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FUTURE OF THE CITY BUSES IN INDIA: INSIGHTS FROM THE SUCCESS OF ELECTRIC BUSES IN PUNE

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Abstract

Cities can benefit from e-buses in a variety of ways, including increased reliability, efficiency, cleanliness, quietness, and cost competitiveness. E-buses are acknowledged by stakeholders in Pune as a crucial solution to problems with air quality and congestion. While ensuring that both drivers and passengers appreciate the service, the City bus services in Pune offer commuters an effective, air-conditioned form of transportation.

Pune has taken the lead in implementing steps to support sustainable and citizen-friendly mobility. The performance of e-buses over the past year has been quite positive for the city because it has given the general public access to a healthy mode of transportation. The successful implementation in Pune would pave the way for other cities in India to start their own adoption processes for e-buses in their fleets.

Public transportation electrification is a crucial component in decarbonizing urban mobility in India and around the world. Despite the fact that the domestic Indian market for electric buses (e-buses) is still in its infancy, predictions show that by 2030, 4 out of 10 buses sold there may be electric.

Keywords: Eco-friendly City bus, Urban transport systems, Electric bus, Vehicle Pollution.

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1. INTRODUCTION

The city of Pune in Maharashtra is an excellent example of the electrification of public transportation because it was an early and substantial adopter of electric buses. There are now 2,169 buses in the fleet of Pune Mahanagar Parivahan Mahamandal Limited (PMPML), of which there are 500 e-buses in operation. This makes PMPML one of the largest municipal e-bus fleets in operation in India. Once PMPML commissions the remaining e-buses it has tendered, Pune will be on course to fulfill the target that was established in the Government of Maharashtra's Electric Vehicle (EV) Policy 2021, which is to electrify 25% of the public transport bus fleet by 2025. This will put Pune on track to accomplish this goal many years ahead of schedule.

During the second phase of the Faster Adoption and Manufacturing of Electric Vehicles Scheme, also known as FAME II, the Department of Heavy Industry of the Government of India allotted a total of INR 3,454 crores, which is equivalent to around USD 456 million, in the form of fiscal incentives for the purchase of municipal electric bus services. In its efforts to bring electric buses to the streets of Pune, PMPML was granted adequate funding and backing from both the Central Government and the State Government.

The procurement and operation of e-buses in Pune provide insightful information and useful points of comparison regarding the ways in which inter-agency collaboration, policy support, the design of business models, bidding and contracting conditions, and the development of infrastructure can be used to facilitate the adoption of e-bus in Indian cities. This case study provides insights into each of these areas by describing Pune and its journey toward sustainable transportation, providing an overview of the city's motivation, planning process, and tenders and contracts, summarizing key enablers and challenges, outlining economic, environmental, and public health benefits, and outlining next steps.

2. BACKGROUND INFORMATION ON THE CITY AND ITS INSPIRATION

2.1. Pune

The state government of Maharashtra recently issued an order to incorporate 23 new villages into the Pune Municipal Corporation (PMC). As a result of this order, Pune has recently surpassed Mumbai to become the city in Maharashtra with the largest geographical area. The city of Pune is located in India and spans a total area of 516 square kilometers. Its population is estimated to be 3.7 million and that of the metropolitan area is over 6 million. In addition, it is often referred to as the "Oxford of the East." Pune's prominence can be attributed, in part, to the city's administration, educational institutions, secure environment, industrial sector, and rich cultural heritage. It is also recognized as the most welcoming city in India overall, according to India's Ease of Living Index for 2018, which was released in 2018.

Despite this, the city's population, in addition to the number of cars and other types of transportation, is expanding at a breakneck speed. The total number of vehicles that were registered to be driven in Pune increased from 1.9 million in the year 2011 to 4.1 million in the year 2020. This increase occurred between the years 2011 and 2020. It is estimated that the city's transportation industry is responsible for around one-fifth of Pune's yearly greenhouse gas emissions, which is equivalent to 1.1 million metric tons of CO2 emissions. These numbers can be found in the city's Environmental Impact Statement. Emissions from automobiles are also responsible for around 25 percent of the city's total particulate matter (PM) emissions, which routinely exceed the standards set by international organizations. These emissions are a major contributor to the city's poor air quality.

2.2. Pimpri-Chinchwad

The industrial township of Pimpri-Chinchwad, which is the twin city of Pune, is renowned as the "Detroit of the East" due to the enormous number of original equipment manufacturers (OEMs) that are located there. Pune is the larger of the two cities. The Pimpri-Chinchwad Municipal Corporation (PCMC) is the governing body of the Pimpri-Chinchwad township and is in charge of its administration. Its name comes from the combination of the words "Pimpri" and "Chinchwad." This industrial belt and the areas that are immediately surrounding it have seen a boom in the growth of ancillary and small-scale businesses as a direct result of the growth of large-scale core industries.

2.3. Pune Mahanagar Parivahan Mahamandal Ltd. (PMPML)

In the Pune Metropolitan Region (PMR), PMPML operates public transportation buses. Pune Municipal Transport (PMT) and Pimpri-Chinchwad Municipal Transport (PCMT), two bus service providers, amalgamated to become PMPML on October 19, 2007. In a 60:40 ratio, PMC and PCMC own PMPML together. PMPML is governed by an independent Board of Directors (BOD), which includes representatives from the PMC, PCMC, and other organizations as members and the Chairman and Managing Director as its head.

At present, PMPML has 2,169 buses in its fleet, comprising diesel, compressed natural gas (CNG), and electric (e-bus) vehicles. The buses serve over 12 lakh (1.2 million) passengers daily on more than 350 routes inside PMR.

2.4. Clean mobility programs already in place

Pune's municipal administration has put into place a number of sustainable transportation projects to decrease vehicle emissions, including the following:

• Conversion of the fleet of autorickshaws to CNG: In 2009, Pune required that current autorickshaws be converted from diesel to CNG by offering financial incentives for up to 50% of the cost of doing so. The PMC has offered financial incentives for CNG conversion kits totaling more than INR20.1 crores (USD2.7 million).

• Infrastructure for non-motorized transportation development: Pune is a leader in the planning and construction of infrastructure for bicyclists and pedestrians. To direct the creation of a street network that supports demand growth, combines motorized and nonmotorized transport alternatives, and promotes accessible, safe, and pedestrian-friendly streets, the city administration produced Urban Street Design Guidelines (USDGs).

• Adoption of low-emission public transportation: PMPML has pledged not to add any additional diesel buses to its fleet of 1,662 CNG buses, which it presently operates. Either CNG or electric will be used for future purchases.

• The electrification of the government fleet: As of 1 April 2022, all new cars leased for government use must be electric, according to the Maharashtra State Electric Vehicle (EV) Policy 2021. Pune is a pioneer in this area; the PMC recently approved a proposal to lease 38 electric cars for eight years to be used for the daily commuting of its officials.

• Other significant measures include the adoption of a thorough bicycle plan by the city administration to build a vast network of bicycle routes and the creation of a progressive parking regulation to discourage the usage of private vehicles and promote public transportation.

2.5. The driving forces behind Pune's purchase of electric buses

The municipal government and PMPML studied the possibility of adding e-buses to PMPML's fleet in 2018 to supplement current clean mobility programs. The

following are some of the various driving forces behind Pune's interest in e-buses:

2.5.a. Goals that are in line with those of the community, state, and nation

It is common knowledge that the city of Pune was an early pioneer in the field of environmentally friendly transportation, and the governments of the city, the state, and the federal level have all imposed stringent criteria for the city's public transit system in order to maintain this reputation. At the municipal level, the Comprehensive Mobility Plan (CMP) for Pune has established the target of achieving 90 percent of passenger trips using non-motorized and public transportation by the year 2031. This target was established for the city. The plan included a definition of this objective. The Electric Vehicle Policy 2021 of the Government of Maharashtra has established a target for the electrification of 25 percent of the public transportation bus fleet in the urban agglomeration of Pune by the year 2025. This aim was established at the level of the state. E-buses have the ability to help PMPML achieve its recently proclaimed objective of placing 950 new buses into service on a variety of municipal routes. This goal will be accomplished by putting the 950 new buses into operation.

2.5.b. Subsidies for electric vehicles offered by local governments and the federal government

The purchase of a diesel or natural gas bus of the same size can be up to three or four times as expensive as the purchase of an electric bus of the same size. This is despite the fact that electric buses have several benefits. If the government were to offer financial incentives to encourage the use of electric buses, then access to these vehicles might become easier for the general population. In order to stimulate the acquisition of 500 electric buses, the PSCDCL, PMC, and PCMC each provided financial incentives totaling 50 lakhs Indian rupees, which is equivalent to around 66,000 United States dollars. At the federal level, the Department of Heavy Industry (DHI) is offering demand incentives in the context of FAME II in the amount of up to INR55 lakhs (USD72,000) per bus. These incentives are being offered in accordance with particular criteria that the State Transport Undertaking (STU) is required to satisfy.

2.5.c. Lower vehicle emissions and improved quality of the air in the surrounding area

E-buses are able to improve the air quality in their surrounding areas and lower the amount of emissions produced by automobiles since they do not emit any emissions from their tailpipes and have fewer CO2 emissions than vehicles powered by internal combustion engines (ICE). This allows them to reduce the amount of emissions produced by automobiles.14 The National Clean Air Programme (NCAP) mandates that by the year 2024, the levels of PM2.5 and PM10 must have decreased by between 20 and 30 percent in Pune and the other 132 cities that are part of the program. In order to achieve these objectives, the city of Pune in India established the Clean Air Project India, also known as CAP India. This is an organization that focuses on ecologically responsible mobility initiatives in order to lower levels of air pollution.

3. PLANNING FOR PROCUREMENT AND IMPORTANT PARTIES

In 2018, the Board of Directors of PMPML passed a resolution that called for the organization to work with PSCDCL to buy 500 electric buses over the course of two separate phases by 2019–20. After that, PSCDCL provided a contribution of 125 crores, which is equivalent to 16.5 million dollars USD. A working committee was established by Pune's urban local bodies (ULBs) in order to direct planning and procurement, and under the FAME II

program, PMR was allocated 150 electric buses.

3.1. Participants, their roles, and their responsibilities

Between July 2018 and September 2018, PMPML organised a number of working group meetings for the purpose of debating and aligning on bus specifications, possible depots, the estimated average daily run, and other concerns.

essential parameters. PMPML worked along with PMC, PCMC, and PSCDCL on this project. The Central Institute of Road Transport (CIRT), Ernst and Young (EY), and the Maharashtra State Electricity Distribution Company Limited (MSEDCL) all provided the working group with technical assistance. These three organizations also participated in the meeting and shared their technical expertise. The successful e-bus procurement and operations in Pune may be mainly credited to the ULBs and organizations engaged coordinating their efforts and having a common understanding of their respective roles in the process.

3.2. Get the model for purchase

When it came to the purchase, operation, and maintenance of electric buses, PMPML came to the conclusion that it would be best to utilize either a gross cost contract (GCC) or an operating expenditure (OPEX) model. In the GCC or OPEX model, which is an innovative public-private partnership contract structure for the provision of public transportation services, a transit authority makes a per-kilometer payment to a private bus operator in exchange for the private bus operator providing municipal bus services along certain routes. In other words, the transit authority pays the private bus operator for the provision of municipal bus services. In this case, PMPML is the entity responsible for establishing service standards and paying a price per kilometer, in addition to controlling things like scheduling, route planning, and fare collection. It is the responsibility of the operator to provide crew members in addition to the responsibility of operating and maintaining the buses as a service. The operator is responsible for both the acquisition of the infrastructure and the drivers as well as the provision of these services. This paradigm lessens the risk that STUs face in both the financial and the technological arenas. However, in order to verify that their requirements are being satisfied by the operator, STUs are expected to keep a careful eye on the key performance indicators.

3.3. Purchase schedule

The procedure for purchasing an electric bus in Pune consisted of two parts. To begin, the PMPML issued two tenders for the purchase of 150 e-buses in the months of September and December of the previous year. Of those 150 e-buses, 25 were 9-metre AC e-buses and 125 were 12-metre AC e-buses. Second, PMPML put out two more solicitations for bids in July 2019 and September 2020, this time for 350 and 150 12-metre AC e-buses, respectively.

In February of 2019, the first 25 electric buses were put into service, and in August of 2019, the remaining 125 electric buses from the first round of tendering were put into service. In March of 2022, 70 further electric buses were put into operation. The delivery of the final 430 electric buses was completed by August 2022.

4. DETAILS OF THE TENDER AND SERVICE LEVEL AGREEMENT

4.1. Important terms from the request for proposals summarized

Four letters of award (LOA) were signed for the four RFPs that PMPML launched. The quantity and characteristics of buses, the contract length, the average daily run, and who is responsible for the expenditures are all terms in GCC tenders.

The bid price is heavily influenced by grid infrastructure upgrades and electricity for charging. The other crucial elements were payment conditions and bank guarantees.

Buses that are a combination of 9 and 12 meters in length, air-conditioned, and both compatible and non-compliant with PMPML's BRT system are included in all tenders. The daily minimum assured run was between 200 and 225 kilometres. The buses for the first three tenders were required to travel 125 km on a single charge, with the remaining 100 km being covered by opportunity charging; the buses for the fourth tender were required to travel 225 km on a single charge, without the use of opportunity charging.

Even if PMPML is financially in charge of the electricity costs, the operator was required to make sure the buses' energy usage doesn't go beyond 1.4 kWh/km.

4.2. Key words from service level agreements summarized

For all tenders, PMPML and the chosen service provider, BYD-Olectra, signed service level agreements (SLAs) outlining each party's responsibilities in order to ensure effective commissioning and smooth operations. The first three bidders received financial assistance from PSCDCL in the amount of INR 50 lakhs (USD 68 million) each bus. For the final FAME II tender, DHI offers financial incentives of up to INR55 lakhs (USD75,000) each bus.

To make it simple for the operator to operate and maintain the operating e-buses, PMC and PCMC gave the operator, BYD-Olectra, land and space for parking and charging infrastructure at the designated depots. The e-buses may operate for 18 to 20 hours each day, with a maximum load of 42 or 60 passengers for 9- and 12-meter buses, respectively. With the help of 80 kW AC charging stations, the e-buses normally charge in four hours or less. The base kilometer rate will increase by 1% starting in the third year of the contract.

5. FACILITATORS AND CHALLENGES

Pune's experience with the purchase and use of e-buses provides useful knowledge and points of reference on the types of interagency cooperation, policy support, business model design, tendering and contracting terms, and infrastructure development that might facilitate the adoption of e-buses in Indian cities.

5.1 Preparing, Hiring, and Funding

• The Urban Local Bodies (ULBs) in Pune have a long tradition of being among the first in the city to adopt newly developed technologies. The management of the PMC, PCMC, PMPML, and PSCDCL was enthusiastic about the deployment of electronic buses, and they provided the required political will. There was the establishment of a working group, the formulation of a comprehensive strategy, the identification of potential sources of financing, and the monitoring and guaranteeing of progress. The municipal government received assistance from the Maharashtra state government in the form of the Maharashtra State Electric Vehicle Policy 2021.

• Coordination across departments: In order to be ready for the purchase of electric buses in Pune, the municipal administration established a working group and held regular meetings to report on their progress as well as discussions in order to get people's opinions. In addition, urban local bodies such as PMC, PCMC, PMPML, and PSCDCL defined specific responsibilities for themselves, consultants, and partners in order to ensure cooperation among all of the stakeholders involved.

• The selection of the procurement model utilized by the GCC and previous experience: PMPML admitted, over the course of a number of meetings that were conducted by PMPML, CIRT, and EY, that the GCC procurement model might be able to aid it in deploying e-buses with the least amount of financial impact and the least amount of technological risk possible. Since

PMPML and CIRT had worked together in the past to buy CNG buses through the use of the GCC model, it was able to make use of components of earlier document templates, such as RFPs and SLAs, thanks to this history of collaboration. Because of this, the company was able to save both time and money. In addition to this, it assisted them in preparing for the particular contract conditions that may be required, such as bank guarantees, recurring payments, and penalties.

• The existence of tax policies at the municipal, state, and federal levels that are to one's advantage: The electric buses were eligible for tax incentives under PSCDCL, which totaled INR125 crores (USD16.5 million) for 500 vehicles and amounted to a total of INR125 crores (USD16.5 million). The remaining 150 electric buses could potentially be eligible for financial incentives under the FAME II program, which could total up to 55 lakhs of Indian rupees, which is approximately $73,000 in American currency.

• We place a high focus on safety. PMPML worked closely with CIRT to guarantee that customers have a pleasant and secure riding experience on all of their buses. This was accomplished through tight coordination. Monocoque low-floor buses are built to endure the demands of day-to-day urban commuting while requiring less maintenance owing to an onboard Vehicle Health Monitoring System (VHMS). These buses are also designed to be more energy efficient. PMPML is responsible for the development of these buses. The electric drivetrains of the e-buses and their batteries each have a built-in automatic fire extinguisher as part of the standard equipment, and the batteries themselves are fire-resistant.

5.2 Launching, Operations, Maintenance

• Thorough selection of depots and routes: Before beginning e-bus operations, PMPML, with assistance from CIRT and EY, chose the depots and routes that would be the most suited for electrification in consideration of a number of characteristics. These depots and routes were determined to be the most suitable for electrification. In the case of the reduced number of depots, an exhaustive feasibility assessment was carried out to ascertain whether or not there would be sufficient space for parking, infrastructure for charging, and maintenance. The grant of land by the city administration made it possible for the deployment of the electric buses without causing any disruption to the operations that were already underway.

• Analysis of the schedule and trial runs: CIRT also carried out extensive vehicle homologation. In order to discover any potential operational concerns, many weeks of trial runs were carried out while employing a city-specific drive cycle for testing purposes. In addition, PMPML, the Traffic Police of Pune, and CIRT worked together to create a schedule for the e-buses so that they could continue to operate at the required frequency even when there was a lot of traffic.

• Making preparations in advance for grid upgrades: the Urban Local Bodies (ULBs) and the Maharashtra State Electricity Distribution Company Limited (MSEDCL) worked together in advance to collaborate on the extension of the electric system. This included the Bhekrai Nagar high-tension (HT) distribution lines depots in Nigdi. Because of this, commissioning was successful.

• Driver training: BYD-Olectra provided comprehensive training for drivers in order to assure smooth operations. This was done because the fuel economy of a vehicle is directly correlated to the driving behavior of the operator, including acceleration, throttle power, and braking. The cautious treatment of the electric buses was another factor that contributed to the absence of mechanical failures.

• Expertise in fleet management: It has been asserted that BYD-Olectra possesses excellent fleet management. Since the

beginning of operations in January 2019, there has not been a single instance of a bus breaking down due to insufficient range, voltage, or the functionality of charging stations. In other words, there has not been a single breakdown incident.

5.3. Challenges

• There is a limited capacity for local production, and only early-stage models are now available. As a result of the fact that the adoption of electric buses in India is still in its infancy, the country's production capacity is now somewhat restricted. This results in difficulties for high-volume supply orders and guarantees that those items will not be fulfilled on time. Because original equipment manufacturers (OEMs) rely largely on parts and engines made in other countries, having a model selection and delivery timetable that is flexible can help promote early adoption. It is projected that there will be a greater degree of competition in the bidding process, that costs will reduce, that more levels of customization will be feasible, and that delivery times will likely decrease as the number of e-buses produced increases and as more models become available.

• Bank guarantees: The STU as well as the operator have the capability to more effectively formulate bank guarantees. There is the potential for improvements to be made to bank guarantees, which are also sometimes called securities. In order to lower the cost of borrowing money, it is feasible that the length of time that the performance bank guarantee is in force could be cut down. In addition, the length of the bank guarantee that is connected to the government incentives may be shortened if the capital worth of the electric buses is amortized over the course of time.

• Keeping a close eye on both the total number of customers and the amount of fuel used: Because there were so many people traveling in the vehicle, its energy efficiency (as measured in kWh/km) was far lower than what was anticipated. Despite having a seating capacity of only 40 people and a total payload of only 70 passengers, these buses are able to carry up to 85 to 90 passengers concurrently during peak service. This is despite the fact that they are only capable of carrying a total of 70 passengers. Consumption of energy as well as the cost of power have both increased as a direct result of this.

• A more precise selection of depots and routes: despite the fact that the depots and routes for e-bus operations were planned out before the operations began, the current routes that are made accessible to the e-bus operator are very similar to those that are used by CNG buses. This allows for a more seamless transition between the two types of bus transportation. The criteria that are used to identify depots for electric buses as well as routes are capable of being significantly improved if a number of different factors are taken into consideration.

• Recent breakthroughs in fleet management technology: STUs in India have not yet embraced intelligent transport management systems (ITMS) for the purpose of data-driven routine route planning and usage, as well as effective fleet optimization. The planning and scheduling of electronic bus routes for student transportation units (STUs) can be made more effective with the assistance of ITMS.

By disseminating this information addressing potential facilitators as well as potential impediments, the municipal government of Pune hopes to motivate and educate other cities in India and the Global South in their efforts to successfully include e-buses into their public transit fleet. This will be accomplished through the sharing of this information. STUs in India and public transport organizations in other countries are strongly invited to get in touch with us so that we can supply them with extra information. This will allow us to better serve you.

6. ENVIRONMENTAL AND ECONOMIC BENEFITS

6.1. Analysis of total cost of ownership

What is indicated by the term "total cost of ownership," or TCO, is the cost of the acquired good or service, in addition to all of the other expenditures that are linked with owning and operating the means of transportation. These costs include fuel, maintenance, insurance, and depreciation. The total cost of ownership (TCO) of an electric bus with government incentives was calculated to be INR51.49/km (1.09 USD/mi), which is around 6% and 15% less expensive than the TCO of CNG and diesel buses, respectively.

The present model of an electric bus that operates in Pune is evaluated in comparison to a CNG bus, a diesel bus, and a school bus, all of which are included in the analysis. Each bus has a length of twelve meters and is outfitted with an air conditioning system. The expenses for the equipment and installation connected with an 80 kW AC charging station and a 150 kW opportunity charging station are paid in full for the purpose of the e-bus program.

Over the course of its lifetime, each electric bus has the potential to save INR69 lakhs (about $91,000), which results in a total savings of INR450 crores (approximately USD60 million) for the fleet of 650 electric buses. Despite the higher initial investment and ongoing expenses involved with charging infrastructure and battery replacement, the operation of electric buses is more cost-effective due to lower operating and maintenance expenses. This is because electric buses have fewer moving parts, which reduces the likelihood of mechanical failure. When compared to the price of diesel in Maharashtra, which is currently INR94.72/litre (which is similar to INR19.25/km), the cost of electricity is currently INR6/kWh (which is comparable to INR6.79/km). In addition, the costs associated with maintaining conventional buses can be up to three times more than the costs associated with maintaining electric buses.

6.2. Environmental and air-quality benefit analysis

PM2.5 and CO2 emissions can be decreased by switching to e-buses. This estimate shows that PMPML's fleet of 650 electric buses could save 96,000 tons of CO2 and 1.2 tons of PM2.5 in net emissions over the course of the buses' lifetimes, which is almost the same as the lifetime CO2 emissions of 2,000 gasoline-powered cars.

6.3. Some important learnings from e-bus procurement and operation in Pune are as follows:

1. Political leadership has the potential to hasten the introduction of the e-bus. Senior officials from the Pune Municipal Corporation (PMC), Pimpri-Chinchwad Municipal Corporation (PCMC), Pune Smart City Development Corporation Limited (PSCDCL), and Pune Municipal Pollution Management Limited (PMPML) have been dedicated to working together to execute strategies to alleviate local air pollution for a number of years now. They are also responsible for laying the groundwork for the city's decision to buy electric buses to add to its existing fleet of public transit vehicles. These decision-makers were united in their pursuit of a common objective; they shared a common knowledge of the system; and they were steadfast in their encouragement of the necessary measures to fulfill their commitment.

2. Coordination across departments can help speed up the process of planning for E-buses. Together with PMC, PCMC, and PSCDCL, PMPML initiated the formation of an e-bus working group. They got professional assistance in the areas of business model creation, tendering and contracting, and planning charging infrastructure from the Central Institute of Road Transport (CIRT), Ernst & Young (EY), and the Maharashtra State Electricity Distribution Company Limited (MSEDCL).

By holding frequent meetings and clearly outlining everyone's responsibilities, we were able to assure that decisions would be made effectively and that actions would be coordinated.

3. Electric buses could be less expensive overall than their diesel counterparts in the long run. The predicted total cost of ownership (TCO) for a 12-meter, air-conditioned electric bus in Pune is INR56.52/km (USD1.2/mi), which is approximately 6% less than the estimated TCO for a comparable diesel bus, which is INR59.89/km (USD1.26/mi). In the United States, this translates to a cost savings of $0.26 per mile. Because of government incentives such as PSCDCL and FAME II, the cost of TCO is currently 15% lower than that of diesel and is more cost-effective than that of compressed natural gas. During a period of ten years, each electric bus has the potential to save INR69 lakhs (USD91,000), which translates to cost savings of INR450 crores (USD60 million) for the fleet of 650 electric buses. In addition, the reductions in overall operational costs far outweigh the influence of government incentives.

4. Utilization of the gross cost contract procurement model. The rollout of electric buses in urban areas can be sped up significantly. According to the gross cost contract (GCC) or the operational expenditure (OPEX) procurement model, a public transportation agency will make a per-kilometer payment to a commercial bus operator for bus service on certain routes. Buses, drivers, infrastructure, fueling, and maintenance are typically all a part of the service that is provided. When it comes to the introduction of e-buses, public transportation agencies face a number of challenges on the technological, financial, and operational fronts; the Indian government is working to mitigate as many of these challenges as it can through the promotion of an innovative procurement strategy. This technology has made it possible for Pune and a number of other cities in India to adopt e-buses into their fleet in a seamless manner; it is possible that other countries will find a use for it as well.

5. Familiarity with the GCC model. Before beginning the tendering and contracting process helped to ensure a smooth process. PMPML and CIRT were able to make use of certain parts from past tendering and contracting templates, such as requests for proposals (RFPs) and service-level agreement papers, due to their prior experience acquiring compressed natural gas buses using a GCC model. This was made possible by the fact that PMPML and CIRT had previously acquired compressed natural gas buses using a GCC model. Because of this, it was quite easy for them to establish unique GCC terms like bank guarantees, escrow accounts, and fines.

6. The technology that is currently in use for e-buses and charging infrastructure is capable of meeting performance specifications. The electric buses in PMPML's fleet adhere to the specified duty cycles, and BYD-Olectra, the company that operates them, reliably travels between 200 and 225 kilometers on a daily basis. The buses are maintained by charging stations that provide opportunity charging during the day and charging stations that provide 80 kW nighttime charging. To this point, there have been no complaints about problems with the infrastructure, the services, or the maintenance.

7. Proactive planning can guarantee efficient commissioning and safe operation when dealing with large loads. There is a possibility that electric bus fleets will require a service capacity of several megawatts at a single connecting point. This is due to the fact that high-power charging stations typically take up centralized positions within a single storage facility. The local distribution utility, MSEDCL, and the operator, BYD-Olectra, worked closely together with PMC, PCMC, and PMPML to plan for the connection of charging stations and e-bus charging, as well as to perform the necessary adjustments to the grid, including the construction of high-tension (HT)

distribution lines. This was done in order to prepare for the connection of charging stations and e-bus charging. This was done in order to get ready for the connecting of charging stations and charging for the electric buses. They also discovered the prospect of nighttime pricing, which offers an electricity price that is fifty percent less expensive. This would result in a lower peak load and, as a result, a reduction in operational expenses.

8. Electric buses have the potential to significantly cut both local air pollution and emissions of carbon dioxide. If a greater number of people in Pune used electric buses, it is feasible that the city's emissions of carbon dioxide (CO2) and fine particulate matter (PM2.5) may be lowered. If placed next to a fleet of diesel buses of the same size, the 650 electric buses have the potential to prevent the emission of 1.2 tons of PM2.5 and 96,000 tons of CO2 throughout the length of their lifespan. This is in comparison to the fleet of diesel buses. This is roughly identical to the amount of carbon dioxide emissions that would be generated by 2,000 automobiles if they were fueled by gasoline.

9. E-buses are supported by the general public, by operators, and by the governments of urban municipal organizations. The benefits of electric buses have been recognized by various stakeholders throughout the entire city. Authorities within the government are excited to expand the number of public transit vehicles in the city's fleet, which will simultaneously provide people with a service that is of excellent quality and produces little emissions. Both drivers and passengers have reported that the environment is now more comfortable and tranquil.

10. The Maharashtra state government has set an electrification target for public transportation. With the clear directive from the State government, PMPML is on track to meet that target three years earlier than originally anticipated. One of the targets of the Maharashtra State EV Policy 2021 is to electrify 25 percent of the bus fleet that is used for public transportation in Pune by the year 2025. There were 500 electric buses in the PMPML fleet as of March 2023, which represented 20% of the overall fleet. After the scheduled launch of additional e-buses later this year, this percentage will reach exactly 25%, surpassing the goal three years earlier than it was originally planned.

7. CONCLUSION: THE WAY AHEAD FOR INDIA IN ITS ENDEAVOR OF E-BUS FOR URBAN TRANSPORT

The Ministry of Finance (MoF) of the Government of India has provided a budget for dealing with the problem of air pollution to 42 cities in the country with a population of more than 1 million people. The National Clean Air Programme will use these funds, which were approved by the 15th Finance Commission, to help these cities' air quality. A sum of INR504 crores (USD 67 million) has been allotted to the Pune urban agglomeration for the years 2020 to 2026. In India, 4 out of every 10 buses built by 2030 may be electric. E-bus sales must rise in order to reach this level of market penetration. Monetary rewards, demand assurance, and effective deployments are essential components to cut costs, boost industry confidence, and encourage investment in manufacturing. The city government of Pune hopes to encourage and provide guidance for efforts to electrify buses in other Indian cities and around the world through this report and current initiatives.

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