Scale-up Concept: Electric Bus Rapid Transit Opportunities

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

PROJECT PARTNERS

This report has been prepared for the project SOLUTIONSplus. The project has received funding from the European Union's Horizon 2020 research and innovation programme under the grant agreement no. 875041

This report has been developed in close cooperation with the project e-BRT203o (grant agreement no. 101095882).

TITLE

Scale-up Concept: Electric Bus Rapid Transit Opportunities

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PICTURES

All the pictures are provided by the SOL+ partners

June, 2024

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Executive Summary

This report provides an in-depth analysis of the deployment and challenges associated with electric Bus Rapid Transit (eBRT) systems, with a specific focus on cities in Africa and Latin America. As urban areas across the Global South grapple with increasing congestion, pollution, and the need for sustainable public transport, eBRT presents a promising solution. However, the implementation of these systems faces significant obstacles, including high costs, infrastructure needs, and the integration of renewable energy sources.

The general deployment of eBRT systems has gained momentum globally due to the need for sustainable urban transport solutions. Electric buses (e-buses), central to eBRT systems, offer substantial benefits such as reduced greenhouse gas emissions, lower operating costs, and improved air quality. These systems are increasingly attractive as advancements in technology reduce the costs of e-buses and charging infrastructure. Despite the benefits, challenges remain, particularly in the Global South, where financial constraints, unreliable power grids, and the need for large-scale infrastructure changes pose significant barriers to the widespread adoption of eBRT.

In Africa, cities like Cape Town, Dar es Salaam, and Dakar are at various stages of implementing BRT systems, with Cape Town and Dakar making significant strides toward electrification. However, these efforts are often hindered by high costs and infrastructure challenges. For example, Cape Town's efforts to transition to eBRT have been slow due to administrative hurdles and the need for grid stability. Similarly, Dar es Salaam's integration of e-mobility has been limited to pilot projects, with broader electrification efforts constrained by financial and infrastructural challenges.

Latin American cities such as Bogotá, Quito, and Buenos Aires have also been pioneers in BRT systems and are now leading the way in adopting eBRT. Bogotá's TransMilenio system is one of the world's most extensive, and the city is actively integrating e-buses into its fleet. However, similar to African cities, these efforts face challenges related to high costs and the need for substantial infrastructure upgrades. Quito, for instance, has made progress in expanding its e-bus fleet, but physical space limitations and investment needs continue to pose challenges.

To overcome these barriers and accelerate the adoption of eBRT, the report recommends several strategic approaches. These include leveraging international funding and partnerships to finance infrastructure and technology costs, investing in renewable energy to ensure grid stability, and adopting a phased approach to electrification. Additionally, enhancing institutional capacity through training and public-private partnerships can help cities manage the transition to eBRT effectively. By addressing these challenges, cities in the Global South can maximize the benefits of eBRT and contribute to more sustainable urban development.

1. Introduction

The EU-funded project, EBRT2030 - European Bus Rapid Transit of 2030: electrified, automated, connected -, aims at supporting the next generation of innovative and effective public transport (PT) systems thus accelerating the transition towards zero emission road mobility across Europe and improving the life of European citizens (eBRT2030, 2023). This project will bring some technological innovations in the light of the digitalization and electrification of mobility, to demonstrate the applicability of a new generation of eBRT systems in different urban contexts with innovative solutions that are economically viable and enhanced with new automation and connectivity functionalities (eBRT2030, 2023).

The innovations are organized in three clusters: a) vehicle systems; b) charging infrastructure, and c) automation, management and IoT (internet of things) connectivity systems. All these innovations are part of the so-called Intelligent Transport Systems (ITS) whose main goals are to control public transportation networks, to maintain their performance, and to provide users (passengers and decision makers) with up-to-date information about trips and network operating conditions (Elkosantini & Darmoul, 2013). Seven pilot projects will take place in European cities and one demo in Bogotá.

Although there has been a global increase of 5% (8 additional cities) in BRT systems in the last 10 years, mainly in Asia, Latin America and Africa, ridership has decreased in both Asia (-7%) and Latin America (-5%) (Figure 1).

Figure 1: . Distribution of ridership in the Global South (Adapted from (EMBARQ, 2023)

The growth in the use of private motorized vehicles usage, both cars and motorcycles, in both regions can explain the drastic drop of daily trips by public transport, including BRTs. While in Latin America the share of car trips has increased by 1.2% in the last 10 years, in Asia the rise is around 10% and it is expected to reach 12% by 2050 (Buchholz, 2021). However, the expansion of built BRTs has increased in all the regions with an average growth of 24.4%, particularly in the African continent with an increase of 48%. Additionally, the number of cities with BRT systems decreased in the developed regions, namely Europe, North America and Oceania (Table 1).

Table 1: Comparison of BRT ridership and length in the last 10 years by continent

	2014	2023	2014	2023	2014	2023
Regions	**Pax/day**	**Pax/day**	**Length (km)**	**Length (km)**	**# of cities**	**# of cities**
Africa	242.000,00	491.578,00	80	152	3	6
Asia	8.485.822,00	7.951.756,00	1295	1740	36	45
Europe	1.785.829,00	2.936.513,00	799	925	51	46
Latin America	19.685.144,00	18.857.445,00	1615	2042	59	64
Northern America	891.035,00	1.005.796,00	785	744	25	22
Oceania	430.041,00	436.200,00	94	109	6	5

This report highlights the general deployment of eBRT systems, with an emphasis on Africa and Latin America. The report includes a detailed overview of the status quo of eBRT in selected cities, to assess the current state and potential for electrification interventions in Bus Rapid Transit (BRT) systems, identify key challenges in implementing electric Bus Rapid Transit (eBRT) systems in the Global South and provide strategic recommendations for enhancing the adoption of eBRT, with a focus on overcoming the region-specific barriers.

2. Overview of Electric Bus Rapid Transit (eBRT)

2.1 General Deployment of eBRT

The deployment of eBRT systems has gained momentum globally due to the increasing need for sustainable urban transport solutions. E-buses, which are integral to eBRT, offer numerous benefits, including reduced greenhouse gas emissions, lower operating costs, and improved urban air quality. These systems are becoming more attractive as technological advancements reduce the costs of e-buses and charging infrastructure.

The eBRT systems are often integrated with Intelligent Transport Systems (ITS), which enhances the efficiency and reliability of public transportation. These systems incorporate real-time passenger information, automated fare collection, and traffic management systems.

2.2 Challenges in eBRT Implementation

The transition to eBRT systems is fraught with challenges. High initial costs for e-buses and charging infrastructure, coupled with limited local technical expertise, are significant barriers. Furthermore, the existing power grid in many regions of the Global South is often unreliable, which complicates the integration of eBRT systems that rely heavily on consistent electricity supply.

Another challenge is the need for large-scale infrastructure changes, including the installation of charging stations, the restructuring of existing BRT lanes, and the integration of renewable energy sources to ensure the sustainability of the system. Additionally, there are operational challenges such as training personnel to handle new technologies and managing the transition from traditional fuel-based buses to electric ones.

3. Status of eBRT in Africa

3.1 Overview of BRT Systems in Africa

BRT systems in Africa have expanded significantly over the past decade, with key systems implemented in cities like Cape Town, Dar es Salaam, and Dakar. Kigali aand Nairobi are the only city without a BRT system, however, plans are underway to introduce BRT system into their public transportation systems. These systems are seen as a solution to the growing urban congestion and are designed to provide efficient and reliable public transportation. However, despite the rapid expansion, the transition to electrification in African BRT systems is still in its nascent stages.

3.2 Challenges and Opportunities

In Africa, the challenges to eBRT implementation are multifaceted. Financial constraints are one of the primary barriers, as the cost of e-buses and the required infrastructure is significantly higher than traditional diesel buses. Moreover, the power supply in many African cities is unreliable, which raises concerns about the feasibility of operating a fully e-bus fleet. However, there are opportunities to overcome these challenges, such as leveraging international funding, and investing in renewable energy projects to stabilize the power grid.

3.3 Cities in Africa

Cape Town, South Africa

The transport system (physical mobility) in the City of Cape Town refers to the mass public transport (transit) systems providing access to opportunities with the metropolitan rail system, the MyCiTi (BRT system) as well as Golden Arrow buses and minibus taxis (MBTs), private transport and metered taxis. The majority of passengers are transported by MBTs with 60% for MBT, Golden Arrows Bus Service (GABS) buses accounting for 32% and MyCiTi BRT for 8% (City of Cape Town, 2023a).

The City of Cape Town launched its BRT, MyCiTi BRT, in 2011 as part of the city's Integrated Rapid Transit (IRT) plan to provide efficient, reliable, and affordable public transport. Initial concept and planning were first introduced in 2007-2008 (The City of Cape Town, 2008). The system includes dedicated bus lanes, modern depots, and an extensive network of routes that serve approximately 67,000 passengers per day.

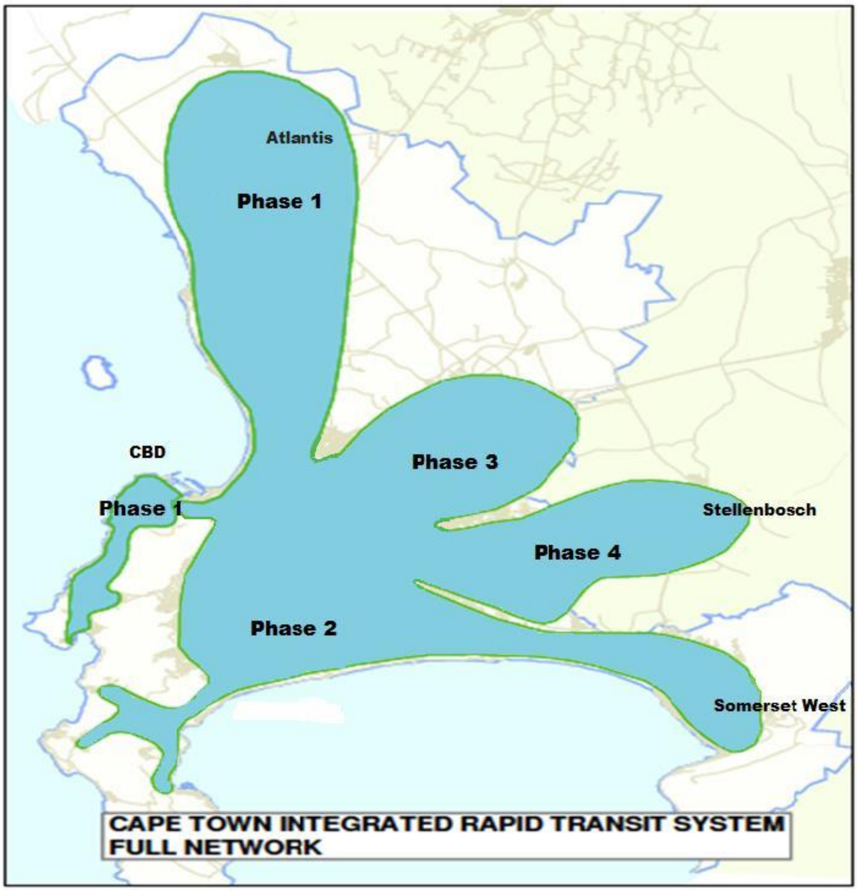

Figure 2: Overview of the phased implementation of the Integrated Rapid Transit System

South Africa has long embraced transport electrification since the Government introduced in 2017 the

National Green Transport Strategy (Department of Transport, 2017) and the New Energy Vehicle White Paper on the advancement of new energy vehicles, which was endorsed in 2023 by the Government to establish a clear policy foundation to coordinate a long-term strategy for advanced vehicle and vehicle component manufacturing (the dtic, 2023). On the local level, the Western Cape Government developed its Green Transport Strategy in 2018, which sets out the provincial government's approach to promote green and sustainable transport modes, including e-mobility and low-emission vehicles (Western Cape Government, 2018). Through these national policies, Cape Town has been exploring various e-mobility initiatives, including pilot projects for e-buses (since 2013) and renewable energy integration for charging and efforts to achieve grid stability in the city. Despite these efforts, the transition to eBRT has been slow.

Cape Town has indicated commitment to transition towards electrification of the transport industry. On the national level, for example, through GEF funding, there are plans to roll out 39 e-buses and the associated charging infrastructure in two cities, namely City of Tshwane and eThekwini Municipality (GreenCape, 2024). The project will be implemented over the period of five years with the first buses expected to be on the road in 2025. In the city,there are test pilots to retrofit existing diesel modes of public transport in Cape Town, a project testing the feasibility of an electric minibus taxi in the Western Cape region (Stellenbosch University, 2023). There are ongoing feasibility studies of e-bus operation in Cape Town led by Golden Arrows Bus Services (GABS, a bus operating company based in Cape Town. GABS plans to include at least 60 e-buses in its fleet renewal programme, aiming to be added to Cape Town's roads by December 2025 (The Presidency: Republic of South Africa, 2023). Cape Town is at the forefront of renewable energy initiatives. The City of Cape Town's strategy provides a pathway to increase capabilities to mitigate load-shedding in the short term, while also driving and enabling the transformation of the municipal electricity utility and local energy system to sustainably provide Cape Town's residents and businesses with reliable, affordable and carbon-neutral energy in the long term (City of Cape Town, 2023b).

Dar es Salaam, Tanzania

Dar es Salaam, Tanzania's largest city, relies heavily on its public transport system, which includes minibuses (daladalas), motorcycles, and a rapidly growing BRT network. The city's transport infrastructure is characterized by heavy congestion, with daladalas traditionally dominating the public transport sector. Launched in 2016, Dar es Salaam's BRT system is the first of its kind in East Africa. It features dedicated bus lanes, seven trunk routes covering over 20.9 km, and serves thousands of passengers daily. The BRT system has been pivotal in reducing travel times and easing congestion in the city (ITDP, 2017).

Figure 3: BRT in Dar Es Salaam. Source: Dar Rapid Transit Agency, 2024

The system currently operates on fossil fuels, but efforts are underway to introduce e-mobility solutions, including the electrification of feeder services like three-wheelers. The SOLUTIONSplus project, funded by the European Union, has supported the integration of e-mobility in Dar es Salaam, showcasing the potential for expanding eBRT in the city (SOLUTIONSplus, 2020). The BRT system runs on dedicated lanes. Also, some of the system's facilities such as bus stations, shelters, waiting areas, and ticketing facilities which depend on electricity to deliver functional services to passengers could integrate energy provided through renewable sources such as solar PV.

There is motivation to contribute to local, national and international environmental objectives: This was conveyed in the 2018 revised Dar es Salaam Urban Transport Master Plan which indicates that the BRT system is expected to act as “a catalyst for environmental change and air quality improvement”, as well as national policies including the Tanzania's National Climate Change Strategy (NCCS, 2012), the Tanzania National Energy Policy of 2015 and the country’s Nationally Determined Contributions submitted to the UNFCCC in 2015 and updated in 2021. Ongoing initiatives to test e-mobility services include continuous efforts to sustainably develop the energy sector. There are also plans to install charging infrastructure at key BRT stations to support further electrification efforts (DART Agency, 2023). Several capacity building activities have been to enhance local stakeholders’ knowledge on the sector including topics covering general topics on sustainable transportation and the benefits of integrating e-mobility services; charging infrastructure development; battery solutions and End-of-Life Management of EV Batteries; among other relevant training topics related to e-mobility developing. Tanzania’s goal to expand access to modern energy services and increase the share of renewable energies has been boosted by recent improvements in generation, transmission, and distribution of electricity. Efforts have particularly targeted power generation from diversified renewable energy resources ranging from biomass, hydro, geothermal, solar and wind. The country’s energy policy also seeks to promote energy efficiency in the transport sector.

Dakar, Senegal

Dakar's public transport system is diverse, with informal minibuses (car rapides), regular buses, and taxis serving the city’s population. However, the system has struggled with inefficiencies, congestion, and pollution, prompting the development of more formalized transport solutions like the BRT.
Dakar’s BRT system, launched in 2024, is a state-of-the-art project featuring an 18.3 km corridor operating with fully e-buses The BRT system is expected to carry 300,000 passengers a day and reduce travel journey time from 95 to 45 minutes for a wide variety of riders.The system was designed to address the city’s growing transport needs, reduce congestion, and improve connectivity between the city center and outlying areas. It incorporates quality inclusive designs along stations and pedestrian facilities, ensuring accessibility for many transit-dependent communities (CETUD, 2022). The system is expected to significantly reduce carbon emissions and provide a model for other African cities. The primary challenges experienced with the e-bus fleet include maintaining the efficiency of solar power systems and expanding the network to other areas of the city, given the high initial investment costs.

Figure 4: Dakar’s BRT connects downtown Dakar and the suburb of Guediawaye. Photo: CETUD - Conseil Exécutif des Transports

Urbains Durables.

The city is working on expanding its public transport network with additional sustainable transport options to improve the BRT system, supported by international funding and development programs. These include: i) building a fully separated BRT line, and safe, convenient, and secure access and crossings for pedestrians, ii) a bus fleet with an advanced intelligent transportation system (ITS) to help manage and operate the services, as well as collect fares, iii) installation of street furniture along feeder routes, improvements to feeder and vicinal roads within the corridor.

The government has developed a Sustainable Urban Mobility Plan (SUMP) 2020-2035 through the revision of its transport master plan and has been piloting and implementing public transport projects. SUMP is founded on a perspective towards multimodal transportation, highlighting the importance of effective, high-capacity public transit, gradual integration of eco-friendly vehicles, and prioritizing walking and cycling as fundamental components of the network. It is anticipated that the SUMP will lead to a 15% decrease in Dakar's transportation-related CO2 emissions by 2035 in comparison to the present scenario (AW, CISSE and DIENG, 2022).

Dakar Public Transport Network Restructuring project plans to prioritise the upgrade of public transport infrastructure and updating the bus fleet, aiming to enhance the quality of public transportation services in Dakar. Anticipated outcomes include reduced travel and wait times for passengers, decreased traffic congestion, enhanced access to educational and employment facilities, improved environmental sustainability through lower emissions of pollutants and greenhouse gases, and a decrease in road accidents. Ultimately, the project is expected to boost operational efficiency by lowering operating expenses (European Investment Bank, 2022).

Nairobi, Kenya

Nairobi’s transport system is dominated by informal public service vehicles (matatus), buses, and other privately owned public service vehicles (PSVs). The city faces severe traffic congestion, air pollution, and a growing need for efficient and sustainable public transport solutions. The government aims to alleviate traffic congestion in the city and the rapidly increasing ownership of private cars through the implementation of the Bus Rapid Transit (BRT) system as planned in the Strategic Plan 2023-2027.

The Nairobi Metropolitan Area Transport Authority (Namata) initiated plans for the city’s BRT system in August 2020, with initial designs for depots and stations anticipated to be completed by June 2022. However, the project has stalled due to financial constraints. The initial plans of the BRT system, still under construction, aim to introduce five main lines across major routes in the city. The 3 transport corridors envisaged are: i) The Athi River Town to Kikuyu Town (approximately 38 km); ii) Thika Town to the Central Business District (approximately 50 km); and Jomo Kenyatta International Airport to the Central Business District (approximately 25 km) (Mito, 2024). Despite the existing challenges and stalling of the project, Namata has emphasised to provide a high-capacity, reliable alternative to alleviate traffic congestion and reduce travel times across the city.

Figure 5: A Bus Rapid Transport (BRT) station under construction along Thika Road at Safari Park footbridge. Source: Kenha.

The government has committed to deploying zero-emission buses as part of its “Clean Line” initiative, which is supported by European funding to provide safe, clean, high quality and efficient public transport system in Nairob. The system is expected to improve traffic flow through dedicated BRT lanes and reduce pollution in Nairobi through deployment of e-bus fleet, improved real-time passenger information system and ticketing, fare collection and validation systems (Charles and Barker Limited and Ramboll, 2021) with plans to launch the first line by 2030 (European Commission, 2023). Additionally, the city is involved various activities in partnership with international organisations, to prepare for the implementation of e-buses by improving the of regulatory frameworks and tools needed to create a conducive environment for promoting the adoption, and expansion of the e-mobility industry, enhancing institutional capacity & technical expertise aiming to improve the organizational capabilities of various stakeholders, and supporting with piloting activities (TUMI, 2022; Kwoba et al., 2023).

Kigali, Rwanda

Kigali’s public transport system primarily consists of buses, minibuses, and motorcycle taxis. The city has been proactive in managing urban mobility, with a strong focus on modernizing its transport infrastructure to reduce congestion and emissions (MININFRA, 2021).

Kigali is in the planning stages of implementing its first BRT system, designed to address the increasing demand for efficient public transportation in the city. The BRT system is expected to integrate with Kigali’s existing bus network to provide seamless, sustainable mobility. Phase 1 (2019 – 2024 is planned to have a total length of 116 km and aims to improve the sustainable growth of Kigali, ensure connectivity between key nodes of the city (Surbana Jurong Consultants Pte Ltd, 2020). Seventeen kilometers of dedicated corridor for public transport are expected to get operational on a pilot basis before mid-2024.

Despite the absence of a BRT system, the City of Kigali has a well-established public transport system that is serviced through public and private operations. (Surbana Jurong Consultants Pte Ltd, 2020). E-ticketing System is used where bus passengers ride a bus using a smart card (so called “Tap & Go”).

Transportation in Rwanda is mostly based on internal combustion engine (ICE) vehicles that have negative environmental impacts. The Government of Rwanda (GoR) strives to ensure safe and environmentally sound transport for goods and people to enable green development and innovation while reducing dependency on fossil fuels in the transport sector. In this regard, a study on introduction of electric vehicles (EVs) was conducted resulting in the government developing a strategic paper demonstrating the requirements to accelerate the adaptation of EVs in Rwanda (MININFRA, 2021). Through its Vision 2050, Rwanda updated in 2020 its NDCs to encourage the shift to EVs as part of its climate action plan to promote green mobility and reduce emissions and air pollution. The Government of Rwanda’s e-mobility programme aims at achieving a phased adoption of e-buses, passenger vehicles (cars) and motorcycles from 2020 onwards (Republic of Rwanda, 2020).

Current developments regarding e-bus electrification include a pilot project operating 4 e-buses. Results from the project informed the development strategy and financing model for scaling e-buses, resulting in a Kigali E-Bus Master Plan developed by the SOLUTIONSplus partners ITDP and City of Kigali, in consultation with the bus operators and the electricity energy distribution company Energy Utility Corporation Limited (EUCL). The pilot incorporates a model to determine the routes that can go electric in the short and long terms, the energy required to power the e-buses, and the charging infrastructure technology to be adopted. Ten bus operators in Kigali have expressed their interest in acquiring e-buses with BasiGo, for a total of 142 e-bus reservations.

Figure 6: From left to right: an e-bus piloted, the e-bus charging station (Empower Africa, 2024)

4. Status of eBRT in Latin America

4.1 Overview of BRT Systems in Latin America

Latin America has a rich history of BRT systems, with cities like Bogotá, Quito, and Curitiba pioneering the model. These systems have been critical in managing urban congestion and providing reliable public transport. Latin America is also leading in the adoption of eBRT, with several cities already integrating e-buses into their BRT systems.

4.2 Challenges and Opportunities

The challenges in Latin America mirror those in Africa, including high costs and infrastructure needs. However, Latin America benefits from a more developed public transport infrastructure and a growing commitment to reducing carbon emissions. Cities like Bogotá and Quito have already started integrating e-buses into their BRT systems, supported by strong political will and international funding.

4.3 Cities in Latin America

Bogotá, Colombia

Bogotá's transport system is extensive, with a mix of buses, minibuses, taxis, and one of the world's most successful BRT systems, the TransMilenio. The city faces challenges of congestion, air pollution, and the need for continuous improvement of its public transport network.

TransMilenio system is one of the most extensive and successful BRT systems in the world. Currently, the system has 114.4 km of trunk track in operation, 11 trunks in operation, 138 stations, 9 portals, 13 workshop yards and 53 garage yards. Additionally, the trunk system has 2,192 buses (GOV.CO, History of TransMilenio, 2024). Operational since 2000, it is one of the largest and most efficient in the world. It serves over 2.5 million passengers daily with a network of dedicated lanes, high-capacity buses, and strategically placed stations throughout the city. The BRT system uses various design features to accommodate high passenger volume. These include the use of high-capacity buses, exclusive/dedicated running ways, level boarding, off-board fare payment (ESMAP, 2009).

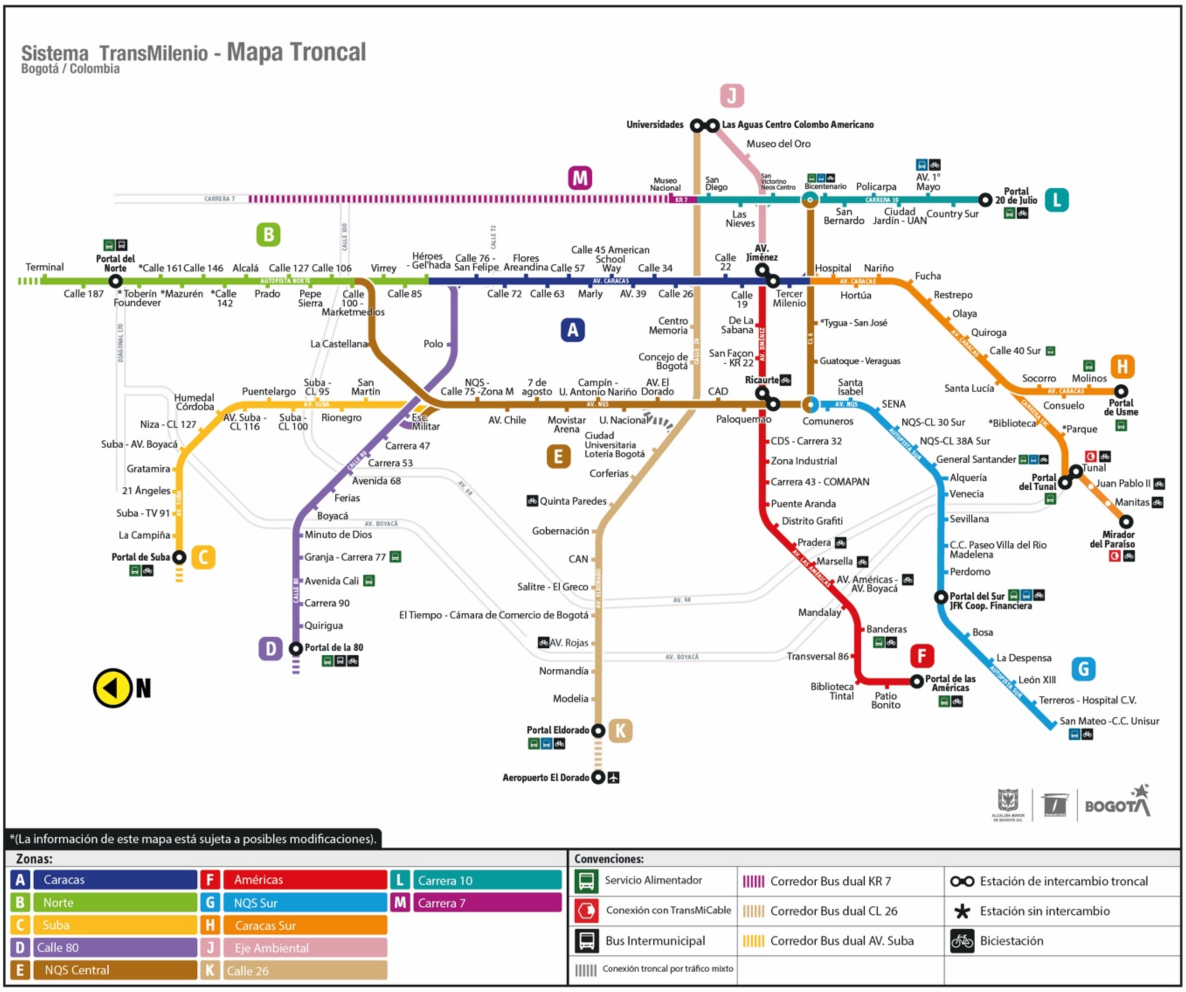

Figure 7: Bogota TransMilenio System Map (GOV.CO, 2024b)

Bogotá is now pioneering the integration of e-buses into its fleet, with plans to expand its e-bus network as part of its broader environmental intitiatives. The Public Transport System Expansion Plan in Bogotá and the Cundinamarca Region, as established in the Zero and Low Emissions Motorised Mobility Public Policy (PCBE) contained in the document - CONPES D.C. 30 of 2023, constitutes the roadmap towards 2040 to promote the use of zero and low emissions technologies in all transport segments in the city. This plan integrates various strategies, actions, and specific actors to consolidate sustainable mobility and improve air quality in the region. Implementing financial incentives such as subsidies and tax exemptions for acquiring zero and low emissions vehicles and charging infrastructure. The goal for 2025 is to provide subsidies for the acquisition of 1,000 e-buses and charging stations. By 2030, increase incentives to cover 50% of the additional costs of e-buses compared to diesel buses, and by 2040, maintain fiscal incentives to ensure that the total cost of ownership of e-buses is competitive with traditional technologies. Of consideration are plans to update and strengthen environmental regulations to regulate public transport emissions and promote the use of clean technologies; and establish technical and operational standards for the public transport fleet to ensure compliance with zero and low emissions objectives.

The renewal of the public transport fleet would include the acquisition of e-buses for the Integrated Public Transport System (SITP) and TransMilenio. It is projected that by 2040, the entire fleet will be composed of zero-emission vehicles, with the gradual incorporation of at least 1,500 e-buses in the SITP/TMSA by 2025. By 2030, the e-bus fleet will increase to 4,000 units, and by 2040, the fleet renewal will be completed with a total of 8,000 e-buses, achieving 100% zero-emission public transport buses. A network of electric charging stations will be developed, strategically distributed throughout the city and region. These stations will be located in bus terminals, depots, and intermediate points along the routes of e-buses. The proposed goals for 2025 include establishing at least 50 rapid charging stations for e-buses at strategic points in the city, expanding the network to 150 rapid charging stations and 200 slow charging stations by 2030, and ultimately implementing a robust charging infrastructure with at least 300 rapid charging stations and 400 slow charging stations integrated with renewable energies by 2040.

Quito, Ecuador

Quito's public transport system is well-developed, with a combination of buses, trolleybuses, and the Metro. The city's hilly terrain and narrow streets present unique challenges for urban mobility, making public transport crucial for daily commutes.

Quito's BRT system, known as Metrobus-Q, is a well-established network featuring five main trunk lines with a total length of 83.8 km. The system plays a critical role in the city's public transportation, handling a fleet of approximately 2500 privtely owned buses operating in a mixed traffic. And handling 1.8 million daily trips. A fleet of approximately 2,500 privately owned buses operate in mixed traffic and handle 1.8 million daily trips.

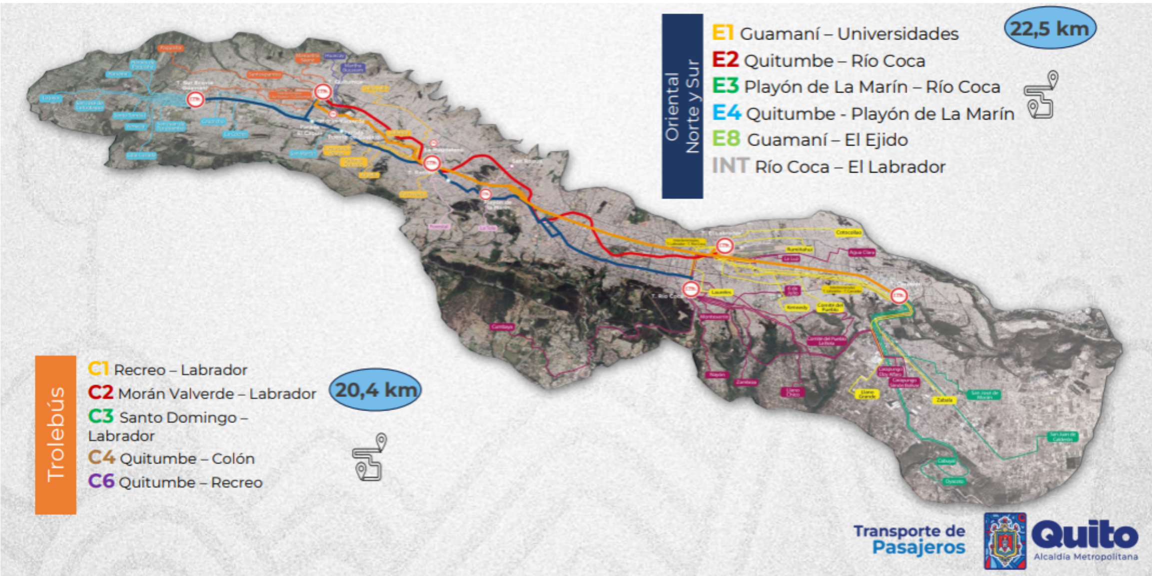

Figure 8: Mobility Secretary of Quito. BRT corridors presented on the SOLUTIONSplus City's Road Map Workshops on January 2024.

An Integrated Mass Transit System for Passengers of the Metropolitan District of Quito (SITM) was introduced, which consists of all the subsystems: Metrobús-Q, Conventional and Metro de Quito. Its purpose is to integrate all the public transport subsystems of Quito and its suburban area (surrounding valleys). The SITM has the following characteristics: i) expansion of the public transport offer based on the construction of PLMQ, which became effective in 2015; ii) fare and operational integration of all bus services (Metrobús-Q and Convencional) with the Metro; and iii) definition of an adequate institutional framework for the new mobility model.

The city continues to explore ways to expand its e-bus fleet and integrate renewable energy into its transport system. Through the development of a roadmap supported by German cooperation agency GIZ, the government's geological and energy research institute IIGE details through a study potential of Ecuador's e-buses expansion that could represent 34% of the country's bus fleet in 2040 (Instituto de Investigación Geológico y Energético, 2023). The City of Quito has therefore prioritised the gradual transition of its fleet toward e-buses, starting in 2022. The city aims to operate 100% zero-emission vehicles once all diesel and hybrid powered buses have been retired. The goal is to improve air quality in Quito and contribute to Quito's commitments to reduce its GHG emissions. The initiatives are expected to improve the quality of transportation services in the city and lead the transition to more sustainable transit systems in Quito and Ecuador (C40 Cities Finance Facility, 2020).

In 2018, tests began in the city with three 100% e-buses of the Chinese brand BYD, for a period of two months. One of the vehicles was articulated with a capacity for 160 passengers, while the other 2 buses of 12-meter long had a capacity of 80 people. The tests were carried out by the private transport company UnitransQ (ICLEI, 2023). The goals that the city of Quito has set for itself correspond to: i) Implementation of at least 10% of the fleet per route with e-buses by 2023, ii) incorporating electric mobility into the urban and interparroquial public transport service by 2025, iii) 100% zero emissions public transport by 2040 (ICLEI, 2023). However, there are challenges the city is experiencing to introduce more BRT corridors, which include limited physical space for further expansion of the BRT network and the need for substantial investment in new e-buses.

Buenos Aires, Argentina

Buenos Aires boasts a comprehensive public transport network, including buses, subways, and trains. Despite its extensive system, the city struggles with traffic congestion and air pollution, driving the need for more sustainable transport solutions. As a result, the city developed a Plan for Sustainable Mobility to tackle these problems, with the introduction of the BRT system forming a key element of this Plan (C40 Cities, 2016). Over the past 10 years, Buenos Aires has transformed its public transportation by introducing the Metrobús network.

Buenos Aires operates a comprehensive Metrobus network that includes ten corridors. These corridors allow for efficient, comfortable and safe journeys for over 1 million passengers daily and cover over 120 km across communes of the city. Designed as a BRT system, it mixes bi-articulated buses with conventional buses (BA, 2024). The system is a critical component of the city's efforts to reduce traffic congestion, pollution, and offers a reliable alternative to private car use. It features key elements such as bus stops at comfortable stations equipped with security cameras, screens that provide real-time information and WiFi service, dedicated lanes, and modern traffic signals, safety features and extended networks running on a highway.

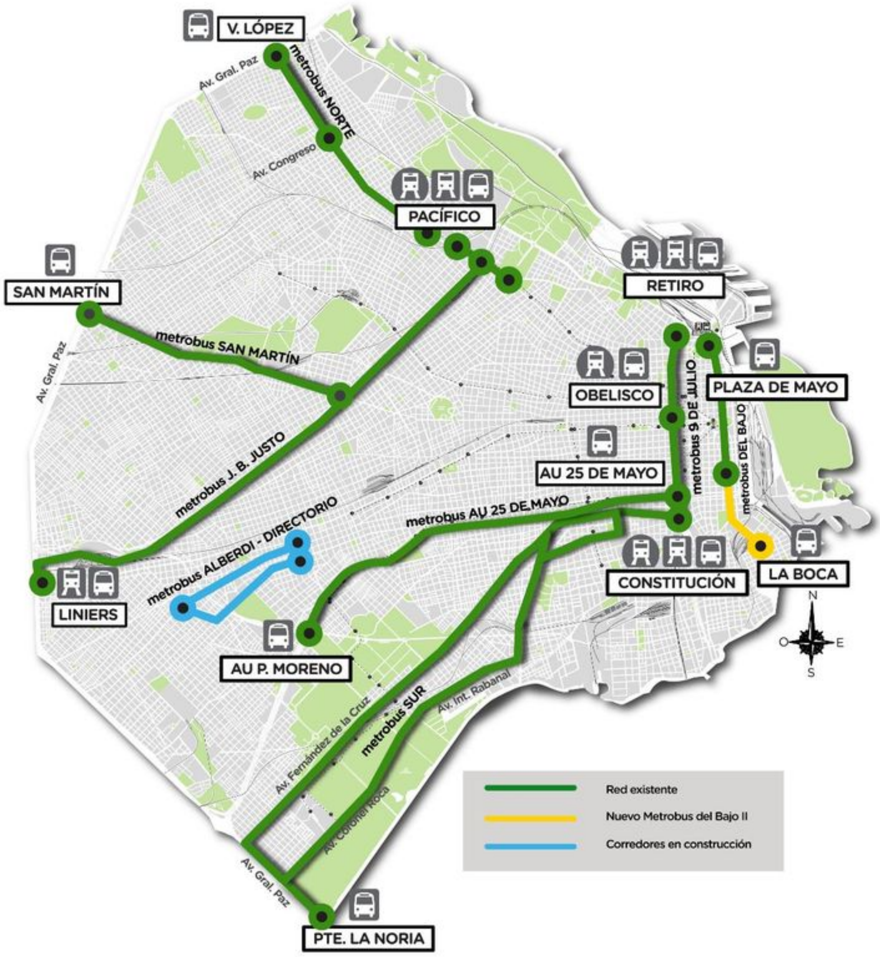

Figure 9: Metrobus network in Buenos Aires (BA, 2024)

Buenos Aires has committed to become a carbon neutral, resilient and inclusive city by 2050. In order to become a carbon neutral city by 2050, Buenos Aires has set goals to reduce the use of cars in large cities and encourage the use of sustainable means of transportation. There are 9,700 buses circulating in the city, carrying an average of 4,500,000 passengers per day. Almost 100% of these buses use diesel fuel, which contributes to an increase in the production of GHG and other pollutants that affect air quality. The city has been exploring the integration of e-buses into its BRT system as part of its Sustainable Mobility Plan. The city has conducted pilot projects and is planning further expansions of its e-bus fleet. The pilot test closed the gap between clean technologies and the currently operating bus system. Two e-buses are currently operating in the city with 3 electric chargers installed at the bus terminals (Government of the City of Buenos, 2020). Some of the challenges for electrification of the BRT system include the high initial cost of electrification and the need for upgrading existing infrastructure to accommodate e-buses.

Curitiba, Brazil

Curitiba is known for its innovative urban planning and efficient public transport system. The city’s transport network includes buses, minibuses, and a pioneering BRT system that has become a model for cities worldwide. Curitiba’s BRT system, operational since 1974, is one of the most successful and emulated systems globally (Rabinovitch & Leitman, 1993).

Curitiba’s BRT system, one of the oldest and most successful globally, serves as a model for other cities. Currently, it serves approximately 1.23 million passengers daily, facilitating over 14,100 trips across 254 routes (CBW, 2020). The city's fleet of 1,250 buses collectively travels around 273,000 km can be credited to the system's successful alignment with the city's urban development, its cost-effectiveness, and the superior quality of service it offers ((ITDP, 2020; Wright, 2001; World Bank Group, 2019). The system consists of five main lines which span to 74 km (Network, 2019 and is renowned for its efficiency and integration with the city’s urban planning. Despite efforts from the municipal government to provide subsidies for travel and the introduction of an electronic ticketing system to promote public usage, the bus transport system encountered new challenges due to economic expansion and population growth, which contributed to decrease in popularity of the BRT system (Halais, 2012). Some of the issues were operational such as lack of punctuality and also inadequate last-mile connectivity may have contributed to this decrease in popularity (Kiyoko Hashiguchi, et al., 2020).

Figure 10: BRT in Curitiba. Source: greencity times.com

The Urban Development Authority of Curitiba (URBS) opted to revamp the BRT system by implementing a range of enhancements and strategic measures to increase ridership and address the challenges that emerged at various phases (Gurdian, 2015). A new electronic ticketing system was implemented in 2002 to replace traditional coin-operated payment methods, aiming to enhance the boarding process and reduce fare evasion. The transportation administration of Curitiba has been engaged in the ongoing enhancement of its bus transit system with the construction of the Green Line, which commenced in 2009, marking it as the first corridor to feature overtaking lanes for various bus services. The buses operating on the Green Line utilize 100 percent biodiesel buses (Lindau; Hidalgo; Facchini, 2010).

Curitiba has been exploring since 2010 the incorporation of e-buses into its BRT system as part of its sustainability initiatives. In 2010, the first test of hybrid buses (batteries and diesel) in partnership with Volvo were conducted, which make up the fleet to this day. In 2014, a 3-months test of BYD fully electric articulated bus was conducted with comparative study carried out between four propulsion technologies for buses (diesel, hybrid, biodiesel and electric), with the main objective of evaluating the 100% electric vehicle proposed by BYD in relation to other technologies that were already in operation or testing in Curitiba. By 2025, the city has the opportunity and plans to introduce electromobility into the city‘s new public transit bidding process. Some of the challenges related to electrification of e-buses include aligning the electrification efforts with Curitiba’s existing BRT infrastructure and ensuring financial viability (TUMI, 2020).

Mexico City, Mexico

Mexico City has a complex and extensive transport system that includes a mix of metro, buses, minibuses, and taxis. The city faces significant challenges with traffic congestion and air pollution, making the public transportation system critical for daily commutes. The metro system is one of the largest in the Americas, and the city has been working to improve and expand its public transit options to meet the demands of its growing population.

Mexico City's Metrobús, inaugurated in 2005, is a major component of the city's public transport system. It spans 240 km across seven lines and serves millions of passengers daily. The system features dedicated lanes that reduce travel times and improve reliability (Espinoza, 2023). On average, Metrobús is used by 1,4 million people daily (Secretaría de Movilidad, 2020). Metrobús is integrated with other transport modes, making it a vital part of the city's efforts to manage urban mobility and reduce traffic congestion.

Figure 11: Line 5, Station Escuadrón 201 (Metrobús, 2024)

Mexico City has initiated efforts to electrify its Metrobús fleet as part of broader environmental goals to reduce greenhouse gas emissions and improve air quality. The city has initiated efforts to electrify its

Metrobús fleet as part of broader environmental goals to reduce greenhouse gas emissions and improve air quality. Operations of an electrified metrobus line (Line 3) currently runs with 60 articulated e-buses (López, 2022). Line 4 integrated 20 e-buses out of its 55 units by December of 2023 and by February of 2024, the whole fleet of 55 buses were replaced with electric vehicles (Metrobús, 2024). However, despite these efforts, the city still faces challenges such as the high costs of e-buses and the need for substantial infrastructure upgrades, including the installation of charging stations and the enhancement of the existing power grid to support increased electricity demand.

5. Opportunities for eBRT Implementation

Cities in the Global South should view eBRT as part of a broader urban mobility strategy that includes non-motorized transport, pedestrian-friendly infrastructure, and smart city technologies. This holistic approach can maximize the benefits of eBRT and contribute to more sustainable urban development. In addition, these cities can benefit from sharing knowledge, experiences, and best practices in eBRT implementation. Regional collaborations and networks can facilitate the exchange of ideas and foster innovation in addressing common challenges. Some of the recommendations that are needed to provide a strategic framework for cities in Africa, Latin America, and the broader Global South to implement and expand their eBRT systems effectively include:

- Leveraging International Funding and Partnerships: African cities should actively seek international grants and loans, such as those from the Global Environment Facility (GEF) and the World Bank, to finance the initial high costs of e-buses and infrastructure. Partnerships with international organizations can also provide technical expertise and support in implementing eBRT systems.
- Investing in Renewable Energy and Grid Stability: Given the unreliability of the electricity grid in many African cities, investments in renewable energy sources, such as solar or wind power, are crucial. These can be integrated into the eBRT system to ensure a stable and sustainable power supply for e-buses.
- Focusing on Incremental Implementation: More feasibility studies should be conducted to test potential electrification of bus fleets, especially considering various topography and infrastructure that is quite new. This allows cities to test and optimize the infrastructure and operational strategies before committing to full-scale electrification.
- Enhancing Institutional Capacity Building and Training: There is a need to invest in training programs for local technicians, drivers, and maintenance staff to handle the new technologies associated with e-buses. In addition, policies and regulatory framework in some cities would require enforcing support the transition to e-buses, including incentives for operators to switch to electric vehicles, subsidies for e-bus purchases, and regulations that promote the use of renewable energy, which would need involvement of revelevant local government stakeholders.
- Scaling Up Successful Pilots: Cities that have already piloted eBRT systems should focus on scaling up these initiatives. Successful pilot programs in cities can provide a framework for broader implementation across the region.
- Public-Private Partnerships (PPPs): Engage private sector entities through public-private partnerships to share the financial burden and bring in innovation. These partnerships can be instrumental in developing the necessary infrastructure, including charging stations and maintenance facilities.
- Prioritizing Equity and Accessibility: In designing BRT systems it is crucial to ensure that eBRT systems are accessible to all, including low-income communities, women, and people with disabilities. Cities should prioritize the design of infrastructure that serves underserved areas and ensure that fare structures are affordable for all segments of the population.
- Monitoring and Evaluating Progress: Establishing robust monitoring and evaluation frameworks will help cities track the progress of eBRT implementation, assess the impact on urban mobility and environmental sustainability, and make necessary adjustments. Continuous learning and adaptation are key to the long-term success of eBRT systems.

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