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REPORT ON FINDINGS AND NEXT STEPS IN

SCALING UP E-BUS DEPLOYMENT IN INDIA

In partnership with Convergence Energy Services Limited (CESL) | October 2024

Foreword by USAID

Apurva Chaturvedi
Senior Clean Energy Specialist
USAID

With rapid urbanization and a booming economy, emissions from the transportation sector have increased, accounting for 20% to 30% of emissions in South Asia. Decarbonizing transportation is crucial to achieving the net zero emission goals in the region. Electrifying public transport, especially buses, offers a strategic solution to reduce emissions while providing a cleaner, more efficient public transport. South Asia has already begun this transition towards e-bus adoption, however further acceleration is necessary.

Through targeted policies, schemes, and innovative business models, India has been able to successfully deploy e-buses, especially in cities, and achieve cost parity with diesel buses. The India experience in this sector can reduce the learning curve, thereby enabling large-scale deployment of e-buses in the region.

The United States Agency for International Development in India (USAID) India is unwavering in its commitment to supporting India's transition to cleaner transportation. Through initiatives such as the US-India Payment Security Mechanism (PSM), the scale of e-bus deployment is expected to undergo an orbital shift. Our strong partnership with Convergence Energy Services Limited (CESL), since its inception, has also been instrumental in implementation of the Government of India's e-bus schemes like FAME II and PM eBus Sewa.

During the last year, USAID and CESL convened five consultations, bringing together key stakeholders across the e-bus segment. Policymakers, bus operators, Original Equipment Manufacturers (OEMs), charge point operators, and financiers participated in these consultations, sharing their insights and expertise. This report consolidates the key findings and recommendations from these consultations, providing a roadmap for overcoming the challenges hindering e-bus adoption.

I sincerely hope that this report will provide insights and learnings to the readers as they work towards e-bus deployment in their respective countries.

MD & CEO's Message

Shri Vishal Kapoor
MD & CEO, Convergence Energy Services Limited (CESL)

Dear Stakeholders,

Transportation is a critical sector impacting India's journey towards a clean energy transition, aligned with our ambitious climate goals and our vision of building a prosperous and developed India (Viksit Bharat) by 2047.

With the second largest road network in the world, and a sizable daily ridership of over 70 million passengers on public buses alone, India presents a unique opportunity to accelerate adoption of electric buses.

CESL, with its expertise in e-bus procurement and deployment, has been at the forefront of this transformation. Our collaboration with USAID SAREP has been instrumental in identifying key challenges and opportunities in scaling up e-bus adoption. Through our joint efforts, we have been able to design and implement effective tendering processes, aligning bid and concession documents to facilitate wider participation and ensure the best possible outcomes.

To gain a deeper understanding of the challenges and opportunities in the e-bus ecosystem, we conducted a series of five stakeholder consultations across India. These consultations brought together diverse stakeholders, including government officials, industry experts, and representatives from various user institutions. By engaging with these stakeholders, we were able to gather valuable insights and identify key recommendations for scaling up e-bus deployment.

I am pleased to present this white paper, which summarizes the key findings and recommendations from these consultations. This report offers a comprehensive overview of the current state of e-bus adoption in India, identifies key challenges, and proposes actionable solutions.

I am confident that this white paper will serve as a valuable resource for policymakers, industry stakeholders, and investors, guiding our collective efforts towards a cleaner, greener, and more sustainable India.

As we move forward, I am optimistic about the continued success of our partnership with USAID SAREP and our unwavering commitment to scaling up e-bus deployment in India. Together, we can create a brighter future for our nation.

Thank you.

Acknowledgement

The authors of this white paper would like to express their gratitude to the team at Convergence Energy Services Limited (CESL), comprising of Shri Vishal Kapoor, MD & CEO, CESL, Mr. Rajneesh Rana, Head (Convergence) and all CESL officials, whose support was instrumental in conducting stakeholder consultations with the primary beneficiaries.

We extend our sincere gratitude to Mr. Ravi Gadepalli, Principal Consultant at Transit Intelligence, for his invaluable insights and unwavering support throughout the consultation period. His contribution, including sharing international best practices for promoting e-bus adoption, has been instrumental in shaping our efforts.

We would like to express our sincere appreciation to Ms. Apurva Chaturvedi, Senior Regional Clean Energy Specialist at USAID, and Ms. Namrata Mukherjee, SAREP, for their invaluable guidance and insightful direction throughout the stakeholder consultations. Their expertise and dedicated support were instrumental in shaping the discussions and ensuring the success of this initiative.

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List of Acronyms

ARAI	Automotive Research Association of India
BaaS	Battery-as-a-Service
BCMS	Battery Charging and Management Services
BMTC	Bengaluru Metropolitan Transport Corporation
BODS	Bus Open Data Service
CAGR	Cumulative Annual Growth Rate
Capex	Capital Expenditure
CESL	Convergence Energy Services Limited
CISG	Contracts for the International Sale of Goods
CNG	Compressed Natural Gas
CO2	Carbon Di-oxide
COP	Conference of the Parties
CTU	Chandigarh Transport Undertaking
DC / AC	Direct Current / Alternating Current
DFI	Development Finance Institution
DHI	Department of Heavy Industries
DIMTS	Delhi Integrated Multi-Modal Transit Systems
DISCOM	Distribution Company
DTC	Delhi Transport Corporation
E-bus	Electric Bus
ECE	Economic Commission for Europe
EESL	Energy Efficiency Services Limited
EU	European Union
EV	Electric Vehicle
FAME	Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India
GC	Grand Challenge
GCC	Gross Cost Contract
GHG	Green House Gases
IT	Information Technology
ITS	Intelligent Transport System
KM	Kilometer
LTO	Lithium-titanium-oxide
MaaS	Mobility-as-a-Service
MHI	Ministry of Heavy Industries
MoP	Ministry of Power
MoRTH	Ministry of Road Transport and Highways
NBFC	Non-Banking Financial Company
NCAP	National Clean Air Programme
NCC	Net Cost Contract
NDC	Nationally Determined Contribution
NEBP	National Electric Bus Programme

NEMMP	National Electric Mobility Mission Plan
NITI	National Institution for Transforming India
OEM	Original Equipment Manufacturer
Opex	Operational Expenditure
PLI	Production Linked Incentive
PPP	Public-Private Partnership
PSM	Payment Security Mechanism
SRTU	State Road Transport Undertakings
STU	State Transport Undertakings
TfL	Transport for London
UK	United Kingdom
USAID	United States Agency for International Development
WVTA	Whole Vehicle Type Approval

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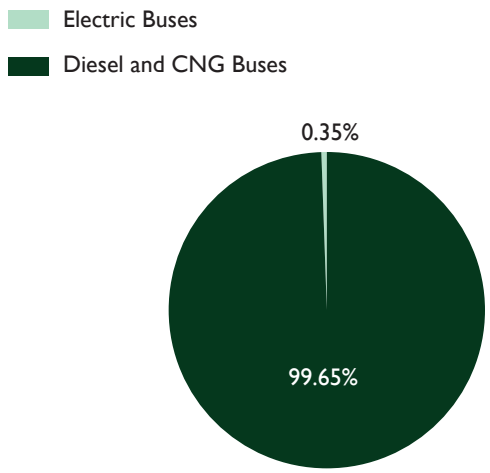
1. Introduction to Electric Buses

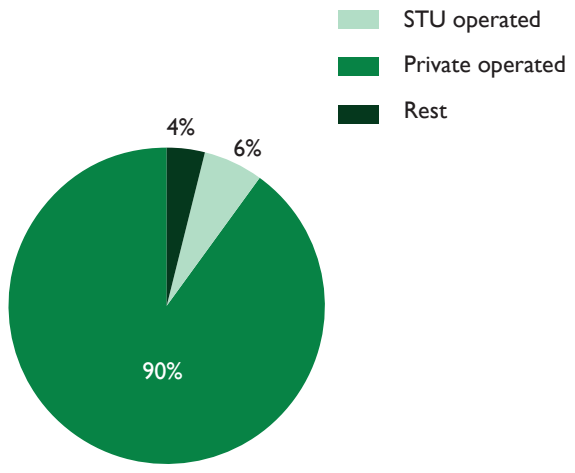
India's commitment to transitioning towards a sustainable future is demonstrated by its ambitious 'Panchamrit' goals, announced at the COP26 summit in Glasgow in 2021. Among these targets, India aims to achieve net-zero emissions by 2070, with significant milestones set for reducing greenhouse gas (GHG) emissions intensity, increasing non-fossil energy capacity, and meeting a substantial portion of its energy needs from renewable sources by 2030. The transportation sector, a significant contributor to India's CO2 emissions—accounting for 12% of the country's CO2 emissions—plays a crucial role in achieving India's Nationally Determined Contribution (NDC) targets. Recognizing the need to decarbonize this sector, India has embarked on an accelerated path to adopt electric vehicles (EVs). The transition to EVs is a necessary step for achieving the Panchamrit targets and also a critical component of India's strategy to ensure a sustainable and resilient future.

Buses are India's predominant form of public transport, accounting for approximately 40% of road-based travel demand (measured in passenger-kilometers traveled) (TERI, 2024). This makes India the third-largest bus market in the world (MoRTH, 2023). The transition to electric buses (e-buses)presents the opportunity to convert the maximum passenger kilometer (km) of travel to zero-emission transport in Indian cities. It has the potential to yield a variety of benefits, including improved energy efficiency and air quality, along with longer-term climate change mitigation benefits.

There are about 23 lakh registered buses in India as of March 2024, a number expected to reach approximately 32 lakh by 2030. Approximately 1.40 lakh of these buses are operated by public transport agencies such as state and municipal transport undertakings. Around 90% of the total bus stock is operated by private operators, serving as rural and intercity services, school buses, corporate transport services, tourist buses, and other applications. Central and state governments, local authorities, and other government departments use the remaining buses.



Registered E-buses in India



Break-up of Registered Buses in India

2. Policy Scenario for E-Buses in India

The market for e-buses in India is not market driven but is defined by government policies and efforts in terms of both demand and supply. This section aims to assess the current policy focus for e-buses and identify implementable lessons for the future.

The Central government launched 'The National Electric Mobility Mission Plan (NEMMP)' in 2013 to be administered by the Department of Heavy Industries (DHI). In 2015, DHI launched the 'Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME)' Scheme with an initial outlay of INR 7.95 billion. FAME's mandate involved demand creation for electric vehicles, technology proliferation, launch of pilot projects, and building charging infrastructure. During the first phase of FAME (2015-2019), 465 e-buses were sanctioned for distribution to different cities.

FAME-II was announced in 2019 as an extension of FAME, with a much larger outlay of INR 100 billion for three years. The most significant outlay was for demand incentives, followed by charging infrastructure and administrative expenditures. E-buses receive a subsidy of INR 20,000/kWh of battery capacity, double that of most other segments. The maximum incentive for a bus is pegged at INR 50 lakh, with the scheme covering only buses with an ex-factory retail price below INR 2 crore. The table below provides details of e-buses held by SRTCs as of Sep'23[1]:

1 SRTU Fleet Handbook - 2024

Table 1: Stock of E-Buses by STUs as of September 2023

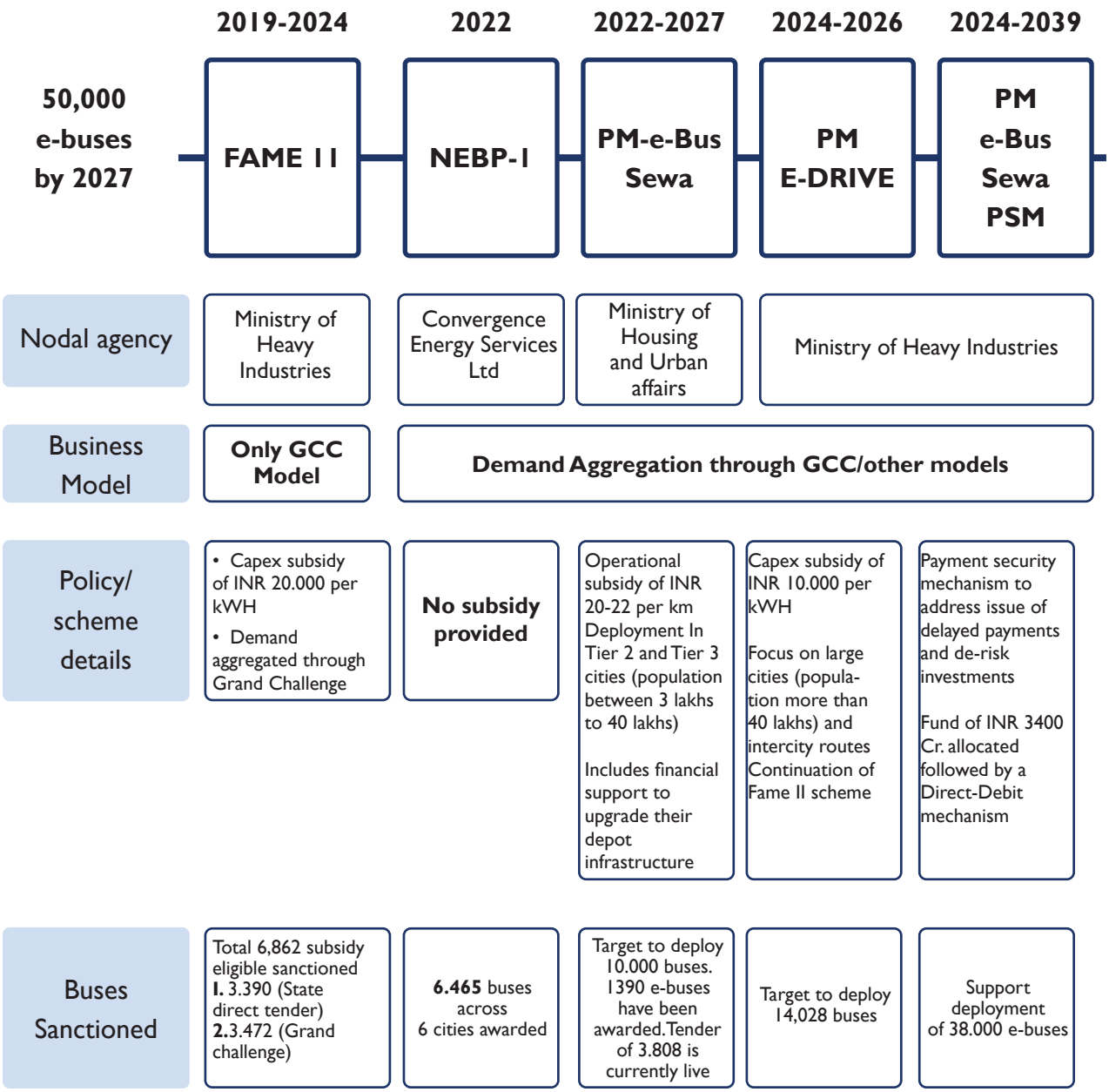
Sl. No.	STU	E-Buses
1	Ahmedabad Janmarg Limited	200
2	Andaman & Nicobar Administration	40
3	Andhra Pradesh SRTC	100
4	Assam SRTC	15
5	Bengaluru Metropolitan Transport Corporation	391
6	Bhubaneswar-Puri Transport Services (CRUT)	50
7	Bihar SRTC	25
8	BEST Undertaking	426
9	Calcutta State Transport Corporation	59
10	Chandigarh Transport Undertaking (CTU)	80
11	Delhi Integrated Multi-Modal Transit Systems (DIMTS)	100
12	Delhi Transport Corporation (DTC)	1180
13	Gujarat SRTC	50
14	Himachal RTC	110
15	J&K SRTC	40
16	Kadamba Transport Corporation (Goa)	83
17	Karnataka SRTC	50
18	Kerala SRTC	110
19	Maharashtra SRTC	137
20	Mira Bhayandar Municipal Transport	7
21	Nagpur Municipal Corporation	96
22	NMMT Undertaking	195
	Total E-Buses	**3544**

The Government of India also launched a USD 10 billion (INR 840 billion) National Electric Bus Program (NEBP) in June 2022 with an aim to deploy 50,000 new e-buses across the country by 2027 in a phased manner. To further strengthen the decarbonization of public transport, the Government of India launched the PM-e-Bus Sewa Scheme in August 2023 with an aim to augment bus operations by deploying 10,000 e-buses.

Recently, to boost public transportation in India, the Union government has announced to support the deployment of more than 50,000 electric buses through two different schemes - PM Electric Drive Revolution in Innovative Vehicle Enhancement (PM E-DRIVE) and PM-eBus Sewa-Payment Security Mechanism (PSM) - with a total outlay of INR 7,826.33 crore. The PM E-DRIVE scheme will support 14,028 units of electric buses with a corpus of INR 4,391 crore over a period of two years, while the PM-eBus Sewa-PSM scheme will support 38,000 units with INR 3,435.33 crore.

Under the PM E-DRIVE scheme, STUs will procure electric buses. The demand aggregation will be done by CESL in the nine cities with more than 40 lakh population. The cities are Delhi, Mumbai, Kolkata, Chennai, Ahmedabad, Surat, Bangalore, Pune, and Hyderabad. Intercity and interstate e-buses will also be supported in consultation with states.

The PM-e-Bus Sewa-PSM scheme will support the deployment of electric buses from FY25 till FY29 and their operation for a period of up to 12 years from the date of deployment. The scheme includes a payment security mechanism to ensure timely payments to OEMs and bus operators. If an STU defaults on payments, CESL will cover the payments using the scheme funds. The infographic below summarises the key government initiatives to accelerate the e-bus adoption in India.



The government's efforts have laid a strong foundation for e-bus deployment, setting the stage for sustainable public transportation. Expanding these schemes will further accelerate India's progress toward comprehensive electrification, ensuring broader adoption across public transport networks. There are more than 8,000 e-buses registered in India as of March 2024 (VAHAN Dashboard).

Table 2: Status of GC, NEBP, and PM-e-Bus Sewa Tenders

Particulars	Grand Challenge	NEBP-I	PM e-Bus Sewa I	PM e-Bus Sewa II
Number of Buses Tendered	5,450	6,465	3,825	3,808
Number of Buses Delivered	1,200	30	0	0
Applicability of Subsidy	Yes	No	Yes	Yes
Partner Ministry/ Organization	Ministry of Heavy Industries	NITI Aayog	Ministry of Housing & Urban Affairs	Ministry of Heavy Industries
States/Cities	5 cities	6 states/cities	11 states / 50 cities	18 states
GCC Model	Yes	Yes	Yes	Yes
PSM	No	No	Yes	Yes

Currently, CESL has made the second tender under PM-e-Bus Sewa Scheme live on their website for 3,808 e-buses.

3. E-Bus Technical Characteristics

E-buses come in various sizes and configurations, each tailored to specific operational needs, city infrastructure, and passenger volumes.

3.1. Size Variants

The most common sizes for e-buses in India are the 7-meter, 9-meter, and 12-meter variants. These buses differ not only in physical dimensions but also in their battery capacity, range, and charging strategies.

7-meter e-buses (Mini Bus)

- Designed primarily for intra-city and feeder services, these buses are compact and ideal for narrow urban streets and low-passenger routes;
- Typically, it offers a range of 100-150 km;
- Seating capacity is around 13-22 passengers plus driver;

9-meter e-buses (Midi Bus)

- These mid-size buses are versatile. They are commonly used on both urban and sub urban routes and offer a balance between capacity and manoeuvrability;
- Typically, it offers a range of 150-200 km;
- Seating capacity is around 23-34 passengers plus driver;

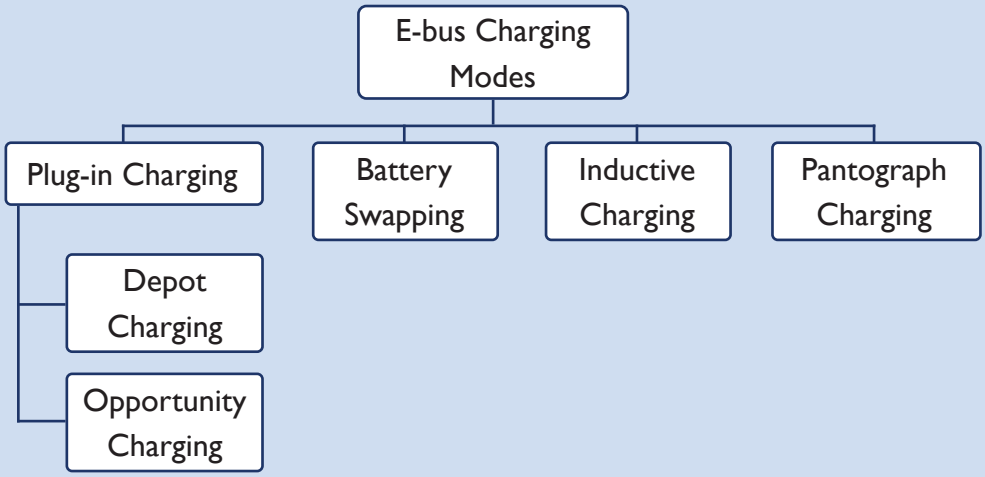
12-meter e-buses (Standard Bus)

- The most common variant for city transport is full-sized buses, which are used in high demand routes and long-distance intercity travel;
- Typically, it offers a range of 200-300 km;
- Seating capacity is around 35-70 passengers;

3.2. Charging Strategies

There are two main strategies or modes of e-bus charging prevalently used in India, namely Conductive Charging and Battery Swapping. Conductive charging is done through plugs that need to be connected to the e-bus. Battery swapping involves replacement of a depleted battery with a charged battery.

Figure 1: Electric Bus Charging Strategies / Modes



3.2.1. Conductive Charging

Depot charging and opportunity charging are the two most commonly used strategies for charging e-buses using conductive chargers.

Depot charging is when e-buses are charged at the depots or where the buses are parked after service hours. It is also known as overnight charging. It is generally done using slow DC chargers, ensuring longer battery life and grid stability due to charging during off-peak hours. *Opportunity charging* is when the e-bus is charged between the depot routes with ultra-fast DC chargers. This adversely affects the battery cycle life and significantly increases the load on the grid.

3.2.2. Battery Swapping

Battery swapping addresses the significant drawback of long in-depot charging times for plug-in battery buses, offering a turnaround time comparable to diesel or CNG refueling. However, this benefit comes with the trade-off of a reduced range, as the batteries must be smaller and lighter for easier swapping. Additionally, battery swapping requires automated robotic arm systems, adding to the infrastructure costs beyond the standard battery chargers. These extra expenses can make battery swapping less appealing for widespread adoption.

In addition to these two charging strategies, inductive charging and pantograph charging have also been piloted in a few countries for e-bus charging.

4. Understanding E-Bus Benefits

The transition from conventional diesel-powered buses to e-buses presents many benefits, not only in terms of environmental impact but also regarding economic, operational, and public health advantages. This section explores the key benefits of e-buses over conventional buses.

4.1. Environmental Benefits

One of the most significant advantages of e-buses is the reduction of greenhouse gas emissions compared to conventional diesel buses. Diesel buses are significant source of GHGs such as carbon dioxide (CO), methane (CH), and nitrous oxide (NO), which contribute to global warming and climate change. A report by the International Energy Agency (IEA) states that a single diesel bus emits about 4.65 metric tons of CO per year. In contrast, an e-bus powered by a renewable energy grid emits zero tailpipe emissions.

4.2. Operational Benefits

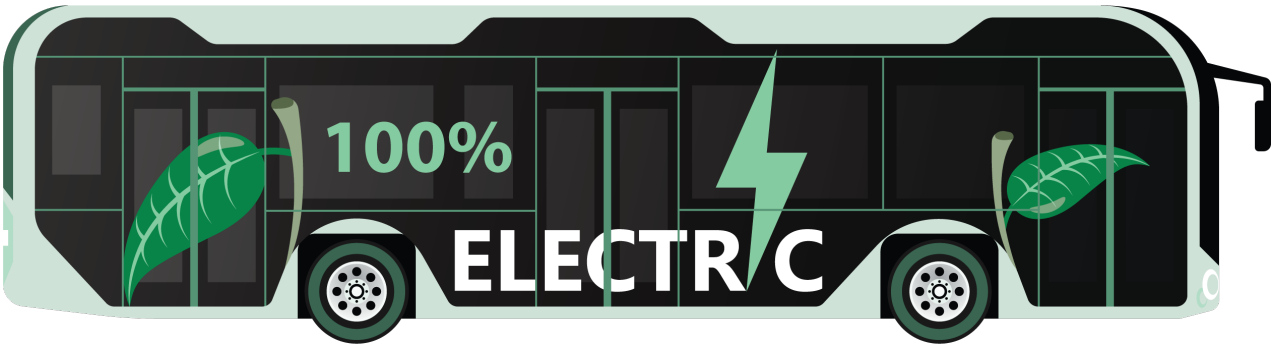
E-buses are much quieter than diesel buses, reducing noise pollution in urban areas. This is particularly important in densely populated cities where noise pollution is a significant issue. In addition, e-buses are equipped with regenerative braking systems, which capture and store energy when the bus slows down. This increases overall energy efficiency and reduces wear and tear on the brake systems, resulting in lower maintenance costs.

4.3. Social Benefits

The growth of the e-bus industry leads to job creation in sectors such as battery manufacturing, charging infrastructure development, and EV maintenance. The localization of e-bus components also strengthens the domestic manufacturing ecosystem. With zero exhaust emissions, e-buses contribute to healthier living conditions by reducing respiratory diseases linked to air pollution. This leads to lower healthcare costs and improved public health outcomes.

4.4. Economic Benefits

While the upfront cost of e-buses is significantly higher than that of conventional buses, fuel and maintenance expenses are significantly lower. Therefore, higher utilization (daily kilometers travelled) of an e-bus leads to more operational cost savings compared to a diesel bus.



5. Challenges in E-Bus Adoption

The adoption of e-buses in India presents a transformative opportunity to advance the country's public transportation system, reduce pollution, and achieve sustainable mobility goals. However, this transition presents a variety of challenges and barriers that span financial, operational, technological, and regulatory domains, as highlighted below:

5.1. Financial Challenges

High Upfront Costs

The initial capital cost of an e-bus is significantly higher than that of a conventional diesel bus. For instance, the cost of an e-bus in India can range from INR 80 lakh to INR 1.5 crore, which is approximately 2.5 to 4 times higher than a comparable diesel bus. This high upfront cost is a significant deterrent for State Transport Undertakings (STUs) /Authorities and private operators, especially in a price-sensitive market like India.

Inadequate Financing Options

Financing options for e-buses are limited and often come with high-interest rates due to perceived risks associated with the new technology. Leasing models, though available, are not widely adopted. This limits the spread of financial risk and makes it difficult for smaller operators to invest in e-buses.

5.2. Operational Challenges

Range Anxiety and Limited Charging Infrastructure

The average range of an e-bus is around 150-250 km per charge, depending on factors such as battery capacity and operating conditions. This range may not be sufficient for longer routes, leading to range anxiety among operators. The lack of widespread charging infrastructure exacerbates this problem.

To complement the government's proactive policies, further streamlining the process of obtaining electricity connections for e-bus charging points will enhance efficiency. The Ministry of Power's recent guidelines "Guidelines for Installation and Operation of Electric Vehicle Charging Infrastructure-2024" mark an important step, and continued alignment with DISCOMs will be key to faster infrastructure deployment.

Land Acquisition and Permits

Given the rapid urbanization and space constraints in cities, facilitating smoother land acquisition and clearance processes will unlock new opportunities. Collaboration between urban planning authorities and transport agencies can expedite these efforts, supporting India's sustainability goals.

Long Charging Times

Fast charging can take 2-3 hours, while regular charging may take up to 4-8 hours. This downtime reduces the operational efficiency of e-buses compared to diesel buses, which can be refuelled in minutes. The requirement for charging during off-peak hours also complicates scheduling, especially for operators with high-frequency services.

5.3. Technological Challenges

Limited Domestic Manufacturing Capacity

India's e-bus sector has made remarkable strides, and the growth of local manufacturing capabilities will further strengthen the ecosystem. Promoting domestic production of advanced EV components, alongside strategic partnerships to mitigate global supply chain disruptions, will ensure resilience in the sector's growth.

6. CESL Series of Stakeholder Consultations

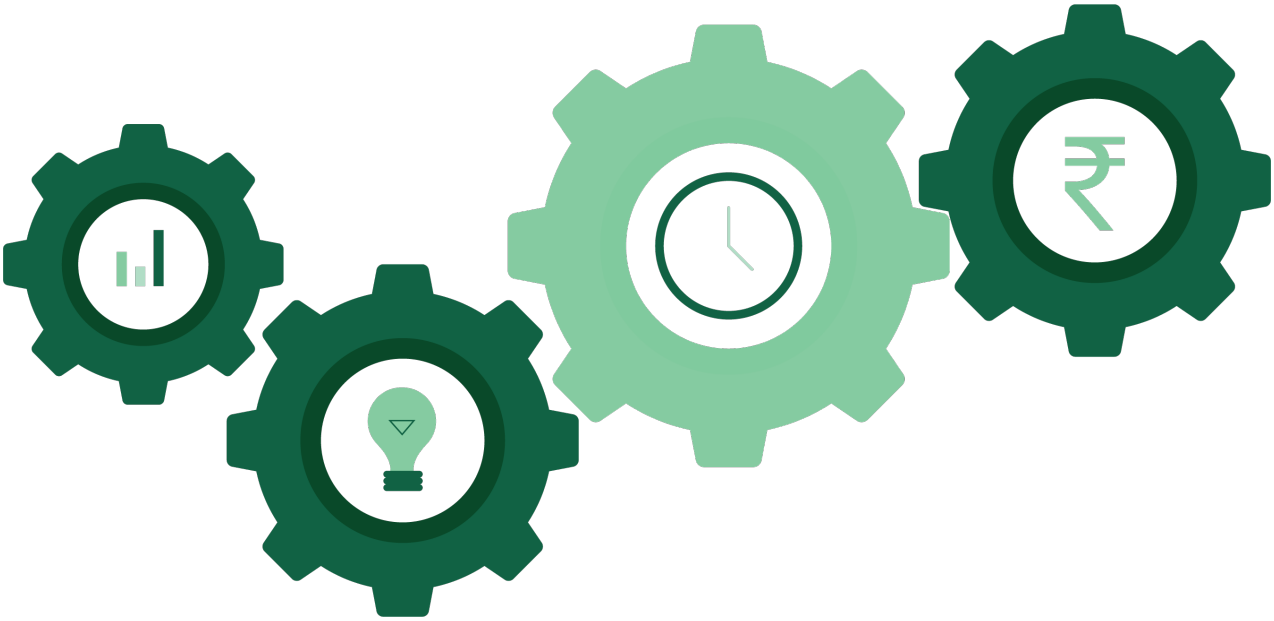
Convergence Energy Services Limited (CESL) has been a frontrunner in aggregating demand for e-buses in India. CESL is a wholly owned subsidiary of Energy Efficiency Services Limited (EESL), under the administration of the Ministry of Power (MOP), Government of India. CESL has experience in tendering over 20,000 e-buses in India through multiple tenders. A brief of all tenders floated, and demand aggregated by CESL has been summarized below:

Grand Challenge (GC)	• CESL managed to standardize e-bus specifications, terms & conditions of public transport across cities and subsequently issued a 'Grand Challenge' tender which was able to aggregate demand of 5,450 e-buses across five cities under the Gross Cost Contract (GCC) model with FAME subsidy benefit. The 'Grand Challenge' tender discovered the lowest bid rates for e-bus operations in Indian cities. • Procurement model moved from outright purchase of buses to an asset light Mobility as a Service (MaaS) model for the public transport authorities.
National Electric Bus Program I (NEBP I)	• CESL was nominated as the Program Manager for aggregating demand under NEBP and ensuring deployment of 50,000 e-Buses. CESL concluded the first tender under NEBP by aggregating a total demand of 6,465 e-buses across 6 Indian states/cities/ State Transport Undertakings (STUs) on a GCC or wet lease model. This phase of tendering targeted Type-I intra-city (5,315 e-buses), Type-II mofussil (200 e-buses), and Type-III inter-city (950 e-buses) operations. • The prices discovered under this tender did not include any subsidies and were 31% lower than diesel and 18% lower than CNG buses.
National Electric Bus Program II (NEBP II)	• A second tender, NEBP II was issued for aggregating demand of 4,675 e-buses on a dry lease GCC model. • Under the dry lease model, the e-bus is owned and maintained by the Operator for a per km fees throughout the contract period and the drivers for the e-buses are provided by the STUs.
PM e-Bus Sewa Scheme	• The Government of India recently approved 'PM-e-Bus Sewa' to augment city bus operations. Under this scheme, 10,000 e-buses will be deployed on PPP model in 169 cities. • CESL has been nominated as the Central tendering agency under PM-e-Bus Sewa Scheme. Under Phase 1, CESL had issued the tender by aggregating a demand of 3,825 e-buses and the tender was concluded in Feb'24. Under Phase II, CESL had issued a tender with a demand of 3,808 e-buses.

All of these tenders focus primarily on STUs. However, there is a large market of e-buses being operated in the private sector. Therefore, to scale e-bus deployment in India, CESL, in partnership with USAID, planned to organize a series of five stakeholder consultations to deliberate upon and discuss the challenges in e-bus adoption. The findings of these stakeholder consultations are being summarized in this white paper. Below is a list of stakeholder consultations completed:

Theme	Objective /Topics to be covered	Location	Date
New Business Models for E-Bus Procurement	• Understanding the model – major players, advantages and disadvantages, structure etc. • Leading international practices, major risks/ concerns, possible use-cases • Support required from government / CESL	Goa	8th Feb 2024
Scaling International Footprint of Made-in-India Electric Buses	• Understanding the current supply and demand side scenario of the Indian e-bus ecosystem • Understanding the current manufacturing capacity and requirements to enhance the domestic manufacturing capacity • Understanding the quantum of taxes, duties, etc. levied for exporting e-buses • Market expectations and understanding the technical specifications for e-buses to be exported • Major risks/concerns • Support required from Government and / or CESL	Mumbai	24th April 2024
Scaling up Financing for E-buses Through Project Finance and Leasing Structures	• Understanding leasing and other financing structures for funding e-buses • International practices/structures in leasing buses • New sources/modes of financing e-buses including leasing • Suggestions for improving the Payment Security Mechanism (PSM) • Support required from Government and / or CESL	Mumbai	12th June 2024

Theme	Objective /Topics to be covered	Location	Date
Leading Best Practices in E-bus Operations	• Leading/international practices in bus operations - customer experience, utilization pattern, route optimization, scheduling, how to integrate IT to ensure smooth operation of e-buses • Plug-in charging, battery swapping and pantograph charging • User requirements, aspects for enhancing customer experience, addressing disability and other aspects	Mumbai	9th July 2024
Deployment of E-Buses in Areas Other Than STUs	• Mapping the needs and requirements of each user institution – schools, hospitals, airports, inter city buses • Understanding the bottlenecks for each institution and identifying the most applicable business model for implementation of the pilot • Designing the pilot its implementation to be taken up subsequently	Delhi	3rd Sep 2024



7. Stakeholder Consultation 1 – New Business Models for E-Bus Procurement

The procurement model for conventional buses by State Transport Undertakings (STUs) in India traditionally follows a capital expenditure (CapEx) approach, wherein the state-owned entity directly purchases the buses, owns them, and is responsible for all operational and maintenance activities. In contrast, the procurement model for e-buses has evolved into more innovative financing and operational structures.

The transition to e-buses in India is facilitated through various business models designed to address the high upfront costs, technological challenges, and operational uncertainties associated with this emerging technology. The suitable business model ensures that the financial burden is appropriately distributed between the STU, private operator, and government making the project financially viable in the long run.

7.1. Prevalent E-Bus Procurement Models in India

Some details have been provided on the available e-bus procurement models in India as below:

7.1.1. Outright Purchase Model

In the Outright Purchase Model (which was the most preferred in FAME I), the STU or the private operator purchases the e-buses directly, owning and operating them entirely. This model places the responsibility for all aspects of bus operation, including charging infrastructure, maintenance, and fleet management, on the operator. The initial capital investment is high, as the operator must bear the total cost of the e-buses upfront.

Some of the challenges associated with this model are mentioned below:

- High upfront capital costs make it difficult for financially constrained STUs;
- The operator bears long-term risks, such as battery degradation and maintenance issues;
- The requirement for charging infrastructure investment adds to the financial burden.

Under FAME I, cities like Bangalore and Mumbai experimented with the outright purchase model but faced challenges related to the high initial costs and operational inefficiencies. Bangalore Metropolitan Transport Corporation (BMTC) struggled with the high upfront costs and eventually adopted a mixed approach, combining outright purchases with service-based contracts.

7.1.2. Gross Cost Contract (GCC) Model

The transition to e-buses in India is largely confined to the organized public bus system, where SRTUs are the primary players. Innovative models such as GCC have provided new ways for STUs to address e-bus high upfront cost challenges and unlocking long-term operational efficiency. Under this model, the public agencyretains control over farebox revenues and pays a fixed fee per-kilometer to an external contractor responsible for procuring and operating the e-buses. The contractor must engage an Original Equipment Manufacturer (OEM) that manufactures e-buses. OEMs can bid for tenders either independently or in partnership with an operator responsible for daily operations. The subsidy for each bus is then directly transferred to the OEM by the Department of Heavy Industry (DHI). In the latest PM e-Bus SEWA scheme, the subsidy flows directly from the Ministry of Heavy Industries (MHI) to the operators.

Some of the benefits of this model are below:

- Lower Upfront Cost: The STU does not need to bear the capital cost of bus procurement. Instead, the private operator is responsible for the initial investment, and the STU pays for the service through regular payments;
- Performance-Based Payments: Payments to the operator are typically linked to performance metrics such as kilometers operated, bus availability, and service quality. This incentivizes the operator to maintain high operational standards.

FAME II (2019-2024) mandated the GCC model, offering operational subsidies based on the perkilometer cost. This helped reduce the financial burden on STUs while promoting the adoption of e-buses. FAME II allocated INR 10,000 crore, with a significant portion earmarked for e-buses under the GCC model.

Delhi adopted the GCC model for its e-bus procurement under FAME II, wherein private operators like Tata Motors and Ashok Leyland were contracted to supply and operate e-buses. This model helped Delhi scale its e-bus fleet without incurring the high upfront costs associated with outright purchase.

Some challenges in this model have been highlighted as below:

- Contract management can be complex, requiring robust monitoring mechanisms to ensure service quality;
- The financial viability of the model depends on the subsidy structure and the ability of the STU to make regular payments;
- The private operator assumes significant technology, operations, and maintenance risks.

7.1.3. Net Cost Contract (NCC)

In the NCC model, the operator retains the revenue from ticket sales as part of its income, which offsets the operation costs. The operator is responsible for collecting revenue from passengers, providing the buses, and managing the operations. In the NCC model, the operator assumes both operational and revenue risks, as the revenue from ticket sales may vary based on demand, fare structures, and passenger load. If ridership is lower than expected, the operator bears the losses. This model grants greater autonomy to the operator but also places more responsibility on them for optimizing operations. Depending on the agreement, the operator has more control over aspects such as scheduling, routes, and possibly fares. The NCC model is less commonly used in India compared to the GCC model, as it involves higher financial risk for operators.

7.1.4. Battery-as-a-Service (BaaS)

BaaS separates the ownership of the battery from the vehicle. In this model, the bus operator leases the battery from a service provider rather than owning it outright. The operator pays a recurring fee for the use of the battery, including the maintenance and replacement costs.

By leasing the battery, the initial purchase price of the e-bus is significantly reduced, making it more affordable for operators. The service provider takes on the responsibility of battery maintenance and replacement, mitigating the risk of battery degradation for the operator. BaaS allows for easier scaling of e-bus fleets as operators can adjust battery capacity according to their operational needs without worrying about long-term depreciation. While BaaS is more prevalent in India's electric two-wheeler and three-wheeler segments, companies like Sun Mobility and Amara Raja are exploring its application in the e-bus sector. The adoption is still in its nascent stages but holds promise for the future.

The BaaS model requires robust infrastructure and reliable service providers, which are currently limited in India. Ensuring battery availability and managing the logistics of swapping or recharging leased batteries can be operationally challenging.

Battery swapping is a sub-component of the BaaS model. In this setup, a service provider owns the batteries and offers battery-swapping services to bus operators. The bus operator compensates the swapping service provider through a subscription-based model or per-swap payment system.

The BaaS model reduces the initial purchase price of an e-bus by 30-40% since the most expensive component—the battery—is leased rather than bought. This makes it easier for operators to adopt e-buses. Also, battery life is extended and downtime for e-buses is minimized due to optimal charging cycles and timely maintenance by the BaaS provider. The BaaS model is more suited for commercial non-STU operators, where minimizing downtime is critical. The BaaS model has been widely adopted for both personal EV and e-buses in multiple countries including Taiwan, China and Indonesia.

7.2. Key Findings of the Consultation

The consultation brought together participants from over ten different organisations including government representatives, e-bus operators, battery-swapping service providers, leasing companies, e-bus and battery OEMs, technology innovators, and financiers. The session was attended by twenty-one stakeholders. The primary focus was to explore and discuss innovative business models, such as BaaS, battery swapping, and bus leasing, alongside the well-established GCC model. Some key takeaways from the consultation are highlighted below:

7.2.1. Battery Swapping as a fast emerging alternative model

A BaaS provider representative (he/him) emphasized that battery swapping for e-buses offers a more economical solution compared to fixed battery systems. The initial investment for battery swapping models is lower because the batteries are smaller, reducing the upfront costs. Additionally, the energy consumption is lower, as the batteries are 5-15% lighter, leading to a decrease in electricity requirements.

Swap stations also offer the potential to support the grid during peak demand periods, serving a dual purpose beyond just charging e-buses. These stations are designed to function similarly to traditional fuel stations, with robotic arms capable of swapping out a battery in just two minutes, significantly reducing downtime.

The representative shared insights from a case study where e-buses utilizing battery swapping were deployed. In this case, the buses averaged around 225 kilometres per day and completed over 2,500 swaps within a year. The flexibility in the placement and size of the battery allows customization based on the specific usage of the buses, which is particularly advantageous for non-STU applications such as schools, hospitals, and private operations where daily mileage is relatively low.

Further illustrating the global context, the representative referenced China's rapid adoption of battery swapping for commercial vehicles. With the world's largest electric vehicle market, China has over 1,400 battery swapping stations, serving more than 170,000 EVs. This rapid expansion is driven by the country's push for electrification and the benefits of reduced downtime and operational efficiency that battery swapping offers.`

These insights underscore the potential for India to similarly transition to battery swapping models, particularly in commercial and private bus operations where flexibility and lower costs are critical. As the technology matures and scales, battery swapping could become a key enabler in India's shift towards electric mobility, particularly in sectors where traditional fixed battery models may be less viable.

7.2.2. Importance of specialised battery management service provider for BaaS

Another BaaS provider representative (he/him) shared valuable insights on deploying an e-bus fleet under the BaaS model that involves providing Battery Charging and Management Services (BCMS) for 1,000 e-buses. This approach has proven effective in managing both battery performance and energy usage, making the model more cost-efficient for bus operators. The representative highlighted that integrating BCMS and financing into the BaaS model adds significant value by enabling active battery monitoring, which reduces maintenance costs and optimizes charging processes, leading to lower energy expenditures.

The managed service approach through BCMS mitigates technology risks, such as battery degradation or failure, and contributes to overall revenue growth for bus operators. This model also supports predictive maintenance by monitoring battery health in real-time, allowing for timely interventions before any issues escalate. By ensuring that batteries are charged during off-peak hours, BCMS further reduces operational costs by taking advantage of lower electricity rates.

Globally, the trend of separating the financing of batteries and e-buses is gaining momentum. This model allows operators to avoid the high upfront costs of purchasing batteries, which can account for up to 40% of the total cost of an e-bus. Instead, operators can lease the batteries or opt for a pay-per-use model, thereby aligning their expenses more closely with revenue generation.

A case study from the UK demonstrates the success of this approach. Transport for London (TfL), responsible for the city's public transport, has been a leader in deploying e-buses across London.

To accelerate this transition, TfL introduced a split-ownership model, where the e-buses and their batteries are financed and owned by different entities. This model allows bus operators to avoid the high upfront costs associated with batteries, a significant part of an e-bus's total cost. The separation of assets also enables more frequent battery upgrades, keeping the fleet at the cutting edge of technology without requiring full bus replacements.

Inspired by these global trends, the BaaS provider mentioned they are planning a pilot project in India to implement a similar model. This pilot aims to test the viability of separating battery and bus financing, potentially offering Indian bus operators a more flexible and financially sustainable pathway to electrification. The pilot could serve as a blueprint for scaling up BaaS in India, particularly in sectors with the most pronounced financial barriers to e-bus adoption. By leveraging the BCMS framework, this pilot would reduce operational costs and enhance the reliability and longevity of the e-bus fleet, making the transition to e-buses more attractive for a broader range of operators across India.

7.2.3. Bundled e-bus leasing package for private operators

A representative from a financial group (he/him) shared global insights on funding electric vehicles through leasing platforms, drawing from their extensive experience in the US and Europe. In India, their leasing platform has already supported 50 e-buses for corporate mobility and another 50 for inter-city transport. Based on their experience in India, the representative highlighted several challenges private bus operators face in adopting e-buses.

One major challenge is the fragmented nature of the market, where bus ownership typically changes every 5-6 years. This high turnover makes it difficult for financial institutions to establish long-term relationships with private operators. Additionally, e-buses face the hurdle of lacking dedicated or easily accessible charging networks or hubs. This lack of infrastructure is compounded by the reluctance of private operators to invest in their own charging infrastructure, further complicating the widespread adoption of e-buses.

To address these challenges, the financial group offers an integrated model that goes beyond mere financing. They provide private operators with the capital needed to procure e-buses and ensure the maintenance of these assets throughout their lifecycle. Moreover, they offer additional services such as charging and energy management, which are critical for the smooth operation of e-buses. This complete approach reduces the operational burden on private operators and mitigates the risks associated with owning and operating e-buses.

Such integrated models have shown considerable success in their global operations, particularly in Europe. For instance, leasing companies in Germany have collaborated with municipalities to provide e-bus fleets along with the necessary charging infrastructure and maintenance services. This model has been instrumental in cities like Hamburg and Berlin, where e-bus adoption has been accelerated by reducing the financial and operational barriers for operators.

In India, the financial group's focus extends beyond e-buses to include e-trucks and e-four wheelers. This broader focus is driven by the need to support the electrification of commercial vehicles across various sectors, including logistics and last-mile delivery.

7.2.4. Credit rating for batteries

A representative from a battery OEM (he/him) emphasized the importance of establishing a robust banking mechanism to facilitate separate financing for both e-buses and batteries. He noted that while the BaaS model holds promise, particularly with the potential for second-life battery applications, banks may remain hesitant to finance such initiatives due to perceived risks.

To address this, he proposed the implementation of a credit rating mechanism specifically for batteries. Such a mechanism would involve evaluating and assigning credit ratings to batteries based on their performance, durability, and potential for second-life applications. This rating system would provide banks with an additional layer of assurance, thereby increasing their willingness to finance BaaS models.

7.2.5. Credit enhancement mechanisms

It was also highlighted that the government or financial institutions may offer guarantees on loans for e-bus purchases. For example, the National Clean Air Programme (NCAP) has provisions to back loans for e-buses, thereby reducing the risk for lenders.

Issuing green bonds specifically for financing e-buses can attract investment from institutional and retail investors looking for environmentally sustainable options. The issuance of green bonds was seen in the Delhi government's initiative to raise funds for its e-bus fleet. In 2019, the Delhi government raised ₹5,000 crore through green bonds to finance its e-bus initiative, underscoring the effectiveness of credit enhancement mechanisms in mobilizing capital.

7.2.6. Monetization of residual value of batteries

It was mentioned that e-bus operators can collaborate with battery recycling firms to recover valuable materials from used batteries. For instance, companies like Exide Industries and Amara Raja Batteries are setting up recycling plants in India, aiming to process and reuse materials from old batteries.

Batteries that are no longer suitable for e-buses can be repurposed for energy storage systems in residential or commercial applications. For example, used e-bus batteries can be integrated into grid energy storage systems, helping to stabilize the power grid.

7.2.7. Tripartite agreements to ensure appropriate risk allocation and clarity among stakeholders

Three-party agreements among a) Original Equipment Manufacturers (OEMs) - responsible for manufacturing and supplying e-buses; b) Battery Swap Operators - provide battery-swapping services and manage infrastructure; and c) Customers (Bus Operators) - use the e-buses for their operations should clearly outline the responsibilities of each party regarding battery supply, maintenance, and swapping services. For instance, the agreement may specify the conditions under which batteries are swapped and the service level expectations for uptime and reliability.

These agreements should also include clauses to allocate risks related to battery performance, maintenance costs, and infrastructure reliability. For example, if a battery fails prematurely, the battery swap operator might bear the replacement cost, while the OEM ensures battery performance through warranties. In some models, revenue generated from the use of swapping stations is shared between the battery swap operator and the bus operator, providing an incentive for both parties to ensure high utilization and operational efficiency.

8. Stakeholder Consultation 2 – Scaling International Footprint of Made-in-India E-Buses

The Global Electric Bus Market size is estimated at USD 45 billion in 2024, and is expected to reach USD 136.9 billion by 2029, growing at a CAGR of 20.38% during the forecast period (2024-2029)[1]. Several European countries (such as Belgium, Norway and Switzerland) and China achieved sales shares above 50% in 2023, and more than one-fifth of bus sales were electric in Canada, Chile, Finland, the Netherlands, Poland, Portugal and Sweden. Globally, almost 50, 000 e-buses were sold in 2023, equating to 3% of total bus sales and bringing the global stock to approximately 6,35,000 in total[2].

8.1. Major E-Bus OEMs in India

Several manufacturers have emerged as major players in the e-bus sector, each contributing to the nation's ambitious goal of achieving mass electrification of public transportation. Here's a detailed look at the key e-bus players in India.

1 Electric Bus Market Size-Industry Report on Share, Growth Trends & Forecast Analysis (2024-2029). Mordor Intelligence: Retrieved from: https://www.mordorintelligence.com/industry-reports/electric-bus-market

2 4 International Energy Agency (IEA). Global EV Outlook 2024. Retrieved from: https://iea.blob.core.windows.net/assets/a9e3544b-0b12-4e15-b407-65f5c8ce1b5f/GlobalEVOutlook2024.pdf

8.1.1. TATA Motors

Tata Motors is one of India's largest vehicle manufacturers and a key player in the e-bus market. The company has been heavily involved in both producing and deploying e-buses across various cities.

Key Models -

Tata Starbus Electric: Available in 9-meter and 12-meter variants, this model has been a part of several state transport tenders.

8.1.2. PMI Electro Mobility

In collaboration with Beijing Foton Motors, PMI Electro Mobility has become one of the topcontenders in India's e-bus market. PMI focuses on providing high-quality electric buses with advanced battery and charging technologies.

Key Models -

PMI offers buses in different sizes, including 9-meter and 12-meter variants. These buses are equipped with advanced lithium-iron-phosphate (LFP) batteries for safety and longer life cycles.

8.1.3. Switch Mobility (Ashok Leyland)

A subsidiary of Ashok Leyland, Switch Mobility is a global electric vehicle company focused on buses and commercial vehicles.

Key Models -

- Switch EiV 12: A 12-meter e-bus designed for long urban routes and highway applications.
- Switch EiV 7: A smaller 7-meter variant designed for short city commutes.

8.1.4. JBM Auto

JBM Auto has made significant inroads into India's e-bus market with its innovative range of e-buses.

Key Models -

JBM Eco Life Electric: A flagship e-bus available in both 9-meter and 12-meter variants.

8.1.5. Olectra Greentech

Olectra Greentech is one of India's most prominent e-bus manufacturers. Olectra's e-buses are known for their advanced technology and long battery life.

Key Models -

K6 (9-meter) and K9 (12-meter) models.

8.2. Key Findings of the Consultation

It was a half-day long consultation that brought together representatives from leading e-bus OEMs, including PMI Electro Mobility, Switch Mobility, JBM Motors, Pinnacle Mobility Solutions and VE Commercial Vehicles Ltd, to discuss and deliberate on expanding India's international footprint of made-in-India e-buses. The discussion helped answer some key questions to understand the Indian e-bus OEM's willingness and readiness to export e-buses to other Asian countries and beyond, the major challenges in doing so, the key enablers to address these challenges, and the policy level support expected from the government. Some key takeaways from the consultation are highlighted below:

8.2.1. Standardised homologation process recognisable across Asian countries

An e-bus OEM representative (he/him) highlighted the key challenges related to Indian homologation standards. He explained that technical specifications for e-buses often vary across countries due to unique geographical conditions. For instance, buses in hilly areas may require stronger motors, while those in coastal regions need enhanced corrosion resistance. This makes it challenging for OEMs to adopt a one-size-fits-all approach.

The representative proposed that mutual recognition of Indian homologation standards by other Asian and South Asian countries could create significant export opportunities for Indian OEMs. Such mutual recognition would enable manufacturers to use the same production lines for exports, much like China's model, which hassuccessfully expanded its EV exports by standardizing production for multiple markets.

> China's BYD, for example, has become a leading global e-bus exporter due to its standardized production approach, exporting buses to over 50 countries, including key markets like Europe, South America, and Africa.

However, he noted that any major design changes required by different countries would demand modifications to production lines. Such changes would only be viable for long-term, high-volume orders, typically above 100–200 e-buses.

He further emphasized that India's expertise in operating e-buses across varied climatic conditions—ranging from the Himalayas to coastal regions—demonstrates its technological adaptability. Tailoring products to meet specific market needs, including compliance with international emission and safety norms, will highlight India's R&D capabilities and readiness for global expansion.

Beyond the technical aspects, he stressed that successful e-bus exports must offer a comprehensive package that includes workforce training, after-sales support, and warranties. Indian OEMs could learn from Tata Motors, which, when exporting buses to the Middle East, provided training to local operators and offered extensive after-sales services. Such support enhances the overall product value and ensures long-term partnerships with foreign buyers.

He further suggested that the central government could play a pivotal role in facilitating e-bus exports by streamlining compliance with international standards and supporting OEMs with export incentives. India's National Electric Mobility Mission Plan (NEMMP) 2020 already aims to push the country as a hub for EV manufacturing, and exports could be a natural extension of this goal. The central government could also offer tax breaks or subsidies for manufacturers who align with export targets, much like the production-linked incentive (PLI) schemes seen in other industries.

Finally, the representative called for the establishment of a national e-bus roadmap, which would provide a strategic framework for the sector. This roadmap would offer much-needed clarity on government support, allowing OEMs to plan their manufacturing expansions and investment strategies accordingly. India's FAME scheme has already catalysed the adoption of e-buses domestically, with more than 8,000 e-buses sanctioned under the scheme. By expanding this vision to include exports, India could further strengthen its position as a global leader in electric mobility.

Another e-bus OEM representative (he/him) added to the discussion by stressing the importance of international certification for exporting Indian e-buses. He mentioned that without recognized certifications, Indian e-buses would face significant barriers in foreign markets. TUV India's vehicle certification program was highlighted as a viable solution. TUV collaborates with the Automotive Research Association of India (ARAI) to leverage its advanced testing facilities and expertise to help manufacturers meet ECE and other global standards.

The certification process typically takes 3-4 months, during which the e-buses undergo rigorous testing to meet the target export market's safety, environmental, and performance standards. Buses exported to Europe must comply with stringent Euro 6 emission norms, which require advanced exhaust systems and battery management technologies. TUV India's certification is crucial for Indian e-bus manufacturers aiming to penetrate highly regulated markets, such as Europe, North America, and Japan. Without this certification, Indian OEMs could face legal and regulatory hurdles, preventing them from entering these high-value markets.
An e-bus OEM representative (he/him) highlighted the significance of international certifications like the Whole Vehicle Type Approval (WVTA), widely used within the European Union (EU) for vehicle homologation. WVTA certifies that a vehicle meets the rigorous standards required for sale and operation across all EU member states. He pointed out that countries adhering to WVTA regulations follow stringent rules, including local greenhouse gas (GHG) emission norms, and would not accept vehicles that fail to meet these high standards. This certification ensures that e-buses are not only safe and efficient but also environmentally compliant, which is a non-negotiable requirement in most developed markets

8.2.2. Capacity building and robust after-sales service network for e-bus importing countries

An e-bus OEM representative (she/her) emphasized the importance of thoroughly understanding the labour market in the importing country when exporting Indian e-buses. This understanding would give OEMs insight into the local availability of skilled labour, the cost of operations and maintenance, and the overall competitiveness of Indian electric buses in those markets. Countries with higher labour costs, like those in Europe, may require more advanced automation in maintenance procedures, while those with lower labour costs may benefit from manual processes. This clarity will help OEMs design tailored training programs to equip local workers, adjust pricing strategies to remain competitive, and navigate the complexities of labour laws and regulations effectively.

She also pointed out that OEMs will seek profitability in these markets, often driven by their experience in the Indian domestic market. India's growing e-bus market, driven by programs like the FAME scheme, has provided a solid base for OEMs to scale up production. With over 8,000 e-buses already deployed across various cities, OEMs like Tata Motors, Ashok Leyland, and PMI Electro Mobility have gained valuable insights into operational efficiency, cost control, and market demand. These lessons could be transferred to export markets, but only if profitability can be ensured through strategic planning and cost management.

An e-bus OEM representative (He/Him) emphasized the importance of establishing a robust aftersales service network in the importing countries. He suggested that training local personnel to manage the maintenance and servicing of e-buses could be financed by the local authorities in the importing country. Companies like BYD have successfully implemented this approach, which has entered European and South American markets by providing extensive training to local technicians and service personnel, ensuring that their e-buses are properly maintained throughout their life cycle.

In India, companies like Ashok Leyland have initiated similar strategies, offering after-sales support for their e-buses in various domestic markets. Expanding this model globally would allow Indian OEMs to ensure that their vehicles continue to perform optimally, while also creating local jobs and enhancing relationships with foreign buyers.

8.2.3. Dependence on imported raw materials for battery production

An e-bus OEM representative (she/her) highlighted a critical challenge: India's dependence on imported raw materials for battery production. With lithium, nickel, and cobalt being essential components in battery manufacturing, India currently relies on countries like China, Australia, and Chile for these resources. This dependency not only increases the cost of production but also adds to India's import bill, a concern that would be exacerbated by scaling up e-bus exports. The increasing global demand for electric vehicles, coupled with raw material shortages, could lead to further price surges, putting pressure on Indian OEMs to balance profitability with the high costs of battery components. The global rise in lithium prices in 2022 by nearly 400% affected EV manufacturers worldwide, including those in India.

India is exploring ways to secure a stable supply of raw materials to mitigate these challenges. For example, there have been discussions about forming partnerships with resource-rich countries and investing in domestic recycling technologies to recover critical minerals from used batteries. Furthermore, the government is encouraging research into alternative battery technologies, such as solid-state batteries or sodium-ion batteries, which could reduce dependence on imports in the long term.

8.2.4. Economic Commission for Europe (ECE) regulations for Southeast Asian countries

An e-bus OEM representative (he/him) discussed the relevance of the Economic Commission for Europe (ECE) regulations in Southeast Asian countries and their impact on Indian OEMs seeking to export electric buses. ECE regulations are designed to create a uniform vehicle design system, ensuring high safety, environmental, and performance standards across the automotive industry. These regulations, widely adopted in Europe, are increasingly being embraced by Southeast Asian countries to align their vehicle standards with global norms. For Indian electric bus manufacturers, however, the strict technical requirements posed by ECE standards can present significant challenges.

The ECE framework covers various aspects of vehicle design, including safety features, emission controls, and electric vehicle performance metrics such as battery safety, energy efficiency, and durability. For Indian OEMs, the transition to meet these rigorous standards can be complex and costly. While India's domestic regulations are evolving, they are generally less stringent than those of ECE. This creates a gap that Indian manufacturers need to bridge when looking to export their products to countries that adhere to ECE regulations, such as Malaysia, Thailand, and Indonesia.

He highlighted that although the adoption of ECE regulations in Southeast Asia is still evolving, countries in this region are progressively moving toward these standards to enhance the quality of their automotive markets. For instance, Singapore, a frontrunner in adopting ECE norms in the region, requires compliance with these regulations for electric vehicles, including buses. This has set a high bar for Indian manufacturers, who must invest in upgrading their technology and production processes to meet these standards.

Tata Motors faced significant hurdles when adapting its electric vehicles to meet European emission and safety standards before entering the international market. To comply with ECE regulations, Tata had to upgrade its electric vehicle offerings with advanced battery management systems, improved crash safety designs, and enhanced emissions controls, all of which required significant investment and time.

stringent technical standards related to battery safety and performance under ECE regulations. The ECE R100 standard covers the safety requirements for the battery system of electric vehicles, including impact resistance, fire safety, and protection against electrical hazards. Indian e-bus manufacturers often face challenges in ensuring their vehicles comply with these high-performance and safety benchmarks. As a result, they may need to re-engineer parts of the vehicle or source more advanced battery components, which can drive up costs.

Despite these challenges, compliance with ECE regulations can provide Indian OEMs with a competitive advantage in global markets. Meeting these standards enhances the safety, reliability, and environmental credentials of Indian-made e-buses, making them more attractive to international buyers. Chinese manufacturers like BYD and Yutong have successfully penetrated European and Southeast Asian markets by adhering to ECE standards. They have exported thousands of e-buses to cities like London and Amsterdam, gaining a reputation for safety and quality. Similarly, if Indian OEMs can meet ECE requirements, they can access lucrative markets and compete on a global scale.

8.2.5. Establishing payment security mechanism in importing countries

An e-bus OEM representative (he/him) highlighted the need for a payment security mechanism in the importing country. This is essential for safeguarding exporters from adverse economic or political conditions that could disrupt transactions. Countries experiencing political instability or economic downturns may face difficulties in meeting their payment obligations. A well-defined payment security mechanism, such as escrow accounts or government-backed guarantees, would ensure that Indian OEMs receive payment on time, regardless of external circumstances. This can be particularly important for emerging markets where economic volatility is a concern.

8.2.6. Globally accepted legal structure for agreements

An e-bus OEM representative (he/him) emphasized the importance of adopting a globally accepted legal structure for contractual agreements when dealing with international trade. By using standardized contracts that clearly outline the terms of sale, payment conditions, and dispute resolution mechanisms, both the exporter and importer are protected. This minimizes potential disputes and ensures that any issues are resolved through agreed-upon legal frameworks. India can take inspiration from the UN's Convention on Contracts for the International Sale of Goods (CISG), a globally recognized framework that offers clarity in international trade contracts and reduces legal uncertainties.

8.2.7. Continued government support for e-buses

An e-bus OEM representative (he/him) highlighted one of the unique advantages Indian OEMs have —India's diverse geography. From the hot and humid coastal areas to the rugged terrain of the Himalayas, Indian e-buses are exposed to a wide range of climatic conditions during testing and operation. This gives Indian e-buses a significant edge when exporting to markets with varied geographical and environmental conditions. Countries with diverse climates, such as those in Southeast Asia, Latin America, and Africa, could benefit from Indian e-buses that are already proven to operate efficiently in extreme weather conditions.

From a policy perspective, he stressed that government support is crucial for encouraging e-bus exports. India's government could incentivize OEMs to invest in global markets by offering subsidies or tax benefits for export-oriented production. Additionally, targeted policies such as extending the PLI scheme to include e-buses could drive more OEMs to focus on exports.

9. Stakeholder Consultation 3 – Scaling up financing for e-buses through project finance and leasing structures

Most e-buses in India have been awarded using the Gross Cost Contracting (GCC) model where the bus operators are paid at a per km basis, thereby reducing the burden of high initial investment on State Transport Undertakings (STUs) and moving towards the service-based model. Until now, most of the financing was being done based on the strength of the balance sheets of the respective operators/OEMs, which poses a major challenge for the scale-up of on-ground deployment of e-buses. In addition, balance sheet financing has limited capacity and will also impede the ability of OEMs to ramp up the manufacturing capacity of e-buses, which is essential for rolling out the large number of e-buses required for achieving the envisaged targets.

Further, in many countries, leasing is also being used as a major source of financing for e-buses and such models are operational in countries like Chile, where the ownership and operation of buses are segregated. In such models, e-buses are purchased and leased out to operators who are responsible for farebox collection, running and maintenance. The leasing model is another option that can be evaluated for financing e-buses, hence, accelerating the deployment.

9.1. Key Findings of the Consultation

It was a half-day consultation that aimed to discuss and deliberate about the different aspects of financing options such as project financing and leasing, their major requirements, associated risks/challenges as well as potential solutions in order to achieve the targets under various initiatives/schemes of the Government of India. Representatives from leading banks, NBFCs and fleet operators joined the consultation.

9.1.1. Crucial aspects of a bankable concession agreement

A representative (He/Him) from a financing entity highlighted key aspects of a bankable concession agreement during the discussion. First, he emphasized the importance of the agreement's structure, particularly how payments are linked—whether through availability-linked payments, take-or-pay models, or usage-based payments—and the termination payment regime. He noted that both state and central authorities have made significant progress in structuring concessions that are financially viable, with banks now accepting them, effectively mitigating the associated risks.

However, two additional nuances remain critical when evaluating such agreements. The first is the authority signing the concession. The strength and stability of the authority are essential, especially for a long-term concession spanning twelve years or more. If the agreement is signed at the state or district level, it's crucial to assess how committed the authority is to be sustaining and supporting the project over time. A well-laid-out plan for expansion or continued support is necessary to ensure stability. The second nuance pertains to the payment security mechanism. While this was absent in earlier agreements, it has now been introduced, though its operational effectiveness is yet to be seen. Understanding how this mechanism will function in practice remains a key concern for stakeholders.

In addition to these points, the representative also discussed the importance of supply and manufacturing capacity within India. While the government has pushed for the localization of components, there remains a significant dependency on imports, especially for batteries. Given the current geopolitical climate, this dependency introduces an element of risk, and how it will evolve in the coming years is yet to be determined.

9.1.2. Counterparty and product related risks

A representative (he/him) from a government NBFC highlighted their commitment to supporting the EV sector by creating a dedicated funding window for e-buses, structured as project finance. He emphasized that, given the national importance of the EV sector, this initiative is designed to facilitate greater investment. However, he identified two key risks associated with such financing. The first is counterparty risk, as they primarily deal with state entities, and the funds depend on budgetary settlements. With long payment windows, this can result in delayed payments, adding uncertainty to the process. The second risk is product-related, which, while evolving, could be mitigated through the introduction of specialized insurance products. He noted that, despite these risks, they are prepared to engage in project financing, expecting the market to adapt over time.

9.1.3. Discussion on simplifying the Payment Security Mechanism (PSM)

A representative (he/him) from a bank proposed simplifying the payment security mechnism (PSM) in concession agreements by suggesting a clear separation of penalties for equipment and bus services/performance. He provided an example to illustrate his point: if the value of the bus in a contract is ₹1,000 and the value of the services, such as providing drivers and running the bus, is ₹300, the authority should be obligated to pay the total ₹1,000 to the operator, regardless of any issues, as the financier's primary concern is the bus itself. While financiers can assume the risk associated with the equipment, they cannot bear the performance risk tied to the operator running the buses. Therefore, any deductions due to service issues should be made from the ₹300 allocated for service provision, not from the equipment payment.

However, it was clarified to the representative that this arrangement would likely be unacceptable to e-bus manufacturers or operators, as they would not agree to delink these payments. Additionally, the challenge for authorities in distinguishing between product-related and service-related issues was pointed out. Since buses are a critical public service, they need to operate consistently, and it would not be feasible for financiers to recover their funds while the public suffers from service disruptions due to bus unavailability.

A lender raised concerns regarding the operation of the escrow account, which the operator and the authority jointly maintain. According to the contract, the operator controls the escrow account, and the lender must obtain permission from the operator to withdraw any payments,

adding complexity to the process. However, it was clarified that similar escrow arrangements, particularly in GCC contracts, have been successfully in place for the past 10-15 years. The possibility of revisiting this arrangement for termination payments was suggested for future consideration

Another suggestion was to implement differential payment security amounts based on the economic progressiveness of the states. For instance, a progressive state like Delhi could have a lower payment security requirement, while a state like Bihar could have a higher security amount. However, it was clarified that such differentiation is not feasible at this stage, as the e-bus market in India is still in its early stages of development and lacks maturity for such tailored approaches.

A valuable suggestion was made to restructure the subsidy currently provided to operators and manufacturers. The proposal involves dividing the subsidy into two parts. The first part would bedirected to the manufacturer to support the capital expenditure (CapEx) for e-buses, with disbursement staggered over time in three tranches. The second part would go to the operator in through subsidized tariffs for e-bus charging at stations where the government owns the land. This approach would improve the operator's cash flow, reducing the risk for banks when providing loans. Additionally, it ensures more efficient utilization of government subsidies.

10. Stakeholder Consultation 4 – Leading Practices in E-Bus Operations in India

As the adoption of e-buses in India gains acceleration, it becomes important to understand the leading practices in the operations of e-buses, which can be subsequently adopted across the industry. Operational planning, the increasing role of Information Technology (IT) in harnessing realtime insights, and advanced battery management systems for optimal charging of e-buses, are some of the practices that can be incorporated to ensure smooth and efficient e-bus operations. The operation of e-buses can be categorized into the following areas:

Operations Planning for e-Buses: This section focuses on route planning for e-buses, considering factors like type/length of route, utilization of route, type of terrain, number of stops on the route and how IT can be integrated in getting real-time insights enabling better planning, route optimization and efficient operations of e-buses.

Battery/Charging Technology: Focusing on battery management systems and associated data analytics for efficient operations of e-bus, as well as on current charging technologies like plug-in charging, swapping and emerging technologies like pantograph charging. This will also consider advanced batteries that can communicate with charging stations for optimal charging ensuring better energy management and providing essential data for maintenance as well as predictive maintenance.

Designing of e-Buses/ User Convenience: Focusing on the importance of user experience in public transport in terms of comfort, reliability, safety (especially regarding women's safety) and most importantly, making it all-inclusive.

10.1. Key Findings of the Consultation

The stakeholder consultation aimed to provide a platform to share experiences and best practices of e-buses operating in India and abroad, thereby encouraging their adoption. This stakeholder consultation brought together E-bus OEMs, fleet operators, battery companies and charge point operators, and so on to discuss and deliberate on the leading best practices for adopted for e-bus operations.

10.1.1. Digitization of e-buses

Standardizing manual operations data into formats like GTFS and NeTEx, which capture key city route information, is essential. This would significantly simplify the process for bidders assessing e-bus opportunities. Currently, bidders often conduct on-ground surveys to understand routes, which is an outdated practice. By digitizing metrics such as kilometers operated and electricity consumed, payment to bidders can be more accurate and timely.

Transport for London (TfL) offers a structured approach to data management. Private operators are required to maintain operational data in a standardized format, which is then shared with TfL for public access. TfL also uses GPS-based telematics to generate daily bus performance reports. The UK government's Bus Open Data Service (BODS) is a similar platform, where all public bus schedules and timings are made openly available. India could benefit from adopting such a system. Likewise, DOVA, a public transport authority association, in the Netherlands, manages a similar reporting system. Although DOVA initially focused on passenger information, it now serves as a tool for contract management.

In both cases, the national government covers the cost of data management servers, while the operators bear the costs of data cleaning, maintenance, and sharing. One potential drawback of centralized data systems is the risk of operators manipulating the data to meet contract SLAs or their own interests. However, since the data is transmitted in real-time with minimal latency directly from the buses, the chances of data manipulation are significantly reduced. As a way forward, we can begin by gathering insights from the UK and the Netherlands regarding the types of data required from operators and the reasons behind the importance or lack thereof of certain data types. Based on these learnings, we should establish standardized e-bus data protocols tailored for India. Following that, a national Intelligent Transportation System (ITS) backend system should be developed. This should be complemented by creating planning and scheduling tools, along with skill development initiatives for operating and maintaining ITS hardware.

10.1.2. Operational challenges from the STU's point of view

A representative from the public transport corporation emphasized the critical role of efficient e-bus charging. Inefficient charging can lead to extended bus downtime, ultimately affecting end users who bear the cost. Effective route planning is also crucial, ensuring a steady supply of passengers and optimal utilization.

10.1.3. Operational challenges from bus operator's point of view

A representative from a private bus operator emphasized the need for adequate charging stations for buses, recommending that chargers be installed at public bus depots and that public access to all chargers be permitted. He also pointed out several challenges with the GCC tenders, such as the lack of standardization in tender terms and conditions, the responsibility placed on bidders to conduct detailed planning for EV infrastructure, and the issue of capital being tied up in charging infrastructure investments.

10.1.4. Leading best practices of e-bus operations in India

A representative from a bus manufacturing company outlined the best practices in e-bus operations in India. He noted that various battery chemistries, besides LTO, are currently being tested for buses. He also emphasized that the future of charging lies in ultra-fast DC charging and pantograph charging systems. Integrating an Intelligent Fleet Management System is crucial to efficiently monitor and manage each bus. Additionally, advanced safety and security features are being incorporated into buses. He stressed that data management and analytics will play a pivotal role in the future of the e-bus industry.

11. Stakeholder Consultation 5 – Deployment of E-Buses in Areas Other Than State Transport Undertakings (STUs)

As India aims for its 2070 net-zero targets, the electrification of buses presents a significant opportunity. As of now, e-bus adoption in India has been driven by government support through initiatives like the FAME scheme, NEBP, PM-e-Bus Sewa Scheme, PM E-DRIVE and PM-e-Bus-PSM scheme aimed at transitioning fleets operated by STUs. Given that 90% of all bus services are provided by the private sector, aligning policy incentives for private operators with those for public entities will ensure a more comprehensive transition to electric mobility.

11.1. Key Findings of the Consultation

This closed-door consultation sought to provide a platform for private bus stakeholders, including schools, hospitals, and rural and intercity bus operators, to share their challenges regarding adoption of e-buses and explore viable solutions to accelerate the adoption of e-buses.

11.1.1. Non-availability of parking space in the bus depot

During the stakeholder consultation, private bus operators conveyed their strong interest in transitioning to e-buses, yet several challenges currently impede their ability to make this shift. One of the primary obstacles highlighted was the restriction that prevents private buses from parking in government-operated bus depots. As a result, drivers are forced to park their buses at distant locations, often far from the actual pickup points, leading to operational inefficiencies. This issue not only increases fuel consumption but also causes delays in pickup and drop-off schedules, negatively impacting service reliability.

One key recommendation was granting private e-buses access to government bus depots for both parking and charging purposes. This move would eliminate the inefficiencies caused by remote parking and make it easier for operators to maintain their vehicles.

11.1.2. Lack of e-bus charging facility in the bus depot

Another significant challenge highlighted was the lack of charging infrastructure within these bus depots. Private operators face immense difficulties in keeping their e-buses charged and operational throughout the day without access to charging stations or even basic plug points. The absence of well-distributed and reliable charging facilities, particularly in urban areas, limits the feasibility of operating e-buses on longer routes, where the need for mid-route charging is essential.

Installing charging stations or at least basic plug points within bus depots was strongly advocated. Currently, the government's FAME II scheme offers subsidies for setting up charging stations, but expanding these facilities to include private operators is crucial to accelerating the e-bus transition.

11.1.3. Lack of financing mechanisms for e-buses

Financial constraints further complicate the situation. Many private bus operators struggle to secure the capital needed for purchasing e-buses, which are typically more expensive upfront compared to their diesel counterparts. This funding gap makes it difficult for operators to make the switch, despite their willingness to transition to greener options. According to a report by the NITI Aayog, e-buses in India are priced between ₹1.3 lakh and ₹2.5 crore, nearly double the cost of conventional buses, making access to affordable finance a critical issue.

It was suggested that corporate guarantees be introduced to secure funding for private operators. Corporate-backed guarantees could enable private bus operators to access more affordable financing options, easing their investment in e-buses. In addition, public-private partnerships (PPPs) could play a significant role, where private bus operators collaborate with state and central governments to share the cost burden.

11.1.4. Other recommendations

Another strategy put forward was to begin the deployment of e-buses in tier-2 and tier-3 cities. These cities, with their less congested roads and greater availability of land, offer more space for setting up EV charging stations along highways and main roads. Cities like Indore and Nagpur have already demonstrated success with smaller-scale e-bus fleets. Nagpur became the first city in India to have an e-bus fleet under the FAME I scheme, with the city's transport department reporting significant reductions in fuel costs and emissions. Starting the transition in smaller cities can help operators iron out operational challenges before scaling up to more complex urban environments like tier-1 cities, which face additional hurdles such as traffic congestion and limited space for new infrastructure.

A pilot project was also recommended as an initial step to electrify key routes. The Delhi-Mumbai route, one of India's busiest and longest, was suggested for this pilot. By focusing on this route, stakeholders could assess various aspects such as the specifications required for e-buses to handle long-distance travel, the optimal placement of charging stations, and the infrastructure needed to support high volumes of daily commuters. Data gathered from this pilot could provide valuable insights for customizing bus designs, refining charging station placement, and optimizing route electrification strategies. Such a pilot would also offer an opportunity to address real-world challenges and make course corrections before further expanding the electrification efforts to other major routes.

A similar pilot project in the Bengaluru-Kolkata route, which introduced e-buses on long-distance intercity travel, revealed the necessity for fast-charging stations at regular intervals. The operational success of that pilot led to the deployment of additional e-buses on other long routes, significantly boosting confidence in e-buses as a viable alternative for long-distance travel.

12. Key Recommendations

1. Access for Private Buses to Charge at Public Bus Depots:	Many bus depots, such as Delhi ISBT and Ahmedabad, have charging points installed for e-buses, but currently, only public buses or STU buses are permitted to use these chargers. Since these public e-buses primarily require overnight charging and only return to depots at night, the utilization of these charging points remains low. Allowing private e-buses to access these depots for charging would reduce idle charger time and increase utilization. This approach will also eliminate the cost and effort of private e-bus operators to install separate charging infrastructure outside the depots, making it a win-win for both the government and private e-bus operators.
2. Installation of Fast Chargers along Highways/ Expressways:	E-buses are being increasingly adopted for intercity and interstate travel, requiring them to cover long distances. To support this, charging points should be installed along highways and key transport corridors (at rest stops and bus terminals) to ensure uninterrupted travel on long routes. The National Highways for Electric Vehicles (NHEV) initiative, a pilot program by the Government of India, aims to upgrade highways into e-highways. Two technology trials have already been conducted on the Delhi-Agra and Delhi-Jaipur routes, part of the 12 National Corridors proposed for electrification in the Ministry of Power's Guidelines and Standards (dated 14th Dec 2018). High-traffic highways/expressways connecting metro cities should be prioritized, and the deployment of fast chargers along these routes must be fast-tracked with government support. Expanding highway charging infrastructure will not only incentivize private operators to invest in e-buses for intercity transport but also reduce the need for heavy, high-capacity batteries, thereby lowering e-bus costs and improving operational efficiency.
3. Promoting Battery Swapping Solutions:	Traditional wired charging for e-buses typically takes 2-6 hours, leading to significant idle time, which is a major challenge for efficient bus operations. Battery swapping enables quick refueling within 5-10 minutes, drastically reducing downtime. Given that most buses operate on fixed routes, strategically placed battery swapping stations along these routes can eliminate the need for heavy, high-capacity batteries, lowering the upfront cost of e-buses. This also allows added passenger capacity, thereby increasing operational revenues. Additionally, battery swapping allows for

	batteries to be slow-charged in controlled environments, extending their overall life cycle. To accelerate adoption, battery swapping stations should be included in charging station aggregation tenders, and incentives should be provided to support their development. To address compatibility issues, a national-level guideline on standardized e-bus battery dimensions could be introduced to ensure uniformity across manufacturers. Pilot battery swapping projects can be launched in cities with existing e-bus infrastructure, such as Ahmedabad and Pune, to demonstrate the feasibility of the solution.
4. Adopting Innovative and Customizable Business Models:	Innovative e-bus ownership models such as leasing, Battery-as-a-Service (BaaS), pay-per-use, and public-private partnerships (GCC/NCC) can significantly benefit bus operators. Battery leasing or BaaS shifts the financial burden of battery ownership and maintenance to the battery solution provider, improving cash flow for bus operators and ensuring access to the latest battery technologies without additional investment. Pay-per-use or subscription models allow operators to pay based on usage, offering flexibility in managing fleet sizes and costs according to actual demand. CESL-led GCC model has allowed STUs to pay a fixed cost per km to a private bus operator, eliminating the need for large upfront investments in purchasing e-buses, as well as the burden of operating and maintaining the fleet. These models can be tailored to meet the specific needs of different stakeholders, by adjusting terms related to leasing periods, payment structures, and service levels.
5. Advancing Local Manufacturing and Battery Recycling:	Indian manufacturers often rely on imported battery technology and components. Many Indian e-bus OEMs also struggle to meet international quality and safety standards, such as WVTA. To enhance the competitiveness of the Indian e-bus industry, governments can implement various strategies in addition to the PLI auto & auto-components and Advanced Chemistry Cells (ACC) scheme. Grants and tax breaks can be provided for research and development in e-bus technologies, including battery efficiency, lightweight materials, and advanced manufacturing processes. Skill development for employees in the e-bus industry should be facilitated through e-learning modules, certification courses, and apprenticeship programs. Additionally, battery recycling should be mandated for batteries that no longer have sufficient State of Charge for transportation, while second-life battery applications should be explored for further use. The government

	can support access to critical minerals for battery cell manufacturing by facilitating global partnerships and securing long-term supply agreements with rare-earth and critical mineral rich countries.
6. Standardised Homologation and Export Readiness:	The mutual recognition of Indian homologation standards by other countries can significantly enhance export opportunities for Indian e-bus OEMs. To support this initiative, the government should focus on establishing advanced testing facilities and capacity-building programs aimed at equipping Indian e-bus OEMs to meet the rigorous quality and technical specifications required by highly regulated markets. This support should encompass guidance on adhering to international standards such as ECE regulations and WVTA process, which are essential for facilitating the export of Indian e-buses. Government should also facilitate industry partnerships (such as TUV SUD) which can further expedite the process of obtaining global e-bus certifications.

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