



Pioneering Electric Buses in Pune

A Case Study of the City's Initial Procurement and Operations

By Pune Municipal Corporation, Pune Mahanagar Parivahan Mahamandal Limited, Pune Smart City Development Corporation Limited, RMI, and RMI India



About the Authors



Pune Municipal Corporation (PMC)

Pune Municipal Corporation (PMC) is the civic body that governs Pune, the second most populous city in the state of Maharashtra. It is responsible for the civic needs and infrastructure of the metropolis, which covers an area of over 330 square kilometres and has 3.4 million residents. PMC has been administering Pune and serving its citizens since 1950.



Pune Mahanagar Parivahan Mahamandal Limited (PMPML)

Pune Mahanagar Parivahan Mahamandal Limited (PMPML) is the public transport bus service provider for the twin cities of Pune and Pimpri-Chinchwad in the Pune Metropolitan Region and is jointly owned by PMC and Pimpri-Chinchwad Municipal Corporation (PCMC) in a 60:40 split.



Pune Smart City Development Corporation Limited (PSCDCL)

Pune Smart City Development Corporation Limited (PSCDCL) is a Special Purpose Vehicle (SPV) company established in 2016 under the Smart City Mission by the Ministry of Urban Development, Government of India. PSCDCL is aimed at promoting cities that provide core infrastructure and give a decent quality of life to citizens through the application of smart solutions. PSCDCL is owned by the Government of Maharashtra and Pune Municipal Corporation (PMC).



About RMI

RMI is an independent nonprofit organisation founded in 1982 that transforms global energy systems through market-driven solutions to align with a 1.5°C future and secure a clean, prosperous, and zero-carbon future for all. We work in the world's most critical geographies and engage businesses, policymakers, communities, and NGOs to identify and scale energy system interventions that will reduce greenhouse gas emissions at least 50% by 2030. RMI has offices in Basalt and Boulder, Colorado; New York City; Oakland, California; Washington, D.C.; and Beijing.



About RMI India

RMI India is an independent think-and-do tank. RMI India takes inspiration from and collaborates with RMI, a 40-year-old non-governmental organisation. RMI India's mission is to accelerate India's transition to a clean, prosperous, and inclusive energy future.

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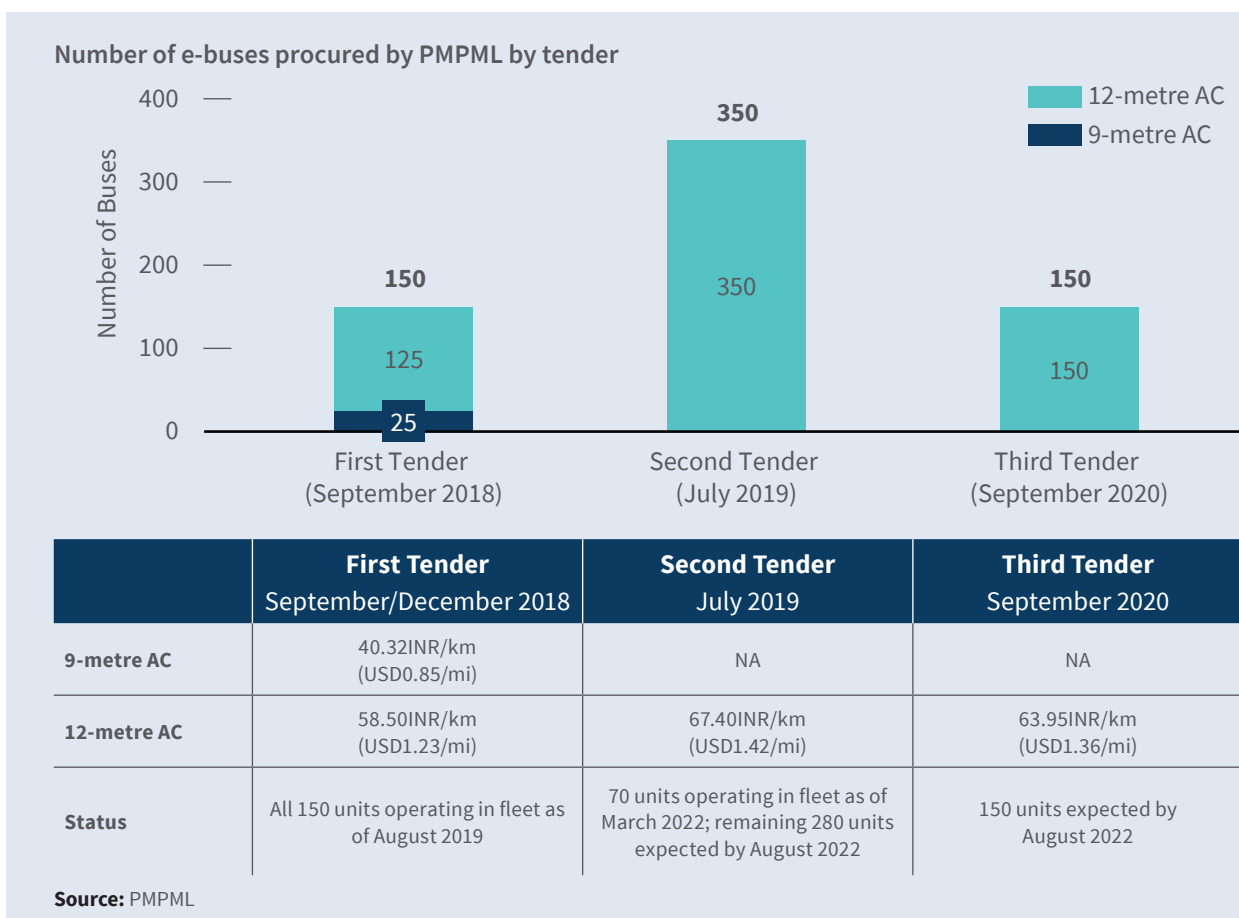
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Executive Summary

Electrification of public transport is a critical aspect of decarbonising urban mobility in India and globally. Although India’s domestic electric bus (e-bus) market is nascent, projections indicate 4 in 10 buses sold in the country could be electric by 2030.¹ The Government of India’s Department of Heavy Industry allocated INR3,454 crores (USD456 million) in fiscal incentives for procurement of city electric bus services under the second phase of the Faster Adoption and Manufacturing of Electric Vehicles Scheme (FAME II).

As a leading early adopter of e-buses, Pune, Maharashtra, represents a valuable case study on public transport electrification. Pune’s public transport agency, Pune Mahanagar Parivahan Mahamandal Limited (PMPML), currently has 220 e-buses operating in its fleet of 2,169 buses—one of the largest municipal e-bus fleets operational in India. As of February 2022, the initial 150 e-buses have completed more than 2 crore km (12.5 million miles (mi)). Once PMPML commissions the remaining 430 e-buses it has tendered (see Exhibit 1), Pune will be on track to meet the target outlined in the Government of Maharashtra’s Electric Vehicle (EV) Policy 2021—25% electrification of the public transport bus fleet by 2025—several years ahead of schedule.

Exhibit 1. Number of e-buses procured by PMPML across three tenders and final quoted bid prices.

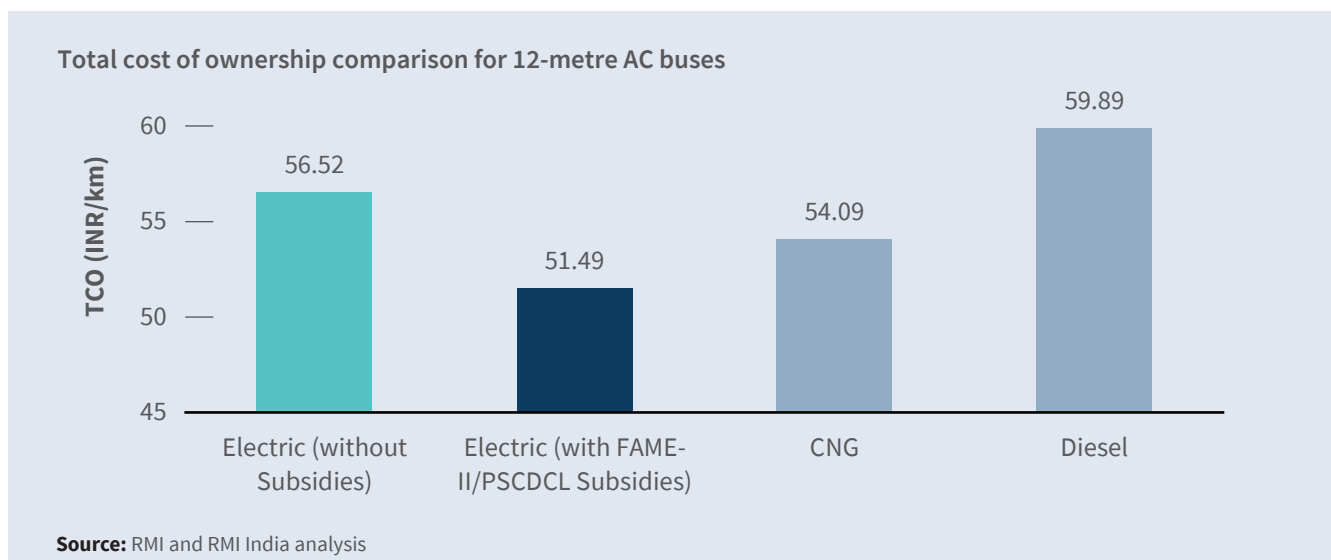


Pune’s experience in e-bus procurement and operation offers valuable insights and points of reference on the forms of interagency coordination, policy support, business model design, tendering and contracting terms, and infrastructure planning to enable e-bus adoption in Indian cities. This case study offers insights on each of these areas by uncovering Pune and its sustainable transport journey; providing an overview of the city’s motivation, planning process, and tenders and contracts; summarising key enablers and challenges; and outlining economic, environmental and public health benefits, and next steps.

Key insights from Pune’s experience in e-bus procurement and operation include the following:

- Political leadership can be a catalyst for e-bus adoption.** Senior leaders of the Pune Municipal Corporation (PMC), Pimpri-Chinchwad Municipal Corporation (PCMC), Pune Smart City Development Corporation Limited (PSCDCL), and PMPML have been dedicated to the joint implementation of initiatives to address local air pollution since many years and are the architects of the city’s commitment to procure e-buses for its public transport fleet. These decision-makers were aligned in their objective, shared a common understanding of the system, and persistently supported the requisite activities to follow through on their commitment.
- Interdepartmental coordination can expedite e-bus planning.** PMC, PCMC, and PSCDCL formed an e-bus working group with PMPML. They received technical support from Central Institute of Road Transport (CIRT), Ernst and Young (EY), and Maharashtra State Electricity Distribution Company Limited (MSEDCL) on business model design, tendering and contracting, and charging infrastructure planning. Regular meetings and clear delineation of roles and responsibilities ensured efficient decision-making and coordinated activities.
- E-buses can be more economical than diesel counterparts.** The total cost of ownership (TCO) of a 12-metre, air-conditioned e-bus in Pune without government incentives is estimated at INR56.52/km (USD1.2/mi)—about 6% lower than a comparable diesel bus at INR59.89/km (USD1.26/mi). With government incentives from PSCDCL and FAME II, TCO is 15% lower than diesel and more economical than compressed natural gas (see Exhibit 2). Each e-bus can provide cost savings of INR69 lakhs (USD91,000) over 10 years, resulting in cost savings of INR450 crores (USD60 million) for the fleet of 650 e-buses. In addition, cumulative operational cost savings are notably greater than the government incentives.

Exhibit 2. Total cost of ownership of 12-metre AC e-buses compared with CNG and diesel buses.



- **The gross cost contract procurement model can accelerate e-bus adoption in cities.** Under the gross cost contract (GCC) or operational expenditure (OPEX) procurement model, a public transport agency pays a private bus operator a per-km rate for a bus service on specific routes. The service typically includes buses, drivers, infrastructure, fueling, and maintenance. This innovative procurement model is promoted by the Government of India to mitigate the technological, financial, and operational risks faced by public transport agencies with regard to e-bus adoption. Pune and several other Indian cities have smoothly integrated e-buses into their fleet using this model, and other countries may also benefit from it.
- **Prior experience with the GCC model can ensure smooth tendering and contracting.** PMPML and CIRT had prior experience procuring compressed natural gas buses on a GCC model, allowing them to leverage components of previous tendering and contracting templates, including request for proposals (RFPs) and service-level agreement documents. This helped them easily structure unique GCC terms such as bank guarantees, escrow accounts, and penalties.
- **Current e-bus and charging infrastructure technology can meet performance requirements.** The e-buses operating in PMPML's fleet meet specified duty cycles, with the operator, BYD-Olectra, regularly completing the contracted 200–225 km per day. The buses charge overnight on 80 kW charging stations and are supported by daytime opportunity charging. There have been no reported service, maintenance, or infrastructure issues to date.
- **Proactive planning for large loads can ensure efficient commissioning and safe operations.** E-bus fleets can require several megawatts of service capacity at a single interconnection point due to concentration of high-power charging stations at one depot. PMC, PCMC, and PMPML worked closely with the local distribution utility, MSEDCL, and the operator, BYD-Olectra, to plan for the connection of charging stations and e-bus charging, making the requisite grid upgrades, especially the installation of high-tension (HT) distribution lines. They also identified potential for peak load reduction and operational cost savings through night time charging, which represents a 50% lower electricity tariff.
- **E-buses can reduce local air pollution and carbon dioxide emissions significantly.** Adoption of e-buses has the potential to reduce fine particulate matter (PM_{2.5}) and carbon dioxide (CO₂) emissions in Pune. The fleet of 650 e-buses can avoid 1.2 tons of PM_{2.5} and 96,000 tons of CO₂ emissions over the lifetime of the vehicles compared with an equal-sized fleet of diesel buses—equivalent to the lifetime CO₂ emissions of nearly 2,000 petrol-fueled cars.
- **E-buses have been well received by urban local bodies, operators, and the public.** Stakeholders across the city have recognised the benefits of e-buses. Drivers and riders report quieter, more comfortable conditions, and government officials are grateful to expand the size of the city's public transport fleet with a high-quality, low-emission service for citizens.
- **PMPML is on track to meet the Government of Maharashtra's public transport electrification target three years ahead of schedule.** One of the objectives of the Maharashtra State EV Policy 2021 is to achieve 25% electrification of Pune's public transport bus fleet by 2025. With the current fleet of 220 e-buses, the share of e-buses in PMPML's fleet stands at about 10% as of March 2022. With the scheduled commissioning of 430 more e-buses later this year, this share will increase to exactly 25%—meeting the target three years early.

The city of Pune will continue to work toward integrating more e-buses into PMPML's fleet. Through this case study, PMC, PMPML, and PSCDCL aim to inspire and inform the efforts of other cities in India and the Global South to successfully incorporate e-buses in their own public transport fleets.

Testimonials

E-buses offer many value propositions to cities: they are more efficient, more reliable, cleaner, quieter, and increasingly cost competitive. Stakeholders across Pune recognise e-buses as a critical solution to address issues related to air quality and congestion. PMPML provides commuters an air-conditioned, efficient mode of transport while ensuring drivers and riders enjoy the service.

Pune Municipal Corporation (PMC) officials:

“Pune has been on the forefront to adopt initiatives to promote sustainable citizen-centric mobility. The successful operation of e-buses over the past year has been extremely encouraging for the city, as it has provided a clean means of transportation for the masses. PMC, PSCDCL, and PMPML will continue to collaborate with civil-society organisations, academic institutions, and experts to continuously identify and adopt measures toward ensuring citizen-friendly mobility.”

—**Mr. Vikram Kumar**, Municipal Commissioner, PMC

“The overwhelmingly positive response that we have received from citizens about their experience travelling on these e-buses has been extremely heartening. Pune has been regarded as a pioneer of sustainable mobility in the country, and soon we will be known for operating the largest fleet of e-buses in India.”

—**Dr. Kunal Khemnar**, Additional Municipal Commissioner (Estate), PMC

Pimpri-Chinchwad Municipal Corporation (PCMC) officials:

“The e-buses are a step forward in the city’s aspiration to promote the adoption of electric mobility, and the buses have been extremely popular among the citizens. In addition to providing a comfortable journey, these buses have experienced minimal breakdowns, which was a usual sight with the diesel-based buses. We firmly believe the adoption of e-buses for public transport fleet will help the city in faster adoption of e-vehicles by ensuring safe, reliable, accessible, and affordable charging infrastructure.”

—**Mr. Rajesh Patil**, Municipal Commissioner, PCMC

Pune Smart City Development Corporation Limited (PSCDCL) official:

“Pune Smart City’s focus is on sustainable and inclusive development. The aim is to evaluate compact areas and create a replicable model that guides and inspires the entire city and even other cities across India. With this aim, PSCDCL has established a sustainable transport network for the city and reduced the pollution levels in the city with the e-bus project. Soon, Pune will be regarded as the pioneer of sustainable mobility in the country.”

—**Dr. Sanjay Kolte**, CEO, PSCDCL

Pune Mahanagar Parivahan Mahamandal Limited (PMPML) official:

“We are committed to continuing to grow PMPML’s bus fleet to meet the needs of Pune’s urban agglomeration. Adding e-buses to the fleet is a win-win solution because we can expand the size of our fleet without tailpipe emissions.”

—**Mr. Laxminarayan Mishra**, Chairman and Managing Director, PMPML

BYD-Olectra:

“Our team would like to thank PMC and PMPML for their constant support to Olectra and their commitment to e-bus adoption. The experience of launching this service in Pune has been rewarding and full of valuable lessons. Successful deployment in Pune will set the path for others in India to embark on their own journeys of adopting e-buses for public transportation fleet.”

—**Mr. Chandan Gupta**, General Manager – Corporate Affairs, Olectra Greentech Limited

Driver:

“I have been driving PMPML buses for years. The switch to an e-bus has been a wonderful experience for me. It is cooler in the summer because there is no heat from the radiator; it is smoother and quicker to accelerate and brake; and it is practically noiseless. Overall, it is easier to drive and makes me feel great about my job’s contribution to the city.”

—**Mr. Sunil Waghmare**, a PMPML bus driver operating e-buses since the last two years

Citizen and passenger:

“The older (diesel- or CNG-based) buses were noisy and dusty and I would often feel nauseous in them. The electric buses are pollution-free, air-conditioned, and much smoother.”²

—**Ms. Kirti Chaudhary**, a 30-year-old Bhekrai Nagar local who travels by bus daily



1. Introduction: City Background and Motivation

1.1. Pune

Pune recently became the city with the largest geographical area in Maharashtra after the Government of Maharashtra issued an order to include 23 new villages in PMC. PMC has a geographical area of 516 square kilometres and a population of 37 lakhs (3.7 million).³ Ranked as the country's most livable city in India's 2018 Ease of Living Index and known as the "Oxford of the East," Pune is recognised for its governance, educational institutions, safety, industry, and culture.⁴

However, the city is rapidly growing in terms of population and vehicle stock. Between 2011 and 2020, the total number of vehicles registered in Pune increased from 1.9 million to 4.1 million. Each year, Pune's transport sector emits an estimated 1.1 million metric tons of CO₂—about one-fifth of the city's annual greenhouse gas emissions.⁵ Vehicular emissions contribute to about 25% of the city's particulate matter (PM) emissions, which, on average, exceed international guidelines.⁶

1.2. Pimpri-Chinchwad

Pimpri-Chinchwad is Pune's twin city and an industrial township known as the "Detroit of the East" due to the presence of several automotive original equipment manufacturers (OEMs). The Pimpri-Chinchwad Municipal Corporation (PCMC) is the civic body that governs the Pimpri-Chinchwad township. The establishment of large-scale core industries has led to the growth of ancillary and small-scale industries in and around this industrial belt.

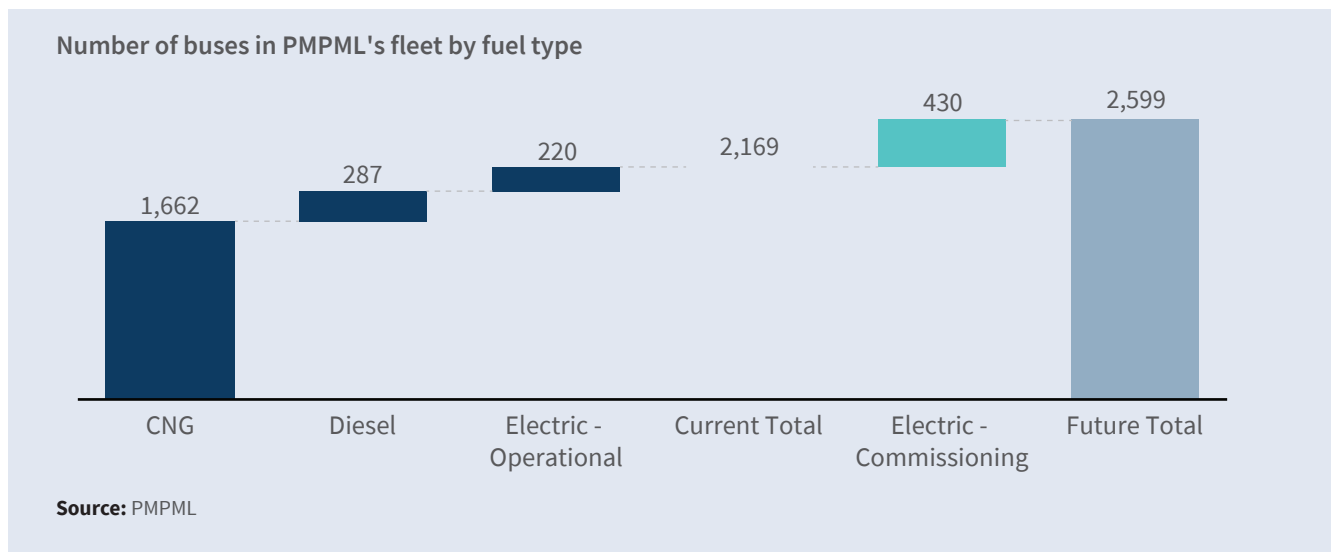
1.3. Pune Mahanagar Parivahan Mahamandal Limited

PMPML is the public transport bus service provider in the Pune Metropolitan Region (PMR). PMPML was formed on 19 October 2007 when two bus service providers, Pune Municipal Transport (PMT) and Pimpri-Chinchwad Municipal Transport (PCMT), merged into a single entity. PMPML is jointly owned by PMC and PCMC in a 60:40 split. An independent Board of Directors (BOD) governs PMPML; it counts Chairman and Managing Director as the head and leaders of the PMC, PCMC, and others as members.

Currently, PMPML's fleet comprises 2,169 buses, including diesel and compressed natural gas (CNG) buses and electric buses (e-buses) (see Exhibit 3). The buses operate on over 350 routes in PMR and cater to approximately 12 lakh (1.2 million) passengers per day.⁷

Exhibit 3.

PMPML fleet composition by fuel type. Future total does not account for retirements or additional procurement.



1.4. Existing clean mobility initiatives

To address vehicular emissions, Pune's civic administration has implemented many sustainable transport initiatives, including the following:

- **Conversion of autorickshaw fleet to CNG:** In 2009, Pune mandated the conversion of existing autorickshaws from diesel to CNG by providing fiscal incentives for up to 50% of the cost of retrofitting a vehicle. The PMC has provided more than INR20.1 crores (USD2.7 million) in fiscal incentives for CNG conversion kits.
- **Development of nonmotorised transport infrastructure:** Pune is a pioneer in the design and development of pedestrian and cycling infrastructure. The city administration established Urban Street Design Guidelines (USDGs) to guide the development of a street system that accommodates demand growth; integrates motorised and nonmotorised transport options; and promotes accessible, safe, and pedestrian-friendly streets.⁸
- **Adoption of low-emissions public transport:** PMPML currently operates 1,662 CNG buses in its fleet and has made a commitment to not procure more diesel buses. Future procurements will be either CNG or electric.
- **Electrification of government fleet:** The Maharashtra State Electric Vehicle (EV) Policy 2021 outlines all new vehicles leased for government use must be electric starting 1 April 2022. Pune is an early adopter, with the PMC recently approving a proposal to hire 38 electric cars for day-to-day transportation of its officials for eight years.
- **Other important initiatives:** The city administration adopted a comprehensive bicycle plan to create an extensive network of cycling paths and drafted a progressive parking policy to discourage private modes of transportation and encourage public transport use.⁹

1.5. Motivating factors behind Pune's electric bus procurement

To complement existing clean mobility initiatives, the city administration and PMPML explored the potential to introduce e-buses to PMPML's fleet in 2018. The various motivational factors for Pune's interest in e-buses include the following:

1.5.a. Alignment with city, state, and national objectives

Pune is a recognised leader in sustainable mobility and has an ambitious set of goals for public transport established at the city, state, and national levels. At the city level, Pune's Comprehensive Mobility Plan (CMP) has set a goal to fulfill 90% of passenger trips through nonmotorised and public transport by 2031.¹⁰ At the state level, the Government of Maharashtra's EV Policy 2021 has set a target to electrify 25% of the public transport bus fleet in Pune's urban agglomeration by 2025.¹¹ At the national level, the Ministry of Housing and Urban Affairs (MoHUA) has published service-level benchmarks for urban transport, indicating cities with populations of 4 million or more should have a service level of 400–600 buses per 1 million citizens—suggesting that Pune should increase its public transport bus fleet by over 1,500 buses. PMPML recently announced its target to commission 950 new buses on various routes in the city, and e-buses can help meet this goal.¹²

1.5.b. Local and national electric vehicle subsidies

Despite their many benefits, e-buses can be up to three to four times the upfront cost of comparable diesel or CNG buses. Government fiscal incentives can help make e-buses more cost competitive with other fuel types. In Pune, PSCDCL, PMC, and PCMC allocated fiscal incentives of INR50 lakhs (USD66,000) per bus for the procurement of 500 e-buses. At the national level, the Department of Heavy Industry (DHI) is allocating demand incentives of up to INR55 lakhs (USD72,000) per bus under FAME II (subject to criteria that the state transport undertaking (STU) must follow).¹³

1.5.c. Improved local air quality and reduced vehicular emissions

E-buses can improve local air quality and reduce vehicular emissions because they emit zero tailpipe emissions and lesser CO₂ emissions than internal combustion engine (ICE) vehicles.¹⁴ Under the National Clean Air Programme (NCAP), Pune and 132 other cities have been mandated to reduce PM_{2.5} and PM₁₀ by 20–30% by 2024.¹⁵ To achieve these targets, Pune launched the Clean Air Project India (CAP India) and focuses on sustainable mobility initiatives to mitigate air pollution.¹⁶



2. Key Stakeholders and Procurement Planning

In 2018, the BOD of PMPML, in partnership with PSCDCL, passed a resolution to procure 500 e-buses by 2019–20 in two phases. Subsequently, PSCDCL allocated INR125 crores (USD16.5 million) to support the procurement. In addition, PMR was allocated 150 e-buses under FAME II. To drive planning and procurement, Pune's urban local bodies (ULBs) created a working group.

2.1. Stakeholders, roles, and responsibilities

PMPML facilitated several working group meetings between July 2018 and September 2018 to discuss and align on bus specifications, potential depots, expected average daily run, and other key parameters. PMC, PCMC, and PSCDCL worked in partnership with PMPML. Central Institute of Road Transport (CIRT) and Ernst and Young (EY) provided technical support to the working group, and Maharashtra State Electricity Distribution Company Limited (MSEDCL) participated and provided technical inputs. Coordination and clear understanding of responsibilities among the ULBs and agencies involved has been key to Pune's successful e-bus procurement and operations. Exhibit 4 summarises the respective roles and responsibilities of the agencies involved.



Exhibit 4.

Description of roles and responsibilities of various stakeholders involved in the Pune e-bus procurement process.

Organisation	Role	Responsibilities
Pune Municipal Corporation (PMC)	<ul style="list-style-type: none"> PMC funds PMPML for city bus operations and owns land for depots and public transport infrastructure. PMC provides viability gap funding of 60% for the procurement and operational costs of PMPML. 	<ul style="list-style-type: none"> PMC allocated a dedicated e-bus depot at Bhekrai Nagar. PMC was the nodal agency to coordinate with Maharashtra State Electricity Distribution Company Limited (MSEDCL) on the requisite upstream electricity infrastructure. PMC has committed to construct a mega-charging station for e-buses at Manjri depot.
Pimpri Chinchwad Municipal Corporation (PCMC)	<ul style="list-style-type: none"> PCMC funds PMPML for city bus operations and owns land for depots and public transport infrastructure. PCMC provides viability gap funding of 40% for the procurement and operational costs of PMPML. 	<ul style="list-style-type: none"> PCMC allocated a dedicated depot at Nigdi for operation of e-buses. PCMC was the nodal agency to coordinate with MSEDCL to provide the requisite upstream electricity infrastructure at Nigdi depot.
Pune Smart City Development Corporation Limited (PSCDCL)	<ul style="list-style-type: none"> PSCDCL coordinates with the Smart City Mission and conducts innovative projects throughout the city. 	<ul style="list-style-type: none"> PSCDCL identified and allocated a Smart City funding pool of INR125 crores (USD16.5 million) for e-bus procurement. PSCDCL earmarked INR70 crores (USD9.2 million) for charging infrastructure and grid infrastructure upgrades. PSCDCL funded 75 12-metre e-buses in PMPML's first tender.
Pune Mahanagar Parivahan Mahamandal Limited (PMPML)	<ul style="list-style-type: none"> PMPML is responsible for the planning, procurement, and operation of buses. PMPML handles route planning and scheduling, fare collection, and more. PMPML provides basic civil infrastructure at depots. 	<ul style="list-style-type: none"> PMPML ran the procurement process for 650 buses and supported commissioning. PMPML handles scheduling, monitoring daily kms, and fare collection of e-buses on an ongoing basis. PMPML also bears the electricity cost for charging e-buses (subject to limits on energy consumption).
Maharashtra State Electricity Distribution Company Limited (MSEDCL)	<ul style="list-style-type: none"> MSEDCL manages upstream electrical distribution infrastructure. 	<ul style="list-style-type: none"> MSEDCL was responsible for installing 11 kilovolt (kV) high-tension (HT) cables at the two selected depots of Nigdi and Bhekrai Nagar.
Central Institute of Road Transport (CIRT)	<ul style="list-style-type: none"> CIRT serves as a technical advisor to PMPML and provides input on technical specifications and testing services to support e-bus procurement. 	<ul style="list-style-type: none"> CIRT led the development of RFP and other bid documents. A CIRT team accompanied city officials on a site visit of the winning bidder's manufacturing facility to assess quality standard and delivery timeline. CIRT conducted crash tests on prototypes and fully built buses and supported safety homologation. CIRT supported bid evaluation and conducted trials to analyse performance in real-world driving conditions and on a hill/<i>ghat</i> run.

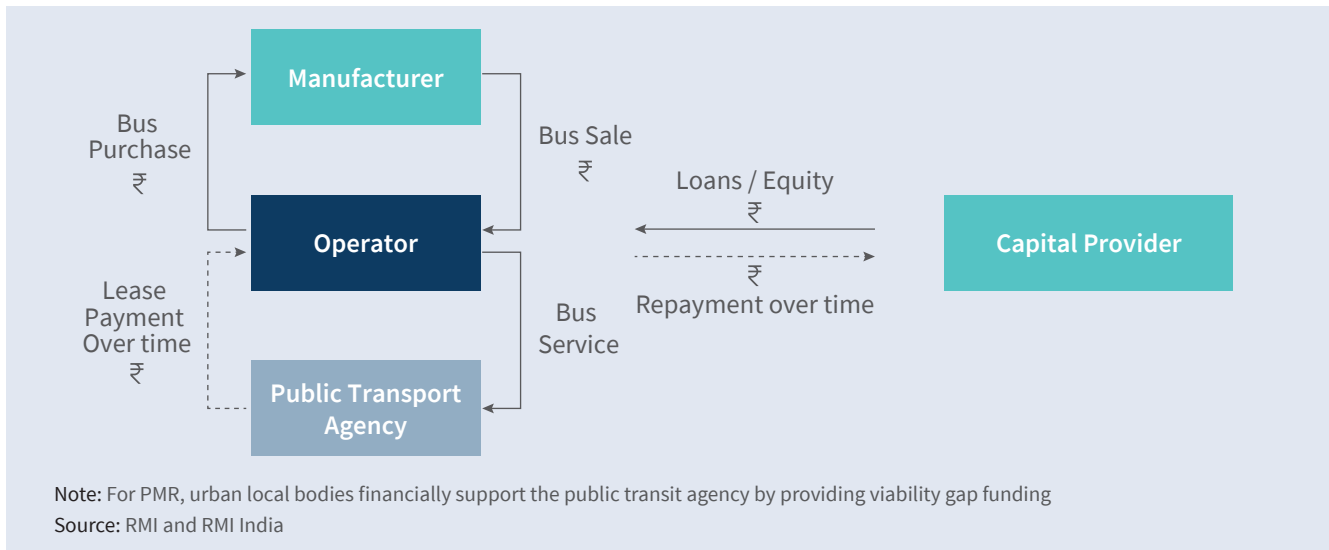
Source: PMC, PMPML, PSCDCL, and CIRT; RMI and RMI India analysis

2.2. Procurement model

PMPML decided to procure, operate, and maintain e-buses on a gross cost contract (GCC) or operational expenditure (OPEX) model. The GCC or OPEX model is an innovative public-private partnership contract structure for public transport services wherein a transit authority pays a private bus operator on per-km basis for city bus services on specific routes. In this case, PMPML pays a per-km fee; sets service standards; and handles scheduling, route planning, and fare collection. The operator procures the buses and infrastructure and operates and maintains the buses as a service, including the provision of drivers and crew. This model reduces capital and technology risk for STUs. However, STUs must monitor key performance indicators to ensure that the operator meets their requirements.¹⁷ See Exhibit 5 for a schematic of the structure of parties and capital flow in a standard GCC model.

Exhibit 5.

Illustrative example of structure of parties and capital flow in a GCC or OPEX contract for city bus services.



2.3. Procurement timeline

Pune's e-bus procurement was conducted in two phases. First, PMPML issued two tenders in September and December 2018 for 150 e-buses—25 units of 9-metre AC e-buses and 125 units of 12-metre AC e-buses, respectively. Second, PMPML issued two more tenders for 350 and 150 units of 12-metre AC e-buses in July 2019 and September 2020, respectively.

The first 25 e-buses have been operational since February 2019 and the other 125 e-buses from the first phase of tendering have been operational since August 2019. In March 2022, 70 more e-buses entered operations. The remaining 430 e-buses are scheduled for delivery by August 2022. Exhibit 6 summarises the timeline of each tender and its key milestones.

Exhibit 6.

Timeline of three tenders and their key milestones.

	Number of units	Type of buses	Request for proposals	Prebid meeting	Bid submission	Letter of award	Final bid price	Selected operator	Full operations
Phase 1a	25	9-metre AC Non-BRT-compliant	18 September 2018	25 September 2018	26 October 2018	6 December 2018	INR40.32/km (USD0.85/mi)	BYD-Olectra	February 2019 25 buses
Phase 1b	125	12-metre AC BRT-compliant	21 December 2018	3 January 2019	5 January 2019	8 March 2019	INR58.50/km (USD1.23/mi)	BYD-Olectra	August 2019
Phase 2a	350	12-metre AC BRT-compliant	25 July 2019	31 July 2019	13 October 2019	28 January 2021	INR67.40/km (USD1.42/mi)	BYD-Olectra	August 2022 (expected)
Phase 2b	150	12-metre AC BRT-compliant	10 September 2020	23 September 2020	27 October 2020	29 December 2020	INR63.95/km (USD1.36/mi)	BYD-Olectra	August 2022 (expected)

Source: PMPML

3. Tender and Service Level Agreement Details

3.1. Summary of key terms from request for proposals

PMPML floated four RFPs and four letters of award (LOA) were signed. Terms in GCC tenders such as the number and specifications of buses, contract period, average daily run, and who bears the costs of electricity for charging and grid infrastructure upgrades play a significant role in determining the bid price. Bank guarantees and payment terms are the other important factors.

Across tenders, buses that are a mix of 9- and 12-metres, compliant and noncompliant with PMPML’s bus rapid transit (BRT) system, and air-conditioned are included. Minimum assured run ranges from 200–225 km per day. According to the service requirements, the buses for the first three tenders must operate for 125 km on a single charge, and the remaining 100 km can be completed with opportunity charging; the buses for the fourth tender must operate for 225 km on a single charge without opportunity charging. Although PMPML is financially responsible for electricity charges, the operator must ensure the energy consumption of the buses does not exceed 1.4 kWh/km. Exhibit 7 provides a compendium of key terms in the RFP documents.

Exhibit 7. Table summarising key terms in the RFP documents.

Section	Sub-Section	Phases 1a and 1b	Phase 2a	Phase 2b (FAME II)
Contract details	Contract type	GCC	GCC	GCC
	Number of buses and their specifications	150 AC buses: 25 × 9m non-BRT-compliant 125 × 12m BRT-compliant	350 × 12m AC BRT-compliant	150 × 12m AC BRT-compliant
	Contract period	10 years Potential 2-year extension	10 years Potential 2-year extension	12 years
	Seating capacity	9 m bus: 31 + driver 12 m bus: 39 + wheelchair + driver		
	Total passenger capacity	9 m bus: 42 (peak loading) 12 m bus: 60 (peak loading)		
	Number of buses for each corporation	90 – PMC 60 – PCMC	210 – PMC 140 – PCMC	90 – PMC 60 – PCMC
	Daily minimum average guaranteed run per bus on a fleet basis	225 km/day/bus	200 km/day/bus	225 km/day/bus
	Dead km	PMPML shall not make any payment for dead km and shall pay 0.5 times of the base km rate for any under-utilised km or over-utilised km in relation to the daily assured km.		
	Depots for operation	Nigdi and Bhekrai Nagar	Baner, Wagholi, Charholi, and Pimple Saudagar	Pune Station and Wakad/Bhosari
	Performance security amount	INR18 crores (USD2.5 million)	INR42 crores (USD5.6 million)	INR7.8 crores (USD1.0 million)
	Earnest Money Deposit (EMD) bid security	9 m buses: INR25 lakhs (USD33,000) 12 m buses: INR2.5 crores (USD330,000)	INR7 crores (USD925,000)	INR2.5 crores (USD330,000)

Section	Sub-Section	Phases 1a and 1b	Phase 2a	Phase 2b (FAME II)	
Planning & Scope of operator	Charging infrastructure	The selected operator shall develop charging infrastructure including development, supply, and erection of transformers and all necessary electrical systems, sub-systems, accessories, and parts as required for charging infrastructure at the depots identified by PMPML.			
	Charging costs	Electricity charging cost will be borne by PMPML. Payment liability of PMPML shall be limited to consumption of ≤ 1.0 kWh/km for 9m and ≤ 1.4 kWh/km for 12m.	Electricity charging cost will be borne by PMPML. Payment liability of PMPML shall be limited to consumption ≤ 1.4 kWh/km for 12m.		
	Electricity charges paid by PMPML to MSEDCL	INR8–9/kWh (USD0.11–0.12/kWh) 50% discounted tariff during night-time charging			
	Capacity of chargers	80 kW fixed charger and 150 kW opportunity charger			
	Range conditions	Assured operation of 225 km per bus per day. The bus must operate 125 km on single charge. The remaining operation of 100 km must be completed with opportunity charging.	Assured operation of 200 km per bus per day. The bus must operate 125 km on single charge. The remaining operation must be completed with opportunity charging.	225 km in single charge without opportunity charging; if operator wants to use opportunity charging of 30 minutes, it is 160 km.	
	Fleet availability	The number of contracted buses must be always available for operations.			
	Delivery schedule of registered buses	9m buses <ul style="list-style-type: none"> 100% within 50 days from date of LOA 12m buses <ul style="list-style-type: none"> First lot of 70 buses within 120 days from date of LOA Remaining 55 buses within 150 days from date of LOA 	<ul style="list-style-type: none"> First lot of 75 buses within 120 days from date of LOA Second lot of 75 buses within 150 days from date of LOA First lot of 100 buses within 180 days from date of LOA Second lot of 100 buses within 210 days from date of LOA 	<ul style="list-style-type: none"> First lot of 75 buses within 270 days from date of LOA Remaining 75 buses within 365 days 	

Source: PMC, PMPML, and PSCDCL; RMI and RMI India analysis

3.2. Summary of key terms from service level agreements

PMPML signed service level agreements (SLAs) with the selected service provider, BYD-Olectra, for all tenders to ensure efficient commissioning and smooth operations by delineating each party's obligations. The first three tenders were supported by fiscal incentives of INR50 lakhs (USD68 million) per bus from PSCDCL. DHI provides fiscal incentives for the last tender under FAME II of up to INR55 lakhs (USD75,000) per bus. Exhibit 8 presents a compendium of key terms in the SLAs.



Exhibit 8. Table summarising key terms in SLAs.

Section	Sub-Section	Phases 1a and 1b	Phase 2a	Phase 2b (FAME II)
Incentives	Authorities releasing incentives	PMC, PCMC, and PSCDCL	PMC, PCMC, and PSCDCL	DHI
	Incentive per bus	INR50 lakhs (USD66,000)	INR50 lakhs (USD66,000)	40% of estimated capital cost, subject to a maximum incentive 55 lakhs (USD73,000)
	Incentive transfer schedule	100% on delivery of buses in minimum lot of 10 buses against bank guarantee of equal amount	100% will be made 30 days prior to the commencement of delivery of buses in minimum lot of 25 buses	<ul style="list-style-type: none"> • 20% after the issue of supply order and signing of the SLA • 40% after delivery of all buses • 40% after six months of successful commercial operation of all buses
Scope of PMPML	Power supply	PMPML will make 22 kVA power supply line available at designated depots.		
	Rate paid to the operator (without electricity)	9m: INR40.32/km (USD0.85/mi) 12m: INR58.50/km (USD1.23/mi) ⁱ	INR67.40/km (USD1.42/mi)	INR63.95/km (USD1.36/mi)
	Depots and land availability	Land for charging, parking, and bus maintenance spaces provided at Nigdi and Bhekrai Nagar depots.	Land for charging, parking, and bus maintenance spaces provided at Baner, Wagholi, Charholi, and Pimple Saudagar depots.	Land for charging, parking, and bus maintenance spaces provided at Pune station and Wakad/Bhosari depots.
	Bus routes	Provide routes to be undertaken by operator and formulate operational plan to ensure that distance travelled by contracted fleet matches the daily minimum average guaranteed run established in the RFP.		
Scope of Operator	Buses	Buses supplied by the operator shall conform to all Central Motor Vehicle Rules (CMVR) technical specifications and requirements as notified by DHI, Government of Maharashtra, and other authorities.		
	Charging cost	Charges for additional energy consumption above predetermined limits shall be borne by the operator.		
	Depots	Cost and responsibilities of depot construction, operations, and maintenance are borne by the operator. City administration is responsible for allocating land at designated depots.		
	Bank guarantee	The operator shall agree to submit a bank guarantee of an amount equal to the subsidy transferred to the operator.		

Source: PMC, PMPML, and PSCDCL; RMI and RMI India analysis

Exhibit 9 highlights the specifications of the e-buses currently operating in PMPML's contracted fleet. For operational e-buses, PMC and PCMC provided the operator, BYD-Olectra, land and space for parking and charging infrastructure at the identified depots to ensure easy operation and maintenance for the operator. The e-buses are suitable for 18–20 hours of daily operation, with peak loading of 42 passengers and 60 passengers for 9- and 12-metre buses, respectively. The e-buses typically charge in about four hours with 80 kW AC charging stations.

ⁱ 1% escalation in the base km rate shall be provided from the third year of the contract

Exhibit 9. Specifications of current e-bus models operating in PMPML fleet.

Feature	Specifications	
	9-metre eBUZZ K7 (Non-BRT-compliant)	12-metre eBUZZ K9 (BRT-compliant)
Length (excluding bumper)	8.9 m	12.0m ± 0.4 m
Width	2.6 m	2.6 m
Height (unladen)	3.8 m	3.8 m
Floor height above ground	0.9 m maximum	0.9 m (-0.01m) maximum
Seats	31 + driver	39 + driver + wheelchair
Peak load	42 (sitting + standing)	60 (sitting + standing)
Battery capacity	200 kWh	380 kWh
Estimated range	180 km	250 km
Cycle life	7 years or 7 lakh km (whichever is later)	10 years or 10 lakh km (whichever is later)

Source: PMPML and CIRT



4. Enablers and Challenges

Pune’s experience in e-bus procurement and operation offers valuable insights and points of reference on the forms of interagency coordination, policy support, business model design, tendering and contracting terms, and infrastructure planning, which can enable e-bus adoption in Indian cities. Exhibit 10 and the following section summarise select enablers of Pune’s success and challenges faced.

4.1. Summary of select enablers and challenges

Exhibit 10. Summary of select enablers and challenges from PMPML’s e-bus procurements.

	Enablers	Challenges
Planning, contracting, and financing	<ul style="list-style-type: none"> • Political leadership • Interdepartmental coordination • Selection of GCC procurement model and prior experience • Availability of local and national fiscal incentives • Prioritisation of safety 	<ul style="list-style-type: none"> • Limited domestic production capacity and early-stage model availability • Structure of bank guarantees
Commissioning, operations, and maintenance	<ul style="list-style-type: none"> • Comprehensive depot and route selection • Trial runs and scheduling analysis • Driver training • Proactive planning for grid upgrades • Fleet management proficiency 	<ul style="list-style-type: none"> • Management of passenger loading and energy consumption • Further refinements to depot and route selection • Technology improvements for fleet management

Source: PMC, PMPML, PSCDCL, and CIRT; RMI and RMI India analysis

4.2. Enablers

4.2.1. Planning, contracting, and financing

- **Political leadership:** ULBs in Pune have consistently been early adopters of new technology. The PMC, PCMC, PMPML, and PSCDCL leadership were keen to adopt e-buses and provided the political will to do so. They created a working group, formulated a structured plan, identified funding sources, and monitored and ensured progress. The Government of Maharashtra also provided momentum to the city administration through the Maharashtra State EV Policy 2021.

- **Interdepartmental coordination:** The civic administration developed a working group to prepare for e-bus procurement in Pune and held regular meetings to discuss progress and consultations to seek input. In addition, urban local bodies—including PMC, PCMC, PMPML, and PSCDCL—outlined clear responsibilities for themselves, consultants, and collaborators, thus ensuring coordination across the parties involved.
- **Selection of GCC procurement model and prior experience:** During various meetings organised by PMPML, CIRT, and EY, PMPML recognised the GCC procurement model could help it adopt e-buses with minimal financial implication and technology risk. PMPML had prior experience working with CIRT to procure CNG buses using the GCC model, allowing it to leverage components of previous document templates, including RFPs and SLAs. It also helped them anticipate how to structure unique contract terms such as bank guarantees, monthly payments, and penalties.
- **Availability of local and national fiscal incentives:** The e-buses received fiscal incentives of INR50 lakhs (USD66,000) per vehicle through PSCDCL, totaling INR125 crores (USD16.5 million) for 500 e-buses. The remaining 150 e-buses will receive incentives of up to INR55 lakhs (USD73,000) through the FAME II scheme.
- **Prioritisation of safety:** Through extensive coordination with CIRT, PMPML ensured the buses are extremely comfortable and safe for passengers. PMPML is the pioneer of monocoque low-floor constructed buses, which are expected to comfortably withstand the stress of daily urban transport and require less maintenance due to an onboard Vehicle Health Monitoring System (VHMS). The batteries and electric powertrain of the e-buses are fireproof and installed with an automatic fire extinguisher in the battery pack.

4.2.2. Commissioning, operations, and maintenance

- **Comprehensive depot and route selection:** Prior to commencing e-bus operations, PMPML, with support from CIRT and EY, identified depots and routes most suitable for electrification based on various factors. It conducted a detailed feasibility analysis for the shortlisted depots to ensure availability of space for parking, charging infrastructure, and maintenance. The city administration's provision of land made it possible to deploy the e-buses without disrupting existing operations.
- **Trial runs and scheduling analysis:** CIRT also performed detailed vehicle homologation, developed a city-specific drive cycle for testing, and conducted several weeks of trial runs to identify possible challenges in operations. In addition, PMPML, Traffic Police (Pune), and CIRT worked together to plan the scheduling for the e-buses to ensure they could operate at the required frequency, even during peak congestion.
- **Proactive planning for grid upgrades:** ULBs proactively coordinated with MSEDCL to work on electric grid augmentation, including installation of high-tension (HT) distribution lines at the Bhekrai Nagar and Nigdi depots. This allowed for efficient commissioning.
- **Driver training:** Since vehicle efficiency depends on driving pattern, especially acceleration, throttle power, and braking, BYD-Olectra thoroughly trained drivers to ensure smooth operations. The cautious handling of the e-buses also ensured zero breakdowns.
- **Fleet management proficiency:** BYD-Olectra's fleet management is reportedly excellent. There has not been a single breakdown incident where a bus stopped due to lack of range or voltage or issues with the performance of charging stations since commencing operations in January 2019.

4.3. Challenges

4.3.1. Planning, contracting, and financing

- **Limited domestic production capacity and early-stage model availability:** Given the early stage of e-bus adoption in India, production capacity is currently low, posing challenges related to high-volume supply orders and timely delivery. Considering the high dependence of OEMs on foreign components and powertrains, flexibility in model choice and delivery timelines can support early adoption. Over time, as e-bus production volume and model availability increase, bidding is likely to become more competitive, prices will decrease, more customisation will be possible, and delivery timelines will improve.
- **Structure of bank guarantees:** There is scope for improving how the STU and operator structure bank guarantees (also known as securities). In particular, the duration of the performance bank guarantee duration can be lowered to reduce the cost of financing. In addition, the tenure of the bank guarantee related to government incentives can be reduced considering the amortisation of the capital value of the e-buses.¹⁸

4.3.2. Commissioning, operations, and maintenance

- **Management of passenger loading and energy consumption:** The energy efficiency (in kWh/km) has been lower than expected due to high passenger loading. While these buses have seating capacity of 40 passengers and total payload capacity of 70 passengers, the number of passengers can reach 85–90 during peak hours of service. This increases energy consumption and electricity cost.
- **Further refined depot and route selection:** Although the depots and routes for e-bus operations were identified before operations commenced, the existing routes offered to the e-bus operator are similar to those for CNG buses. The depot and route selection criteria for e-buses can be further refined, considering the range of the e-buses and their sensitivity to city topography and traffic conditions.
- **Technology advancements for fleet management:** STUs across India have yet to adopt intelligent transport management systems (ITMS) for efficient fleet optimisation and regular data-driven route planning and utilisation. ITMS can help make the planning and scheduling of e-buses for STUs more efficient in the future.

By sharing these enablers and challenges, the civic administration of Pune aims to inspire and inform the efforts of other cities in India and the Global South to successfully incorporate e-buses in their public transport fleet. STUs in India and public transport agencies in other countries are welcome to reach out for more information.

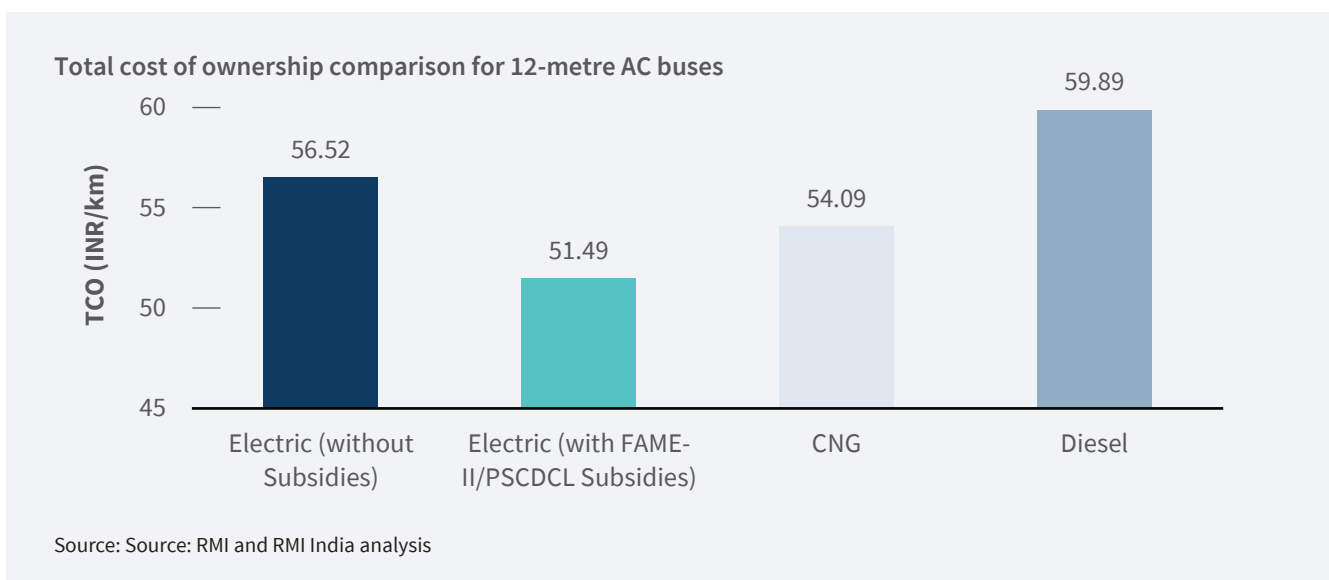


5. Economic and Environmental Benefits

5.1. Total cost of ownership analysis

The TCO of any mode of transport is the price of a purchased vehicle or service plus all other costs related to owning and operating it.^{19,20} According to this analysis, the TCO of an e-bus with government incentives is INR51.49/km (USD1.09/mi)—about 6% and 15% lower than that of CNG and diesel buses, respectively. The results of the TCO analysis are summarised in Exhibit 11.

Exhibit 11. **Total cost of ownership of 12-metre AC e-buses compared with CNG and diesel buses.**



The analysis compares a CNG bus and a diesel bus with the e-bus model currently operating in Pune. All buses are 12 metres and air-conditioned. The equipment and installation costs of the e-bus’s share of an 80 kW AC charging station and a 150 kW opportunity charging station are included. Key assumptions are based on PMPML’s fleet and duty cycles and summarised in Exhibit 12.

Each e-bus can save INR69 lakhs (USD91,000) over its lifetime compared with a CNG or diesel variant, resulting in cost savings of INR450 crores (USD60 million) for the fleet of 650 e-buses. Despite the additional costs of charging infrastructure and battery replacement, operating e-buses is cheaper due to lower operating and maintenance costs.ⁱⁱ

ⁱⁱ Electricity is INR6/kWh (or INR6.79/km) and the current cost per litre of diesel in Maharashtra is INR94.72/litre (or INR19.25/km) and maintenance cost of conventional buses can be thrice that of e-buses.

Exhibit 12.

Key assumptions for total cost of ownership and benefit analysis of 12-metre buses in Pune.

Key assumptions

- Average life of the vehicle: 10 years
- Average daily kms: 225 km
- Battery lifecycles: 2,000
- Battery capacity: 320 kWh
- Incentive for e-bus: INR50 lakhs
- Road tax, registration, and other taxes are the same regardless of fuel type
- Staff requirement and other manhours are the same regardless of fuel type
- Nationally Determined Contributions (NDC) compliant electricity grid with 175 gigawatts of renewable power capacity by 2022
- CO₂ emissions calculations are for well-to-wheel for all fuel types
- PM_{2.5} emissions are from vehicle tailpipes only and based on BS-VI equivalent emissions factors

Source: PMPML; RMI and RMI India analysis



5.2. Air-quality and environmental benefit analysis

The transition to e-buses can also reduce PM_{2.5} and CO₂ emissions. According to this analysis, PMPML's fleet of 650 e-buses could result in net emissions savings of 1.2 tons of PM_{2.5} and 96,000 tons of CO₂ compared with an equal-sized fleet of diesel buses over the lifetime of the vehicles—equivalent to the lifetime CO₂ emissions of nearly 2,000 petrol-fueled cars.

6. Conclusion: Path Forward

6.1. Current next steps

The city of Pune and PMPML have established themselves as pioneers of e-bus adoption in the country. As of March 2022, the initial 150 e-buses have completed more than 2 crore km (12 million mi). Moving forward, Pune and PMPML will focus on commissioning the remaining 430 e-buses by August 2022.

6.2. Near-term next steps

The Ministry of Finance, Government of India, released funds to address the challenge of air pollution in 42 cities with a population more than 1 million. The funds are given based on the recommendations of the 15th Finance Commission and will be used under the National Clean Air Programme to improve air quality in these cities. The Pune urban agglomeration has been allocated a fund of INR504 crores (USD67 million) for 2020–26. About one-third of the fund will be used by PMC for public transport electrification and upstream electric infrastructure upgrades, including the following activities:

- **Procuring more e-buses:** PMC plans to procure an additional 300 7-metre e-buses using the GCC model. They will offer a fiscal incentive of INR35 lakhs (USD46,000) per bus. These e-buses will be used for feeder services to the growing metro network in the PMR. This procurement will likely take place in 2022.
- **Developing e-bus depots:** PMC will develop six e-bus depots for operations and maintenance, with the requisite charging infrastructure. PMC will spend INR5 crores (USD660,000) on each depot, all of which will be EV-ready by 2024.
- **Setting up charging infrastructure:** PMC plans to set up 500 charging stations at depots and bus stands of PMPML for public and PMPML's use. PMC will spend approximately INR40 crores (USD5.3 million) to develop these charging stations.

6.3. Path forward for Pune and beyond

By 2030, 4 of the 10 buses sold in India could be electric.²¹ To achieve this level of market penetration, e-bus sales must continue to increase. Fiscal incentives, demand assurance, and successful deployments such as those by PMPML are key elements to reduce cost, build industry confidence, and stimulate investment in manufacturing. Through this report and ongoing efforts, the civic administration of Pune aims to inspire and inform bus electrification efforts in other Indian cities and around the world.

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Pioneering Electric Buses in Pune

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