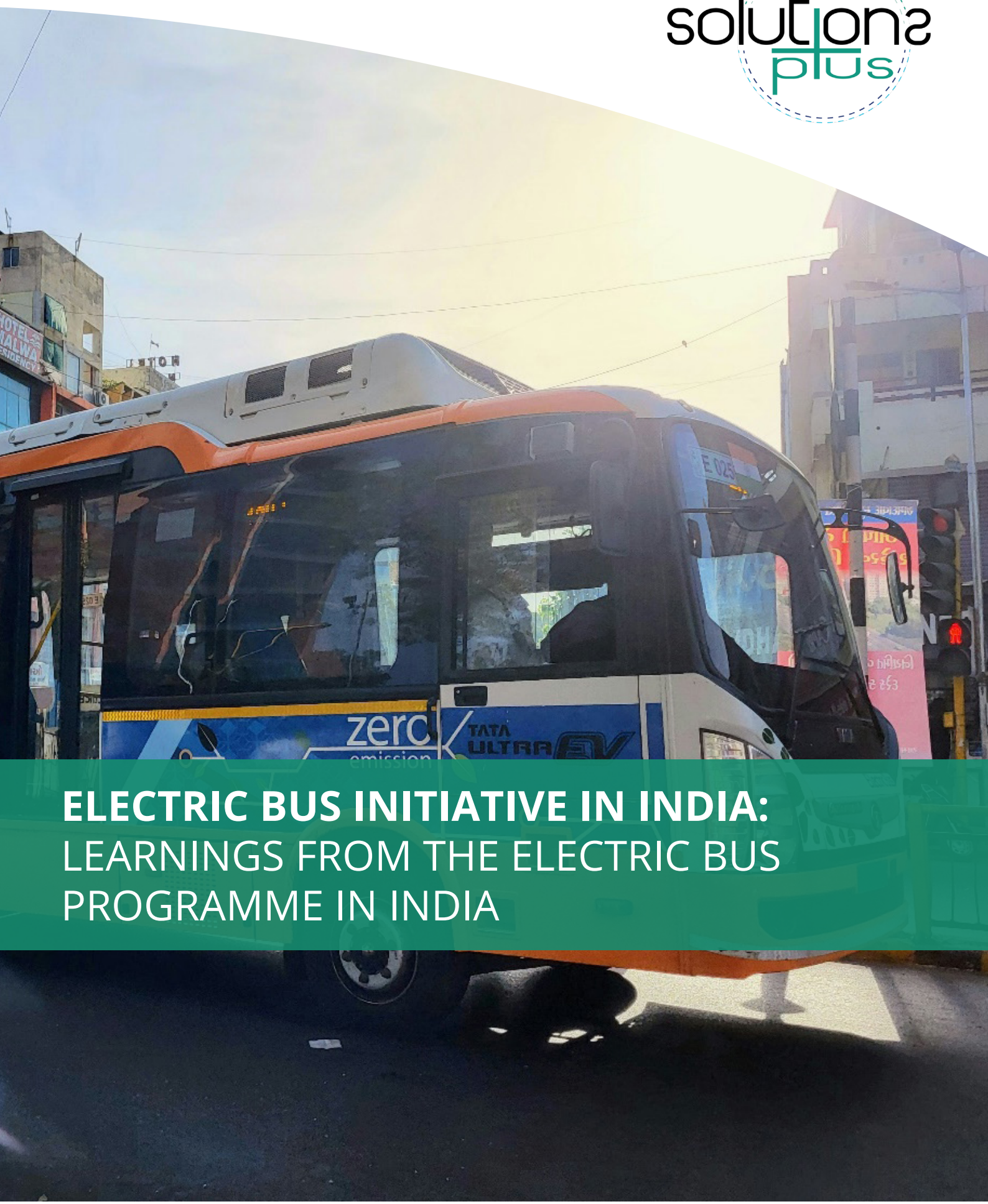

ELECTRIC BUS INITIATIVE IN INDIA:
LEARNINGS FROM THE ELECTRIC BUS PROGRAMME IN INDIA

This project has received funding from the European Union Horizon 2020 research and innovation Programme under grant agreement no. 875041

PROJECT PARTNERS

ABOUT

This document is issued under the SOLUTIONSplus project, which is funded by the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 875041

TITLE

Electric Bus Initiative in India:
Learnings from the electric bus programme in India

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June, 2024

Contents

Executive Summary 1

1 Introduction 3

1.1 Significance of Public Transport and Role of Buses 3

1.2 Global e-Bus Developments 3

2 e-Bus Policy Landscape in India 5

2.1 National mission on e-Mobility, Ambition, Enabling Policies, and Initiatives 5

2.2 State-Level Policies for e-Buses 7

2.3 Case Studies of e-Buses from Two Cities; Pune and Kolkata 10

3 Approach; Stakeholders' Perspectives- Challenges and Opportunities 11

3.1 Stakeholders Mapping for e-Buses in India 11

3.2 Stakeholders' Consultation Framework 12

3.3 Stakeholders' Perspectives on e-Bus Experiences and Barriers/ Challenges for Scaling Up 13

3.3.1 Government authorities' perspective 13

3.3.2 OEMs perspective 16

3.3.3 Private and public bus operators' perspective 19

3.3.4 Experts from other Institutions, including independent experts' perspective 21

3.3.5 End User Experiences and Impact of e-Mobility 24

4 Recommendations 25

References 27

Annexes 29

Annex 1: Questionnaire used for interview with stakeholders 29

Annex 2: Case study of electric buses in Pune 32

Annex 3: Case study of electric buses in Kolkata 35

Annex 4: Business models for e-Bus Operations 37

Annex 5: Electricity Prices for Charging 39

List of Tables

Table 1: E-Bus policies in states....8
Table 2: List of stakeholders interviewed....12

List Of Figures

Figure 1: An electric bus running on the Pune BRT corridor....32
Figure 2: Total cost of ownership comparison for 12-metre AC buses....33
Figure 3 : An Electric Bus operating in Kolkata....35
Figure 4: Outright Purchase Model....37
Figure 5: Gross Cost Contract Model....38
Figure 6: Electricity Prices for Charging in Different States....39

Abbreviations

BEVs	Battery Electric Vehicles
CERC	Central Electricity Regulatory Commission
CESL	Convergence Energy Services Limited
CNG	Compressed Natural Gas
EESL	Energy Efficiency Services Limited
e-Mobility	Electric Mobility
EV	Electric Vehicle
FAME	Faster Adoption and Manufacturing of Electric and Hybrid Vehicles
FCEVs	Fuel Cell Electric Vehicles
GCC	Gross Cost Contract
GoI	Government of India
MHI	Ministry of Heavy Industry
MoHUA	Ministry of Housing and Urban Affairs
NEBP	National Electric Bus Programme
OEMs	Original Equipment Manufacturers
OPEX	Operational Expenditure
OPM	Outright Purchase Model
PLI	Performance Linked Incentives
SPV	Special Purpose Vehicle
STU	State Transport Undertakings
TCO	Total Cost Of Ownership

Executive Summary

Introduction

Public transportation, particularly buses, stands as a linchpin in shaping sustainable urban landscapes, offering solutions to pervasive challenges like air pollution, traffic congestion, and social disparities. This section delves into the pivotal role of public transport and the evolving significance of buses in championing environmental sustainability, economic efficiency, social inclusion, and overall urban development.

The global electric vehicle (EV) market, with a spotlight on electric buses, has undergone remarkable growth, spearheaded by China. By 2016, China was incorporating 340 electric city buses daily, solidifying its position with over 80% global market share as of 2022. Europe, notably in countries like Finland, Norway, and Denmark, has witnessed substantial growth, while the United States and India are emerging markets, with India projected to contribute over 10% to global electric bus demand by 2025. This global trend aligns with ambitious goals for zero-emission buses in various regions.

e-Bus Initiative in India

Recognising the potential of electric mobility to mitigate urban pollution and bolster energy security, India initiated the National Electric Mobility Mission Plan 2020 in 2013 (BEE, 2020). The Faster Adoption and Manufacturing of Electric and Hybrid Vehicles (FAME) scheme, comprising FAME I and FAME II, aimed to bolster EV adoption and develop charging infrastructure (PIB, 2022). The National Mission on Transformative Mobility and Battery Storage, sanctioned in 2019, underscored strategies for transformative mobility and phased manufacturing programs for EVs, components, and batteries.

The triumph of e-Bus programs under FAME II was evident in the bulk procurement model, especially through the Gross Cost Contract (GCC) method led by Convergence Energy Services Limited (CESL). CESL achieved substantial cost reductions, with rates 27% lower than diesel and 25% lower than compressed natural gas (CNG) without subsidies. Encouraged by this success, the government launched the National Electric Bus Programme, targeting the deployment of 50,000 electric buses by 2027, with CESL playing a pivotal role in outlining roadmaps for this ambitious initiative (UITP, 2024).

Despite initial challenges, CESL successfully concluded tenders for thousands of e-Buses, illustrating their potential to mitigate operating losses. However, a subsequent tender faced challenges as Original Equipment Manufacturers (OEMs) refrained from bidding, a major reason was a change in the contract model. Additional programs, like the PM-e-Bus Sewa Scheme, focusing on smaller cities, underscore the government's commitment to expanding e-Bus initiatives beyond metropolitan areas.

e-Bus Policy Landscape in India

India's policy landscape propels e-Bus manufacturing and adoption through fiscal and regulatory measures. FAME I and II provided subsidies and incentives, with FAME II emphasizing e-Buses and employing the GCC model. State-level policies complement national efforts, offering subsidies, tax exemptions, and concessions to promote e-Bus adoption.

Case Studies: Pune and Kolkata

Pune emerges as a compelling case study, showcasing successful electric bus adoption. Key success factors include political leadership, interdepartmental coordination, economic viability, the GCC procurement model, and positive stakeholder reception. Pune is on track to surpass the Government of Maharashtra's electrification targets.

Kolkata, grappling with severe air pollution, integrated 80 e-Buses into its fleet. Challenges related to charging infrastructure were addressed through software reconfigurations. The case study underscores the importance of sustainability measures, cleaner energy sources, and innovative charging solutions.

Stakeholders' Perspectives on Barriers

Among several barriers, financial risks for OEMs and scaling issues emerged as major challenges, along with limited private-sector involvement. Appropriate policies and mechanisms to address the risk are needed, including making subsidies applicable to the private sector also. Charging infrastructure in the current model is limited to public sector depot charging, making its access to the wider e-Bus segment difficult. It also restricts e-Bus movement on selected routes and long distances infeasible. There are concerns related to standardization and interoperability also for charging equipment. OEMs no longer find the current GCC model viable for scaling up and recent changes increased their operation risk also, resulting in a lack of interest in the third tender by CESL. The need for financial aggregators, collaboration for grid optimization, and attracting private sector capital were some of the recommendations made by stakeholders to address these issues. The need for alternate models for financing and charging was also emphasised- leasing options for small operators for example. There are success stories and two case studies from Pune and Kolkata that demonstrate the potential for e-Bus adoption, emphasizing the importance of political leadership, economic viability, and stakeholder collaboration.

1 Introduction

1.1 Significance of Public Transport and Role of Buses

Public transportation is essential to contemporary cities, especially in fast-developing countries like India. This is because buses play an important role and provide many benefits in public transportation. Buses can help reduce air pollution and greenhouse gas emissions as they help minimise the use of automobiles and emissions per capita by carrying more people. Because buses carry more people, with effective bus services, more people utilise public transit instead of driving, thus reducing traffic and traffic congestion. A good public transport service helps make society more equitable and just as it helps those who are isolated due to age, disability, or income get about. This includes seniors, disabled persons, and low-income bus commuters. Cities with strong public transport systems, particularly buses, may build higher-density, mixed-use developments without substantial road networks or parking, making cities more efficient and energy efficient. Buses provide more flexibility compared to train service, giving flexibility and coverage. They also adjust well to urban growth and population fluctuations. In all, public transit buses improve environmental sustainability, economic efficiency, social inclusion, and urban growth. As technology and cities change, so does their function.

1.2 Global e-Bus Developments

The global development of the electric vehicle (EV) market, particularly in the electric bus segment, has seen substantial growth, with China leading the way. China has been the undisputed leader in electric bus adoption, with a significant number of electric buses added to its urban fleets. By 2016, China had added 340 electric city buses every day, far surpassing other regions.

At the end of 2017, there were three million city buses in operation worldwide, 385,000 of which were electric buses, accounting for 13% of the global fleet. However, this figure is heavily skewed, as almost all these electric buses operate in China, making the share of electric buses in China's circulating city buses around 17% (SB, 2024)

China's ambitious plans for electrifying public transport include cities like Shenzhen committing to having 100% electric buses by the end of 2017 and Beijing aiming for 10,000 electric buses by 2020. Despite facing a decrease in 2017 due to subsidy reductions, the Chinese market rebounded with a significant increase in sales.

As of 2022, China dominates the global electric bus market, holding over 80% of the market share. In 2022, approximately 66,000 electric buses were sold worldwide, with 54,000 sold in China alone, representing 80% of global sales and 85% of electric truck sales (Statzon, 2024).

In Europe, the electric bus market gained traction after 2017, with a threefold increase in 2018. Despite challenges in 2020 during the COVID-19 pandemic, the European electric bus market continued to grow, registering 3,282 additions in 2021 and 4,152 in 2022. Notably, some European countries, such as Finland, Norway, and Denmark, have seen a significant share of newly registered buses being electric.

The United States had a low-level e-Bus penetration but had reached 0.5% of the total U.S. public transit bus market by 2017 with 9% transport agencies involved in e-Buses. WRI reported that as of June 2022, US school districts have committed to 12,275 electric school buses in 38 states.

With over 70,000 buses sold in 2017,India has significant potential for switch to electric buses. The Indian electric bus market is showing promise, and by 2025, it is expected to account for more than 10% of the total annual global demand for electric buses.

According to Bloomberg NEF, municipal e-Buses are expected to increase from 417,000 units in 2019 to over 645,000 units in 2025 (about 39% of the global municipal bus fleet) and reach 67% of the global bus fleet by 2040 (SB, 2024). According to consultancy ING study, a third of the 200,000 buses in European public transport will be zero-emission by 2030. In that year, zero-emission buses will cover two-thirds of the new city bus registrations (for reference, see footnote 1).

Overall, the electric bus market is witnessing substantial growth globally, with China in the lead, Europe rapidly expanding, the U.S. experiencing notable adoption, and India showing significant potential. The shift toward electrification in public transportation is a prominent trend, with various regions setting ambitious targets for zero-emission buses.

2 e-Bus Policy Landscape in India

2.1 National mission on e-Mobility, Ambition, Enabling Policies, and Initiatives

Public transportation in Indian cities varies a lot in quantity and quality. In larger metropolitan cities, metro systems have been introduced; however, formal public transport in cities is mainly provided by buses. Running and operating buses in India has always been a challenging proposition, and almost 90% of the buses operated by State Transport Undertakings (STUs) incur losses. The importance of electric mobility in reducing urban pollution and contributing to energy security by reducing oil imports had been realised by the Government of India, which was reflected in the National Electric Mobility Mission Plan 2020 (GOI, 2012) prepared by the government in collaboration with the Indian automobile industry and launched in 2013. The National Electric Mobility Mission Plan (NEMMP) estimated a demand for 5 to 7 million EVs (including hybrids) in the country by 2020. The plan also came out with incentive and infrastructure requirements to achieve targets. Considering the high upfront cost of the e-Buses, the government of India thereafter provided fiscal and regulatory measures to accelerate both the manufacturing and uptake of e-Buses in India through schemes such as FAME I & II. These and other initiatives are discussed below.

FAME I: FAME I, which was launched in 2015, provided subsidies for the purchase of various types of EVs, including e-buses. FAME was implemented through four focus areas, namely (i) Demand Creation, (ii) Technology Platform, (iii) Pilot Project, and (iv) Charging Infrastructure. Market creation through demand incentives was aimed at incentivising various vehicle segments. The scheme provided financial incentives for the adoption of 465 e-buses before ending in 2019. The procurement process under FAME I was not easy; piloting could only be done for e-buses in nine cities.

FAME II: FAME II was launched in India in April 2019 to further support the e-mobility programmes. In FAME II, e-bus was given a higher priority, and 35% of financial incentives were earmarked for procuring around 7000 e-buses, and it was mandatory to use the Gross Cost Contract (GCC) model for e-bus procurement (See Annex 4). The initial experience with FAME II was varied, and many cities could not conclude the procurement process, and the prices discovered varied widely across cities. In all, 3500 buses were procured between 2019 and 2021. NITI Aayog decided to restructure the e-Bus procurement under FAME II to reduce costs and increase e-Bus's uptake. It was decided to focus on metropolitan cities (Mumbai, Delhi, Bengaluru, Hyderabad, Ahmedabad, Chennai, Kolkata, Surat, and Pune) and use the services of EESL, which had extensive experience in centralised procurement. In addition to the financial incentives provided in FAME II for e-Bus procurement, the government also announced performance-linked incentives (PLI) of around USD 5.8 billion for EV manufacturers, component manufacturers and advanced cell manufacturers to help bring down the costs of EVs and promote local manufacturers.

The FAME thus provided incentives to both demand (buyers of electric buses) and supply (manufacturers of electric buses) sides. Financial support was allocated to assist e-buses costing up to INR 20 million, with a subsidy cap of INR 5 million. However, it is important to note that the FAME subsidy was exclusively for state-run agencies and not for private bus operators. Subsidies were geared towards operational expenditure (OPEX)-based financing rather than outright purchases.

India achieved a breakthrough in the adoption of electric vehicles through bulk procurement of e-buses using the Gross Cost Contract (GCC) model[1]. Convergence Energy Services Limited (CESL), a subsidiary of Energy Efficiency Services Limited (EESL), discovered the lowest-ever prices for the biggest-ever tender of 5,450 electric buses in five cities (termed as Grand Challenge Method) under the FAME II subsidy program. The rates discovered were 27% lower than diesel and 25% lower than CNG without subsidy. This was achieved by aggregating demand and floating a unified tender with standardised parameters and contract terms.

CESL successfully concluded its **second tender** for 6465 buses also under the GCC model, with prices that were 29% lower than the cost of running diesel buses (Live Mint, 2023). Initial experience with e-buses in India has shown that though they have high upfront costs, they can help in reducing operating losses. Therefore, the electrification of public transport is defined as a key priority for the government (CESL, 2023). Buoyed by the success of two big tenders for e-Buses, CESL launched its third tender for 4675 buses in January 2023. The GCC contract was modified to keep the responsibility of operating buses with the STUs. The OEMs (who were bidders) were to provide buses, maintenance and charging facilities. However, the tender was unsuccessful as OEMs did not come forward to bid for several reasons, including a change in the contract model.

Since FAME subsidies are only for public-sector bus procurement, private-sector initiatives for e-bus operation have been limited so far.

National Electric Bus Programme: In June 2022, the government announced an ambitious plan to deploy 50,000 electric buses by 2027 under the $10-billion National Electric Bus Programme (NEBP) initiative. This programme will help India achieve its target of 40 per cent e-Bus penetration by 2030 and carbon neutrality by 2070. CESL was given the responsibility to prepare a roadmap for this along with other think tanks

PM e-Bus Sewa Scheme: Another programme, the PM-e-Bus Sewa Scheme, targeting 10,0000 e-Buses on a PPP model in several smaller cities, was launched in 2023. CESL launched a tender under this scheme in November 2023 for the procurement of 3600 buses.

National Mission on Transformative Mobility and Battery Storage: In 2019, the Government of India approved the "National Mission on Transformative Mobility and Battery Storage"[2] (NMTMBS), which is run by an Inter-Ministerial Steering Committee chaired by NITI Aayog. The mission's goal is to help India improve its air quality, reduce India's oil import dependence, and enhance the uptake of renewable energy and storage solutions. The mission recommends and drives strategies for

[1] Under the GCC Contract, the buses' ownership, operation, and maintenance remain with the bus operators. In return, the operator receives a fee for operation and maintenance of buses. Also see Annex 4

[2] https://www.niti.gov.in/verticals/e-mobility-national-mission-transformative-mobility-and-battery-storage

transformative mobility and Phased Manufacturing Programmes for EVs, EV Components and Batteries. Its mandate is also to develop roadmaps to implement domestic battery manufacturing.

The NMTMBS seeks to support EV adoption through extensive stakeholder and inter-ministerial consultations as well as by implementing an end-to-end policy framework for transforming the mobility landscape with a particular focus on:

- Manufacturing
- Specification & standards
- Fiscal incentives
- Overall demand creation and projections
- Regulatory framework
- Research & Development

The government is bringing out appropriate policies and regulations in line with recommendations by the mission.

2.2 State-Level Policies for e-Buses

The electric bus market is in its nascent stage of development in India, with around 3,000 registered electric buses as of July 2023 and pending orders for nearly 7,000 units. Maharashtra, Uttar Pradesh, Delhi, and Gujarat collectively contribute to over 75% of the total registrations. Specifically, the penetration rates are 15% in Uttar Pradesh (UP), 12% in Karnataka, and 8% in Maharashtra. The significant growth in the Indian electric bus market in recent years is attributed to factors such as increased consumer demand, standardised products, technological advancements, and improvements in charging infrastructure (Kavitha, 2023).

To further promote e-mobility, several states formulated their policies, utilising the FAME funds and introducing additional incentives. By 2022, approximately 18 out of 28 states in India had notified their EV policies. In 2023, six states—Uttar Pradesh, Maharashtra, Tamil Nadu, Gujarat, and Rajasthan—led EV sales, accounting for 60% of the total in the country.

While Delhi boasts the highest EV penetration among states, with 45% of all buses sold in 2023 being electric, the electric bus market is still in its initial stages. Maharashtra, Uttar Pradesh, Delhi, and Gujarat are leaders in vehicle registrations, contributing to 75% of the total 3,000 registered electric buses as of July 2023, with an additional 7,000 in the pipeline.

State policies generally offer purchase subsidies for EVs, excluding buses, along with central subsidies, but some states also provide other subsidies to all EVs, such as registration tax exemption, for example. Most state-level policies also grant road tax exemptions for electric vehicles, with a focus on addressing implementation issues related to charging infrastructure. Capital subsidies for EV charging infrastructure are prevalent across states, and some go beyond, offering concessional land and preferential treatment for public charging stations utilising renewable energy. These charging stations, however, may exclude e-bus charging due to the high investment and other requirements.

State governments emphasise supply-side interventions in their EV policies, with Tamil Nadu, Andhra Pradesh, and Telangana particularly announcing significant measures. These include capital subsidies

for vehicle manufacturers, component suppliers, charging infrastructure, and battery manufacturers. Some states also differentiate incentives based on enterprise size to support both the MSMEs, and the larger manufacturers. Measures such as reimbursement of state GST, interest subsidies on loans, land development incentives, and the creation of industrial clusters are also taken to encourage EV transitions.

Table 1 gives a summary of EV policies applicable to electric buses in different states. The table excludes states like Gujarat that do not explicitly mention electric buses in their policy documents.

Table 1: E-Bus policies in states

State	Aim of Policy	Incentives/Concessions/Other Initiatives and Subsidies (In addition to those provided by the National Government)
Andhra Pradesh (Policy announced in 2018 and applicable up to 2023)	• Convert 100% of the APSRTC bus fleet of over 11,000 buses into e-Buses (BEVs/FCEVs) by 2029 • The first phase of 100% conversion of the bus fleet in the top four cities by 2024	• Reimbursement of Registration charges, Road tax, & Net SGST for all private EVs until 2024
Kerala (Policy announced in 2019)	• Deploy a pilot fleet of 3000 e-Buses by 2020 • Up-gradation of 6000 plus existing buses to e-Buses by 2025	• Provide battery swapping system at bus depots to cater trip lengths up to 35 km
Karnataka (Policy announced in 2017 and applicable up to 2022)	• To attain 100% e-mobility by 2030, school buses in Bengaluru city shall be encouraged to move towards EV • Launch of 1000 new e-Buses during the policy period	• Exemption from the payment of taxes on all EVs
Delhi (Policy announced in 2020 and applicable for 3 years)	• Induction of 1000 e-Buses by 2020 • BEVs to contribute 25% of all vehicle registration by 2024 • By 2023, pure e-Buses to constitute at least 50% of all new public transport vehicles with 15 seats or more procured for the city fleet including for last-mile connectivity.	• Road tax and registration fees to be waived for all BEVs during the 3-year period of this policy
Maharashtra (Policy announced in 2018 and applicable up to 2023)	• BEVs to contribute to 10% of new vehicle registrations by 2025 • 15% electric buses by 2025 (25% for Urban Agglomerations) • In the five targeted urban area, achieve 25% electrification of public transport by 2025	• Subsidy of 10% on ex-factory cost will be available for the first 1,000 STU e-Buses with a maximum limit of Rs. 2,000,000 per vehicle • Road tax & registration fees – 100% exemption
Tamil Nadu	• State Transport Undertaking (STU) operates 21,000 public transport buses. Around 5% of	

State	Aim of Policy	Incentives/Concessions/Other Initiatives and Subsidies (In addition to those provided by the National Government)
(Policy announced in 2019 and applicable up to 2029)	these buses (around 1000 buses) shall be replaced as e-Buses every year. and gradual transition of institutional buses to EVs will be encouraged • One slow-charging unit for every electric bus and one fast-charging station for every10 electric buses shall be provided.	
Uttar Pradesh (Policy announced in 2019 and applicable up to 2024)	• To launch 1000 electric buses (BEVs/FCEVs) and achieve 70% EV public transportation on identified green routes in identified 10 EV cities by 2030.	• Ten cities including Noida, Ghaziabad, Meerut, Mathura, Agra, Kanpur, Lucknow, Allahabad, Gorakhpur, and Varanasi will be declared as model cities in the first phase to adopt EVs,
Madhya Pradesh (Policy announced in 2019 and applicable up to 2024)	• Replace 50% of fleets under city Public transport Special Purpose Vehicles (SPVs) with e-Buses by 2026.	• The first 1500 electric buses or total electric buses in 5 years, whichever is less, will be charged 1% motor vehicle tax. • Vehicle registration fees will be exempted for 2250 electric buses or total electric buses in 5 years, whichever is less. • If a permit is required for operations of E-Buses, then the first 1500 E-Buses or total e-Buses in 5 years, whichever is less, will be exempted by the transport department.
Telangana (Policy announced in 2020)	• 100% electric buses by 2030 (for intra-city, intercity, and interstate transport in a phased manner. • Phase 1 -25% by 2022, Phase 2-50% by 2025, Phase 3-100% by 2030 • Airport flight shuttles and PUSHPAK buses to be transitioned to EV on priority	• 100% exemption from road tax and registration fee for first 500 e-Buses.
Punjab (In draft stage)	• Replace 25% of the existing bus fleet with e- Buses within 5 years from the date of policy notification.	• 100% waiver on Permit Fee & Motor Vehicle Tax for private bus operators plying on selected routes for a period of 5 years and 10 years if such bus is manufactured in Punjab
Bihar (In draft stage)		• End-user incentive – 15% subsidy on base price with an upper limit of Rupees 2,000,000 (for first 1000 e-Buses or a Policy period of 5 years, whichever is earlier) • Road tax & registration fees - 100% exemption.

Source- (i) JMK Research (policies up to 2021 as quoted in https://e-vehicleinfo.com/state-wise-ev-policies-for-electric-bus-in-india/); (ii) https://e-vehicleinfo.com/ev-policies-and-subsidies-of-13-states-of-india/; and (iii) https://e-amrit.niti.gov.in/state-level-policies

Many states had overly ambitious targets even for 2022 and 2023 which they could not achieve as policies and incentives offered alone were not enough to achieve the targets. Also, supply-side constraints and other barriers, including infrastructure, financing, and business models to operate buses under FAME II remain leading to lower-than-expected use of the incentives. In most cases, policies are due for review and learning from experiences may help devise suitable policies in line with ambitions.

2.3 Case Studies of e-Buses from Two Cities; Pune and Kolkata

Case studies from two cities, Pune in the state of Maharashtra and Kolkata in the state of West Bengal, have been summarised in Annex 2 and Annex 3. The Pune case study was published by RMI India (PMC et al., 2022), and the Kolkata case study was published by The Energy and Resources Institute (TERI, 2020). The case studies provide insight into the procurement process, enabling factors and business models that led to the success of e-Bus programmes in these two cities.

The Kolkata case study refers to **the period before the CESL bulk procurement** model was adopted and technology prices (battery particularly) were relatively higher. Therefore, the total cost of ownership (TCO) for a 9m e-Bus comes out to be INR 47.6/km, while the TCO for an equivalent diesel bus was found to be INR 37/km. However, the running cost of the e-buses comes out to be INR 22/km which is one-third of the same for a diesel bus. Due to falling price of batteries, and increasing prices of diesel, the government expected the e-Buses to be commercially viable within the next 2-3 years in India. The major drivers behind the implementation of electric buses are the efforts towards reducing air pollution levels and expected cost-competitiveness of these buses over diesel in future. The Government of West Bengal had therefore principally decided not to induct any new diesel buses in the city of Kolkata, and only CNG-based and electric buses are to be procured from now onwards. Further, their plan is to have an entire city fleet of 5,000 e-buses by 2030 and set-up 241 EV charging stations across the city. For comparison, in the case of the Pune study, for a 12-meter-long airconditioned bus, TCO was INR 56.5/ km without FAME subsidy and INR 51.4/ km with subsidy, while it was INR 59.8/ km for a diesel bus. Diesel prices have been increasing; they were 21% higher in 2022 compared to 2020, which also partially explains the low TCO in 2020 for diesel buses in the Kolkata study.

3 Approach; Stakeholders' Perspectives- Challenges and Opportunities

3.1 Stakeholders Mapping for e-Buses in India

Stakeholders identification: For this study, the following stakeholders were identified in India's e-Bus eco-system for consultation.

1. **Government Authorities**: Government authorities include the Central/ State Level and Local Level (Municipal Corporation and City authorities. The Ministry of Heavy Industries of the Government of India (GoI) has formulated policies and programmes (FAME I and FAMEII) to promote e-mobility. GoI also gave Convergence Energy Services Limited (CESL) a mandate to procure e-Buses in bulk (to drive down prices) in line with the states' requirements. Besides the decision to procure e-Buses for states in bulk and subsidy through FAME II (starting 2019), the business model also includes operations to promote public-private partnerships to scale up operations and help states address financial barriers.

   State Governments are implementing the policies and programmes and have additional policies to provide subsidies and incentives as well as targets for e-buses. Finally, local authorities are the executing arm of the state governments in cities and other jurisdictions. They manage e-Bus fleets in cities, including route planning, infrastructure development (charging stations, depots), and ensuring compliance with regulations.

2. **Public Transportation Agencies/Operators:** It includes both State Transport Undertakings (STUs) and Private Operators. They operate bus services and are responsible for transitioning their fleets to electric buses. Private Operators may also operate buses. Maintenance of e-buses is done either independently or through public-private partnerships.

3. **Manufacturers and Suppliers:** It includes bus manufacturers, also referred to as OEMs (original equipment manufacturers). In addition, there are Battery Manufacturers, an important part of e-Bus, and Charging Infrastructure Providers.

4. **Financial Institutions:** It includes banks and financial institutions, including multilateral financial institutions, that provide loans and financing options for e-Bus purchases and infrastructure development.

5. **NGOs and Others:** These included various foundations, academic and research institutions, multilateral institutions, and experts.

6. **Regulatory Authorities:** e-Bus operation involves two prominent sectors- electricity and transport and regulatory authorities from both sectors may play a key role when the e-Bus scale-up takes place.

Stakeholders were selected from these categories, wherever available, and interviewed. A list of the stakeholders interviewed is attached (Table 2). Some of them were interviewed online due to non-availability.

Table 2: List of stakeholders interviewed

Government Authorities (including State Government and Local Government and Central Regulatory Agency)	Original Equipment Manufacturers (OEMs)	Private and Public Sector Operators	Experts from Other Institutions including Independent Experts Institution
Principal Secretary (Transport), Delhi Government	VP (Sales & Business Development), PMI Electro Mobility Solutions	Chartered Speed (Bus Operator), Ahmedabad	Programme Management Officer, UNEP
Chief, Regulations, Central Electricity Regulatory Commission	Business Head (e-Mobility), JBM Group		Executive Program Director - Integrated Transport, Clean Air and Hydrogen WRI
Ex-Senior Advisor (Power Markets), Central Electricity Regulatory Commission			Senior Programme Lead, CEEW
Town Planner and Executive Engineer, Surat Municipal Corporation			Professor, CEPT University
			Senior Transport Specialist, The World Bank
			Ex-Head, e-Mobility, CESL
			Consultant, Transport, World Bank
			pManifold
			Ex-VP and Head e-Mobility, Ashok Leyland
			Ex-GM, Tata Motors
			Sustainable Mobility Professional, SG Architects

1. Interviewee has worked with the manufacturer, but he has been interviewed in the "Expert" category here. However, his views have been useful from a manufacturer's perspective also.

2. Interviewee has worked with the manufacturer, but he has been interviewed in the "Expert" category here. However, his views have been useful from a manufacturer's perspective also.

3.2 Stakeholders' Consultation Framework

A general questionnaire was designed to cover various questions for all categories. However, not all questions were administered to all stakeholders- there were also category-specific questions, and those were administered only to the categories to which they were applicable. The questionnaire was primarily designed to cover the categories they were administered as indicated in Annex 1. Since these were open interviews, stakeholders also provided additional input based on their experiences. All these have been included in the various sub-sections within this section. Considering the richness of the inputs, first inputs from various categories of stakeholders have been discussed, and finally, a summary of barriers and policy measures needed is presented.

3.3 Stakeholders' Perspectives on e-Bus Experiences and Barriers/ Challenges for Scaling Up

Stakeholders from various categories had similar views on many barriers. The categorisation here, therefore, does not mean that views indicated in a category are exclusively from that category—it primarily indicates the importance given to those aspects by that category. It has also been indicated in each sub-section.

3.3.1 Government authorities' perspective

This section presents a summary of the perspective of the government representatives, including a state government representative (Delhi) and a local government representative (Surat City). As already mentioned, **in addition, this section also includes views common across all categories of stakeholders.**

The first part of this section covers an overview of the electric bus programme at the national level, supplemented by an overview of the e-Bus programme of the Delhi State and Surat City (who were interviewed), which may help understand the perspective of stakeholders from these institutions.

1. Overview of Electric Bus Programmes

National Electric Bus Programme: The Ministry of Urban Development's ambitious 63,000 crore plan is set to boost electric bus services in cities. It aims to bring 10,000 city buses under a public-private partnership and plans for substantial scaling up. A substantial growth in the electric bus market is anticipated, with around 50,000 buses on the road in the next five years, driven by government tenders.

A Delhi government official and a Surat municipal corporation official were interviewed about issues related to electric buses in their jurisdictions. Below is a brief background of their electric bus programmes.

Delhi Electric Bus Programme: Delhi aims to have 80% of its bus fleet electric by 2025, which would take its fleet of e-Buses to 8000. By 2030, all e-commerce, food delivery, and ride-hailing companies will go electric. Capital cost is about 15% of the total costs of bus operation over 12 years, and FAME subsidy covers about 30% of the capital cost. Delhi Government is a part of the aggregate procurement done through CESL. Since only government fleets are considered so far, charging stations are installed inside the depot by operators for which the government provides an 11 KV line. Since intercity electric

bus services have not been started by the Delhi Government, with 250-300 kms on a single charge, the range is not an issue. Battery swapping has not been considered due to weight.

The challenges that Delhi authorities face include in the CESL procurement model, OEMs have to take financial risk, which is becoming an issue due to OEM's reluctance to take this risk. Also, dependency on depot charging means intercity operations requiring a larger range or opportunity charging is not feasible. Privatisation is currently not seen as feasible due to the affordability of public transport for the poor.

Surat Electric Bus Programme: Surat currently has 192 electric buses, with a purchase of 180 buses in the pipeline and the target is to increase the fleet size further by adding 450 more buses. The procurement of buses for the city has been facilitated by CESL, thereby benefiting from price discounts under CESL tenders. Under FAME I Surat Municipal Corporation procured electric buses by floating tenders using the Outright Purchase Model (OPM)[3]. The Corporation also procures buses on gross cost contracts (GCC), wherein the operator provides the bus, and they pay for the per kilometre use of the bus. The subsidy provided by the central government is transferred to the bus manufacturer (who also operates the buses), which results in lower per-kilometer costs for the gross cost contracts. In addition to the benefits from the central government, the state government also provides a subsidy of Rs. 25 per kilometre to the city government to operate electric buses. Seven depots in Surat have charging facilities, and charging facilities in seven more are under construction, in all, there are more than 50 charging points for electric buses. The Surat Municipal Corporation provides the charging infrastructure.

2. Stakeholders (Government Authorities) perspective on barriers

The views expressed by the governmental stakeholders on the status of e-Bus development and barriers to the deployment and scale-up are summarised below.

Economic and Financial Barriers: The FAME subsidy covers only a small percentage of the overall procurement cost but the operating costs of electric buses being low, the switch from diesel and CNG to electric buses was found feasible under the current GCC Model. In the GCC model of procurement, the bus is owned, operated, and maintained by service providers (an OEM or a consortium of OEM and bus service providers) for a specific rate and contract period. Many OEMs are however either not willing to take financial risk or facing financing challenges, and therefore, scaling up e-Buses has become an issue. Also, OEM's strength is in the production and selling of buses, not in financing or operating buses that the current GCC model requires.

One of the stakeholders also mentioned that the viability of e-Buses without government subsidies is an issue as the e-Bus programme currently gets subsidized electricity for charging besides capital and other subsidies from the state and the central governments.

On electricity price regulation, it was pointed out that tariffs had been made attractive for charging purposes, and incentives for charging at night are proposed. One of the stakeholders emphasized the need for electricity storage to ensure electric buses run on green fuel and, at the same time highlighted the cost challenges of battery storage, with standalone storage being expensive. The need for business

[3] Refer Annex 4 for more details on OPM

viability and long-term strategies for battery storage through electric vehicles (EVs) was also pointed out.

Technical and Infrastructure Barriers: Currently, the Delhi Government only has depot charging, which is a barrier to long-distance services such as inter-city services. This also creates a barrier for private bus operators, some of whom have initiated inter-city services, as they cannot access the depot charging. Opportunity charging infrastructure is needed even for city buses, but it does not yet exist.

Unlike traditional bus fuels (CNG and diesel), which have filling stations all over, the Delhi Government's current model (dependency on depots) for charging restricts the e-Bus routes to only those that have depot charging. The alternative is to go for buses with higher battery capacity to increase range, but this increases cost. The other option is to make charging infrastructure available across the city with charging managed by a third party. Buses with smaller batteries can also operate within a city, in this case using opportunity charging. This has been tried in China, and initial learning emphasised the importance of reducing dependency on depot charging, suggesting a need for more interoperability and considering alternative models such as third-party management of charging infrastructure.

One of the stakeholders indicated that though electric buses are available in the market, the availability of batteries and semiconductors is an issue since these are imported. The central government has taken the initiative to address this issue by initiating the production of batteries and semiconductors within the country.

Policy and Regulatory Barriers: Regulatory recommendations have been made on charging tariffs tied to the average cost of supply with margin. Though tariffs are specified in the tenders, further standardisation can help create certainty for operators.

Other areas for framing policies include the challenges in the adoption of modern technologies due to unclear guidelines. Also, as of now, there is no policy on the disposal of batteries, and with e-buses already in operation for a few years now, a policy is needed to prevent adverse environmental impacts.

Institutional Barriers and Business Model Issues: The institutional mechanism to operationalise the governmental e-Bus initiative primarily includes the Ministry of Heavy Industry (MHI), and Ministry of Housing and Urban Affairs (MoHUA) at the central (federal) level and industrial and transport ministries/ departments and STUs at the state level. Convergence Energy Services Limited (CESL), a public sector entity, is the demand aggregator and procurer on behalf of various state governments / STUs. Both central ministries act as regulatory bodies for the e-Bus programme that has a target of 50,000 e-Buses by 2027, whereas electricity-related regulation is looked after by the Central Electricity Regulatory Commission (CERC). MHI provides subsidies through the government's FAME scheme. Other stakeholders may get involved depending on the requirement.

Business Model Issues: Stakeholders were interviewed on the business models also. Their views are summarised in this section.

One of the stakeholders opined that in the current GCC model, in cases where bus operators' (primarily STUs) financial health is not good, OEMs/ bidders are apprehensive about the payment security and, therefore, do not bid for such cities. Privatisation has been suggested by some experts, and there are examples of privatisation models from the electricity sector that are encouraging. However, affordable public transport for the poor is a very political question, so the privatisation of bus operations is difficult.

For cities with financially weak bus operators, an alternate model was suggested by stakeholders, and some experts advocated it. In this model, financial aggregators with a mandate to invest in green infrastructure could buy buses from OEMs and enter into contracts with bus operators. The need for financial aggregators, involving banks and financial institutions, was expressed by stakeholders to manage bus purchases, maintenance agreements, and contracts with bus operators, reducing the financial burden and risks for OEMs.

Yet another issue, the scarcity of operators with the required net worth to manage large fleets, was brought out by an expert. The expert suggested having Special Purpose Vehicles (SPVs), who could dry lease or directly purchase buses from OEMs considering the maintenance and technological expertise requirements of e-Buses and the lack of interest and capacity of many OEMs to take this responsibility. The evolution of bus operators in the EV domain was considered important by a few experts. The bus operators could buy the e-buses from OEMs, manage the GCC or other types of contracts, and run the buses. They could also work on a hybrid model, where they purchase the buses while service providers manage operations. This could help allay the fears of jobs disappearing with the service providers (primarily STUs)

Awareness and Other Barriers: There are challenges in educating the public and creating awareness about electric buses. There is a need to ensure awareness among all stakeholders, emphasise the need for awareness campaigns, and address concerns related to battery life.

3.3.2 OEMs perspective

Some specific issues pointed out by OEMs beyond those pointed out by government authorities in the previous section are covered in this section. It also includes some of the OEM's concerns that are common with experts and bus operators.

Economic and Financial Barriers: One of the OEMs was particularly concerned about e-Bus funding and a lack of government support on this. It is a main hurdle since the FAME subsidy through Production Linked Incentive (PLI) scheme excludes e-Bus start-ups due to FAME's stringent criteria, creating an uneven playing field. Also, start-ups are not able to get bank funding due to balance sheet requirements. Therefore, there is a need for a guarantee mechanism, or a hybrid model in which buses are purchased by the State Undertakings (STUs) and run by OEMs or operators, and STUs pay for e-Bus maintenance and operation. The need for equity funding was also emphasised, and it was indicated that due to uncertainty over issues such as high total cost of ownership (TCO), disposal price of buses, battery life, etc, equity funders are not yet ready to come on board. The issue of political risks (freebies and others), which can make STUs default, was also brought out. The political risk is considered a big financial risk requiring a payment guarantee. High prices of e-buses were also cited

as a reason why a big fleet market (school buses, staff buses, companies' buses, etc.) has not yet opened to e-buses. Current FAME subsidy is not available to the private sector, making the transition to e-Buses unviable for them. The national level e-Bus target of 50,000 by 2027 is for the public sector, and the private (end-use) sector is not included in this. The private sector needs to be opened, and for that, prices will need to come down by 20%, according to a stakeholder. This is because the current incentive scheme applies to bus supplies to the public sector only. Alternatively, the private sector also needs to be incentivised

Two stakeholders indicated that the high price of e-buses requires viable models, including lease financing. It was mentioned that in the current GCC model, the bidders (OEMs only are bidders so far) face a variety of risks, which include financial, driver, kms, revenue and other risks. It was suggested that equity companies taking such risks is a better option.

The charging expert pointed out challenges related to government control over pricing through nodal agencies in each state. It was mentioned that risks are associated with subsidies and their impact on charging station operators' business cases.

Technical and Infrastructure Barriers: The charging Infrastructure expert specified the need for the adoption of a charging-as-a-service model, thus treating charging infrastructure as a service requiring expertise in electrical, electronic, and IT domains. The need for charging infrastructure was stressed, particularly for intercity travel. The challenges related to building an efficient charging infrastructure and its connectivity with e-Buses were brought out. The issues include station availability, slot estimation, charging time calculations, etc. It was also mentioned that connectivity problems posed hurdles for real-time data collection and analysis, revealing a gap in GPS connectivity to buses despite ample phone connectivity.

Technical challenges also include derating charging rates above 120 kW. The need for standards in the electric bus sector was highlighted, and collaborations with organisations leaders in this area were suggested. Other technological challenges, such as optimising routes, data management, and connectivity for efficient operation of e-buses, were also pointed out.

Battery disposal and its environmental impact were pointed out as other important issues related to battery use requiring regulation besides battery technology challenges, including standardisation and the need for charging infrastructure development, particularly for intercity travel. Challenges to battery technology include the need for reliable power in villages to extend the reach of e-Buses to rural areas and ensure that it is green electricity. One expert also suggested that there was a need to explore the battery swapping technology further. Another expert pointed out that the size of the battery was a big constraint for swapping technology. Battery swapping technology has been tested in India for two and three-wheelers and found feasible; it was also being considered for e-buses in India at one point in time, but after some experience, its limited market potential was acknowledged.

Regarding safety, the OEM highlighted safety features and passenger comfort, including plans for testing advanced systems like a 360-degree camera and a driver assistance system (DAIS).

Policy and Regulatory Barriers: Limiting FAME subsidies to only government procurement has resulted in keeping the private sector, by and large, out of e-Bus operation. As a result, a large market segment consisting of buses used in the fleet (e.g., school buses) remains neglected. Also, existing subsidy criteria make e-Bus start-ups ineligible for subsidy due to high turnover requirements. A

suggestion was also made to expand subsidies beyond city transportation. It was also opined that banks' priority sector lending policies need to include the e-Bus sector.

Political risks remain, which include policies that introduce freebies without compensating STUs, affecting the payment security of the operators. Significant political intervention in big public transportation entities like BEST, BMTC, etc., can seriously dent sound decision-making processes. The current model requires bidders (OEMs) to take responsibility for charging infrastructure. This, however, is limited at depot charging. , leading to other constraints, such as routing, range, etc., in e-Bus operations. All these areas may need to be visited, and appropriate policies that address stakeholders' apprehensions should be formulated.

Institutional /Business Model Barriers: Engagement of the private sector through private operators can bring in efficiency but political risks will need to be addressed for the good health of STUs. Political risk includes freebies that lead to payment security risk. In the freebies culture, states announce either free travel or below-cost fares for certain categories without compensating STUs. In such cases, it is a high-risk business for banks as well as bus manufacturers as STUs can default.

On institutional responsibility at the federal level, it was pointed out that though several ministries are involved, there is a lack of a single ministry dedicated to electrification, and a suggestion was made that the Principal Scientific Advisor's office could function as the central authority. The need for building competence in the e-mobility area was also highlighted. The need for collaboration and partnerships among various stakeholders to address the challenges of grid optimisation was also suggested.

Some stakeholders were concerned about the lack of active private sector participation in the e-Bus programme. Unlocking private sector money is deemed crucial for scalability, and for that, multilateral agencies may need to work on financial instruments to attract private sector capital. There is a need for the development of an ecosystem where private sector capital is attracted to invest in electric buses, and it becomes feasible to withdraw physical subsidies while maintaining supportive policies. Financing emerged as one of the main issues, and an equity funding business model and guarantee mechanism to get bank financing was suggested. It was also suggested that e-Bus should be included in the priority sector lending of the banks, which will help the availability of funds at reduced cost. A Payment Guarantee Scheme is expected to help address the political and related financial risks faced by OEMs / operators. As a result of perceived financial risk, there were no bidders in the CESL tender in 2023 for 4675 buses, which were offered on a Dry Lease Model. A dry lease model helps maintain employment in STUs; the buses are owned and maintained by service providers for a period of 10 & 12 years whilst being operated by STUs. Service providers are paid a monthly fee per bus. Manufacturers became ineligible for the subsidy in this model, increasing their costs, which was one of the reasons for the reluctance of all major e-Bus manufacturers to participate in the tender.

Capacity Building Barriers: Transitioning to electric buses would also require capacity building of drivers. The use of analytics to monitor drivers' behaviour, emphasising aspects such as regenerative braking and battery performance, was also suggested.

There are challenges associated with scaling up, including manufacturing capacity, power availability, and managing large fleets. Key stakeholders, including relevant government departments, are actively exploring solutions to address these challenges. The need for reliable power in villages is also needed.

3.3.3 Private and public bus operators' perspective

At this stage of the e-Bus programme implementation in the country, only a few large corporations have been able to enter the business, and this has helped the authorities to organise the operations better in India. Electricity as fuel also allows operators to have more certainty on operational costs, as they do not have to put up with fuel price fluctuations. A benefit the large operators see in the driver and passenger comfort is the elimination of vibrations and noise. Reduced need for maintenance was also pointed out as a big advantage of e-Buses. This is because electric vehicles have around 10-20% moving parts compared to conventional ICE vehicles, which substantially reduces the need to maintain them. The bus operators also indicated that simpler operations and opportunities to use advanced technology have allowed them to scale up the operation multiplefold in some cities. This possibility of scaling up the operation also makes electric bus operation exciting for them.

Many concerns, however, remain. Some of the concerns expressed by operators were common with the previous two categories of stakeholders, and this section covers the concerns that are either specific to the bus operators, **or the concerns are same, but the perspective is somewhat different.**

Economic and Financial Barriers: Electric buses are more expensive compared to ICE vehicles but offer better fuel economy. The higher cost and restricted availability of fuel (lack of charging stations) create a barrier for small businesses to enter the business of e-Bus operations.

The high cost of electric vehicles, charging infrastructure, and availability issues make it difficult for smaller private bus operators to get into the business of e-bus operations. However, the interviewed operator also feels that scaling up the operation beyond public transport is necessary. It will need smaller operators to come in, and the challenge will be to organise it in a way that unfair practices are kept at bay and safety and legal boundaries are not compromised.

Financial risk is a major issue. The tenure for loans is still 4 to 5 years; interviewed private operators suggested that banks are also not willing to finance beyond 85% for electric buses. So, the financial risk is still very high and serves as a barrier. This is especially a barrier if, for example, the entire school bus fleet has to be converted to electric buses.

An interesting development in the recent past has been relatively easier access to finance, particularly for large corporate operators. There are options from a few leasing companies to give EV assets for a 10-year lease, which is a step in a positive direction for the growth of the e-bus industry.

Technical and Infrastructure Barriers: CESL has facilitated bus purchases and has used economies of scale to get better deals on electric buses for public sector operators. However, in the same-size shoe-fits approach used by CESL, they standardise the type of bus and type of operations, leaving little scope for the bus operators to optimise services according to the demand and the geography. Technically, electric buses are very comforting for bus operators, bus drivers, and passengers because electric

buses, unlike traditional diesel ICE engine buses, have fewer vibrations, less noise, and only around 10% moving parts compared to diesel ICE engines. So, the number of quality checks required is limited as there are no filters, high-pressure pipes, etc., on electric buses.

Institutional /Business Model Barriers: By having simpler and more advanced technology, public and private operators can scale up operations multi-fold with the same management team, which gives them a significant advantage in developing profitable business models.

Multiple players and operators are required to operate and promote public transportation across the country, such as in India. Operators need to be convinced to switch from old buses to new buses, and people need to switch from private automobiles to buses. Small players often provide customised services, which may be better than corporate public transport operators because small players are better connected to their customers. These small players can play a key role in getting people to shift to public transport modes like electric buses, for example, shifting students from private transport to public transport. Thus, although small players are required, the worrying part is that this can lead to unorganised and unfair business practices, leading to a lack of or poor checks, use of inferior technology to maximise profits and unsafe operations. It is important to ensure that shortcuts are not taken in terms of bus operations, which otherwise can compromise the safety and comfort of the passengers. Also, if safety is compromised for a modern technology like electric buses, it can easily create a negative image of the technology, affecting its uptake.

In the current system, public transport using electric buses is not dependent on external infrastructure. The buses operate on fixed routes and have fixed operations, allowing the operators to plan their captive infrastructure, including EV chargers, parking, etc. Electric buses are expected to be used both for shorter trip operations like intra-city operations and for inter-city operations. They can be used for trips under 300 km, but beyond that, they will need a significant improvement in battery technology.

For the conversion from diesel to electric buses, city authorities have taken the lead and adjusted business models as they seem to fit in their city context. For example, a cash-rich city would prefer to buy buses and dry lease them to operators. However, some cities are not so cash-rich. These cities would ideally operate on a gross cost model, such as per-kilometre rates. There are some hybrid models as well.

However, in centralised procurement, a single type of contract is being done across the states and cities, which limits their freedom to select a business model that will best suit them. For example, Surat has cash available at low cost and may prefer to buy and own e-buses. The central procurement however forces them to accept a gross cost per kilometre contract model, which makes them dependent on the OEMs or the bus operators and payments linked to their costs (their interest rates). So, in this model, their operating prices will go up, and there could also be other operational issues.

Similarly, some state transport undertakings (STU) get electricity at a lower price. In this case, they provide the electricity, and private operators do the entire operation on a wet lease. If the operator buys the electricity, they may have to pay a higher price. For example, in one case, the electricity price was ten rupees a unit, but for the STU, it was four rupees. In some cases, the city may already have workshop infrastructure, or they may need to create it afresh. Thus, the same business model for

every city/state may not provide an optimal solution; things need to be customised according to the needs of the city.

There are also wet-lease models, such as the one that the BEST (the local government public transport operator) uses in Mumbai. In this case, a private contractor takes care of operations and maintenance of buses procured from a manufacturer and also takes care of staff recruitment and their salaries. The BEST pays the contractor for the service provided per kilometre running of the bus per day.

In Surat and some other cities in India, electric bus operations have been integrated with shared bicycles. This has spurred the demand and patronage of the bus rapid transport system in Surat, and ridership has gone up by 2000 to 3000 trips/day.

3.3.4 Experts from other Institutions, including independent experts' perspective

Several experts from a variety of institutions, including research and academic institutions, NGOs, multilateral financing institutions, international organisations, and a few independent experts who have been at the forefront of driving the e-Bus agenda in the country, were interviewed. As can be expected, many of the barriers indicated by the three categories of stakeholders already covered were also endorsed by them. However, they provided especially useful insight on barriers based on their experiences, and **their perspective reflected some additional issues**, which have been covered in this sub-section.

Economic and Financial Barriers: The capital cost of buses is around 3-4 times that of a diesel bus, and therefore, upfront costs are the main barrier. The e-bus market is dominated by 2-3 manufacturers, and hence, there is not a lot of competition, and the lead time for getting e-buses is between 1 and 1½ years. Manufacturing capacity is a big concern, and though the demand for e-Buses is around 12-13,000 buses per year, the supply from the 3 major manufacturers is only around one thousand buses per year. High import duties (100% on full buses and 40% on CKDs) make the imported buses expensive. It is also not easy to get loans for e-buses compared to diesel buses, where leasing is quite common. Besides the high upfront costs, banks are not sure of the life and resale value of e-Buses. Private bus operators rely on vehicle financing and not project financing. High upfront cost was indicated as a significant barrier by an expert who also indicated complexities in accessing funding from entities like the Green Climate Fund. This was a big challenge, particularly for private operators, due to a lack of access to government incentives.

During phase I of FAME II, the OEMs quoted different prices for different city tenders because they perceived different risks. These risks arose due to different terms of model contracts and the different creditworthiness of the cities. CESL, by creating one standard model contract, reduced the risks and aggregated the demand. CESL, through demand aggregation, was able to reduce the costs to an extent that would eliminate any need to provide financial incentives for e-buses. The tenders were led by OEMs, which had the balance sheet to support such heavy investment, but the bus operators – public and private have been relegated to the background.

Technical and infrastructure Barriers: Different states have different electricity tariffs (See Annex 5). Electricity tariffs have two parts: a fixed capacity cost and energy charges. Energy charges are a small part of the operating costs; however, the fixed capacity costs are a concern. The main issue with

electricity is ensuring grid capacity and integrating renewable energy for charging. Charging infrastructure needs are overestimated, and hence, if charging has to be provided on a standalone basis, it will require a lot of viability gap funding. The second issue with charging is the fixed charges that need to be paid for capacity installed. These are much bigger than the amount paid for power consumed. Unlike industries which can increase capacity utilisation by adding shifts, buses will be charged according to service cycle and as a result, not a lot of capacity for charging will be used during the day. However, capacity utilisation can be improved if we use the same charging for private cars that are standing still during the day.

The availability of power and the high investment requirements required to charge infrastructure were considered two major infrastructural challenges.

e-Bus battery sizes are not optimized for the service, so bus operators opt for larger battery sizes, which further increase costs. The bus manufacturers are not using the modularity associated with battery sizes.

On battery life, it is difficult to comment since, firstly, OEMs may not share data on battery health since we have GCC contracts and bus operators do not need to share this information. Secondly, we have not crossed the 3–4-year mark where issues concerning battery life will become visible.

Private bus operators typically have no designated parking places, and therefore, it is difficult for them to arrange charging of e-buses, and since they have only a few buses (5-10 in many cases), investing in charging infrastructure will be expensive.

Grid optimisation challenges, especially during peak times, and the impact of the bidirectional nature of the grid with electric vehicles were pointed out, among other issues. A lack of granular grid monitoring at the distribution level and OEMs' tendency to overlook grid challenges makes it further complicated. Further studies are required so that appropriate action can be taken and regulations can be made. A related concern was the potential impact on the power sector with a large-scale shift to electric vehicles. This necessitates the need for renewable energy sources and improvements in grid stability.

One expert argued that e-bus technology has evolved over time, leading to improvements in technology, reliability, and range. However, a lack of skilled workforce across various verticals in the e-bus industry was pointed out, emphasising the need for skilled individuals to support the growing sector.

Policy and regulatory Barriers: Policy incentives have focused on stage carriages operated by the public sector (state transport undertakings) on designated bus routes in cities, and not much focus has been on contract carriages, e.g., used by schools to transport school children or buses operated by private operators. However, as a large proportion of buses are operated by private operators, the e-Bus program is missing out to a large segment of buses. One of the recommendations, therefore, was to extend incentives to private sector operators to encourage their participation. However, it is quite possible that asset leasing companies will provide the financing for private operators. The GST on e-Buses is only 5%, and therefore, as local manufacturers come up, leasing of e-Buses will also happen.

The government is providing financial incentives to create demand for e-buses and incentivizing local manufacturing; however, this is not good for public finances. It was suggested that in place of financial

incentives, the government can provide demand guarantees that remove uncertainty for manufacturers. A suggestion was also made that policies need to evolve, emphasising a transition from physical subsidies to non-physical subsidies through favourable regulations and policies.

Policies are needed to promote local manufacturing of buses and batteries in India. The import duties on batteries are high; however, there is a need to strike a balance between cheap imports and promoting battery manufacturing in India. A suggestion was also made to promote local manufacturing, for which import duties could be one of the measures in the initial phase of three years.

Institutional /Business Models Barriers: Cities, in general, are not credit-worthy, and therefore, it becomes difficult for cities to raise finances for the procurement of buses. Under phase I for FAME II, cities followed different model concession agreements, and as a result, bidders avoided smaller cities. Larger cities (metropolitan) have relatively better capacity and are more credit-worthy. It is for this reason that the EESL tender focus was on nine large metropolitan cities (Mumbai, Delhi, Bengaluru, Hyderabad, Ahmedabad, Chennai, Kolkata, Surat, and Pune) and at the end, out of these, only five cities participated in the tender. These five cities demanded 5500 buses, much more than the budget available for 3700 buses. For the additional buses, it was proposed that cities bring their funds, but only Delhi came forward, and hence, only 4000 buses were put out for tender.

The success of the demand aggregation model was indicated by some experts, which led to joint tenders and collaboration among cities to reduce costs and make e-buses more accessible. An expert said, “Under the GCC contract, the bidders quote a price for running the buses for 1 km, and we had expected this rate to be around Rs 55 per km. However, it turned out to be Rs 48 per km.” At this rate, the TCO of e-buses was even lower than that of diesel buses. OEMS has led the e-bus contracts since they have the balance sheet to finance the bus procurement, and the bus operators are only facilitating, whereas it should have been otherwise. However, there is a need to create business models with financing options, concessional loans, and shared charging networks for private operators.

The GCC model has been under discussion for quite some time among experts. Various risks, including financing, operational, revenue (due to financial instability of state transport undertakings (STUs), and others faced by bidders (OEMs only are bidders so far), were changed to dry leasing in the third CESL tender. The failure of the tender is attributed to OEMs' concerns about high operational costs, including apprehensions about relinquishing control of the buses to STU drivers (driver risk), in addition to the other risks associated with the GCC model. Furthermore, the cost of e-Buses under the dry lease tender was higher, as they did not qualify for incentives under the FAME. The dry lease model, therefore, had to be given up by the CESL. Some OEMs may not even be able to participate in more tenders since they may have reached a stage where they cannot take more risks, opined an expert.

Capacity Building Barriers: The model contracts have certain KPIs, and the payments are linked to the achievement of these KPIs. Many cities do not have capacities to track the KPIs, and this can mean delays in payments to OEMs that operate buses under the GCC model. Delhi is the most efficient city in terms of contract management, with 70% of e-Bus payments made within 7 days and the rest within 15 days. Technical capacities needed for implementation have been a major cause of failure in the past, e.g., BRT systems in India, and we need to be careful it does not happen again.

The challenges in building competence for e-mobility were also highlighted, indicating various technical challenges associated with the use of e-mobility in India. These include issues with high-voltage wiring harnesses of the e-Buses, thermal management, etc. The need for standards in the electric bus sector and the need for collaborations with leading organisations in this area were also mentioned.

Awareness and other Barriers: Private bus operators' awareness and confidence in e-bus technology are low. Some of these operators have 5 to 10 vehicles and are averse to risk with e-buses. This also sometimes leads to discussions on safety concerns and driver acceptance of e-buses.

3.3.5 End User Experiences and Impact of e-Mobility

End users and drivers' experiences: Some stakeholders also gave their opinions on end users' experiences. They mentioned that so far as users' experience is concerned since e-Buses are new, air-conditioned, and noiseless, they have good user acceptance. It is far higher in the case of a shift from diesel to electric (compared to a shift from CNG to electric) since both noise and smoke are key issues with diesel buses.

Because the buses are better quality, have less vibrations, no noise, and are air-conditioned with other facilities like phone charging etc., the end users find it convenient and comfortable. The patronage of public transport has increased since electric buses were introduced in cities.

Drivers also like e-Buses since they are easier to drive, have fewer vibrations, and no change of gear is required. Evolving acceptance of e-Buses among drivers emphasizing these factors and overall comfort was mentioned. A positive reception is seen as a crucial aspect of end-users' as well as drivers' experiences.

Impact of e-mobility: One of the stakeholders mentioned that the perception that the introduction of EVs would lead to job losses is completely wrong. Surat Municipal Corporation, for example, has introduced EVs and is continuously recruiting fresh staff to support its public transport operations. Additional staff is also required at the charging stations and other facilities. However, another stakeholder was of the opinion that though e-buses will not impact the overall jobs on the operations side much, some jobs would become redundant within state transport undertakings and be taken up by (contractual) bus operators. The jobs in diesel bus component manufacturing will be reduced. Vehicle maintenance is also less for e-buses, and therefore, such jobs can also be reduced.

4 Recommendations

In order to strengthen and advance the electric bus ecosystem in India, the study proposes a set of integrated recommendations that emerge from a thorough understanding of stakeholder perspectives and the challenges inhibiting widespread adoption.

- **Dynamic Policy Framework:** The government should adopt a dynamic policy framework that evolves with the industry, specifically addressing the financial risks faced by Original Equipment Manufacturers (OEMs). This would instill confidence and active participation from OEMs. Some stakeholders suggested some models, including the hybrid model in place of the current GCC model.
- **Inclusive Subsidy Mechanism:** Extending subsidies and incentives to include the private sector is crucial since a larger number of buses (e.g., school buses, office buses, tourist buses) are operated by private operators for fleet operations. This expansion would also mean that the charging infrastructure for buses goes beyond the depots, which will also be a plus for e-Buses operated by STU in cities. It will also promote healthy competition, fostering innovation and a more diversified industry landscape.
- **Financial Aggregator Establishment:** Establishing financial aggregators can alleviate operational risks for OEMs. This move ensures smoother financial transactions, reducing uncertainties associated with the Gross Cost Contract (GCC) model. Introducing leasing options tailored specifically for smaller operators can enhance their financial accessibility and encourage wider e-Bus adoption.
- **Attracting Private Sector Capital:** Initiatives that attract private sector capital into the electric bus manufacturing sector should be facilitated since capacity and competition are limited as of now. This will require providing policy certainty, reducing risks for OEMs through innovative business models and attracting global players with expertise to drive investment, innovation, and overall industry growth.
- **Diversification of Charging Models:** There is a need to explore and implement alternative charging infrastructure models beyond the current depot-centric approach. This will add flexibility to e-Bus operations and address existing limitations. Both public and private sector stakeholders need to join hands to explore and implement alternative charging infrastructure models that address operational constraints and scalability issues. Collaboration with stakeholders to collectively address challenges related to charging infrastructure, including grid capacity, standardisation, and cost-effectiveness, is essential for sustained progress.
- **Interoperability Prioritisation:** Interoperability of charging infrastructure should be a priority. Ensuring seamless operations that accommodate the diverse needs of various cities is crucial for a scalable and efficient system.
- **Collaboration for Grid Optimization and Standardization of charging tariffs:** Collaboration between manufacturers and regulatory authorities is vital to optimise the electric grid. This collaboration ensures efficient and sustainable e-Bus operations. Implementation of standardised charging tariffs nationwide is essential. This move ensures uniformity,

streamlining the charging infrastructure and enhancing operational efficiency across different cities.

- **Investment in Capacity-Building:** Investing in capacity-building initiatives to enhance the skills and knowledge of stakeholders involved in the e-Bus ecosystem is imperative. This promotes a skilled and adaptable workforce.
- **Improving operational and financial performance of STUs**: STUs poor financial health is a major risk for OEMs especially under GCC model. Privatisation of STUs was not found to be an easy route therefore other means should be explored that improve transparency of operations and financial health. For example, the relevant government should compensate the STU for any concession they ask the STU to make for any category of traveller- women, students, handicapped, etc.

These recommendations collectively strive to create an environment conducive to the widespread adoption and scaling up of electric buses in India. By fostering innovation, sustainability, and collaboration, the electric mobility sector can play a pivotal role in addressing urban challenges and contributing to the nation's economic and environmental goals. India's experiences can be valuable for many developing countries in formulating policies and establishing an ecosystem conducive to the adoption and scale-up of e-Buses.

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Annexes

Annex 1: Questionnaire used for interview with stakeholders

Issues	Questions	Government Authorities (including regulatory agencies)	Public Transport and other agencies	Manufacturers	Private Sector operators	Multilateral Financing Institution	Other multilateral Institutions, Research and Academics, NGOs, Experts
Ambitions	What enabling plans, strategies, and ambitions correlate to the implementation of the EV Buses?	√		√			
	What are your expectations from EV Buses being implemented in cities? Alt. also used: How do you see the e Bus program developing in India?	√	√	√	√	√	√
Policies	Do you think further actions are needed in terms of policies, regulations, financing etc. to scale up? What are they?	√	√	√	√	√	√
Economic	Do you think that the current import duties and vehicle taxes lead to high EV purchase costs? Will it affect the uptake of e-Buses in India? Are EV buses easily available in the market?	√	√	√	√	√	√
Battery Cost	Do you see the cost of battery replacement as a barrier?		√	√			
Electricity Cost	Price of electricity for charging? Will the price of electricity make use of EVs unviable?		√	√	?	?	√
Credit access	How easy or difficult is access to credit for EVs		√	√	√	√	√
Business Models	Are existing business models/jobs/services affected by	√	√	√	√	√	√

Issues	Questions	Government Authorities (including regulatory agencies)	Public Transport and other agencies	Manufacturers	Private Sector operators	Multilateral Financing Institution	Other multilateral Institutions, Research and Academics, NGOs, Experts
	the e-Mobility solutions to be introduced?						
Battery	Do you think battery life, range of EV Buses, reliability, and performance as barriers? Alt. also used: Do you think battery life, range, reliability, and performance are still an issue for E Buses	√	√	√	√	√	√
Charging	Is charging infrastructure adequate? What are the concerns if any?	√	√	√	√	√	√
Implementation	What are the potential obstacles to project implementation? Alt. also used: What are the potential issues for implementation of e-Bus projects in cities		√	√	√	√	√
	What are the planning implications (externalities) for the transport system? (how need to change?)	√	√	√	√	√	√
	Are maintenance facilities (including skilled workforce) available?		√	√			
Safety	Are the proposed solutions safer than those currently used?		√	√			
End users	Is there customer acceptance or even preference? (is it an Issue?)	√	√	√	√	√	√
Other	CESL's latest round is 31% cheaper compared to diesel and 18% CNG without subsidy per km cost. Will this advantage of electric cost over diesel continue?	√					

Issues	Questions	Government Authorities (including regulatory agencies)	Public Transport and other agencies	Manufacturers	Private Sector operators	Multilateral Financing Institution	Other multilateral Institutions, Research and Academics, NGOs, Experts
	1 lakh buses by 2030; Each battery 200kW means 100000*0.2= 50,000 MW load. Can the grid take it by 2030? What is all needed?	√ (only regulatory auth.)					

Annex 2: Case study of electric buses in Pune4

The shift towards electrifying public transportation is pivotal in reducing urban carbon emissions. Despite the infancy of India's domestic electric bus (e-Bus) market, forecasts predict that 40% of buses sold in the country could be electric by 2030. Pune, Maharashtra, stands as a noteworthy case study, being an early adopter in the realm of e-Buses, shedding light on the electrification of public transport.

Pune's public transport agency, Pune Mahanagar Parivahan Mahamandal Limited (PMPML), currently boasts one of India's largest municipal e-Bus fleets, with 220 e-Buses operating among its 2,169-bus fleet. With an additional 430 e-Buses awaiting commissioning through the tender process, Pune is poised to surpass the target set by the state government's electric vehicle policy, achieving 25% electrification of the public transport bus fleet by 2025 — three years ahead of schedule. Pune is also running these buses on the BRT corridor (Figure 1)

Figure 1: An electric bus running on the Pune BRT corridor
Photo courtesy: Dinesh Hukmani, iStock

[4] PMC, PMPML, PSCDCL, RMI, and RMI India, *Pioneering Electric Buses in Pune: A Case Study of the City's Initial Procurement and Operations*, April 2022.

Pune's experience in e-Bus procurement and operation provides key insights for successful adoption in public transport fleets:

1. **Political Leadership as Catalyst:**
    - Political leaders from various municipal bodies in Pune demonstrated dedication to addressing air pollution, driving the joint commitment to procure e-Buses.
    - Alignment among decision-makers, common understanding, and persistent support facilitated the implementation of initiatives.
2. **Interdepartmental Coordination:**
    - The formation of an e-Bus working group involving multiple departments ensured efficient decision-making and coordinated activities.
    - Technical support from external entities on business model design, tendering, contracting, and charging infrastructure planning expedited the planning phase.
3. **Economic Viability of E-buses:**
    - The Total Cost of Ownership (TCO) for e-Buses was found to be 15% lower than diesel buses, making them more economical (see Figure 2).
    - Government incentives further increased cost savings, with each e-Bus providing significant savings over 10 years.
4. **Gross Cost Contract Procurement Model:**
    - The Gross Cost Contract (GCC) or Operational Expenditure (OPEX) model was instrumental in accelerating e-Bus adoption and mitigating risks faced by public transport agencies.
    - Previous experience with the GCC model facilitated smooth tendering and contracting processes.

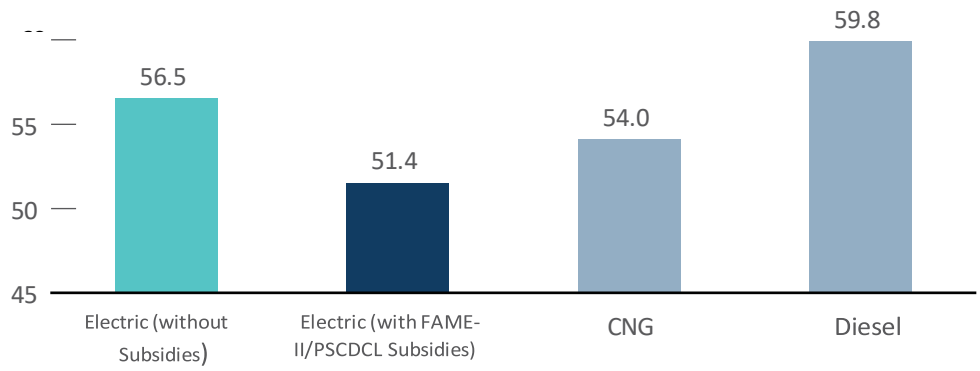

Figure 2: Total cost of ownership comparison for 12-metre AC buses

Source: RMI and RMI India analysis; Reproduced from PMC et.al (2022).

5. **Performance of e-Bus Technology:**
    - Current e-Bus and charging infrastructure technology met performance requirements, with no reported issues in service, maintenance, or infrastructure.
    - e-Buses successfully completed contracted daily distances using overnight and daytime charging.
6. **Proactive Planning for Efficient Operations:**
    - Proactive planning for large loads ensured efficient commissioning and safe operations, addressing the need for substantial service capacity at charging stations.
    - Collaboration with the local distribution utility facilitated grid upgrades and identified opportunities for cost savings through off-peak charging.
7. **Environmental Benefits:**
    - Adoption of e-Buses in Pune has the potential to significantly reduce PM2.5 and CO2 emissions compared to diesel buses.
    - The fleet of 650 e-Buses could avoid 1.2 tons of PM2.5 and 96,000 tons of CO2 emissions over the lifetime of the vehicles.
8. **Positive Stakeholder Reception:**
    - e-Buses have been well-received by drivers, riders, government officials, and urban local bodies, with reported benefits including quieter and more comfortable conditions.
9. **Exceeding Electrification Targets:**
    - Pune is on track to meet the Government of Maharashtra's public transport electrification target three years ahead of schedule, aiming for 25% electrification by 2025.
10. **Inspiring Global Efforts:**
    - Pune aims to inspire other cities in India and the Global South to successfully incorporate e-Buses into their public transport fleets through its experience and success.

Through comprehensive planning, collaboration, and economic considerations, Pune's case study provides a roadmap for cities looking to embrace environmentally friendly e-Buses in their public transportation systems.

Annex 3: Case study of electric buses in Kolkata5

The city of Kolkata has a dense yet one of the most robust networks of public transportation – a combination of railways, rapid sub-urban Metrorail, trams, buses, three-wheelers, and ferries. 925 bus routes are operating in the Kolkata Metropolitan Area (KMA), out of which 38% are being operated by state transport undertakings (STUs) while private operators operate the remaining routes. Kolkata has a well-established inter-state road connectivity network with other parts of the country through national and state highways (NH-2, 6, 34 & 117).

Air Pollution from Transport: Kolkata faces severe air pollution, recording high levels of particulate matter (PM) and Nitrogen Oxide (NOx) emissions despite fewer vehicles than other cities. Older diesel buses contribute significantly, accounting for 33% of particulate matter emissions. Monthly PM2.5 and PM10 values exceed specified limits from October to March. Shared mobility is predominant, with 80-85% access, using buses, metro, and trams. The city operates 1,553 diesel buses, adhering to Euro-III & IV standards. Fuel economy averages 2-3 km/litre. Emission-compliant conventional fleets strive to meet government standards, and a fully charged bus can cover over 150 km.

Figure 3 : An Electric Bus operating in Kolkata
Photo courtesy: Rima Das Mukerjee, iStock

[5] Successful Operation of Electric Bus Fleet – "A Case Study of Kolkata" The Energy and Resources Institute, New Delhi, 2020.

Impact of Electric Buses: Despite successfully incorporating 80 e-Buses into existing depots with manageable capital expenses, the challenge lies in expanding charging infrastructure for additional buses. Initial concerns, such as charger tripping and grid synchronization issues, were resolved through software re-configurations. Validation during installation is crucial to prevent operational glitches. The 9m e-Buses exhibited a shorter-than-expected driving range, prompting regular monitoring of charging impact on the distribution network. WBTC actively plans sustainability measures, including encouraging solar-powered charging. Under FAME-II's OPEX model, higher bus prices pose a challenge to transitioning to cleaner public transport. Infrastructure constraints limit point-to-point charging, leading to the establishment of nine terminus points for intermediate charging. WBTC plans to incorporate cleaner energy sources and explores potential benefits through time-of-use tariffs and solar-plus-storage solutions. TERI's detailed case study, part of the Global EV Outlook 2020, provides comprehensive insights.

Annex 4: Business models for e-Bus Operations

In India two business models have been commonly used for bus procurement and both of them have been used for e-Bus procurement under FAME I & II.

Outright Purchase Model (OPM)

The OPM model is illustrated in Figure 4. The bus, battery and charger are sold by the OEM to State Transport Undertaking (STU). The STU is responsible for operation and maintenance. The OEM has limited risks and the STU bears all the risks and has to arrange all finance for purchase as well as operation and maintenance. This was the preferred business model under FAME I.

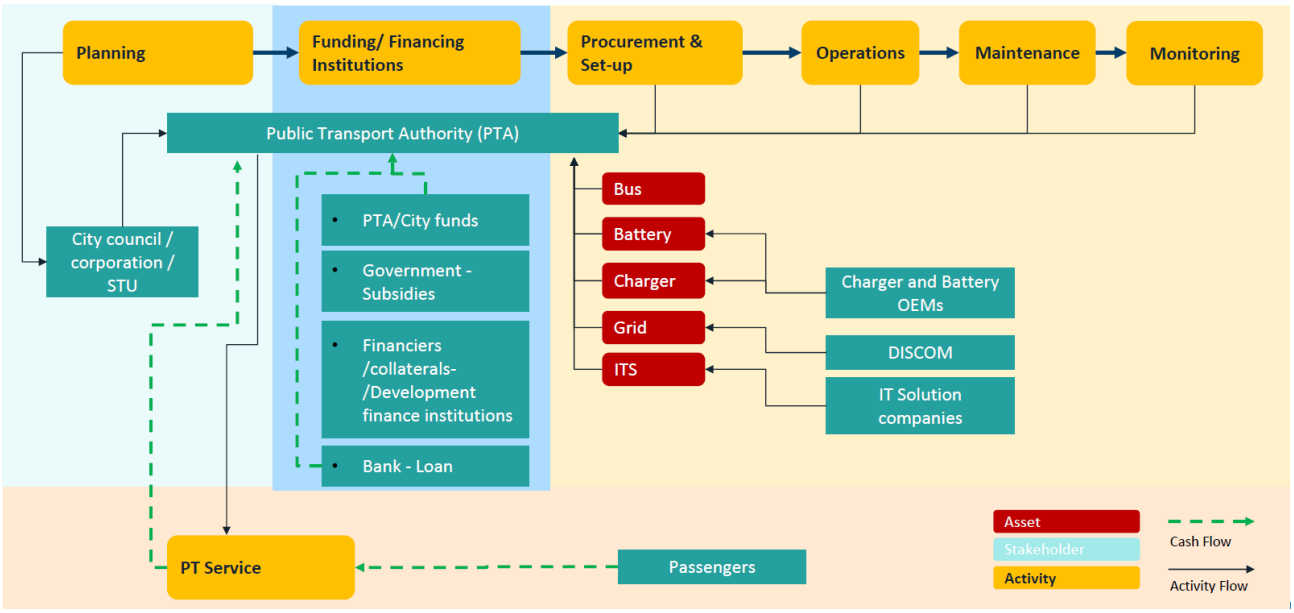

Figure 4: Outright Purchase Model

Source : C40 & TUMI(2023)

Gross Cost Contract Model (GCC)

The GCC model is illustrated in Figure 5. The OEM owns, operates, and maintains the buses, batteries and charging infrastructure for an assured payment for operating the buses. The OEM bears all the risks whereas the STU bears limited risks. This has been the preferred business model under FAME II and the model used by CESL for the grand challenge.

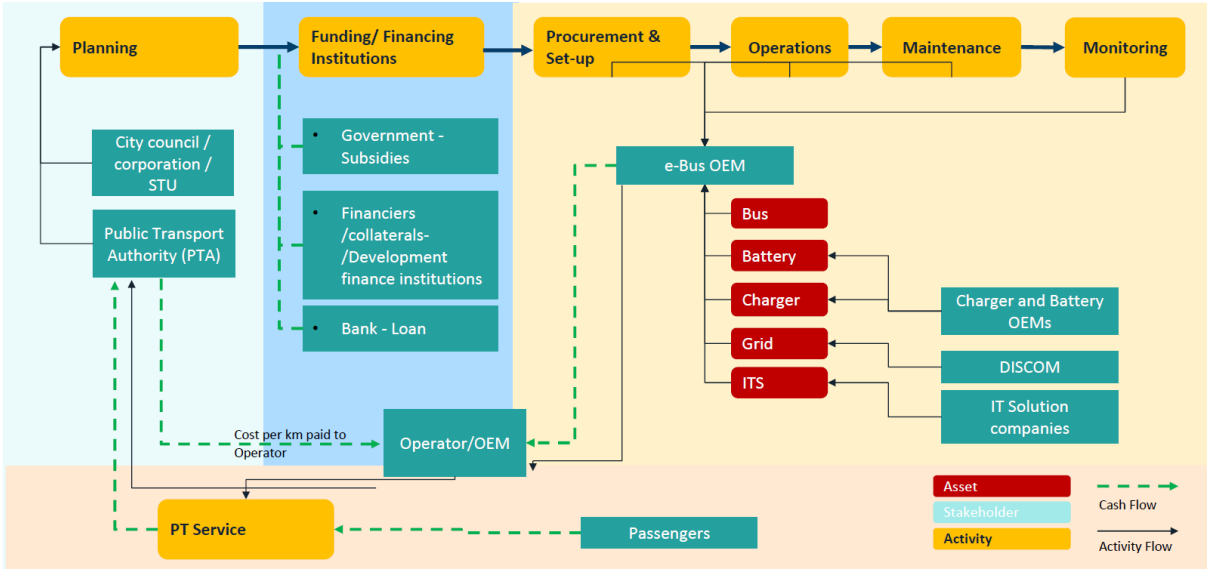

Figure 5: Gross Cost Contract Model

Source : C40 & TUMI(2023)

Hybrid Model

Under this model the buses are purchased by the STU, but the operation and maintenance are the responsibility of the bidder (OEMs), who have a better understanding of the e-Bus technology. The OEMs are paid for the maintenance. In yet another hybrid model, buses are owned and maintained by OEMs but operated by STUs (the service providers). OEMs are paid on a per km basis and with a guarantee of minimum kilometers for payment purposes.

Annex 5: Electricity Prices for Charging

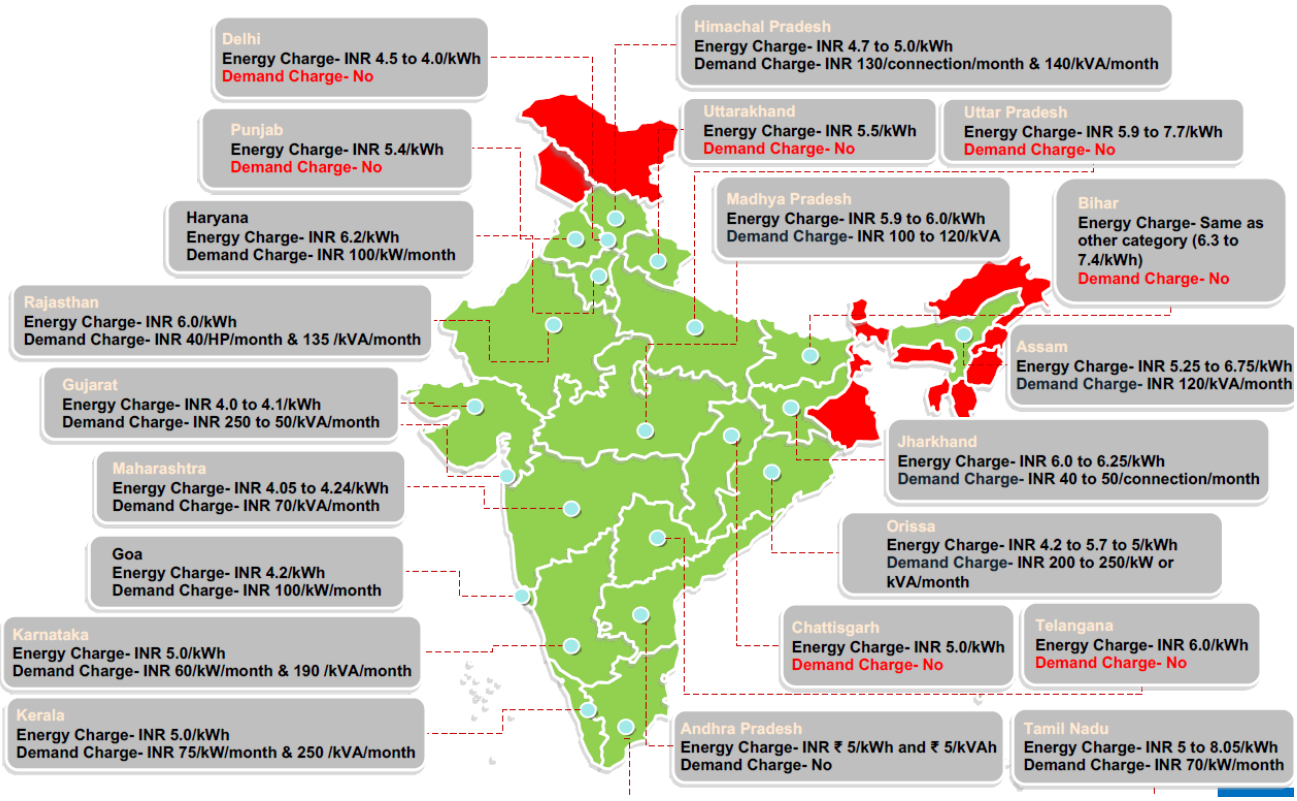

Figure 6: Electricity Prices for Charging in Different States

Source : C40 & TUMI(2023)


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