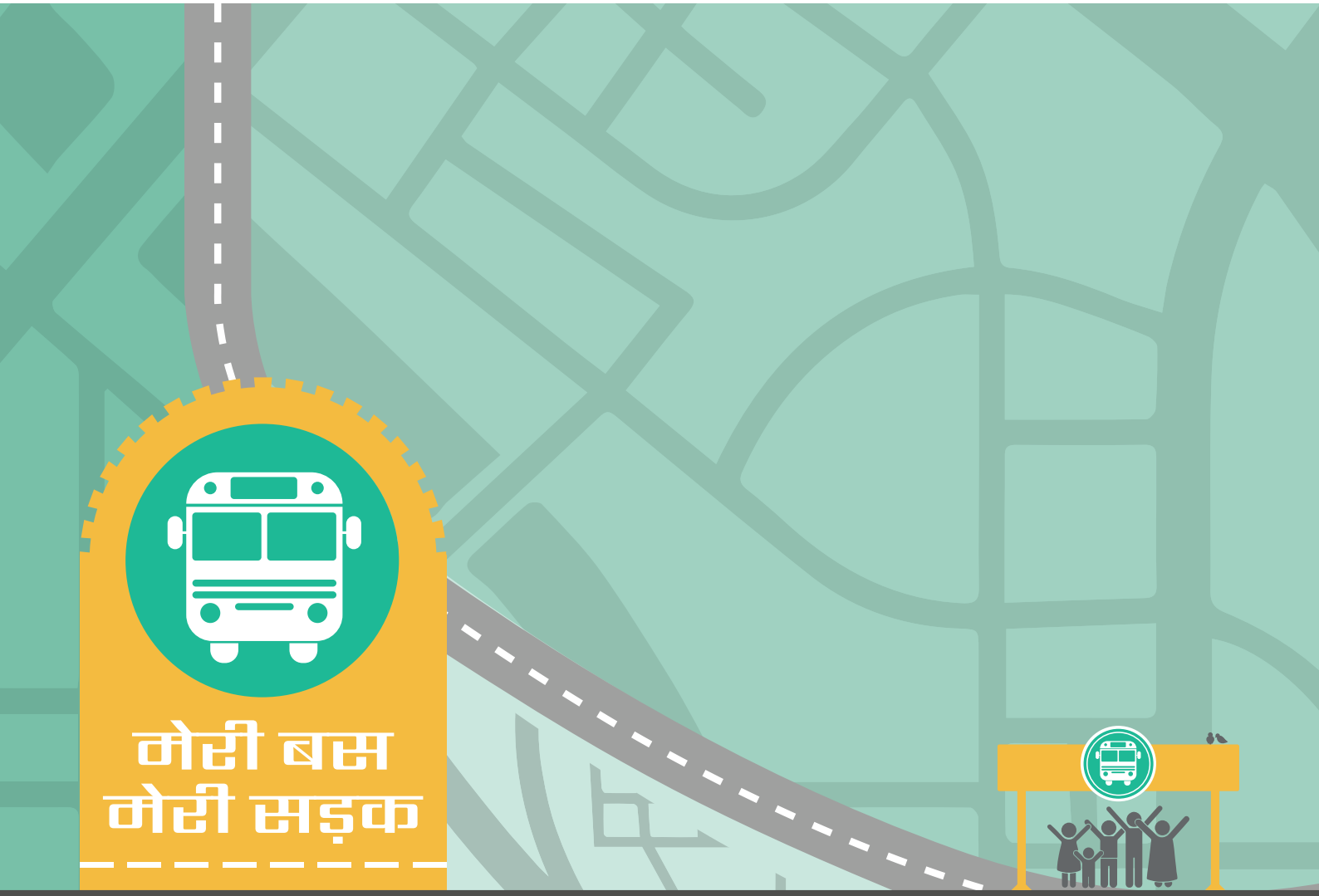
DIRECTORATE URBAN TRANSPORT
Government of Uttar Pradesh



Investing in Bus Fleets to Help Uttar Pradesh Achieve the Trillion-dollar Economy Goal

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CLEANER AIR & BETTER HEALTH PROJECT

REPORT | JUNE 2024

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Investing in Bus Fleets to Help Uttar Pradesh Achieve the Trillion-dollar Economy Goal

Report
June 2024
ceew.in

Uttar Pradesh continues to expand its urban bus fleet to cater to its rising urban population.

Image: Udit Narayan Mall/ CEEW

Foreword

Dr. Rajender Pensiya, IAS
Director, Directorate of Urban Transport
Special Secretary, Urban Development Department, Government of Uttar Pradesh

Uttar Pradesh's quest for a 'One-trillion' Gross State Domestic Product (GSDP) is an important turning point in the state's economic trajectory. This ambitious vision demands thoughtful strategic action in key sectors, especially the mobility and transport sectors.
I appreciate the timely study undertaken by CEEW under DUT guidance to develop the background study for the state urban bus programme. This study also notes the significance of an efficient public transportation system in connecting the workforce with economic engines.

The government of India, under the able leadership of the Honourable Prime Minister Shri Narendra Modi ji, has emphasised e-buses under *Faster Adoption and Manufacturing of* (*Hybrid &*) *Electric Vehicles 2* (*FAME II*) and the *PM E-Bus Sewa* Scheme. Further, the government of Uttar Pradesh under leadership of Shri Yogi Adityanath ji continues to leverage the national funding schemes and subsidies available to newer e-buses.

The Directorate of Urban Transport, Government of Uttar Pradesh (DUT) has long focused on the importance of a robust urban bus systems in achieving the state's economic goals. DUT has been considering additional 6 cities beyond the existing 14 cities to deploy the urban bus services soon. However, this report takes a long term view of UP's urbanization and comprehensively analyzes its 26 major cities with population greater than 5 lakhs, by 2041.

The true celebrations of the centenary year 2047 of independent India shall be ideally realised with more buses, better services and robust governance of mobility-systems.

The study focuses on the adoption of sustainable and cost-effective transport solutions. The deployment of midi and standard buses is proposed to ensure optimal service in varied city sizes and travel patterns. It is entrusted that the decision-makers, city bus authorities, and other associated stakeholders will find the insights herein to be informative and implementable.

With its findings and insights, the report will hopefully serve as a background study for the Uttar Pradesh State Urban Bus Programme (SUBP). The need of the hour is to focus on strategic investments, infrastructure development, and enhanced operational efficiency. These three pillars of urban bus systems will play a pivotal role in moving workers affordably to meet the state's GSDP target and realization of cleaner air and better health for all. DUT remains committed to collectively work with all stakeholders for the prosperous future of Uttar Pradesh.

Buses provide affordable access to jobs, education and health care.

Image: Udit Narayan Mall/ CEEW

Contents

Rising bus fleet would need cities to augment their depot and refueling infrastructure. Seen here, bus depot in Dubbaga, Lucknow.

Image: Drokpa

Executive summary

Uttar Pradesh's plan to achieve a gross state domestic product (GSDP) of USD 1 trillion hinges on its fast-growing transport and tourism sector (Deloitte 2023). Affordable and efficient public transport (PT) plays a critical role in connecting manufacturing, tech-clusters, tourism, and education hubs while mobilising the skilling sector and entrepreneurs in sunrise sectors.

Cities contribute more than 75 per cent of the GSDP, and buses are vital in transporting people within and across these hubs. Thus, developing bus services, bus stops, and accessible infrastructure is critical to propelling UP's economy. The Government of Uttar Pradesh (GoUP) has, therefore, renewed its focus on bus systems to enhance connectivity across the state and provide accessibility to jobs. To support this transformation of PT, there is a need to estimate the total bus demand in UP over the next two decades.

The Directorate of Urban Transport (DUT) in UP currently operates about 1,235 buses in 14 cities. It is planning to expand its bus services under the *PM-eBus Sewa Scheme* and state programmes. The Council on Energy, Environment and Water (CEEW), as part of the United States Agency for International Development (USAID)–supported Cleaner Air and Better Health (CABH) project, conducted an assessment of the number of buses required in 26 cities of UP, whose population is projected to surpass 3 lakh people by 2031. Further, this report estimates the required manpower, the viability gap funding (VGF) needed, and related infrastructure costs. The assessment will facilitate drawing up the UP State Urban Bus Programme (SUBP).

Key Findings

The research used bus routes and cycle-times based established methodology to calculate the number of buses required in two scenarios – Low Ambition and High Ambition (40% and 60% viable trips shift to buses) (Vuchic 2007). The analysis done improved on this methodology by considering the potential growth in the city habitat area, trip lengths and consequently route lengths, and the number of routes, which all impact bus demand. The analysis projects an estimation for bus requirements for two decades till 2041. Further, it also provides the required outlay to implement the short-term plans by 2031 across the 26 studied cities. For 2041, the outlay requirement will need to be calibrated basis the changes in city growth and travel demand patterns.

Findings related to travel demand in cities, the bus modal share, and trip lengths are important for developing an urban bus programme.

About 3.75 crore residents in 26 cities will drive the mobility demand till 2031

- The findings suggests that by 2031, there will be 13 metropolitan cities in UP. Lucknow & Kanpur will have a population of >40 lakh, and the remaining 11 will have populations of 10–40 lakh. 13 other large cities will also have populations of 5–10 lakh.

Buses are integral to meeting travel demand

- The study finds that, two-wheelers (2Ws) have a higher modal share in metropolitan cities as compared to large cities. However, people prefer buses for commutes longer than 5 km.
- About 50 per cent of the total three-wheeler (3W) trips are more than 5 km long in all the major cities. Individuals taking these long trips are highly likely to opt for buses (Khanna et al. 2024a).

E-buses are cheaper for typical intracity operations in UP cities

- Buses will likely serve 60 lakh (6 million) riders per day by 2031 across 26 cities in the low-ambition scenario and 80 lakh (8 million) riders in the high-ambition scenario.
- In terms of lifetime vehicle and energy costs, e-buses are likely to be 23–32 per cent cheaper for UP cities compared to compressed natural gas (CNG) buses with an average utilisation of 140–200 km per day.

State Urban Bus Programme (SUBP)

- The GoUP's **vision for urban PT in the state**, and the state electric vehicle (EV) policy, explicitly focus on buses. E-buses will ensure maximum benefits for several cities reeling from worsening air quality, especially due to vehicular pollution.
- Midi buses (9 meters) are appropriate for cities in the 5-10 lakh and 10-20 lakh population category.
- Standard buses (11-12 meters) are to be deployed in cities if they have midi bus headways of <5 minutes during peak hours. Thus, several populous cities like Lucknow, Kanpur, Ghaziabad, Agra, Prayagraj, Varanasi, Meerut, Bareilly, Aligarh, Moradabad,

> By 2031, 26 cities across the state need 12,229 buses to ferry approximately 6 million people daily.

Saharanpur, and Muzaffarnagar will need standard buses.

- The analysis estimates a total of **12,229 midi and standard bus combinations in the low-ambition scenario** and **about 15,583 standard buses in the high-ambition scenario by 2031**.

Recommendations

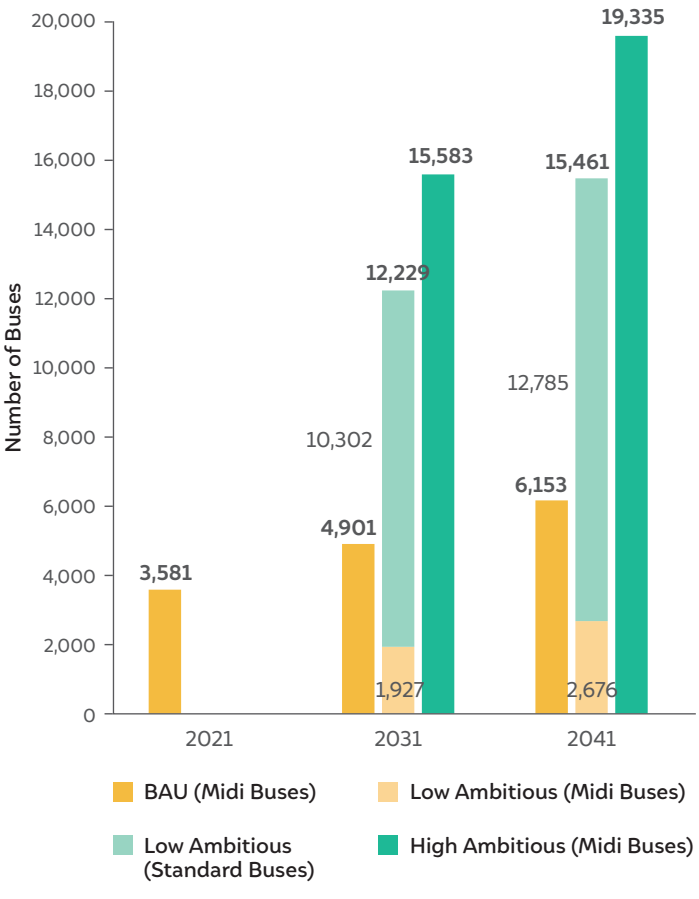
Given the growth trajectory of the state, the study suggests that the DUT should aim to procure buses as per the low-ambitious scenario 2031. For this, the *Urban Transport Fund* and state schemes would require the following investments:

- A combined outlay of INR 15,700 crore to procure 12,229 buses for 26 cities, to meet the daily ridership demand of ~60 lakh by 2031.
- An investment of INR 3,000 crore as a one-time cost to set up charging and depot/terminal infrastructure (excluding land costs).
- Operation and maintenance (O&M) costs of about INR 3,286 crore per year in the short term for maintenance, two battery replacements per bus, energy, and personnel. The Fare box revenue is estimated at INR 2,500 crore for 2031, which is 76 per cent of the O&M cost. Thus, to sustain bus services, a VGF of INR 786 crore per year (24 per cent) is required in the short term.

The SUBP will positively impact mobility, abate emissions and congestion, and enhance the economy. An estimated 40 lakh (4 million) passengers will shift from 3Ws and 2Ws to affordable and clean buses. This shift shall result in the yearly reduction of 59 KT of particulate matter (PM) 2.5, 6 MT of carbon monoxide (CO), and 0.6 MT of nitrous oxides (NOx) emissions by 2031. Additionally, over 2 crore (20 million) passenger kilometres are estimated to shift from 2Ws and 3Ws to buses daily, which will lead to substantial decongestion leading to economic savings in road infrastructure costs, fuel, and time. Thus, the SUBP is integral to the accessibility and connectivity needs of the vital city workforce. Indeed, it will help propel UP to a trillion-dollar economy.

Figure ES1 Bus demand in 26 cities of UP under different scenarios

S. No.	Cities	City's projected population by 2031	Bus type requirement
1.	Lucknow	4640415	Standard
2.	Kanpur	4036106	Standard
3.	Ghaziabad	3911811	Standard
4.	Agra	2895121	Standard
5.	Meerut	2208447	Standard
6.	Varanasi	2164866	Standard
7.	Prayagraj	1805516	Standard
8.	Bareilly	1660880	Standard
9.	Moradabad	1562756	Standard
10.	Aligarh	1554539	Standard
11.	Saharanpur	1362349	Standard
12.	Firozabad	1229540	Midi
13.	Noida	1065442	Midi
14.	Gorakhpur	995642	Midi
15.	Muzaffarnagar	929448	Standard
16.	Jhansi	841862	Midi
17.	Mathura	822449	Midi
18.	Ayodhya	596947	Midi
19.	Farrukhabad	423710	Midi
20.	Shahjahanpur	416556	Midi
21.	Rampur	411666	Midi
22.	Bulandshahr	408325	Midi
23.	Orai	402806	Midi
24.	Etawah	396913	Midi
25.	Mau	396372	Midi
26.	Hapur	372874	Midi



Source: Authors' analysis

1. Introduction

People in Indian cities are shifting to personalised modes of transport due to the lack of safe and reliable public transport (PT). This is leading to an increase in congestion and emission levels. However, given the land-use patterns, travel patterns, and socio-economic profiles of Indian cities, bus-based PT is a viable alternative. Also, the central government is augmenting city bus operations with initiatives such as the *Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles Scheme (FAME)* (MHI 2019) and *PM-eBus Sewa Scheme* (MoHUA 2023). Under the *PM-eBus Sewa Scheme*, 10,000 e-buses are to be deployed under public–private partnerships (PPP) in 169 cities, with population greater than 3 lakh. Further, the related infrastructure is to be upgraded in 181 cities under *Green Urban Mobility Initiatives* across the country. Globally, **province or national governments** suggests a simple **index of the number of buses per 1,000 persons** in different plausible regional scenarios. As per the toolkit developed by the Public–Private Infrastructure Advisory Facility (PPIAF 2006), the bus requirement in a city is 0.5–1.2 per 1,000 persons. But Indian cities fall far short of these numbers (NIUA 2021).

In Uttar Pradesh (UP), the 14 cities (with existing bus services) under the *PM-eBus Sewa Scheme* will get 1,500 buses, and 6 new cities will start bus services with 500 buses. Considering the relevance of buses to the dense and mixed land use of cities, there is a need to analyse the city-wise bus demand over the next two decades in the state.

The state currently operates 1,235 buses (including 740 e-buses under *FAME I and II*) in 14 cities, and it plans to expand bus services to 20 cities, with 2,000 more e-buses, under the *PM-eBus Sewa Scheme* (DUT 2023). **This report calculates the number of buses required by 2031 in 26 cities of UP.** This assessment will help inform the UP State Urban Bus Programme (SUBP) and lays out the necessary manpower, viability gap funding (VGF), and infrastructure requirements.

Midi size e-buses are operational across 14 cities in UP.

2. Bus estimation approach

Conventionally, the number of buses required is advised as a standard number per 1,000 persons in the city or region (NITI Aayog and BCG 2018; MoRTH 2023; NIUA 2021). This report estimates bus requirements more precisely for 26 select cities of UP, whose projected population will be greater than 3 lakh people by 2031. These estimates are prepared using an established bus route and cycle time based methodology (Vuchic 2007). The analysis improvises Vuchic's methodology by considering the growth in the city's area, its trip lengths and consequently route lengths, and the number of routes, typical modal share and potential modal shifts - all of which impact bus demand.

2.1 Existing bus estimation standards and their criteria

The analysis reviews various bus requirement standards and the criteria used to estimate the requirements for cities of different sizes (Table 1).

Bus fleet requirements can be estimated based on speed, fleet size, policy direction, and ridership.

The **first** method calculates the cycle time for a route using the speed of the bus along with the route length and terminal time. The number of buses required is calculated using the following formula (Boyce 2006):

$$\textit{Number of buses} = \frac{120 \times L}{S \times H} + \frac{T_a + T_b}{H}$$

Here, L = *route length*, S = *speed (kmph)*, T_a & T_b = *terminal time at route start (a) and end (b), and* H = *headway.*

In the **second** method, the fleet size depends on broad policy decisions. For instance, for a bus system operating with a 30-minute headway, the number of buses required can be calculated by dividing the cycle time by the defined headway. The resulting number can be rounded up to the next whole number to get the bus requirement (Boyce 2006).

Table 1 Bus requirement standards

Source	Standard
Ministry of Urban Development (MoUD 2013)	For cities with > 40 lakhs (4 million) population: 0.60 buses per 1,000 persons For cities with 10-40 lakhs (1–4 million) population: 0.40 buses per 1,000 persons For cities with < 10 lakhs (1 million) population: 0.30 buses per 1,000 persons
Public–Private Infrastructure Advisory Facility (PPIAF 2006)	0.5–1.2 buses per 1,000 persons
The International Energy Agency (Gota and Fabian 2009)	0.5 buses per 1,000 persons
Central Institute of Road Transport (Gota and Fabian 2009)	0.4 buses per 1,000 persons
Asian Development Bank and Ministry of Finance Toolkit (Mehta 2010)	0.6 buses per 1000 population

Source: Authors' compilation

The **third** method is a function of vehicle capacity and peak point travel demand, as discussed in a Transportation Research and Injury Prevention Centre (TRIPC 2019) white paper. The TRIPC model considers population, area, number of routes, ridership, and route length as inputs, along with assumptions related to the load factor, peak point demand, average speed of the bus, and seating capacity (Tiwari and Jain 2023).

$$Cycle\ time = \frac{120 \times L}{S} + T_a + T_b$$

Here, L = *route length*, S = *speed (kmph)*, T_a & T_b = *terminal time at route start (a) and end (b), and number of buses required = cycle time/headway.*

This gives the number of buses required for each type (standard- 11-12 meters, midi – 9 meters, and mini buses - 7 meters)) for the different scenarios defined.

$$Headway = \frac{Seating\ load \times Capacity \times 60}{Peak\ point\ demand}$$

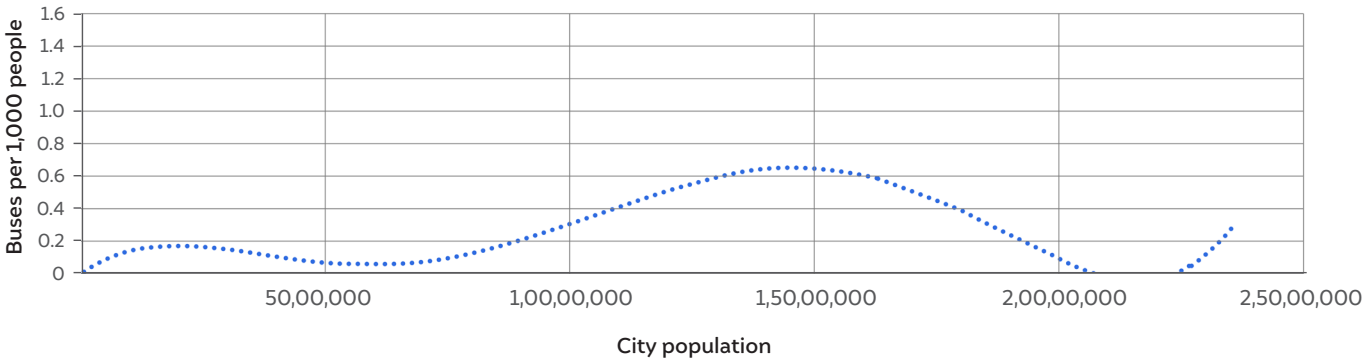
Using a similar approach to above method, SGArchitects and Shakti Foundation (2021) estimate bus supply, ridership demand, and annual resource requirements. This study estimates the current relationship between city size and the number of buses. It find that Indian cities typically have 0.05–0.65 buses per 1,000 people in cities with a population of 50 lakhs to 1.5 crore. The analysis estimates the ratio of buses required per 1,000 people in the population travelling a daily one-way distance of 6–15 km for low-ambition (0.2–0.9) and high-ambition (0.2–1.35) scenarios.

Thus, an assessment of urban bus requirements should consider variations in city populations, density, urban area growth, which influences trip lengths, current modal shares, and the trip length frequency distribution (TLFD). Most Indian city travel patterns suggest that for short trips (<5 km), people use intermediate public transport (IPT), such as auto-rickshaws, tempos and shared Tata Magics, and motorised two-wheelers (2W). Buses are typically preferred for longer trips of 5–15 km (Khanna 2024a; Electriwala and Kumar 2024; Tiwari and Jain 2012; Tiwari and Jain 2023).

2.2 Study Methodology and model

The study develops a bus demand estimation model that considers the city's population, urban agglomeration area, and demographic and geographic growth patterns. The model considers typical Indian city bus service route lengths and the number of routes. It estimates the city's bus demand at peak hours, headway, bus utilisation in kilometres, and the number of passengers ferried per day. It estimates the number of buses required for the low-ambition and high-ambition scenarios in 26 cities of the state (Table 2).

Figure 1 Current number of buses per 1,000 people in the population (business-as-usual scenario)



Source: SGArchitects, and Shakti Foundation. 2021. "National Bus Resource Requirement (Road Map for Overcoming the Gaps)." Delhi: Shakti Foundation.

BOX 1 Study inputs and assumptions

- The city's population and area is projected for all 26 cities of UP till 2041.
- The average bus route length in a city is assumed to be equal to the diameter of the city, and it is calculated using the projected area.
- The speed of buses in the city and terminal time is assumed to be 18 kmph and 10 minutes, respectively. Using the average route length, speed of the bus, and terminal time, the cycle time of the route is calculated.
- The Trip Length Frequency Distribution (TLFD) is taken from the Census (2011) district (urban) data.
- Potential ridership of a bus system includes the people who are already using the bus and riders who will shift to buses in the future. The number of people already using the bus are calculated by assuming a constant modal share, taken from the Census (2011) district (urban) data.
- Peak hour ridership is estimated by considering a peak hour factor of 10 per cent. Using the estimated peak point ridership, assumed seating capacity (40 for standard buses and 30 for midi buses), and a load factor of 1.2, the headway is calculated.
- The average trip length is taken as half of the route length.
- The number of standard and midi buses required is estimated by using the calculated cycle time and headway.

Source: Authors' compilation

Table 2 Assumptions in scenario development

	CEEW study	SGArchitects		TRIPC model	
Scenario	Percentage of riders using other modes for trip lengths of 5–20 km willing to shift to buses	Trips by urban bus services	Electric fleet composition to be achieved for urban services (number of years)	Percentage of three-wheeler (3W) riders with trip lengths of >5km willing to shift to buses	Percentage of 2W riders with trip lengths >5km willing to shift to buses
BAU scenario	As per Census (2011) With no modal shifts	35–40% of 7–15 km	13.2% (30)	–	–
Low-ambition scenario	40%	66% of 7–15 km	100% (10)	15%	10%
High-ambition scenario	60%	100% of 7–15 km	100% (10)	30%	30%

Source: Authors' compilation

The model for estimating urban bus requirements in UP cities uses satellite images to estimate the growth in city habitat areas over the last three decades. This enables the assessment of changes in routes and lengths. It also accounts for growth in populations, city area, and per capita trip rates over the next two decades. Further, it estimates and considers city-specific modal shares and TLFD to assess potential shifts in medium-length trips (5–20 km). Experts suggest a typical 30-80% shift from 2W and 3W in Indian cities when reliable bus services are available (Electriwala and Kumar 2014; TRIPC 2019; Tiwari and Jain 2023). Thus, the study assumes two scenarios for potential people trips shifting from other modes to buses:

1. **Low-ambition scenario**: About 40 per cent of riders currently using other modes with trip lengths of 5–20 km will shift to buses.
2. **High-ambition scenario**: In this scenario, about 60 per cent of riders currently using other modes with trip lengths of 5–20 km will shift to buses.

The analysis considers the modal share of the district urban area and from Census (2011). Thus, the model estimates the bus numbers for 2021 as per the BAU scenario (no modal shift from other modes) to provide comparable reference for today. The BAU 2021 estimates are provided in all bus demand estimations for uniformity and ease of understanding. All the estimations assume modal shifts from the year 2024 onwards for low ambition and high ambition scenarios and are further projected till 2041.

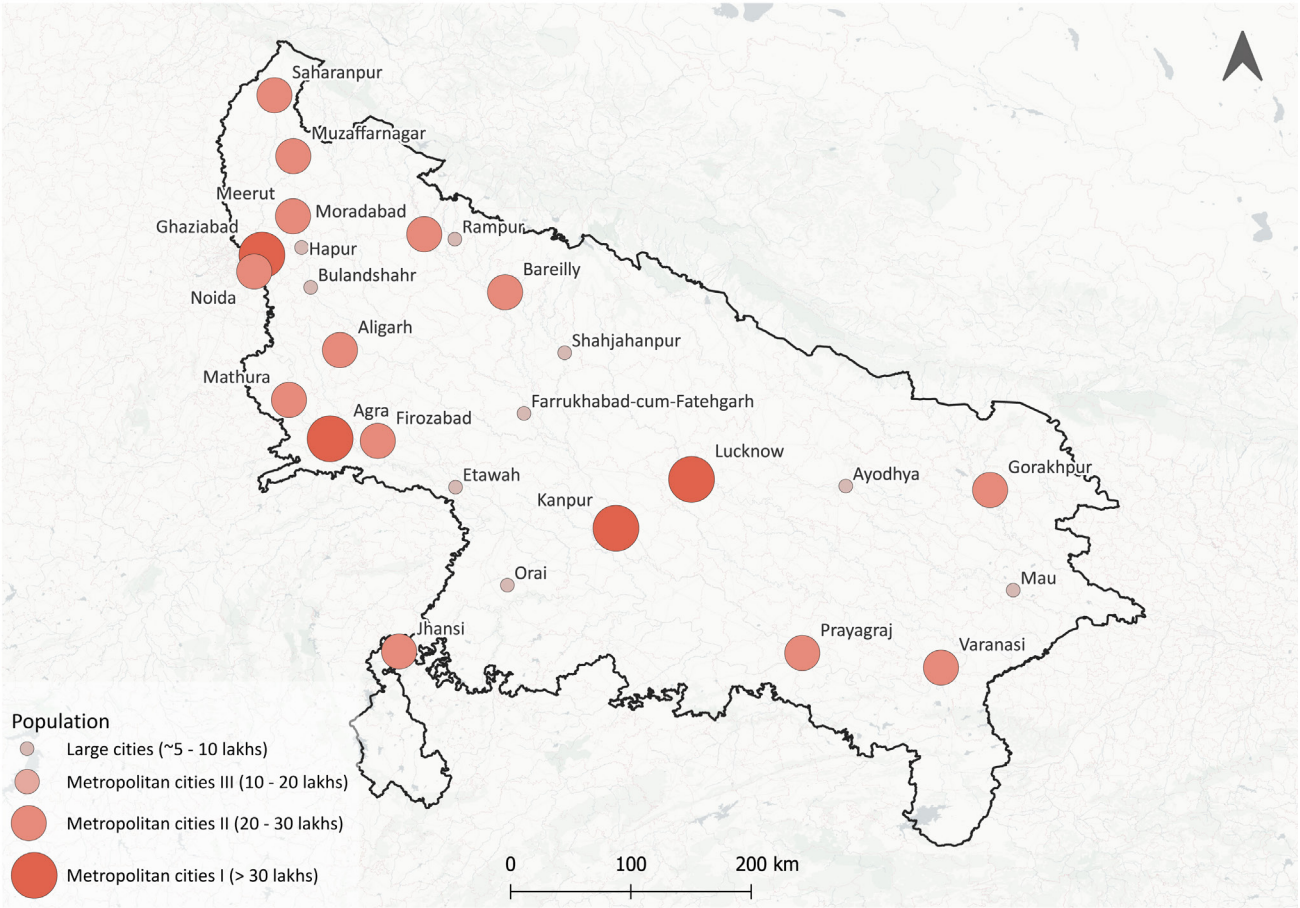
The presented analysis estimates bus procurement, infrastructure and operations costs and revenues based on various inputs collected from market survey of specifications and costs from key OEMs, UP Govt reports and interviews with city bus service services providers and the published annual reports of bus performance by Central Institute of Road Transport (Khanna et al, 2024b, CIRT 2022). Finally the study estimates the ambient air pollutants abatement (PM, NOx, CO) using ARAI factors, due to modal shift of ICE vehicle passengers.

2.3 UP cities driving mobility demand

UP is the most populous state in the nation, with 19.96 crore people living in 240,928 km. It has an average population density of 828 persons per km. The state has 18 divisions and 75 districts (Census 2011). It had an annual urbanisation rate of 2.53 per cent between 2001 and 2011 (MoHUA 2019). The western region of the state is comparatively more urbanised (32.45 per cent) due to its proximity to Delhi and the state capital Lucknow and Kanpur, as compared to the eastern region (13.40 per cent). Clearly, there is a regional imbalance in this regard (TCPD, GoUP).

The study assessed 26 cities for the study and estimated the population for 2021, 2031, and 2041. The populations for the 16 large cities, i.e., Lucknow, Kanpur, Ghaziabad, Agra, Varanasi, Meerut, Prayagraj, Bareilly, Moradabad, Aligarh, Saharanpur, Gorakhpur, Noida, Jhansi, Muzaffarnagar, and Mathura, were obtained from the Organisation for Economic Co-operation and Development (OECD).

Figure 2 Population distribution in the cities of UP by year 2041



Source: Authors' compilation

The populations for the remaining 10 cities – Firozabad, Ayodhya, Orai, Bulandshahr, Farrukhabad-cum-Fatehgarh, Etawah, Mau, Rampur, Shahjahanpur, and Hapur – were estimated using the most suitable arithmetic, geometric, incremental, or compound annual growth rate (CAGR) method (see Annexure 2).

The analysis suggests that by 2041, there will be 17 metropolitan cities in UP as compared to the 8 metropolitan cities it had in 2011. Among these, Lucknow will have a population >50 lakh, and the remaining 16 cities will each have a population of 10–50 lakh. There will be nine other large cities with populations of ~5–10 lakh. A total of 26 cities will have populations of about 5 lakh or more in 2041. These cities must have robust bus-based PT systems for intracity movement and effective travel demand management to manage congestion.

There are a few urban agglomerations, such as Ghaziabad–Noida, Moradabad–Rampur, and Varanasi–Mirzapur, which are located 23 km, 27 km, and 58 km, respectively, from each other. Adjoining cities such as Noida–Greater Noida, Varanasi–Mughal Sarai, and Prayagraj–Naini can be considered as twin cities. So a combined PT facility that caters to the twin cities and nearby areas must be considered. All 26 cities are categorised as follows:

1. Metropolitan cities I with populations of >30 lakhs
2. Metropolitan cities II with populations of 20–30 lakhs
3. Metropolitan cities III with populations of 10–20 lakhs
4. Large cities with populations of ~5-10 lakhs.

Charging and depot infrastructure require significant capital cost in addition to costs of procuring e-buses.

3. Bus demand in UP cities

2Ws have a high modal share in metropolitan cities as compared to large cities – 2W account for a 25 per cent in metropolitan cities I and 17 per cent in large cities. However, for trips more than 5 km, 2W use is higher - about 45 per cent of people in metropolitan cities I and 32 per cent of people in large cities. Study also notes that about 50 per cent of the total 3W trips are more than 5 km in all major cities. Therefore, people who have trip lengths of more than 5 km can be encouraged to use buses (Khanna et al. 2024a). Other travel pattern parameters are explained further in the relevant sections.

The following section elaborates on travel patterns, modal shares and typical mode wise - urban trip length frequencies in each category of city and estimates the decade-wise bus demand for midi and standard buses.

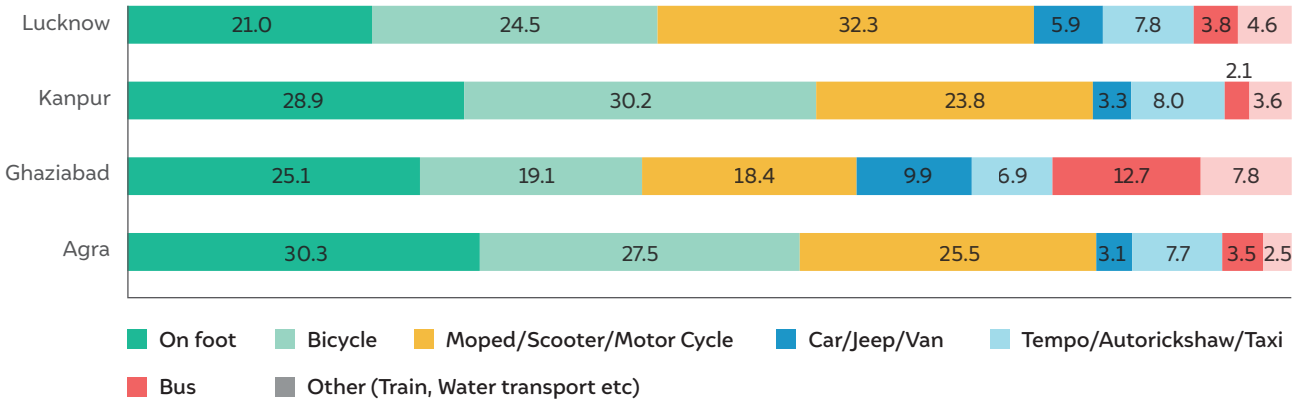
3.1 Bus requirement in metropolitan cities I (>30 lakh population)

Four cities – Lucknow, Kanpur, Ghaziabad, and Agra – are in this category. These cities are the largest in the state and play an important role in its development.

In these cities, about 25 per cent of trips are made using 2Ws. People are more dependent on IPT as compared to PT. Indeed, the PT share in the four cities ranges from 2 to 13 per cent and the IPT share ranges from 7 to 8 per cent. Only Ghaziabad has a PT share 3 per cent larger than the IPT.

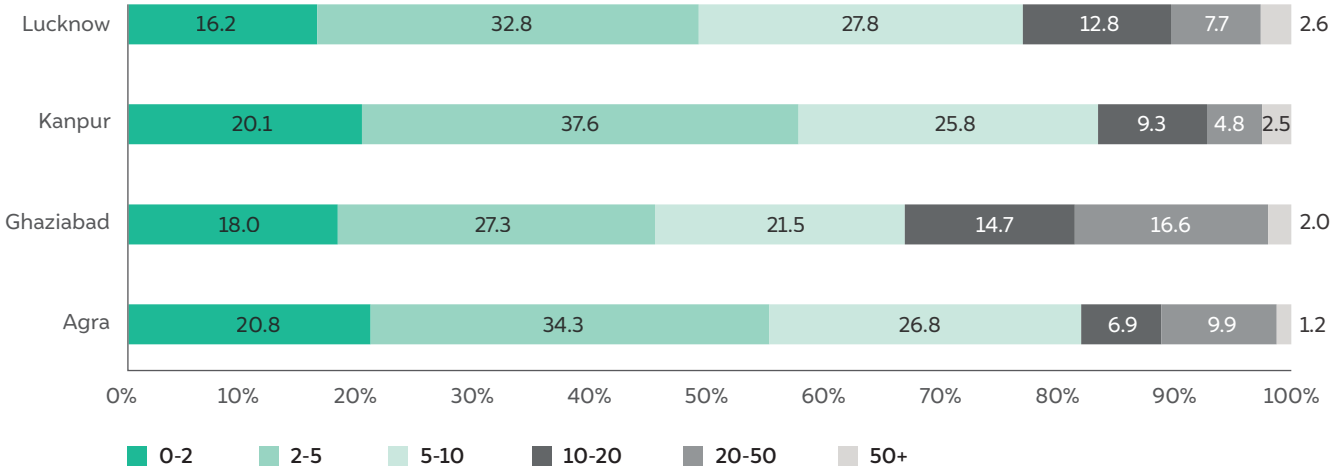
In all metropolitan cities I, about 31–37 per cent of all trips are 5–20 km (Figure 5). Furthermore, 31 per cent of such trips are made using modes other than buses, i.e., mopeds/scooters/motorcycles and tempos/auto-

Figure 3 Modal share of metropolitan cities I (%)



Source: Census. 2011. "B-28: 'Other Workers' by Distance from Residence to Place of Work and Mode of Travel to Place of Work, India – 2011." Last modified January 21, 2021. https://censusindia.gov.in/nada/index.php/catalog/13954.

Figure 4 TLFD for metropolitan cities I (km)



Source: Census. 2011. "B-28: 'Other Workers' by Distance from Residence to Place of Work and Mode of Travel to Place of Work, India – 2011." Last modified January 21, 2021. https://censusindia.gov.in/nada/index.php/catalog/13954.

rickshaws/taxis. Thus, these riders can be considered potential bus users for when more buses are added and service coverage is enhanced (Khanna et al. 2024a).

Potential ridership for buses is calculated by adding the existing bus ridership and the riders shifting from other modes to buses. The number of people who may shift were estimated by multiplying the total number of trips with the percentage of trips of more than 5–20 km. The study assumed a percentage of shift for both the low- and high-ambition scenarios.

All these cities will have an average daily ridership of 2.6 lakh in the business-as-usual (BAU) scenario, 9 lakh in the low-ambition scenario, and 12.1 lakh in the high-ambition scenario.

The average route length for a city depends on its size. Therefore, the largest cities in the state will have an average route length of about 19 km (in 2041) and about 26–35 operational routes, depending upon the population of the city.

Standard and midi bus requirements for the years 2021, 2031 and 2041 considered for the analysis were calculated for the BAU, low-ambition, and high-ambition scenarios for metropolitan cities I.

The results are presented in Figure 5. All cities in this category will operate standard buses (11–12 m). However, as demand intensifies in peak hours in 2030s Lucknow and Ghaziabad may consider or a platoon of two-three standard buses.

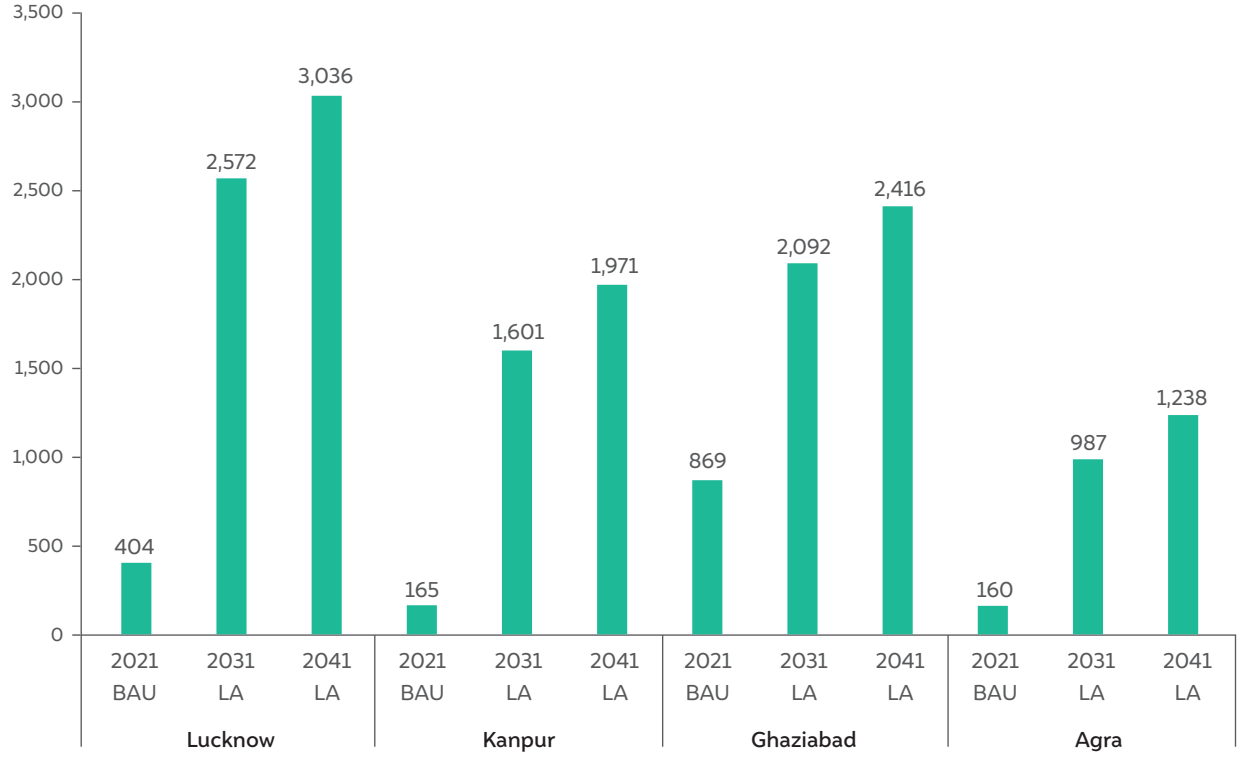
In the low-ambition scenario, 7,251 standard buses will be required by 2031. However, by 2041, the demand will grow and an additional 1,410 buses will be required in four metropolitan cities. Details of the bus requirements for other scenarios are in Annexure 4– city-wise bus demand estimation.

3.2 Bus requirement in metropolitan cities II (20-30 lakh population)

Seven cities – Meerut, Varanasi, Prayagraj, Firozabad, Bareilly, Aligarh, and Moradabad – are in the category of metropolitan cities II, as they will be home 3- 4 lakh households each by 2041.

Around 22 per cent of the trips in these cities are completed using 2Ws. These cities are equally dependent on both PT and IPT – they have a 4 per cent share each.

Figure 5 Standard bus requirement in metropolitan cities I (low-ambition scenario - LA)



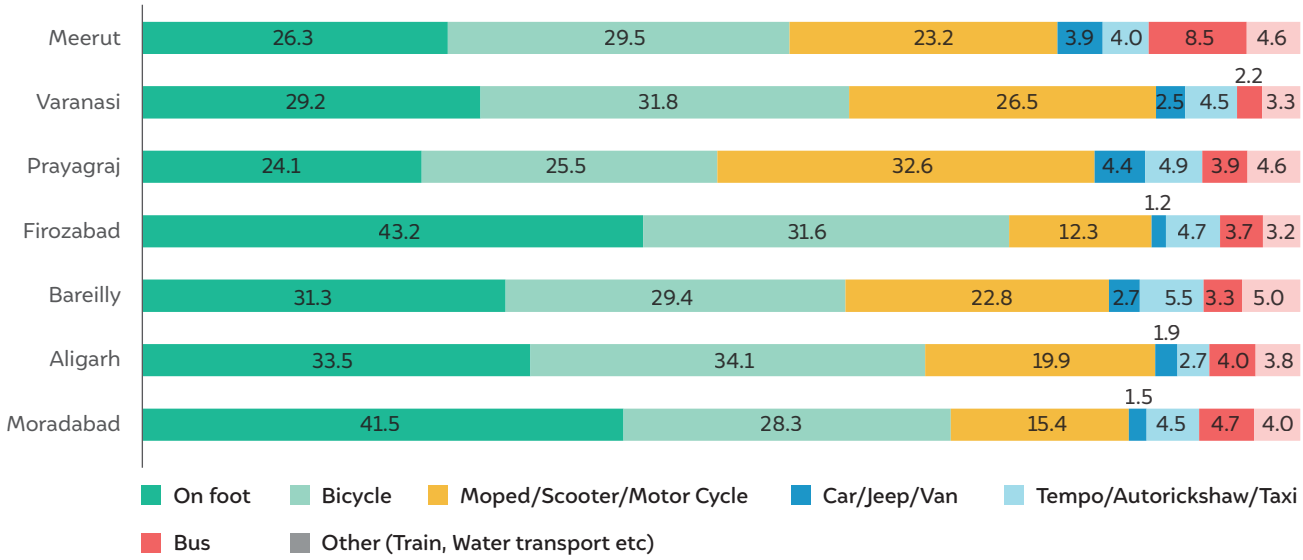
Source: Authors' analysis

In metropolitan cities II, about 18–30 per cent of all trips are 6–20 km. Around 25 per cent of people making such trips use modes other than buses. These people can be considered potential bus users. These cities will have a daily ridership of about 90,000 in the BAU scenario, 2.9 lakh in the low-ambition scenario, and 3.9 lakh in the high-ambition scenario. The average route length in these cities will be about 14.2 km (in 2041), with 19–29 operational routes, depending on the population.

Standard and midi bus requirements for year 2021, 2031, 2041 were calculated for the BAU, low-ambition, and high-ambition scenarios (Annexure 4 – city-wise bus demand estimation). The annual bus requirements for the most probable low-ambition scenario are presented in Figure 8. Only Firozabad is envisaged to deploy midi buses, while the other six cities will operate standard buses.

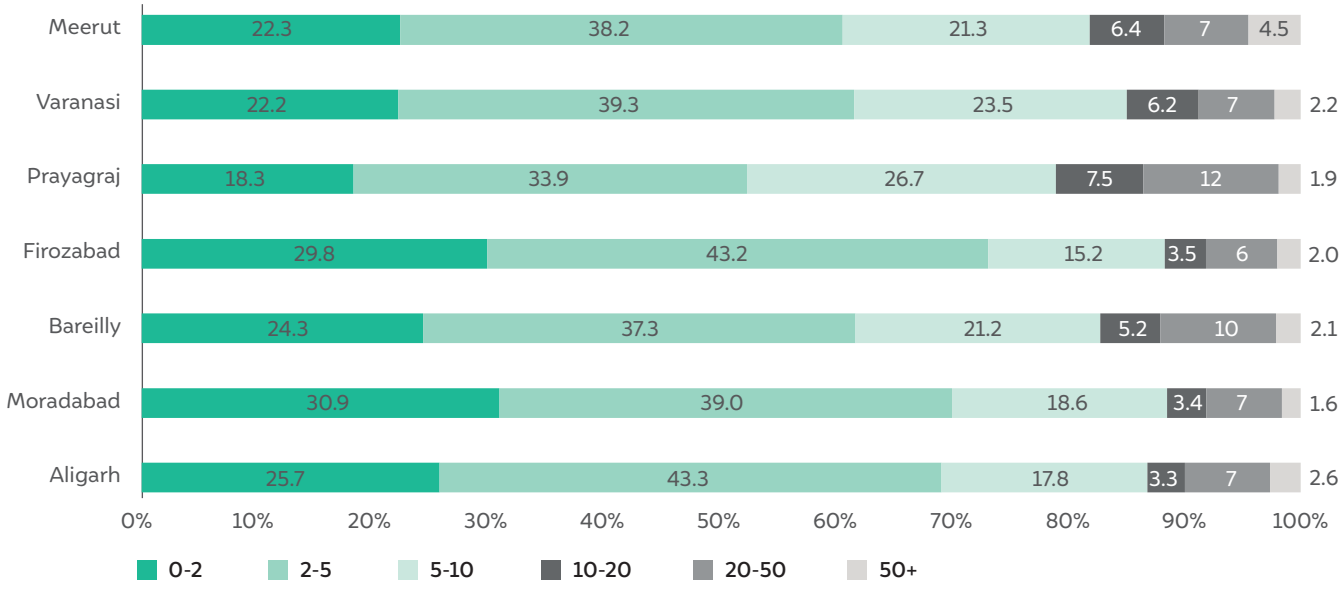
In the low-ambition scenario, 237 midi buses and 2,605 standard buses will be required by 2031. However, by 2041, the demand will grow and an additional 180 midi buses and about 861 standard buses will be required for all seven metropolitan cities II. Details of the bus requirements for the other scenarios are provided in Annexure 4 – city-wise bus demand estimation

Figure 6 Modal share of metropolitan cities II (%)



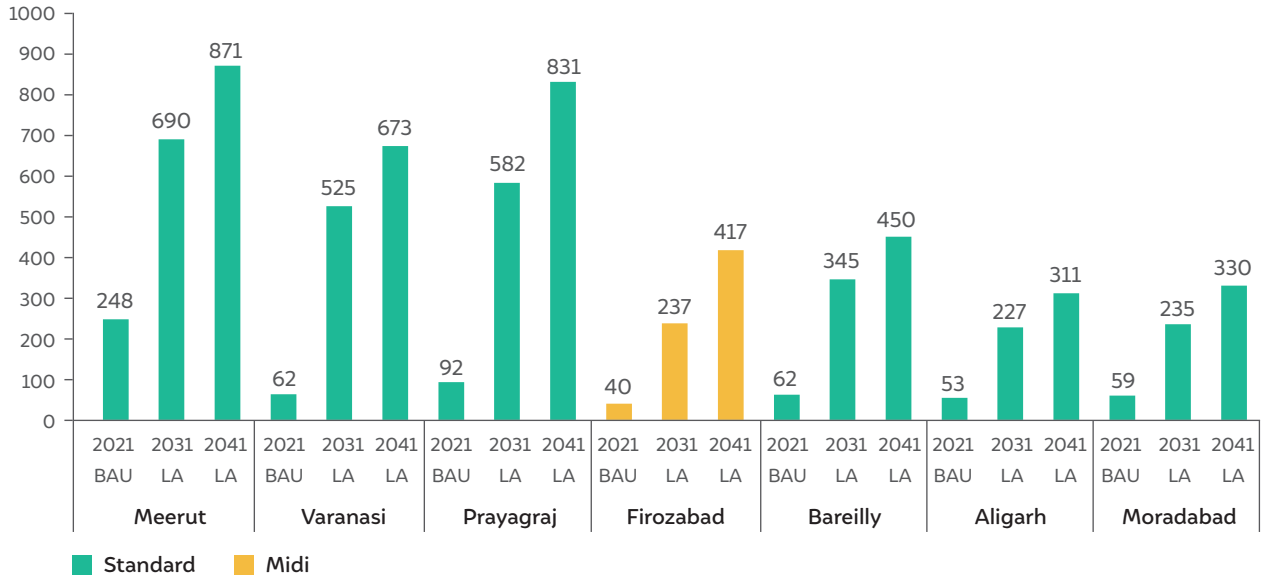
Source: Census. 2011. "B-28: 'Other Workers' by Distance from Residence to Place of Work and Mode of Travel to Place of Work, India – 2011." Last modified January 21, 2021. https://censusindia.gov.in/nada/index.php/catalog/13954.

Figure 7 TLFD for metropolitan cities II (km)



Source: Census. 2011. "B-28: 'Other Workers' by Distance from Residence to Place of Work and Mode of Travel to Place of Work, India – 2011." Last modified January 21, 2021. https://censusindia.gov.in/nada/index.php/catalog/13954.

Figure 8 Bus requirement for metropolitan cities II (low-ambition scenario)



Source: Authors' analysis

3.3 Bus requirement in metropolitan cities III (10-20lakh population)

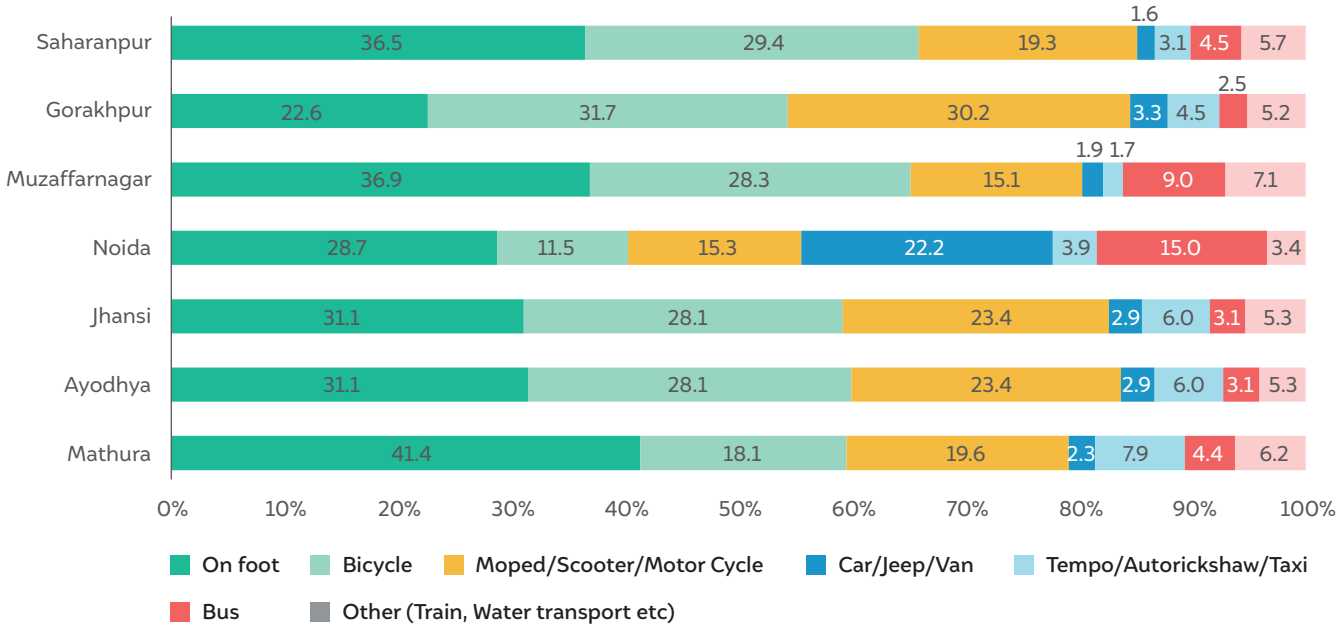
Seven cities – Mathura, Jhansi, Noida, Muzaffarnagar, Gorakhpur, Ayodhya, and Saharanpur – have been placed in the metropolitan cities III category as they will have populations of —2.5 to 3 lakh households by 2041.

About 21 per cent of trips in these cities are completed on 2Ws. On an average, people living in these cities are more dependent on PT (7 per cent) than IPT (5 per cent).

But Noida (15 per cent) and Muzaffarnagar (9 per cent) have higher PT shares than the other cities.

In metropolitan cities III, about 19–34 per cent of all trips are 6–20 km long. Also, 22 per cent of people use modes other than buses for such trips. These people can be considered potential bus users in metropolitan cities III. These cities will have a daily ridership of about 60,000 in the BAU scenario, 1.4 lakh in the low-ambition scenario, and 1.8 lakh in the high-ambition scenario.

Figure 9 Modal share of metropolitan cities III (%)



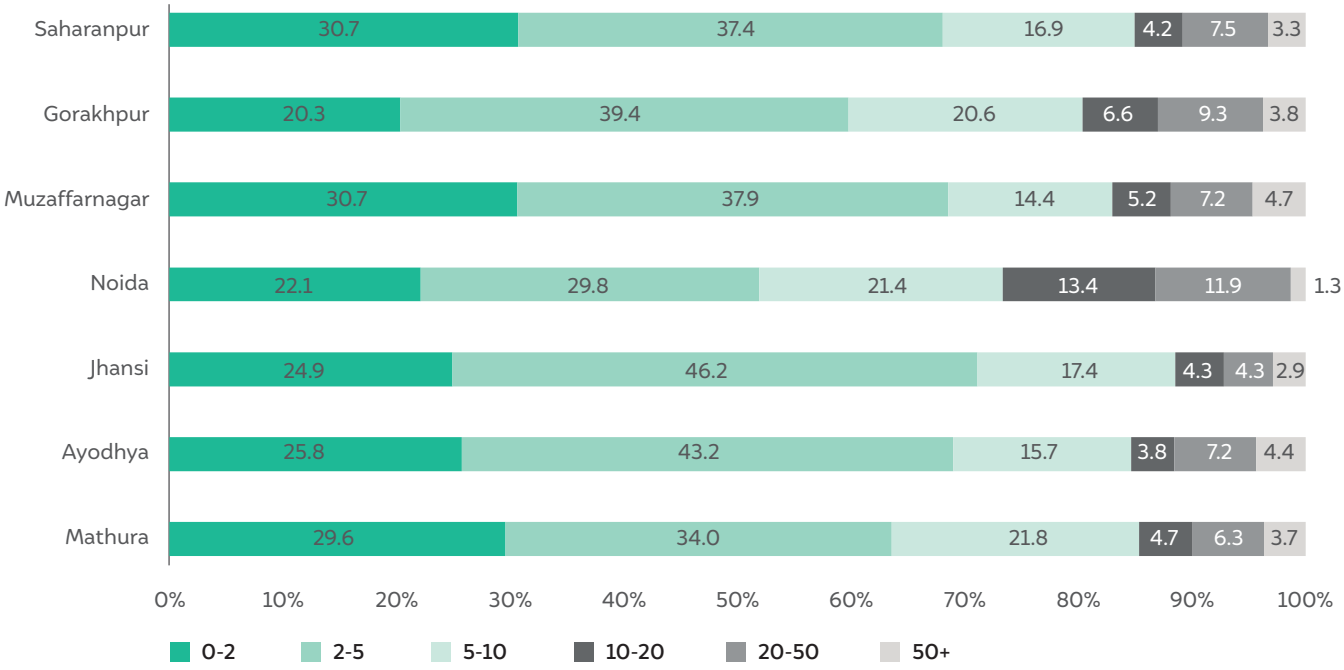
Source: Census. 2011. "B-28: 'Other Workers' by Distance from Residence to Place of Work and Mode of Travel to Place of Work, India – 2011." Last modified January 21, 2021. https://censusindia.gov.in/nada/index.php/catalog/13954.

The average route length for these cities will be about 13 km (in 2041), with 14–32 operational routes, depending on the population.

The standard and midi buses requirements for year 2021, 2031 and 2041 were calculated for the BAU, low-ambition, and high-ambition scenarios (see Annexure 4 – city-wise bus demand estimation). The annual bus requirements for the most probable low-ambition scenario are presented in Figure 11. Saharanpur and Muzaffarnagar are envisaged to deploy standard buses, while the other five cities are likely to operate midi buses in the near future.

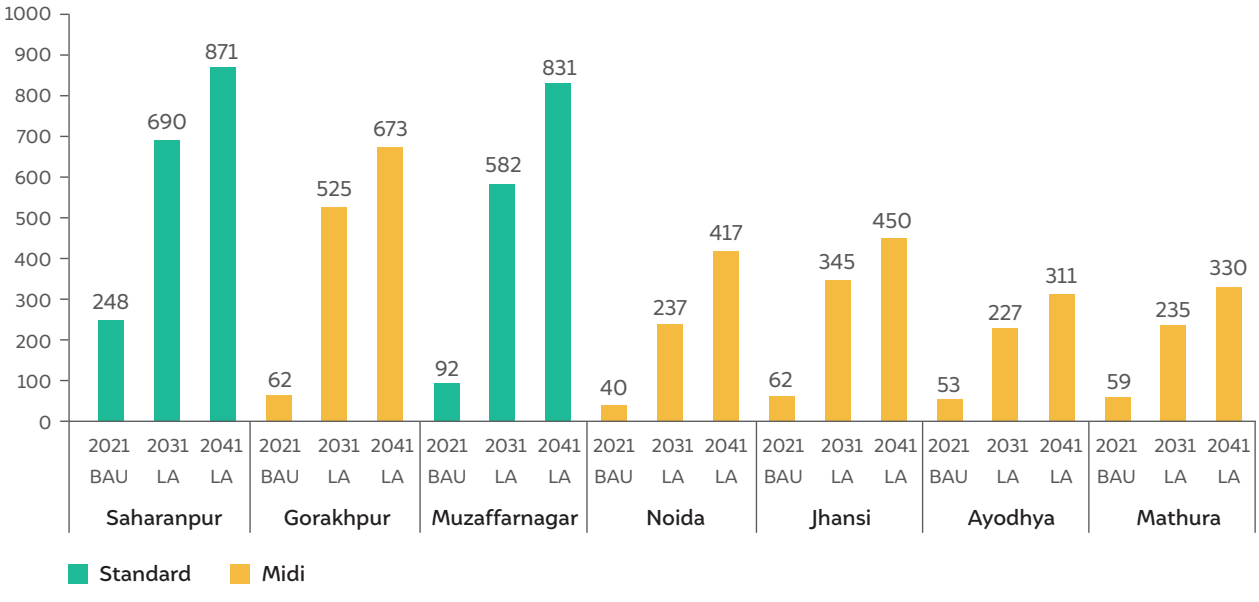
In the low-ambition scenario, 1,352 midi buses and 446 standard buses will be required by 2031. However, by 2041, the demand will grow and an additional 390 midi buses and about 213 standard buses will be required for all seven metropolitan cities III. Details of the bus requirements for other scenarios are in Annexure 4– city-wise bus demand estimation.

Figure 10 TLFD for metropolitan cities III (km)



Source: Census. 2011. "B-28: 'Other Workers' by Distance from Residence to Place of Work and Mode of Travel to Place of Work, India – 2011." Last modified January 21, 2021. https://censusindia.gov.in/nada/index.php/catalog/13954.

Figure 11 Bus requirement for metropolitan cities III (low-ambition scenario)



Source: Authors' analysis

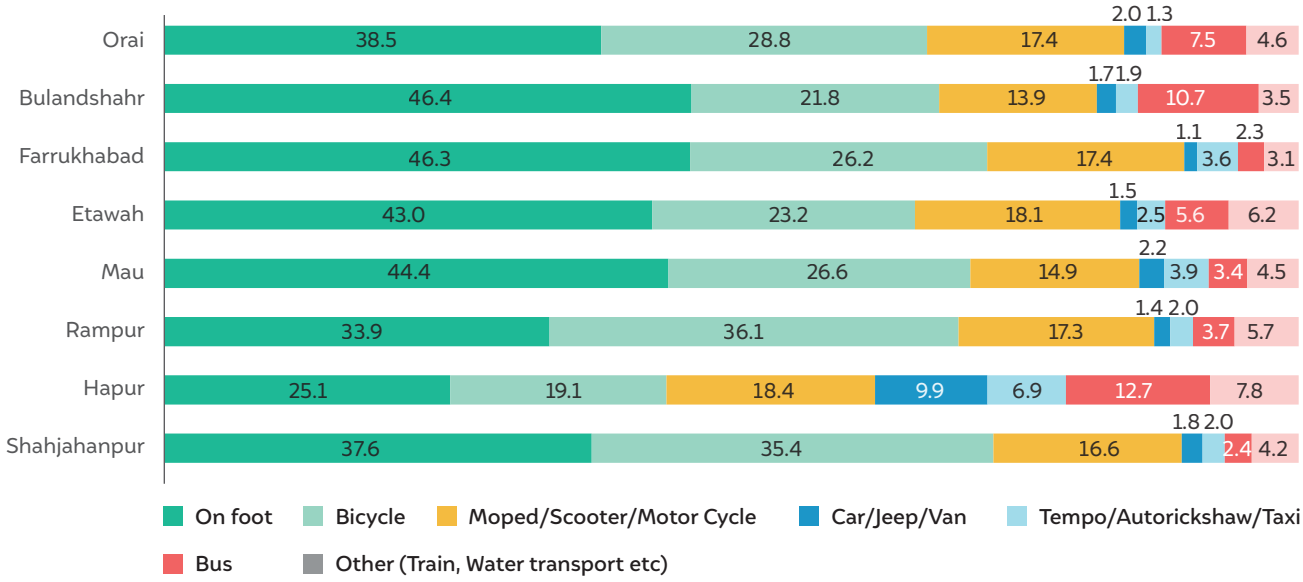
3.4 Bus requirement in large cities (about 5-10 lakh population)

Eight cities – Auraiya, Bulandshahr, Farrukhabad, Etawah, Maunath Bhanjan (Mau), Rampur, Hapur, and Shahjahanpur – will have a population of about 5–10 lakh by 2041 and fall into the category of large cities.

Only 17 per cent of trips are completed using 2Ws in large cities, and it decreases with the city population/. People living in large cities are also more dependent on PT (6 per cent) as compared to IPT (3 per cent). Hapur has a higher PT share (13 per cent), as it was part of the Ghaziabad district in the Census (2011). Bulandshahr has a PT share of 11 per cent as compared to a 2 per cent IPT share.

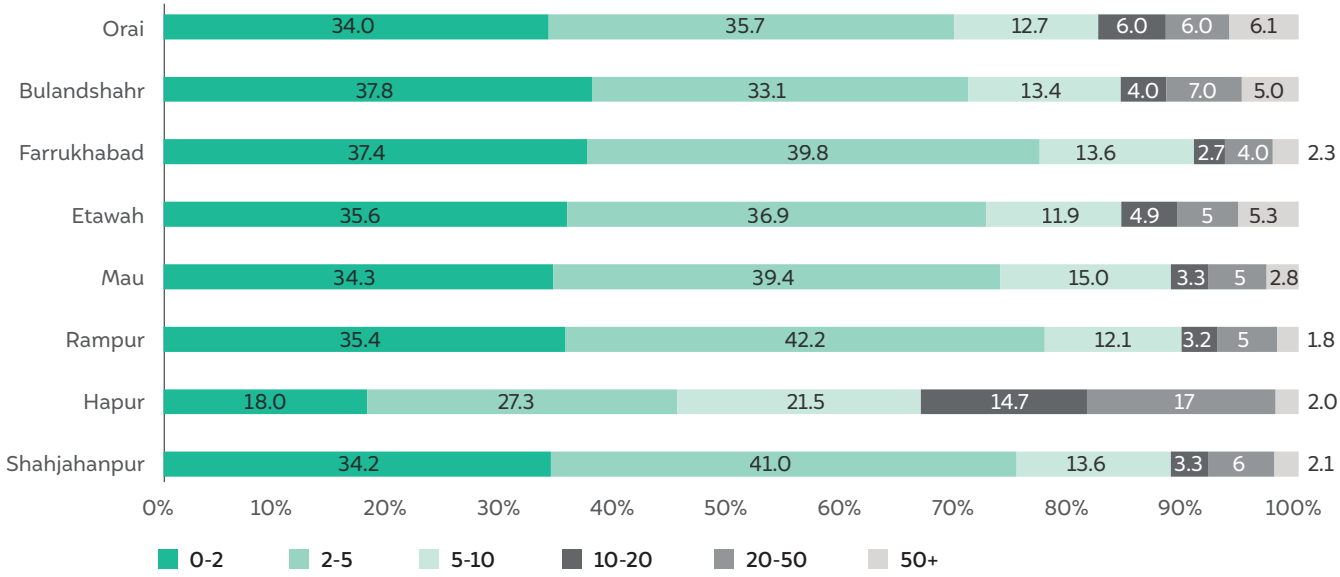
In all large cities, about 15–19 per cent of all trips are 6–20 km long. About 17 per cent of people travelling such distances use modes other than buses. These people can be considered potential bus users. Large cities will have a daily ridership of about 20,000 in the BAU scenario, 44,000 in the low-ambition scenario, and 55,000 in the high-ambition scenario. The average route

Figure 12 Modal share of large cities (%)



Source: Census. 2011. "B-28: 'Other Workers' by Distance from Residence to Place of Work and Mode of Travel to Place of Work, India – 2011." Last modified January 21, 2021. https://censusindia.gov.in/nada/index.php/catalog/13954.

Figure 13 TLFD for large cities (km)



Source: Census. 2011. "B-28: 'Other Workers' by Distance from Residence to Place of Work and Mode of Travel to Place of Work, India – 2011." Last modified January 21, 2021. https://censusindia.gov.in/nada/index.php/catalog/13954.

length for large cities will be about 8 km (in 2041). These cities will have 12–14 operational routes depending upon their populations.

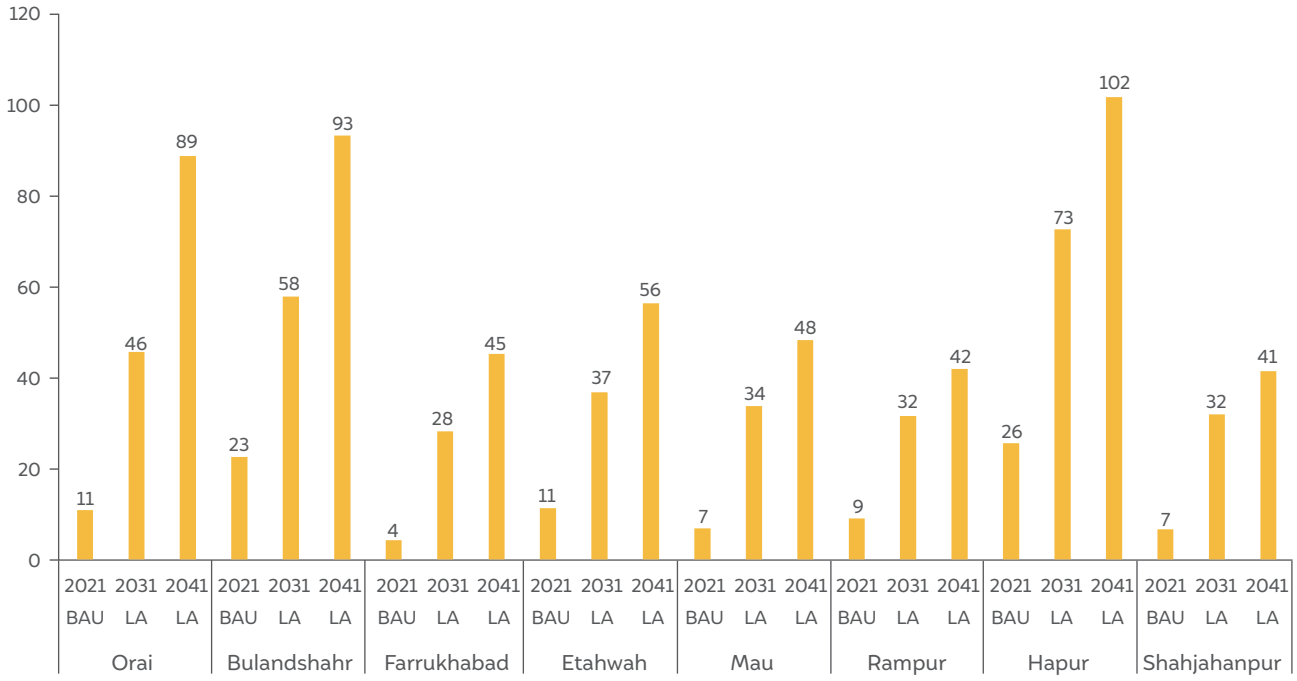
The standard and midi bus requirements for each year were calculated for the BAU, low-ambition, and high-ambition scenarios (Annexure 4 – city-wise bus demand estimation). The numbers of both types of buses required for the most probable low-ambition scenario are presented in Figure 14. Hapur and Bulandshahr are expected to use standard buses, while the other six cities are likely to operate midi buses in the near future.

In the low-ambition scenario, 338 midi buses will be required by 2031. However, by 2041, the demand will grow and an additional 179 midi buses will be required for all eight large cities. Details of the bus requirements for other scenarios are in Annexure 4 – city-wise bus demand estimation.

4. State urban bus programme - SUBP

UP state has 18 divisions and 75 districts (Census 2011). The state is expected to catch up on urbanisation growth given its economic performance, which is better than the national average. Cities remain critical hubs for economic development contributing more than 75 per cent of the gross state domestic product (GSDP). Buses will be vital facilitators of this contribution.

Figure 14 Midi bus requirement for large cities (low-ambition scenario)



Source: Authors' analysis

4.1 Bus requirements under SUBP

It is estimated that about 375 lakh residents in 26 cities will drive most of the mobility demand till 2031. There will be 13 metropolitan (10 lakh plus population) cities in UP, with two mega cities, Lucknow, and Kanpur that will have a population of more than 40 lakh. 13 other large cities will have populations of 5–10 lakh. 2Ws have a higher modal share in metropolitan cities as compared to large cities. But people prefer buses for commutes longer than 5 km. About 50 per cent of all 2W and 3W trips are longer than 5 km in the analysed cities. People making these long trips are highly likely to switch to using buses (Electricwala and Kumar 2014, Khanna et al. 2024a).

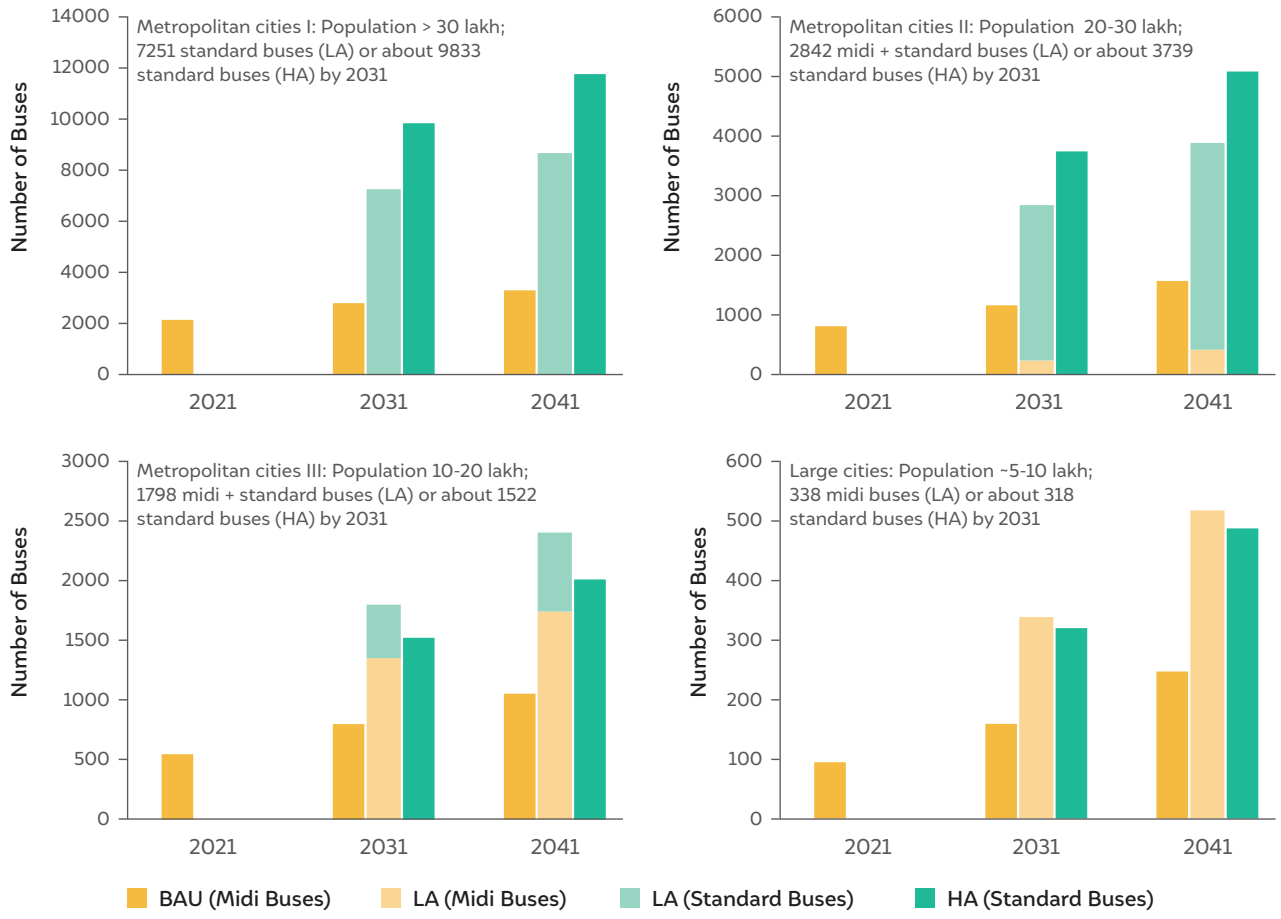
The estimates indicate that buses will serve 60 lakh riders per day by 2031 in all 26 cities in the low-ambition scenario and 80 lakh riders in the high-ambition scenario.

Thus, the study recommends a long-term, inclusive **State Urban Bus Programme (SUBP) that covers at least 26 cities in the state in order to meet the large urban mobility demand sustainably.** The vision of the Government of Uttar Pradesh (GoUP) for urban PT in the state, and the state electric vehicle (EV) policy, explicitly focus on buses. E-buses will ensure maximum benefits for several cities reeling from worsening air quality, especially due to vehicular pollution.

Midi buses are appropriate for cities with populations below 5 lakh. Standard buses can be deployed in cities with midi bus headways of <5 minutes during peak hours. Thus, several cities such as Lucknow, Kanpur, Ghaziabad, Agra, Varanasi, Meerut, Prayagraj, Bareilly, Moradabad, Aligarh, Saharanpur and Muzaffarnagar will need standard buses.

The analysis estimate a need for **12,229 midi–standard bus combinations in the low-ambition scenario and about 15,583 standard buses in the high-ambition**

Figure 15 Cluster-wise bus requirements under different scenarios for 2021, 2031, and 2041



Source: Authors' analysis

scenario by 2031. The Directorate of Urban Transport (DUT) could aim for rolling out about 12,000 midi and standard buses under the UP SUBP by 2031.
The GoUP aims to drive growth by leveraging bus systems to enhance connectivity across the state and provide accessibility to workplaces. Considering the relevance of buses to Indian cities and the state government's focus on bus systems, **a SUBP is urgently needed**. UP's path to a GSDP of USD 1 trillion relies on the fast-growing USD 40 billion transport and tourism sector (Deloitte 2023). Affordable and efficient PT is critical to connecting manufacturing, tech clusters, tourism, and education hubs.

4.2 E-buses are cheaper than CNG and diesel buses

A lifecycle cost comparison was done for compressed natural gas (CNG) and electric buses to identify the most suitable technology for bus operations in cities based on daily utilisation. E-buses are more cost-effective when the daily vehicle utilisation crosses at least 60 km (Figure 17). This is estimated using just vehicle costs and energy costs over a period of 15 years, as the other operational costs remain the same for both technologies. As utilisation increases to 150 km, e-buses become about 25 per cent cheaper to operate than their CNG counterparts. In terms of lifetime vehicle and energy costs, e-buses are 23–32 per cent cheaper than CNG buses, considering an average utilisation of 140–200 km per day.

A focus on e-buses aligns with the state government's vision and EV policy. Zero tail-pipe emissions from e-buses will ensure maximum benefits for citizens.

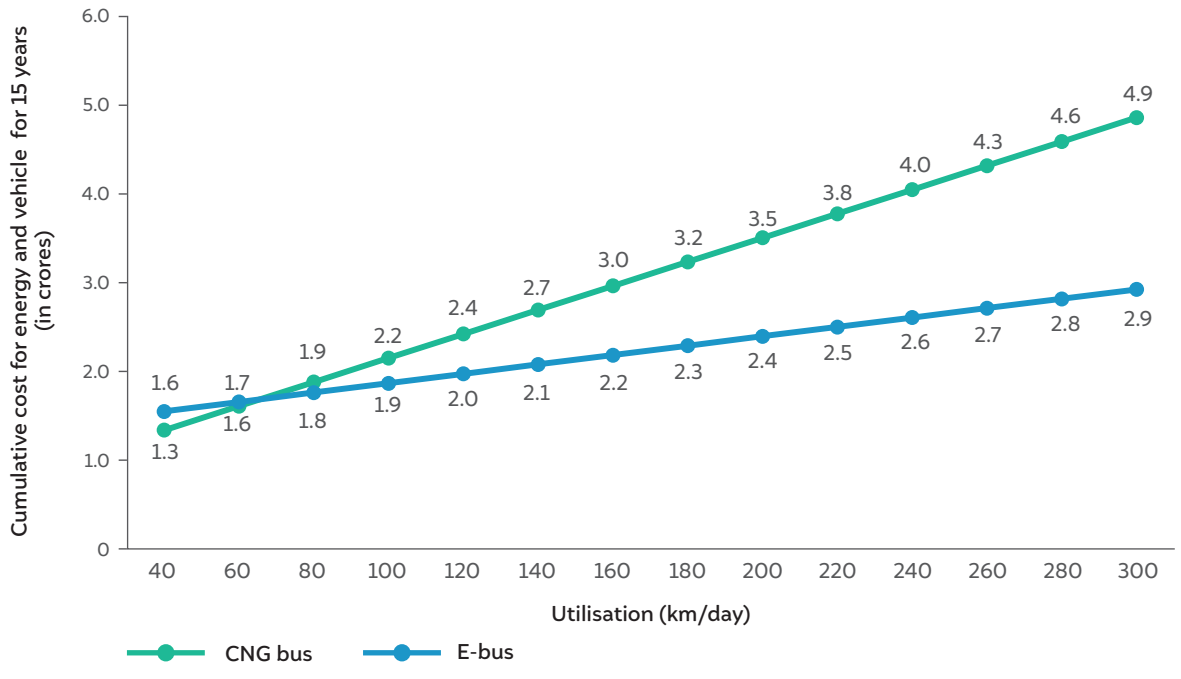
4.3 SUBP – Short-term roadmap (2024–2031)

The study recommends creating a short-term roadmap for the first seven years of the SUBP to lay out the investment requirement for each year. This will help meet the bus requirement by 2031. The plan will inform policymakers about the yearly investment required for creating infrastructure (construction and charging), bus procurement, maintenance, energy, and personnel. It will also outline the potential fare box revenue for cities, and the extent of VGF required to sustain the programme and bus services.

Investments in bus systems: The study estimates a combined outlay of INR 15,700 crore to procure 12229 buses to meet the daily ridership demand of 59.6 lakh per day by 2031. The analysis also envisage an investment of INR 3,000 crore as a one-time cost to set up charging and depot/terminal-related infrastructure (excluding land costs) in 26 cities over the next seven years.

Annual costs and revenues for operating bus services: The study estimates operation and maintenance (O&M) costs of about INR 3,286 crore per year in the short term. This includes maintenance costs

Figure 16 Cummulative cost of energy and capital (bus cost) of CNG and e-buses against utilisation per day (km)



Source: Authors' analysis

as well as costs associated with battery replacement (twice during service years, distributed evenly per year across the lifecycle), energy, and personnel. The fare box revenue is estimated at INR 2,500 crore for 2031, which is 76 per cent of the O&M cost. Hence, to sustain bus services, INR 786 crore per year (24 per cent) is required as VGF in the short term. Detailed assessments are discussed in subsequent sections, and the details of cost assumptions are given in Annexure 3.

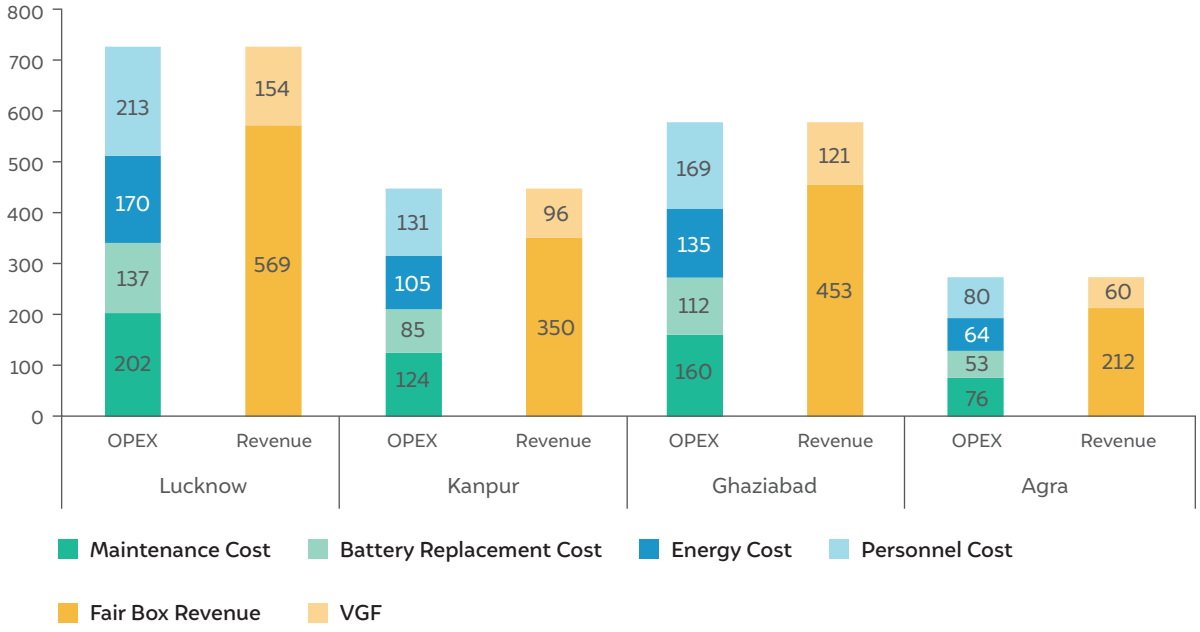
Metropolitan cities I

The study estimates the costs and revenues per year for the short term (2024–2031) in the low-ambition scenario. About 7,251 buses are required in metropolitan cities I to meet the daily ridership demand of 31.7 lakh by 2031.

Bus procurement will cost about INR 9,800 crore. About INR 1,750 crore, as a one-time cost, is necessary to set up charging and depot/terminal-related infrastructure in the four cities (excluding the land costs, as those can be covered by urban local bodies [ULBs] and other land-owning agencies).

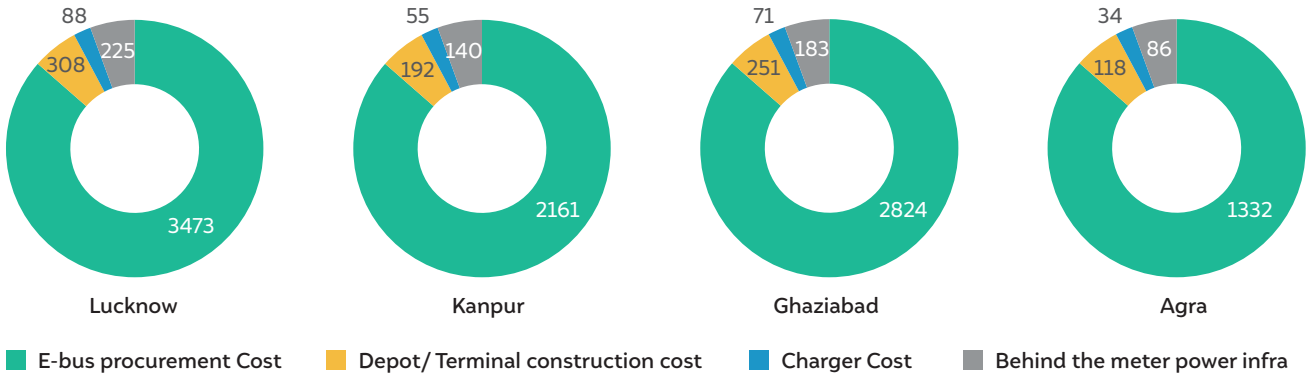
The analysis estimates O&M costs of about INR 2,015 crore per year in the short term. This includes maintenance costs of INR 563 crore, battery replacement costs of INR 387 crore (twice during service years, distributed evenly per year across the lifecycle), energy costs of INR 473 crore, and personnel costs of INR 593 crore. The fare box revenue is estimated at INR 1,585 crore for 2031, which is 79 per cent of the O&M cost. Hence, to sustain the bus services, INR 431 crore per year (21 per cent) is required as VGF in the short term.

Figure 17 Cost breakup of O&M, farebox revenue, and VGF for metropolitan cities I in the short term (crore)



Source: Authors' analysis

Figure 18 Breakup of upfront procurement and infrastructure cost for metropolitan cities I in the short term (crore)



Source: Authors' analysis

Metropolitan cities II

For the seven metropolitan cities II, the study estimates that 2,842 buses will be required to meet the daily ridership demand of 16.7 lakh by 2031. Bus procurement costs will total about INR 3,739 crore. Around INR 686 crore, as a one-time cost, is needed to set up charging and depot/terminal-related infrastructure.

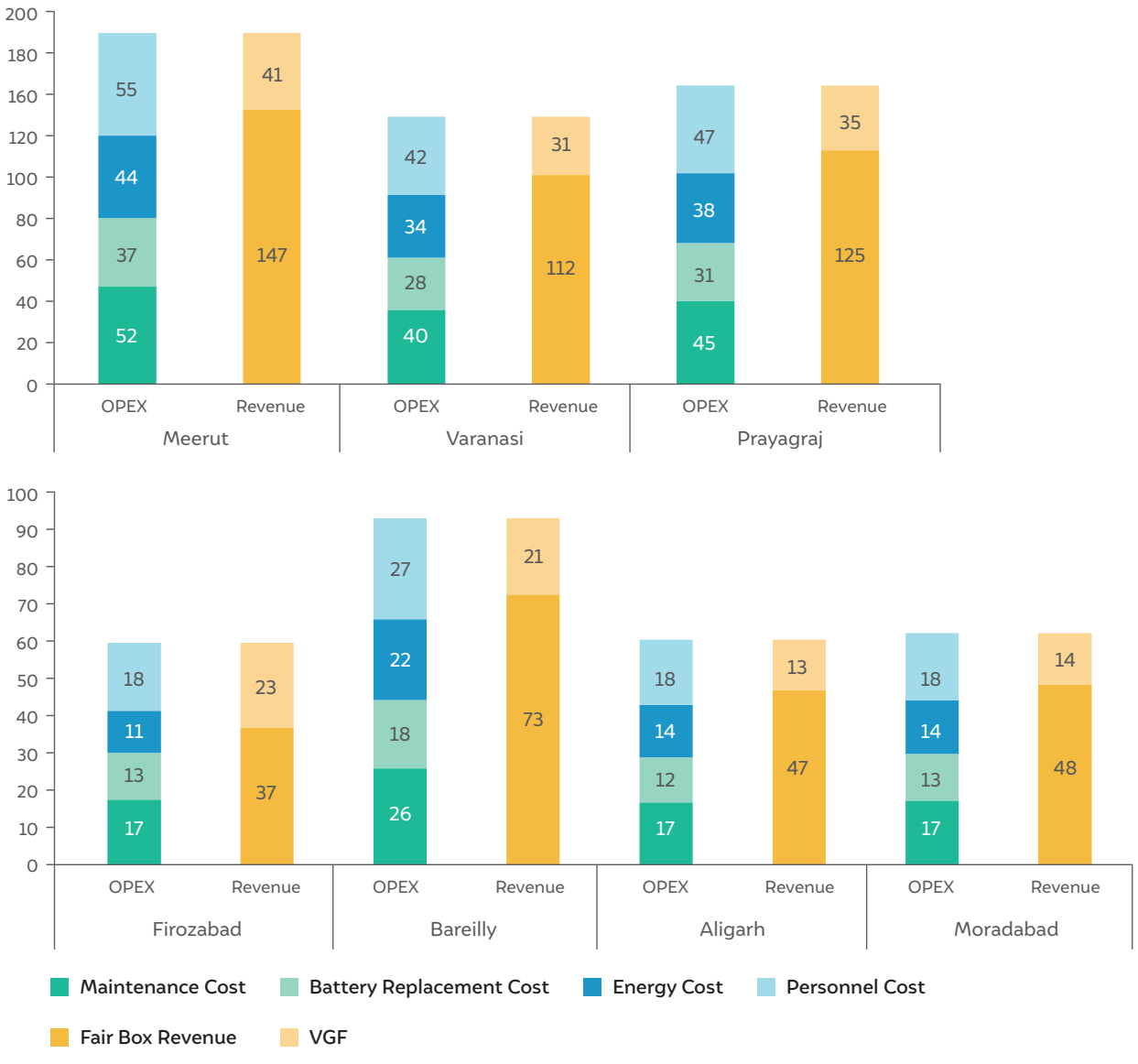
The study estimates combined O&M costs of about INR 767 crore per year in the short term. This includes maintenance costs of INR 214 crore, battery replacement costs of INR 152 crore, energy costs of INR 177 crore, and personnel costs of INR 225 crore. The fare box revenue is estimated at INR 589 crore for 2031, which is 77 per cent of the O&M cost. Therefore, to sustain bus services, INR 178 crore per year (23 per cent) is required as VGF in the short term.

Metropolitan cities III

For the seven cities in this cluster, an estimated 1798 buses are required to meet the daily ridership demand of 8.4 lakh by 2031. Bus procurement costs will be about INR 1,873 crore. Approximately INR 434 crore is necessary, as a one-time cost, to set up charging and depot/terminal-related infrastructure.

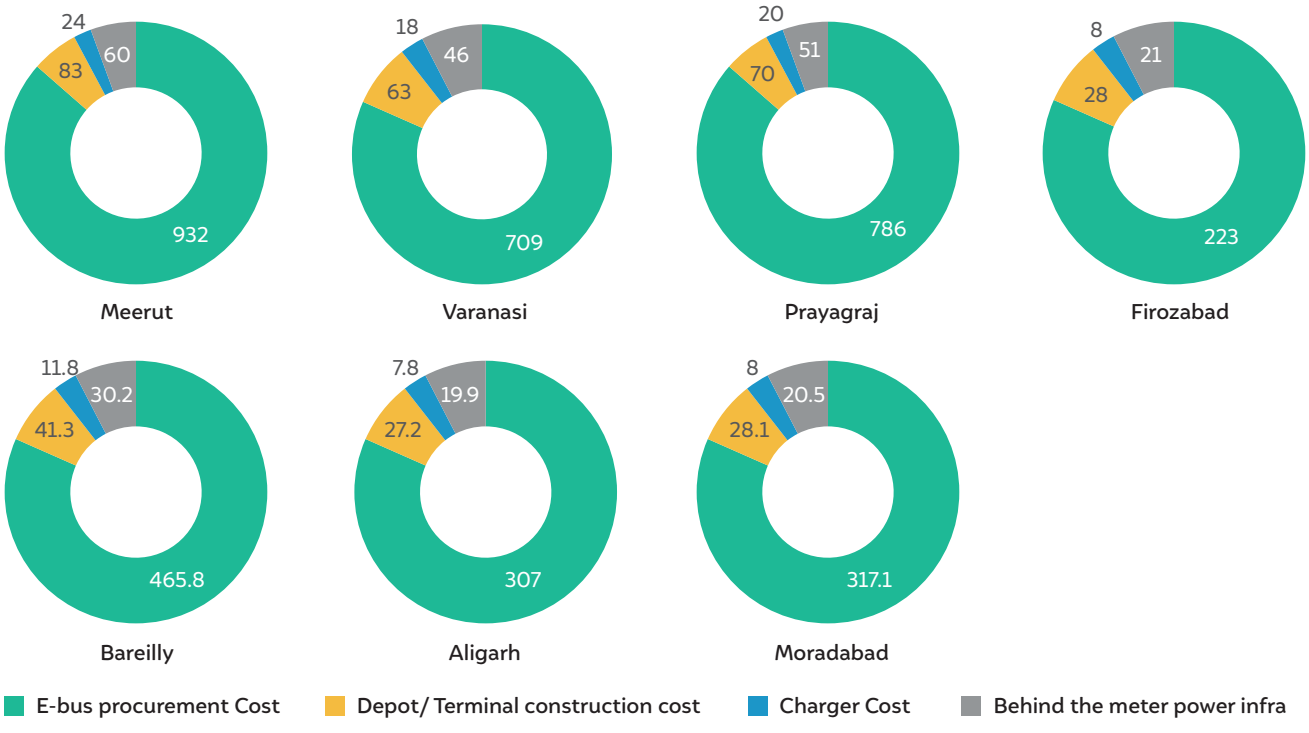
The study estimates O&M costs of about INR 425 crore per year in the short term, which includes maintenance costs of INR 124 crore, battery replacement costs of INR 86 crore, energy costs of INR 85 crore, and personnel costs of INR 131 crore. The fare box revenue is estimated at INR 277 crore in 2031, which is 65 per cent of the O&M cost. Hence, to sustain bus services, INR 148 crore per year (35 per cent) is required as VGF in the short term.

Figure 19 Cost breakup of O&M, farebox revenue, and VGF for metropolitan cities II in the short term (crore)



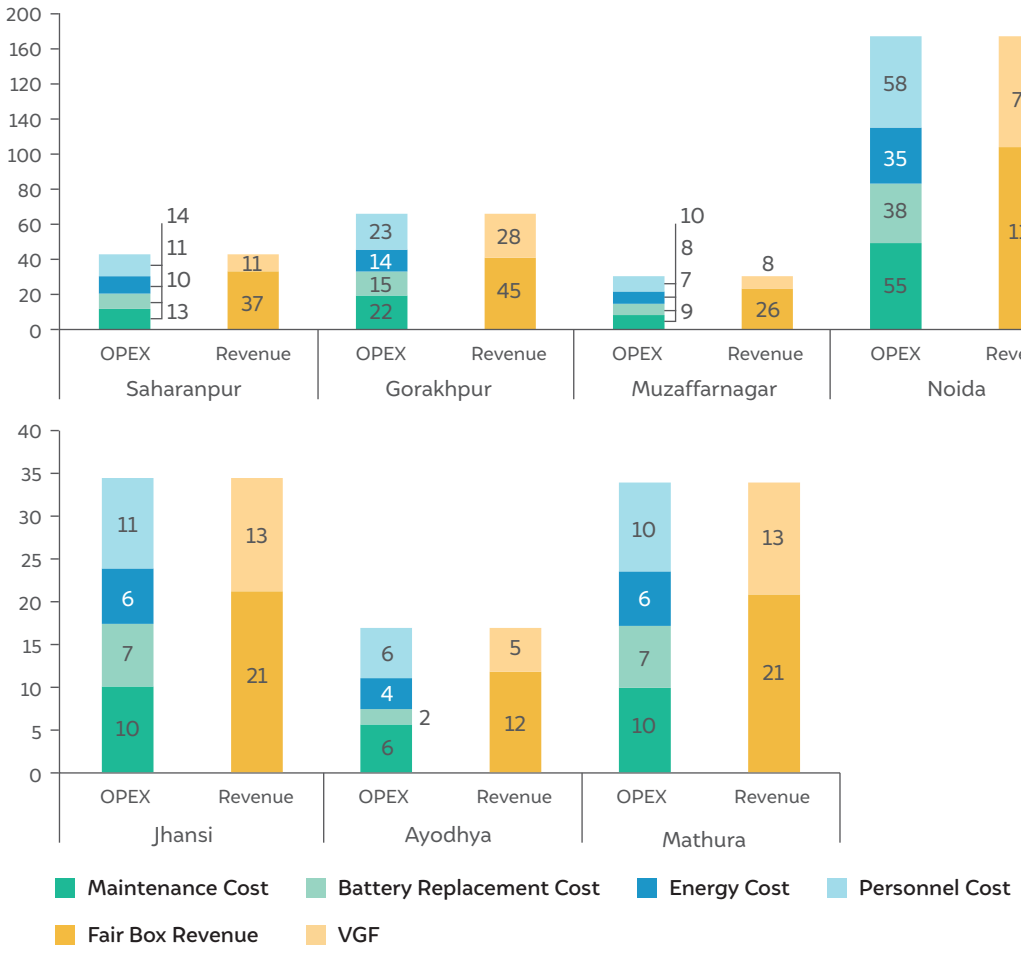
Source: Authors' analysis

Figure 20 Breakup of upfront procurement and infrastructure costs for metropolitan cities II in the short term (crore)



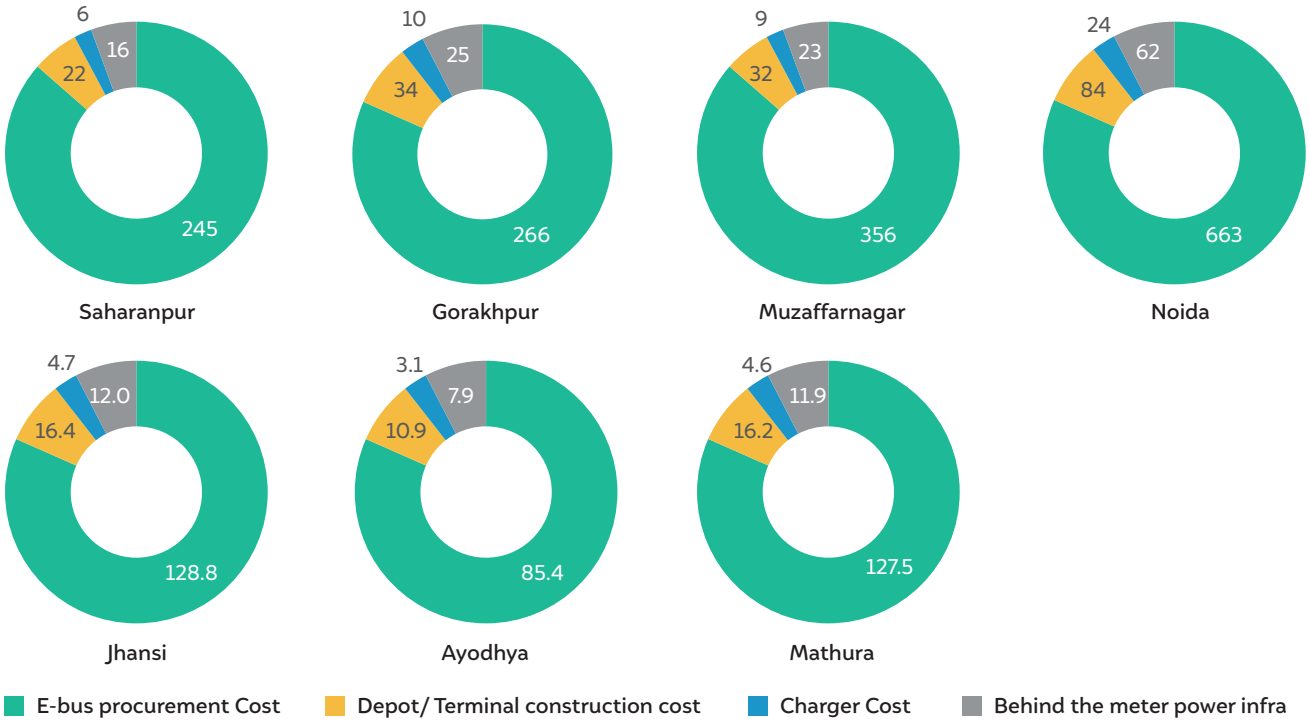
Source: Authors' analysis

Figure 21 Cost breakup of O&M, farebox revenue, and VGF for metropolitan cities III in the short term (crore)



Source: Authors' analysis

Figure 22 Breakup of upfront procurement and infrastructure cost for metropolitan cities III in the short term (crore)



Source: Authors' analysis

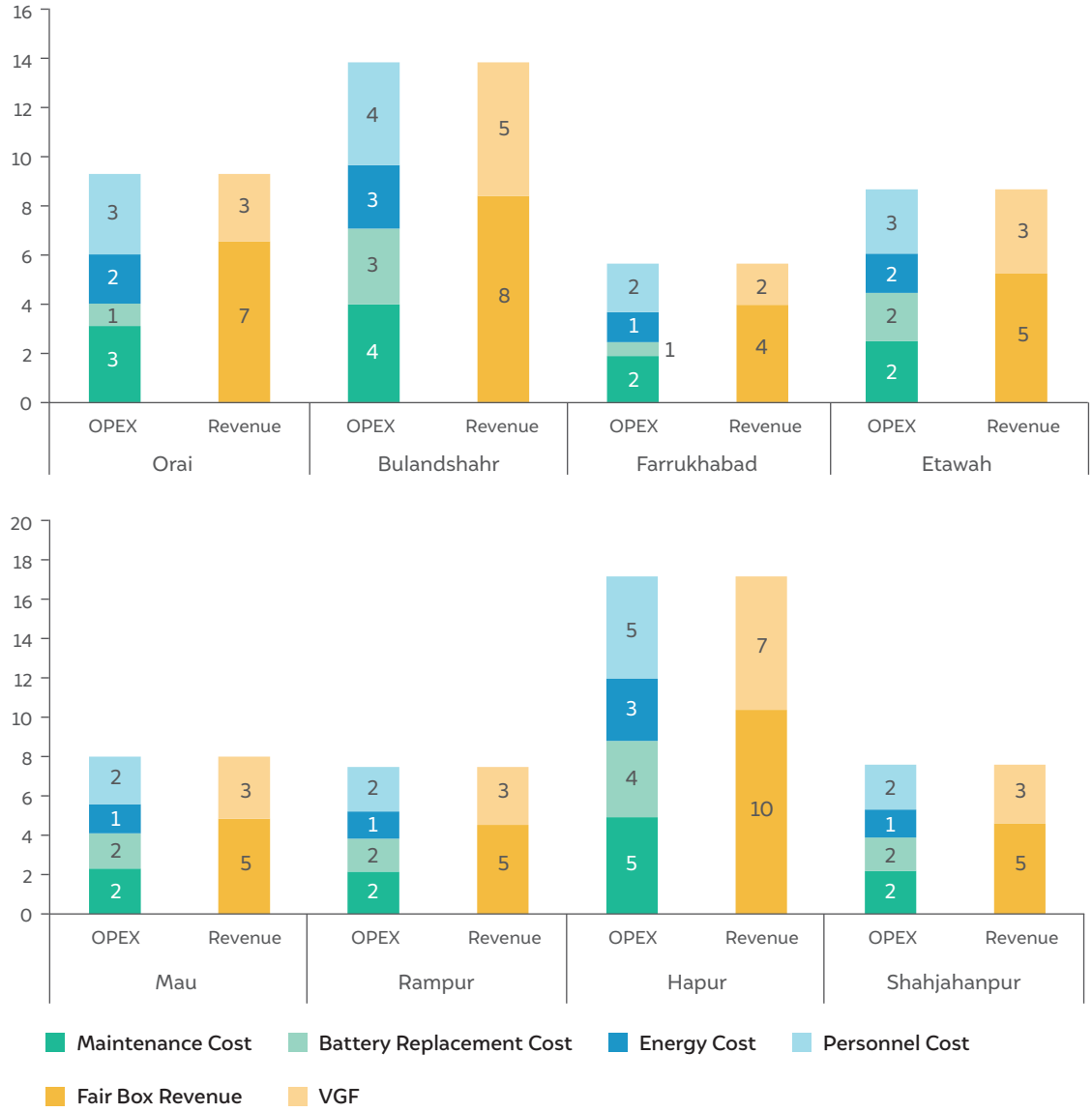
Each new bus sustained by its personnel is creating an opportunity for employment and livelihoods.

Large cities

For the eight large cities, an estimated 338 buses are required to meet the daily ridership demand of 2.8 lakh by 2031. Bus procurement costs will total about INR 318 crore. About INR 82 crore, as a one-time cost, is required to set up charging and depot/terminal-related infrastructure.

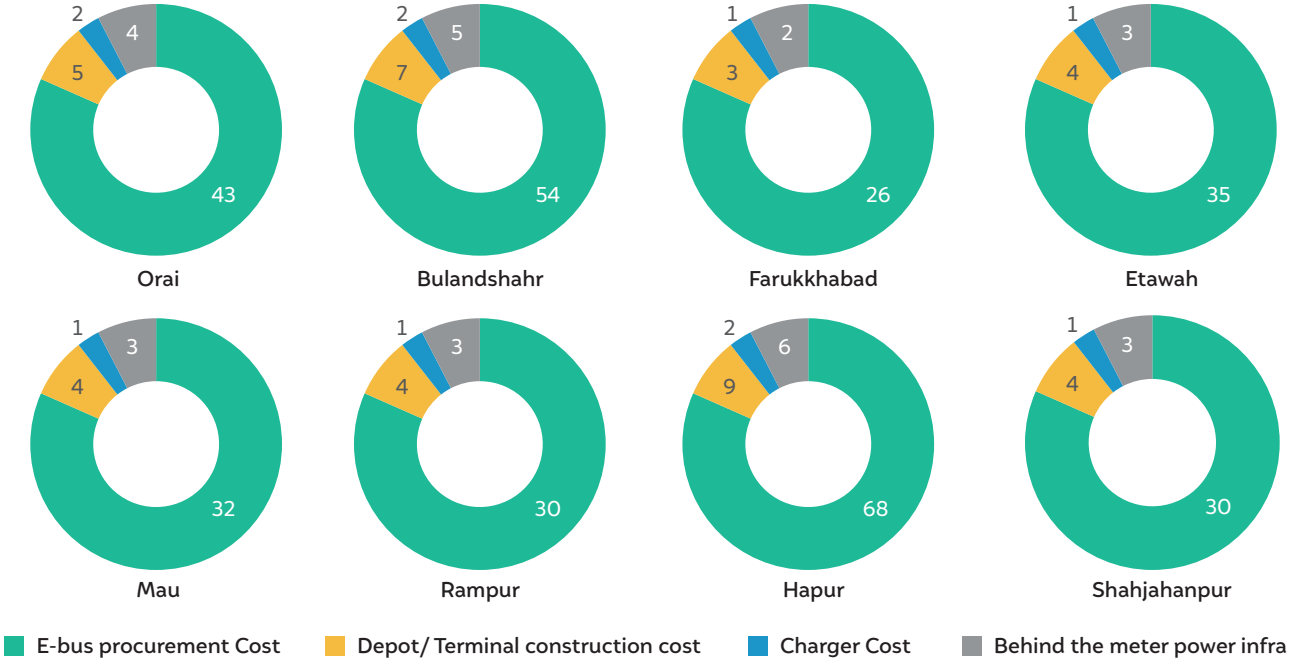
The study estimates O&M costs of about INR 78 crore per year in the short term. This includes maintenance costs of INR 23 crore, battery replacement costs of INR 16 crore, energy costs of INR 15 crore, and personnel costs of INR 24 crore. The fare box revenue is estimated at INR 48.5 crore in 2031, which is 62 per cent of the O&M cost. Hence, to sustain bus services, INR 29 crore per year (38 per cent) is required as VGF in the short term.

Figure 23 Cost breakup of O&M, farebox revenue, and VGF for large cities in the short term (crore)



Source: Authors' analysis

Figure 24 Breakup of upfront procurement and infrastructure cost for large cities in the short term (crore)



Source: Authors' analysis

4.4 Potential benefits

With the addition of 12,229 buses by 2031, the SUBP will positively impact mobility, abate emissions and congestion, and enhance the economy. An estimated 40 lakh passengers will shift from 3Ws and 2Ws to affordable and clean buses. This shift shall result in the yearly reduction of 59 KT of particulate matter (PM) 2.5, 6 MT of carbon monoxide (CO), and 0.6 MT of nitrous oxides (NOx) emissions by 2031.

Additionally, about 2 crore passenger kilometres per day will be covered by buses instead of 2Ws and 3Ws in 2031, which will lead to substantial decongestion, fewer investments in road infrastructure, and savings in fuel and time. Thus, the SUBP is integral to achieving the accessibility and connectivity needs of the vital city workforce and propelling UP to a trillion-dollar economy.

4.5 Way Forward

The study methodology and findings are suitable for implementing broad city-level estimates of bus requirements and bus service planning. However, detailed route-level assessments are recommended at the time of bus system planning in sync with comprehensive mobility planning and city development plans. Directorate of Urban Transport must continue to champion the urban bus services planning across cities. Various other initiatives like Terminal and bus depot planning, charging infrastructure deployment along with bus stops and their access improvement must be integral to SUBP. UP cities will continue to power the economy with its reliable and affordable bus systems.

Annexures

Annexure 1: SGArchitects and Shakti Foundation (2021) Bus Resource Estimation Model

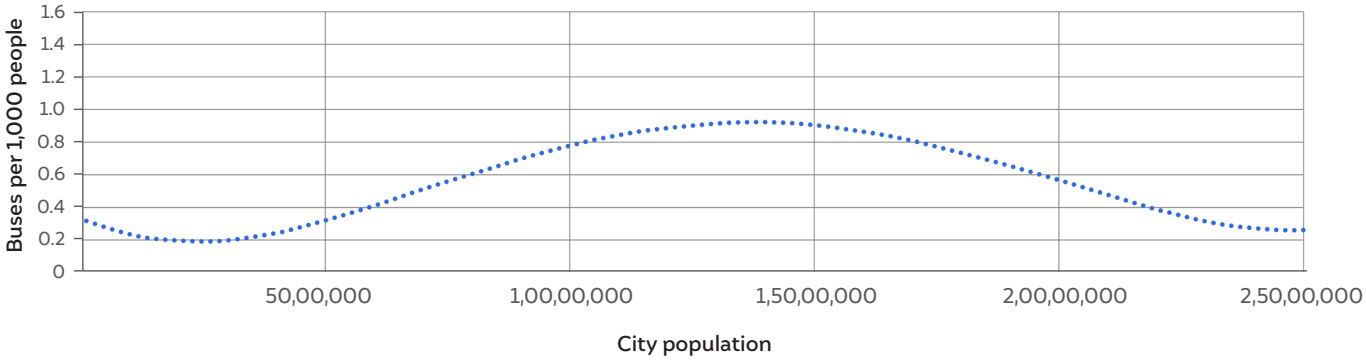
Trip length data was taken from the Census 2011 for 35 cities. The number of buses required for these trips was derived from documented urban bus operational characteristics in India; for example, average occupancy, vehicle utilisation (VU), average trip length, and fleet utilisation. The derived number of buses used for the total population allowed for calculating the buses per 1,000 people in the population for each city. These values were derived for three scenarios:

1. BAU scenario, with 33 per cent of the total trips in the city with a length of 6–15 km covered by buses.
2. Low-ambition scenario, with 66 per cent of the total trips in the city with a length of 6–15 km covered by buses.
3. High-ambition scenario, with 100 per cent of the total trips in the city with a trip length of 6–15 km covered by buses.

The values were used to plot a trend line for each scenario which can predict the values for each city in each scenario. The derived standards can be used to calculate the bus requirement for a given population in a city. Derived standards for each scenario are given in the following figures (SGArchitects and Shakti Foundation 2021).

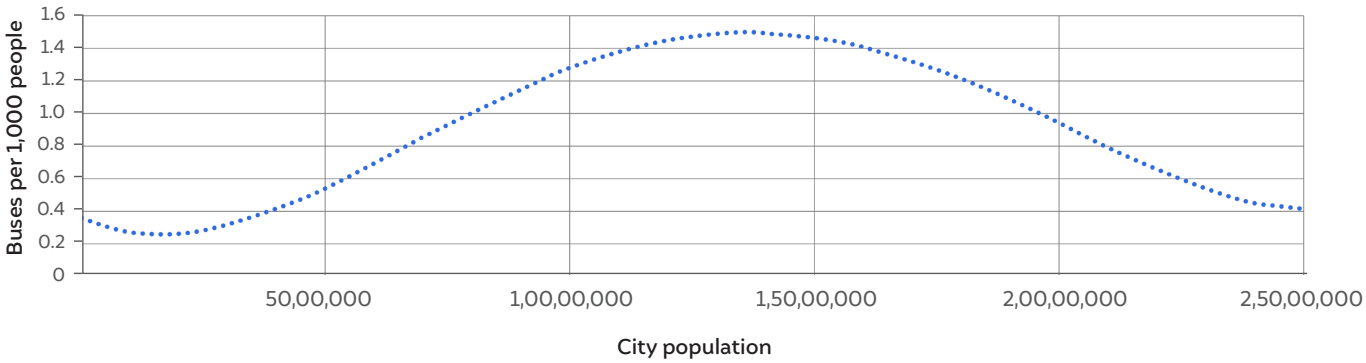
The primary outputs of this model are i) supply and demand estimates, and 2) annual resource requirements. The supply and demand in bus passenger trips were generated using base values and assumptions. The annual resource requirements include the total land to be acquired, bus terminals and depots to be developed, procurement of internal combustion engine (ICE) and electric buses, total emissions, and budgetary support.

Figure A1 Number of buses per 1,000 people in the population (low-ambition scenario)



Source: SGArchitects, and Shakti Foundation. 2021. "National Bus Resource Requirement (Road Map for Overcoming the Gaps)." Delhi: Shakti Foundation.

Figure A2 Number of buses per 1,000 people in the population (high-ambition scenario)



Source: SGArchitects, and Shakti Foundation. 2021. "National Bus Resource Requirement (Road Map for Overcoming the Gaps)." Delhi: Shakti Foundation.

Annexure 2

Table A1 Populations of 26 cities for 2021, 2031 and 2041.

S. No.	City	2011	2021	2031	2041	Source/Method
1.	Lucknow	2,972,713	3,746,466	4,640,415	5,377,615	OECD
2.	Kanpur	2,943,226	3,287,744	4,036,106	4,694,364	OECD
3.	Ghaziabad	2,434,500	3,225,128	3,911,811	4,234,588	OECD
4.	Agra	1,795,043	2,319,959	2,895,121	3,403,690	OECD
5.	Meerut	1,452,968	1,772,502	2,208,447	2,620,574	OECD
6.	Varanasi	1,458,983	1,740,214	2,164,866	2,569,250	OECD
7.	Allahabad	1,234,374	1,450,152	1,805,516	2,156,093	OECD
8.	Firozabad	604,214	861,919	1,229,540	1,753,955	GP
9.	Bareilly	1,008,775	1,320,367	1,660,880	1,987,380	OECD
10.	Moradabad	937,586	1,240,629	1,562,756	1,874,869	OECD
11.	Aligarh	918,901	1,232,540	1,554,539	1,860,370	OECD
12.	Saharanpur	734,625	1,071,092	1,362,349	1,640,570	OECD
13.	Gorakhpur	699,426	796,229	995,642	1,207,918	OECD
14.	Muzaffarnagar	514,684	729,249	929,448	1,131,554	OECD
15.	Noida	663,074	878,414	1,065,442	1,153,356	OECD
16.	Jhansi	558,588	668,860	841,862	1,026,252	OECD
17.	Ayodhya	331,062	443,288	596,947	818,791	AP
18.	Mathura	471,157	646,493	822,449	1,004,511	OECD
19.	Orai	190,575	277,065	402,806	585,613	GP
20.	Bulandshahr	230,024	306,471	408,325	544,029	GP
21.	Farrukhabad-cum-Fatehgarh	276,581	342,331	423,710	524,436	GP
22.	Etawah	256,838	319,284	396,913	493,417	GP
23.	Mau	278,745	299,293	396,372	478,428	IP
24.	Rampur	325,313	349,536	411,666	468,576	IP
25.	Shahjahanpur	329,736	373,146	416,556	459,966	AP
26.	Hapur	262,983	292,005	372,874	450,222	IP

Source: Authors' analysis

Annexure 3

Table A2 Cost components of SUBP projections.

Components	Cost		Unit
Infrastructure cost	Construction cost (A)	1,100,000	INR per bus
	Behind the meter power infra cost (B)	900,000	INR per bus
	Normative project cost (A + B)	2,000,000	INR per bus
	Charger cost	1,365,000	INR
	Area per 100 buses	5	acres
E-bus procurement cost	Midi	9,400,000	INR
	Standard	13,500,000	INR
O&M cost	Personnel cost	19.37	INR per km
	Maintenance cost	7.05	per km
	Energy cost	8	per kWh
Battery size	Midi	150	kWh
	Standard	200	kWh
Battery cost		200,000	INR per kWh
Energy efficiency	Midi	1	kWh/km
	Standard	1.3	kWh/km
Charger to bus ratio		1:4	–
Charger efficiency		90	%
Seating	Midi	30	–
	Standard	40	–
Fare		1.61	INR/km
Load factor		1.2	–
Service days		340	–
Maintenance cost escalation		10	%
Personnel cost escalation		8	%
Infrastructure cost escalation		3	%

Source: Authors' compilation

Acronyms

2W	two-wheeler
3W	three-wheeler
BAU	business-as-usual
CAGR	compound annual growth rate
CNG	compressed natural gas
CO	carbon monoxide
DUT	Directorate of Urban Transport
FAME	*Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles*
GoUP	Government of Uttar Pradesh
GSDP	gross state domestic product
HA	high ambition
ICE	internal combustion engine
IPT	intermediate public transport
KT	kilo tonnes
kWh	kilowatt-hour
LA	low ambition
MT	mega tonnes
NOx	nitrous oxides
O&M	operation and maintenance
OECD	Organisation for Economic Co-operation and Development
PM	particulate matter
PPP	public–private partnership
PT	public transport
SUBP	*State Urban Bus Programme*
TLFD	trip length frequency distribution
TRIPC	Transportation Research and injury Prevention Centre
UP	Uttar Pradesh
VGF	viability gap fund
VU	vehicle utilisation

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