Transitioning to Sustainable Mass Transportation Systems

Market Assessment and Operating Models for Electric Bus Deployment in Nigeria

OCTOBER 2024

Acknowledgment

We extend our heartfelt gratitude to the following organizations whose invaluable contributions have played a pivotal role in the completion of this technical report on Transitioning to Sustainable Mass Transportation.

National Automotive Design and Development Council (NADDC)

The NADDC's unwavering support and guidance have been instrumental. Their expertise in automotive design and development, coupled with their commitment to sustainability, has enriched our understanding and helped shape our recommendations especially regarding technical considerations of charging infrastructure.

National Council on Climate Change (NCCC)

We are deeply thankful to the NCCC for their crucial insights and assistance in navigating the complex landscape of climate change policy. Their dedication to addressing climate challenges has been a guiding light, illuminating our path toward sustainable transportation solutions. It is always a privilege collaborating with NCCC on vital knowledge products addressing the nations climate change objectives.

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Collaborative Effvorts

We would also like to acknowledge the collaborative efforts of all individuals and organizations in Lagos State who contributed their time, expertise, and resources to this endeavor. Your collective commitment to sustainability has been the driving force behind the completion of this report.

This report stands as a testament to the power of collaboration and collective action in addressing the challenges of our time. Together, we can pave the way for a more sustainable and resilient future.

"The SEforALL report on transitioning to sustainable mass transportation is a timely and essential resource for modernizing Nigeria's transportation system. By adopting the strategies outlined in this report, we can significantly reduce emissions, enhance public health, and create a more efficient and accessible transportation network throughout the country. The Lagos State Ministry of Transport fully endorses this report as a crucial guide in our collective pursuit of a cleaner, greener, and more sustainable future for all Nigerians.

MR. OLUWASEUN OSIYEMI
Honorable Commissioner for Transportation Lagos

"As Nigeria progresses towards actualizing commitment to the Energy Transition Plan and ZEV Declaration of COP26, more so with the set 2060 Net Zero goal in focus, in-depth research and analysis are critical tools necessary to ensure informed decisions. The SEforALL Report on "Transitioning to Sustainable Mass Transportation Systems Market Assessment and Operating Models for Electric Bus Deployment in Nigeria" is one of such. The National Council on Climate Change commends SEforALL for providing the detailed insights into the Nigerian transport sector and innovative deployment models. This report will support the expansion of opportunities for the uptake in electric mobility across Nigeria.

DR. NKIRUKA MADUEKWE
Director-General, National Council on Climate Change (NCCC)

"By embracing cleaner technologies and renewable energy, we can significantly enhance the efficiency and environmental impact of our public transport systems, setting a new standard for urban mobility in Nigeria. In this regard, the National Automotive Design and Development Council (NADDC) fully supports the SEforALL comprehensive report on electric buses and their integration into existing BRT systems. This forward-thinking approach aligns with our mission to foster innovation and sustainability in the automotive sector.

ENGR. (DR.) NUA O. OMISANYA
Director, Industrial Infrastructure, National Automotive Design and Development Council (NADDC)

"The Lagos State Government is proud to have contributed data to SEforALL's insightful report on transitioning buses to sustainable mass transportation systems. This report reflects our ongoing commitment to fostering a greener and more efficient public transport network. By leveraging sustainable technologies and practices, we can improve the quality of life for our residents, reduce emissions, and set a precedent for other cities in their pursuit of sustainable mass transportation.

IDOWU OGUNTONA
MD/CEO, Lagos Bus Services Limited (LBSL)

"On behalf of the Nigerian Electricity Regulatory Commission, I want to commend SEforALL for its thorough report on transitioning buses and development of charging infrastructure for mass adoption of EVs in Nigeria. As we have seen around the world, the transport sector provides a great opportunity for the decarbonization of the economy, so this report could play a significant role in the actualization of Nigeria's 2060 carbon neutrality target.

DR. YUSUF ALI
Commissioner PRS Division, Nigerian Electricity Regulatory Commission(NERC)

Executive Summary

This report on electric mobility report emerges within the context of the nation's ambitious Energy Transition Plan (ETP), which articulates the country's strategy towards reaching carbon neutrality by 2060. This comprehensive report underscores Nigeria's commitment to sustainable energy practices, notably exemplified by the removal of fuel subsidies and a focus on transforming the transportation sector.

Nigeria's ETP highlights that the transport sector contributes approximately 15% of Nigeria's total greenhouse gas emissions and prioritises adoption of e-mobility as the key decarbonization pathway within the sector. With the transport sector contributing significantly to global greenhouse gas emissions, urgent investment in low and zero-emission vehicles is crucial. Africa, including Nigeria, is witnessing a growing awareness of e-mobility, supported by initiatives such as SEforALL's partnership with the Nigerian government, which aims to advance clean energy access and introduce electric buses to achieve carbon neutrality goals.

Within the context of decarbonizing the transport sector, deployment of public mass transit solutions offers an opportunity to mitigate higher transport costs, serves as a viable alternative to passenger cars and enables significant carbon emissions reductions. This report highlights the benefits of transitioning to sustainable mass transportation systems with emphasis on planning criteria, technical specifications, and infrastructure requirements necessary for the successful integration of electric buses (e-buses) into Nigeria's urban transport system.

The steady uptake of electric buses globally has provided for extensive data on deployment models for adoption across states within Nigeria. Recommendations provided on best practice for policy design, innovative financing and de-risking mechanisms and operating models such as the Gross Cost Contract (GCC) model provide insights to policy makers and government stakeholders on successful deployment strategies. A comprehensive case study of the Lagos State Bus Rapid Transit (BRT) System offers insights into its operational framework, infrastructure readiness, and strategic planning for the successful deployment of electric buses (e-buses).

By providing a thorough review of the Nigerian transport and automotive policy landscape, recommendations are proposed aimed at addressing the weaknesses and enhancing the success of e-mobility in Nigeria. These include introduction and review of policies and laws to create a conducive environment for the development and adoption of electric vehicles (EVs), particularly e-buses. Such policies include the Nigerian Automotive Industry Development Plan (NAIDP), the National Renewable Energy and Energy Efficiency Policy (NREEEP), the Finance Bill, and Free Trade Zone regulations.

In conclusion, the report seeks to establish a sustainable and scalable model for the adoption of electric buses across Nigeria's mass transportation systems. This includes conducting thorough techno-economic evaluations, analysing Total Cost of Ownership (TCO), defining robust procurement business models, identifying infrastructure requirements, and setting procurement specifications and considerations. Insights from the report are intended to provide a comprehensive roadmap for the long-term integration of e-buses into Nigeria's transportation landscape, with potential replicability across the country.

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CHAPTER ONE

Introduction

1.1 Background and Objectives of the Nigeria E-bus National Programme

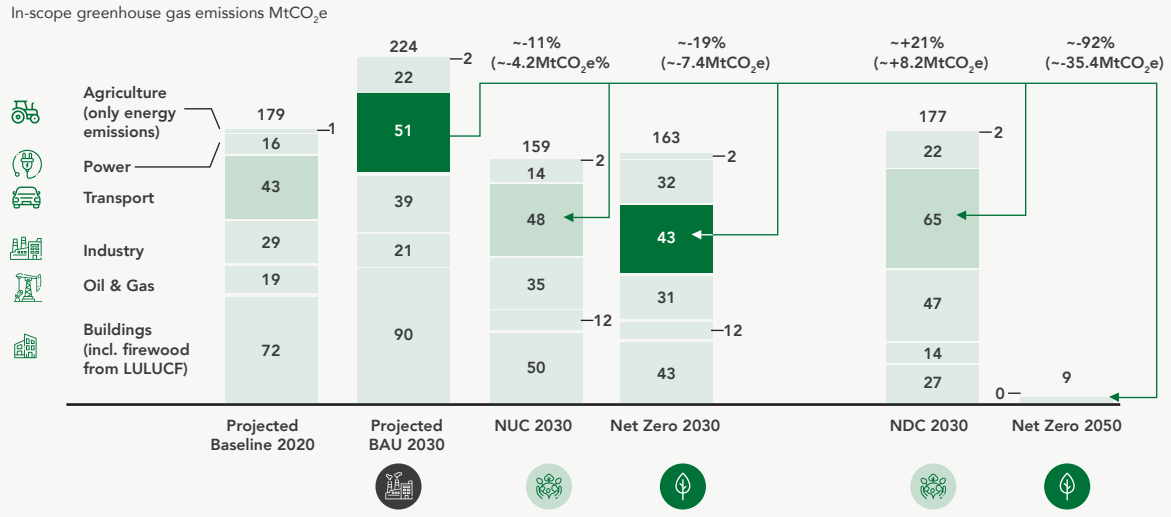
Nigeria, in alignment with its ambitious goal to achieve net zero emissions, has embarked on a comprehensive Energy Transition Plan (ETP). As part of this strategy, the nation has taken significant strides, including the removal of the fuel subsidy, marking a pivotal shift towards sustainable energy practices. Presently, Nigeria is actively advancing into the implementation phase of the ETP, with a particular focus on transforming its transportation sector.

Central to the ETP's agenda is the advancement of e-mobility solutions, with a special emphasis on the scale-up of electric bus (e-bus) mobility. Recognizing the urgent need to decarbonize the transportation sector, the ETP underscores the importance of transitioning to cleaner, more sustainable modes of transit. By prioritizing e-bus mobility, Nigeria aims to not only mitigate carbon emissions but also enhance urban air quality and foster technological innovation within the transportation sector.

This report delves into the e-bus mobility ambition and context within Nigeria, with a specific focus on the bustling metropolis of Lagos. Through a comprehensive case study conducted on e-buses in Lagos, valuable insights and learnings have been derived to inform and guide policymakers, stakeholders, and industry players in their pursuit of sustainable transportation solutions. Drawing on data and evidence, we can identify a critical path to success in achieving SDG7.

Furthermore, this report serves as a roadmap for the envisioned next steps by the Nigerian government. By outlining key recommendations and strategies, it aims to catalyze further action and investment in e-bus infrastructure and adoption, thereby accelerating

FIGURE 1: Projected GHG Emissions in Nigeria



Nigeria's transition towards a greener and more resilient transportation system.

The ambitions of SDG7 on climate change are extraordinary, requiring transformation at a scale never undertaken before. Swift action must be taken by leaders in governments, private sector companies, institutions, financiers, development banks, unions, communities, entrepreneurs, and civil society.

Globally, the transport sector accounted for ~24% of in-scope GHG emissions in 2020, with this percentage largely driven by volume of internal combustion engine (ICE) passenger cars.[1]

In 2022, the rebound in passenger and cargo transport activity following Covid-19 pandemic led to a 3% increase in transport CO2 emissions compared to 2021. The transport sector grew by more than 250 MtCO2 to 8 GtCO2. With an even average annual rate, the transport sector grew by 1.7% from 1990 to 2022 – faster than any other end-use sector aside from the industry sector.

It is however important that to meet the net zero emissions target of 2060, CO2 emissions from the transport sector must fall by more than 3% per year from 2030. To get this done, strong regulations and fiscal incentives, as well as considerable investment in infrastructure to enable low and zero-emission vehicle operations, will be needed.

According to OICA report in 2014, there are about 42.5m vehicles in use in Africa; and by 2040, the World Bank projected a growth of 400%, making Africa's vehicle growth rate of 10% the fastest when compared to other continents – Europe's rate is at 4%[2]. Across African countries, the transition from ICE buses to e-buses have witnessed some significant awareness, with pockets of e-mobility pilot programs across sub-Saharan Africa. ESI Africa reported that as of February 2023, Kenya has registered 1,350 electric vehicles with plans to launch about 300 charging stations. South Africa was mentioned to have the most advanced e-mobility market in Africa with 1,000 EVs counted in 2022 – out of a total fleet of 12million automobiles[1].

In partnering with the Nigerian Government, SEforALL is supporting Nigeria's carbon neutrality target set for 2060 by fostering programmes and initiatives across clean and affordable electricity, improving access to electricity by reducing energy poverty, clean cooking, and introduction of electric buses. Towards this, we propose to adopt an ambitious long-term roadmap towards large-scale induction of electric buses to meet the twin objectives of enhancing public transport usage and its transition to electric buses thereby delivering significant GHG mitigation benefits.

The primary objective of this report is to establish a sustainable and scalable model for the adoption of electric buses in Nigeria's mass transportation system. This will be done by:

- Conducting thorough techno-economic evaluations
- Analysing Total Cost of Ownership (TCO)
- Defining robust procurement business models
- Identifying infrastructure requirements
- Setting procurement specifications and considerations

The aim is to provide a comprehensive roadmap for the long-term integration of e-buses into Nigeria's transportation landscape that may be replicable across the country.

[1] SEforALL, Move Nigeria Project Brief. "In-Scope Greenhouse Gas Emissions MtCO2e." 2022

[2] OICA. World Vehicles in Use. Organisation Internationale des Constructeurs d'Automobiles, 2014, www.oica.net/category/vehicles-in-use/

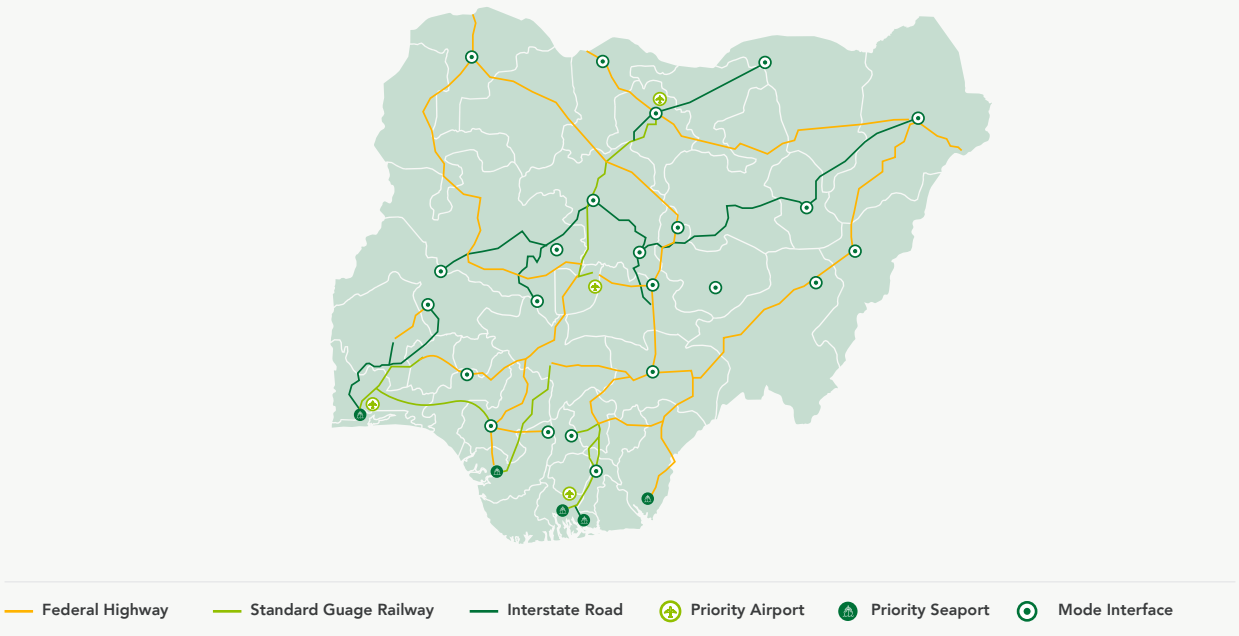
CHAPTER TWO

Context and Rationale

2.1. Overview of Nigeria's Transportation Sector

It is estimated that Nigeria has about 21 million registered vehicles serving passenger and goods movement needs. However, just like other African countries, most mobility in Nigeria is done by foot as poor road infrastructure and access to public transport characterise the current state of transportation in Nigeria. Road-based transport dominates as the principal means of moving goods and people across the country; and contributes significantly to the Nation's Gross Domestic Product (GDP) (2.7%) along with other sub-sectors. Nigeria's transport sector is dominated by gasoline and diesel-powered Internal Combustion Engine (ICE) vehicles. Passenger transport constitutes most of the vehicular activity within road transport and it's dominated by privately-owned cars and light commercial vehicles. In 2018, the share of road vehicles was 57.70% commercial, 40.98% private, and Government and diplomatic (1.32%) vehicles. Cars are the highest GHG emitter among all vehicles and hence reducing their mode share is crucial to achieve Nigeria's decarbonization targets.[3]

FIGURE 2: Nigerian Travel Infrastructure



[3] SEforALL, Move Nigeria Project Brief. "In-Scope Greenhouse Gas Emissions MtCO2e." 2022

In 2020, IEA reported that the transport sector is the greatest CO_2 emitter in Nigeria, accounting for about 60% of total national emissions, making the transition in this sector a high-impact goal. The Nigerian transport sector comprises road, rail, air, and marine sub-sectors, but the road transport sector is the greatest. Among these subsectors, using fossil fuels as the sole energy source is common, and there has not been a notable diversification of energy sources. Although ICE buses account for 5% of total transport emissions within the transport sector, it is expected that deploying e-buses could offer a 75% emissions reduction potential for the transport sector by displacing 20–30 private and passenger cars per bus.[4]

FIGURE 3: ICE Bus Emissions in the Transport Sector

60%

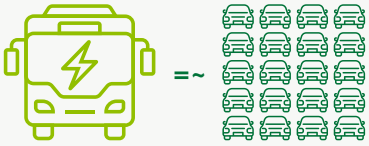
Transport sector is the biggest polluter in Nigeria

Contributing a whopping 60% of the country's total CO2 emissions. This makes transitioning this sector critical for reducing Nigeria's carbon footprint.

75%

Electric buses offer significant emission reduction

Replacing traditional buses with electric ones has the potential to cut emissions by 75%. Additionally, each electric bus can displace 20-30 cars on the road, further reducing emissions.



Deploying e-buses could offer emissions reduction potential for the transport sector by displacing 20-30 private and passenger cars per bus

To address the emission challenges, the Nigerian Government, while signing the Paris Agreement, committed to achieving net-zero emissions by 2060 and developed the Nigeria Energy Transition Plan (ETP), which emphasizes the critical need to transition to cleaner forms of transport, such as electric vehicles, to reduce the transport sector's greenhouse gas emissions, which currently make up around 15% of Nigeria's total emissions.

Whilst navigating the implementation of the ETP, there are several noteworthy policy developments in regulating the mobility industry that require updates to reflect current realities within the country with the aim boost e-mobility penetration in Nigeria.[5]

[4] International Energy Agency. "CO2 Emissions from Fuel Combustion". 2020.

[5] SEforALL, Overall Mobility - BRT Overview in Nigeria. "Breakdown of Nigerian Road Travel." 2023

FIGURE 4: Policy Developments Regulating the Mobility Industry

2013

Nigerian Automotive Industry Development Plan (NAIDP)

10-year plan aimed at curtailing Nigeria's dependence on vehicle imports and stimulating domestic production.

2014

Nigeria Industrial Revolution Plan (NIRP)

5-year programme to diversity Nigeria's economy and revenues through industry and to increase manufacturing contribution to GDP to 10% by 2017.

2019

African Continental Free Trade Area Agreement (AfCTA)

Signed by Nigeria in 2019, and will require member countries remove tariffs from 90% of goods, stimulating intra-African trade

2020

Courier and Logistics Service Regulations

New regulations increased the licensing and renewal fees for courier companies, also mandating them to contribute 2% of total revenues to the postal fund.

2021

Finance Bill

Reduction of import duties and levy on vehicles for transportation of goods and persons to 10% and 5% respectively in order to reduce inflation by cutting down cost of transportation.

2022

Draft Auto Bill (Review of NAIDP)

The federal Government is currently in the process of reviewing the 2013 Automotive Industry Development Plan in a bid to further stimulate the automotive industry

Notably, about 28 States out of the 36 States in Nigeria have existing intra or interstate public transport services.

- Intra-state
- Inter-state
- Infra and inter-state

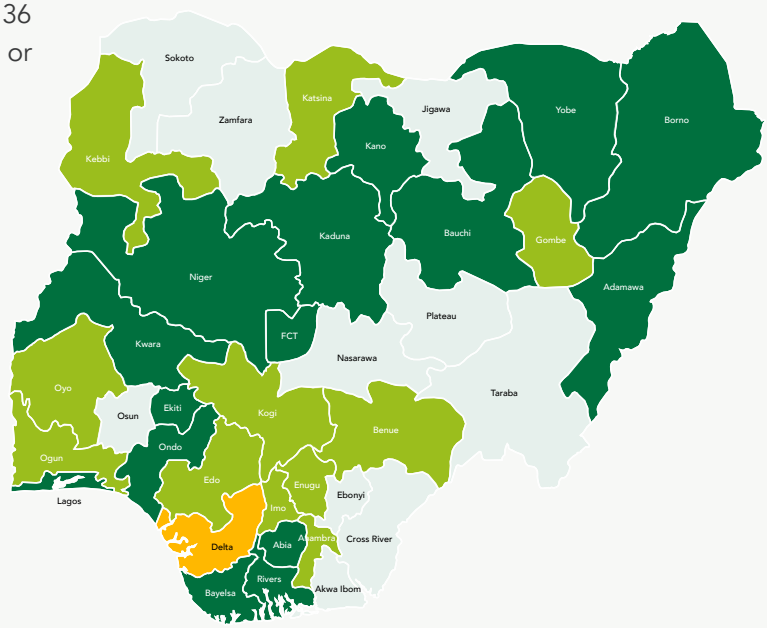


TABLE 1: Existing Intra or Interstate Public Transport Services in Nigeria

S/N	STATE	TYPE OF PUBLIC TRANSPORT (INTER OR INTRA STATE)
1	Abia	Intra
2	Abuja FCT	Intra
3	Adamawa	Intra
4	Anambra	Inter and Intra
5	Bauchi	Intra
6	Bayelsa	Intra
7	Benue	Inter and Intra
8	Borno	Intra
9	Delta	Inter
10	Edo	Inter and Intra
11	Ekiti	Intra
12	Enugu	Inter and intra
13	Gombe	Inter and intra
14	Imo	Intra
15	Kaduna	Intra
16	Kano	Intra
17	Katsina	Inter and Intra
18	Kebbi	Inter and Intra
19	Kogi	Inter and Intra
20	Kwara	Intra
21	Lagos	Intra
22	Niger	Intra
23	Ogun	Inter and Intra
24	Ondo	Intra
25	Oyo	Inter and Intra
26	Rivers	Intra
27	Yobe	Intra

Amongst all the above listed stated-owned public transport system, Lagos has the most efficient and robust intra-city transit system in Nigeria. However, other states of the federation are investing in their public transport system to support economic growth, environmental sustainability, and social inclusivity. Investments in public transport can reduce traffic congestion, lower greenhouse gas emissions, and provide accessible mobility options for all citizens, thereby improving quality of life and fostering more equitable urban development.

TABLE 2: Distribution of Types of Passenger Vehicles in Operation

S/N	CUSTOMER SEGMENT	IMAGE	PASSENGER CAPACITY	USE CASE	RANGE	ORGANIZATION	PROCUREMENT
1	Danfos and Molue		<25	Passenger	Inter-state	Private operators (NURTW)	Private & fragmented
2	Private bus/van companies		15-65	Passenger	Inter-state	Private operators (e.g., Chisco, ABC Transport)	Private & centralized (within company)
3	Logistics companies		NA	Cargo	On-demand	Private operators (e.g., GIG)	Private & centralized (within company)
4	BRT		45+	Passenger	Intra-state	Public	Private & centralized
5	Coaster/feeder buses		25-30	Passenger	On-demand	Organizations that operate private fleet (e.g., businesses, schools, hospitals)	Private & centralized (within organization)

2.2 Overview of Transportation Sector in States in Nigeria

Abuja Federal Capital Territory (FCT)

With a population of 3.84 million people, Abuja has made progress in developing its public transport system. In December 2020, FCT Permanent Secretary disclosed that FCT Administration had secured funding of $950,000, as part of the Clean Technology Fund (CTF) administered through Africa Development Bank (AfDB) for a feasibility of implementing a BRT project in Abuja 3. The planned BRT project will span 32.2 kilometres, including 23 bus stops, connecting the Central Business District (CBD) in the Federal Capital Territory (FCT) to Auta-Balefi in Nassarawa State.

Kano State

Despite primarily relying on minibuses and tricycles and the primary modes of transportation, Kano State Government has also invested in improving its mass transportation systems. The state government allocated N2.5 billion to acquire 100 buses for a BRT project, along with 50 cabs. The state signed an MOU with Zhengzhou Yutong Bus Company and Zhengzhou Public Bus Communication Co. Ltd for the supply of the buses. Furthermore, according to official statistics by the Kano Road and Traffic Agency (KAROTA), there are 60,000 registered tricycles operating in the city, generating significant revenue and serving as the main mode of mass transportation. However, due to security concerns, in 2022 a ban on tricycle operations after 10pm was implemented by the state government. This further increased the impetus of the state to develop its BRT systems to accommodate for nighttime movement.

Oyo State

Oyo State, with a population of 7.976 million people (as of 2022), has taken steps to address road congestion and support low-income earners in Ibadan and its environs. The state government announced plans to provide 106 long buses at a cost of N9.3 billion for zero-fare public transportation efficiency. The mass transit scheme is operated by Pacesetter Transport Services, which is a state government owned entity.

Ogun State

Ogun State has a transportation masterplan in development. A component of this plan is developing a BRT system which plans to offer inter-state BRT services between Sagamu-Mowe and Lagos, as well as Ota and Lagos. The BRT pilot buses were launched in April 2022, however there is no information as to how many buses were part of this pilot. The state has also introduced park and ride services on the Mowe-Ibafo-Lagos corridor.

Kaduna State

Kaduna has a current population of 9.03 million people, which is expected increase to 3 million by 2030. In light of its booming populace, the state has embarked on developing a BRT system. In 2022, the Kaduna State Transport Regulatory Authority (KADSTRA) signed an agreement with the French Development Agency (AFD) to implement a state-of-the-art BRT system. The project aims to have at least 100,000 inhabitants with direct access to the BRT corridor, with an estimated daily ridership of 160,000 passengers. The system is expected to reduce emissions, saving 45,000 tons of CO2 equivalent per year. The project outputs include a 24-kilometer corridor, 30 bus stations, a bus depot, intelligent transport system (ITS) facilities, and 120 articulated 18-meter buses.

Kwara State

In response to the subsidy removal, the Kwara State government deployed large buses to transport students and workers in public tertiary institutions within the metropolis. The government also reduced the workdays for civil servants from five to three. Additionally, the state commissioned Dar Al-Handasah, one of the world's leading consultancies on project management and infrastructure development, to create a masterplan for the sustainable growth and development of Ilorin, the seventh-largest city in Nigeria with a population of 1.03 million. The draft master plan, unveiled in May 2023, explores various sustainable transport options, including mass transit and dedicated cycle lanes, to reduce traffic congestion and facilitate infrastructural development

Enugu State

The state is said to have one of the best road networks in the Southeast. In 2011, the Enugu State Government announced the introduction of its mass transit commuter project called the 'Coal City Shuttle', taking off with about 30 long buses built by Innoson Vehicle Manufacturing Company Limited (IVM) in Nnewi, Anambra State. However, there is no indication if these are still in operation. To get around the city, the primary modes of transport are motorcycles (locally known as 'okadas'); for longer distances, minibuses (which have replaced commercial buses (locally known as 'danfo') along fixed routes or taxis. Tricycles were recently introduced and have effectively replaced the use of taxis. Several Transport companies also operate within the state using larger 20-seater buses for inter-state transport links. These buses operate from designated motor parks and include operators such as GUO Transport and Peace Mass Transit.

Rivers State

The State Government has made substantial investments in road construction and maintenance, especially around Port-Harcourt, however smaller cities and rural areas do not enjoy the same level of infrastructural development. In 2020, the Rivers State Transport Company charged with the inter-city and inter-state transport needs of its residents was shut down by the then administration, leaving the sector controlled by the private sector businesses which charge higher fares. However, in 2023, following the removal of fuel subsidy, the new administration launched a free transport intervention scheme which consists of 17 buses designated to operate various routes within the city. There are currently no plans indicated by the state government for a BRT system.

2.3 Transitioning to Electric Buses in Nigeria

The imperative for transitioning to electric buses in Nigeria is driven by the need to reduce greenhouse gas emissions, combat air pollution, and decrease dependency on fossil fuels in the transport sector. With Nigeria's commitment to achieving carbon neutrality by 2060, electric buses offer a sustainable alternative that aligns with environmental goals, improves urban air quality, and supports the global shift towards cleaner energy sources. This transition also presents an opportunity for Nigeria to modernize its public transport system, enhancing efficiency and accessibility for its growing population.

With the removal of fuel subsidy in May 2023, improving the public transport sector to cushion the effects and harness the gains of having more cars on the road is urgently needed. The snapshot below shows the direct advantage of integrating e-buses in the transport system.[4]

FIGURE 5: Relevant Road Transport Statistics

96%

Road transport dominance:

Road transport accounts for a whopping 96% of all transport methods.

77%

PMS consumption

The transport sector consumes a significant 77% of the country's total PMS, and of that, 96% is used by road transport.

Source: Third National Communication, NBS

[4] International Energy Agency. "CO2 Emissions from Fuel Combustion". 2020.

In Nigeria, awareness of e-mobility remains relatively low, despite the innovative mobility initiatives seen in other African countries. The table below highlights some notable EV projects in Nigeria.[5]

TABLE 3: List of Current E-Mobility Initiatives in Nigeria

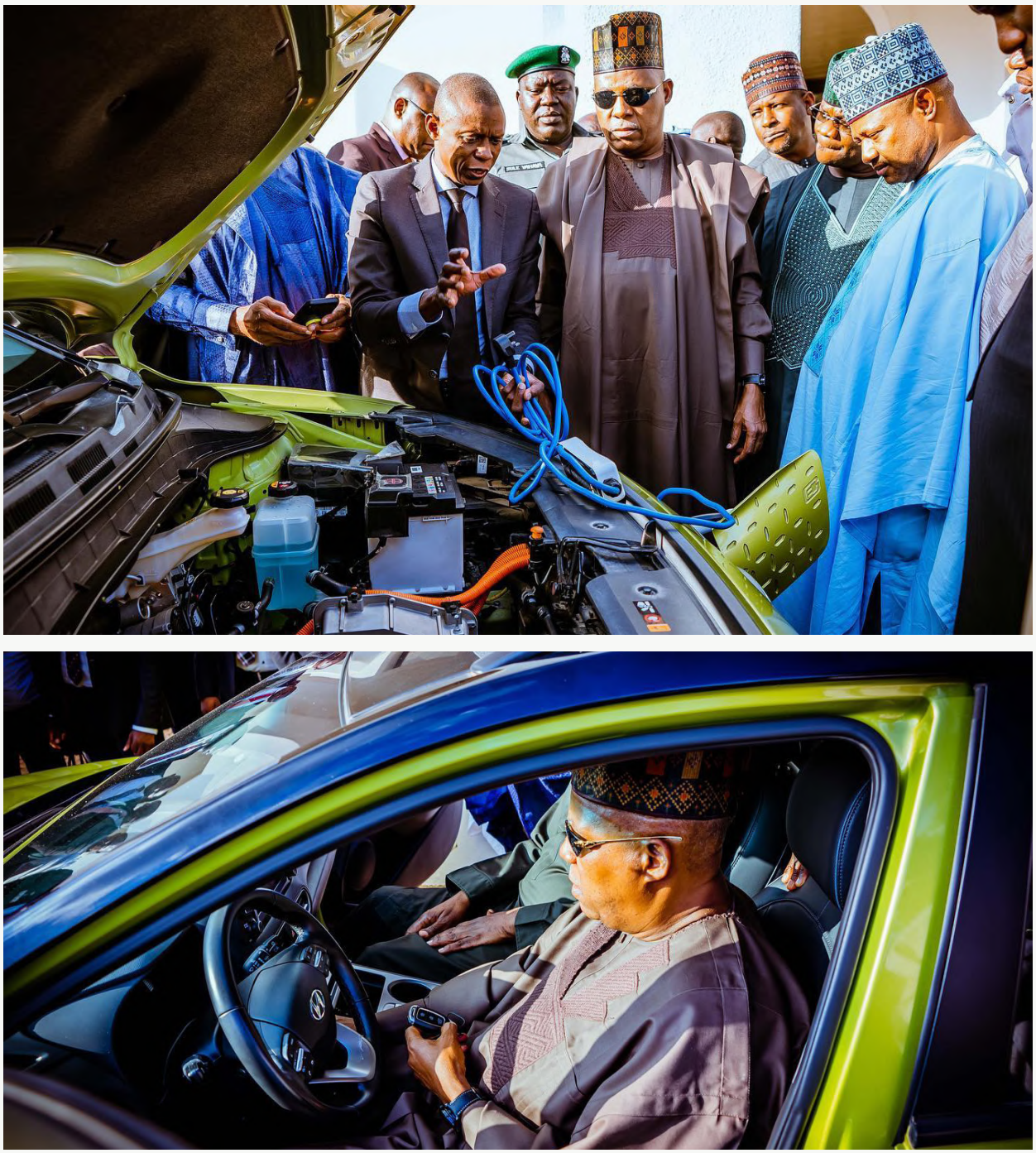
S/N	PROJECT DESCRIPTION	LOCATION
1	National Automotive Design and Development Council (NADDC) commenced a pilot project with aim of setting up **EV charging stations** at Usman Dan Fodio University in Sokoto State, the University of Lagos in Lagos State and in the University of Nigeria Nsukka in Enugu State.	Sokoto, Lagos and Enugu State.
2	Possible EVs, Nigeria's leading electric vehicle experience and manufacturing company launched an **e-taxi fleet** with initial 30 units of taxis and plans to expand to at least 20,000 electric vehicles across Nigeria. By Possible EVs.	Abuja
3	Presentation of **Nigerian made 14-seater E-buses** by JET Motors EVs	Kaduna
4	Installation of Nigeria's first **commercial EV charging station** powered by Sterling bank	Lagos
5	Oando Clean Energy Limited (OCEL) in partnership with the Lagos Metropolitan Authority (LAMATA) commenced **Proof-Of-Concept to validate the business case for E-buses in Nigeria** through the test and operation of two E-buses.	Lagos
6	Electric Power bikes and Swap stations for courier and delivery services by eFTD	Lagos
7	FCDO-LINKS in partnership with Sterling Bank PLC and two (2) female cooperatives in Kano launched a pilot project to demonstrate the **commercial viability of keke NAPEP (tricycles)** by supporting women with purchase of e-powered keke NAPEP and training mechanics to maintain tricycles.	Kano
8	Presentation of **minibuses** to private individuals and corporate organisations to enhance entrepreneurial development and empowerment in Borno State	Borno
9	Shell Foundation supported a project that introduced **electric two-wheelers** to Gbamu Gbamu community in rural southwest in partnership with MAX, a mobility company, and Rubitec Solar, a renewable energy developer.	Ogun
10	The presentation of the electric car, KONA, took place at the State House in Abuja by Mr. Jelani Aliyu, the Director General and Chief Executive Officer of NADDC, following the NEC endorsement highlighted that the mass production of electric vehicles is poised to mitigate the impact of fuel subsidy removal in the country.	Abuja

[5] SEforALL, Overall Mobility - BRT Overview in Nigeria. "Breakdown of Nigerian Road Travel." 2023

The Vice President of Nigeria, Kashim Shettima, officially unveiled an electric car that has been assembled and designed within the country. This milestone comes in the wake of the National Economic Council's endorsement of the National Automotive Design and Development Council (NADDC) initiative to initiate large-scale production of electric vehicles in Nigeria.

The presentation of the electric car, KONA, took place at the State House in Abuja by Mr. Jelani Aliyu, the Director General and Chief Executive Officer of NADDC, following the NEC meeting held on Friday, June 16th, 2023. Mr. Aliyu highlighted that the mass production of electric vehicles is poised to mitigate the impact of fuel subsidy removal in the country.

FIGURE 6: The Vice President of Nigeria and the DG/CEO NADDC at launch of Hyundai EV at State House



E-buses offer several benefits compared to Internal Combustion Engine (ICE) powered diesel buses, including the following:

TABLE 4: Key Benefits of E-buses over Diesel Buses

CRITERIA	DESCRIPTION
Lower maintenance cost	e-buses have fewer moving parts than traditional ICE buses, which means they require less maintenance and have lower maintenance costs over the lifespan of the buses
Lower operating costs	e-buses have lower operating cost because they use electricity for one time charging instead of fossil fuels; and electricity is cheaper and more efficient
Reduced emissions	e-buses produce no tailpipe emissions, which helps to reduce pollutions and GHGs, and improve air quality within the cities
Quieter operations	e-buses are much quieter than traditional ICE buses, which can help to reduce noise pollution in urban areas
Improved passenger experience	e-buses offer a smoother and more comfortable ride when compared to ICE buses because they have fewer moving parts and generate less vibration and noise while in motion

Electric Vehicles provide an opportunity to attract substantial investments and create additional revenue streams. In terms of carbon emissions savings, transitioning to electric vehicles have the potential to reduce the country's greenhouse gas emissions by up to 1,300 tons of CO_2 equivalent over the lifespan of a bus.

FIGURE 7: Benefits of Electric Buses[6]

Saving 2,500 TCO_2e of GHG over each bus lifespan

Cities shifting passenger transport to buses and electrifying them at the same time can save c. 2,500 TCO_2e of GHG over the lifetime of each bus.

Electric Buses Powered by Renewables to Slash Emissions by 680 TCO_2e

Powering these buses by 100% renewable energy (RE) will deliver a further reduction of ~680 tCO2e in GHG emissions.

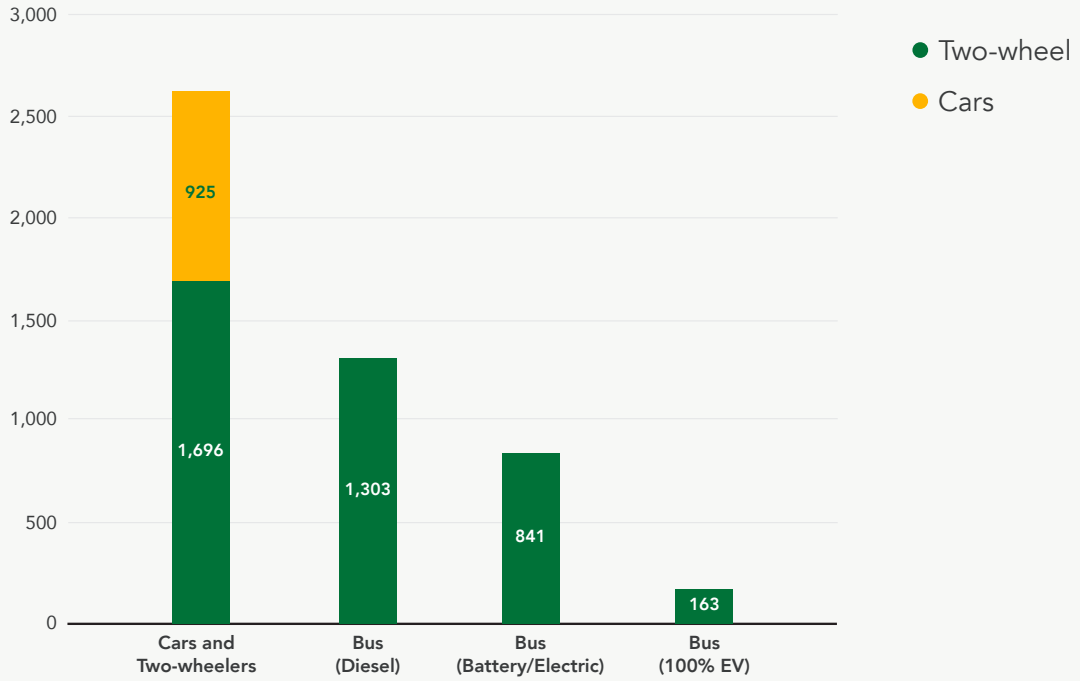
Switch to buses can save 1,300 TCO_2E of GHG

The maximum reduction in GHG emissions in urban passenger transport would be delivered by encouraging users of cars and two-wheelers to switch to buses (i.e. passenger mode-shift), even ICE buses, this can deliver a GHG reduction of-1300 CO2e during the life of a bus.

100% EV can save 680 TCO_2E of GHG

The transition from diesel to electric in the Intended Policy Scenario (Life-cycle assessment of passenger transport; an Indian case study) will deliver~460 CO2e GHG emission savings during the life of a bus, as mentioned earlier.

FIGURE 8: Life-cycle GHG Emissions for Urban Buses (TCO2e)



To realize the advantages explained above, the deployment of e-buses requires thorough planning to balance the high capital investments with benefits from lower cost of operations.

[6] International Energy Agency. "CO2 Emissions from Fuel Combustion". 2020.

CHAPTER THREE

Market Assessment for E-Bus Deployment

3.1 Planning Criteria for E-buses

In the deployment of electric buses (e-buses), comprehensive planning emerges as the basis for establishing a resilient and sustainable transit system. This section delves into the pivotal planning criteria necessary for the effective integration of e-buses within Nigeria's urban landscapes. Key considerations such as Route Planning, Passenger Ridership, Bus Depots, and Power Availability and Reliability are not just operational facets; they form the very blueprint of a successful e-bus ecosystem.

Figures 11 to 13 illustrate the sequential thought process, from preliminary planning stages through mass adoption strategies, underscoring the interconnectedness of these elements. Effective Route Planning ensures optimal coverage and service efficiency, while passenger ridership data drives the allocation of resources to meet demand. Additionally, the strategic location of bus depots and assured power availability are fundamental in maintaining the operational integrity of the e-bus fleet. Together, these criteria embody the meticulous planning necessary to transcend traditional transit models, paving the way for a greener, more efficient future in public transportation.

FIGURE 9: Stages in the Deployment of E-Bus

Identify the key technical specifications for procurement	Select depots for deployment	Select routes, schedules and assured daily-km of operation

Routes	Maximize ROI and user benefit by focusing on high-ridership, high- revenue routes while minimizing disruption to charging depot operations.
Technical	• Number of buses, 9m Vs 12m, AC or Non-AC, etc. • Average daily range of bus (in km)
Location	Strategic depot siting to align with priorities such as proximity to Low- Emission Zones and ease of Implementation.
Cost	Cost of buses and power infrastructure to be deployed

Route Planning: Considering severe traffic jams experienced across major cities, resulting in long commuting hours, dedicated BRT lanes and traffic segregation are major considerations while planning for deployment of e-buses. Dedicated routes will help in establishing travel time for the buses, number of bus stops, estimated number of passengers, and bus details (length, width, and height) while planning these routes. For example, a 70 passenger 12m AC e-bus can perform a daily trip of 200km – 220km; and as such, the daily commuting route of such BRT bus must be planned not to exceed this limit for a single charge.

Passenger Ridership: Whilst mobility across most African countries is still predominantly pedestrian, one of the barriers to transitioning to vehicular transport is the inadequate number of buses. Government and private players must deploy e-buses in areas where ridership is most effective and available (busy road networks and densely populated areas).

Bus Depots: Creation of bus-holding area and citing these depots according to peak movement time of passengers are essential in considering where buses can be parked after daily operations, and where their operations will begin. These holding area/location and the numbers required along a dedicated route will help determine number of buses that can be kept at each depot after daily operations.

Power Availability and Reliability: Bus depots are most likely to be used as locations to charge the buses after daily operations. Each bus will require up to four hours of overnight charging and 30-45 minutes of opportunity charging during the day-if required. Therefore, it is important that power supply is available throughout the night and specific periods of the day when needed for opportunity charging of buses. As such, apart from a grid source, a backup supply source will be required and in place as redundant source of supply should the grid supply fail. Further details of such backup power supply are provided in the following sections.

Cost of Procurement: E-bus deployment involves capital expenditure required for the purchase of buses and construction associated with the upstream power infrastructure and on-site charging infrastructure. While this is higher than the capital cost of diesel buses, the overall operational cost is lesser when compared to running ICE buses, and the additional capital cost is recovered during the life of the e-buses. Designing the procurement business model to balance these costs is crucial for the success of e-bus deployments.

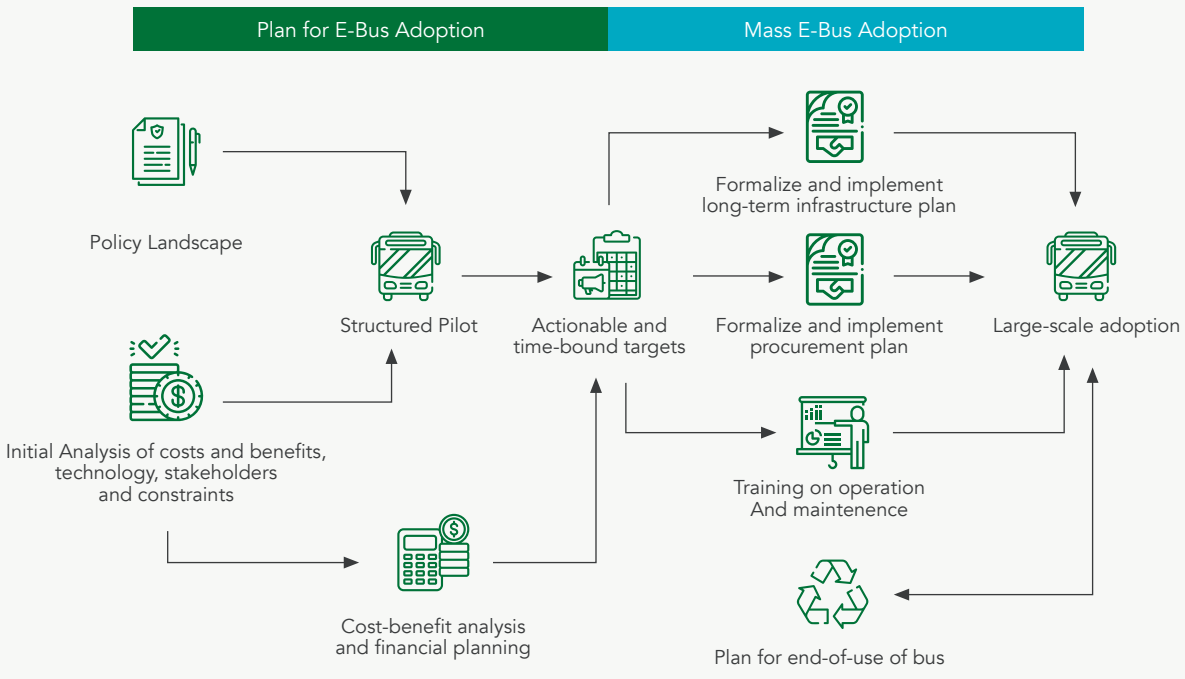
Operations and Maintenance: For a guaranteed service and to maximize the useful life of the buses, private sector participation is encouraged and preferred for the operations and maintenance of the buses. For manufacturers and assemblers of e-buses, local presence for after-sales support and availability of spares should be considered during the procurement of the e-buses.

Fare collection: For assurance on capital recovery and to encourage foreign investors participation, a digital and secured fare payment system must be used. Manual ticketing and cash collection promotes leakages, unaccountability, and fraud; and as such, poses a high risk to investor confidence and must be discouraged.

FIGURE 10: Key Considerations for Sustainable E-Bus Deployment

1. **Does the State have an operational mass transit system**
2. **Does the State have a transport ministry/regulator/ authority?**
3. **Does the State assure effective use of existing resources?**
4. **Is there alignment to timing and quantum of available funds from Federal govt.**
5. **Is there a market for suppliers and service providers?**

FIGURE 11: Thought Process Flow for Mass Adoption of E-Buses



3.2 Overview of Electric Bus Specifications and Features

The table below shows an overview of vehicle categories within the Nigeria transportation sector. For example, the Lagos BRT buses operated by LAMATA fall under the BRT system with bus capacity ranging between 38 and 70 passengers.

Based on the operational needs within Nigeria's public transport system, technical specifications of proposed-buses are summarized in the table below:

TABLE 5: E-Bus Technical Specifications to Consider

Specifications	Mini Bus	Standard Bus	Standard Bus (Inter-city)
Bus Length	Maximum 9m	Maximum 12m	Maximum 12m
Battery Type	Advanced Cell Chemistry: Li-Ion based (LTO or NMC)		
Bus Range (km)	120-180 km	140-180 km	250-350 km
Floor Height (mm)	Low (450mm) and standard (900mm)	Low (450mm) and standard (900mm)	Standard (900-1250mm)
Seating Capacity	26-32 (+D)	36-39(+D)	43-48(+D)
People with Disability (PWD) accessibility	Yes	Yes	No

A comprehensive breakdown of technical requirements for the e-buses, to be incorporated in an E-Bus Request for Proposal (RfP), has been included in the annexure to this report.

3.3 Charging Infrastructure and Standards for E-bus Charging

Essentially, uninterrupted and reliable power supply are key criteria in the construction and citing charging stations for the e-buses. Where a bus depot along a dedicated BRT route cannot be used as a charging station, the closest charging station must be situated where an e-bus can go to after its daily operation without draining the remaining battery charge before getting to its charging station.

Likewise, the quantum of power available at a charging depot will determine the number of e-buses that can be kept overnight for charging at such depots. Though, e-buses do not require long hours of charging (overnight charging hours per bus are typically between 1 hour 30 mins – 2 hours, with a maximum of 4 hours with specific manufacturers), the number of chargers available at a charging depot must be enough to charge the buses parked at this depot within the hours of non-operation of the buses – most likely in the deep night hours of 11pm – 5am. It is recommended that 260 kW DC chargers are installed to charge buses in less than 2 hours.

FIGURE 12: Dual Head Fast EV Charger Terminals

The Combined Charging System (CCS) is a fast-charging system which ensures full charging of the e-buses within 1–2 hours. It is based on an open and universal standard for e-vehicles. The CCS combines single-phase with rapid three-phase charging using alternating current at a maximum of 43 kilowatts (kW), as well as direct-current charging at a maximum of 200 kW and the future perspective of up to 350 kW – all in a single system. The charging station products available on the market today can offer a maximum of 350 kW.

The CCS includes the connector and inlet combination as well as all the control functions. It also manages communications between the e-vehicle and the infrastructure. The key features of the CCS include the following:

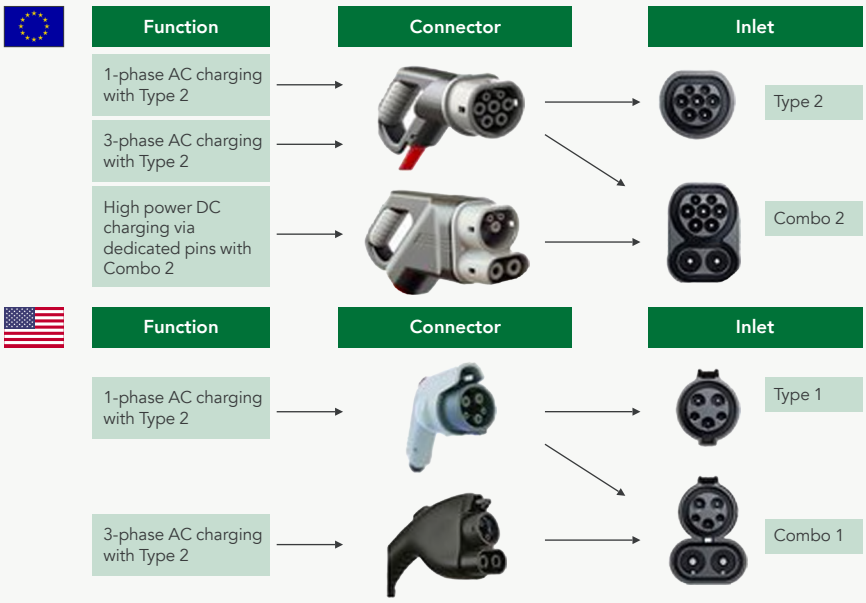
AC charging:

- With the electrical interface specification for power transmission, which includes safety-related signalling for AC charging that complies with the international IEC 61851-1 standard.
- With a Type 2 connector in Europe that is compliant with the international IEC 62196- 2 standard.

DC charging:

- With the electrical interface specification for power transmission, which includes safety-related signalling for DC charging that complies with the international IEC 61851-23 standard.
- With the Combo 2 connector in Europe, compliant with the international IEC 62196-3 standard.

FIGURE 13: E-bus Charger Types



CSS with

- **IDENTICAL** Safety Measures (PWM)
- **IDENTICAL** Charging Communication (PLC)

covering ALL charging scenerios worldwide

For fast charging options, the CCS 2.0 (Combo 2) European type are most preferred. The table below shows the characteristics of the CCS 2.0 fast chargers:

AC charging:

- With the electrical interface specification for power transmission, which includes safety-related signalling for AC charging that complies with the international IEC 61851-1 standard.
- With a Type 2 connector in Europe that is compliant with the international IEC 62196- 2 standard.

DC charging:

- With the electrical interface specification for power transmission, which includes safety-related signalling for DC charging that complies with the international IEC 61851-23 standard.
- With the Combo 2 connector in Europe, compliant with the international IEC 62196-3 standard.

TABLE 6: Types and Features for Fast CCS 2.0 Chargers / Source: Tesla.com

	CSS 2.0 Features		
Charging Type	AC BS	AC HLC	DC HLC
Charging Connector	Type 2 Connector	Type 2 Connector	Combo 2 Connector
Charging Inlet	Type 2 Inlet or Combo 2 Inlet*	Type 2 Inlet or Combo 2 Inlet*	Combo 2 Inlet
Charging Mode	Mode 2 or 3	Mode 2 or 3	Mode 4
Load Balancing	Reactive	Reactive and/or Scheduled	Reactive and/or Scheduled
Charge Authorization Mode	EIM	EIM and/or PnC	EIM and/or PnC

*if DC HLC is supported

3.4 Power Infrastructure and Supply Options for E-Bus Charging

The following table provides a summary of the approach to be adopted to assess the upstream power capacity needed to enable fast charging at depots.

TABLE 7: Capacity Needs of Power Connection to Depots

S/N	DESCRIPTION	9M AC BUS	12M AC BUS
1	Battery Capacity of the vehicle (kWh)	180	325
2	Energy Consumed (kWh/Km)	1	1.3
3	Daily Run (km)	200	225
4	No. of e-buses	1,000	1,000
5	Proposed Capacity of Charger (kW)	260	260
6	Estimated no. of Chargers to meet energy demand-Dual Gun **(2 charging cords per charger, 8 hrs. = 8 buses)**	4	4
7	Peak power demand (kW)	250 (130)*	250 (130)*
8	Peak power demand (kW)	65,000 (33,800)*	65,000 (33,800)*
9	Total Charger load at the bus depot (kVA) @peak demand = 0.8	81,250 (42,250)*	81,250 (42,250)*
10	Upstream Capacity required/Depot (MVA)	81.25 (42.25)*	81.25 (42.25)*
11	Proposed solar capacity = 100% of peak demand (kW)	**6,500 (3,380)**	**6,500 (3,380)**

*Capacity when charged with dual 2 cord chargers

From the table above, below are power requirements for the type of e-buses to replace ICE buses:

- Adopting DC fast charge with a minimum capacity of 260 kW for the e-bus pilot. These fast chargers typically allow full charge within 2 hours thereby minimizing the charging time per bus at the depot.
- A typical charger to bus ratio of 1:4 is considered based on current deployments in Indian cities. However, since overnight charging allows for eight (8) hour charge time (10pm – 5am), one charger can serve 8 buses, hence the reduction in the number of chargers from 250 to 130.
- Therefore, 1,000 e-buses would require about 250 chargers-assuming all buses operate from a single depot. The chargers are typically provided by the OEM delivering these buses and hence their installation is not the responsibility of the regulator.
- The peak power required at the depot depends on the number and type of chargers used but not the type of bus used. Therefore, the peak power load assuming all 100 buses are deployed in one depot and 25 chargers with 260 kW power are deployed to charge them will be 6,500kW.
- It is estimated that an upstream power of 81.25MVA would be required to serve all buses from the same depot. The peak power requirement can be reduced if buses are distributed across depots.

As considered under the selection criteria, an uninterrupted and reliable power supply at bus depots is crucial to the daily operational success of the e-buses. At present, about 18 million people in urban areas representing 16% of Nigeria's population, and 67 million people in rural areas representing 66% of the population are without access to electricity.[7] Nigeria has a total installed power capacity of 12.5GW, with 4GW dispatch capacity, 3.6GW maximum transmission capacity, and 3.1GW maximum power capacity distributed to all grid connected customers. This implies a huge underserved and unserved population and locations across the country and electricity supply to bus depot will and can be limited. Therefore, there is the need to provide backup power supply to ensure power availability during charging hours for the e-buses.

[7] Nigeria Bureau of Statistics, National Data Archive NBS, Nigeria, Powered by NADA 4.2 and DDI, https://www.nigerianstat.gov.ng/nada/index.php/home.2024

For the pilot approach, below are some considerations:

i. **Grid Supply:** If available, this will be the main supply for both the station load and for the bus chargers. Tariff from grid supply is cheaper when available compared to other supply sources.

ii. **Independent Power Plant (IPP) Supply:** Where there are existing IPPs within bus depot's locations, extending such medium voltage connection (11kV or 33kV) will improve power availability at bus depots. IPP availability increases power reliability at bus depots for charging. However, IPP tariffs are slightly higher compared to grid tariffs.

iii. **Solar PV Supply/Mini Grids:** Considering the space required, cost of development, and no carbon emissions, solar PV with battery installations across bus depots will be proposed. Having a minimum of 10% of the total peak demand for an identified bus depot will be a great advantage in the scenario where the grid and IPP supply fails. This is sustainable, and available solar installation grants can apply here to further reduce the cost burden of setting up solar PV installation across bus depots.

3.5 Payment Systems

Lagos State was the only State in Nigeria with a digital payment system for its intra-city bus system until most recently when Oyo State and the Federal Capital City in Abuja launched similar digital fare payment systems.

FIGURE 14: Cowry Card Digital Payment System

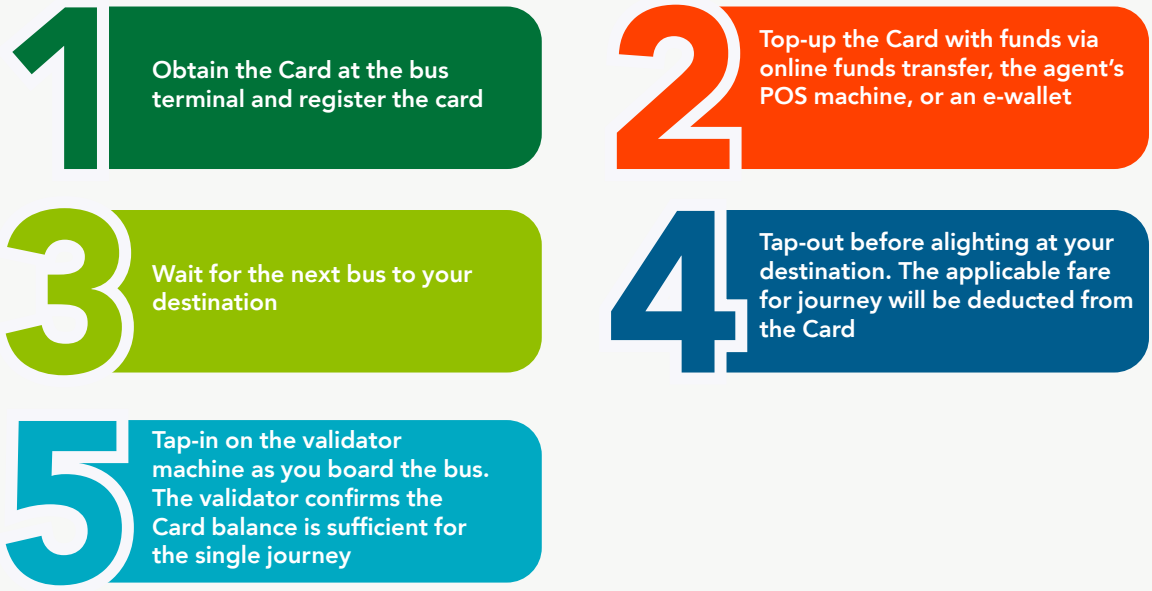
Cowry Card as popularly called is a payment pre-loaded fare payment card used in Lagos to commute on the BRT buses. Developed by an indigenous Nigerian company – Touch and Pay Technologies Limited – the card is accepted and used across other modes of transport available in Lagos: road, water, and the rail system.

This payment solution helps reduce cash transactions in transport operations in order to protect stakeholders' investments, aid contact tracing, and protect commuters on their daily trips around Lagos

The payment card is preloaded at bus depots or online via wallets and payment agents. A card user will tap the card on the validator located at the entrance of the buses, as shown in the figure above.[9]

[9] www.cowry.com.ng

FIGURE 15: How the Cowry Card Works



3.6 Considerations for Deployment of E-Buses

The following key activities addressed below aim to ensure that the introduction of e-buses complements and enhances the existing public transport system, rather than competing with it, leading to a more efficient, user-friendly, and sustainable urban transit system.

- **Stakeholders Collaboration:** Engage with existing public transport operators, local governments, and community groups to understand current systems and identify integration points.
- **Route Optimization:** Analyze existing routes to determine where e-buses can be most effectively integrated. This might involve supplementing high-demand routes or replacing less efficient ones.
- **Unified Ticketing System:** Develop or integrate into a unified ticketing system that works across different modes of transport, allowing for ease of transition between e-buses and other public transport.
- **Public Awareness Campaigns:** Implement educational and awareness campaigns to familiarize the public with e-buses, their benefits, and how they fit into the existing transport network.
- **Driver and Staff Training:** Ensure that drivers and transport staff are adequately trained in the operation and maintenance of e-buses and in providing quality service to passengers.
- **Real-Time Information Systems:** Implement real-time tracking and information systems for e-buses, integrated with existing transport systems, so passengers can plan their journeys efficiently.
- **Infrastructure Development:** Coordinate with urban planning to ensure the necessary infrastructure, like charging stations, is integrated into the cityscape and accessible where needed.
- **Pilot Programmes:** Start with pilot programmes on select routes to gather data, adjust operations, and refine strategies before full-scale implementation.

3.7 Safety and Security for E-Bus Charging Infrastructure

Ensuring the safety of passengers, drivers, and the public is paramount in the deployment and operation of e-bus charging infrastructure. It is essential to establish comprehensive safety standards and develop robust emergency preparedness guidelines to address potential accidents and emergencies involving e-buses and their charging stations.

Safety Standards:

- **Design and Construction:** Charging stations should be designed and constructed according to the highest engineering standards to ensure structural integrity and operational safety.
- **Electrical Safety:** Implement stringent electrical safety measures to prevent risks such as short circuits, overloading, and electric shocks. This includes the use of ground fault circuit interrupters (GFCIs) and adequate insulation.
- **Fire Safety:** Equip charging stations with fire suppression systems and ensure that materials used in construction are fire-resistant. Regular fire safety drills and training should be conducted.
- **Accessibility:** Ensure that all charging stations are accessible to all users, including the disabled, and comply with local accessibility laws to prevent accidents and injuries.

Emergency Preparedness:

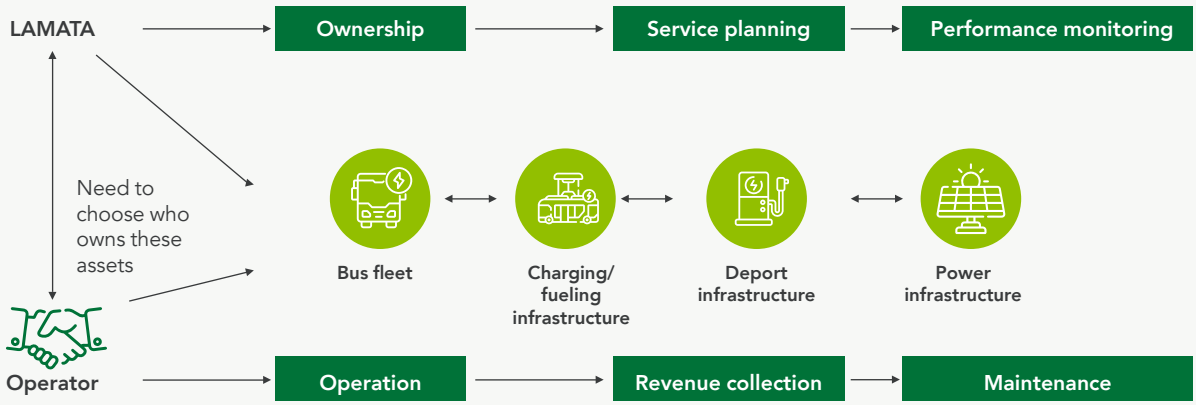
- **Emergency Response Plans:** Develop and regularly update emergency response plans tailored to the specific risks associated with electric buses and charging stations. These plans should include procedures for dealing with electrical fires, hazardous material spills, and severe weather conditions.
- **Training for Personnel:** Conduct regular training for all personnel involved in the operation and maintenance of charging stations, focusing on emergency response, first aid, and the use of fire extinguishers.
- **Coordination with Local Emergency Services:** Establish protocols for coordination with local fire, police, and emergency medical services to ensure rapid response times in the event of an incident.
- **Public Information:** Provide clear and visible safety information and emergency instructions at all charging stations to inform users about what to do in case of emergencies.

CHAPTER FOUR

Business Model Analysis for E-Buses Procurement

The selection of a suitable business model for e-bus deployment is a critical aspect that necessitates careful consideration of various factors. This involves the delineation of risks and responsibilities among the multiple stakeholders involved in the implementation process. The chosen business model dictates the framework for ownership, operations, and maintenance of essential components within the e-bus ecosystem, including the buses themselves, charging infrastructure, depots, and power usage tariffs.

FIGURE 16: Stakeholder Procurement Responsibilities



- **Ownership:** The business model determines who will own the e-buses and related infrastructure. This could involve direct ownership by a government agency, private operators, or a combination of both through public-private partnerships (PPPs).
- **Operations and Maintenance:** Responsibility for the day-to-day operations and maintenance of the e-buses and associated infrastructure is defined within the chosen business model. This includes tasks such as scheduling, vehicle maintenance, and ensuring the functionality of charging stations.
- **Charging Infrastructure:** The business model outlines the ownership, installation, and management of charging infrastructure necessary to support the e-bus fleet. This includes decisions regarding the location of charging stations, their capacity, and accessibility.
- **Depots:** The selection of a business model also addresses the establishment and management of depots where e-buses are stationed, serviced, and stored when not in use. This includes considerations such as depot location, size, and facilities.
- **Power Usage Tariffs:** Determining the tariffs for electricity usage by e-buses is an integral component of the business model. This involves negotiating rates with utility providers and ensuring cost-effectiveness for e-bus operators.

- **Regulatory Oversight:** Regardless of the chosen business model—whether it be Direct Procurement, Gross Cost Contract, or Unbundled AssetCo—the regulator plays a pivotal role in overseeing key aspects of e-bus operations. This includes service planning, ensuring performance standards are met, and regulating transport fares to maintain affordability and accessibility for commuters.

In essence, the business model analysis encompasses a comprehensive evaluation of the allocation of responsibilities and risks across the e-bus ecosystem. By delineating these elements, stakeholders can make informed decisions to support the successful deployment and operation of e-bus systems within the transportation network.

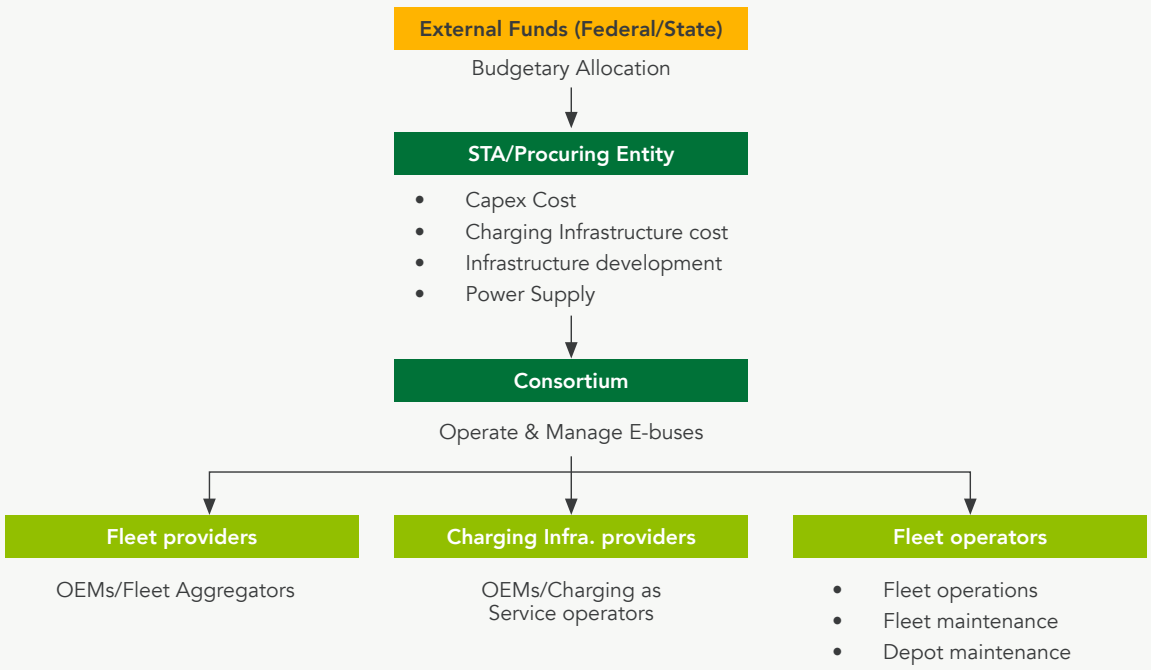
4.1 E-bus Procurement Options

In navigating the transition towards e-bus mobility, the choice of an appropriate business model stands as a pivotal decision, shaping the dynamics of ownership, operations, and maintenance within the e-bus ecosystem. This section delves into the analysis of three distinct business models—Direct Procurement, Gross Cost Contract, and Unbundled AssetCo—each offering unique approaches to the deployment and management of e-bus systems. By examining the attributes and implications of these models, we aim to provide insights that inform strategic decision-making and foster the sustainable advancement of e-bus mobility initiatives.

4.1.1 Direct Procurement

This model approach considers outright purchase of the buses, which involves higher upfront costs – including the purchase price of buses, taxes, and other associated expenses. Buying the e-buses means the purchaser owns the assets, which can be advantageous; however, this translates to taking the technology risk alone.

FIGURE 17: Direct Procurement Business Model

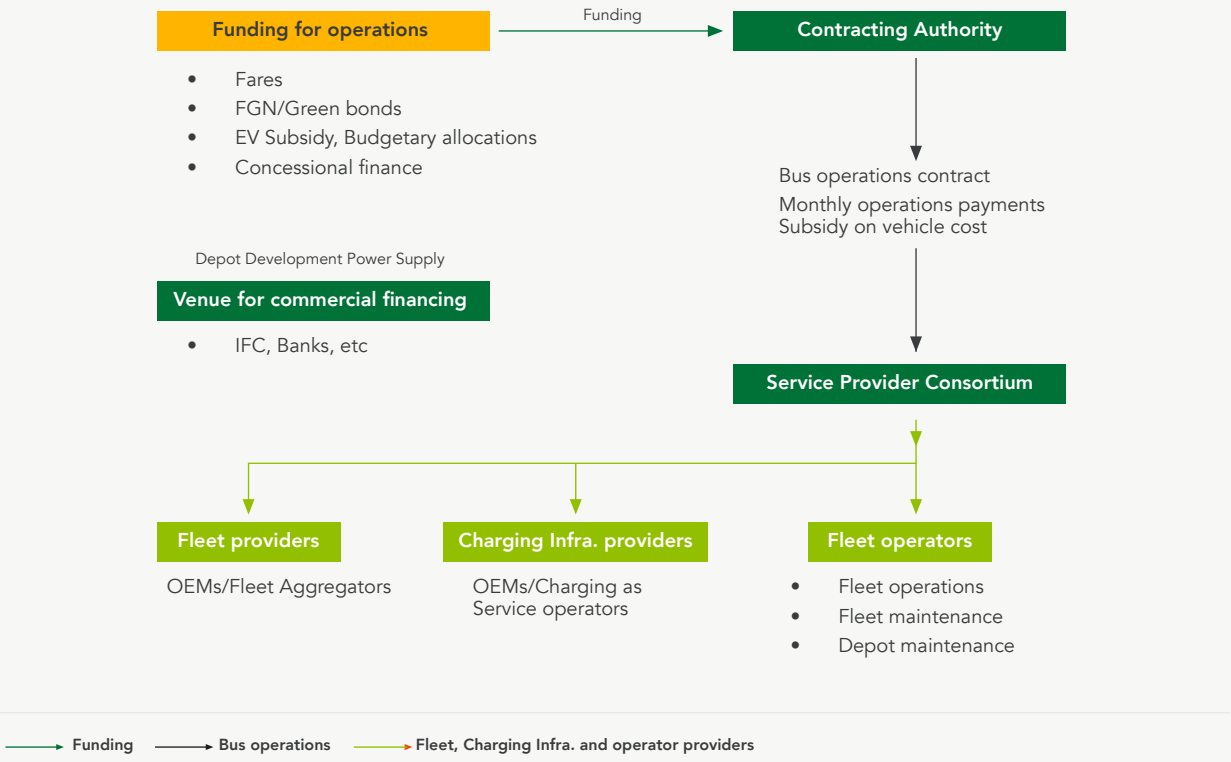


4.1.2 The Gross Cost Contract (GCC)

The GCC is a simpler business model approach that allows the regulator to engage operator(s) for the operations of the bus service over a certain number of years. Under the GCC, the operator(s) is paid a fixed amount (typically per-km fees to be paid for an assured-km of operation and variable fees in case of additional-km of operations) or percentage of fare collected to provide the bus service for a specific period.

Here, the regulator collects all revenue through the fare collection system and a sum or percentage of the revenue is shared with the operator of the bus service. The service provider is in-charge of both the ownership and operations of assets (buses and chargers).

FIGURE 18: Gross Cost Contract Business Model



As an example, this model has been successfully utilized in India where they have seen a surge in adoption of e-mobility solutions for their mass transportation needs. In terms of deployment approach:

- India initially adopted a CAPEX procurement approach wherein subnational transport authorities were offered a capital subsidy to bridge the gap between the capital costs of electric and diesel buses. A key challenge was that the subnational transport projects struggled with operations and maintenance of the buses and faced significant capital constraints.
- This led to the design of an OPEX model or the Gross Cost Contract (GCC) approach. This involves the government inviting bids for remuneration on a per km run basis with the operations and ownership of the buses resting with the OEMs under a contractual period of 10-12 years. This allowed the state transport authorities to maintain an asset-light balance sheet, while switching fleets to electric buses which have a lower overall cost of operation.
- At the Federal level, efforts were also made to aggregate demand by standardizing requirements such as bus specifications, passenger payloads and minimum distance for operational routes. This enabled central agencies such as Convergence Energy Solutions Ltd (CESL) to develop robust GCC tenders for OEMs to apply for in order to benefit from economies of scale.
- To provide additional comfort to the OEMs against the risk of state transport authorities not being able to fulfill their payment obligations, a Payment Security Mechanism (PSM) was put in place which ensured three months' worth of receivables were secured in a ringfenced account automatically disbursed to the OEMs in the event of delay in payments (approx. 3months) from the state.
- There are currently 18 states that have signed up to the GCC model through which 12,000 buses have been deployed.
- On charging infrastructure, a cost sharing approach has been developed with the OEMs providing the 'front-facing segment' of the charging infrastructure (stations, ports, depots, etc.) while the state government provided support on the back-end infrastructure (e.g. provision of land, installation of upstream transformers and support in securing state level licenses).
- The energy provision component to be used to charge the buses requires close coordination with energy distribution companies for optimal depot design, planning and load management.
- Key lessons learnt from deployment of e-buses showed profitability when buses operated routes of 200km/day. Route planning to identify high intensity corridors was also crucial to ensure viability.

The Government of India has joint working groups on the automobile sector with countries, including Japan and Germany. A similar working group may be established between India and Nigeria to facilitate cooperation, advance adoption in Nigeria, and highlight achievements in India.

4.1.2.1 Financing Mechanism for E-Bus and Infrastructure Procurement

Financing the acquisition of e-buses and developing the requisite infrastructure encompasses several financial models and mechanisms, each tailored to address the unique challenges of large-scale, sustainable infrastructure development.

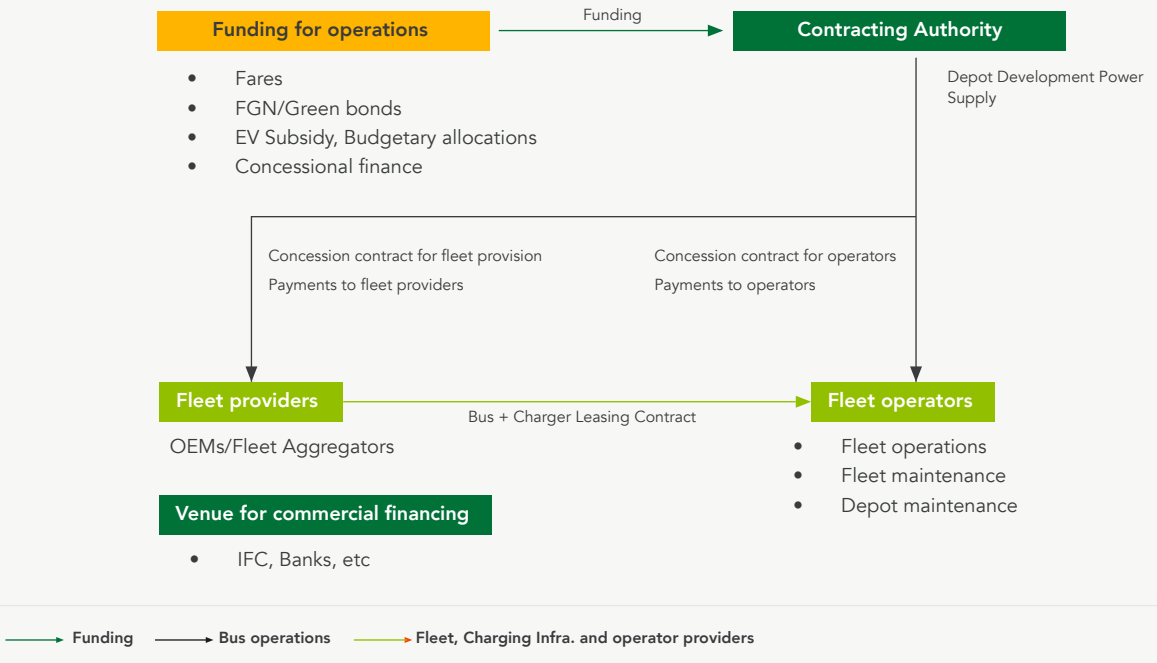
Considering the GCC model's application to financing e-buses and their essential infrastructure, it's clear that a variety of financial strategies must be employed. This necessity stems from the imperative to overcome the financial hurdles inherent in deploying large-scale, environmentally sustainable infrastructure projects.

These models not only provide innovative solutions to financing challenges but also align with broader goals of sustainability and economic diversification. From government funding and public-private partnerships (PPPs) to green financing and special purpose vehicles (SPVs), each option presents unique advantages for managing the complexities of financing e-buses and their supporting infrastructure, ensuring a balanced approach that incorporates risk management, efficiency, and environmental stewardship.

4.1.3 Unbundling Asset Ownership (AssetCo. Model)

Under the unbundling asset ownership, the asset ownership and operations are taken up by different actors. The regulator will retain a part of services such as revenue collection while the remaining aspects of service delivery such is outsourced to different actors, i.e., a fleet financier/ lessor to own the fleet and a separate operator to operate and maintain buses while the vehicle manufacturer provides support for major maintenance issues such as battery replacement and bus body refurbishment. Most of the assets are owned by a third party or the operator; and this comes with a varied lifecycle of bus ownership and operator contracts. Charging infrastructure can be a separate service or as part of a bus contract provision.

FIGURE 19: AssetCo or Unbundled Business Model



4.2 Total Cost of Ownership (TCO) Analysis

The TCO model establishes the lifecycle cost of e-bus operations combining capital and operational costs, enabling financial institutions to assess stakeholders' debt management capacity based on factors like cash flow, payment reliability, and risk distribution.

A TCO[10] based approach helps balance the higher capital and financing cost of e-buses with lower operation and maintenance costs. Technology alternatives like e-buses versus diesel buses can be evaluated using a TCO based approach. Similarly, choice of 12m versus 9m buses, AC versus non-AC buses, small range versus large range buses can be evaluated.

To check TCO analysis, input data for this mode will be required from the regulator on current staff and operating costs of diesel buses to establish with e-buses.

FIGURE 20: TCO Analysis

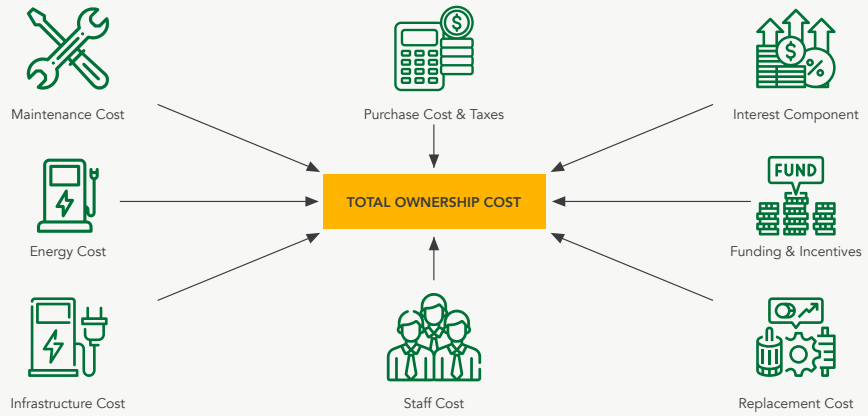
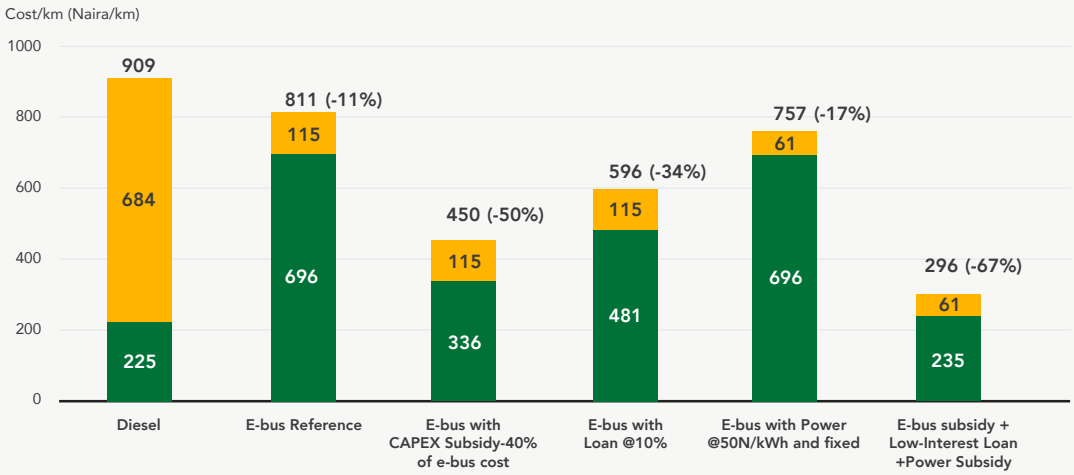


FIGURE 21: TCO Scenario for CAPEX within Lagos BRT System



Cost estimates w/o subsidy: Bus cost- NGN 45m for diesel, NGN 120m for e-bus, Charger cost: NGN 18m Battery size: 250 kWh, Cost of battery: NGN 100,000 per kWh, Loan to Value ratio: 80%, Loan tenure: 72 months, Interest on loan: 30%; Fuel/ Energy efficiency: 0.47kmpl (diesel), 1.1 kWh/km (electric); Cost of diesel: 1,000 NGN/l, Electricity (Grid): 70 NGN/kWh, Annual escalation of diesel and electricity tariff: 6% per-annum.

Source: LSBL Data (Sept. 2023), SEforALL projections

[9] "Total Cost of Ownership." TCO Analysis for Bengaluru, India, UITP, 2023.

For TCO analysis conducted on LBSL for diesel and electric 12m AC buses, comparing alternative CAPEX, financing and energy Costs, our assumption are as follows:

- Staff, admin and ticketing costs are assumed to be the same for both electric and diesel fueled buses
- Insurance cost is linked to CAPEX, but it is minor cost and hence it was excluded from the analysis
- Sensitivity analysis used considered the following key variables impacting TCO as: CAPEX subsidy, cost of finance, and power tariff subsidy.

From the analysis, we found that:

- E-buses are 11% cheaper than diesel buses without any incentives
- 40% subsidy on bus cost can deliver 50% TCO savings Vs diesel
- Reducing interest rate on loan to 10% can make e-buses TCO to be 34% lower than diesel buses
- Fixing power tariff for e-buses at N50/kWh will make TCO of e-buses 17% lower than diesel buses
- Combining the above performances can make e-bus TCO 67% lower than diesel buses

Conclusively, CAPEX subsidy on e-bus will deliver the maximum TCO savings through lower capital cost and associated financing costs. Also, lower interest rates on e-bus loans have the best TCO impact, followed by subsidy on power tariff.

Furthermore, the TCO analysis done has shown that Gross Cost Contract (GCC) is the most favourable business model for e-bus deployment by demonstrating the following points:

- **Comprehensive Cost Consideration:** TCO analysis takes into account all costs associated with e-bus deployment over its entire lifecycle, including acquisition, operation, maintenance, and disposal costs. This holistic approach ensures a thorough evaluation of the financial implications of each business model.
- **Risk Mitigation**: GCC typically transfers operational risks, such as maintenance and performance uncertainties, to the service provider or contractor. This minimizes the financial risk borne by the regulator or transit authority, as they are not directly responsible for unexpected costs related to vehicle maintenance or performance.
- **Budgetary Predictability:** Under GCC, costs are typically fixed and predictable, as the operator is responsible for meeting specified performance standards within the agreed-upon budget. This provides greater financial certainty for the public entity, facilitating more accurate long-term budget planning and allocation of resources.
- **Efficiency and Accountability:** The service provider in a GCC arrangement is incentivized to optimize operational efficiency and minimize costs to maximize profitability. This can lead to improved service quality, reduced downtime, and better overall performance of the e-bus fleet, ultimately benefiting both the operator and the transport authority or regulator.
- **Long-Term Value:** By considering the total cost of ownership over the entire lifecycle of the e-bus fleet, TCO analysis can demonstrate the potential for long-term cost savings and value generation with GCC compared to other business models. This can be particularly significant in demonstrating the economic viability and sustainability of e-bus deployment initiatives.

By conducting a TCO analysis that considers these factors, it can be shown that GCC offers compelling advantages in terms of cost-effectiveness, risk mitigation, operational efficiency, and long-term value, making it the preferred business model for e-bus deployment in many contexts.

4.3 E-bus Deployment Global Cost Analysis: Electric vs. Diesel

While the initial procurement costs for e-buses are significantly higher due to advanced battery technology and infrastructure requirements, these expenses are offset by considerably lower operational costs. E-buses benefit from reduced fuel expenses, lower maintenance costs due to fewer moving parts, and potential savings from government incentives and subsidies. As a result, over the lifespan of the vehicle, e-buses often present a more cost-effective solution despite their higher upfront investment.

The cost comparison analysis of the figure below evaluates the economic viability of e-buses versus diesel buses over a 10-year period across four diverse geographical locations: Nairobi, Santiago, Delhi, and Sao Paulo.

In Nairobi, the initial cost for an e-bus is higher than a diesel bus by $40,000, however when considering a 10-year lifespan, e-buses show a lower total cost of ownership (TCO) by $90,000, primarily due to savings in annual fuel and maintenance costs over 10 years. Notably, the difference in annual fuel expenses is substantial, with e-buses saving nearly $44,200 annually compared to diesel buses.

The scenario in Delhi without subsidies shows that e-buses have a lower initial cost compared to diesel buses. Over 10 years, e-buses result in savings of $44,750, again with fuel and maintenance costs contributing to the lower TCO.

In Sao Paulo, despite the higher purchase price for E-buses, the 10-year TCO is lower for e-buses by $98,000 compared to diesel buses, highlighting the long-term economic benefits of electric over diesel.

Across all cases, e-buses demonstrate a lower TCO driven by significant savings in fuel and maintenance costs. These findings support the strategic recommendation for cities to invest in electric bus fleets for their public transportation systems, not only for environmental benefits but also for economic efficiency in the long run. The data suggest that while the initial investment in e-buses may be higher, the operational savings justify the transition, aligning with global trends towards sustainable and cost-effective public transport solutions.

TABLE 8: Cost Comparison Between E-Buses and Diesel Buses in Existing Cases, 2022

Cost/bus ($)

Comparison	Kenya (Nairobi) Bus Deport Charge Case		Chile (Santiago) Bus Deport Charge Case		India (Delhi) Without Subsidies		Brazil (Sao Paolo) Bus Deport Charge Case	
Engine Type	E-bus	Diesel	E-bus	Diesel	E-bus	Diesel	E-bus	Diesel
Capital (Vehicle)	320,000	280,000	300,000	196,964	241,000	115,000	320,000	120,000
Fuel/Year	32,000	52,000	8,800	21,600	8,750	24,375	8,400	34,600
Maintenance	8,000	1,000	13,600	19,200	4,800	6,250	5,400	9,000
10-year Total	**720,000**	**810,000**	**524,000**	**604,964**	**376,500**	**421,250**	**458,000**	**556,000**

4.4 SWOT Analysis for E-buses Deployment

A comprehensive SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis, offers a strategic evaluation of electric bus deployment within Nigeria's urban mobility landscape. It aims to dissect the internal and external factors influencing the adoption of electric buses, providing a balanced perspective on the potential benefits and challenges. Through this analysis, we identify the critical pathways and considerations necessary for the successful integration of electric buses into Nigeria's public transportation system, aligning with environmental sustainability goals and urban development needs.

FIGURE 22: SWOT Analysis

STRENGTHS

1. Low operational cost when compared to ICE buses
2. No emissions as this helps to meet Net Zero emissions targets set by the Country
3. Improves air quality and environmental conditions
4. Improves passenger experience as the buses are quieter and run with lesser moving parts

WEAKNESSES

1. High cost of capital for buses and charging infrastructure
2. Little or no technical competence on maintenance of electric buses
3. Dependence on imported components due to the absence of local manufacturing or assembly plants, compounded by the unavailability of in-country spares

S W O T

OPPORTUNITIES

1. Increased revenue as a result of reduced operational cost
2. Attract electric vehicle manufacturers/assemblers into the country
3. Local manufacturing of electric vehicle spares in the country to serve the rest of Africa
4. Improve technical competence of local engineers/technicians
5. Job opportunities for drivers and maintenance engineers
6. Gender inclusion as repairs are not extreme

THREATS

1. Unstable power supply
2. Absence of policies to encourage e-mobility in Nigeria
3. Inconsistent foreign exchange regulations
4. Inadequate charging infrastructure
5. Technology Obsolescence
6. Public Acceptance and Adaptation
7. Policy and Regulatory Hurdles

In conducting a SWOT analysis, it is essential to identify strengths within weaknesses and recognize opportunities within threats. The following outlines strategies for national and state governments to leverage weaknesses into strengths and transform threats into opportunities.

1. Weakness: High Initial Cost of E-Buses

Strategic Response: Explore financing options such as green bonds or international grants. Collaborate with manufacturers for bulk purchase discounts or flexible payment terms.

2. Weakness: Lack of Local Technical Expertise

Strategic Response: Establish training programs in partnership with e-bus manufacturers. Implement knowledge transfer initiatives through international collaborations.

3. Weakness: Import-Dependent Components due to Absence of Local Manufacturers

Strategic Response: The procurement documentation should encompass the requirement for E-bus suppliers to establish a small-scale assembly facility and maintenance workshop. A PLI scheme and a phased manufacturing programme may offer financial incentives to manufacturers based on their production output, encouraging local manufacturing of EVs and components.

4. Threat: Unstable Power Supply

Strategic Response: Establish private agreements with independent power producers, state and national utilities, and integrate renewable energy technologies to the energy mix.

5. Threat: Inadequate Charging Infrastructure

Strategic Response: Develop a phased infrastructure roll-out plan, prioritizing high-density routes. Explore public-private partnerships for infrastructure development.

6. Threat: Technology Obsolescence

Strategic Response: Include clauses in procurement contracts for technology updates. Establish a policy for regular technology review and upgrade.

7. Threat: Public Acceptance and Adaptation

Strategic Response: Launch comprehensive public awareness campaigns. Introduce pilot programmes in select areas to demonstrate benefits and gather feedback.

8. Threat: Policy and Regulatory Hurdles

Strategic Response: Work closely with government bodies to streamline policy formation. Advocate for e-mobility supportive policies and regulations

Based on careful evaluation of the SWOT, TCO and business model analysis it is recommended that Nigeria adopts GCC model of procurement for e-buses in its initial years. This would allow the authorities to sign a single contract with a firm/consortium in charge of delivering the entire system. As technology becomes mature and the authorities build in-house capacity to manage contracts efficiently, more evolved models like unbundled asset ownership and operations may be taken up.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CHAPTER FIVE

Policy Regulatory Framework

5.1 Policy Direction

To address the weaknesses and threats identified, a significant step will be to design new policies to further enhance the success of e-mobility in Nigeria. Some of the policies and laws to be revised or introduced will be discussed in this chapter

TABLE 9: Policy Recommendations to Enhance E-Mobility in Nigeria

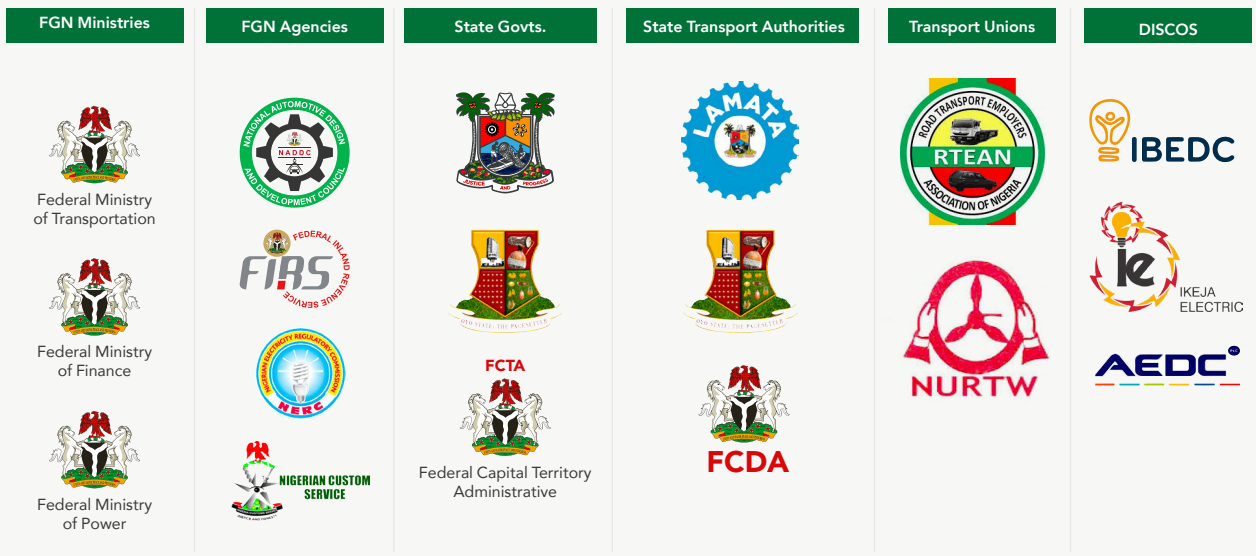
SN	POLICY	POLICY/LAW DETAILS	RECOMMENDATIONS
1	Nigerian Automotive Industry Development Plan (NAIDP)	10-year plan of 2013 which is now undergoing review is aimed at curtailing Nigeria's dependence on vehicle importation by encouraging local production or assembly including e-vehicles	Review policy to mandate vehicle manufacturing companies including e-bus manufacturers to establish assembly and manufacturing plants in Nigeria
2	National Renewable and Energy Efficiency Policy (NREEEP)	Policy serves as the blueprint for sustained development, supply, and utilisation of renewable energy resources within the country	Waivers for all renewable materials and components such as panels, batteries, inverters, e-vehicle chargers etc. to attract investments, build scale and reduce the cost of renewable power supply
3	Finance Bill	A proposed review of the existing bill to include VAT and Import Duty Exemption for vehicle manufacturers and assemblers within Nigeria	Review law to exempt local vehicle manufacturers and assemblers from paying import VAT and Duties for parts and machines. Implement production linked incentives (PLI) proven in concept in similar transport initiatives
4	Free Trade Zone (National and State)	Review of National and State land allocation policies for purpose of industrialization within the Country	Encourage Government to allocate land to e-vehicle assemblers and manufacturers within the Free Trade Zone (FTZ), enjoy tax holidays within the FTZ, employ locals within FTZ host communities as technicians and staff members

5.2 Regulatory Framework

Engagement with key government and industry stakeholders at both national and state levels is imperative to foster the development of specific regulatory frameworks. These frameworks are essential to support the deployment of electric buses, providing a foundation for the establishment of policies, incentives, and standards that align with the operational, environmental, and economic goals of the e-bus initiative.

By collaboratively crafting tailored regulations, we can address the unique challenges and opportunities of introducing e-buses, ensuring a coordinated, effective transition to sustainable public transportation systems. The diagram below depicts some key government and industry stakeholders to engage at national and state levels.

FIGURE 23: Government/Industry Stakeholders



Some specific regulatory frameworks that have the potential to facilitate the adoption of e-buses at both the national and state levels include:

Incentive Policies for E-Bus Adoption: Propose tax incentives or subsidies for e-bus procurement and operation. This could include reduced import duties for electric buses and their components, tax breaks for operators using e-buses, or direct subsidies to lower the initial purchase cost. Production Linked Incentives (PLI) schemes can also be introduced for automobile manufacturers (OEMs) as well as for Advanced Chemistry Cells (ACC) manufacturers to encourage domestic manufacturing as well as research and development. Efforts should be made to aggregate demand by standardizing requirements such as bus specifications, passenger payloads and minimum distance for operational routes in order to benefit from economies of scale. Furthermore, development of the local supply chain through mechanisms such as a phased manufacturing programme, PLI and human capital development will support the sector and create the enabling environment for mass adoption.

Environmental Standards: Implement strict environmental regulations that favour e-buses over traditional diesel buses. This could include low-emission zones where only electric buses are allowed or emission standards that traditional buses cannot meet.

Public Procurement Policies: Modify public procurement policies to prioritize e-buses for city transportation contracts. This could involve setting a quota for electric buses in public transport fleets or providing preferential treatment in bidding processes

for operators using e-buses. Developing government tenders and procurement policies to prioritize locally manufactured e-buses, providing a stable market for domestic manufacturers and having contracts often include long-term purchase agreements to ensure sustained demand.

Public-Private Partnership (PPP) Framework: Create a legal framework to facilitate PPPs in the development of e-bus infrastructure, ensuring clarity in roles, responsibilities, and benefits for both the public and private entities. Policies supporting the establishment of charging stations and battery swapping stations, are crucial for the operation of e-buses.

CHAPTER SIX

Checklist of Considerations to Actualize Deployment

6.1 Implementation Checklist for Decision Makers

Based on the detailed planning exercise explained in the previous chapters and consultations with other regions with e-bus deployment experience like India, the following checklists are prepared to guide decision makers regarding the activities needed for the successful implementation of e-buses across Nigeria.

6.1.1 Operational and Technical Considerations

TABLE 10: Operational and Technical Considerations

CATEGORY	REQUIREMENTS
Specifications	• Technical details of the buses and chargers procured – to determine daily range, battery capacity and charging time • Local assembly capacity • Warranty agreements • Strategies to address technology changes
Business Model	• Assess the total cost of ownership for e-buses including procurement, maintenance and charging infrastructure • Assess financing options (grants for deployment & scale up) • Procurement documentation as required – RFPs, MCA, ToR • Determine insurance, operation and maintenance costs • Consider the entire life cycle of the buses, from manufacturing to disposal, to ensure a positive environmental impact.
Operations	• Bus route and depot identification • Dedicated bus lane or traffic segregation for e-buses • Route planning and management across the pilot cities
Payment	• **Digital Payment Mechanism** – to guarantee effective e-ticketing and fare collection across all deployment cities, revenue/collection accounts management must be digital.

6.1.2 Charging Infrastructure Considerations

TABLE 11: Charging Infrastructure Considerations

CATEGORY	REQUIREMENTS
Depots	• Bus depot selection and space assessment along BRT route • Civil works (plinths and canopy construction, electrical wiring, lighting install chargers)
Power	• Charger power requirement • Disco assessment on power reliability • Energy mix potential (Disco + IPP + Solar PV with battery storage) • Charging hours and demand (Night charging preferred)
Scalability	• Design the deployment strategy with scalability in mind, allowing for the expansion of the electric bus fleet in the future. • Consider emerging technologies and advancements to future-proof the electric bus deployment

6.1.3 State Transport Authority (STA) & Other Stakeholders Engagement

Before embarking on the deployment of e-buses, it is crucial to consider various factors pertaining to regulators and transport authorities, as they play a pivotal role in shaping the regulatory framework and overseeing the implementation process.

TABLE 12: STA & Other Stakeholders Engagement

CATEGORY	REQUIREMENTS
Engagement	• Identify cities and their State Transport Authorities (STA) to identify stakeholders, bus operators, route fares, collections account management etc. • Operators and Stakeholders – to engage relevant authorities for seamless rollout e.g. Power Company, Transport Unions, Fare Collection Company etc.
Training & Capacity Building	• Hiring of drivers, support staff, fare collection company, electrical technicians etc. • Develop training programmes for bus drivers and maintenance staff to ensure they are well equipped to operate and maintain electric buses. • Collaborate with educational institutions to build local expertise in electric vehicle technology • Monitoring and evaluation period • OEM participation in local assembly

6.1.4 Policy Considerations

Before embarking on the deployment of e-buses, it is imperative to consider a range of policy factors that can significantly influence the success and sustainability of such initiatives.

TABLE 13: Policy Considerations

CATEGORY	REQUIREMENTS
Regulatory Incentives	• Policy and Regulatory Framework for Electric Buses • Identify State Transport policy & harmonization of specifications • Fiscal incentives and waivers for public transport purpose electric vehicle • Incentives for EV manufacturers to localize production • Explore new electricity tariff for charging stations
Advocacy	Advocate for supportive policies and incentives from local and national governments to encourage the adoption of e-buses
Public Awareness	• Conduct public awareness campaigns to educate residents about the benefits of electric buses and address any concerns. • Solicit feedback from the community to incorporate their preferences and needs into the deployment strategy
Environmental Impact	Assess and communicate the environmental benefits of electric buses, including reduced emissions and improved air quality

CHAPTER SEVEN

Case Study: The Lagos BRT System

7.1 The Lagos Bus Rapid Transit System

The Lagos intra-city transit system and commuting routes is large dominated by a mix of state-owned buses, and the National Union of Road Transport Workers (NURTW) controlled yellow-buses – Danfos- as popularly called. These buses (state-owned or NURTW regulated) are today fuelled by petrol or diesel purchased at different deregulated prices at fuel stations across the state and other parts of the country at large.

The Lagos BRT System has been operational since 2008 and currently have about 750 buses – mostly internal combustion engine (ICE) buses. The bus system is operated by the Lagos Metropolitan Area Transport Authority (LAMATA) since its creation in 2007. LAMATA is an agency responsible for planning, implementing, regulating, and franchising public transport infrastructure and operations in Lagos State. LAMATA births an intermodal integrated transport system for Lagos and have developed a Strategic Transport Master Plan for Lagos that will run till 2032.[6]

Integrating electric buses into Nigeria's transport system requires effective planning for a fit-for-use deployment strategy; and amongst the key considerations is an effective bus service systems that ticks the following deployment strategies namely: infrastructure readiness, dedicated bus route and depots; and a digital fare, ticketing, and payment platform.

Lagos is the most-ready state in Nigeria for e-bus deployment considering the following:

- Availability of dedicated BRT corridors offering good operating conditions and route planning
- Presence of a separate agency – LAMATA specifically for the purpose of operation of the BRT, and experience in bus contracting models
- Presence of Government-backed private operators like Primero and Lagos Bus Service Limited (LBSL) with experience in daily operations and staffing
- Availability of good quality data on operational and financial performance on bus services
- A digital payment solution for ticketing, fare allocation and daily revenue sharing allocations to operators

The case study presented in this report holds significant importance in the context of preparing for initial investment and subsequent mass adoption of e-buses nationally. By analysing the real-world implementation of e-bus systems, particularly in a dynamic urban setting like Lagos, valuable insights and lessons can be gleaned to inform strategic decision-making at both local and national levels. Understanding the challenges, successes, and best practices identified through the case study provides stakeholders with actionable intelligence to effectively plan and execute e-bus deployment initiatives, laying a solid foundation for scaling up such efforts across the country. As Nigeria endeavours to transition towards a sustainable and electrified transportation system, the findings from this case study serve as a critical resource for policymakers, investors, and industry stakeholders seeking to navigate the complexities of e-bus adoption and drive meaningful impact on a national scale

FIGURE 24: LAMATA Framework in Lagos State Transportation

1992 — **Transport Sector in Lagos**

- Recognizing the need to improve the transport sector, the State conducted a number of studies.
- Commenced the Lagos Mass Transit and Transport Systems (LMTS) Management Program study.
- Study recommended the creation of LAMATA to coordinate transport policies, and programs.

1996 — **LAMATA Framework**

- Detailed framework for establishment of LAMATA was proposed following recommendations from LMTS.
- LAMATA was envisioned to provide strategic planning platform to address long-neglected transport needs of the metropolis and coordinate activities of different executing agencies to provide a common and consistent basis for implementation.

2002 — **LAMATA, a semi-autonomous body**

- LAMATA was established as a semi-autonomous corporate body
- LAMATA created by a State Act (LAMATA Law) on January 13, 2022 and signed into law by the then Governor of the State, Sen. Bola Ahmed Tinubu.
- Law grants LAMATA several powers to facilitate the discharge of its statutory functions, including the power to levy and collect user charges in connection with the provisions of its services and to collect any other tariffs, fees and road taxes as may be authorised by the Governor.

FIGURE 25: Existing and Proposed Bus Routes in Lagos

Today, LAMATA has five (5) operators within the Lagos BRT system under a franchise or management contract model, and a payment solution provider – Cowry Card.

There are two (2) notably operational BRT corridors in Lagos with the third nearing completion:

i. Ikorodu – TBS (37kM)
ii. Oshodi – Abule Egba (18kM)
iii. Lagos – Badagry Expressway Corridor (25kM) - still under construction

There are other intra-city corridors within Lagos where the BRT shuttles, but the above mentioned are the major dedicated routes.

LAMATA has the following bus composition within its fleet for the major dedicated BRT routes:

- High-Capacity Buses: 70 Passengers (40 Seated + 30 Standing)
- Medium-Capacity Buses: 38 Passengers (27 Seated + 11 Standing)

As mentioned under the functions of LAMATA, the agency regulates the operations of the Lagos BRT system under Public Private Partnership arrangement with five (5) major operators as shown in the table below.[8]

TABLE 14: Lagos BRT Regulator and Operators

Role	Organization	Description	Fleet Ownership	Fleet Management
Regulator	LAMATA	The Lagos Metropolitan Area Transport Authority (LAMATA) is a government agency created to coordinate transport planning, policies, and public transport infrastructure implementation in the state.	✓	✗
Private Sector	PRIMERO Transport Services Limited	Primero Transport services was the first operator in the network. It currently has an operational fleet of -200 high-capacity buses and owns 50% of the fleet	✓	✓
	LBSL LAGOS BUS SERVICES LIMITED	Lagos Bus Services Limited is a government-owned private limited company with 312 high-capacity buses, 252 of which it owns	✓	✓
	TJ Motors	TeeJay Motors, a local automobile company, was licensed to operate 60 medium-capacity, buses on behalf of LAMATA in 2021	✗	✓
	TSL	Transport Services Limited (TSL) was licensed to operate a mixed fleet of 100 buses on behalf of LAMATA in 2021	✗	✓
	ALMAGAMATED	Amalgamated was licensed to operate a fleet of 70 high-capacity buses on behalf of LAMATA in 2021	✗	✓

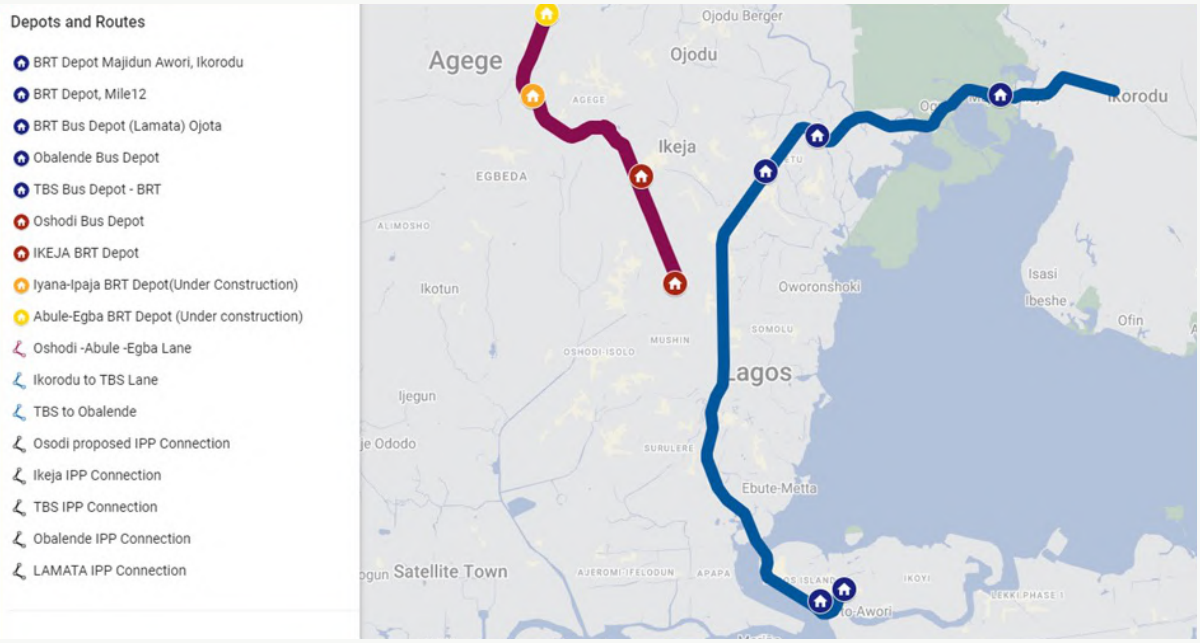
7.2 Proposed E-bus Deployment Plan along the Lagos BRT Corridors

Below are identified bus depots along the two BRT corridors of LAMATA and are being considered for use as charging stations:

TABLE 15: Lagos BRT Regulator and Operators

Ikorodu – TBS (37km)	Oshodi – Abule Egba (18km)
Majidun	Oshodi Bus Terminal
Mile 12	Ikeja Bus Terminal
LAMATA Yard (Ojota)	Abule Egba – under construction
Obalende	Iyana Ipaja – under construction
TBS	NA

FIGURE 26: LAMATA's Dedicated BRT Route under Consideration for E-bus Deployment



*Ikorodu - TBS: 37km Oshodi - Abule Egba: 18km

7.3 Proposed Connection Schematic at Bus Depots

Below are the proposed connection schematics for bus depots with one or two chargers.

FIGURE 27A: Proposed Connection Schematic for Bus Charging 1

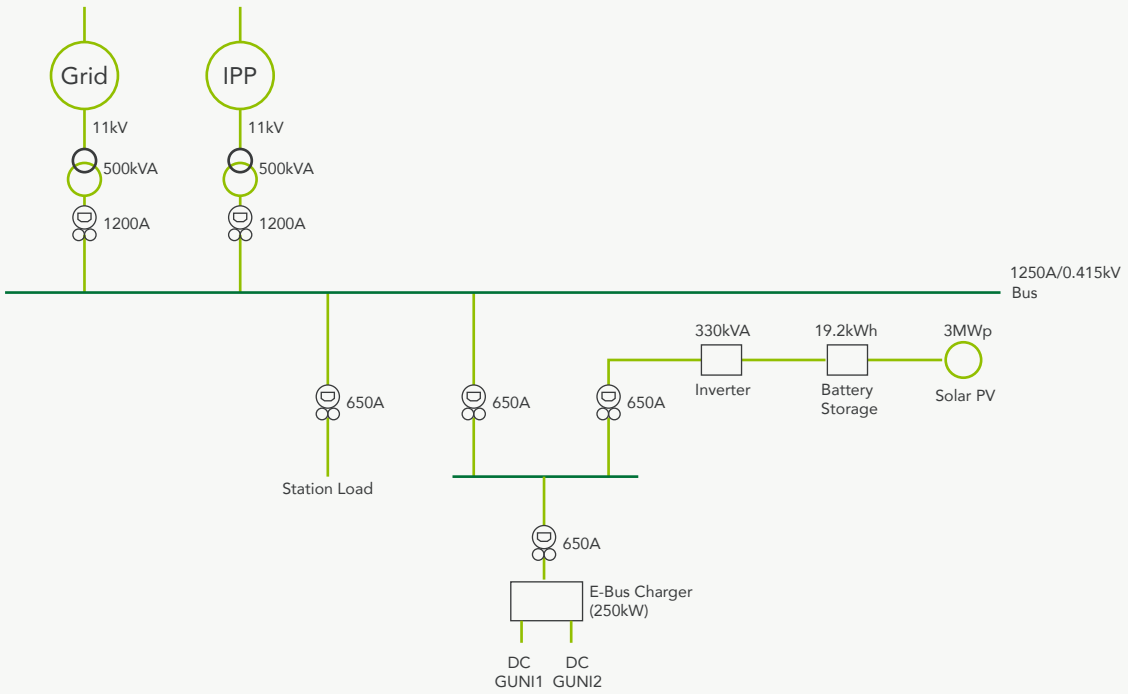
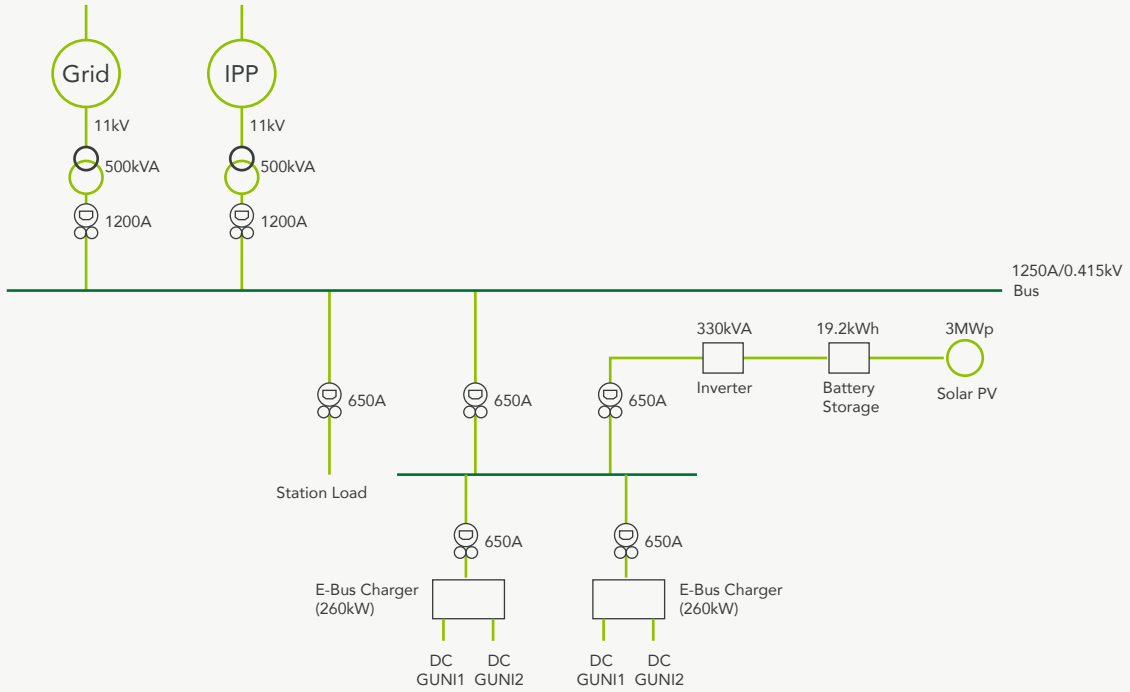


FIGURE 27B: Proposed Connection Schematic for Bus Charging 2 (Dual Charger)



For LAMATA bus depots, the table below shows our proposed charger deployment and distance to proposed IPP location:

TABLE 16: Lagos Bus Depots and their Current Land Space

Route/Bus Depots	Proposed Number of Buses	Proposed Number of Chargers	IPP Connection Status	Distance to IPP Substation
Ikorodu – TBS (37kM) = 700 Buses, 12meter AC buses, 70 passengers per bus				
Majidun	134	18	Not Available	10kM
Mile 12	50	7	Not Available	4kM
LAMATA Yard (Ojota)	500	63	Not Available	1kM
TBS	8	2	Not Available	200m
Obalende	8	2	Not Available	300m
Osodi – Abule Egba (18kM) = 300 buses, 12meter AC buses, 70 passengers per bus				
Osodi Bus Terminal	200	25	Not Available	300m
Ikeja Bus Terminal	100	13	Not Available	750m
Iyana – Ipaja	Under Construction			
Abule – Egba	Under Construction			

The table below are highlights of some Lagos bus depots and their current land space relative to parking space and potential power mix considerations:

TABLE 17: Lagos Bus Depots and their Current Land Space

Bus Depot	Depot Size	Available Parking Space (m^3)	Potential Number of Buses per Available Parking Space**
Majidun	40,100	28,300	786
Mile 12	11,500	5,240	145
Ojota (LAMATA Yard)	22,470	20,420	567
Oshodi Terminals	29,500	9,090	252
LBLS Yard Oshodi	31,413	18,100	502
Ikeja Terminal	6,980	5,880	163
Iyana Ipaja		Under construction	
Abule Egba		Under construction	

**One 12m AC e-bus = $36m^2$

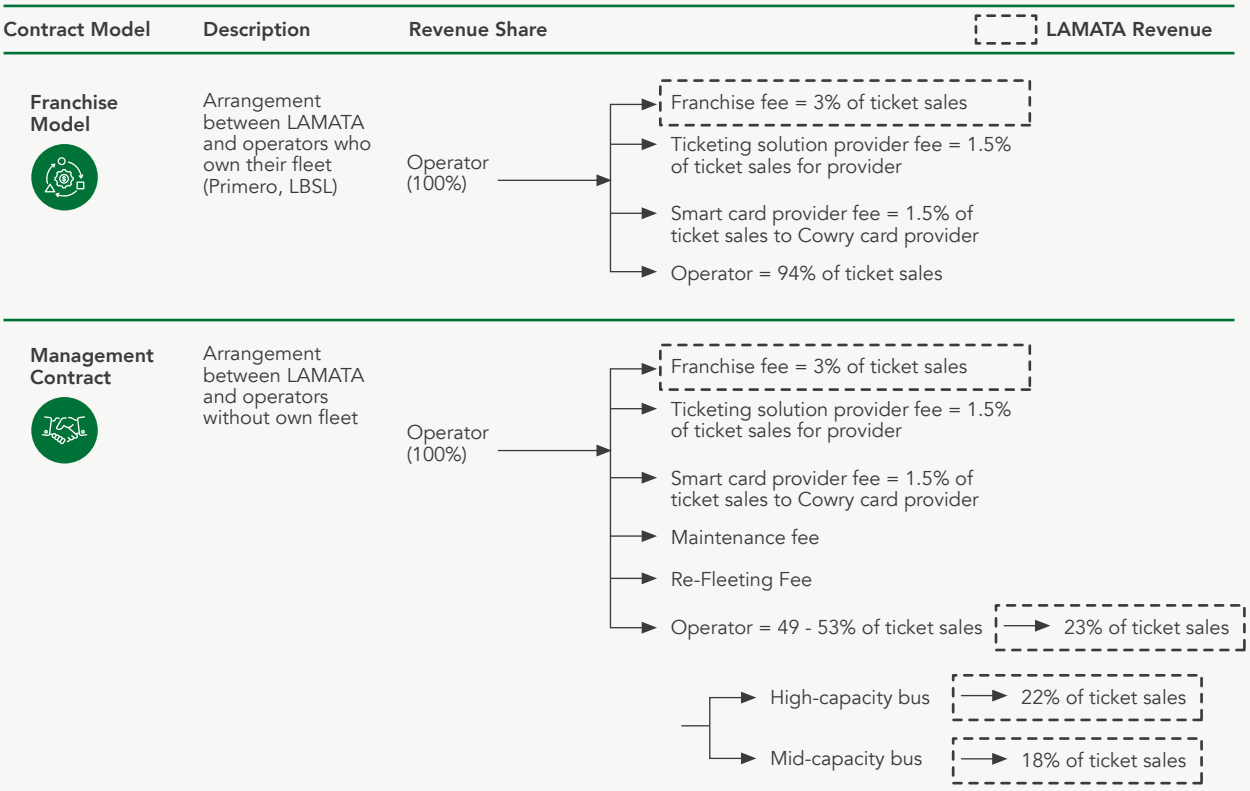
TABLE 18: Power Availability of Bus Depots (for Pilot Deployment)

Location (Depots)	Feeder Option	Substation/ Feeder Capacity (MW)	Available Capacity (MW)	Stranded Capacity (MW)	Peak Load (MW)	Available Hours
Ikorodu	Existing 33kV Feeder Extension	24	15	15	9	22:31
	Newly Constructed 33kV Feeder from TCN Substation	224	150	17	13	
Mile 12	Existing 33kV Feeder Extension	24	11	11	13	22:31
	Newly Constructed 33kV Feeder from TCN Substation	96	85	27	13	
Ojota (LAMATA Yard)	Existing 33kV Feeder Extension	24	24	20	4	22:45
	Newly Constructed 33kV Feeder from TCN Substation	96	85	38	4	
Oshodi Terminals	Existing 33kV Feeder Extension	24	11.1	11.1	12.9	21:44
	Newly Constructed 33kV Feeder from TCN Substation	128	45	115.1	12.9	
LSBL yard Oshodi	Existing 33kV Feeder Extension	24	11.1	11.1	12.9	21:44
	Newly Constructed 33kV Feeder from TCN Substation	128	45	115.1	12.9	
Ikeja Terminal	Existing 33kV Feeder Extension	24	5	5	19	22:24
	Newly Constructed 33kV Feeder from TCN Substation	212	172	70	19	

7.4 Fare Collections and Distribution

LAMATA currently engages with private operators on two contract models – a franchise model and a management contract model. the representation below shows how revenues are shared between LAMATA and these operators (the percentages in the figure below are subject to changes based on adjusted sharing formula from LAMATA):[11]

FIGURE 28: How Revenues are Shared between LAMATA and these Operators

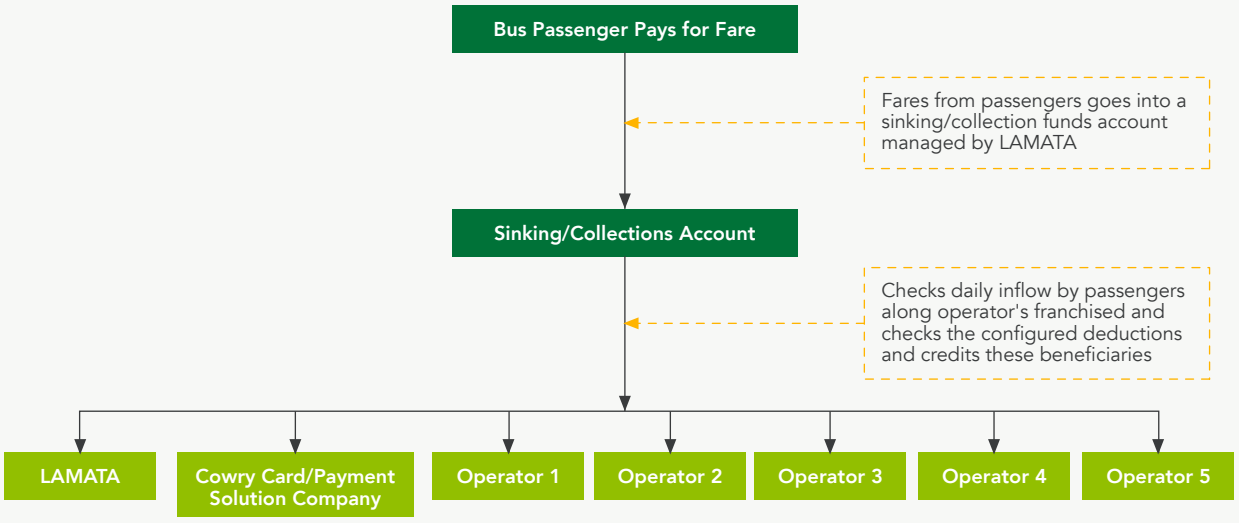


Upon a Tap-in and Tap-out operation by a passenger, the equivalent fare amount for the distance traveled by the passenger is deducted and the amount goes into sinking/collections account created and managed by LAMATA.

There is a configuration done by Touch and Pay Technologies where corresponding percentage deductions of all funds collected daily by each operator are being deducted from the sinking/collections accounts and credited to all beneficiaries as illustrated in the diagram above. This configuration checks the amount of inflow from the operator daily, and credits all the configured beneficiaries (to their respective bank accounts) between 11pm – 11:59pm after the day's operation ends.

The configuration as explained may change upon receiving instructions of a change from LAMATA to Touch and Pay Technologies. This may be consequent to a new charge introduced and agreed by LAMATA and operators, or a loan facility obtained by an operator through LAMATA.

FIGURE 29: Proposed Payment Model (Preliminary Payment Security Mechanism)



7.5 Recommendations

The Lagos BRT System, operational since 2008 under the management of the Lagos Metropolitan Area Transport Authority (LAMATA), provides a comprehensive case study for the successful deployment of e-buses in Nigeria. The buses, powered by internal combustion engine, present a unique opportunity for transformation towards sustainable urban mobility.

LAMATA's strategic planning, regulatory functions, and establishment of a Transport Fund highlight the critical role of institutional frameworks in supporting transit system improvements. The agency's experience in bus contracting models, operation of dedicated BRT corridors, and implementation of a digital fare collection system sets a solid foundation for integrating e-buses into the existing transport infrastructure.

Key takeaways from the Lagos BRT System include:

- **Dedicated Infrastructure:** The presence of dedicated BRT corridors and bus depots provides an optimised environment for e-bus operations, offering a blueprint for infrastructure readiness essential for e-bus deployment.
- **Digital Payment Solutions:** The digital fare collection system enhances operational efficiency and revenue management, a critical aspect for the financial sustainability of e-bus operations.
- **Strategic Planning:** LAMATA's development of a Strategic Transport Master Plan underscores the importance of long-term planning in addressing transport needs and coordinating efforts across different modes of transport.

To harness these insights for nationwide e-bus deployment, a phased approach beginning with a pilot scheme is recommended. The success of the Lagos model can guide the expansion of e-bus systems across Nigeria, leveraging:

- **Policy Support:** Develop comprehensive policies that encourage e-bus adoption, including incentives for procurement, integration of renewable energy for charging infrastructure, and emission reduction targets.
- **Stakeholder Engagement:** Engage with all stakeholders, including transport unions and power regulators, to ensure a collaborative transition to e-buses.
- **Infrastructure and Payment Security:** Prioritize the development of necessary charging infrastructure and secure payment mechanisms to ensure the operational and financial viability of e-bus systems.

In conclusion, the Lagos BRT System offers valuable lessons for the scalable implementation of e-buses in Nigeria. By adopting best practices from Lagos and tailoring strategies to local contexts, Nigeria can advance towards its goal of sustainable and efficient public transportation, contributing to national ambitions of carbon neutrality and enhanced urban mobility.

CHAPTER EIGHT

Conclusion

8.1 Implementation Guide for E-bus deployment

As we delineate the roadmap for transitioning towards e-buses within Nigeria's urban mobility framework, a strategic, methodical approach is paramount. In light of this, Table 19, the 'Implementation Guide,' offers a detailed, step-by-step blueprint, marking a critical juncture in our report. This guide meticulously outlines the phases over a 24-month timeline, from project inception through to full-scale deployment, encapsulating the essential tasks, milestones, and stakeholder engagements required. By presenting this implementation guide, we aim to provide not only a structured methodology but also a tangible action plan that aligns with the strategic objectives and sustainability goals previously discussed. This phased approach ensures that each stage of the e-bus deployment is carefully planned and executed, reflecting the report's commitment to operational excellence, environmental stewardship, and the achievement of Nigeria's ambitious public transportation and carbon neutrality targets.

TABLE 19: Implementation Guide

Months 1-2: Project Initiation	Form Project Steering Committee, finalize project scope and objectives, and secure initial funding.
Months 3-6: Stakeholder Engagement and Policy Development	Government Liaison Team to engage stakeholders, draft supportive policies, and initiate regulatory processes.
Months 7-10: Infrastructure Planning	Infrastructure Development Team to finalize charging station locations, commence construction and setup.
Months 11-14: Procurement of E-Buses	Procurement Team to issue tenders, evaluate bids, and finalize contracts.
Months 15-18: Training and Capacity Building	Training Department to train drivers and maintenance staff, establish operational protocols.
Months 19-20: Pilot Programme Launch	Operations Team to implement the pilot programme, collect data, and gather feedback.
Months 21-24: Evaluation and Planning for Scale-Up	Evaluation Committee to assess the pilot, make necessary adjustments, and plan for the full-scale roll-out.

8.2 Conclusion

As Nigeria strides towards sustainable transportation, the deployment of electric buses (e-buses) emerges as a pivotal initiative. This report provides a strategic framework, incorporating international best practices and aligning with Nigeria's sustainable development goals, to facilitate the seamless introduction of e-buses. To ensure the success and scalability of electric bus deployment, it is critical to establish robust systems for monitoring and analyzing usage patterns. This involves the collection of comprehensive data on electric bus operations, including charging frequency, duration, energy consumption, and the subsequent impact on the local grid. Such data will not only aid in optimizing the charging infrastructure to prevent overloads and enhance efficiency but also provide valuable insights that can inform future policy decisions and infrastructure investments. Leveraging advanced analytics and IoT technology, transport authorities can track real-time information to adjust operations dynamically, improving the overall management of the fleet.

Furthermore, developing and implementing clear performance metrics is essential for assessing the effectiveness of the electric bus initiative. These metrics should cover a range of factors, from the energy efficiency of the buses and the reliability of charging equipment to user satisfaction and environmental impact. By setting these benchmarks, stakeholders can evaluate the practical benefits of electric bus deployment against anticipated outcomes, thereby identifying areas for improvement. Regular assessment using these metrics will also support transparent reporting to government bodies and the public, fostering greater accountability and facilitating continuous improvement in the deployment strategy.

Through a detailed examination of Nigeria's current transportation sector, we established the context and rationale for transitioning to e-buses. This transition is not merely environmentally imperative but also a strategic move to modernise the urban transport system, improving air quality, and reducing the dependency on fossil fuels. The market assessment section delved into the critical elements necessary for the successful integration of e-buses, emphasizing meticulous planning, robust infrastructure, and the development of supportive policy and regulatory frameworks.

The exploration of various business models for e-bus procurement illuminated the path towards sustainable operations. It pointed to the Gross Cost Contract (GCC) model as particularly suitable for Nigeria, balancing initial investments with long-term operational savings. This model, backed by a thorough Total Cost of Ownership (TCO) analysis, emerged as a pragmatic approach to procurement, showcasing the economic viability of e-buses over their operational lifecycle.

Policy recommendations further underscored the necessity for legislative and regulatory support to create a conducive environment for e-bus deployment. The report advocates for policies that incentivize e-bus adoption, facilitate the development of charging infrastructure, and encourage local manufacturing and assembly of e-buses and their components.

The Lagos BRT system case study provided a practical perspective, demonstrating the feasibility and benefits of integrating e-buses within existing transit systems. This example not only highlighted the operational and environmental advantages but also offered valuable lessons for scaling up e-bus deployment across the nation.

Drawing on the insights and analyses from each section, the conclusion reaffirms the strategic importance of adopting e-buses in Nigeria. It encapsulates the envisioned pathway towards a greener, more efficient public transportation system, characterized by reduced emissions, enhanced urban mobility, and alignment with broader sustainability goals. The report culminates in a pragmatic step-by-step implementation guide, laying out a clear roadmap for stakeholders to transition from planning to action. This comprehensive approach ensures that the deployment of e-buses in Nigeria is not just a visionary goal but a feasible, strategically planned initiative poised for success.

Annexure

Reference Documents

- TCO Analysis for a BRT Operator – LBSL in Lagos
- Factory Acceptance Test (FAT) Protocol for Electric Buses

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SUSTAINABLE ENERGY FOR ALL

ABOUT SEforALL

Sustainable Energy for All (SEforALL) is an independent international organization that works in partnership with the United Nations and leaders in government, the private sector, financial institutions, civil society and philanthropies to drive faster action on Sustainable Development Goal 7 (SDG7) – access to affordable, reliable, sustainable and modern energy for all by 2030 – in line with the Paris Agreement on climate change.

SEforALL works to ensure a clean energy transition that leaves no one behind and brings new opportunities for everyone to fulfil their potential. Learn more about our work at **SEforALL.org.**