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EXECUTIVE SUMMARY

BARRIERS TO ADOPTING ELECTRIC BUSES

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ACKNOWLEDGMENTS

This report was developed under the project "Transitioning to a zero-emission transport world through bus electrification" along with its sister report, *How to Enable Electric Bus Adoption in Cities Worldwide*. We are grateful for the financial support of Germany's Federal Ministry for Economic Cooperation and Development for this project.

We would like to express our gratitude to the many people whose ideas and contributions were invaluable to the structure and content of this report. Several staff contributed to its creation. Emma Stewart was instrumental in helping to structure and initiate the report. Our internal reviewers at WRI helped guide the direction of the report: Anne Maassen, Anusha Chitturi, Celina Bonugli, Eric Mackres, Jone Orbea, Sergio Avelleda, Su Song, and Tolga Imamoglu. We would particularly like to acknowledge Renata Marson, Laura Malaguzzi Valeri, Maria Hart, and Emilia Suarez for their dedication and support in the research and review process. We also thank Emily Matthews and Sarah DeLucia for timely and crucial editorial support. We would like to thank the communications team—Romain Warnault, Jenna Park, Schuyler Null, and Billie Kanfer —who provided support in editing, graphic design, and outreach.

We would like to thank the following external reviewers, whose expertise in transport electrification were invaluable to the report: Adalberto Maluf (BYD Latin America), Bianca Bianchi (World Bank), Daniel Moser (GIZ), Gail Jennings (independent researcher), and Rebecca Collins (SEPTA). We are also grateful to the local stakeholders who participated in the case studies research and helped improve the credibility of this report.

The research underpinning this publication also received support from the "Climate Technology Transfer Mechanisms and Networks in Latin America and the Caribbean" project. The project, implemented by the Inter-American Development Bank (IDB) and financed with resources from the Global Environment Facility (GEF), promotes the development and transfer of technologies to contribute to the reduction of greenhouse gas emissions and vulnerability to climate change in Latin America and the Caribbean. The project prioritizes the topics of mitigation and adaptation to climate change in the sectors of energy efficiency and renewable energy, transport, forest monitoring, and resilient agriculture. WRI is the project executing agency for the transport component of the project.

We are pleased to acknowledge our institutional strategic partners, which provide core funding to WRI: Netherlands Ministry of Foreign Affairs, Royal Danish Ministry of Foreign Affairs, and Swedish International Development Cooperation Agency. We are also pleased to acknowledge the Stephen M. Ross Philanthropies for its support of WRI's Ross Center for Sustainable Cities program.

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FOREWORD

You're the mayor of a big city. It's time to invest in new buses for your over-crowded public transport system. Should you buy traditional diesel-burning buses that account for a significant share of the air pollution, ill health, and carbon emissions in the city? Or, invest in the future: clean, non-polluting, energy-efficient, affordable electric buses?

An easy answer, surely?

But it's a harder decision than many realize. Electric buses have huge advantages, and over the coming decade will need to replace traditional fleets on a massive scale if we are to address climate change and enjoy healthy air. However, despite their huge promise, their adoption has been uneven and, except in China, limited in scale. Most cities that have pursued electric bus adoption have struggled at some point. Some cities have even abandoned their electric aspirations and returned to the fossil-fuel status quo. This is unfortunate and typically unnecessary.

This report, *Barriers to Adopting Electric Buses*, and its sister report, *How to Enable Electric Bus Adoption in Cities Worldwide*, identify the barriers and offer practical solutions. We present the key conclusions from research analyzing 16 case studies on six continents, with a wide range of urban development patterns, from emerging cities in India to sprawling metropolises in Latin America and megaregions in China.

Common obstacles identified in this report include lack of operational knowledge on electric bus systems; unfamiliar procurement and financing schemes; and institutional deficiencies in terms of authority, funding, and land for the changes needed. The barriers outlined are cautionary tales that can guide high-level planners safely along the road to electric bus adoption. *How to Enable Electric Bus Adoption in Cities Worldwide* offers a framework to overcome these barriers and is addressed to transit practitioners and on-the-ground technical staff.

The lessons from these 16 early adopters can help cities avoid past mistakes and make the complex transition to electric buses faster and more successful. This first-of-its-kind collection of in-depth case studies is an invaluable guide to what can go wrong, and what to do next.

The good news is that a growing number of cities are demonstrating that success is possible through collaboration and persistence. Our hope is that these successes be replicated at great scale.

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EXECUTIVE SUMMARY

Electric buses (e-buses) can help cities address air quality issues and reduce greenhouse gas emissions (along with a clean grid). The transition to e-buses, however, has been subject to growing pains as industries and governments alike struggle to nurture the nascent e-bus marketplace into maturity. This report identifies some of the largest and most common barriers to e-bus adoption. Cities must fully understand the barriers to electric bus adoption to act swiftly and decisively to surmount these obstacles.

HIGHLIGHTS

- WRI conducted 16 comprehensive case studies, predominantly of cities in the global South, to identify a variety of technological, financial, and institutional barriers that policymakers face during different stages of electric bus (e-bus) adoption.
- Key technological barriers are created by (1) the lack of relevant information for decision-making and (2) the current operational limitations of e-buses and charging infrastructure.
- Key financial barriers emerge from (1) the difficulties agencies face in making the necessary changes to rigid procurement structures and (2) the lack of long-term, sustainable financing options.
- Key institutional barriers stem from (1) the lack of political leadership and pragmatic public policy and (2) the lack of institutional authority, funding, and physical real estate.
- By mapping key technological, financial, and institutional barriers from 16 case studies worldwide, the report provides cautionary tales to help officials anticipate the challenges they will face and plan accordingly to avoid costly mistakes.

LIST OF ACRONYMS AND ABBREVIATIONS

BYD	Build Your Dreams (electric bus manufacturer)
CNG	compressed natural gas
CO_2	carbon dioxide
e-bus	electric bus
GHG	greenhouse gas
SEPTA	Southeastern Pennsylvania Transportation Authority
TCO	total cost of ownership
TDA	Transport and Urban Development Authority (Cape Town, South Africa)

Glossary

- **Action**: An act taken toward reaching a particular goal. In this report, the terms *step* and *action* are used interchangeably.
- **Barrier**: An obstacle or circumstance that can prevent transit agencies and/or governments from initiating, continuing, or expanding their fleet of e-buses.
- **Development stage**: The advancement of an e-bus program in a particular city. This report adopts five different development stages, as shown in Table 3.
- **Electric bus (e-bus)**: A bus with a propulsion system that runs entirely on electricity, which is housed inside the bus in a battery (typically a lithium-ion battery). For this report, e-buses do not include buses powered by parallel electric infrastructure, such as the overhead electric wires typically used to power trolley buses.
- **E-bus lifecycle**: The overall processes required for e-bus adoption, including initial preparation, planning, e-bus procurement, operation and maintenance (O&M), and processes after buses reach the end of their useable life span.

- **E-bus pilot program**: A project to explore e-bus technology, usually initiated and organized by a transit agency or government entity. E-bus pilot programs involve the procurement, testing, and operation of e-buses, typically with a limited number of e-buses, and sometimes for a limited duration of time.
- **E-bus tradespace**: The entire industry and supply chain surrounding e-buses. This includes the manufacturing, procurement, management, and disposal of e-buses and their associated infrastructure. This report divides the e-bus tradespace into three main elements: (1) vehicles and batteries, (2) agencies and operators, and (3) grid and charging infrastructure.
- **Emissions**: All substances that are discharged in the air. For this report, this term usually refers to tailpipe emissions from buses.
- **Enabler**: An element (such as a policy or an action) that can help transit agencies and governments initiate, continue, or expand their fleet of e-buses.
- **Global North**: A general term for countries with established and relatively mature economies. The global North is sometimes referred to as the "developed world," and typically includes Europe, Oceania, and the developed countries in Asia and North America.
- **Global South**: A general term for countries with emerging economies. The global South is sometimes referred to as the "developing world," and typically includes Latin America, Africa, and the developing countries in Asia.
- **E-bus project**: A term used generically to describe the entirety of a city's efforts to adopt e-buses.
- **Step**: An act taken toward reaching a particular goal. In this report, the terms *step* and *action* are used interchangeably.

Context

Electric buses (e-buses) have the potential to provide many benefits. Since e-buses have zero tailpipe emissions and are increasingly becoming commercially viable, they are emerging as a pragmatic option for reducing transit emissions. E-buses can help reduce CO_2 emissions globally (if the electricity is generated from a clean grid) while also reducing local pollutants. E-buses can also be a tool to improve energy efficiency (when strategically integrated and utilized as a grid resource), increase energy security due to reduced fossil fuel dependency, improve passenger comfort by reducing vibration and noise, and lower operating costs. Electrifying municipal bus fleets presents a unique opportunity to reduce emissions in the transportation sector while also bringing cobenefits to the cities making the transition.

The adoption of e-buses has accelerated in recent years, but the e-bus movement is still in its early stages. Globally, e-bus sales increased over 80-fold between 2011 and 2017 (Bloomberg New Energy Finance 2018). Nevertheless, e-buses still represent a new technology, which, compared to conventional diesel buses, is relatively untested and uncertain.

The adoption of e-buses has accelerated in recent years, but it is not happening fast enough to contribute toward reaching long-term global climate objectives. Leading sources on climate change indicate that investment in e-buses and other low-carbon technologies needs to double over the next two decades to maintain global warming well below a relatively safe threshold of 2 degrees Celsius (°C) (GEF 2017; IPCC 2018). Thus, the transition to e-buses and other energy efficient technologies needs to be accelerated.

Growth in the use of e-buses has been concentrated in China (where 99 percent of all e-buses are operating) and the global North (OECD/IEA 2018; Bloomberg New Energy Finance 2018). Since the basic technology behind e-buses is equivalent worldwide, this geographic divergence in adoption suggests that the barriers to adoption are not solely technical but also specific to local characteristics of cities in the global South. To effectively and equitably adopt e-buses worldwide, more research is needed to understand not only the universal barriers to e-bus adoption but also the particular barriers facing cities in the global South.

About This Report

This report identifies and presents the main barriers that cities face when implementing e-buses, especially in the global South. The barriers outlined in this report are meant to serve as cautionary tales to help guide high-level planners (such as city and state elected officials and transit agency administrators) safely along the road to e-bus adoption.

Analysis for this report is framed by a literature review and based predominately on 16 WRI-conducted case studies. Research for this report was initiated by a review of relevant current literature. Publications were reviewed that covered the emerging findings and discussions on the topic of e-buses and on the broader topic of barriers to implementing clean energy technologies. Given the nascency of the market and the lack of current research on e-buses, WRI conducted 16 case studies to take the current pulse of e-bus adoption and inform the barriers stated in this report. These 16 case studies covered cities around the world (with a particular focus on the global South) and provided the foundation for the findings in this report.

This report may be read in conjunction with a parallel publication, *How to Enable Electric Bus Adoption in Cities Worldwide*. This additional report, based on the same 16 case-study cities, identifies and elaborates on the pathways that different cities have taken toward electric bus adoption and highlights the enabling conditions for electric bus adoption under different circumstances. Together, these two reports can help officials anticipate the challenges they will face and plan accordingly to successfully implement e-bus fleets.

This report was written by the electromobility team at WRI. WRI is a global research organization that spans more than 60 countries, with more than 700 experts and staff. The overall mission of WRI is to turn big ideas into action at the nexus of environment, economic opportunity, and human well-being. The goal of the WRI team working on electric vehicles is to shine a light on the barriers and enablers regarding electric vehicle adoption, to promote greater understanding of the opportunities and risks. This report has been published in partnership with the German Federal Ministry for Economic Cooperation and Development.

Key Barriers to Adopting Electric Buses

Based on analysis from 16 case studies and the literature, this report provides a matrix of barriers facing e-bus adoption. Barriers are categorized by (1) three major elements of the e-bus tradespace and (2) three general barriers to clean energy innovation. Table ES-1 presents this barriers matrix.

From this matrix, this report distills six key barriers facing transit agencies trying to adopt e-buses. These six key barriers are organized into the three general categories identified in this report (technological, financial, and institutional) and represent issues that transcend different elements within the e-bus tradespace. The case studies and literature suggest that these barriers will likely be faced by many transit agencies and are potentially debilitating issues that must be resolved for e-bus endeavors to move forward. These six key barriers are listed below:

Table ES-1 | Barriers Matrix

		GENERAL BARRIERS		
		Technological	**Financial**	**Institutional**
E-BUS TRADESPACE ELEMENTS	**Vehicles and batteries**	■ Lack of information on the advantages and disadvantages of e-buses ■ Range and power limitations of e-buses ■ Design flaws in e-buses ■ Disjointed or limited e-bus marketplace	■ High up-front capital costs of e-buses ■ Lack of financing options	■ Difficulties for manufacturers in engaging with cities ■ Lack of a plan to remove current bus stock
	Agencies and operators	■ Lack of information on how to start ■ Lack of operational data	■ Rigid financial management and business models ■ Scaling investment past initial pilot programs	■ No enabling policies supporting adoption of e-buses ■ Negative public perception ■ Coordinating maintenance duties ■ Weak governmental coordination ■ Informal transit
	Grid and charging infrastructure	■ Lack of understanding of the requirements to upgrade infrastructure ■ Limitations of the charging ports and stations ■ Grid instability ■ Lack of standards and regulations on charging infrastructure	■ Large capital expenses for grid infrastructure ■ Difficult to determine grid infrastructure responsibilities	■ Lack of space and land to install infrastructure ■ Limited planning for long-term implications

Source: Authors.

Key Technological Barriers

- **LACK OF KNOWLEDGE:** In general, cities lack the information needed to make informed decisions at almost all stages, from establishing an initial discussion to scaling up e-buses en masse. Cities lack both general knowledge on the barriers and enablers to implementing their e-bus fleet and city-specific data on the operational viability of their e-buses. Specifically, there is a lack of relevant information and data for cities to determine several key considerations:
  - The proper inputs required for an initial cost-benefit analysis of the e-buses and infrastructure
  - Strategies and techniques to optimize the design and implementation of an e-bus project
  - The operational characteristics, limitations, and maintenance requirements of e-buses available on the market
  - Infrastructure planning needs to be completed prior to adoption
- **TECHNICAL LIMITATIONS OF THE E-BUSES AND CHARGING INFRASTRUCTURE:** Technological limitations exist in all three components of the e-bus tradespace:
  - *Vehicles and batteries* produce limited range and power relative to conventional buses. The battery manufacturing industry, nascent and immature, faces a learning curve in its effort to produce reliable, road-tested products.
  - *Agencies and operators* lack the knowledge needed to adopt new operation models to accommodate for the range and power limitations of e-buses.
  - *Grid and charging infrastructure* are also new and evolving technologies that face limitations and stability challenges.

Key Financial Barriers

- **DIFFICULTIES FOR AGENCIES IN CHANGING PROCUREMENT PRACTICES:** Transit agencies and government institutions typically use rigid financial management models, which incentivize low-cost, low-risk procurement. Most procurement models do not consider the unique cost structure (more expensive up front but cheaper to operate than conventional buses) and uncertain risks inherent in e-buses and their corresponding infrastructure. Traditional procurement practices also do not allocate responsibilities for the new tasks associated with e-bus operations, such as maintaining the batteries and grid infrastructure. Although the total lifetime cost of owning e-buses is often lower than that of conventional buses, and agencies may recognize that a new approach toward procurement is needed, traditional models often prove difficult to change.

- **LACK OF LONG-TERM, SCALABLE FINANCING OPTIONS:** Given the risk, uncertainty, and nascency surrounding the e-bus industry, financing is a tremendous barrier that must be overcome if e-buses are to be implemented on a large scale. This is particularly true for municipalities that have not demonstrated strong credit worthiness with past investments. Scaling e-bus projects requires a large, risk-tolerant capital investment, both to procure the vehicles and to supply the necessary charging infrastructure and grid upgrades. Often no financial institutions are willing to make this investment, outside of small-scale pilot projects. Thus, the e-bus fleets in many cities are currently operating as nonscalable demonstrations.

Key Institutional Barriers

- **LACK OF LEADERSHIP AND PRAGMATIC PUBLIC POLICY:** One of the most frequently cited institutional barriers was the lack of enabling public policies and/or a specific implementation plan to guide e-bus adoption. In many cities, there are either (1) no laws or roadmaps to provide a strategy plan or financial backing for implementing e-buses, or (2) ineffective plans in place that lack clear goals and financial incentives. One main reason that guidelines and policies are not created and/or implemented is the lack of genuine interest from politicians and key stakeholders. When there are limited incentives and lackluster political support, it can be difficult for some cities to issue appropriate tenders to procure e-buses.

- **LACK OF INSTITUTIONAL AUTHORITY, FUNDING, AND LAND:** In many cases, a major barrier to initiating or furthering e-bus projects was the lack of institutional capacity. Some cities lack the resources or jurisdictional authority to coordinate an e-bus project. Informal transit posed a noteworthy barrier for many cities, since the owners and operators of informal transit vehicles are typically not accountable to transit agencies or other government bodies.

  The lack of government access to land and property also presented a substantial barrier to upgrading and installing the charging and grid infrastructure that e-bus projects require. Charging infrastructure requires land with permanent space to house it, which is often very difficult to find for transit agencies and municipalities. While property ownership issues are not conventionally thought of as barriers to e-bus adoption, owning and/or having permanent contracts over land to install and manage charging infrastructure is often crucial, especially as e-bus fleets are scaled up.

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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.

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.

PHOTO CREDITS

Cover photo Municipalidad de Santiago; table of contents Ben Low; foreword Ken Shimoda; p. 2 Galeria de Fan Bus; p. 4, 8 jo.sau; p. 9 WRI Ross Center for Sustainable Cities.

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