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EXECUTIVE SUMMARY

# HOW TO ENABLE ELECTRIC BUS ADOPTION IN CITIES WORLDWIDE

*A Guiding Report for  
City Transit Agencies  
and Bus Operating Entities*

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# FOREWORD

Imagining the world in 2030 can be a dangerous thing. But it can also help us plot how to achieve the net-zero carbon world we need to survive. Large-scale electrification is a necessary step down this road, and bus fleets are an opportunity to make an outsized impact on air pollution and greenhouse gas emissions in dense urban environments.

One way to do this is demonstrated by cities like Shenzhen, which have been ambitious and aggressive, adopting large-scale fleets with the help of multiple incentives. Other cities have been more cautious, piloting electric buses but hesitating to scale beyond a few dozen vehicles. Most cities have been holding back, making no immediate plans and no progress toward integrating electric buses into their existing, largely fossil-fuel-based fleets.

Electric buses could pioneer a new age of clean and efficient urban transport and put cities on track toward sustainability. But adoption is not accelerating fast enough for the world to meet transport-related global climate objectives and limit global temperature rise to below 2 degrees Celsius.

Those reading this report – especially transit practitioners, city employees and on-the-ground technical staff – will find practical solutions to adopting electric buses. Its precursor report, *Barriers to Adopting Electric Buses*, is a high-level document that focuses on the current obstacles to adopting electric buses. In these two sister reports, WRI aims to tackle several pressing questions to help change the trajectory of cities and put them

on track towards sustainability. In case studies of 16 electric bus projects in 16 cities, we analyze different pathways cities have taken toward electric bus adoption, the enabling conditions for success, and common problems.

Based on the observed successes in our case studies and through other literature, we identified common enabling factors, including structured and flexible pilot programs; well-informed and methodical cost-benefit analyses; and actionable and time-bound targets for scaling-up adoption from a small number of buses to entire fleets.

The report utilizes in-depth case studies, clear steps, and illustrative adoption paths, to provide not only a compelling vision of the future, but also a clear pathway to harnessing the air quality, climate, and other benefits of electric buses for a more sustainable future.

The revolution is underway!



**Andrew Steer**  
President  
World Resources Institute



**Ani Dasgupta**  
Global Director  
WRI Ross Center





# EXECUTIVE SUMMARY

Electric buses (e-buses) have zero tailpipe emissions and lower operational costs, can help cities address local noise and air quality issues, and reduce greenhouse gas emissions when the grid is clean enough. However, the process of transitioning to electric transportation poses many significant challenges that must be addressed through careful planning and coordination. This report is based on lessons learned from 16 cities that are working toward electrifying their bus transit fleets. It provides background information on e-buses and offers a planning and implementation framework for cities with varying levels of experience in e-bus adoption.



## HIGHLIGHTS

- Electric bus adoption projects should be planned and carried out in a thoughtful way. For initial planning and small-scale projects, five steps should be followed: consider the existing policy landscape; conduct an initial analysis to understand costs, benefits, stakeholders, and constraints; plan and launch a structured pilot project; collect local data, update the initial cost-benefit analysis, and explore financing options; and set actionable and time-bound targets for long-term and large-scale adoption.
- For the mass adoption of large-scale electric bus projects, at least four components should be considered: formalizing and implementing a long-term infrastructure plan for large-scale electric bus fleets; formalizing and implementing e-bus procurement plans adjusted to city conditions, and financial instruments to reduce costs and risks; providing training to bus operators based on international best practices and local experiences; and planning for the end-of-use of the buses, especially their batteries.
- Cities adopting electric buses can be categorized into five development stages, depending on policy readiness and on-the-ground implementation level, and cities may take different actions depending on their development stage to ensure quality adoption and enhancement.
- Transit agencies and bus operating entities play a key role in electric bus adoption. They should be actively involved at the planning and analysis stages of a city's electric bus adoption projects, together with city policymakers and utility companies; be serious about piloting and testing projects, using them as valuable learning tools to improve planning and operation; and consider the long-term environmental and social benefits of clean technology.

It is an exciting time for clean energy technologies, and the transport sector is undergoing a particularly important transformation. As part of this revolution, cities around the world have begun to consider integrating electric buses into their transit fleets. E-buses have been tested and adopted in several major metropolitan areas in the past decade. However, nearly all the cities adopting e-buses are located in China, Europe, and the United States. Challenges exist to expanding the adoption of e-buses around the world, especially in the global South. In general, the barriers lie in three major categories—technological, financial, and institutional—and deal with issues related to vehicles and batteries, operations, and charging infrastructure. However, a systematic review of potential solutions and an adoption framework are seldom provided for cities that need help adopting electric buses.

## About This Report

The aim of this report is to fill in knowledge gaps and provide actionable guidance for transit agencies and bus operating entities to help them overcome the most common and debilitating barriers to e-bus adoption. We analyzed e-bus activities in 16 cities<sup>1</sup> as case studies to ensure that all recommendations are rooted in real-world experiences. The case studies were selected to reflect a wide range of geographies and levels of experience in e-bus adoption, with a focus on the global South. The research was completed through a literature review of academic papers and reports, interviews, and on-the-ground gathering of information from primary sources.

We focus on two key questions: What pathways have cities taken toward electric bus adoption? And what are the enabling conditions for electric bus adoption in cities? These questions helped us identify key actions that cities have taken to adopt e-buses under different circumstances.

This report may be read in conjunction with *Barriers to Adopting Electric Buses*, a sister publication produced by World Resources Institute (WRI). That report, based on the same 16 case study cities, identifies and elaborates on the main barriers that cities face when implementing e-bus projects, especially in the global South. The barriers outlined in that report are meant to serve as cautionary tales, helping officials anticipate the challenges they may face and plan accordingly to avoid costly mistakes.

## Different Stages of E-Bus Adoption

Based on city actions taken to date, we developed a categorization system to assess the relative progress made by each of the 16 cities toward mass e-bus adoption. The cities are predominantly from the global South but two cities from the United States and Europe (Philadelphia and Madrid) are also included because their advancement in e-bus adoption can provide some useful information for other cities. Specific city-level actions were also categorized as either policy- or implementation-based actions:

- **POLICY-BASED ACTIONS:** The city government has considered or is actively considering specific e-bus policies or adoption targets.
- **IMPLEMENTATION-BASED ACTIONS:** The city (or some operators) has procured and is operating e-buses either as a pilot or as part of its public transit operations.

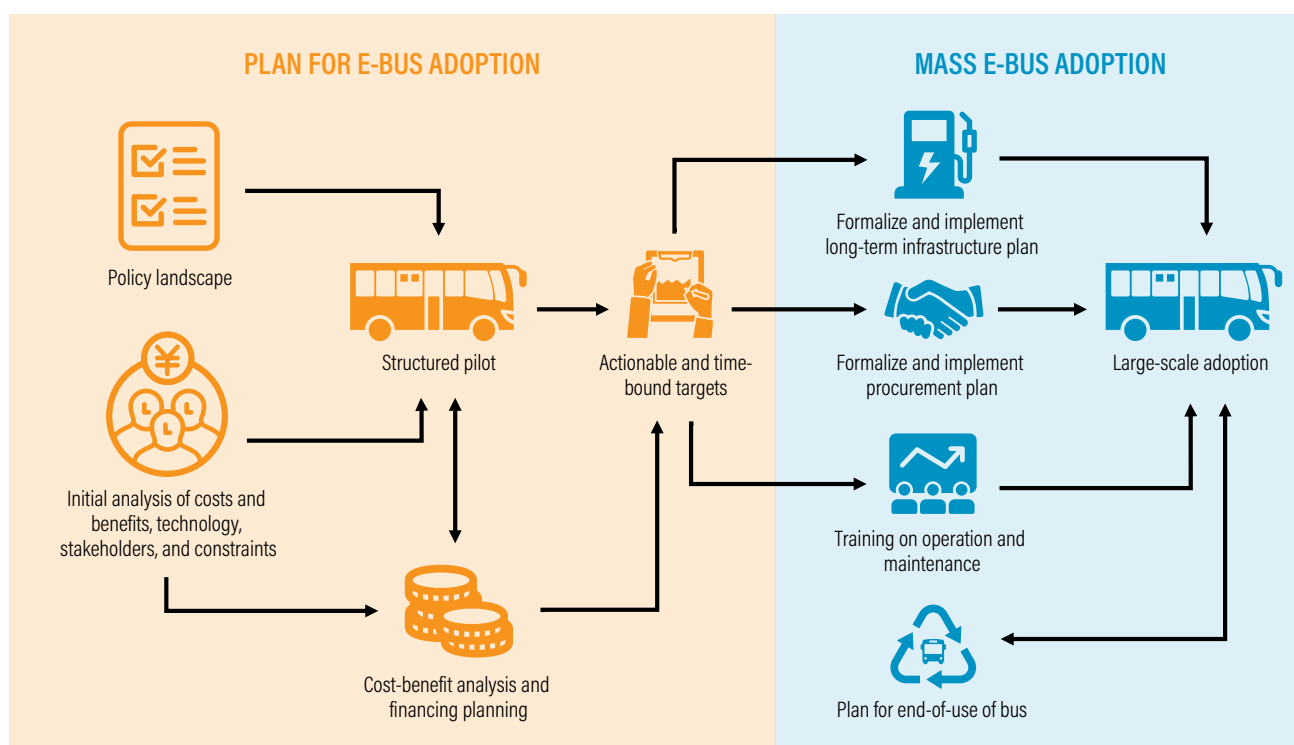
The extent to which each of the 16 cities has taken concrete policy and/or implementation actions

was evaluated to place each city into one of five categories, called Stages 0 to 4. Cities can use this evaluation system as a guide to determine where they stand in terms of their stage of electric bus adoption.

## Solutions to Enable E-Bus Adoption in Cities

Transit agencies and bus operating entities are encouraged to maximize electric bus adoption targets based on local conditions, and to develop a responsible strategy for implementation. This report provides step-by-step guidance to establish and achieve e-bus adoption targets using concrete and diverse real-world experiences. We define nine steps to be taken by stakeholders interested in moving toward full e-bus adoption (Figure ES-1). The first five steps cover initial preparation and planning, and the next four steps address how to scale up to reach mass e-bus adoption.

Figure ES-1 | Enabling Factors and Actions in the Planning and Scaled-Up Lifecycle of E-Bus Adoption



Source: Authors.

## Initial preparation and planning for e-bus adoption

Perhaps the most difficult step toward any bold transformation is making the decision to get started. Information provided in this section is intended to make that decision as easy as possible. Five major steps are described in this report for building an actionable e-bus adoption plan:

1. **Consider the policy landscape.** Before starting any project, transit agencies and bus operators should review existing policies in the country and city, either supportive of, obstructive to, or indirect to electric bus adoption; analyze the potential impact of their adoption of e-buses; and analyze the potential impact if the policies were to change. City officials who want to increase the e-bus fleet size of the city should also consider the potential to use different policy instruments to incentivize adoption, and coordinate between sectors to facilitate effective policy implementation.
2. **Perform an initial analysis.** When the project is starting from scratch, questions that arise should be answered based on concrete analysis. It is key for transit agencies and bus operating entities to conduct an initial analysis to understand the following: the total cost of owning electric buses; the environmental and social benefits generally and in the local context; the existing and potential new stakeholders; the constraints of adopting electric buses in the city; and any potential solutions to address the constraints. If cities lack sufficient capacity to conduct any part of this analysis, they can reach out to peers or research institutes for help.
3. **Launch a structured pilot project.** Cities should avoid “analysis paralysis” by taking action and gaining practical experience. Pilot projects are a low-barrier opportunity for cities to test ideas and learn by doing. A good electric bus pilot project has clear definitions on the scale and timing, specifies the data needed, includes data collection mechanisms, and plans ahead for charging infrastructure regardless of the scale of the current e-bus fleet. In addition, choosing more than one bus model to test can reduce the vulnerability of the project and give more flexibility for the city to adapt to technology upgrades. Lastly, it is important to

have a flexible planning process that takes into account emerging results and lessons learned through trial and error and that supports information sharing and peer learning.

4. **Update the cost-benefit analysis and explore financing options.** Based on the initial analysis and operational data collected, a more advanced cost-benefit analysis of the project should be conducted. Different financing options should also be researched and analyzed to ensure the electric bus adoption plan will be sustainable over the long term. Considering that transit agencies and bus operating entities normally do not monetize the environmental benefits of reduced pollution from the public transport sector, the results of the cost-benefit analysis and financial analysis may differ, leaving room for innovative financing mechanisms.
5. **Set actionable and time-bound targets.** Targets are easy to set but hard to follow if they are not analysis-based, actionable, and time-bound. Stakeholders should work together to reduce duplicative efforts or miscommunication and define a reliable electric bus adoption target for the city based on the city’s ambition and information collected. This can also improve the actionability of the project and help ensure the targets are achieved.

## Reaching mass e-bus adoption

Scaling e-bus implementation is a fundamental challenge to fully adopting e-bus fleets, but is often given too little attention at the outset of an e-bus program. While many cities around the world have successfully initiated e-bus pilot programs, very few<sup>2</sup> to date have been able to move e-buses to the mainstream and position them as a substantial percentage of their entire bus fleets. Four major steps are described in this report for expanding the scale and quality of an e-bus fleet:

1. **Formalize and implement a long-term infrastructure plan.** Charging infrastructure is one of the most important features of electric buses that conventional buses do not share. Having sufficient infrastructure is paramount to the success of large-scale electric bus adoption due to the increased complexity of an e-bus network. A few aspects should be planned ahead by the transit agency and bus operating entity



together with the utility and urban planning sectors: creating a site plan to address the reality of land scarcity; analyzing and defining the technical specifications of charging stations; exploring innovative charging mechanisms, such as smart charging; and developing plans to deal with power outages. In addition, infrastructure-related expenses, which are often underestimated, should be carefully evaluated.

2. **Formalize and implement an e-bus procurement plan.** As e-buses use a relatively new technology with limited operational experience, transit agencies and bus operating entities should integrate the technological uncertainties into formalized procurement plans. Specific technical details should be defined in the procurement plan, which could be customized to assure the public transport service of the city. Since the technology is evolving quickly, future technology advancement should be considered. The procurement models that work for the city should be carefully studied and analyzed and, ideally, should help incentivize electric bus adoption and reduce the costs and risks for bus operating entities.
3. **Train bus operators—a necessary but often overlooked step in electric bus adoption.** Training can help improve the operation behavior of drivers, increase the

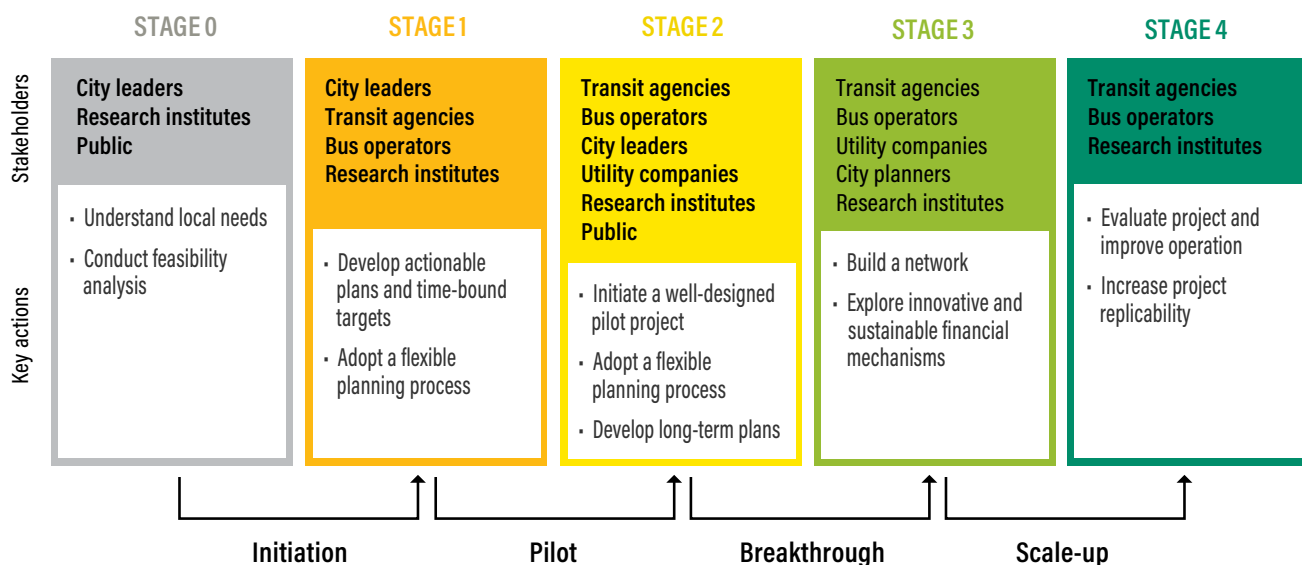
efficiency of buses, extend the life of batteries, and reduce the need for maintenance. These can help decrease the operation and maintenance expenses for the operators

4. **Plan for end-of-use for each e-bus.** E-bus batteries can be harmful to the environment if they are not handled responsibly at the end of their lifespans. Meanwhile, the residual value of e-bus batteries is poorly defined due to the evolving nature of the technology. This potential environmental harm and economic uncertainty for electric buses requires the transit agency and bus operating entity to carefully craft a responsible retirement plan for each electric bus and explore innovative bus and battery scrappage mechanisms with other stakeholders, especially bus and battery manufacturers, to reduce the total costs and risks. This, in turn, can help incentivize the adoption of electric buses and reduce the negative impacts on the environment.

## Recommended Key Actions for Cities at Different Development Stages

Based on the enabling conditions identified in our analysis of the 16 case study cities, we recommend that in addition to following our general guidelines for e-bus adoption cities emphasize the key actions described in Figure ES-2.

Figure ES-2 | Key Actions for City Stakeholders at Different Development Stages



## ENDNOTES

1. Addis Ababa, Ethiopia; Ahmedabad, India; Quito, Ecuador; Mexico City, Mexico; Belo Horizonte, Brazil; Cape Town, South Africa; Bogotá, Colombia; Bangalore, India; Madrid, Spain; Philadelphia, United States; Manali, India; Izmir, Turkey; Campinas, Brazil; Santiago, Chile; Shenzhen, China; Zhengzhou, China.
2. Based on the initial screening done by the authors, these cities are mainly located in China with some in Europe.

## ABOUT WRI

World Resources Institute is a global research organization that turns big ideas into action at the nexus of environment, economic opportunity, and human well-being.

### Our Challenge

Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth's resources at rates that are not sustainable, endangering economies and people's lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

### Our Vision

We envision an equitable and prosperous planet driven by the wise management of natural resources. We aspire to create a world where the actions of government, business, and communities combine to eliminate poverty and sustain the natural environment for all people.

### Our Approach

#### COUNT IT

We start with data. We conduct independent research and draw on the latest technology to develop new insights and recommendations. Our rigorous analysis identifies risks, unveils opportunities, and informs smart strategies. We focus our efforts on influential and emerging economies where the future of sustainability will be determined.

#### CHANGE IT

We use our research to influence government policies, business strategies, and civil society action. We test projects with communities, companies, and government agencies to build a strong evidence base. Then, we work with partners to deliver change on the ground that alleviates poverty and strengthens society. We hold ourselves accountable to ensure our outcomes will be bold and enduring.

#### SCALE IT

We don't think small. Once tested, we work with partners to adopt and expand our efforts regionally and globally. We engage with decision-makers to carry out our ideas and elevate our impact. We measure success through government and business actions that improve people's lives and sustain a healthy environment.

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WRI Ross Center for Sustainable Cities helps create accessible, equitable, healthy and resilient urban areas for people, businesses and the environment to thrive. Together with partners, it enables more connected, compact and coordinated cities. The Center expands the transport and urban development expertise of the EMBARQ network to catalyze innovative solutions in other sectors, including buildings, land use, energy and water. It combines the research excellence of WRI with 15 years of on-the-ground impact through a network of more than 250 experts working from Brazil, China, Ethiopia, India, Mexico and Turkey to make cities around the world better places to live. More information at [www.wrirosscities.org](http://www.wrirosscities.org).

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