and climate.

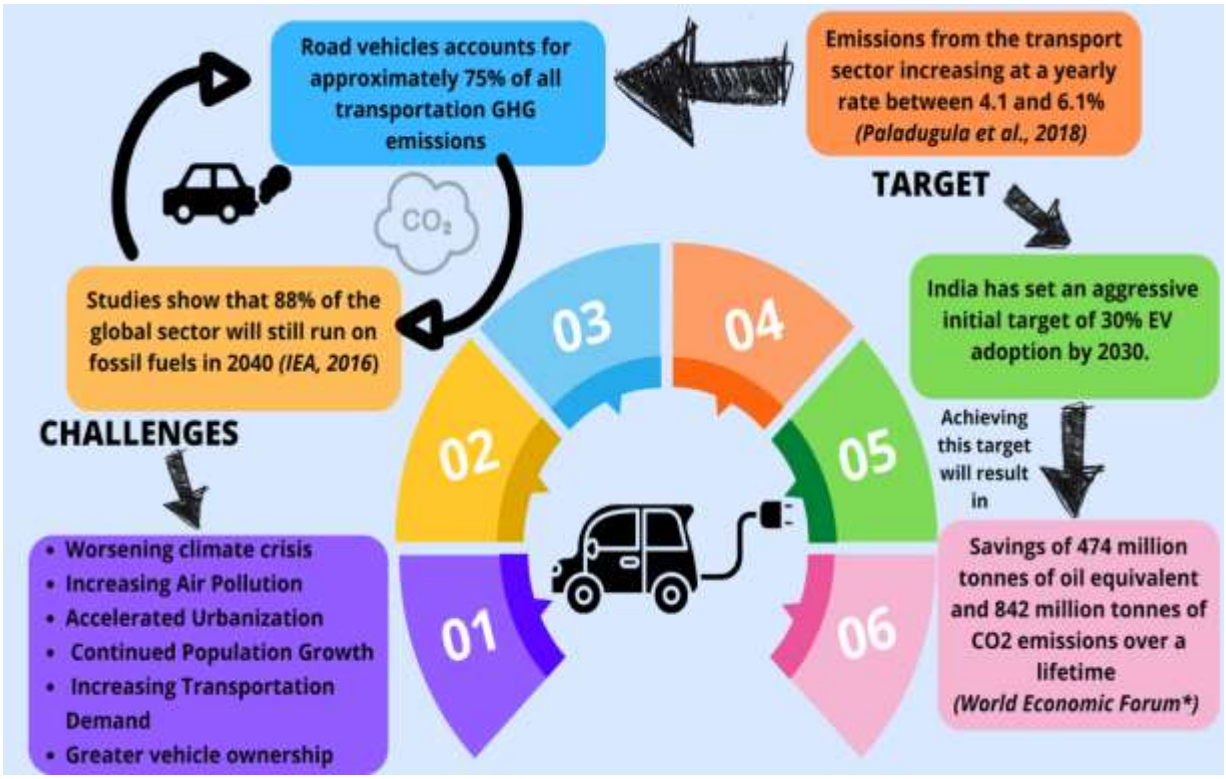


Figure 1 Road map for EV transition
Source: TERI

However, despite state and central policies designed to stimulate EV growth (refer to Annexure 4), India is still in the nascent stages of its EV transition (Singh, *et al*., 2020). Although current EV

penetration is low, India's road vehicle industry is growing rapidly (CEIC Report, 2022), creating immense potential for electrification in the near future. With emissions from the transport sector increasing at a yearly rate between 4.1% and 6.1% (Paladugula, *et al*., 2018) coupled with accelerated urbanization and increased transport demand, an expedited EV transition will be a determining factor in India's efforts to reduce its emissions and achieve a sustainable future.

1.2 Opportunity Area

Although a majority of India's EV planning and deployment activities have come from the state and central levels, the impact of city-level actions has been relatively under-explored. This is a critical gap, as cities have tremendous potential to jumpstart EV adoption and set the country on the path of rapid EV growth. This potential is principally attributed to:

(1) the city's ability to manage local relationships between key players throughout the EV planning and deployment ecosystem, and

(2) the close working relationships between the players and cities (refer to EV ecosystem diagram)

The potential of cities to promote EV diffusion has been essential to the success of EV deployment in several countries including the UK, China, and France. Each country has used local policy to efficiently implement national objectives, monitor progress towards adoption targets, and work around locality-specific challenges. For instance, London has created a dedicated EV infrastructure taskforce (London Assembly, 2018), while Paris has implemented EV purchase subsidies (Randall, 2021). In China, several cities have created structures to make purchase of EVs for municipal use easier (Zhang and Bai, 2016). Although similar policies to promote EV uptake have been enacted at the central and state levels in India, they are yet to be explored at the city level.

1.3 Study Objective

Despite the potential of cities to jumpstart EV adoption, there is uncertainty around the real-world challenges and capabilities of cities to facilitate a more rapid EV transition in India. To close the gap in city-level EV planning and deployment knowledge, TERI conducted a city-level analysis on EV planning and deployment action chains. Given the early stages of EV transition and potential for Indian cities to jumpstart EV adoption, the study serves the following dual purposes:

1. To understand the current status and rank the readiness of Indian cities for EV planning and adoption.
2. To identify the capabilities and roadblocks for future EV planning and deployment in the Indian cities.

To do this, an in-depth analysis on four Indian cities—New Delhi, Bengaluru, Guwahati, and Panaji—with varied landscapes for transport electrification was conducted. In each city, key stakeholders were identified, interviewed, and surveyed on various aspects of the EV ecosystem. This included planning, policy support, and implementation. By analysing their insights, the team was able to construct a general picture of EV readiness and capacity needs at the city level. By isolating key leverage points where local policy measures may be applied to accelerate the EV transition in India,

this study would help to lay the groundwork for the assessment framework for measuring readiness of cities towards a more sustainable transportation sector in the near future.

1.4 Scope and Limitations

The primary value of this study in a generalized Indian city context is to understand the types of challenges and leverage points that Indian cities face as they work to facilitate EV adoption. This understanding will be critical to the design of efficient and executable solutions that promote EV adoption at the local level. A multi-criteria analysis approach is used in this study to analyse a combination of quantitative and qualitative information through a needs assessment survey, interviews and secondary data collection. However, time and resource constraints limited the scope to only four cities for an in-depth study. It also restricted a thorough analysis of public opinion on EVs, although the perspective of civil society organizations was captured and considered as a representative of the social fabric. Limited stakeholder availability also impacted the course of the study. The volume of people involved at different points throughout the EV ecosystem varied greatly by city. As a result, it was difficult to achieve an equal extent of information for every EV readiness indicator for each city. It is worth mentioning, this study is insufficient for comparison of certain types of specific data. However, the surveys, interviews, and secondary research are robust enough to satisfy the study objectives.

2 Electric Vehicle Ecosystem—The Indian Context

2.1 Institutional Ecosystem of Electric Vehicle Planning and Deployment in India

The Indian electric vehicle (EV) policy and implementation framework involves multiple stakeholders from national, state, and city governments. The key policies and planning directives and regulations are laid down by the Central Government while the state and city governments focus more on the implementation of the EV policies and related infrastructure. As the planning and deployment of EVs require a number of different functions, ranging from vehicle registration to the provision of charging infrastructure, a number of different departments are involved at different stages of EV deployment in the city.

Figure 2 Broad mapping of stakeholders
Source: TERI

The Indian EV policy scenario follows the top-down approach. The key guidelines for setting up EV infrastructure as well as the major incentives are provided by the Central Government. The

Ministry of Heavy Industries (MHI) has played a noteworthy role by rolling out action plans and subsidies to accelerate EV transition in the country. The Ministry of Power has laid down the guidelines for setting up EV charging infrastructure and the Ministry of New and Renewable Energy (MNRE) pays attention to the utilization of solar energy for EV charging infrastructure. The MHI's Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME) scheme subsidies for personal vehicles are directly devolved to the buyers, whereas the subsidies for the deployment of public transport buses are transferred to the respective state transportation departments.

The state governments play a responsible role in the EV transition, as they have devised state-specific EV policies. A number of state departments such as power, transport, industry and commerce, and even tourism departments are involved. The policies have set targets regarding the desired extent of EV penetration in the state along with the targets for setting up EV and battery manufacturing units. Certain states have rolled out fiscal incentives for consumers and/or manufacturers. The state authorities are also responsible for planning and implementing EV-related interventions to a major extent. Certain states have already set up or are in the process of setting up state-level committees (SLC) for implementing the EV policy. The creation of SLC is aimed at enhancing inter-departmental coordination involving multiple stakeholders.

2.2 Role of City Government in Planning and Implementation of Electric Vehicle-related Initiatives

The city government is majorly involved as an implementation body. On the contrary, it is a planning body to a limited extent. Some Indian cities have included planning of EV charging stations and related infrastructure in their city development plans and city action plans. At the city level, the planning branch and engineering branch are majorly involved in EV-related works. The electricity distribution companies (DISCOMs) also play an important role at the city level with respect to the electricity demand derived by charging infrastructure. Certain cities, for instance Delhi and Pune, have set up their own EV Cell for effective implementation of EV-related interventions. Further, bus transport corporations have already deployed e-

Figure 3 City, state, and central roles in EV-related initiatives

buses through FAME II subsidies, which acted as a test-bed for proof of concept and proliferation of EVs, besides increasing visibility. Some of the cities where e-buses are being run include Bengaluru, Delhi, Ahmedabad, Guwahati, Pune, Kolkata and Surat. It indicates that state governments and city authorities are taking a lead role in adopting EVs.

Many research and civil society organizations also work with city and state governments to devise implementation plans for EV adoption. They act as a bridge, connecting the views and needs of citizens and the actions of the government. Research organizations and academic institutes are also involved in the studies related to EV technology.

Original Equipment Manufacturers (OEMs), EV charging infrastructure providers, and financing institutions play a crucial role in the on-ground deployment of EVs. They are closely connected with the consumers and the planning and regulating authorities. Figure 5 shows the coordination of stakeholders with the local government in the EV ecosystem while Figure 4 shows the relationship of consumers with stakeholders involved.

Figure 4 Local governmental relation with EV ecosystem

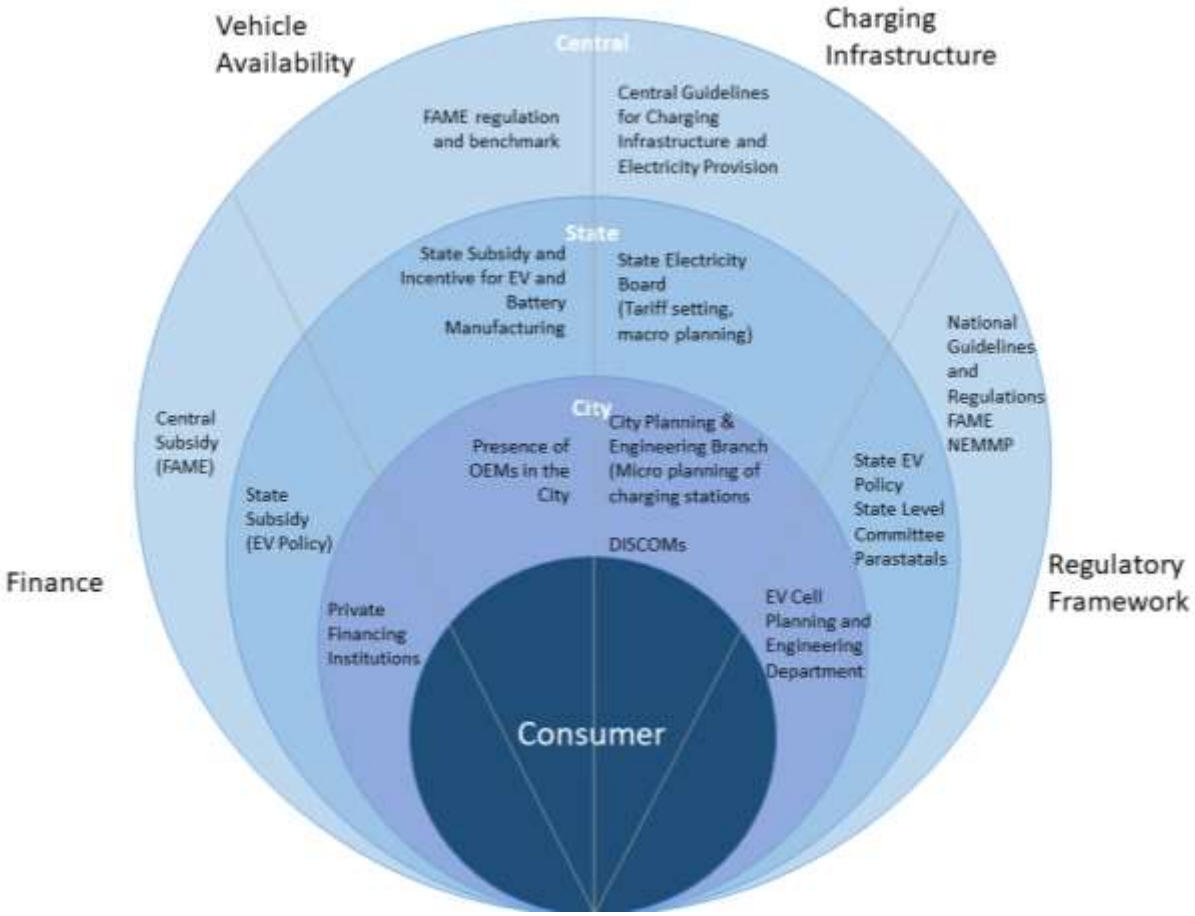


Figure 5 Consumer relation with EV ecosystem
Source: TERI

2.3 Broad Overview of Central Schemes and Policy for Electric Vehicle Deployment in India

The discussions around EVs started in 2011 and the Government of India created an advisory board—National Council for Electric Mobility. In 2012, National Automotive Board came into being to look after the implementation of FAME.

The first focused plan of the Government of India to introduce EVs was the National Electric Mobility Mission Plan (NEMMP), 2020, launched in 2013. The NEMMP has incorporated both demand and supply-side incentives including that for research and development. During the same year, MHI launched the FAME scheme to provide fiscal incentives to individual consumers and private entities for setting up EV charging stations.

In 2019, the guidelines for the provision of charging infrastructure were included in the model building bylaws. Subsequently, a majority of Indian cities have made it mandatory to have provisions for EV charging stations in all new buildings.

Moreover, the second phase of the FAME scheme, which was launched in 2019 and extended till 2024, involves ₹10,000 crore (approx. £ 100 million) of fiscal and non-fiscal support to provide a greater push for EV adoption in the country. FAME has also set a benchmark of minimum technical efficiency for EVs to be eligible for the subsidy, in order to ensure smooth and efficient operation of EVs. FAME II has given focused attention to the provision of EV charging infrastructure and has allocated a special budget for setting up the same. Majority of states have also come up with EV policies to leverage EV adoption and manufacturing in their respective states.

Figure 6 shows a timeline of EV-related policies at the national level for a broad understanding of the EV landscape in India.

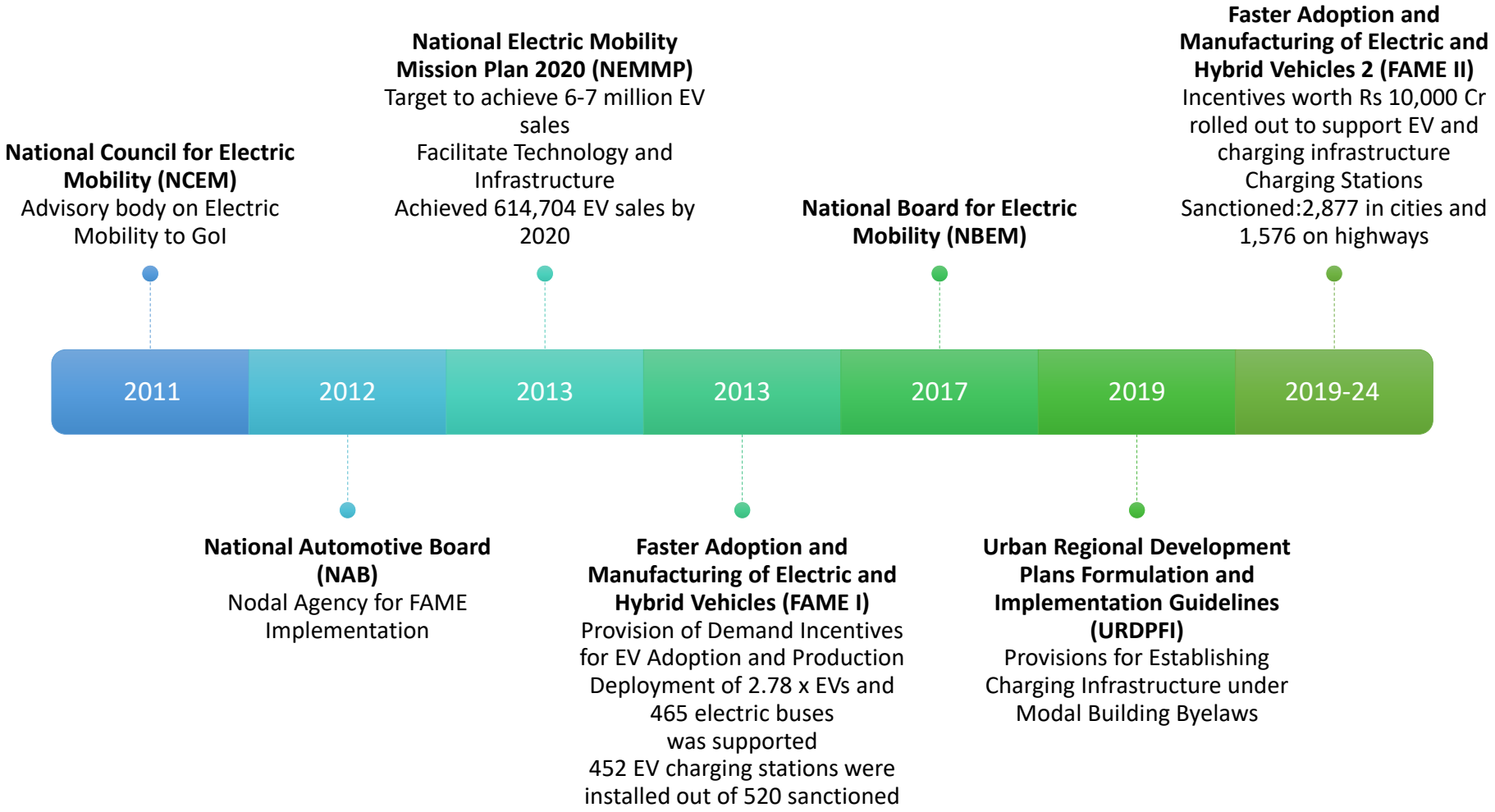
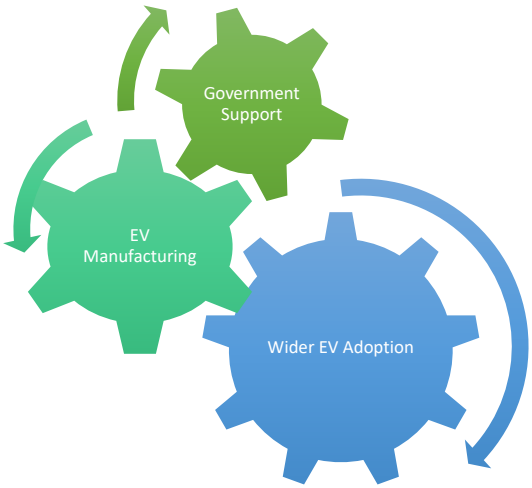


Figure 6 EV-related policy timeline in India

2.4 Electric Vehicle Pattern and Trends in India

The Indian EV market has shown a slow and steady start. The presence of fiscal and non-fiscal incentives by the government has played a decisive role in pushing the manufacturing and adoption of EVs. It is observed that the push and support from FAME II have resulted in a substantial rise in sales of EVs.



Along with the fiscal incentives provided by the central and state governments, the increasing presence of charging infrastructure in the cities has pushed EV adoption. City-level pilots, for instance, the deployment of EVs for municipal solid waste collection and last-mile deliveries for e-commerce has strengthened the positive impression of EVs.

The Indian EV market started with the adoption of electric rickshaws, which were legalized by the parliament in 2015. Gradually, the EV market for two-wheelers (2Ws) also gained momentum and currently, both electric 2W and 3W hold the major share in total EVs present in India. The wider adoption of these vehicles is subject to the suitable range. Also, the number of vehicle models available is higher for 2Ws and 3Ws, as compared to other vehicle forms.

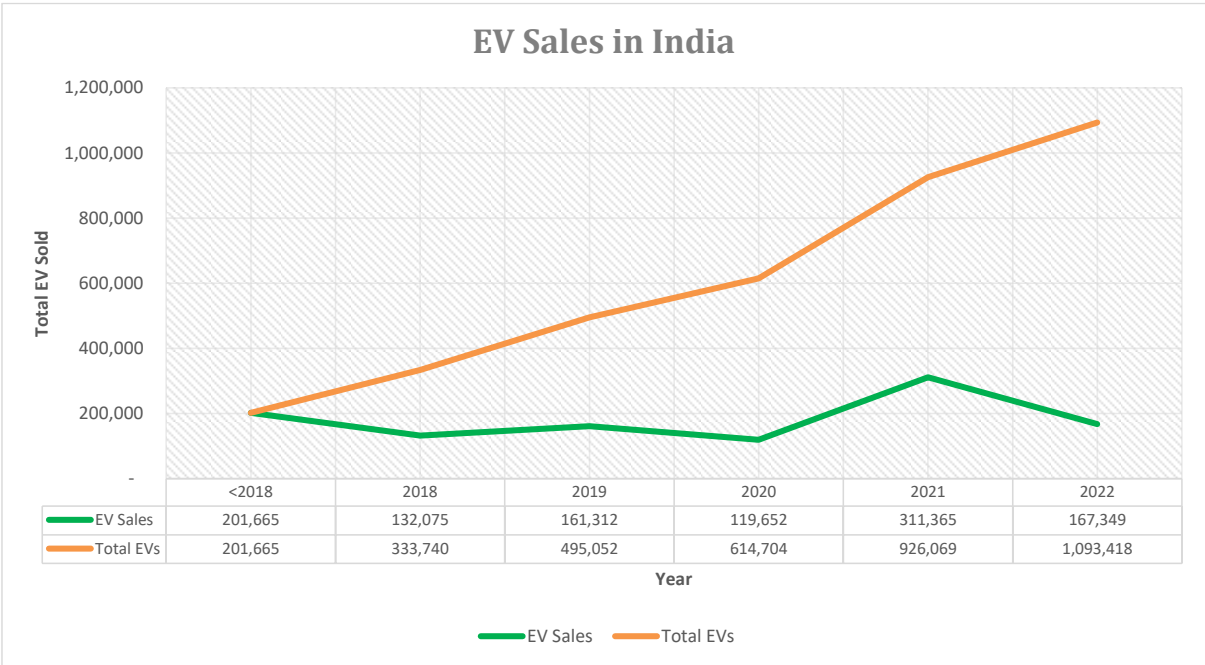


Figure 7 EV sales trend in India
Source: Vahan Dashboard, MoRTH and TERI analysis

Electric 4Ws are yet to establish their market in India, and their uptake is on the lower side due to higher upfront costs and lack of e-variants. The major and well-established OEMs only are currently manufacturing the e-4W. It is unlike the higher presence of start-ups in the e-2W and e-3W segments.

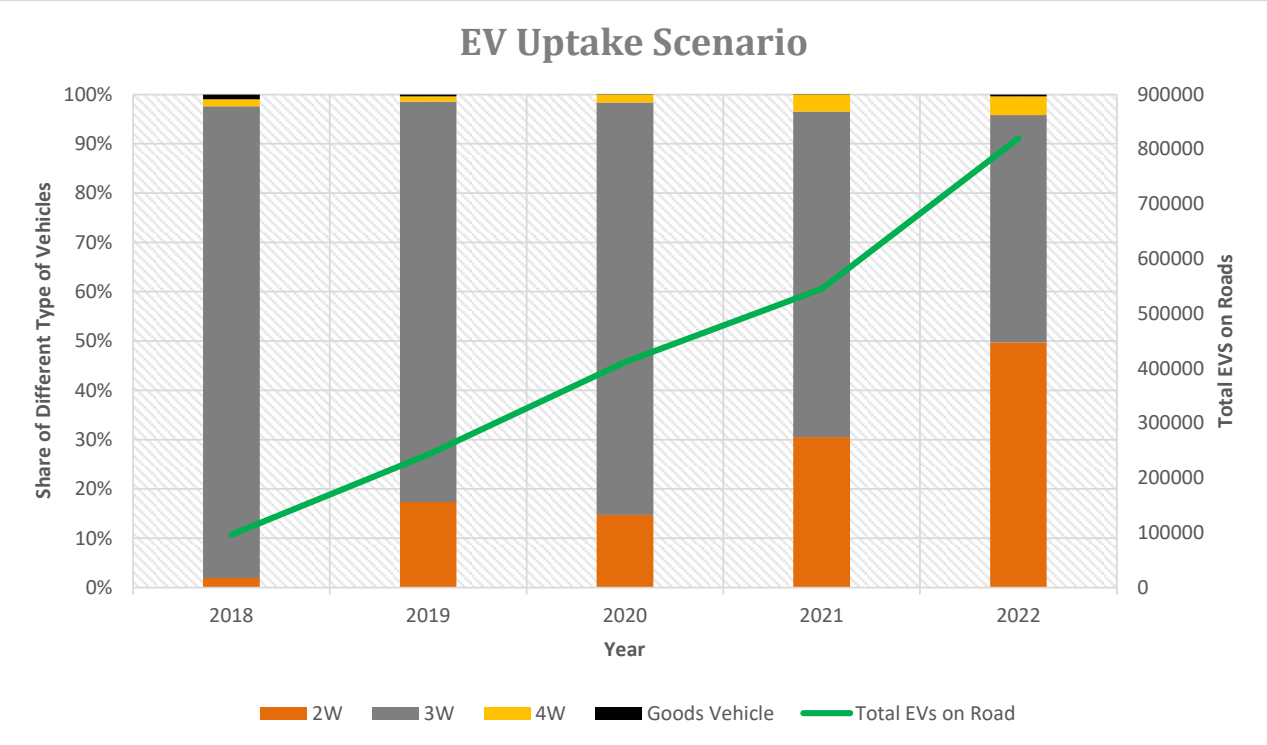


Figure 8 *Sector-wise EV uptake scenario in India*

Source: Vahan Dashboard, MoRTH and TERI analysis

3 Electric Vehicle Readiness Scoring and Current Capacities in Cities

3.1 Selection of Cities

Given the limited scope of the study, four cities with unique transportation characteristics were shortlisted for the readiness scoring and capacity needs assessment. The cities—New Delhi, Panaji, Bengaluru, and Guwahati—were selected, based on comprehensive selection criteria that allowed the evaluation and comparison of cities in five key categories: (i) stage of EV transition,
(ii) physical/environmental attributes, (iii) economic characteristics, (iv) governance/policy, (v) and innovation characteristics (Annexure 2).
Each city's selection justification and characteristics are briefed here:

New Delhi

New Delhi is a high-population megacity with an extensive EV policy and high rates of air pollution compared to the rest of the cities in India. Referred to as the 'EV Capital' of the country, New Delhi's government has shown a strong willingness to innovate in the EV planning and deployment mechanisms. Major work has been around increasing the share of EV two-wheelers (2W), delivery services, and taxis. Additionally, as Delhi is also a Union Territory, it has a unique government structure compared to the rest of India.

Bengaluru

The state of Karnataka, of which Bengaluru is the capital city, was the first state to pass its own EV policy in 2017, but the state has since fallen behind in EV adoption rates and consumer purchase incentives as other states began to pass their own EV policies. Currently, Bengaluru's primary policy for EVs is to be a manufacturing hub, with fairly less emphasis on adoption. However, there appears to be potential for greater EV penetration in government agencies with innovative EV pilots. Finally, Bengaluru's large geographical area, young population, and need for last-mile linkages are factors to be considered for development of a unique transportation landscape that will impact strategies for transport electrification.

Guwahati

Guwahati—the capital of Assam—is a medium-population city that is in the beginning stages of EV transition. The state's EV policy was enacted in late 2021 and balances its priority between manufacturing and adoption. Additional factors that influence EV planning and deployment in this city include its hilly terrain and economic reliance on the petroleum manufacturing sector. Lastly, Guwahati is also a major industrial and business hub, which provides scope for the electrification of commercial vehicles in the city's transportation decarbonisation schemes.

Panaji

Panaji is a low-population, Tier 3 city with a small geographical area and high tourism. The high density of tourists and tourist vehicles also adds complexity to the transportation landscape. Additionally, the large privately-run bus service is likely to impact electrification efforts in mass transit. The state's EV policy intimates a strategic plan for EV growth centred on the installation of a dense, efficient, and affordable charging network.

Table 1 Comparison of selected cities based on the city selection criteria

Criterion	Bengaluru	Delhi	Panaji	Guwahati
Stage of EV transition	Small active EV population	Large active EV population	Very small active EV population	Very small active EV population
	Moderate, rapidly growing charging network	Expansive charging network	Small but growing active charging network, energy surplus	Very small active EV charging network
Physical /environmental characteristics	64% city-wide CO_2 emissions from transport sector (2015)	32% city-wide GHG emissions from transport sector (2015)	38.3% city-wide GHG emissions from transport sector (2013–14)	5250 tonnes of emissions per year in transport sector (2018)
Economic characteristics	Tier-1 population	Tier-1 population	Tier-3 population	Tier-1 population
	Industry composition: IT, biotech, aerospace, manufacturing	Balanced industry composition: Real estate, financial services, transport, Hospitality	Industry composition: Tourism and agriculture	Industry composition: Petroleum, shipping, tea production, general manufacturing
EV policy	EV policy focused on EV manufacturing	EV policy focused on EV adoption	EV policy balanced between EV adoption and manufacturing. Emphasis on charging network	EV policy balanced between EV adoption and manufacturing
Innovation characteristics	Seeks to be at par with Tamil Nadu in EV production	Committed to becoming a global leader in EV adoption	Become model EV state	Embrace adoption and manufacturing; have a large EV fleet in transit and government agencies

Source: TERI

3.2 Readiness Scoring of the Selected Cities

To score the cities' readiness for EV adoption, a multi-criteria analysis (MCA) approach is used in this study. The MCA is a systematic approach that considers the combination of qualitative and quantitative information, and is widely applied in relation to environmental issues and socio-technical transitions. This approach also provides a structured framework including multiple stakeholder judgments to determine complex weighing criteria for scoring.

As the first step to assess the cities, a set of relevant criteria and indicators within each criterion are identified using extensive literature review on EV deployment and adoption. Based on that, each criterion and the indicator are given a qualitative range in order to prevent data aggregation in case of different units of measurement.

The next step entailed the scoring and weighting of the criteria. Each criterion is scored based on the stakeholder consultations, surveys, and secondary analysis, and is further weighted using stakeholders' judgments. The sample stakeholders were selected using a purposive sampling method, based on their role and expertise in the EV space.

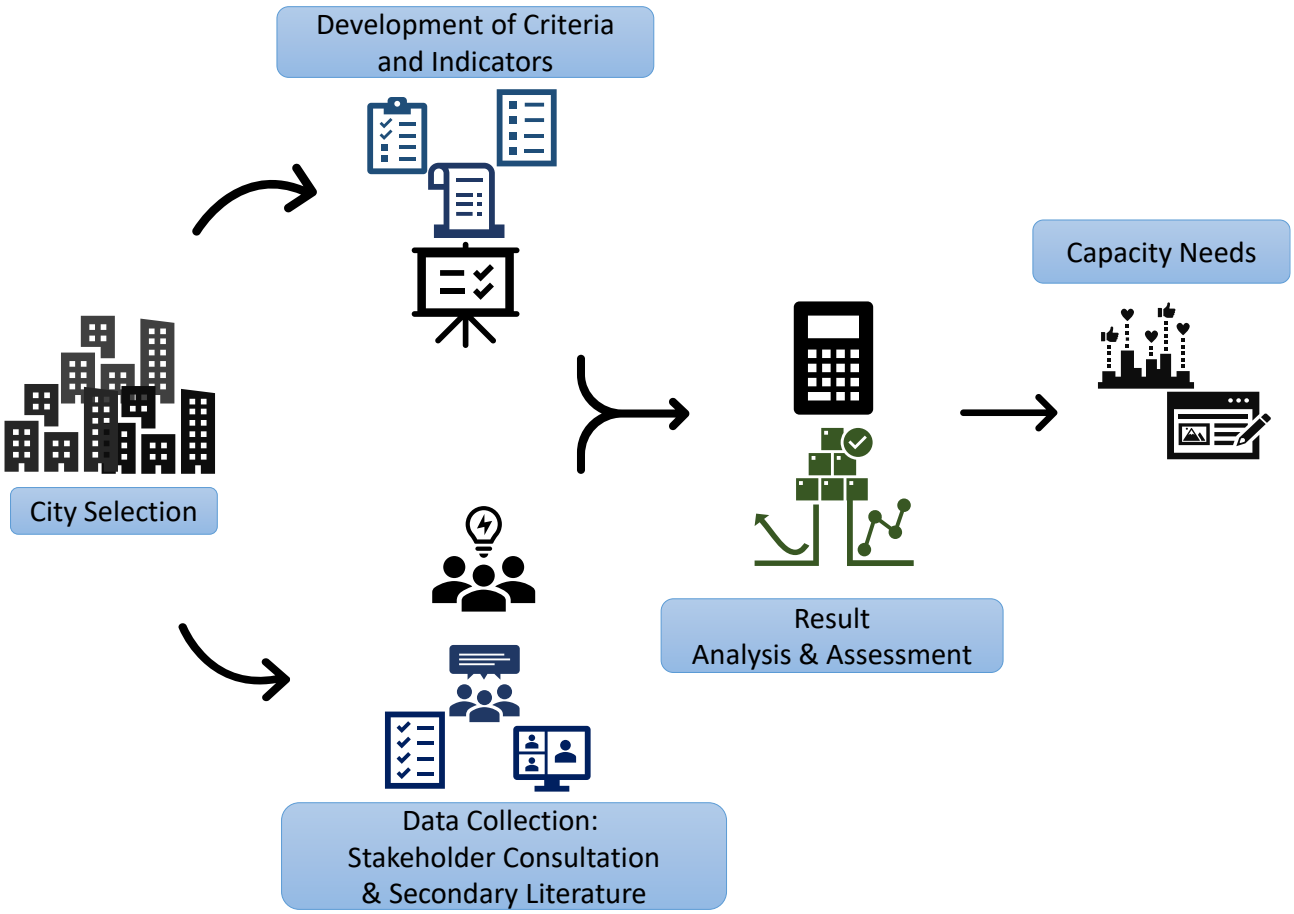


Figure 9 Methodology for the study
Source: TERI

Table 2 lists the weighted summation of the identified criteria from different stakeholders' perspective/judgment. The cross-checking of these weights with different stakeholders helped in increasing the accuracy and reducing subjective bias. Moreover, the assessment is further validated by secondary data, thus, increasing the validity of the research.

Table 2 Assigning of weightages for each criterion for readiness scoring

Criterion	Initial weightage	Stakeholders					Mean	Average weightage after stakeholder inputs
		City government	State government / department	Central agency	CSO/think tank/ research institute	Private Company		
Institutional/ policy	15%	3	4	5	3	3	3.6	**15.1%**
Economic	15%	4	4	3	3	4	3.6	**15.1%**
Technological	15%	4	3	3	3	3	3.2	**13.4%**
Infrastructure	15%	4	4	4	4	3	3.8	**16.0%**
Innovation	10%	3	3	3	4	3	3.2	**13.4%**
Social	15%	3	3	4	3	3	3.2	**13.4%**
Environmental	15%	3	3	4	3	3	3.2	**13.4%**
Total								**100%**

Note: The stakeholder ranges have been obtained from the survey. Likert scale represents 5 as the most important and 1 as the least important. *Source:* TERI

3.2.1 Institutional and Policy Readiness

Local, state, and central governments play a pivotal role in EV transition in cities with the help of policies, regulations/mandates, and other fiscal and non-fiscal incentives. Indian cities are currently aiming towards facilitating a high policy environment that would accelerate EV adoption to a greater extent. Moreover, the literature review further highlights the direct relationship between fiscal incentives by the government and acceleration in EV adoption. These incentives along with regulations and mandates act as a cornerstone of EV transition at the local level, and influence almost all stakeholders involved in the EV ecosystem. In that context, the institutional/policy criterion assesses the city's readiness in regards to policies, incentives, and regulations favourable for EV uptake in the city. This criterion consists of three indicators, as mentioned below.

Indicator-wise Scoring for Institutional Criterion

Indicator IPR1: **Extent of Financial Incentives for EV uptake**					
Description: This indicator assesses the extent to which cities have provided incentives to stakeholders (consumers and manufacturers) for EV uptake under different vehicle segments.					
Progression level	No fiscal incentive for EV uptake	Presence of few indirect fiscal incentives for EV uptake for consumers (registration fee exemption, tax waiver, etc.)	Presence of adequate fiscal incentives for 2W, 3W, and 4W for consumers (purchase subsidies, registration fee exemption, tax waiver, etc.)	Presence of high level of fiscal incentives for all-vehicle segments for consumers (purchase subsidies, registration fee exemption, tax waiver, etc.)	Presence of most fiscal incentives for all-vehicle segments (including incentives for manufacturers and charging infrastructure)
Likert range	1 (0)	2 (25)	3 (50)	4 (75)	5 (100)
New Delhi				✓	
Panaji			✓		
Bengaluru		✓			
Guwahati			✓		

Indicator IPR2: **Extent of Policy actions for EV uptake**					
Description: This indicator focuses on ensuring the extent and implementation of actionable, multi-step targets and plans for EV adoption through policies. Since no city in India has its own EV policy yet, the assessment takes into consideration state-level policies.					
Progression level	No state-level policy for EV adoption	Presence of state-level EV policy with envisioned EV adoption targets	Implementation of state-level EV policy on ground and achievement of >30% envisioned targets	Implementation of state-level EV policy and achievement of >50% envisioned targets	Implementation of state-level EV policy and achievement of >75% envisioned targets
Likert range	1 (0)	2 (25)	3 (50)	4 (75)	5 (100)
New Delhi				✓	
Panaji		✓			
Bengaluru			✓		
Guwahati		✓			

Indicator IPR3: **Presence of Regulatory Frameworks for EV Adoption and Acceleration**					
Description: This indicator assesses the extent and availability of regulatory frameworks that discourage ICE vehicles and encourage EV adoption/acceptance in the city.					
Progression level	No regulatory frameworks for accelerated EV uptake	Charging infra standards for all EVs envisioned in the city	Charging infra standards for all EVs implemented; electricity tariff mandated in the city	Consideration of EV charging in Model Building Bye-Laws (MBBL) 2016 and (URDPFI) Guidelines 2014	Other government regulations on environmental policy
Likert range	1 (0)	2 (25)	3 (50)	4 (75)	5 (100)
New Delhi					✓
Panaji		✓			
Bengaluru				✓	
Guwahati		✓			

Total City-wise Score for Institutional/Policy Criterion				
Indicator	**New Delhi**	**Panaji**	**Bengaluru**	**Guwahati**
Extent of financial incentives for EV uptake	75	50	25	50
Extent of policy actions for EV uptake	75	25	50	25
Presence of regulatory frameworks for EV adoption and acceleration	100	25	75	25
Total Score (x)	225/300	100/300	125/300	150/300
Average (x/3)	83.3/100	33.3/100	50/100	33.3/100
Weighted Score (15.1% of Average)	**12.5**	**5.0**	**7.6**	**5.0**

Current Institutional/Policy Capacities of the Selected Cities

Many experts during the stakeholder consultations emphasized on the importance of institutional/policy push, necessary to bring about short-term and long-term impacts and acceptance of EVs in cities. On a broader level, central initiatives such as the FAME Scheme have proven to increase EV market penetration in all cities as they also increase the citizens' trust. The state governments further provide additional incentives to all four cities due to them being the capital cities, which also acts as a motivator for larger EV adoption. However, since transport-related initiatives are not the city's concern but are handled by the state instead, cities are unable to tap into localized decision-making potential and flexibility for EV encouragement.

New Delhi New Delhi stands out when it comes to the provision of regulatory frameworks for EV adoption. The state has been able to achieve more than 50% of the envisioned targets in its EV policy, with the highest number of the purchase and charging infrastructure incentives in its policy. It provides a concessional power tariff for EV charging and is the only state to offer financial incentives for private charging equipment. The creation of Delhi EV Cell, a separate institutional body responsible for EVs in Delhi, is also a major contributor towards institutional readiness. However, the EV policy still lags behind when it comes to supply-side incentives for manufacturers, as the state does not plan on running any industrial units. Additionally, Delhi scrapped its subsidy of Rs.10,000 per kWh of battery capacity for e4W in 2021 as the response was not up to the mark.	**Panaji** The state of Goa came up with its EV policy fairly recently in 2021. Hence, not much on-ground action has been taken till now. At the institutional level, a high-level committee chaired by the Chief Secretary has been constituted to monitor & implement its EV policy, but no EV cell exists at the local level. Most of the incentives to provide EVs in the city comes from the Central government and the state government further helps in providing viable funding gaps. Also, Goa only provides registration fee exemption and scrappage incentive to 2W, and tax exemption to 2W and 3W. Lastly, the state policy mentions incentives for manufacturers, but no concrete action has been taken yet.
Bengaluru Bengaluru follows the Karnataka state-level framework above the national level ones. Karnataka's EV policy was the first one to be released. While there is a full exemption from road tax and registration fees, the state does not provide any direct purchase incentive due to financial constraints. The focus, instead, is more on investing in EV manufacturers. The state policy also envisions adequate charging infrastructure incentives, but no implementation has happened yet.	**Guwahati** Assam's state-level EV policy was approved in 2021, therefore, not much implementation has happened yet. However, there has been more progress as compared to Panaji. Very high levels of fiscal and non-fiscal incentives are already available for all vehicle segments, charging infrastructure, and manufacturing units in Assam. The state transport department has also funded the deployment of at least 200 electric buses, but only 5-6 have been deployed till now.

3.2.2 Infrastructure Readiness

Charging infrastructure availability and efficiency have a significant impact on the EV adoption in cities. According to Funke, *et al*. (2019), fiscal incentives are observed to promote EV adoption in limited capacity if charging infrastructure for the EVs is inadequate. Less dense cities prefer home charging for their vehicles. However, in a country like India where all cities are densely populated and people live in apartment buildings, public charging infrastructure with fast-charging time is imperative and it also tackles the issue of range anxiety (TERI, 2019). In addition to this, 2W and 3W can use slow chargers due to the smaller size of their batteries, thus iterating the need for both slow and fast type of chargers in cities. Therefore, infrastructure readiness indicators assess the existing EV charging infrastructure in terms of the number and type of charging stations available in the city. City governments and private service providers are largely responsible for indicators assessed under this criterion.

Indicator-wise Scoring for Infrastructure Criterion

Indicator IR1: **Adequacy of Public Charging Stations in the City**					
Description: This indicator assesses the availability of public charging stations in the city. The benchmarking is done on the basis of the highest number of public charging stations in a city in India. Owing to time and resource constraints, this indicator does not take into account the location of charging stations, although charging station location is an important factor in determining the adequacy of the charging network.					
Progression level	No public charging station in the city	<=50 public charging stations, with more envisioned under national/state schemes and policies	>=100 public charging stations in the city	>=200 public charging stations in the city	>=300 public charging stations in the city
Likert range	1 (0)	2 (25)	3 (50)	4 (75)	5 (100)
New Delhi			✓		
Panaji		✓			
Bengaluru			✓		
Guwahati		✓			

Indicator IR2: **Type of Charging Stations in the City**					
Description: This indicator assesses the type of semi-public and public charging stations in the city. Level 1: Offers charging through a 120 volt (V), AC plug; 8–12 hours until fully charged Level 2: Offers charging through a 240 V, AC plug; 3–8 hours until fully charged Level 3: Offers charging through a 480 V, DC plug; 1–2 hours until fully charged					
Progression level	Presence of only level 1 AC-type charging stations in the city	Presence of levels 1 and 2 AC-type private, semi-public and public charging stations in the city but not DC	1–10 level 3 DC-type public charging station; Presence of levels 1 and 2 AC-type private, semi-public and public charging stations in the city	10–75 level 3 DC-type public charging station; Presence of levels 1 and 2 AC-type private, semi-public and public charging stations	>=75 level 3 DC-type public charging stations; Presence of levels 1 and 2 AC-type and level 3 DC-type private, semi-public and public charging stations in the city
Likert range	1 (0)	2 (25)	3 (50)	4 (75)	5 (100)
New Delhi					✓
Panaji			✓		
Bengaluru				✓	
Guwahati			✓		

Total City-wise Score for Infrastructure Criterion				
Indicator	**New Delhi**	**Panaji**	**Bengaluru**	**Guwahati**
Adequacy of public charging stations in the city	50	25	50	25
Type of charging stations in the city	100	50	75	50
Total Score (x)	150/200	75/200	125/200	75/200
Average (x/2)	75/100	37.5/100	62.5/100	37.5/100
Weighted Score (16% of Average)	**12**	**6**	**10**	**6**

Current Infrastructure Capacities of Selected Cities

More than 50% of the experts consulted mentioned charging infrastructure as one of the biggest challenges faced by cities. The central government is currently taking a number of steps to tackle the infrastructure issue for EV adoption in cities. One of the prominent initiatives includes de-licensing the activity of setting up EV charging stations to prevent the resale of electricity, as well as to increase private sector investments and facilitate market adoption. The Ministry of Power also made amendments in the charging infrastructure standards to ensure that at least one charging station would be available in a grid of 3 km X 3 km in the cities and one charging station at every 25 km on both sides of highways and roads (to be implemented). Even so, the charging infrastructure standards focus more on the responsibilities of the state and the centre, with not much mention of city authorities for the same. Furthermore, according to an expert, Indian cities could use curb-side charging or charging in parking, which will provide convenience to people so they do not have to visit a public charging station, but it would also imply that these charging points would not be fast charging as the high power required for fast charging is not available everywhere. Subsequently, cities may have charging infrastructure installed, however, their operational capacity also affects the efficiency of EV charging.

New Delhi	**Panaji**
Out of the four cities, New Delhi has the highest number of public EV charging stations, totalling to 169, and a fair share of these are DC type fast chargers. The state government plans to leverage private partnerships to set up ample private, semi-public and public charging stations throughout the city. Following the same, the government has also set in place a single window process for people to select EV chargers, obtain new electrical connection, install charging points and avail subsidies.	Panaji has a total of only three public EV charging stations (mix of AC and DC type) that have been implemented till now, with 50 more stations proposed for the near future. Additionally, Kadamba Transport Corporation has procured 50 e-buses in addition to 100 more e-buses under the FAME Scheme, however, the main charging infrastructure is in Margao city of Goa, causing issues for the bus operation.

Bengaluru Bengaluru comprises a total of 136 public EV charging stations. But with more than 40,000 EV sales per year, the ratio of the number of EVs per charging station is fairly low. Also, most of the charging stations are not operational. Bengaluru Electricity Supply Company Limited (BESCOM) has set up 70 semi-public charging stations, as they could only install it on their premises due to land acquisition issues, making the location of these charging stations inconvenient. However, BESCOM is also focussing on installing fast DC chargers, with a total of 15 fast chargers.	**Guwahati** Similar to Panaji, currently there are only 4–5 charging stations in Guwahati and many of them are not functional. The state of Assam has envisioned 10 more charging stations for the city under the FAME Scheme recently, but they have not been implemented yet. This is also because majority of the EVs in the city are e-rickshaws and only 25 buses have been deployed, out of which 5–6 buses are operational.

3.2.3 Technology Readiness

Technological factors for EV adoption in cities are interrelated with the infrastructure characteristics. As noted above, while DC type chargers address range anxiety issues by reducing charge time to a great extent, they also use a high amount of power as compared to AC chargers. Cities, therefore, need to be prepared to monitor and mitigate the increased/more variable utility load from EV charging as EV adoption increases. Apart from that, other technological factors such as the battery life, range, vehicle design, durability, and performance, etc., are also considered to be crucial when it comes to the wider acceptance of EVs. Against this background, technological readiness indicators will be assessed on the capacity of the electricity grid and the availability of suitable and diverse vehicle models for EV deployment.

Indicator-wise Scoring for Technological Criterion

Indicator T1: **Capacity of electricity grid**					
Description: This indicator assesses the readiness of the city's electricity grid to monitor and mitigate the increased/more variable utility load from EV charging.					
Progression Level	City's electricity grid is not ready to mitigate the increased/ variable utility load from EV charging at all	City's electricity grid is not ready to mitigate the increased/ variable utility load from EV charging, but a way forward is proposed/being discussed	City's electricity grid is not ready to mitigate the increased/ variable utility load from EV charging, but pilots have been implemented in the city and preparations are being made	City's electricity grid is ready to mitigate the increased/ variable utility load from EV charging with smart grids and smart charging	City's electricity grid is fully ready to mitigate the increased/ variable utility load from EV charging, using smart grids and vehicle-to-grid transmission
Likert range	1 (0)	2 (25)	3 (50)	4 (75)	5 (100)

New Delhi			✓		
Panaji		✓			
Bengaluru		✓			
Guwahati	✓				

Indicator T2: **Availability of diverse EV models**					
Description: This indicator ensures the availability of diverse EV models with different and up-to-grade battery life, range, vehicle design, etc.					
Progression Level	1–5 EV models for all vehicle segments in the city	>5 EV models for 2W and 3W; >3 EV models for 4W	>10 EV models for 2W and 3W; >5 EV models for 4W	>20 EV models for 2W and 3W; >10 EV models for 4W	>30 EV models for 2W and 3W; >20 EV models for 4W
Likert range	1 (0)	2 (25)	3 (50)	4 (75)	5 (100)
New Delhi				✓	
Panaji			✓		
Bengaluru				✓	
Guwahati		✓			

Total City-wise Score for Technological Criterion				
Indicator	**New Delhi**	**Panaji**	**Bengaluru**	**Guwahati**
Capacity of electricity grid	50	25	25	0
Availability of diverse EV models	75	50	75	25
Total Score (x)	125/200	75/200	100/200	25/200
Average (x/2)	62.5/100	37.5/100	50/100	12.5/100
Weighted Score (13.4% of Average)	**8.4**	**5.0**	**6.7**	**1.7**

Current Technology Capacities of Selected Cities

Accessible and reliable electricity—that is an urban development challenge in many Indian cities—acts as a prerequisite for more charging infrastructure in cities. Therefore, all four cities have scored low with respect to the capacity of the city's electricity grid. It was deduced from the stakeholder consultations that DISCOMs play an active role in finding solutions to the issue of variable load on the electricity grid due to EV charging. Many experts pointed towards the direction of smart charging, making optimal use of electricity during non-peak times, thereby reducing load on the grid.

New Delhi While there is no specific intervention by the city government yet, BSES, the DISCOM in New Delhi is proactive in the monitoring and planning for EV charging load management on the grid. The central government (the Ministry of Science and Technology) partners with research institutes like IIT-Delhi to carry out pilot projects on grid supportive EV chargers. One such pilot was deployed in the Smart Grid Lab of IIT-D where a scalable and environment-friendly EV charging station was built with in-built solar photovoltaic interface capability. Additionally, the Delhi government also shows a number of EV models in all vehicle segments with varying range and which are eligible for subsidies.	**Panaji** Panaji's electric grid is not prepared for variable utility load from EV charging; however, the city government has been in many discussions about the same. Nonetheless, implementation of solutions is still not viable. Lastly, there are very less types of EV models available in Panaji, thus making it score extremely low under this criterion.
Bengaluru Similar to New Delhi, BESCOM is very active in Bengaluru when it comes to electricity grid load for EV charging. BESCOM has also carried out studies with CSTEP to explore the concept of block chain and prosumers for a flexible and electricity grid.	**Guwahati** The grid cores in Guwahati have not been prepared for variable load at all, and there is no action taken by the city government or DISCOM due to very low penetration of EVs in the city. Moreover, Guwahati also scored low on the EV model diversity. This is majorly due to the lack of efficient/sturdy EV models for tackling the heavy rainfall patterns and potential landslides. As Guwahati is also situated in hilly terrain, the range of the EV decreases, thus, calling for a more technologically efficient EV model.

3.2.4 Economic Readiness

Mass market penetration of EVs would require lower initial cost and total ownership cost of the vehicle. However, total ownership cost of EV stays relatively high due to high input material cost, higher operational cost and insufficient charging infrastructure resulting in higher pay-back period. Therefore, economic readiness assesses the market penetration of EVs in the city.

Indicator-wise Scoring for Economic Criterion

Indicator E1: **Extent of market penetration of EVs in the city**					
Description: This indicator assesses the market penetration of EVs by measuring the annual EV sales against the total annual sales of vehicles (for the year 2021).					
Progression Level	No market penetration	<2.5% EV share in total sales	2.5%–6% EV share in total sales	6.1%–10% EV share in total sales	>10% EV share in total sales
Likert range	1 (0)	2 (25)	3 (50)	4 (75)	5 (100)
Delhi				✓	
Panaji		✓			
Bengaluru			✓		
Guwahati			✓		

Total City-wise Score for Economic Criterion				
Indicator	**New Delhi**	**Panaji**	**Bengaluru**	**Guwahati**
Extent of market penetration of EVs in the city	75	25	50	50
Average Score	75/100	25/100	50/100	50/100
Weighted Score (15.1% of Average)	**11.3**	**3.8**	**7.6**	**7.6**

Current Economic Capacities of Selected Cities

In India, 2W vehicles account for the largest share of EVs in the market, followed by 3W and 4W. The market penetration of EVs in almost all four cities is fairly low as compared to the international benchmark. This is because many components are still imported, thereby increasing the initial cost of EVs. Eighty per cent of the experts who took the survey also mentioned the high capital cost of EV as one of the major concerns for citizens when it comes to EV adoption. Others also pointed out the relatively higher cost of transition, which includes the higher cost of infrastructure due to it being nascent at this stage. It is in this regard that the central government has been pushing the local manufacturing of EVs by putting import tariffs on vehicles and increasing customs duty on imported EV components. As per a local government official, During FAME I, 2016, the cost of e- buses (12m) were ₹2.2 crore. Under FAME II, the cost reduced to ₹1.75 crore, and today the cost has further reduced to ₹1.4 crore. This is due to the manufacturing cost of vehicles and parts of vehicles reducing with the new technology and with some manufacturing units in India now, and will reduce even further as the demand increases. Moreover, with the current uncertainty around rising fuel prices, the total cost of ownership of EVs becomes lesser than that of ICE vehicles. Many potential EV consumers are not aware of the total ownership cost, hence their reluctance in buying EVs. It is observed here as well that the role of city government in economic readiness is extremely limited, and it is more the central and the state governments coordinating.

New Delhi New Delhi had a market penetration rate of 9% for 2021, with it crossing 10% for the month of February 2022. Delhi became the first state in India to ever cross 10% EV share in the market. This market penetration has been possible because of the focus of EV policy on demand creation and infrastructure ecosystem in parallel.	**Panaji** In Panaji, there were only 165 battery-operated vehicles registered in 2021 and the EV penetration is low at 2.3%.
Bengaluru Bengaluru saw a steady increase in the number of EVs and the market penetration was 5.1%. However, it is still fairly low as compared to Delhi or international benchmark cities.	**Guwahati** Guwahati achieved a 4.5% market penetration of EVs in 2021. This is mainly due to the large share of 2W and 3W in Guwahati, as compared to the 4W.

3.2.5 Social Readiness

The social readiness for EV adoption stems from the institutional, economic, and technological readiness of cities. Factors such as safety, reliability, affordability and availability of infrastructure for EVs can positively or negatively influence citizens' trust in EVs. Consumer perceptions about EV acceptance in cities depend heavily on the EV market penetration. Accordingly, the social criterion will be assessed based on the annual EV sales growth to infer if the social acceptance around EVs is increasing.

Indicator-wise Scoring for Social Criterion

Indicator S1: **Level of acceptance of citizens with respect to EV uptake**					
Description: This indicator assesses the acceptance level of citizens with respect to EVs by evaluating the EV sales growth trends in 2021. The higher the EV sales, the more the social acceptance.					
Progression Level	<50% growth in EV sales in the past year	50%–100% growth in EV sales in the past year	100%–150% growth in EV sales in the past year	>150% growth in EV sales in the past year	EV sales growth exceeds national average (168%)
Likert Range	1 (0)	2 (25)	3 (50)	4 (75)	5 (100)
Delhi			✓		
Panaji		✓			
Bengaluru				✓	
Guwahati		✓			

Total City-wise Score for Social Criterion				
Indicator	**New Delhi**	**Panaji**	**Bengaluru**	**Guwahati**
Level of acceptance of citizens with respect to EV uptake	50	25	75	25
Average Score	50/100	25/100	75/100	25/100
Weighted Score (13.4% of Average)	**6.7**	**3.4**	**10.1**	**3.4**

Current Social Capacities of Selected Cities

All cities show a stark increase in their EV sales growth as compared to the previous years, indicating an increasing social readiness to transition to EVs. One of the reasons for this shift is the institutional/policy push in the form of incentives for citizens. Increasing trust among citizens due to the FAME scheme has resulted in much faster EV penetration in a short time. Rising fuel prices in India also creates uncertainty around the cost as well as the convenience of buying ICE vehicles, which used to be one of the major highlights of ICE, thus prompting a shift to EVs. Nonetheless, even with a high level of EV sales growth, citizens face many issues with EV adoption. The lack of adequate charging infrastructure in the cities is a major factor causing range anxiety. Citizens are also not fully aware of the need for an EV transition and the benefits of EVs (lower total ownership cost, reduced carbon emissions and air pollution, etc.). Citizen trust still wavers around the safety, battery life, and performance of EVs. These issues can be tackled with targeted information campaigns to increase consumer awareness and mainstream EV adoption. Delhi's 'Switch Delhi' is a great example of such initiatives made by the government that informs, educates, and encourages citizens to switch to EVs. In addition, Delhi is ready to deploy a WhatsApp chatbot for citizens to know more about recent developments, and information with regards to vehicle models, dealerships, and cost savings.

New Delhi New Delhi has one of the highest EV sales after Bengaluru, with a 108% EV sales growth in the past year (2021). Being the capital city of India, Delhi has seen ample interest from stakeholders for accelerating EV adoption in the past couple of years, thus also prompting citizens to consider EV models.	**Panaji** Panaji when compared to the other three cities, scored less in terms of EV market sales. With a growth rate of 94% in the annual EV sales of 2021, it shows great scope to do better in terms of infrastructure, technology and government subsidies to incentivize the users and increase the overall social acceptance towards EVs.
Bengaluru Bengaluru has the highest EV sales growth rate when compared to the other three cities. It has an EV sales growth of 160% and is the closest to the national average of 168%, and can be attributed to the young population share and socio-economic status in the city.	**Guwahati** Guwahati has shown relatively lesser social acceptance. It has shown a 95% growth in EV sales, against the national average of 168%, reflecting the need for focused interventions.

3.2.6 Environmental Readiness

Environmental aspects essentially act as vital motivators for EV adoption, both from the perspective of the government and consumers. An EV transition in a city can tackle climate change by reducing a substantial amount of transport emissions, and improve the city's air and noise quality. Contrastingly, it is also important to ensure reuse/recycling of EV batteries to prevent a detrimental impact on the environment. Therefore, it is imperative that the city covers strategies to integrate the EV transition comprehensively in its city pollution and climate action plans. By the same token, the environmental readiness criterion focuses on the actions envisioned and implemented to tackle environmental issues.

Indicator-wise Scoring for Environmental Criterion

Indicator E1: **Extent of EV integration in climate action plans**					
Description: This indicator ensures the presence of targets and actions to streamline the EV adoption process and align it with climate and environmental quality goals.					
Progression Level	No action plan at the city level	EV transition for the city envisioned in city's action plan or state climate action plan	Presence of broad EV transition/integration targets in city's action plan and state climate action plans	Specific, detailed out targets for either passenger or freight transport segments in city's action plan and state climate action plan	Detailed out targets for all transport segments (passenger and freight) in city's action plan and state climate action plan
Likert range	1 (0)	2 (25)	3 (50)	4 (75)	5 (100)
Delhi					✓
Panaji		✓			
Bengaluru			✓		
Guwahati		✓			

Total City-wise Score for Environmental Criterion				
Indicator	**New Delhi**	**Panaji**	**Bengaluru**	**Guwahati**
Extent of EV integration in climate action plans	100	25	50	25
Average Score	100/100	25/100	50/100	25/100
Weighted Score (13.4% of Average)	**13**	**3.4**	**6.7**	**3.4**

Current Environmental Capacities of Selected Cities

Experts in the stakeholder consultations stressed on the role of cities for achieving better environmental quality and tackling climate change. Currently, Delhi, Guwahati and Bengaluru have comprehensive action plans to tackle air pollution. None of the cities have a climate action plan

devised at the city level. Beyond these cities, the city of Mumbai was the first city in India to have its own climate action plan apart from the state level ones.

New Delhi New Delhi is one of the most polluted cities in the world. The city has a comprehensive action plan for air pollution by the Air Quality Monitoring Committee (AQMC), which talks about introducing battery-operated EVs in length with the agency responsible and a timeline of implementation. Measures to increase EV penetration in each segment have also been mentioned in the city action plan. The state climate action plan also highlights EV transition strategies in a similar manner.	**Panaji** Panaji does not have a city-level comprehensive action plan to tackle air pollution. Panaji also has a comprehensive mobility plan but there is no mention of EVs. The climate action plan is at the state level, envisioning the goal of achieving 30% EV transition by 2025. However, there is no concrete policy/implementation plan to reach a certain level of EV adoption in the city itself, despite being the capital city.
Bengaluru Bengaluru also has an action plan for air pollution, with broad EV transition-related actions, implementation timelines and agencies responsible listed down. Even so, there is no segregation of passenger and freight vehicle segments in the action plan. In contrast, there is not much mention of EV-related targets and strategies in the state action plan for climate change and human health.	**Guwahati** While there exists a city action plan for Guwahati to tackle air pollution, only short-term vision for the introduction of EVs is mentioned. There is no mention of EV adoption in the state climate action plan.

3.2.7 Innovation Readiness

Apart from technological innovation with respect to EV models, design, batteries, etc., local innovation in EV-related business and finance models also drive the transition in cities by attracting private players. Unlike the ICE vehicle business, which is only dominated by established players, there is scope of applying new and innovative business and financing models in the EV space for faster and a self-sustaining EV ecosystem in the city. Therefore, the innovation readiness criterion will be assessed to explore innovative business models and the extent of their integration in transit.

Indicator-wise Scoring for Innovation Criterion

Indicator INN1: **Extent of EV integration into city's transit**					
Description: This indicator assesses the extent to which the city government has integrated EVs into transit and other government vehicle fleets. The results are based on the survey responses.					
Progression Level	No integration at all/ Extremely low integration	Low level of integration	Fair level of integration	Good level of integration	Excellent level of integration

Likert range	1 (0)	2 (25)	3 (50)	4 (75)	5 (100)
Delhi			✓		
Panaji		✓			
Bengaluru			✓		
Guwahati		✓			

Indicator INN2: **Innovation in business model and financing**					
Description: This indicator evaluates the presence/adoption of innovative business models by the city government to accelerate EV transition and integration.					
Progression Level	No business models for EV uptake	City has implemented 1–2 innovative business and finance models with private players	City has implemented 3–4 innovative business and finance models with private players	City has implemented 5–9 innovative business and finance models with private players	City has implemented >=10 innovative business and finance models with private players
Likert range	1 (0)	2 (25)	3 (50)	4 (75)	5 (100)
Delhi				✓	
Panaji		✓			
Bengaluru				✓	
Guwahati		✓			

Total City-wise Score for Innovation Criterion				
Indicator	**New Delhi**	**Panaji**	**Bengaluru**	**Guwahati**
Extent of EV integration into city's transit	50	25	50	25
Innovation in business model and financing	75	25	75	25
Total Score (x)	125/200	50/200	125/200	50/200
Average (x/2)	62.5/100	25/100	62.5/100	25/100
Weighted Score (13.4% of Average)	**8.4**	**3.4**	**8.4**	**3.4**

Current Innovation Readiness of Selected Cities

Experts look at innovation in EV planning and deployment as the key to attaining a self-sustaining EV environment in cities. Rather than entirely depending on fiscal incentives from the state and central governments, city governments come together with private players to produce new business models. This is seen in two main areas in the selected cities—ride sharing ecosystem and charging infrastructure. Moreover, creation of a competitive ecosystem among cities with missions such as the Ministry of Housing and Urban Affairs' Smart Cities Mission further facilitates an innovative environment.

New Delhi New Delhi stimulates an innovative environment with a number of new initiatives, one such being the single window clearance for EV registration and subsidies as mentioned earlier. The state government has also been working in the freight space with 36 private companies and RMI for a pilot on last-mile electric delivery vehicles. Other than that, start-ups such as Blu Smart Mobility and Lithium Urban Technologies have started electric vehicle cab and car rental services, thus adding to the innovation in the city.	**Panaji** Panaji has not had much innovation yet, but the city has envisioned many business models to facilitate EV adoption. The private player Ather has set up its outlet in the city and has also installed a couple of charging points for EV owners.
Bengaluru Bengaluru leads innovation as a number of start-ups for EVs, Charging and Battery solutions and fleet are emerging in the city. EV taxi services such as Lithium Urban Technologies, Envii, Sainik Pod, and last-mile delivery solutions are growing at a rapid pace there. A number of partnerships between EV start-ups, last-mile freight and passenger connectivity, and battery/charging providers are also observed. Like Switch Delhi, Bengaluru Apartments' Federation's E-Vaahana Campaign in Bengaluru is a society-led initiative that aims to address the concerns of Resident Welfare Associations (RWAs) and EV owners by bringing together knowledge partners, CPOs, OEMs, and policy experts on a common platform.	**Guwahati** Guwahati is focussing more on the electricity grid for charging infrastructure. The city is running a smart grid pilot for demand side management. Research institutions there, such as IIT Guwahati are also active in the innovation space with an Electric Mobility lab that conducts research to aid the uptake of EVs.

3.3 Final Readiness Score and Discussion

The final readiness score is calculated by adding the weighted scores of all criteria. Table 3 shows the total weighted readiness scores for each city and Figure 10 visualizes the indicator-wise comparison of the four cities.

Table 3 City-wise total readiness scores

Criteria with weightage	New Delhi	Panaji	Bengaluru	Guwahati
Institutional/Policy Readiness **(15.1% of total)**	12.5	5	7.6	5
Economic Readiness **(15.1% of total)**	11.3	3.8	7.6	7.6
Infrastructural Readiness **(16% of total)**	12	6	10	6
Technological Readiness **(13.4% of total)**	8.4	5	6.7	1.7
Social Readiness **(13.4% of total)**	6.7	3.4	10.1	3.4
Environmental Readiness **(13.4% of total)**	13	3.4	6.7	3.4
Innovation Readiness **(13.4% of total)**	8.4	3.4	8.4	3.4
Total Score: (sum of all) out of 100	**72.3**	**30**	**57.1**	**30.5**

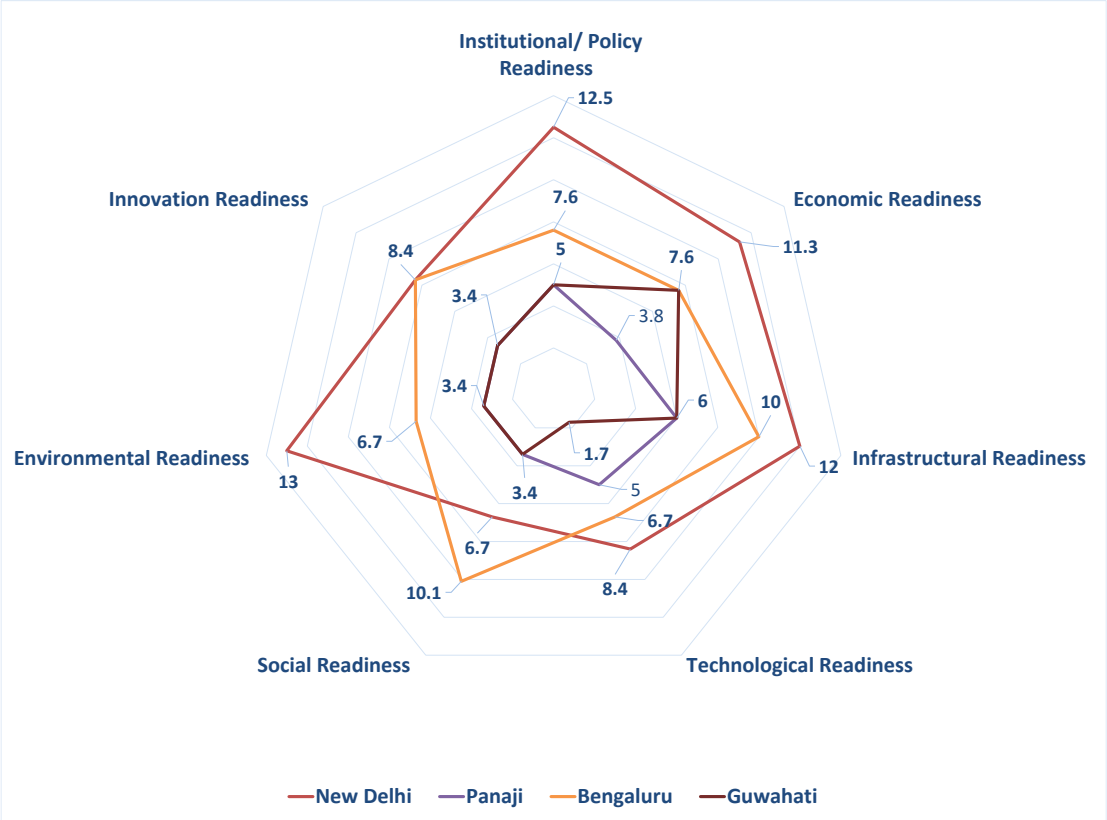


Figure 10 Comparison of criterion- wise readiness scores for the selected cities
Source: TERI

It can be seen that New Delhi scored the highest out of all four cities (72.3/100), with high scores in the Institutional/Policy, Infrastructure, Environmental and Economic criteria. New Delhi exhibits a leading example of accelerated EV adoption using a multi-faceted and integrative approach towards EV planning at the city level. Notwithstanding this, there is still some scope observed in all the criteria, especially the Social and Innovation Readiness criteria, with respect to social acceptance of EVs and electrification of the public transport fleet. On the other hand, while Bengaluru scores relatively less than Delhi in almost all criteria, the city exhibits greater Social Readiness, which can be attributed to factors like the city's share of a young population and steady socio-economic levels. The readiness levels for Panaji and Guwahati are significantly lower as compared to Delhi and Bengaluru. Both Panaji and Guwahati largely rely on central and state-level interventions for EV uptake, with very less involvement of the local government. The two cities are therefore at the early stages of EV adoption and have the most scope with respect to innovation for accelerated EV uptake.

On a general criterion level for all cities, it was observed from the in-depth interviews that each criterion is interrelated/interdependent on one other. Institutional/Policy criterion was seen to be the driving factor for all other criteria. For example, established institutional mechanisms for delicensing the activity of setting up charging stations have led to an increase in the participation of private players, charging infrastructure and higher EV sales as a result of that. Similarly, the amalgamation of adequate infrastructure, institutional mechanisms and EV market penetration enable greater social readiness. Moreover, environmental readiness in the form of well drafted and implemented action plans for better air quality and climate action is also a key motivator for citizens, decision-makers and private players to push to EV agenda in cities. The overall criterion- wise systems mapping for EV readiness is shown in Figure 11.

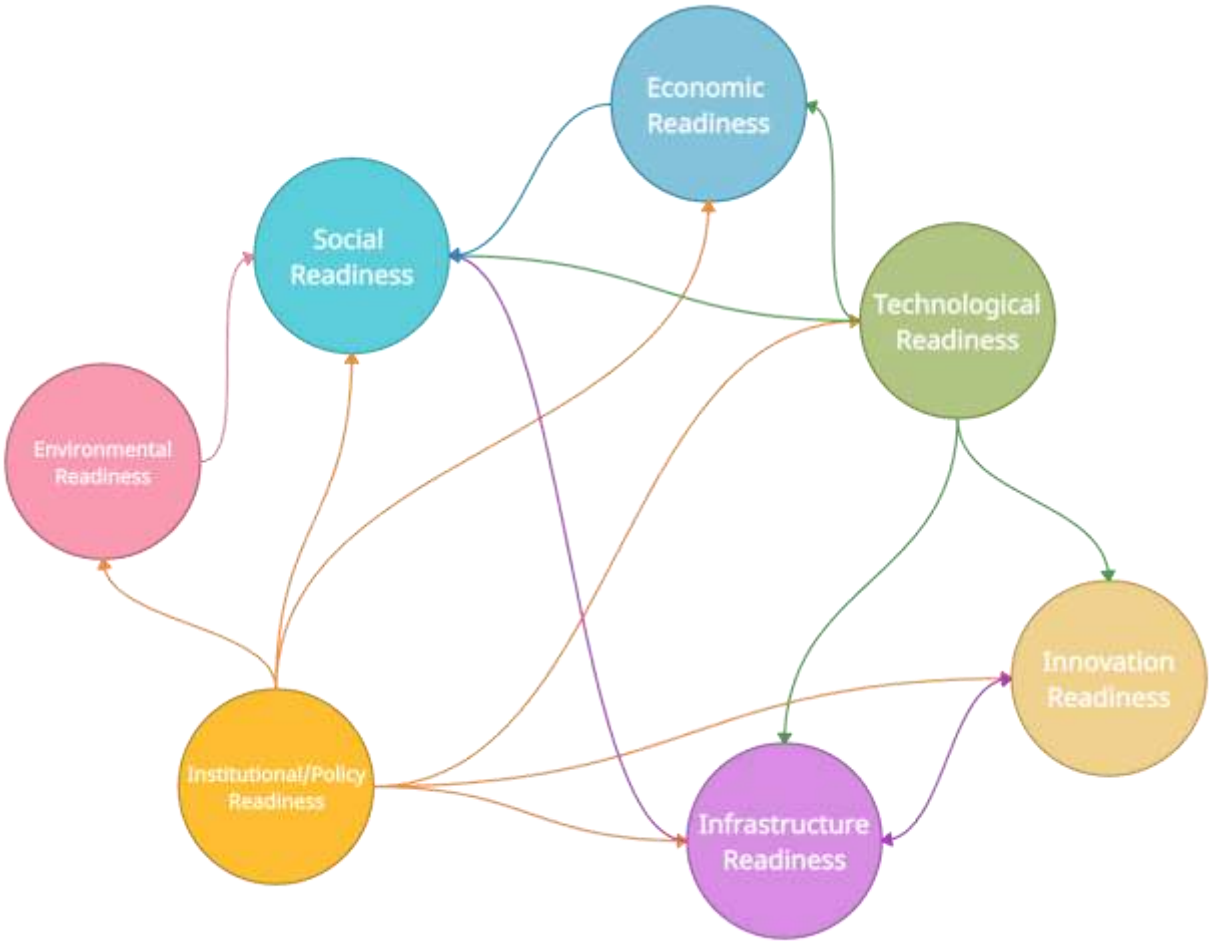


Figure 11 Systems mapping of EV readiness criteria for cities
Source: TERI

4 Capacity Needs of Cities for Electric Vehicle Planning and Deployment

As noted in the above section, all four cities show varying characteristics and readiness levels for EV planning and deployment at the city level. They also leave scope for cross-disciplinary interventions to accelerate EV adoption in the cities (Figure 12). The stakeholder consultations further elucidated the specific capacity needs of each city with regards to each criterion. Figure 13 shows the general capacity needs of Indian cities while Table 4 summarizes the city-wise capacity needs that were identified during the analysis for this study.

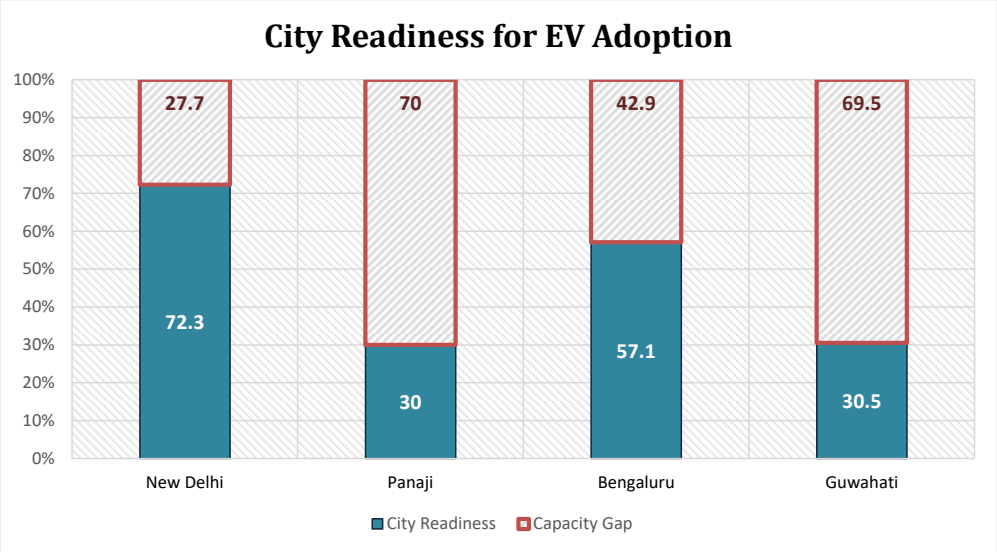


Figure 13 City-wise readiness and capacity gap levels for EV adoption

Figure 12 Overall capacity needs for accelerated EV adoption in Indian cities

Overall capacity needs for accelerated EV adoption in Indian cities

Table 4 City-wise capacity needs for accelerated EV adoption

Criteria	Intervention Areas			
	New Delhi	**Panaji**	**Bengaluru**	**Guwahati**
Institutional/Policy Capacity	More incentives for all vehicle segments, beyond public transport and commercial purposes; Easing of complex criteria for obtaining subsidies	Incentives for manufacturers and creation of city-level EV cell; Easing of complex criteria for obtaining subsidies	Need for Direct Purchase Incentives and charging infrastructure incentives; Easing of complex criteria for obtaining subsidies	Strategic Implementation of the Policy Creation of State Level Committee for Better Implementation; Easing of complex criteria for obtaining subsidies
Economic Capacity		Need to increase market penetration of EVs through private financing mechanisms	Fiscal Incentivization to boost EV transition	Involvement of Private Financing Institutions to Accelerate EV Adoption
Infrastructural Capacity	Private Partnerships in leveraging charging infrastructure	Need for Adequate Provision of Charging infrastructure within the city	More emphasis on charging stations and its Operation and Maintenance	Adequate Provision of Charging Infrastructure Increasing Grid Capacity to Meet the Charging Demand
Technological Capacity		Preparedness and capacity development of electric grid for variable utility load from EV charging and introduction of more EV models in the market		R&D for Assessing the Suitability of Current EV Models in Hilly Terrain and Encourage New Suitable Technologies

Social Capacity	Consumer Awareness Campaigns (about total cost of ownership and to prevent range anxiety)	Consumer Awareness Campaigns	Consumer Awareness Campaigns	Consumer Awareness Campaigns
Environmental Capacity		Need for City-level comprehensive action plan to tackle air pollution	Need for State Action Plan to clarify on EV-related targets and strategies	Need to Devise Focused Action Plan to Tackle Air Pollution with Specific Focus on Transport Emission Reduction
Innovation Capacity	Learning from international best practices to electrify public transport fleet	Implementation of proposed city-level innovative models for faster EV adoption		Private Partnerships to Accelerate the EV Adoption in Various Transport Segments

Note:

Action Required	Intermediate Action Required	Immediate Action Required

References

CEIC, February 2022, “India Motor Vehicles Sales Growth”, ceicdata.com. Details available at https://www.ceicdata.com/en/indicator/india/motor-vehicles-sales-growth#:~:text=India%20Motor%20Vehicles%20Sales%20Growth%20rate%20is%20updated%20monthly%2C%20available,314%2C333.0%20units%20in%20Feb%202022

Dominković, D. F., Bačeković, I., Pedersen, A. S., & Krajačić, G. (2018). The future of transportation in sustainable energy systems: Opportunities and barriers in a clean energy transition. Renewable and Sustainable Energy Reviews, 82, 1823–1838.

Funke, S. Á, Sprei, F., Gnann, T., & Plötz, P. (2019). How much charging infrastructure do electric vehicles need? SEPA review of the evidence and international comparison. Transportation Research Part D: Transport and Environment, 77, 224-242. doi:https://doi.org/10.1016/j.trd.2019.10.024

International Energy Agency. (2020). Tracking Transport 2020.

London Assembly, 31 May 2018, “Mayor launches new taskforce to expand electric vehicle infrastructure”, London.gov.uk. Details available at https://www.london.gov.uk/press-releases/mayoral/taskforce-will-work-on-shared-delivery-plan

NITI Aayog. (2019). India’s electric mobility transformation: Progress to date and future opportunities. NITI Aayog, Rocky Mountain Inst., Basalt, CO, USA, Tech. Rep.

Paladugula, A. L., Kholod, N., Chaturvedi, V., Ghosh, P. P., Pal, S., Clarke, L., & Wilson, S. A. (2018). A multi-model assessment of energy and emissions for India's transportation sector through 2050. Energy Policy, 116, 10–18.

Randall, C., 5 August 2021, “Paris region introduces EV subsidies”, electrive.com. Details available at https://www.electrive.com/2021/08/05/paris-region-introduces-ev-subsidies/#:~:text=The%20subsidies%20of%20up%20to,limited%20to%20one%20per%20person

Shah, K. J., Pan, S. Y., Lee, I., Kim, H., You, Z., Zheng, J. M., & Chiang, P. C. (2021). Green transportation for sustainability: Review of current barriers, strategies, and innovative technologies. Journal of Cleaner Production, 326, 129392.

Singh, Virender, Vedant Singh, and S. Vaibhav. "A review and simple meta-analysis of factors influencing adoption of electric vehicles." Transportation Research Part D: Transport and Environment 86 (2020): 102436.

Zhang, X., & Bai, X. (2017). Incentive policies from 2006 to 2016 and new energy vehicle adoption in 2010–2020 in China. Renewable and Sustainable Energy Reviews, 70, 24–43.

Annexure 1

List of organizations who took part in the stakeholder consultations (interview/surveys)

- Assam State Transport Corporation
- Assam Electricity Regulatory Commission
- Ather Energy
- BangaloreWALKS
- Corporation of the City of Panaji (CCP)
- Council on Energy, Environment and Water (CEEW)
- Directorate of Urban Land Transport (DULT)
- GIZ GmBH
- Guwahati Municipal Corporation
- Hero Electric/Society of Manufacturers of Electric Vehicles (SMEV)
- IIT Guwahati
- Imagine Panaji Smart City Development Limited (IPSCDL)
- Kadamba Transport Corporation (KTC)
- KPMG
- NITI Aayog
- National Research Development Corporation (NRDC)
- Observer Research Foundation (ORF)
- RMI India
- Shakti Sustainable Foundation
- The Energy and Resources Institute (TERI)
- WRI India

Total stakeholder consultations (interviews + surveys) = 30

Annexure 2

Cities Selection Criteria

RCNA Selection Framework: The groupings, subgroupings, and a set of example selection metrics are shown. Due to data availability constraints, certain example metrics were unavailable for all cities during the selection process. The listed example metrics are meant to describe the type of factors we considered. Therefore, they are not a comprehensive list of all the selection criteria used.

Group	Subgroup	Criteria
Stage of EV Transition	Infrastructure capacity	Quality/volume of EV charge points
		Electricity grid capacity
	Existing vehicles	EV sold growth rate
		Number EV/non-EVs by type
Physical/Environmental Characteristics		Region
		Area
		GHGs from transport sector
Economic Characteristics	Population	Population tier/growth rate
	Financials	Average household income/growth rate
		Industry composition
		Government income/GDP per capita/growth rate
Governance/EV Policy		Motivation for EV policy
		Demand-side subsidy amount (by type)
		Supply-side subsidy amount (by type)

		Non-EV subsidies
		Desired growth of EV manufacturing
		Driver privileges (parking access, etc.)
Innovation Characteristics		Stated goals and commitment to achievement
		Presence of EV companies
		Willingness to take risks/desire to emerge as a leader

Annexure 3

List of Stakeholders Involved for each City

	Governance	***EV Policy***	***Traffic and Vehicle Regulation***	***EV and Charging Infrastructure***	***Research and Philanthropy***
Guwahati	Guwahati Municipal Corporation	Department of Industries and Commerce, Government of Assam	Assam State Transport Corporation (ASTC)	Assam Electricity Regulatory Commission (AERC)	Electric Mobility Laboratory, IITG
	Guwahati Smart City Ltd	Department for Promotion of Industry and Internal Trade (North-East Industrial Development Scheme)	RTO Office, Guwahati	Department of Power, Government of Assam	
	Traffic Police Department				
Bengaluru	Bruhat Bengaluru Mahanagar Palike (BBMP)	Commerce and Industries Department, Government of Karnataka	RTO, Bengaluru	Bangalore Electricity Supply Company Limited (BESCOM)	IISc
	Bengaluru Smart City Ltd	Directorate of Urban and Land Transport, Karnataka	Transport Department, Government of Karnataka		Bangalore Apartments' Federation (E-Vaahana Campaign)
	Traffic Police Department		Bengaluru Metropolitan		

			Transport Corporation		
	Solid Waste Management Department, BBMP				
New Delhi	Municipal Corporation of Delhi	Department of Transport, Delhi	Delhi Transport Corporation (DTC)	Delhi Electricity Regulatory Commission	IIT-D
	Traffic Police, Delhi	Switch Delhi, Government of Delhi	RTO Delhi		TRIP
	EV Cell, Delhi				
Panaji	Imagine Panaji Smart City Development Limited (IPSCDL)	Electricity Department		OEMs/Auto manufacturers	
	Transport Department	Goa Energy Development Authority		CPOs (Charge Point Operators)	
	Corporation of City of Panaji (CCP)	Convergence Energy Service Limited (CESL)			

Source: TERI

Annexure 4

Current State-wise policies and incentives

Comparative Analysis – EV Policies (Specific Targets)

State Policies	Delhi Electric Vehicles Policy	Goa Electric Mobility Promotion Plan (GEMPP)	Karnataka Electric Vehicle & Energy Storage Policy	Electric Vehicle Policy of Assam
Status of Policy (Approved/Draft/etc.)	Approved	Approved	Approved	Approved
Year of incorporation	2020	2021	2017	2021
Policy Duration	3 years	5 Years	5 years	5 years
Policy Targets : ***EV Share***	25% EV share out of all new registrations by year 2024	At least 30% of the state's vehicles to be electric by 2025 100% EV share by 2030	100% electric mobility by 2030 for auto rickshaws, cab aggregators, corporate fleet, school buses/vans, goods transport vehicles	25% EVs out of all new registrations by the year 2026 Phase out ICE commercial vehicles by 2030
Policy Targets : ***Government Fleets***	All lease/hired cars used by Delhi Government to be transitioned to EVs by 2021	100% EV transition of state government vehicles by the year 2022	-NA-	100% EV transition of government vehicles by 2030 Can purchase only EVs after 2025 for Govt use
Policy Targets : ***Public Transport***	Induction of 1000 E-buses by the year 2020	50% of ferries running on battery power, in the next four years 50% of all new buses procured for the state fleet to be pure electric	1000 electric public buses in next 5 years	100% e-buses by 2030

State Policies	Delhi Electric Vehicles Policy	Goa Electric Mobility Promotion Plan (GEMPP)	Karnataka Electric Vehicle & Energy Storage Policy	Electric Vehicle Policy of Assam
Legal (Taxes)	Road Tax & Registration Fees Exempted	Registration Fees Exempted, waiver on road tax	Road Tax Exempted	Registration Fees & Road Tax Exempted

Source: TERI

Comparative Analysis – EV Policies (Incentives)

States	Delhi	Goa	Karnataka	Assam
Fiscal Incentives (2W)	Demand incentive ₹30,000 per EV Purchase Incentive ₹5000/kWh (upto ₹30,000)	For first 3000 2Ws: Maximum 30,000 per EV	Support to short distance shared mobility electric 2W taxi	For first 1 lakh 2Ws: ₹20,000 per EV
Fiscal Incentives (3W)	Purchase incentive: ₹30,000 per EV; Interest subvention: 5% on loans	For first 50 3W : E-Autos ₹10,000/kWh upto ₹30,000 E-rickshaws: Purchase incentive of ₹30,000 per vehicle	-NA-	For first 75,000 3W Incentive: ₹ 50,000 per EV Retrofitment Incentive- 15% upto ₹15,000 for autos
Fiscal Incentives (4W)	₹10,000/kWh - first 1000 – up to ₹1.5 lakh Goods Carrier: ₹30,000 per EV	Support Deployment of first 300 4W- Purchase Incentive of ₹10,000 per kWh subject to a maximum of ₹150,000 per vehicle to the registered owner Goods Carrier : ₹30,000 per EV	-NA-	For first 25,000 4W- Incentive: ₹150,000

States	Delhi	Goa	Karnataka	Assam
Incentives - manufacturing	-NA-	For Large Manufacturing units- Cap Subsidy = 20% of fixed capital investment 100% SGST reimbursement for 5 years 100% stamp duty exemption For MSMEs: Cap Subsidy = 30% on office (max-5 lakhs for micro units , 10 lakhs for small & medium units) 100% SGST reimbursement for 5 years 100% stamp duty exemption 100% electricity duty reimbursement for 5 years	Investment promotion subsidy 100% stamp duty exemption Concessional Registration Charges Reimbursement of land conversion fee 100% exemption from tax on electricity tariff Interest free loan on net SGST to large, mega, ultra-mega and super mega enterprises	20% of cost of the plant & machinery- Subject to maximum of : ₹15 lakh - Micro ₹50 lakh - Small ₹1 crore -Medium 10% of cost of the plant, subject to maximum of ₹10 crore for large units Additional interest subsidy of 2% on working capital loan

Source: TERI