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Government of India

Federal Ministry for Economic Cooperation and Development

CITY ELECTRIC MOBILITY STRATEGY (CEMS)

A SUPPLEMENT TO CMP TOOLKIT

NOVEMBER 2022

SUM-ACA
Sustainable Urban Mobility
Air Quality, Climate Action & Accessibility

CEPT UNIVERSITY

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On behalf of the
German Federal Ministry for Economic Cooperation and Development (BMZ)

About GUMP

India and Germany have been working for more than 60 years together on environment-friendly urban development projects. To further deepen this cooperation, in November 2019, the Ministry of Housing & Urban Affairs (MoHUA), the Government of India and the German Federal Ministry for Economic Cooperation and Development (BMZ) signed a Joint Declaration of Intent on Green Urban Mobility Partnership (GUMP). Both countries agreed to collaborate more closely to transform urban transport systems through more efficient, people-centric and low carbon mobility solutions.

BMZ is funding a wide range of sustainable urban mobility infrastructure improvement measures such as city bus transport systems, trams, water transport, cable cars, non-motorised transport, and multimodal integration. In addition, Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) is providing technical cooperation to enhance the capacities of national, state and local institutions and decision-makers for designing sustainable, inclusive and smart solutions for easy and affordable mobility.

The implementation of this agreement is accompanied by a policy dialogue between the Indian and German sides to achieve effective international contributions to fighting climate change jointly.

About SUM-ACA

Sustainable Urban Mobility - Air quality, Climate action, Accessibility (SUM-ACA) is implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and the Ministry of Housing and Urban Affairs (MoHUA), commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ). The project objective is to enable national, state and municipal institutions to promote climate and environmentally friendly, low emission and socially balanced urban mobility systems. The project is part of the Green Urban Mobility Partnership between Germany and India.

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ABOUT THIS REPORT

The Ministry of Housing and Urban Affairs (MoHUA) has mandated the preparation of a Comprehensive Mobility Plan (CMP) for cities as a guiding document for improving the urban transport of the cities. As the development of a CMP is a complex task, MoHUA issued a toolkit with an explanation of the process in 2008. This toolkit was revised in 2014 to address concerns about climate change and sustainable development. Since then, the Government of India has introduced several new policies and programs for the betterment of urban transport. An important initiative pertains to the promotion of electric mobility through the wider introduction of electric vehicles in cities.

Globally, the use of Electric Vehicles (EVs) has increased in recent decades due to supporting policies and technological advancements. According to the National Electric Mobility Mission Plan (NEMMP) 2020, sales of electric vehicles in India are expected to increase up to 16 million due to government support and the FAME policy, which was introduced to encourage a faster adoption and manufacturing of electric vehicles. However, the total EV sales have reached only 1.21 million, i.e. 7.6% of the target (1). The government's initiatives to electrify the transport system have so far focused primarily on public transport and commercial vehicles, but even here, progress to date has not been significant. Since the country is at the nascent stage of electrification and for the rapid growth of vehicles across various cities in the country, it is important to foster the electrification of urban transport to reduce the contribution towards GHG emission and transform transportation into an efficient and sustainable system.

In this context, the document City Electric Mobility Strategy (CEMS) provides a framework for consideration of electric mobility (and other alternate energy options) as an integral part of the CMP strategy by addressing different aspects of CMP preparation. The CEMS supplement provides the following:

1. Process of visioning, formulating objectives, identifying relevant indicators, and setting targets for sustainable mobility,
2. Scenario development (task 3 and 4 of CMP) with a framework to assess the impact of strategies and options incorporating electric mobility,
3. Methodologies for forecasting electric vehicle adoption scenarios, and
4. A framework for identifying actions for faster adoption of electric mobility.

1 https://cef.ceew.in/solutions-factory/tool/electric-mobility

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1 INTRODUCTION

1.1 BACKGROUND

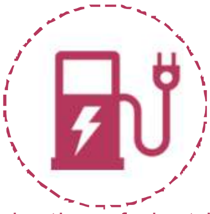
Recognising the importance of mobility in urban areas and its potential impacts on sustainability and economic growth, the Ministry of Housing and Urban Affairs (MoHUA) adopted the National Urban Transport Policy in 2006. The primary objective of the policy is "to ensure safe, affordable, quick, comfortable, reliable and sustainable access for the growing number of city residents"[2] to employment opportunities, education, recreation and such other needs within the cities." Within the broad framework set out in the NUTP, the Government formulated programs and policies, and also invested in various urban areas. MoHUA had mandated the preparation of the Comprehensive Mobility Plan (CMP) as a long-term sustainable urban transport strategy and to serve as a guiding document for improving urban transport in cities.

The CMP process is a complex task as it involves multiple considerations such as land use, energy, environment, social equity, efficiency, economic development, etc. In 2008, the MoHUA issued a toolkit for the preparation of CMP. The CMP toolkit was revised in 2014 to address concerns on climate change and sustainable development. The Government of India has introduced new policies and urban transport programs among which one of the important initiatives in facilitating the adoption of electric vehicles in cities.

The key highlights of this initiative are as follows:

To reduce its emission intensity.

A. India has pledged to reduce its emission intensity (GHG emissions per unit GDP) by 33%-35% below the 2005 levels by the year 2030 as part of its "Nationally Determined Contributions" (NDC) in accordance with the Paris Agreement (PA). India's transport sector being the 4th largest contributor of GHG emissions (accounting for 265 million tons of CO_2 in 2019)[3], has been identified as an intervention area towards this ambitious goal.



Adoption of electric mobility

B. The government of India established a National Mission on Electric Mobility in 2013; its two phases of Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME) scheme in 2015 and 2019 aimed at the adoption of electric mobility for reducing carbon emissions and attaining energy security.

Adoption of electric vehicles across all modes

C. With concerted efforts by both the Central and State governments, the push for electric mobility and to encourage the adoption of electric vehicles (EV) across all modes are through a combination of fiscal and non-fiscal incentives, and regulatory actions.

In this context, implementation strategies as part of the city mobility planning process come into sharp focus and hence this document - City Electric Mobility Strategy (CEMS) - on formulating guidelines for developing electrification strategies for transport in Indian cities will serve as a supplement to the CMP toolkit (2014).

2 Ministry of Environment, Forest and Climate Change
3 CAIT- Climate Data Explorer

1.2 CMP TOOLKIT 2014 & CEMS SUPPLEMENT

The CMP toolkit (2014) prepared by the Institute of Urban Transport India (IUT) under the advice of MoHUA (erstwhile MoUD) includes detailed six tasks to be followed for preparing the CMP given in the figure below.

1 TASK	**Defining the Scope of the CMP**	Planning area; Planning Horizon; Work Plan; Vision; and consultation for validation of CMP
2 TASK	**Data collection and analysis of the existing Urban Transport Environment**	City profile; delineation of Traffic Analysis Zone; land use pattern and population density; transport systems; travel behavior; energy and environment; Service Level Benchmark; analysis and indicators (comparison with benchmark).
3 TASK	**Development of Business as Usual (BAU) Scenario**	Scenarios framework; socio-economic projections; land-use transitions; transport demand analysis; technology transitions; Co2 emissions and air quality; and analysis and indicators (comparison with benchmark).
4 TASK	**Development of Sustainable Urban transport Scenario**	Scenario framework; strategies for sustainable urban transport scenarios; transport demand analysis of alternative strategies; technology transitions under low carbon scenarios; Co2 emissions and air quality; and analysis and indicators (comparison with benchmark).
5 TASK	**Development of Urban Mobility Plan**	Integrated land use and urban mobility plan; formulation of the public transport improvement plan; preparation of road network development plan; NMT facility improvement plan; freight movement plan; mobility management measures; development of fiscal measures and mobility improvement measures and NUTP objectives.
6 TASK	**Preparation of Implementation program**	Implementation programs; identification and prioritisation of projects; funding of projects; and monitoring of CMP implementations.

Figure 1 : Existing CMP preparation framework 2014 (Source: MoHUA)

The focus of the CEMS supplement is to introduce a framework for consideration of electric mobility (and other alternate fuel option) as an integral part of the CMP process. Specifically, this supplement addresses the following aspects of CMP:

a. Process of visioning, formulating the objectives, identification of relevant indicators and setting of targets towards sustainable mobility.

b. Scenario development (Tasks 3 and 4 of CMP) with a framework to assess the impact of strategies and options incorporating electric mobility. The conceptualisation of scenarios based on land use and transport integration mobility improvements, and electrification levels is proposed. An evaluation system to assess performance against defined objectives is suggested.

c. A brief on methodologies for forecasting electric vehicle adoption scenarios are presented.

d. A framework for identifying specific actions required for faster adoption of electric mobility is presented.

Source: https://www.bloombergquint.com/business/government-mulls-installing-electric-vehicle-charging-kiosks-at-69000-petrol-pumps

Photo credits : GIZ

2 VISION, OBJECTIVES, INDICATORS AND TARGETS

Envisioning the future of the city's land-use-transportation system entails the formulation of a long-term vision, setting of objectives and identification of operational indicators. This is important as it aids in streamlining future planning strategies aligning with the plan vision and objectives.

2.1 FORMULATING THE MOBILITY VISION FOR A CITY

The process must begin with extensive consultation with citizens and stakeholders to seek answers to the following questions:

- Where are we now in terms of city mobility development, i.e. what kind of city is ours today, and what kind of mobility do we adopt?
- Where do we want to go, i.e., what kind of a city we want ours to be and what kind of mobility we want to adopt?
- How do we get there, i.e., how may we prepare to change the city as we vision it to be, and by when?

While the first question deals with assessing the existing situation of the city, with respect to its transport system, the benchmarking process of assessing the performance of the city in terms of various indicators would provide essential input and a basis for discussion and consultation. The subsequent questions are targeted at developing an understanding of how the stakeholders visualise the city in the long run and assessing what alternative ways and means can be adopted to reach there.

STAKEHOLDER PARTICIPATION IN THE VISIONING PROCESS

Stakeholders play an important part in the visioning process to arrive at a common understanding of how the city should develop. The process also helps in minimising conflicts and building consensus on the actions and strategies for the future course of action.

Several cities invite citizens for the visioning exercise. The involvement of citizens in the planning process ensures the vision addresses the needs/ideas of different groups. Though inputs from citizens may often be broad and open-ended, they would nevertheless help raise awareness about the plan and also to formulate an inclusive and representative vision.

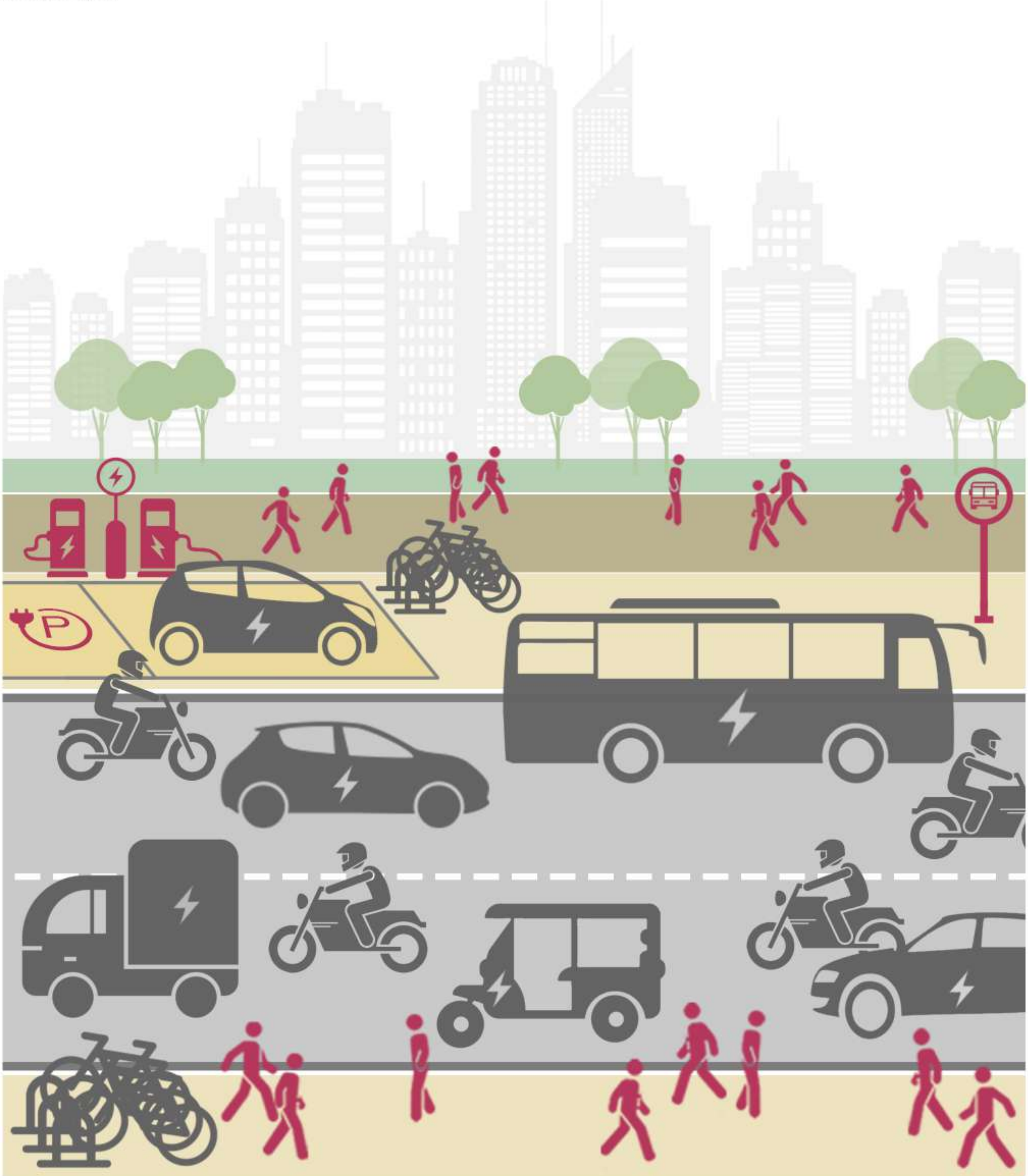
This process should also involve primary stakeholder institutions that are responsible for urban and transport planning and implementation. This helps in creating a collaborative working relationship among groups and institutions related to transport and urban development. This leads organisations to take responsibility for their actions towards desired plan outcomes.

This approach aims at developing a vision based on how citizens want to see their city in the future rather than focusing only on current problems.

FORMULATING THE VISION STATEMENT

A vision statement should be a single, broad, and easy-to-understand that provides a direction for the city's growth. The strategic vision for the transportation system for the city should be 'in sync' with the overall city vision and should render a foresight of the future transport scenario of the city. It helps in defining priorities for developing the objectives and the strategic plan. The transportation vision should be based on ideas and aspirations for the future of transport development for the city. The vision provides an overarching direction to guide the long-term transportation planning activities of the city. It seeks to provide a broad indication or an answer to the questions of **"Ideally, how should the city's transportation system evolve?"** or **"What kind of urban transport system would best serve the city's interests and needs of citizens?"**

A few examples of vision statements and objectives are cited for purpose of illustration on the next page.



EXAMPLES OF VISION STATEMENTS OF CITIES

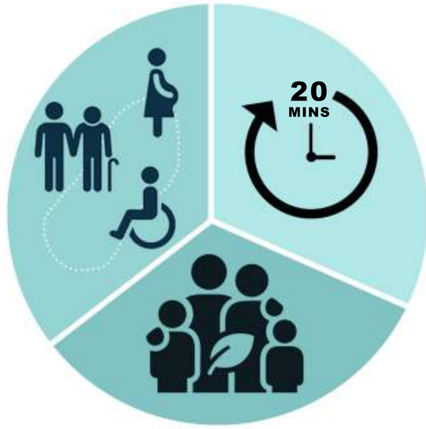
SINGAPORE: THE 45 MINUTE CITY

The LTMP 2040 aims for a convenient, fast and well connected transport network that can get residents around the city in 45 minutes or less; an inclusive transport ecosystem; and a healthier, cleaner, greener transport environment.

The objectives are:

- 45 Minute City with 20 Minute Towns in 2040
- Transport for All
- Healthy lives and safer journeys

Source: Land Transport Master Plan 2040



LONDON: TRANSPORT IS CENTRAL TO THE VISION OF THE MAYOR

The central aim of this strategy is to create a future London that is not only home to more people but is a better place for all those people to live in.

The objectives are:

- Healthy streets and healthy people
- A good public transport experience
- New homes and jobs

Source: The London Plan, March 2021 and Mayor's Transport Strategy, March 2018

NEW YORK: EFFICIENCE MOBILITY – ONE NYC 2050

New York City will enable reliable, safe and sustainable transportation options so that no New Yorker needs to rely on a car.

The objectives are:

- Modernise New York city's mass transit network
- Ensure New York City's streets are safe and accessible
- Reduce congestion and emissions
- Strengthen connections to the region and the world

Source: Strategic Plan 2016, New York City Department of Transportation

TORONTO, CANADA

Climate Action for a Prosperous, Equitable and Healthy Toronto

The objectives are:

• A community-wide and cross-corporate initiative of the City of Toronto, The Atmospheric Fund, designed to engage residents, other stakeholders, experts, and all City operations in identifying ways to reduce Toronto's greenhouse gas emissions by 30 percent by 2020, and by 80 percent by 2050, against 1990 levels.

Source: TransformTO: Climate Action for a Healthy, Equitable & Prosperous Toronto, Implementation Update 2017 and 2018, City of Toronto, Environment and Energy Division

SURAT, INDIA

Surat's mobility vision is to create 'SARAL Parivahan, Samrudh Janjivan'.

Simple to understand, easy to use, safe to travel, reliable and affordable transport towards the prosperity of people'. SARAL also stands for Safe, Accessible, Reliable, Advanced and Low Carbon Mobility in Surat.

The objectives are:

• Improving the quality of life of the people by providing for a Safe and Sustainable transport system.
• Supporting economic growth in the city by enhancing Accessibility for people and goods to major activity centres.
• Ensuring efficient connections by providing Reliable multi-modal travel options.
• Optimising transport system operations and enhancing the travel experience of the people through Advanced technological applications in transport.
• Contributing to the environment by promoting Low carbon mobility.

Source: Surat CMP 2043

2.2 DEFINING CITY MOBILITY OBJECTIVES

Objectives are "statements of desired end state"(4) and provide specific direction of improvements required to achieve the vision.

Objectives should be strategic and adhere to the transportation vision, providing a basis for identifying problems of the day and that would arise in the future. They help in arriving at solutions and provide a basis for evaluating alternative solutions in terms of the extent to which the stated objectives are met. They also aid in the monitoring of progress in implementation.

In general, the primary objective of CMP is to provide a sustainable and efficient transport system, that offers sufficient choices of modes to all citizens, accessibility, and affordability significant for employment, economic activity, and social needs. This ensures that apart from supporting the local economy, societal concerns like equity, environmental objectives like sustainability and improving the quality of life of residents are also considered. Thus, the statements of objectives in a CMP should balance the goal of providing efficient transportation with considerations of social equity, environmental sustainability, and local economic development.

While setting objectives, mentioning possible solutions is best avoided. For example - moving towards a sustainable transportation city by focusing on public transport systems - is fraught with overlooking other possible measures like focus on non-motorised transport (NMT) modes, fuel quality, vehicle technology, etc. An error often made while setting objectives is to include strategies as objectives. Articulating objectives is about what is to be achieved, and not how.

2.3 IDENTIFYING INDICATORS FOR OBJECTIVES

While the objectives help streamline the direction of the plan, they also help in assessing future scenarios and feasible strategies. A set of indicators for each objective enables such assessments.

For example, the trends in road accidents are a measure of safety and can be indicators for the 'safety' objective. Similarly, average network speed in the city is an indicator of 'efficiency', while pollution levels (NOx, SOx, PM2.5) are indicators for the 'environment' objective. Likewise, for the assessment of alternate scenarios, it is essential that indicators are identified for each objective and a comprehensive evaluation framework is set up. In some cases, objectives may have specific and realistic targets based on these indicators to be achieved within a particular time, e.g. specifying the public transport mode share increase over the next 5 years.

Performance in each scenario can then be assessed using the identified indicators that can help in establishing baselines, analysing trends, foreseeing problems, assessing the effectiveness of alternate scenarios in meeting the objectives, and finally, in setting the performance targets.

Base data on travel characteristics shall be collected by the city every two years as it helps in analysing the performance of the city's transport system periodically. The identified indicators can be added to the existing list of data to be collected as it can help to monitor the progress on implementation and assess the achievements of the city's transport system.

4 Bell, M., Bonsall, P., Leake, G., May, A., Nash, C., & O'Flaherty, C. (2006). Transport Planning and Traffic Engineering. Nertherlands: Elsevier Ltd.

2.4 OBJECTIVES AND INDICATORS

A comprehensive assessment of urban transport sustainability has to be evaluated against transportation system objectives as well as social, economic and environmental objectives. A set of seven objectives and their corresponding indicators within the social, economic and environmental dimensions are presented below.

Table 1 : Objectives and Indicators

SR NO.	OBJECTIVES	INDICATORS
A	**Domain: Economic**	
1	**ACCESSIBILITY :** This involves provisioning people's access to walkable streets, bicycle infrastructure and public transport services.	• % of the street network has walkable footpaths on both sides • % of the major street network having both sides green shade • % higher order street network having bicycle priority • % population within 500 m from PT Station or stop • BRT or MRT density per sq. km. of developed area • % NMT Trips • % population having workplaces within 30 minutes of travel by sustainable modes
2	**EFFICIENCY :** This involves maximising the user/society benefits from the transport system Minimising the user/society dis-benefits from the transport system	• % trips on sustainable modes (Walk, Bicycle, & Public Transport) • Average travel time (30 minutes city) • Passenger km per vehicle km (PKT/VKT) • Tonne km per vehicle km (TKT/VKT) • Passenger comfort in public transport (Load factor)
3	**ECONOMIC IMPACTS :** Transport investments lead to improvements in access and thereby productivity. Efficiency in reduction of costs of logistics and labor and improve access or enhancing the environment can lead to increased economic activity and possibly to sustained economic growth.	• Average Daily VKT of passenger vehicles per population • Average Daily VKT of Freight per population • % Congested network • Average network speeds during peak period • Average jobs along the Rapid Transit Network (500 or 750 m distance on both sides)

SR NO.	OBJECTIVES	INDICATORS
B	**Domain: Social**	
4	**AFFORDABILITY :** Setting affordable PT fare is an important social objective because the share of the transport costs in the household budget has a significant impact on the welfare of the urban poor.	• Monthly travel costs for work for average trip length (Affordable limit for bottom 20% population to be <15%) • Concessionary fares to senior citizens, differently-abled, students and women
5	**EQUITY AND SOCIAL INCLUSION IN SERVICE PROVISION :** This includes providing equal opportunities for travel and gainful employment in the sector. The target population includes urban poor, differently-abled, women and the third gender	• Fare concessions for differently-abled • % higher-order network with universal accessibility • % PT supply with universal accessibility • % of women or third gender ridership in PT system • % women or third gender in the PT workforce
6	**ENSURING SAFETY :** This involves reducing the number of fatalities	• % of people finding public streets secure (User perception) • % total security related complaints on public streets • Fatalities per lakh population
7	**ENSURING SECURITY :** This involves reducing the security issues	• % of people finding PT system secure (User perception) • % total security related complaints on PT system per lakh PT ridership • % of sexual harassment cases on PT system per lakh PT ridership
C	**Domain: Environment**	
8	**PROTECTING ENVIRONMENT AND HEALTH :** This involves minimising the proportion of the population exposed to harmful emissions and their impact on health; built environment, level of active mobility and impact on health This also involves assessing minimising the transport sector's contribution to climate change.	• Annual mean levels of fine particulate matter (PM10) in the air (population-weighted) compared to the health threshold • Proportion of adult population with an incidence of non-communicable diseases • Ton of CO_2 equivalent emitted per capita in a year • Noise levels on major streets in residential and commercial areas (dB levels). (5) • Battery recycle policies in place. (6)

5 Prescribed acceptable noise levels as per of World Health Organisation (WHO) is: for the daytime noise (75 dB (A) for Industrial area, 65 dB (A) for Commercial area, 55 dB (A) for Residential area and 50 dB (A) for Silence zones)
6 Refer E-Waste (Management) Rules, 2016; Vehicle Scrappage Policy launched by PM encourages scrapping of old and polluting vehicles, encourage recycling of materials and boost the Indian automobile industry

2.5 SETTING TARGETS

Targets signify a definite form to the commitments in the mobility plan during the intermediate years and in the outcome. Targets correspond to the indicators and support monitoring of the plan in terms of what has been achieved and where the city lags. It is to be noted that multiple indicators measure the achievement of a single objective and visa-versa. As an illustration, mobility objectives, indicators and targets are presented below.

NEW YORK CITY'S MOBILITY OBJECTIVE, INDICATORS AND TARGETS

To illustrate, the mobility objectives of New York City are:

- Modernise New York City’s mass transit networks
- Ensure New York City’s streets are safe and accessible
- Reduce congestion and emissions

In line with these, the indicators and targets are set as:

- Share of New York City trips by sustainable modes to reach 80% in 2050 from 68% in 2017.
- Average city-wide bus speed to reach 10kmph by 2020 from 8kmph in 2018.
- Traffic fatalities to reduce to zero from 208 in 2018.
- New Yorkers that live within 1/4 mile of the bike network should reach 90% by 2022

Source: https://basquetrade.spri.eus/en/commercial-opportunities/usa/new-york-city-aims-for-all-electric-bus-fleet-by-2040/

2.6 DEFINING ENVIRONMENTAL OBJECTIVES AND SETTING TARGETS

Environmental objectives and targets must be established as an integral part of the CEMS. These objectives and targets are not only related to the reduction of GHG emissions and improving air quality in cities, but are also related to conserving and protecting the environment. For future target setting, it is critical to estimate the base year GHG emission (7), air and noise emissions from the urban transport sector. Disposal of batteries is also a major concern.

Some of the approaches for setting up environmental objectives and targets are discussed below:

APPROACH 01

As India does not have a long term GHG emission reduction target specifically for the transport sector, the first approach proposes setting an emission reduction goal based on the 'Sustainable Mobility for All' initiative that suggests that the global transport emissions should be below 0.3 tonnes CO2 per capita in 2050 to be line with the Paris Agreement climate change goals (Global Roadmap of Action Toward Sustainable Mobility, 2019).

APPROACH 02

The second approach proposes translating India's NDC of reducing 33-35% GHG emission intensity by 2030 from 2005 levels across the economy to the transport sector at the city level. This will require setting out a proportionate environmental target for the city's transport sector depending on the horizon year of the plan.

APPROACH 03

The third approach focuses on the review of international and national case studies for similar environmental goals and then developing a target feasible for the case city.

APPROACH 04

The fourth approach is based on translating the state-level target and other city-level targets to transport specific targets if available. Further, it may also include the city's ambition and political will in setting up environmental targets for transport.

7 To estimate GHG emissions from the transport sector at the city level, a excel based tool has been developed. Further details on the tool are presented in Annexure A : City GHG Emissions Estimation Tool

Photo credits : GIZ

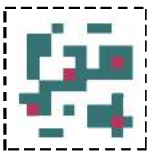
3 BUILDING SCENARIOS - FORMULATING MIX OF STRATEGIES

A 'strategy' is commonly understood as an action plan or a roadmap to bring about the desired future outcome. A mix of strategies is usually adopted by cities to address complex urban challenges, as a single strategy may not fully deliver all desired outcomes. A strategy mix comprises sets of complementary strategies and can be used to define alternate policy scenarios for urban transport planning. These strategies may be broadly classified as 'Land-use-Transport Strategies', 'Mobility Strategies', and 'Fuel Mix Strategies'.
The challenge for urban transport planners is to determine the optimal combination of strategies to achieve the transport system objectives in their respective cities.

This section guides on developing strategies, grouping them as scenarios and assessing their outcomes based on clearly defined objectives and corresponding indicators.

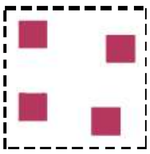
3.1 DEFINING STRATEGY MIX

LAND USE - TRANSPORT STRATEGIES
These strategies relate to structuring urban growth scenarios typically known as sprawl, mono-centric compact development and poly-centric decentralised concentrated development scenarios. These scenarios would consider a combination of parameters such as - population density, city structure (monocentric/ polycentric), street network density, road hierarchy and road network pattern, pedestrian accessibility, and on-street priority for non-motorised transport.



- **SPRAWL**
  The sprawl scenario can be defined as the city's growth extending beyond its administrative boundaries. The city grows horizontally, resulting in large areas around the city getting urbanised with low-density, scattered, personalised vehicle-dependent development.

- **MONO-CENTRIC (COMPACT DEVELOPMENT)**
  The key characteristic of this scenario is mono-centric compact development with dense and proximate development patterns. It has dense development centres/nodes along the corridors.



- **POLY-CENTRIC (DECENTRALISED CONCENTRATED DEVELOPMENT)**
  In this scenario, the city has concentrated growth at a few centres/nodes and low-density development in the rest of the city.

The table below guides in defining land use transport growth scenarios. The difference among the growth scenarios is relative and is compared to the base year. These are presented in two parts; land-use strategies and transport infrastructure strategies. The land-use strategies deal with the structuring of urban spatial growth while transport strategies define the infrastructure state.

Table 2 : Land use Strategies - parameters

PARAMETERS	SPRAWL	POLY-CENTRIC (DECENTRALISED CONCENTRATED DEVELOPMENT)	MONO-CENTRIC (COMPACT DEVELOPMENT)
1. Population Density	Depending on the base year developed area gross density, change in density during the plan period (in percentage) may be adopted for analysis. It is important to note that cities are built as layers year after year and maintaining current levels of gross density would be a desirable objective. Any further infilling leading to a 5% to 10% increase in density would be a great achievement over the plan period. The most likely scenario is that cities would experience an increase in densities up to about 5% from the current level which may also be considered as a good effort. Any decrease in density over and above 5% from the current level would be observed in cities with a tendency to sprawl.		
	Decrease in gross density* between 5% to 20%	Maintains gross density (changes are within +/-5%)	Increase in gross density by 5% to 15%
2. Activity Nodes /No of CBDs	Many centres (distributed non-residential land use) are not desirable as these generate distributed travel patterns which is not conducive for public transport patronage.	As cities grow, both in population and area terms, the cities tend to transform themselves into polycentric cities. Planned transformations are likely to function more efficiently. The activities concentrated in multiple centres are expected to distribute trips and thereby reduce the spatial concentration of traffic and reduce trip lengths.	A compact, monocentric, and relatively high-density city is likely to attract more trips on non-motorised and public transport as the majority of trips are likely to be short to medium distance in length.

Notes:
1.The values in the table are indicative and based on several studies conducted by Center of Excellence in Urban Transport, CEPT University on different cities.
2.*Gross density: number of people per unit of hectare

Table 3 : Transport Infrastructure Strategies - Parameters

PARAMETERS	INADEQUATE STATE < >DESIRABLE STATE		
1. Street network density	<10 km/sq.km or >16 km/sq.km	10-12.5 km/sq.km	12.5-16 km/sq.km
2. Hierarchy and pattern of the network	Hierarchical network and pattern – unclear tending to radial	Somewhat hierarchical network with NMT & Freight Infrastructure	Complete Street – Complete Streets with NMT & Freight Infrastructure
3. Pedestrian access	Few major streets – will have >=1.8m wide footpath	Majority major streets – will have >=1.8m wide footpath	All streets – 18m & above to have >=1.8m wide footpath
4. Priority of NMT	Few/no streets –will have >=2m wide bicycle priority lane	Major streets – will have >=2m wide bicycle priority lane	All streets – 30m & above to have >=2m wide bicycle priority lane
5. Freight (3)	Absence of urban freight infrastructure	Moderate availability of urban freight infrastructure	Well-developed urban freight infrastructure

Notes:
1: The values indicated in the table are indicative and cities need to adopt context-specific values.
2: Urban freight infrastructure includes multi-modal logistic terminals, consolidation centres, loading bays in activity areas, lorry/freight vehicle parks, etc.

3 CAIT- Climate Data Explorer

CMPs often focus on passenger transport and give limited attention to managing freight transport in cities. These plans should also focus on the movement of LCVs and MCVs within the city along with planning for activity location based on the supply chain. The existing supply chain of industries should be evaluated and strategized for an efficient and sustainable alternative such as peripheral multimodal logistic terminals.

MOBILITY STRATEGIES

These strategies are defined based on the level of focus on sustainable mobility options i.e., low, moderate, and an extensive focus on sustainable mobility strategies. The sustainable mobility strategies commonly consider - improvement of public transport infrastructure and services, electric mobility, promoting non-motorised transport and infrastructure, inclusive transport, levels of TOD, multimodal integration, and travel demand management.

LOW FOCUS SCENARIO

In this scenario, less importance is given to sustainable transport alternatives in overall city transport planning. This scenario sees the trends of the past to continue in the future, in terms of the number of buses per lakh population, level of focus on NMT and public transport improvement, presence of transit priority network, TOD, level of multi-modal integration, inclusivity and travel demand management measures.

MODERATE FOCUS SCENARIO

This scenario indicates a moderate focus on investing in public transport and non-motorised transport infrastructure improvement, and to enhancing the service levels to achieve adequate/medium sustainable mobility targets.

EXTENSIVE FOCUS SCENARIO

In this scenario, ambitious targets for sustainable transport in terms of investment in public transport and non-motorised transport, adopting TOD growth strategies, improving levels of multi-modal integration, prioritising inclusiveness, and implementing efficient travel demand management measures can be considered.

Photo credits : CoE-UT, 2021

The table below provides the guidance/ direction to define mobility strategy scenarios.

Table 4 : Parameter-wise description of Mobility Strategies

PARAMETERS	CITY POPULATION (IN LAKHS)	LOW FOCUS	MODERATE FOCUS	EXTENSIVE FOCUS
1. Buses per lakh population	> 40	40	50	75
	10-40	25	40	50
	5-10	15	25	40
	<5	10	15	25
2. Transit priority network (BRT/ Metro Neo/ Light Metro/ MRT) per lakh population (Unit: km per lakh population)	>40	No transit corridor	2	4
	10-40		1	3
	5-10		0	2
	<5		0	0.5
3. Transit Oriented Development		No TOD	TOD on few corridors	Extensive TOD application
4. Multimodal/ Public Transport integration		Independent Systems	Limited integration	High Level of integration (Physical, Fare and Institutional integration)
5. Travel demand management		Incentivising parking supply	Parking policy somewhat effectively implemented as demand management policy	Parking policy effectively implemented as demand management policy. May add Congestion pricing in megacities.
6. Inclusive transport (urban poor, gender, specially-abled) (8)		Limited action to improve inclusiveness	Moderate level: Fare affordability achieved, gender concerns in transport addressed and provided for, universal access provided	Substantive level: Fare affordability achieved, gender concerns in transport addressed and provided for, universal access provided

Notes: The definition/ values in the table are indicative and cities need to adopt context specific values.

The strategy-mix of land use & transport strategies and sustainable mobility strategies based on the parameters defined in table above will help in moving towards the defined mobility goals and targets.

8 List of Indicators focused on Gender Transport: Female mode share in public transport; Access to markets, and income and employment opportunities for women; Access to health and education facilities by women; Affordability focused on women PT users; Extent of safety and security for women passengers while traveling; Job opportunities for women in the transport sector.

ELECTRIFICATION STRATEGY

This set of strategies proposed as part of the CMP toolkit supplement focuses on how electric mobility can be built into the city's long-term mobility plan. The fuel-mix strategy proposed here is based on the extent of EV adoption across different urban transport modes.

a) Passive scenario
Despite numerous policies and schemes, the adoption rate of electric vehicles is low in India. The 'Passive' scenario of the fuel mix strategy reflects the existing BAU scenario of low EV penetration in the vehicular fleet.
b) Active scenario
The 'Active' scenario of the fuel mix strategy would focus on achieving the national targets of EV adoption and significant EV ecosystem maturity in Indian cities. (9)
c) Pro-active scenario
The 'Pro-active' scenario of the fuel mix strategy may focus on exceeding the national targets and significant EV ecosystem maturity in Indian cities. For example, the pro-active scenario may consider an ambitious target of electrification across all modes being greater than 60% share in 20 years. The level of electrification is likely to vary across different modes.

Table 5 : Fuel-mix energy scenario

MODES	PASSIVE	ACTIVE	PRO-ACTIVE
Public Transport	<30% of all new acquisition of bus fleet	30-60% of all new acquisition of bus fleet	>60% of all new acquisition of bus fleet
Government Fleet	<30% of all new acquisition of bus fleet	30-60% of all new acquisition of bus fleet	>60% of all new acquisition of bus fleet
IPT	<30% of EV sale	30-60% of EV sale	>60% of EV sale
Urban Freight (LCVs, 3Wh Goods)	<30% of EV sale	30-60% of EV sale	>60% of EV sale
Personalised Modes	<10% of EVs sale in overall vehicles	10%-40% of EVs sale in overall vehicles	>40% of EVs sale in overall vehicles

Note: The values in the table are indicative and the cities need to adopt context-specific values.

The above table provides guidance/direction to define fuel mix strategy scenarios, however, each city should set its targets taking into consideration its own needs and capacities. While defining scenarios, it is also important to consider the source of electricity production (or alternate fuel). Share of the source of electricity production can vary from city to city and state to state based on the state's or city's current and expected capacity to generate power from renewable sources.

However, the share of source for electricity production is taken at the national or state level, and cannot vary from city to city. Currently, India's target is to achieve 40% of its energy requirement through renewable sources for 2031.(Ministry of New and Renewable Energy (MNRE).

The 'City GHG Emissions Estimation Tool' has been developed for estimating city greehouse gass emissions from urban transport vehicles for the past, base, and future years (alternate scenarios for intermediary and target years). The tool also considers the share of renewable sources for estimating GHG emissions.

9 To achieve the NDC objective of cutting 33-35% of GHG emission intensity by 2030, India has been targeting a minimum of 30% sale of EVs by 2030.
10 The charging infrastructure is expected to be provided as per requirement in the city.

3.2 STRATEGY MIX EVALUATION

The following is a two-stage evaluation framework proposed as part of this electric mobility supplement to the CMP toolkit.

Stage 1: CMP evaluation with Land use-Transport and Mobility strategies.

At this stage, there are nine possible strategy–mix combinations or scenarios as illustrated below which should be evaluated by each city against the mobility targets as discussed in the previous section.

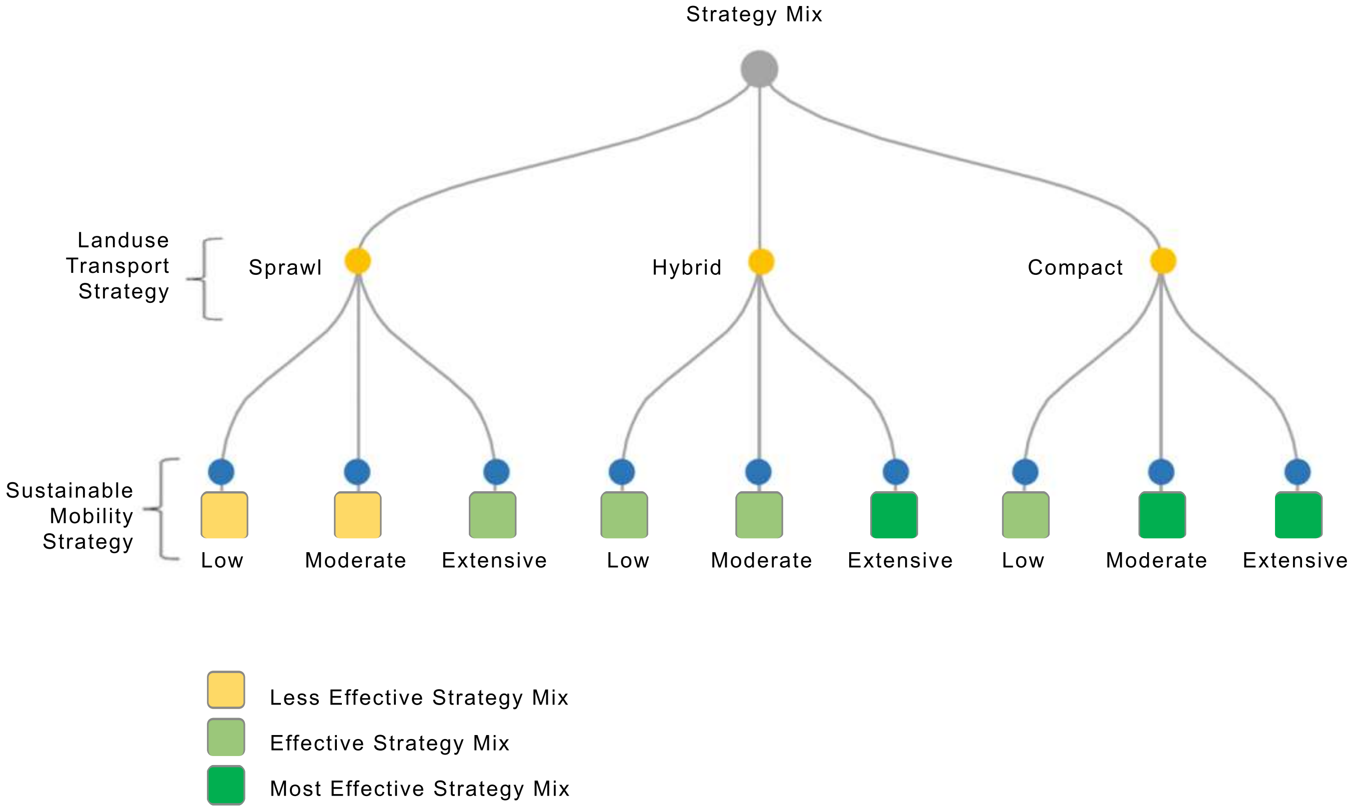


Figure 2 : Strategy mix formed by the combination of Land use - Transport and Mobility Scenarios

Land use and mobility strategies impact mobility patterns and behavior at various levels. This set of strategy mix can be evaluated through various transport model outputs such as PT share, NMT share, trip length, average travel time, etc. for each of the strategy mix scenarios. Further, the scenarios can also be assessed based on the performance indicators presented in Table 2 - Objectives and Indicators. Based on the evaluation framework and performance indicators, the desired strategy mix scenarios which help the city in achieving the desired targets/objectives can be identified.

Stage 2: CMP evaluation with electric mobility/ alternate fuel strategies

This stage illustrates the effect of fuel mix (share of electric mobility) on environmental objectives. The shortlisted strategy-mix will be extended with three fuel mix scenarios i.e. passive, active and proactive as presented in the figure below, and will be evaluated for environmental objectives as discussed in Section 2.6.

The output of this task provides the most desirable mix of strategies that will help the city move towards its social, economic, and environmental objectives.

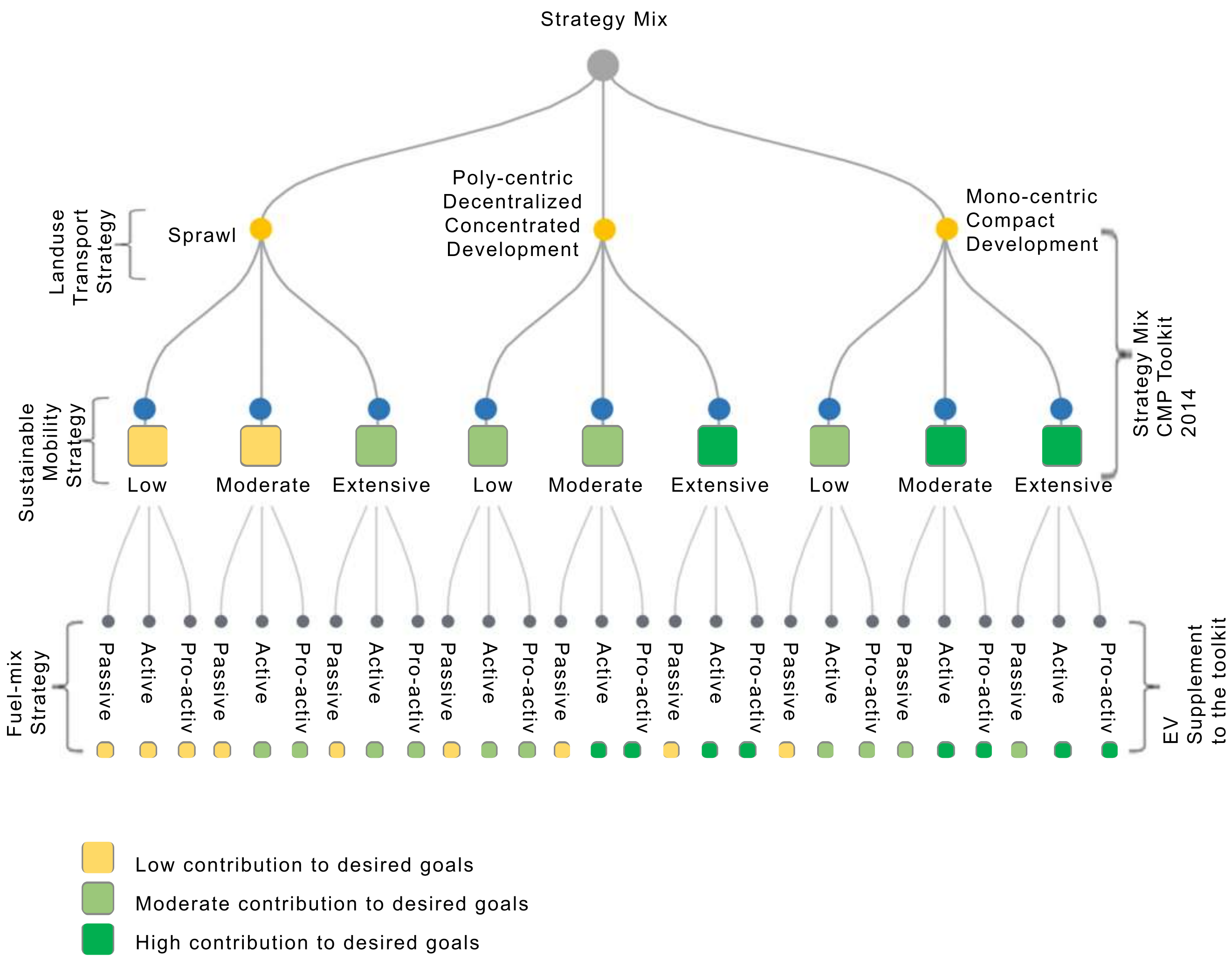


Figure 3 : Combination of strategy mix

3.3 STRATEGY MIX SELECTION

The evaluation framework proposed above presents multiple options for meeting the targets in varying degrees. The selection of the strategy mix from the set of options is dependent on technical feasibility, clearance of regulatory tests, availability of land resources, and financial and institutional capacities for implementation.

Photo credits : CoE-UT, 2021

4 FORECASTING ADOPTION LEVELS OF ELECTRIC VEHICLES

The previous section is providing guidance on developing strategies, grouping them as scenarios, and assessing their outcomes based on defined objectives and corresponding indicators. The framework adopted a four-stage assessment of land use – transport strategies and the expected outputs are presented below.

LAND USE – TRANSPORT STRATEGY FRAMEWORK (STRATEGY & OUTCOMES)

STAGE-1
Land use – Transport Strategies define the future urban structure in terms of:
- Extent of the urban area
- Intensity of development
- Land use distribution, especially the concentration of traffic generating activities
- Street network including infrastructure for pedestrian and non-motorised vehicles

STAGE-2
Mobility Strategies define the future mobility patterns in terms of:
- Spatial patterns of mobility
- Motorised and non-motorised trips
- Mode split
- Vehicle utilisation - Vehicular km traveled

STAGE-3
Electrification Strategies:
- Vehicular stock and utilisation
- Scenarios for the adoption of electric vehicles (Fuel Mix)

STAGE-4
Impact Assessment
- Congestion levels
- Average trip length
- Travel times
- Energy consumption
- Air quality
- Noise levels
- GHG emissions
- Road safety

An integrated land use – transport planning modeling is used to develop stage 1 and 2 scenarios. These models assume conventional energy (petrol, diesel and CNG) options in assessing the impacts (Stage-4). The focus of this section is to develop scenarios for EV adoption (Stage-3) under different policy, technology, and cost assumptions.

The process of developing EV adoption scenarios is formulated in three sequential steps as below:

- Who are the stakeholders at the local level and what are their roles in EV adoption?
- How to forecast new vehicles procurement during the plan period?
- How to estimate EV adoption scenarios?

4.1 STAKEHOLDERS AT CITY LEVEL AND THEIR ROLE IN EV ADOPTION

The national and state governments formulate policies, programs and set regulations to promote sustainable mobility in urban and regional areas. Recently, financial incentives in terms of subsidy in purchase costs, installation of chargers, waiver of registration fee have been offered by the national and state governments.

At the city level, transportation is a multi-dimensional sector involving multiple stakeholders performing interdependent roles. The decision analysis regarding the adoption of electric vehicles should be made through a collaborative process. A potential list of stakeholders and their roles in the adoption of EVs is presented below.

Table 6 : Stakeholders and their role in EV Ecosystem

SR NO	ACTORS	ROLE
1	City Government/Urban Development Agencies	City governments make higher-level decisions in terms of setting a vision for the city, promulgating policies and programs and preparing urban development and transport plans. These may be used as tools to influence the level and pace of electrification of the transport system. They also play additional roles as listed below: - Providers of land for a depot, terminals and charging stations - Promote setting up of public charging facilities - Owners of the large fleet of both passenger and freight vehicles - Providers of public transport as an obligatory service (in several cities) - Policy and regulation related to home/office charging, parking policy, etc.
2	Transport Department/Regional Transport Office	Vehicle registration, fitness certification and issue of permits are essential processes defined under the Motor Vehicle Act to ensure the safety and security of road users. Waving of registration charges and road tax is used as incentives by the state to electric vehicle buyers. Additionally, the state governments may stipulate the registration of 'only electric' vehicles for certain segments of the market.
3	Electricity regulatory commission	The electricity regulatory commission regulates the electricity prices for various types of consumers to manage the consumption of electricity during peak hours and off-peak hours.
4	Electricity Distribution Companies	The adoption of electric vehicles can create a significant impact on energy requirements at the city or state level. Electricity distribution companies must support power supply with a reliable and renewable source of energy. It may involve strengthening or extending the grid, connections to charging stations, etc. and the costs of these may have to be included in the plan of electrification of urban transport.

SR NO	ACTORS	ROLE
5	Vehicle and Battery Manufacturers	Battery costs are significant in the overall cost of EVs. Innovations in battery technology and motors enable the production of electric vehicles with improved specifications and reduced prices. Required service range, the weight of the on-board battery packs, charging time, and distribution of charging stations influence capital and operating costs significantly. Battery manufacturers, distributors and servicing enterprises are likely to bring new business models and stakeholders into the transport market. These developments in the short and medium-term should be factored into the EV adoption decision process.
6	Charging Infrastructure and service providers	The presence of charging infrastructure is essential to relax the range of anxiety issues. Re-energising the battery of an electric vehicle can be time consuming, and the availability of dedicated charging stations can stimulate the adoption of EVs. Current petrol, diesel and CNG fuel stations are prospective EV charging service providers. However, co-locating EV charging along with conventional fuel stations may have fire safety risks that need to be addressed with appropriate regulations.
7	Public Transport Agencies	Public Transport Agencies are key decision makers about public transport fleet for replacement and addition of vehicle fleets to service new demand.
8	Commercial Vehicle Owners & Operators	The passenger and freight commercial vehicles form a significant size of urban transport vehicles and contribute to air and GHG emissions. Collaboration of owners/operators, trade associations, and regulatory authorities is needed to hasten the pace of EV adoption.
9	Private Vehicle Owners (Individuals)	People resist change to a new system due to key concerns such as high upfront cost, unavailability of variant models, absence of infrastructure, and range anxiety. The users complete the EV ecosystem value chain; hence it is important to understand their perceptions and requirements to enable the faster shift to EVs.

4.2 KEY FACTORS INFLUENCING EV ADOPTION DECISION

The decision to adopt EVs is influenced by technological, economic, environmental and market factors as discussed below.

TECHNOLOGY AND OPERATIONAL FEASIBILITY AND FLEXIBILITY:

Technological factors decide the operational feasibility and flexibility

The range potential per charge, battery size, type of chargers, charging time, and charging locations/density are all interrelated and define technical feasibility, operational flexibility, and economics of electric vehicles. Batteries are the most expensive part of electric vehicles and hence the manufacturers optimize the size of the battery pack on-board. The size of the battery pack would determine the travel distance of the electric vehicle before it needs recharging. As the size of the battery pack increases, it adds to the laden weight of the vehicle which can limit the passenger capacity as well as the fuel efficiency of the electric vehicle.

When compared to conventional fuel vehicles, the range offered by EVs is less than half. This deficiency is overcome by providing an opportunity for charging in-between operations. Time taken for charging and recharging would depend on the type of chargers, battery size and the daily mileage required to be covered.

In urban operations, the requirements of the range vary by type of vehicle and service. Public transport buses would require a range potential of 200 to 250 km per day, while urban freight and IPT vehicles require 100 to 125 km. Personalised vehicles require, a range potential of 50 to 100 km on average and more if the vehicles are used for regional travel. The congestion levels on the route may also add to the range requirement by 10-20%.

The manufacturers based on present technology have developed products and systems which are feasible for regular urban applications. For the public transport buses, the options made available are in terms of fast and slow chargers, which may be installed in the depot or on-route at terminals or bus stops to provide operational flexibility. For the IPT and light commercial vehicles, operators have the flexibility of charging the vehicles either at home/parking lots or at public charging stations. The decision can vary based on the availability, convenience, affordability, and duration of charging. Personalised vehicle users are likely to charge at the home, office or other parking lots as the daily vehicle utilisation of these vehicles is less.

ECONOMICS OF OWNERSHIP AND OPERATIONS:

Economics, especially the high purchase costs act against EV adoption decision.

The cost-parity of electric vehicles with diesel, petrol and CNG vehicles is a necessary condition for the wider acceptance of EVs. A comparison of the available models in terms of cost economics is necessary to assess the likely potential of EV adoption. A Total Cost of Ownership (TCO) model which includes capital and operating costs of the vehicle over the life of the vehicle could be used to analyse cost parity of electric vis a vis conventional vehicles.

To make EVs attractive for customers, the national and state governments have provided fiscal and non-fiscal incentives. The fiscal incentives include subsidies for the purchase of vehicles and the establishment of public charging infrastructure. Some states have also waived the registration charges for EV vehicles. It may be noted that in the provision of subsidies, public transport and commercial vehicles are prioritized. The TCO analysis should also consider the fiscal incentives, if applicable.

Computing TCO would involve the prediction of the future costs of key components such as vehicles, batteries, electricity, fuel prices, etc. Assumptions about policies and their implications on costs of ownership and operation need to be included explicitly in the scenario building.

The Table below presents the relative costs of electric vehicles under subsidy and no subsidy.

Table 7 : EV cost comparison across different modes

Cost Item	EV Costs compared to conventional fuel vehicles (EV Costs/Conventional Vehicle Costs) – INR					
	Without Subsidy			With Current FAME Subsidy		
	Purchase Cost	Operation cost (1st year)	TCO/ km	Capital Cost	Operation cost (1st year)	TCO/ km
2W	1.68 times	0.2	0.60	1.06	0.20	0.45
3W- Auto	1.01 times	0.09	0.22	1.21	0.09	0.20
3W- Freight	1.21 times	0.16	0.32	1.04	0.16	0.30
4W- Commercial	1.21 times	0.22	0.63	1.37	0.22	0.60
4W- Private	1.84 times	0.41	0.97	No subsidy	0.41	0.97
Bus	2.13 times	0.50	0.82	1.53	0.50	0.73
Manpower and others	0.87 times			No change		

Note : The values in the table are indicative and based on several studies conducted by the Center of Excellence in Urban Transport, CEPT University on different cities

INCENTIVES AND DISINCENTIVES:

Fiscal and non-fiscal incentives and disincentives are key tools to bring cost parity and promote EV adoption

The high upfront cost is a major constraint for the purchase of an electric vehicle. Fiscal and non-fiscal incentives by the government play a major role in the faster adoption of EVs. Restricting fossil fuel vehicle operations in environmentally sensitive areas may also contribute to EV adoption and cleaner air. Disincentive measures may also include an increase in taxes and parking charges for conventional vehicles. Electric vehicles also showcase a positive image as electric vehicle performance in qualitative terms (comfort, noise, etc.) is superior to conventional vehicles.

MARKET FACTORS:

The market factors in terms of product choices, the existence of critical mass, availability of infrastructure also should be assessed while analysing EV adoption scenarios.

- Consumers look for choices in terms of vehicle models available in the market
- Critical mass is required to push EV adoption beyond the tipping point
- Establishment of EV infrastructure in terms of charging facilities, workshops for maintenance support are necessary conditions for large scale adoption of EVs
- Public charging facilities, though considered as important, both commercial as well as personalised vehicles are likely to depend on home/office/parking place charging.
- Lack of awareness about electric vehicles and their benefits may be a major barrier in transition to EVs.

ENVIRONMENTAL AND SOCIAL FACTORS:

The environmental factors have a positive influence on the EV adoption decision as it is considered clean and green approach. However, its environmental contribution depends on the share of renewable used in electricity generation.

Electric mobility is one of the ways to move towards environmental sustainability in the transportation sector. The shift to electric mobility will not only reduce GHG emissions but provide better living conditions by improving the air quality. Also, uptake of EVs promises a reduction in expenditure on operating and maintenance costs which are likely to impact public transport agency's finances positively. The public sector is more likely to consider the adoption of EVs based on their environmental benefits and public image.

4.3 FORECASTING ELECTRIC MOBILITY SCENARIOS.

As stated in section 3, three broad scenarios are conceptualised. The first is the 'passive adoption scenario', the second is the 'active adoption scenario', and the third is the 'proactive adoption scenario'. These scenarios are possible to envisage for the short and medium-term based on the market scan. However, longer forecast scenarios would require expert group consultations in assessing values for input parameters.

Table 8 : Electric mobility scenarios

ASSUMPTIONS	PASSIVE ADOPTION SCENARIO	ACTIVE ADOPTION SCENARIO	PRO-ACTIVE ADOPTION
1.Technology	Technology to evolve slowly limiting the driving range	Technology to evolve at a moderate pace improving the driving range by 25-30%	Technology to evolve at a rapid pace improving the driving range by 75-100%
2.Economics	Purchase cost parity remain at the current level and only limited subsidies	Purchase cost parity improve moderately making EV costs to be at par with Conventional vehicles with subsidies	Purchase cost parity improve moderately making EV costs to be significantly less than conventional vehicles
3.Incentives/ Disincentives	Subsidies limited in quantity and period Conventional fuel costs to continue to increase rapidly No additional regulations for limiting conventional vehicle use	Subsidies continued over a period Conventional fuel costs to continue to increase rapidly Some regulations limiting conventional vehicle use	Subsidies continued over a period Conventional fuel costs to continue to increase rapidly Significant regulations limiting conventional vehicle use
4.Infrastructure Development	No significant change	Market grows to a minimum size to provide support infrastructure in a cost-effective manner (Low-cost charging, reasonably spread maintenance facilities)	Market grows to big size to provide support infrastructure in a cost-effective manner (Low-cost charging, widespread maintenance facilities)

Note:
The scenarios indicated in the table above are indicative and cities need to adopt context-specific scenarios (passive/ active/ proactive)

4.4 FORECASTING ELECTRIC VEHICLE ADOPTION SCENARIOS

The responses to evolving technology would vary by different urban transport market segments. A generalised methodology for forecasting the level of electrification is presented in the figure below. Further, sector-wise important considerations for electrification of vehicles are also summarised in the following section.

STEP 1

LAND USE - TRANSPORT PLANNING MODEL OUTPUTS

Trips, Mode share, Trip Length, Vehicle utilisation
Vehicle stock in the target year by modes

STEP 2

ESTIMATING TOTAL NEW VEHICLES FROM NOW TILL THE END OF PLAN PERIOD

STEP 2.1

ESTIMATING REPLACEMENT VEHICLES

- Current vehicle stock by age

Decision Parameters
- Scrapping policy for commercial vehicles
- Operator response
- Vehicle retirement policy (Public transport)
- Scrapping policy and user preferences (personal use)
- Vehicle stock required for replacement

STEP 2.2

ESTIMATING ADDITIONAL DEMAND

- Additional vehicle stock

Decision Parameters
- Trends in GDP (Commercial Vehicles)
- Procurement Plan (Public transport)
- User preferences for vehicle ownership (personal use)

STEP 3

ESTIMATING EV SHARE

Decision Parameters
- Public Transport Agency : Operating model, availability of finance, TCO, environmental condition
- IPT Operator : Total cost of Ownership, Regulations, Infrastructure
- Personal Vehicle Ownership : Capital Costs, Total Cost of Ownership, Model Choices, Information

Figure 4 : Methodology for forecasting level of electrification

PUBLIC TRANSPORT EV FLEET SCENARIOS

Electrification of public transport benefits the cities on the social, economic, and environmental objectives. Public Transport is affordable, energy-efficient, climate-friendly, and space-efficient. It is a fleet-based system and the public sector has a greater say in fuel-related decisions. The decision-making for the adoption of EVs can be quick and results can be visible throughout the city.

A business case for public transport electrification arises out of the following:

- Though the capital cost of electric buses is higher than that of diesel and CNG buses, with the availability of FAME subsidy, the total costs of ownership are in favor of electric buses. Some states like Gujarat are providing viability gap funding to cities, over and above the subsidy of GOI, which makes electrification even more attractive.

- The Gross Cost Contract model shifts the capital costs into variable costs and thereby shifts operational risks onto the operator reducing the burden of public sector agencies (battery management, technical manpower, maintenance, etc.)

- As the battery prices are declining rapidly, long-run economics may become even better in terms of reduced total costs of operations falling below the current level of diesel bus operating costs.

The level of electrification of the public transport fleet is primarily the decision of the city government and public transport agency. It would largely be governed by the cities vision, environmental objectives, and targets, public transport mode share targets, technological improvements in E-buses (driving range and operational flexibility), the economics of operations, and bus ownership and operations model.

Bus procurement cycles would form the base for developing public transport EV fleet scenarios.

Source : https://www.sustainable-bus.com/news/indian-electric-bus-market-to-exceed-7000-units-by-2025/

EV ADOPTION SCENARIOS FOR INTERMEDIARY PUBLIC TRANSPORT VEHICLES (TAXIS/THREE-WHEELERS/SHARED SERVICES)

Electrification of intermediate public transport vehicles needs to be prioritised as their transition can be influenced by state intervention in terms of subsidies and regulatory restrictions on the registration of petrol autorickshaws.

Deployment of e-autos and e-rickshaws instead of petrol autorickshaws provides several advantages.

- In addition to environmental performance, e-auto application in narrow urban streets, especially in old cities would be beneficial.
- Currently, available models match the daily range requirement of 100-125 km in one charge
- Compared to autorickshaw capacity of 3+1, e-autos can provide 4+1 capacity
- Better economics because of higher capacity and lower energy prices
- E-autos are cheaper compared to their petrol counterparts (with subsidy).

The level of electrification of IPT vehicles is likely to be influenced by the mode shares, economics of operations, policy on vehicle scrappage and restrictive regulations on operations of conventional fuel vehicles.

It is to be noted that E-Rickshaw as an alternative to E-Auto looks competitive, there are concerns about quality, safety, and life of the vehicle. Necessary verifications need to be conducted before recommending the vehicle for adoption.

E-Auto adoption decision is made by the present and potential operators. Capturing their choice through stated preference surveys forms critical input for forecasting adoption levels. Scenarios with varying levels of subsidy would be the key factor to influence E-Auto adoption.

Also, it is worth noting here that as there is a major increase in the E-three wheelers in the IPT and freight segment and electric 2-wheelers for last-mile deliveries, several start-ups have come up in different cities providing 2-wheeler rental, PBS services (cycles and e-bike) and 4-wheeler automobile-based services (carsharing, rides on demand). These segments are quite organized, and their operations are constantly monitored through data driven technologies. Services of this kind will help in controlling private vehicle ownership by providing various mobility options at affordable rates. The level of electrification in this segment is primarily a decision of the public/ private operators; mode share targets; technological improvements in EV models of bikes, 3-wheeler, and 4-wheeler (driving range and operational flexibility); feasibility of operations; fleet ownership and operations model.

Availability of service, catchment area, fare and operations model would form the basis for the development of E-Shared Mobility.

Source : https://insideevs.com/news/337654/india-to-get-1-million-electric-three-wheelers-for-ride-hailing/

ELECTRIC VEHICLES FOR PERSONAL USE (CARS/TWO-WHEELERS)

The level of electrification of private vehicles is influenced by the income levels, the economics of operations, availability of parking, and vehicle scrappage policy. Public transport improvements and the introduction of traffic restraint measures like parking, entry regulations, etc. may have a significant influence on vehicle ownership and in turn EV adoption rates.

Stated choice surveys shall be conducted to follow up of those who are willing to purchase a new vehicle, and willing to purchase would be input to forecast EV purchases for personal uses. Future price trends and the level of incentives would be critical policy variables determining the economics of operations and thus may be used to generate alternate scenarios.

Source : https://www.eqmagpro.com/no-registration-fee-for-electric-car-bike-soon- ather-hero-and-others-react/

ELECTRIC VEHICLES FOR URBAN FREIGHT MOVEMENT (LCV : 3-WHEELERS, 4-WHEELERS)

Urban Freight movement includes all goods movements coming into, going out, or moving within an urban area. Within the urban centres, under the broad category of light commercial vehicles (LCV) which include three-wheelers and vans are used extensively for goods movement. At the national level, as per the Road Transport Yearbook 2016-17, 30.6% of the registered transport vehicles were LCVs. According to the data of million plus cities in India, 2017 at the city level, LCVs account for 26.9% of the total registered vehicles of which 16.2% are four-wheelers and the remaining 10.7% are three-wheelers. LCVs in India mostly run-on diesel and are considered the key source of GHG emissions.

Prioritising last-mile logistics (LCVs) for electrification appears to be a good starting point as a climate action agenda.

- Electric freight vehicles are zero-tailpipe and low-noise emission vehicles and most suitable for dense urban areas where air quality is a major problem
- Currently, available SCV models match the daily range and payload requirement
- Better economics because of higher lower energy prices
- Financial incentives backed up by regulatory measures would contribute to a faster transition to EVs.

Similar to IPT vehicles, EV adoption of LCVs is determined by battery prices, demand incentives, availability of products in the market, charging infrastructure and business models. These are critical factors in operators' decision making. An important barrier is that the urban freight suppliers' market is informal and often driven by individual drivers with limited finances.

Urban freight modeling and forecasting is to be part of the land use-transport modeling and is to be included in the second stage 'mobility strategy scenarios. It could be a quantity-based model or vehicle-based model depending on the objective and local context. A sample enterprise survey would provide base OD in terms of vehicles and quantity. At this stage, total urban freight vehicle stock, its composition and daily usage are required as input to assess the base scenario. In the absence of detailed modeling, aggregate forecasts based on trends or ratios may be adopted.

Stated preference surveys of owners/operators of LCVs regarding their willingness to purchase an EV would be the basis for forecasting EV adoption in the urban freight sector.

Source : https://carboncopy.info/kpmg-three-wheelers-to-lead-indias-ev-adoption-with-up-to-75-penetration-by-2030/

Photo credits : GIZ

5 IMPLEMENTATION PROGRAM

Task-5 as per the CMP toolkit is the development of the urban mobility plan. Along with the Land Use-Transport and Mobility Strategy, the revised CMP toolkit will also include the strategies for electrification of transport modes as presented in section 3 of this report.

Task 6 of the CMP toolkit focuses on developing the implementation program of the Comprehensive Mobility Plan. It dwells on the preparation of the implementation strategy of the shortlisted proposals for the city. This section identifies ten areas specific to electric mobility which are identified as key action areas towards faster adoption of electric mobility. Their present status depicts the preparedness, and addressing deficiencies would be actions for implementation.(11)

Figure 5 : EV Adoption Preparedness Assessment – Action areas

11 To assess the status of these action areas, an indicator framework has been developed and presented in Annexure B

Table 9 : Focus areas

SR NO.	FOCUS AREAS	POTENTIAL ACTIONS/ INTERVENTIONS
1	**Electricity Generation and Supply**	1. Capacity enhancement of DISCOMs to extend electricity supply to the transport sector. 2. Strategies to increase renewable content in the electricity generation 3. Ensuring 24x7 quality electricity supply (free of outages)
2	**State and City Commitments towards Electric Mobility**	1. Advocate launching of the State/ City EV Policy 2. Establishing framework for EV specific electricity tariff fixation and revision 3. Advocate introduction of EV supportive measures in Motor Vehicle Act (e.g. exemption from vehicle registration, registration charges, etc.) 4. Advocate modification in building bye-laws to include EV charging in parking areas along with necessary fire safety measures 5. Exemption of public parking charges for EV vehicles 6. Phased electrification of state/ local government fleet 7. Phased electrification of municipal waste collection fleet 8. Put in place policy/ strategy/ rules for battery disposal 9. Advocate state for establishing public transport viability gap funding scheme for E-Buses 10. Plan EV awareness drives in the city
3	**Institutional coordination among state & city agencies**	1. Set up a city-level task force including all state and city stakeholders to coordinate the implementation of CEMS
4	**Public Bus System**	1. Public Transport Agency to prepare bus procurement plan with a focus on electric buses and supportive infrastructure. 2. State/ City/ Public Transport Agency to earmark financial resources to meet the requirement in the procurement plan 3. Capacity building of Public Transport Agencies in technologies, maintenance, operations, and business models
5	**Intermediary Public Transport System (E-Autos/ Taxis, Shared mobility)**	1. Advocate State/City level fiscal incentives for electrification of IPTs 2. Advocate restriction on registration of conventional fuel-based autos and taxis 3. Plan promotional activities to educate operators of E-Autos/ Taxis
6	**Non-Motorised Transport (Cycle rickshaws)**	1. Advocate State/City level fiscal incentives for electrification of Rickshaws 2. Plan phasing out of manually driven/ cycle rickshaws (convert to E-Rickshaws) 3. Plan promotional activities to educate operators of cycle Rickshaws

SR NO.	FOCUS AREAS	POTENTIAL ACTIONS/ INTERVENTIONS
7	**Urban Freight Systems**	1. Advocate State/City level fiscal incentives for electrification of Urban Freight 2. Advocate restriction on registration of conventional fuel-based urban freight vehicles 3. Plan promotional activities to educate operators of urban freight vehicles
8	**Charging Infrastructure**	1. Prepare an action plan for establishing Public /Private EV charging infrastructure
9	**Personalised vehicles**	1. Advocate introduction of disincentives on registration on purchase and operations of conventional fuel-based vehicles (e.g., registration charges, parking charges, entry restrictions, etc.)
10	**Public Awareness**	1. Plan and organise education/ awareness campaigns for the public in general.

Photo credits : GIZ

ANNEXURE A: CITY GHG EMISSIONS ESTIMATION TOOL

OVERVIEW

The "City GHG Emissions Estimation Tool" has been developed to help urban transport researchers, planners, and administrators in estimating GHG and air emissions from the transport sector at the city level utilising databases available for Indian Cities. The tool also estimates emissions incurred during fuel production and electricity generation to meet the fuel/ electricity demand for running vehicles.

The details are provided below:

File Name	File Type	Sheets	Type
1. VKT from Transport Model Output	Excel	0_About the Toolkit 1.1 City Information 1.2 Past and Base Year VKT 1.3 Base Year External VKT 1.4 Future Year VKT 1.5 Future Year VKT External Vehicles 1.6 Share of Renewable Energy	Description Input Input Input Input Input Input
2. Emission Factors_Default values	Excel	2.1 Fuel Consumption per km 2.2 Emission Factors (TTW)-Bottom Up 2.3 Emission Factors (WTT)-Bottom Up 2.4 Emission Factors (WTT)-TD 2.5 Emission Factors (WTT)-EV	Default values Default values Default values Default values Default values
3. CEMS_Tool	Power Bi	Cover Page About Tool Contents 1. GHG Emissions 2. Base Year Validation	Description Description Description Output Output

Link to the tool:
https://crdf.org.in/project/ghg-emission-estimation-and-electric-mobility-preparedness-assessment-tools-city-electric-mobility-strategy-cems

The tool indicates estimates for the base year (current year), past year, and future years based onscenarios for intermediary and target year). It provides estimations for GHG emissions incurredduring fuel production i.e. “Well To Tank (WTT)” and fuel consumption i.e “Tank To Wheel (TTW)”.Sum of both provides total emissions incurred from fuel production to fuel consumption phase i.e.‘Well To Wheel (WTW)’.

The input for the excel file “VKT from Transport Model Output” can be filled using Transport Modeloutput that consist of VKT across different vehicle categories and vehicle technology-wise.

The estimation is carried out with “Bottom-up” approach that is focused on vehicle kilometer travelled (VKT) to estimate “Well To Tank (WTT)”, “Tank To Wheel (TTW)” and overall “Well to Wheel (WTW)” emissions:

1. **Well to Tank (WTT):** ((VKT * Emission factor (gCO2 / km for fuel production) * (no. of days in a year)) / (City Population)

2. **Tank to Wheel (TTW):** Emissions (Tons/Year/Capita) = ((VKT * Emission factor (gCO2 / km) * (no. of days in a year)) / (City Population)

3. **Well to Wheel (WTW) = WTT + TTW**

The estimates through the “Bottom-up” approach is validated through the “Top-down” approach for the base scenario. While validating, maximum allowable difference between both the approach is +/- 10%.

ILLUSTRATIVE OUTPUTS

The Power Bi Tool named “CEMS_Tool” consists of five pages including cover page, description about the tool, contents, followed by illustrations of estimates. “1. GHG Emission” indicates carbon emissions and air quality for different years and scenarios. “2. Base year validation” depicts the estimates through two approaches and its difference to validate the calculations.

Figure 6 : Illustrative Outputs from Power Bi Tool

ANNEXURE B: PREPAREDNESS ASSESSMENT FRAMEWORK

A city-level EV adoption preparedness assessment framework will help in preparing action plans for enabling faster adoption of electric mobility(8) as defined in the city electric mobility strategy. The tool enables the planners to identify the action areas to focus on to meet envisaged EV adoption levels as a part of CEMS.

The EV adoption preparedness framework includes:

- Ten Focus Areas (FAs) that cover policy, infrastructure, and customer domains determining EV adoption response
- A set of indicaors for each of the FAs to measure the existing status
- Data sources, measurement of status and method of calculation of preparedness level with regard to each of the FAs and
- Presentation of results in tabular and graphical form (spider diagram)
- Computes overall City Electric Mobility Adoption Preparedness Assessment Index (EV-APAI)

The framework is presented as an Excel model consisting of 13 data sheets. The first 3 sub-sheets contain the following:

1. The first sub-sheet: **'A. GENERAL INFO'** provides information on the tool.
2. The second sub-sheet: **'B. CITY INFO'** is for entering general information about the city
3. The third **'C. ANALYSIS & RESULTS'** presents the analysis and results. The details include:
   - All ten FA wise indicator-input-data (indicator value) in one table,
   - To standardize the unit of measurement, the indicator values are normalised by converting all scores out of 100,
   - Normalised value of each FA (assigning equal weight to each indicator)
   - City EV adoption preparedness status for each of the ten focus areas in the form of a spider deagram, and
   - City Electric Mobility adoption preparedness assessment index based on normalization, equal weighting, and aggregation of the 10 Focus areas.
4. The next 10 sub-sheets are providing data for each of the 10 FAs. The details of the indicator, its description, measurement scale, expected minimum and maximum value, sources of data are provided. For inputing the city score, empty cell highlighted in yellow are given. In these two sub-sheets the city should only enter data in the yellow cells.

The two outputs are:

- The spider-net diagram can help in identifying the areas of improvement that city would need to focus in order to enhance the overall preparedness score.
- The second output of this excel is the aggregate geometric mean of ten FAs as city electric mobility adoption preparedness index. This index score can be used for the preparedness comparisons with different cities as well as to monitor the preparedness of the city over time.

8 The identification of the focus areas and indicators was done after a detailed review of the literature and elaborate consultations with vehicle manufacturers, policymakers, users, academicians, and subject experts

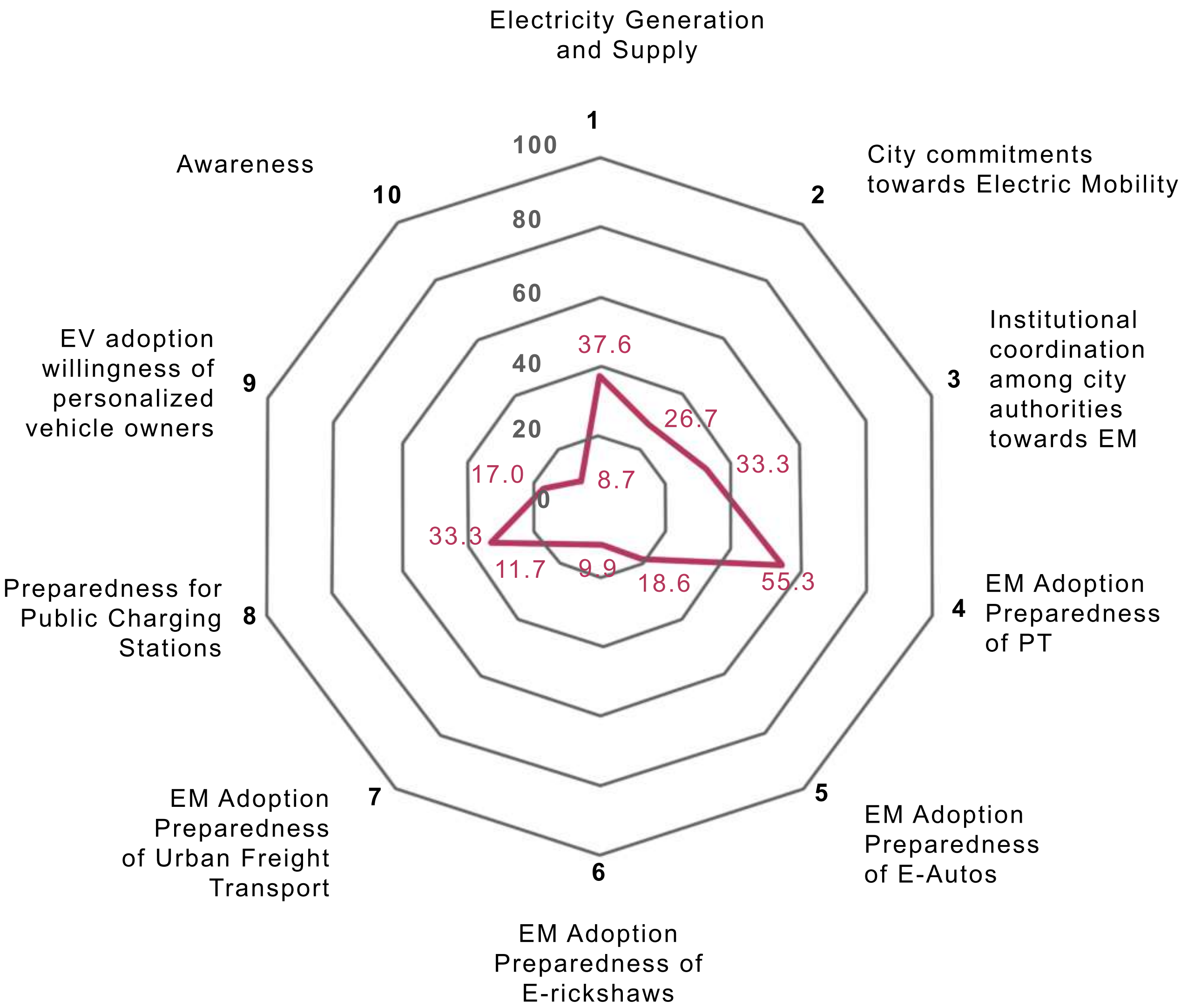


Figure 7 : Illustration of City Electric Mobility Adoption Preparedness Score across 10 FAs.

CITY ELECTRIC MOBILITY ADOPTION PREPAREDNESS SCORE FOR THE CITY IS 21.3

Link to the tool:

https://crdf.org.in/project/ghg-emission-estimation-and-electric-mobility-preparedness-assessment-tools-city-electric-mobility-strategy-cems

LIST OF ABBREVIATIONS

BEV	Battery Electric Vehicles
BRT	Bus Rapid Transit
CBD	Central Business District
CEMS	City Electric Mobility Strategy
CI	Charging Infrastructure
CMP	Comprehensive Mobility Plan
DHI	Department of Heavy Industry
EV	Electric Vehicles
FAME	Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles
GDP	Gross Domestic Product
GHG	Green House Gas
HCV	Heavy Commercial Vehicle
HEV	Hybrid Electric Vehicles
ICE	Internal Combustion Engine
IPT	Intermediate Public Transport
IUT	Institute of Urban Transport
LCV	Light Commercial Vehicle
MCV	Medium Commercial Vehicle
MoRTH	Ministry of Road Transport and Highways
MoHUA	Ministry of Housing and Urban Affairs
MoP	Ministry of Power
MRT	Mass Rapid Transit
NDC	Nationally Determined Contribution
NEMMP	National Electric Mobility Mission Plan
NUTP	National Urban Transport Policy
OEM	Original Equipment Manufacturer
PKM	Passenger km
PKT	Passenger km Travelled
PTA	Public Transport Authority
RTO	Regional Transport Office
SCV	Small Commercial Vehicle
SERC	State Electricity Regulatory Commission
STU	State Transport Undertaking
TCO	Total Cost of Ownership
TKT	Tonne km Travelled
ULB	Urban Local Body
VGF	Viability Gap Funding
VKT	Vehicle km Travelled

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