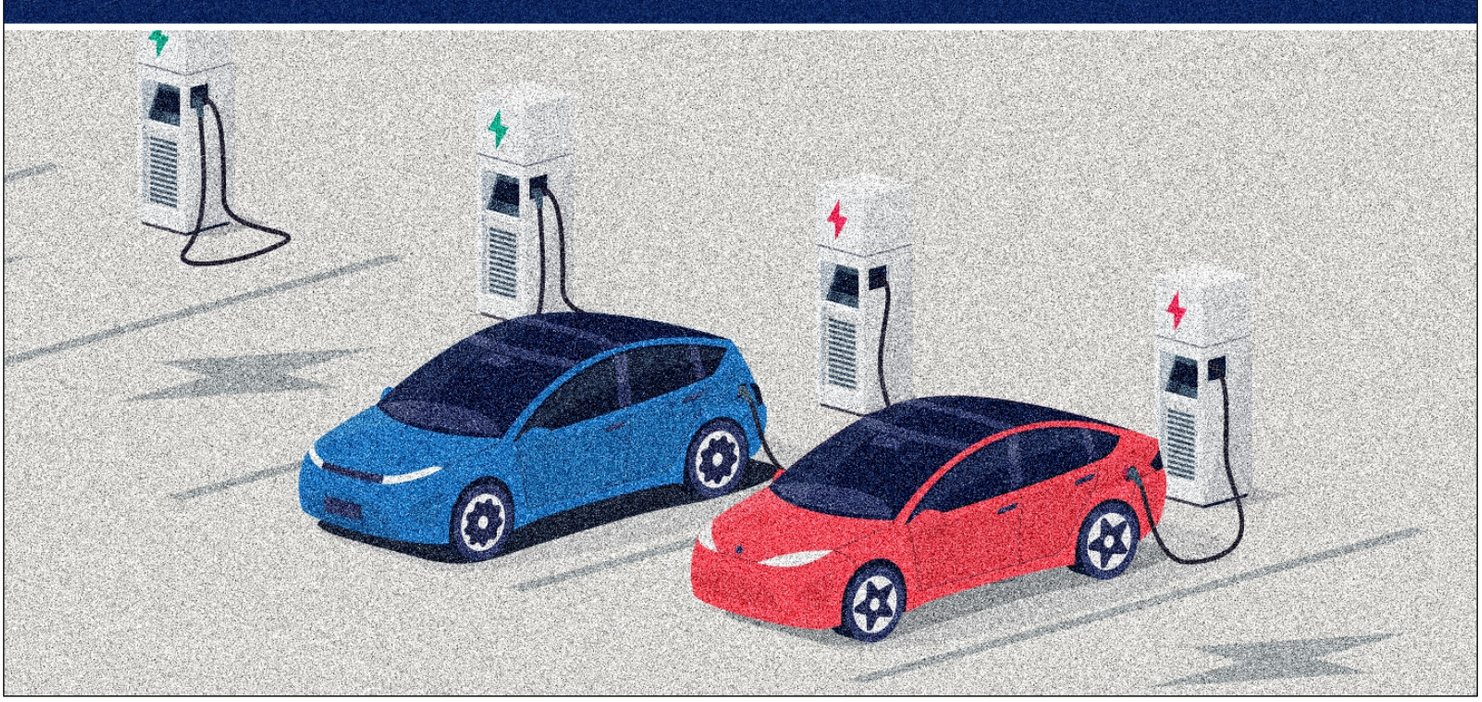
MARKET INTELLIGENCE REPORT:

State of E-mobility in Nigeria

2022

Clean Technology Hub
energy innovation centre



ACKNOWLEDGEMENT

This report was prepared by Byencit Duncan. Clean Technology Hub acknowledges all staff that contributed to this report, particularly Ifeoma Malo, Chioma Ewurum, Abel Gaiya, and other staff for their dedication to this research project.

Clean Technology Hub further expresses its gratitude to Talatu Tarfa, Tolulope Olukokun of Thinkbikes Limited, Glory Oguegbu of Renewable Energy Technology Training Institute (RETTI), Daniel Komolafe of First Electric, Anthony Osibajo of Osquaketeck, Chinedu Uchendu of Jet Motors, Bolade Soremekun of Rubitec Solar, National Automotive Design and Development Council (NADDC), Dr. M.B Shitta of the National Centre for Energy Efficiency and Conservation (NCEEC) as well as other stakeholders for providing useful data in the development of this report.

CONTENTS

LIST OF ACRONYMS

Acronyms	Meanings
ABU	Ahmadu Bello University
BRT	Bus Rapid Transport
CCN	Carbon Credit Network
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
Co_2e	Carbon Dioxide Equivalent
CTCN	Climate Technology Centre and Network
CTH	Clean Technology Hub
E-Mobility	Electric Mobility
EURO III	European 3 Emission Standard
EURO IV	European 4 Emission Standard
EVPP	Electric Vehicle Pilot Project
EV	Electric Vehicles

LIST OF ACRONYMS

FRSC	Federal Road Safety Corps
GDP	Gross Domestic Product
GHG	GreenHouse Gas
GIGL	Good is Good Logistics
ICE	Internal Combustion Engine
KVA	kilovolt Ampere
kW/hr	Kilowatt per Hour
NADDC	National Automobile Development and Design Council
NCEEC	National Centre for Energy Efficiency and Conservation
NCERD	National Centre for Energy Research and Development
NCIC	Nigeria Climate Innovation Centre
NDC	Nationally Determined Contribution
NITT	Nigerian Institute of Transport Technology
R&D	Research and Development
RETTI	Renewable Energy Technology Training Institute
RUWES	Rural Women Energy Security

LIST OF ACRONYMS

SERC	Sokoto Energy Research Centre
t	Tonne
SHS	Solar Home System
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Program
Uni Ben	University of Benin
Uni Lag	University of Lagos
UNN	University of Nigeria Nsukka
US	United States
USD	United State Dollar
ZEV	Zero Emission Vehicle

LIST OF FIGURES

LIST OF TABLES

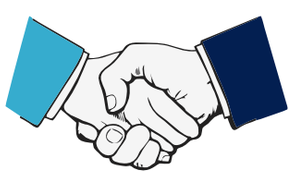
EXECUTIVE SUMMARY

Between 1990 and 2017, Nigeria's greenhouse gas (GHG) emissions increased by 11%, totalling 3.33tCO2e per person. In 2019, the largest sector contributing to GHG emissions was the transportation sector. The government plans to cut GHG emissions by 20% in 2030.

Electric Mobility (E-Mobility) offers a suitable option for reducing transport-related GHG emissions due to the absence of a CO2-emitting combustion engine in comparison to conventional fuel-powered mobility. However, to enable an effective transition to electric mobility, the availability of charging stations is essential. This demonstrates that the pace at which the nation's charging infrastructure is being constructed needs to be accelerated. As a result, electric vehicle adoption will increase.

As a result, it has generated interest from various automotive players as a future market for EVs. Although several entrepreneurs and companies within the sector engage in the assembly of EVs, there is room to explore more opportunities, especially in supply chain and Research and Development (R&D) activities. Fortunately, financial support and grants are gradually sprouting up to support the nascent sector, although EV entrepreneurs continue to complain of an overall lack of funding for the sector by governments, commercial banks, donors and other stakeholders.

The level of awareness of E-Mobility is low, more so in rural and peri-urban areas, and the cost of purchasing EVs is very high, which affects the willingness to purchase. Business models are being developed by various assemblers to ease the weight of payment for EVs and use it as an opportunity to penetrate the market. This market update recommends the following;



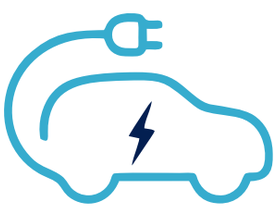
- **Partnership:** Given how interwoven the sector is with multiple sectors such as transportation, renewable energy, Technology, etc. There should be more partnerships between various players within the industry and others within and outside the renewable energy sector.
- **Awareness and Advocacy:** There is a need for more awareness and advocacy hence both government and private stakeholders need to work together on awareness programs.

- **Industry Association:** There is a need to mobilise all the stakeholders within the sector to build a strong ecosystem that can push for the growth and development of the sector.

REPORT STRUCTURE

This report is divided into four sections.

- **Introduction** – it introduces the concept of climate change and its effects across the world. It demonstrates how electric mobility serves as a key technology to achieving sustainability and the benefits of adopting electric mobility. Also, it describes the methodology used in data collection and information gathering.



- **Electric Mobility (E-Mobility)** – this introduces the technology of E-Mobility. It describes electric vehicles (EVs), their components, and the charging infrastructure. It explicitly discusses the technology behind electric mobility and its various components.

- **Current Landscape of EVs in Nigeria** – presents the landscape of E-Mobility here in Nigeria, it covers areas of assembling and manufacturing of EVs, political activities and framework, sector involvement, financing, market support and existing policies within the E- Mobility space. It also captures the demand aspect of E-Mobility, covering consumers' willingness and awareness of EVs. Challenges with regards to EV adoption and business models were also covered in this section.

- **Conclusion and Recommendation** – concludes and provides recommendations on the adoption of EV in Nigeria.

INTRODUCTION

Nigeria's greenhouse gas (GHG) emissions have surged by 11% between 1990 to 2017, leading to a total of 3.33 tC_20e per capital GHG emissions including poor environmental conditions from forms of land use such as Agriculture and Forestry

The government is set reduce GHG emissions by 20% in 2030 or 45% by 2030 conditional on international support

The Bus Rapid Transport (BRT) should account for 22.1% passenger-km by 2035

Nigeria is the most populous country in West Africa, and it faces enormous environmental issues, ranging from air pollution, and poor waste management, as well as land and water pollution. Nigeria's greenhouse gas (GHG) emissions have surged by 11% between 1990 to 2017, leading to a total of 3.33 tCO_2e per capita GHG emissions including poor environmental conditions from forms of land use such as Agriculture and Forestry.[1] The largest driver of GHG emissions is CO_2 emissions from fuel combustion. In 2019, the transport sector was the largest contributor to GHG The government is set to reduce GHG emissions by 20% in 2030 or 45% by 2030 conditional on international support.[3] Nigeria has introduced mitigation measures to reduce GHG emissions in the Nationally Determined Contribution (NDC) in the transport sector, this includes; adding 10,000 extra buses by 2030 and increasing Trucks and buses using Compressed Natural Gas (CNG) to 25% by 2030. Also, the Bus Rapid Transport (BRT) should account for 22.1% of passenger-km by 2035 and make sure all vehicles meet European 3 (EURO III) emission limits by 2023 and European 4 (EURO IV) by 2030. At the sub-national level, Lagos State unveiled its five-year action plan from 2020 to 2025 aimed at reducing GHG emissions. Under transportation, Lagos State will be expanding the BRT network. It also encourages the uptake of low-emissions vehicles, the shift of freight from road to rail and spatial planning to promote transit-oriented development.[4]

Mobility is increasingly moving away from the Internal Combustion Engine (ICE) in favour of other cleaner technologies in order to attain sustainability and minimise greenhouse gas emissions. New technologies are currently being developed, which will determine the direction of mobility in the coming years. Electric vehicles are the key technology for achieving the

[1] Climate Transparency (2020). *Nigeria fact sheet.* https://www.climate-transparency.org/wp-content/uploads/2021/01/Nigeria-CT-2020.pdf
[2] Climate Transparency (2020). *Climate Transparency Report.* https://www.climate-transparency.org/wp-content/uploads/2021/01/Nigeria-CT-2020.pdf
[3] Ibid [4] Nigeria NDC 2021 updated

The demand for electric vehicles across the world is rising with global sales global sales hitting 6.6 millions in 2021

goal of sustainability and environmentally friendly mobility; other technologies include hydrogen fuels, biogas, and others. The demand for electric vehicles across the world is rising with global sales hitting 6.6 million in 2021 and Europe taking the lead with 1.4 million new registrations and China following with 1.2 million sales.[5] There is a need for the transport sector to adopt a low carbon transportation system in order to reduce the amount of GHG emissions. This can be achieved through the adoption of electric mobility (E-Mobility).

Methodology

To fully understand the nature and activities of the nascent E-mobility sector in Nigeria, qualitative and quantitative research methods were adopted. This includes; an in-depth desk review of reports, academic articles, news reports and corporate websites; informative semi-structured interviews with stakeholders within the Nigerian E-mobility and renewable energy sector; and quantitative surveys administered to the general public.

ELECTRIC MOBILITY

Electric mobility (E-Mobility) is hailed as the transportation sector's solution to climate change, particularly for passenger road travel. E-Mobility is the use of electric cars, as well as e-bikes, electric motorbikes, e-buses and e-trucks for mobility in place of the normal conventional Internal Combustion Engine (ICE) vehicles. The common forms of electric vehicles (EVs) in Nigeria are cars, bikes, and tricycles (Keke Nepel).

An Electric Vehicle is propelled by electromagnetism, it uses electricity stored in a battery to power an electric motor. It is powered by electricity and lacks traditional liquid fuel components such as a fuel pump, fuel line, and fuel tank.

[5] IEA (2021). *Global EV Outlook.* https://iea.blob.core.windows.net/assets/ed5f4484-f556-4110-8c5c-4ede8bcba637/GlobalEVOutlook2021.pdf

EV Components

The parts that make up EVs are different from the conventional ICE vehicles. EVs have no need for an engine and transmission, the two vital parts of an ICE vehicle. The key components of an EV are discussed briefly below.

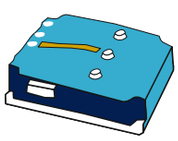
- **Battery**: The battery stores the electricity required for an EV to function. There is also an auxiliary battery that provides electricity to vehicle accessories.

- **Charge port**: The charging port allows the vehicle to charge the traction battery pack by connecting to an external power source.

- **DC/DC converter**: This device converts higher-voltage DC power from the traction battery pack to lower-voltage DC electricity required to operate vehicle accessories and recharge the auxiliary battery.

- **Electric traction motor:** This motor drives the vehicle's wheels with the help of the traction battery pack. Motor generators are used in some vehicles to provide both drive and regeneration.

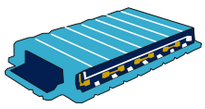
- **Onboard charger:** Converts incoming AC electricity supplied through the charge port to DC power for charging the traction battery. While charging the pack, it also connects with the charging equipment and analyses battery properties including voltage, current, temperature, and state of charge.



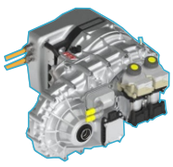
- **Power electronics controller:** This unit controls the speed of the electric traction motor and the torque it produces by managing the flow of electrical energy supplied by the traction battery.

[6]EDF Energy. How do Electric Cars work? https://www.edfenergy.com/for-home/energywise/how-do-electric-cars-work

- **Thermal system (cooling):** This system keeps the engine, electric motor, power electronics, and other components within a safe operating temperature range.



- **Traction battery pack:** Electricity is stored here for use by the electric traction motor.



- **Transmission (electric):** The transmission is responsible for transferring mechanical power from the traction motor to the wheels.[6]

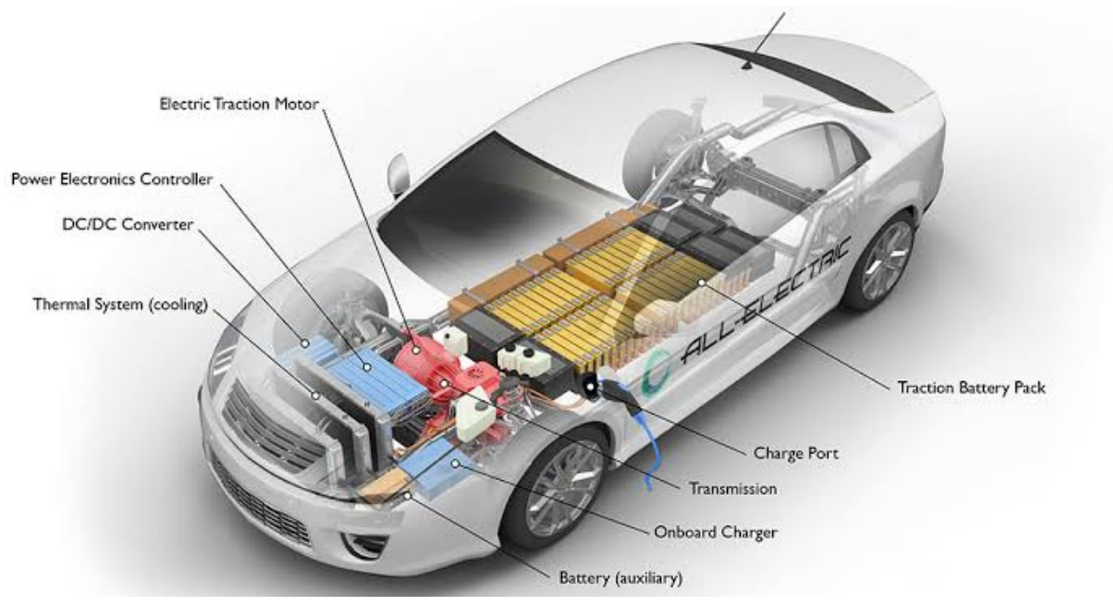


Figure 1: Components of an EV[7]

There are three types of electric vehicles, plug-in electric, plug-in hybrid and hybrid electric. The plug-in electric vehicle uses only electricity, it doesn't need diesel or fuel to function and does not produce any emissions like the conventionally fuelled vehicle. The plug-in hybrid is a combination of battery and combustion engines, when the electric component of the vehicle runs out of charge it switches to the diesel or fuel component. This can be plugged in to charge. Finally, the hybrid electric vehicle runs mainly on fuel but has an electric battery that is charged through regenerative braking.

[7] AFDC. *All Electric Vehicles. https://afdc.energy.gov/vehicles/electric_basics_ev.html*

Electric Vehicles Versus Conventional ICE Vehicles

EVs and conventional ICE vehicles differ in five major ways: principle of operation, physical features, GHG emission and environmental impact, cost, and maintenance.

Principle of Operation

Electric car motors work by mounting one set of magnets or electromagnets to a shaft and another set to a housing surrounding that shaft. By periodically reversing the polarity (swapping the north and south poles) of one set of electromagnets, the EV motor leverages these attracting and repelling forces to rotate the shaft, thereby converting electricity into torque and ultimately turning the wheels.

On the other hand, in an internal combustion engine (ICE), the ignition and combustion of the fuel occur within the engine itself. The engine then partially converts the energy from the combustion to work. The engine consists of a fixed cylinder and a moving piston. The expanding combustion gases push the piston, which in turn rotates the crankshaft. Ultimately, through a system of gears in the powertrain, this motion drives the vehicle's wheels.

Physical Features

An electric vehicle looks like a gasoline-powered vehicle with the exception that the electric vehicle does not have a tailpipe. The electric vehicle has several unique components that serve the same function as the more common components in a gasoline-powered vehicle. These parts are highlighted in the table below.

Table 1: Component comparison of EV and ICE vehicles[8]

Electric Vehicles Component	Component Function	Conventional Vehicles Component
Battery	Store the energy to run the vehicle	Gasoline/Diesel Tank
Charger	Replace the energy to run the vehicle	Gasoline/Diesel Pump

[8]Advance Vehicle Testing Activity. https://avt.inl.gov/sites/default/files/pdf/fsev/compare.pdf

Electric motor	Provide thrust force	Gasoline/Diesel Engine
Controller	Control acceleration/speed	Carburetor
DC/DC converter	Provide power to accessories	Alternator
DC/AC converter	Convert DC to AC to power AC motor	Smog Controls
	Lower the toxicity of exhaust gas	

GHG Emission and Environmental Impact

With zero tailpipe emissions, a compact size and an essentially silent motor, electric vehicles seem to be the best bet were it not for its high purchase price. However, it has been noted that EVs are an indirect pollution source because of emissions by the power plants which supply electricity. This is the reason why they have been criticized as 'pollution elsewhere vehicles. Several studies have compared the emissions of electric vehicles and internal combustion engine (ICE) vehicles and most agree that the net reduction in emissions due to the use of electric vehicles depends on various factors like the source of fuel for electricity generation, the type and age of the conventional vehicle.

The life cycle emissions of an EV depend on the sources of electricity used to charge it, which vary by region. In geographic areas that use relatively low-polluting energy sources for electricity production, plug-in vehicles typically have a life cycle emissions advantage over similar conventional vehicles running on gasoline or diesel. In regions that depend heavily on conventional electricity generation, EVs may not demonstrate a strong life cycle emissions benefit.

Maintenance

The number of moving parts is a significant difference between EVs and ICE vehicles. The electric vehicle has one moving part, the motor, whereas the gasoline-powered vehicle has hundreds of moving parts. Fewer parts translate to less periodic maintenance and better reliability. Since the EVs have only one moving part, the maintenance requirements are fewer

and therefore low maintenance costs. Other components of the EVs like the controller, charger, and batteries have no moving parts and require little or no maintenance. This cannot be said about ICE vehicles as it requires a wide range of maintenance, from frequent oil changes, filter replacements, periodic tune-ups, and exhaust system repairs, to the less frequent component replacement, such as the water pump, fuel pump, alternator, etc.

Costs

Although operational costs for hybrid and plug-in electric vehicles are generally lower than for similar conventional vehicles, purchase prices can be significantly higher. Prices are likely to equalise with conventional vehicles, as production volumes increase, and battery technologies continue to mature.

Table 2: Summary Comparison between EVs and ICE Vehicles

	Electric Vehicles	**Conventional Vehicles**
Energy Source	Electric	Gasoline/Diesel
Drive Mechanism	Motors	Engine
CO2 Emissions	Present (usually lower than ICE vehicles depending on the source of electricity generation)	Present
Fuel Facility Locations	Charging Stations	Gas stations
Purchase Cost	Very expensive (sometimes double the cost of getting a conventional type)	Affordable (depends on car features like engine capacity, wheel drive etc)
Maintenance Cost	Low	High
Operational Cost (charging/fuelling)	Same average cost	Same average cost

EV Charging Infrastructure

The availability of charging stations is paramount for the full, efficient, and effective transition to E-Mobility. A survey by Borderless Access shows that better charging infrastructure influences the purchase rate of EVs by about 54%.[9] This is an aspect that vehicle suppliers must contend with as a complementary component of E-Mobility that can aid the smooth rollout of EVs.

The first solar-powered electric charging station was commissioned in April 2021 by the National Automobile Development and Design Council (NADDC) at Usman Danfodio University, Sokoto. The state of Sokoto, located in Northwest Nigeria, was reportedly chosen because of the greater availability of solar irradiation.[10] In June 2021, another charging station was commissioned at the University of Lagos as part of the NADDC Electric Vehicle Pilot Project (EVPP). This was mainly to advance research and development and to allow students to have first-hand experience of the latest innovations in mobility and renewable energy technologies.

These electric charging stations in Sokoto and Lagos are 100% solar-powered and contain arrays of installed solar panels with 86.4kW/hr capacity. The solar panels are then coupled to three online-offline hybrid inverters with 5-kilovolt ampere (kVA) each and synchronised to give an output of 15KVA/48W.

Charging infrastructure can either be Battery swapping stations where batteries can be swapped or battery charging stations for charging EVs. Currently, most charging stations are privately owned or built by companies providing electric vehicles such as First Electric, God is Good Logistics (GIGL), Max.ng, Phoenix Renewables etc., instead of public charging points. This shows that there is needed acceleration in the pace at which charging infrastructure is being developed within the country. This will drive greater adoption of EVs, as most EV adopters still mostly restrict travel to a radius that would allow them to return home to recharge their vehicle's battery.

Research is ongoing to determine better ways of charging EVs. The present limitation is that drivers of EVs around the world whose EV batteries are running low would have to pull over at the next exit to charge. The search for a charging station may consume time and energy

[9] Consumer attitudes toward electric vehicles in key emerging markets, Borderless Access. https://www.researchworld.com/consumer-attitudes-towards-electric-vehicles-in-key-emerging-markets/

[10] Abdulwaheed Sofiullah (2019). UDUS makes history. The Nation. https://thenationonlineng.net/udus-makes-history/.

hence an embedding of special charging strips in the roads would suffice.[11] This means a vehicle would only have to change lanes to charge while in motion. This will not only save time but improve productivity in warehouses that have the special charging strips installed, as well as pave the way for more sustainable transit. Moreover, there would be too many charging stations if every vehicle in a country was electric, and there are not many homes that would have the charging infrastructure to charge their EVs quickly. Therefore, wireless charging would save both space and time.[12]

Figure 2: Picture of a Charging Station Situated in Borno State.[13]

[11] This was proposed by an associate professor of electrical computer engineering in the College of Engineering.
[12] David Nutt (2021). Research Paves way for wireless charging. Cornell Chronicle. https://news.cornell.edu/stories/2021/04/research-paves-way-wireless-charging-electric-vehicles
[13] Phoenix Renewables. https://northpad.ng/mustapha-gajibo-electric-cars/

CURRENT LANDSCAPE OF EV ADOPTION IN NIGERIA

Nigeria, as Africa's largest economy, presents a sizable untapped automotive market with the continent's largest population and the largest economy in terms of Gross Domestic Product (GDP). For this reason, Nigeria has generated the most interest among automotive players as a future market in Africa for electric mobility apparatus. However, the E-mobility industry in Nigeria is still nascent. Several companies operate within the market as start-ups, others have plans for market entry, and there is potential for many others to key into the opportunities of EVs presented by the sector. Some of these opportunities are present within the supply chain, manufacturing and Research and Development.

Assembling and Manufacturing of EVs

Electric mobility is gradually gaining traction amongst indigenous companies. The private sector is the major player in this movement, is taking the mantle by trying to find viable business models with support from the solar sector. Engineering Students from various institutions across the country are also building prototypes of electric cars and bikes. These institutions include the University of Lagos (Uni Lag), Ahmadu Bello University (ABU), University of Benin (Uni Ben), University of Nigeria Nsukka (UNN), Usman Danfodio University, etc. A list of manufacturers/assemblers of E-Mobility in Nigeria is shown below.

Table 3: Electric Mobility Assembling Companies/Institutions

Type of Vehicle	Company/Institution	Portfolio
Electric Cars	Jet Motors	One of the pioneers of electric vehicles in Africa with a manufacturing plant in Ekpe, Lagos state producing about 5-7 vehicles a day. Jet Motors raised $9 million from Canadian-based Africa Development Capital, Greatman Legend and a number of Asian investors to fund the research and development of its electric vehicles called JET EV. The first prototype has been tested running from Lagos to Benin. Also, Jet Motors signed an agreement with GIG Logistics to deliver 50 electric vans, and this was launched in June 2021 at the headquarters in Lagos.

	Stallion Motors	The Hyundai Kona assembled in Lagos by the Stallion group was the first electric car assembled in Nigeria in collaboration with the Lagos State Government. It was unveiled by the National Automotive Design and Development Council (NADDC) in Abuja.
	First Electric	First Electric is involved in the importation, sale and installation of EVs, First Electric drives for investment in EV infrastructure and EV service workshops to pave the way for mass utilisation of EVs in Nigeria. The company primarily imports electric cars both new and fairly used with the prospect of assembling them locally. First Electric purchases electric cars majorly from the United States (US) and sells
		within Nigeria. They provide charging infrastructure via a charging station installed in their office located in Ajah Lagos State.
	The University of Nsukka(UNN)	UNN produced the first electric campus shuttle bus in 2019 called Lion Ozumba 551 with a grant of NGN1.6 million from the Vice-Chancellor. The dean of the faculty of Engineering took up the challenge to build the shuttle bus after he learned that NADDC was considering the importation of the Electric Vehicle. The five-seat shuttle bus, when charged, can be driven for up to 60 minutes at the top-level campus speed of 30km per hour.
	The University of Lagos	In June 2021, the University of Lagos test-ran its Zero Emission Vehicle (ZEV) which began production in 2018.[14] UNILAG ZEV is a 63 per cent hardware and 100 per cent software home-made (Akoka content) mechatronics automobile device.

[14] https://www.premiumtimesng.com/regional/ssouth-west/470283-unilag-test-runs-zero-emission-vehicle.html.

	Egbin Power Station	Egbin Power Station, a member of the Sahara Power Group, launched the initiatives "Going Electric" and "Clean Energy" to shift to EVs. It is an environmentally-friendly transport system that would see the deployment of 20 electric buses and 500 bicycles for use within its corporate environment to promote sustainability. The EVs were imported from China and fully assembled in Nigeria.
	Nigerian Institute of Transport Technology (NITT)	The institute has set up a 22-member project team for the development of an electric vehicle in compliance with the directives of the Minister of Transportation in 2019. The project team is to develop a prototype of the NITT electric vehicle, promote the model in the Nigerian automobile industry and determine the budgetary allocation for the new project.
	Phoenix Renewables	Phoenix Renewables convert ICE buses to EVs and are currently developing EV buses locally made in Nigeria.
	Thrive Earth	Thrive Earth retrofits existing gasoline tricycles/minibuses with the electric drivetrain. We also assemble/manufacture new, cheap and functional electric vehicles, and operate a convenient battery charge/swap network.
Electric Tricycles	Think Bikes	With the sole mission of accelerating Africa's transition to renewable energy and sustainable transport using technology, practical research, education and advocacy; Think Bike is involved in the building of electric vehicles and also conversion of fuel/gas-powered cars to electric cars. Think Bikes created the electric cargo bike for transporting goods and easy delivery.

	Ebonyi State	As a result of the zero-oil initiative, the Ebonyi State Government has started the production of electric tricycles. The tricycles are built from waste-to-wealth projects by using abandoned containers to construct the tricycles' bodies.[15]
	Carbon Credit Network (CCN)	Assembles motorcycles with solar panels on the rooftop to charge the motorcycles while in use. This solves the problem of waiting at a charging station to charge as the tricycles are charged simultaneously while in use. CCN is pioneering electric cars in Nigeria, starting with tricycles to advancing to both luxury and commercial cars.
	Arthur Energy Technology	Arthur Energy Technology located in Onitsha built a solar-powered tricycle branded "Arton". It also has an assembling plant in Onitsha and the components of the tricycle were 80% locally sourced.[16]
	Rural Women Energy Security (RUWES)	RUWES is currently assembling tricycles and dispatching them to women as starter packs for women empowerment in Kaduna. These tricycles are given as hire purchases with a flexible payment plan and lower interest spread across months. It also trains rural women to assemble the tricycle. The initiative aims to expand to other states and install charging stations in those states. The tricycles can be charged with either electricity or solar. They currently have 50 of which are 6-seaters each.
	Oldang International Limited	In 2017, Oldang International Limited launched solar-powered tricycles in Lagos State.[17]

[15] Agnes Igwe. Ebonyi begins production of electric vehicle. Auto report Africa. http://www.autoreportafrica.com/ebonyi-govt-encourages-zero-oil-economy-commences-production-of-electric-tricycles/

[16] HBS (2017). *Solar powered tricycles: zero emissions.* https://ng.boell.org/en/2017/03/22/solar-powered-tricycles-zero-emissions-while-transporting-thousands-people

Electric Bikes	Max.ng	Max.ng started as a motorcycle-based logistics service company and expanded to passenger transportation in 2017. In June 2019, a total of $7 million in funding was raised through equity and grants to scale its mobility solutions. Max first announced its E-Mobility plans in June 2019 and by November of the same year, an actual design and concept of the vehicle was revealed, called the MAX E series M1. There is also a newly developed EV called MAX E series M2, a faster and more performance-enhanced model. Max also went into partnership with Rubitec Solar to provide battery charging and swapping stations for bikes that are powered by a Rubitec mini-grid in Gbamu Gbamu, Ogun state, Nigeria

[17] The Sun (2017). Solar Powered electric tricycles enter Nigeria market https://www.sunnewsonline.com/solar-powered-tricycles-enters-nigerian-market/.

[18] CTCN (2020). *Developing E-Mobility Policy and framework.* https://www.ctc-n.org/technical-assistance/projects/developing-national-emobility-policy-and-framework-deploying-and.

E-Mobility Policies and Regulations

In June 2020, the Federal Ministry of Transportation, Department of Road Transport and Mass Transit Administration and Federal Ministry of Environment, Department of Climate Change filed a technical request for assistance from the Climate Technology Centre and Network (CTCN) in the development of a "National E-Mobility Policy and Framework for Deploying and Scaling up E-Mobility in Nigeria".[18] The main objective of the policy is the mitigation of the effects of climate change. As of March 2021, the development of the policy framework is still ongoing.

A range of policy-oriented activities relevant to the Nigerian EV sector is being undertaken by some government agencies.[19] These include:

- The Federal Road Safety Corps (FRSC) reviewed the Nigerian Road Safety Strategy which is anchored on the UN Decade of Action to accommodate the advent of electric and solar-based vehicles on Nigerian roads.
- Development and implementation of policies by NADDC for the sustainable low emission transport system in line with the United Nations (UN) Environment Programme and also decreasing tariffs for importers and manufacturers within the local auto sector to import and manufacture only zero-emission vehicles.
- Efforts have been made to replace half of the light-duty trucks with gasoline to diesel-powered buses under the BRT Transport Program in Lagos State, initiated by the World Bank in 2008.[20]

Aside from these decentralised and *ad* hoc government efforts, especially from commercially inclined states, such as Lagos, Ebonyi and Enugu, attempts are currently being made to develop policies by NADDC and the Department of Climate Change towards EVs. However, there are currently no E-mobility policies or action plans in the aforementioned states.

[18] CTCN (2020). *Developing E-Mobility Policy and framework.* https://www.ctc-n.org/technical-assistance/projects/developing-national-emobility-policy-and-framework-deploying-and.

[19] CTCN (2020). Ctcn technical request form. https://www.ctc-n.org/sites/www.ctc-n.org/files/request/CTCN_request_Nigeria_E-mobility_%20June%202020%20.pdf.

[20] Ibid.

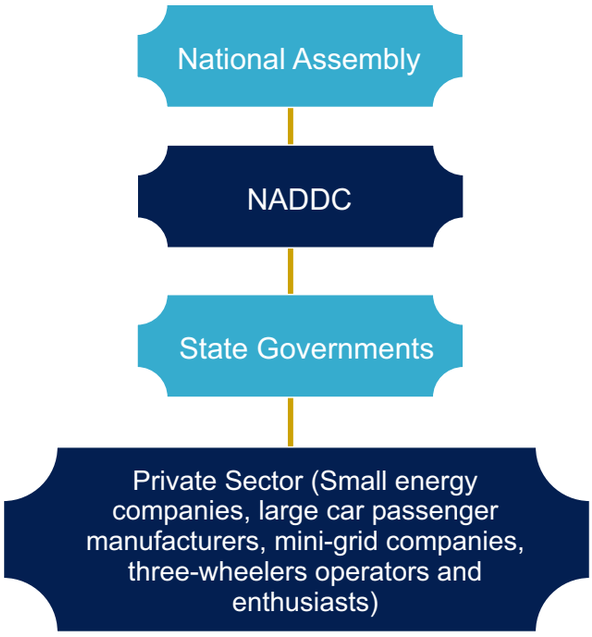


Figure 3: Hierarchy of Involvement in The Contemporary Nigerian E-Mobility Sector. *Most active actors at the bottom and the least active at the top.*

EV Funding and Financing

Several international donors have emerged recently to provide grant funding to EV start-ups in Africa. These funds have mainly been for businesses in the private sector. Recently, the United Kingdom (UK) government through its Manufacturing Africa Initiative scaled up support for Max.ng. The Manufacturing Africa Initiative is supporting Max.ng to raise funds for the assembly of EVs.[21]

Siemens Stiftung's E-Mobility innovation grant was the first of its kind for African entrepreneurs, start-ups, and social ventures to pitch their products and/or services for the implementation of E-Mobility, to advance its uptake and mainstreaming in Africa. It was called "Electric Mobility Made in Africa for Africa". The application for this grant ended in April 2021.[22] ThinkBikes Ltd., a Nigerian-based company, emerged as one of the five winners of the call. ThinkBikes manufactures electric bicycles and scooters locally; making them available for ride-sharing and lease in higher institutions, estates, cities and rural communities at large for affordable clean mobility.

[21]Vivian Chime (2021). UK to support assembling of EV in Nigeria. The cable. https://www.thecable.ng/uk-to-support-assembling-of-electric-vehicles-in-nigeria

[22] Siemens Stifung (2021). E-mobility innovation call. https://www.siemens-stiftung.org/en/media/news/applications-open-for-siemens-stiftung-e-mobility-innovation-call-2021-electric-mobility-made-in-africa-for-africa/

All On, an off-grid energy impact investment company via its technical support facility "The All On Hub", funded and supported the 16-week incubation program by the Nigeria Climate Innovation Centre (NCIC). Twelve renewable energy start-ups were groomed and developed, out of which 8 received a $10,000 grant each for expansion and further development of business ideas. Business ideas include the development of electric vehicles and charging stations, energy efficiency technologies, biogas production and systems built on IoT technology.[23] Think Electric, an EV start-up, emerged as part of the eight start-ups that received a $10,000 grant.[24]

Research and Development

Under the Energy Commission of Nigeria, there are six energy research centres tasked with conducting research on energy solutions in Nigeria.[25] Three of these work in areas strongly linked to electric vehicles. These are:

- The National Centre for Energy Research and Development (NCERD) at the University of Nigeria, Nsukka (responsible for research in solar and renewable energy).[26]
- Sokoto Energy Research Centre (SERC) at Usmanu Danfodiyo University, Sokoto (also responsible for research in solar and renewable energy).[27]
- National Centre for Energy Efficiency and Conservation (NCEEC) at the University of Lagos (responsible for research in energy efficiency and conservation).[28]

These research centres, in collaboration with the NADDC, are responsible for launching the first 100% solar-powered charging station at the Usmanu Danfodiyo University, Sokoto and the University of Lagos, with plans for building others at the University of Nigeria, Nsukka.

These research centres, in collaboration with the NADDC, are responsible for launching the first 100% solar-powered charging station at the Usmanu Danfodiyo University, Sokoto and the University of Lagos, with plans for building others at the University of Nigeria, Nsukka.

[23] Allon (2020). Embryo Incubation Program. https://www.all-on.com/media/media-releases/nigeria-climate-innovation-centre-completes-all-on-hub-sponsored-2020-embryo-incubation-program.html
[24] Allon (2021). Embryo Incubation program winners. https://www.all-on.com/media/media-releases/ncic-completes-all-on-hub-sponsored-off-grid-incubation-program.html
[25] https://www.energy.gov.ng/research_centers.php.
[26] https://www.ncerd-unn.gov.ng/.
[27] https://serc.org.ng/.
[28] https://www.nceec.org.ng/.

EV companies also undertake their own R&D activities. Some are incorporating digital technologies into their vehicles. Phoenix Renewables, for instance, is investing in the development of mobile applications to locate charging stations and to connect investors in electric buses to enable them to track the number of customers and the condition of buses. For some of these companies, R&D expenses may be between 10-50% of total expenses, depending on the degree of technological innovation, sophistication (e.g. conversion of ICE vehicles involves lower costs overall than manufacturing EVs from scratch) and digital functionality being incorporated into the vehicles.

Market Data

Companies in the assembling and manufacturing of EVs need accurate and verifiable data to plan strategically. This is a work in progress as currently, there is no comprehensive market data such as the number of EVs in Nigeria, the number of charging stations, trends in the cost of conversion of fuel/gas-powered vehicles to EVs, cost of assembling of new EVs and annual revenues of EVs companies. Efforts are being made to ensure these data are available for development and decision making purposes.

Figure 4: Summarised stakeholders within the EV sector in Nigeria

Consumers' Awareness and Willingness to EV Adoption

Nigeria is a lower-middle-income country with a per capita income of United States Dollar (USD) 2,097 in 2020.[29] with a per capita income of USD 2,097 as compared to the price of an electric car (about USD 24, 103). Merely 2% of Nigerians can afford new vehicles given the current economic and financial environment. Even used vehicles are expensive to an average Nigerian. The lack of a viable credit system for the purchase of assets partly contributes to this situation, as credit facilities attract interest rates above 20% per annum and require at least a 10% down payment.[30]

Findings from a survey conducted by Clean Technology Hub Nigeria (CTH) to determine affordability and willingness to buy electric vehicles reveals many consumers are willing to consider electric vehicles but are more concerned about issues such as the availability of charging stations, the high cost of purchase and the availability of after-sale services. The survey results are shown in the table below.

Table 4: Survey Summary for Demand for Electric Vehicles

Percentage of Respondents	Decision	Reasons
74%	Willing to transit to E-Mobility	❖ Reduced environmental pollution (28%) ❖ No need for fuel usage (21%) ❖ Preference for climate mitigation (20%) ❖ Affordable maintenance (15%) ❖ Others (16%)
12%	Not willing to transit to E-Mobility	❖ Lack of Infrastructure (51%) ❖ It's too expensive (26%) ❖ Lack of awareness of technology (11%)

[29] IMF and World Bank data
[30] Deloitte Africa Automotive Insights Navigating the African Automotive Sector: Ethiopia, Kenya and Nigeria, 2018

		❖ Others (12%)
14%	Were indifferent about transiting or not	

A survey result by Gllyd Electric is in line with the findings above as a majority (98%) of its respondents in Nigeria are willing to patronise electric taxis.[31] Based on the survey conducted by CTH, 98% of the respondents are aware of electric mobility from social media (71%), news reports (62%) and personal discussions (36%). A similar survey conducted by Borderless Access revealed 39% of the respondents estimate it will take 10 years for electric mobility to gain mainstream acceptance in Nigeria whilst 27%, 12%, and 14% estimate 20, 30 and more than 30 years respectively. A small minority (7%) believe that E-mobility is unlikely to gain mainstream traction in Nigeria. Despite the enthusiasm shown for electric vehicles in the survey, stakeholders in the sector during interviews revealed that whatever actual demand for electric cars exists comes mostly from enthusiasts and bigger automobile companies for logistics.

Electric tricycles and bikes are gaining traction and popularity in the Nigerian mobility sector, especially in the rural and suburban regions. These have been deployed in states like Lagos, Ogun and Enugu. Tricycles (popularly known as *Keke napepe)* are seen by users as a means for overcoming mass transit challenges and include reducing spending on more expensive fossil fuels and reducing wait times for refuelling. Electric tricycles and motorcycles are also propelled by small energy companies, for commercial purposes. At present, the consensus amongst industry stakeholders shows that only electric enthusiasts, climate change activists or individuals found in the engineering or business sectors generally advocate for the adoption of electric mobility.[32]

Transport experts from the United Nations Environment Program's (UNEP) Electric Mobility Initiative argue that tricycles and motorcycles are the priority in moving to electric mobility in developing countries such as Nigeria.[33] These are the fastest growing means of transport in many low and middle-income countries like Kenya and Rwanda, and they, therefore, have a

[31] Glory (2020). Private sector indigenous companies drivin ev revolution. RETTI. https://retti.com.ng/these-private-sector-indigenous-companies-are-already-driving-the-ev-revolution-in-nigeria/
[32] This was obtained from a series of interviews with various stakeholders within the sector.
[33] Siemens Stiftung (2020). *E-Mobility Solutions for Rural Sub-Saharan Africa: Leveraging Economic, Social and Environmental Change*. Munich: Siemens Stiftung, p. 37.

great impact on the climate and pollutant emissions in emerging cities. They also demand fewer investments in charging infrastructure than electric cars and buses mostly require. There is also an economic incentive for motorcycle owners and taxi associations to support e-mobility since motorcycles and tricycles are primarily used as taxis, and a transition to their electric counterparts would further reduce operating costs.[34]

Generally, consumer awareness is very low, largely because people are yet to understand the benefits of electric mobility. Additionally, there is also little consumer education available on the benefits and economic advantages of electric mobility.

Challenges of EV Adoption in Nigeria

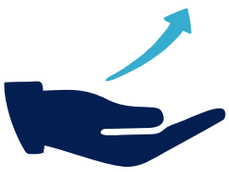
Although EVs have a lot of potential for penetrating the Nigerian market and eventually becoming part of the government's renewable energy policy framework, it faces several challenges. These are elaborated upon below.

- **Lack of Access to Finance**: There are limited funding opportunities for manufacturers of EVs. Players in the sector have complained of difficulties in acquiring equity and debt funding, especially since most banks and other investors are not convinced about economic viability of EV in Nigeria. Nonetheless, the continuation and growth of several initiatives including small energy companies, logistics companies, mini-grid companies and tricycle operators may help improve investors' perceptions of Nigeria as a viable investment destination for EVs over time.

- **Lack of Government Regulation and Support:** There is a stark absence of government policies such as tax holidays, import duty reduction or waivers, concessionary loans and subsidies available to EV manufacturers, assemblers and projects in

[34] *Ibid.*, p. 37.

Nigeria. This not only discourages investments in the sector, but also makes it more difficult for existing players in the sector to grow, expand sales, and overcome bottlenecks along the supply chain.



- **High Cost of Electric Vehicles Acquisition**: A major hindrance to the growth of the electric mobility market is the high cost of acquiring EVs which is due to high manufacturing costs. As a result of the high cost of importing parts, as well as the inability to undertake mass production and exploit economies of scale, the cost of manufacturing becomes high. This cost is then transferred to customers which the average Nigerian cannot afford. [35]

- **Availability of Electricity**: Electricity availability is a paramount challenge that the introduction of EVs will need to confront in Nigeria. The highest peak average power supply in recent times was in January 2017 at around 4,425 MW which is insufficient for a population of around 200 million.[36] Some, therefore, argue that Nigeria does not generate enough electricity for electric vehicles.

- **Charging Facility Technologies for EVs**: Current charging facilities can enable charging EVs from thirty minutes to twelve hours, based on the capacity of the battery, and the speed of the charging station. Several companies are already researching next-generation fast chargers, capable of recharging EVs with a 200km to 300km range within a reasonable time.

[35] Olabode Agunbiade and Peter Siyan (2020). "Prospects of Electric Vehicles in the Automotive Industry in Nigeria". European Scientific Journal, 16 (7), 1857 - 7431.
[36] Power Nigeria (2019). Poor Power Supply in Nigeria: What is the Reason?

- **Environmental Concerns**: While it is accepted that the introduction of EVs will reduce CO_2 emissions, there is also the environmental issue of local battery manufacturing and disposal, which is a challenge in Nigeria, where the normal domestic waste management system is already an area of concern with indiscriminate disposal of waste across the country.[37] These batteries are complex and contain toxic chemicals, making their disposal at the end of an electric vehicle's life a major environmental challenge.

Business Models Options for EV Adoption

African start-ups and companies are beginning to experiment with a variety of business models for commercialization.[38] The direct sales business model (selling at full price) used by the traditional vehicle industry may be limited to business customers (such as transport and logistics companies), but it is not viable for the majority of individual buyers.[39] The private sector is at the forefront of the adoption of E-Mobility in Nigeria and is adopting business models that will help boost the supply and demand for EVs.

1. **PAYGO Model**: This can also be referred to as EV leasing. First introduced by solar home systems (SHS) providers and practised in China by Wanxiang.[40] This model involves the company or owner of EV and the driver (vehicle users) of the EV. It allows vehicle users to secure vehicles with a down payment and pay an agreed amount to the company or owner of the EV daily, weekly, or monthly for a period of time before ownership is finally transferred. An example is the Carbon Credit Network in Nigeria, which has embraced this model for its electric tricycles.[41]

[37] Beatrice Abila and Jussi Kantola (2019). Solid waste management problems in Nigeria. Wathi. https://www.wathi.org/municipal-solid-waste-management-problems-in-nigeria-evolving-knowledge-management-solutions-beatrice-abila-and-jussi-kantola/

[38] Siemens Stiftung, *E-mobility Solutions*, p. 15.

[39] *Ibid*., p. 19.

[40] Claire Weiller, Amy Shang, Andy Neely, Yongjiang Shi (2015). Competing and Co-existing Business Models for EV: Lessons from International Case Studies. Cambridge Service Alliance

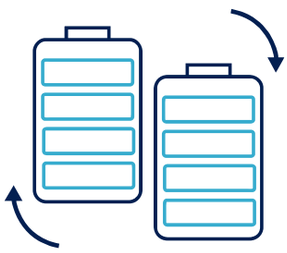
[41] https://www.youtube.com/watch?v=zbhRBJonMaw

Advantages	*Disadvantages*
• The cost of purchasing EVs is spread across a period of time. • Flexibility in the amount to be paid periodically. • Access to EV without full payment	• Inflation and currency devaluation can lead to a reduction in the potential profit or losses for either the vehicle users or the EV contractor despite the interest incorporated in the cost.

2. **Pay-per-use:** The model is used by motorbike drivers in Kenya and Uganda. It enables drivers to rent electric bikes daily for a fee for each use from the providing company. Under this model, the driver is not burdened by the cost of vehicle purchase, battery costs, and electricity prices. This model places a large share of the risks associated with EV technology, market evolution, and infrastructure onto the providing company alone.[42]

Advantages	*Disadvantages*
• The burden of provision and maintenance of the EV falls on the providing company. • Flexibility in terms of usage • Access to E-Mobility without purchasing	• This poses a financial risk to the provider, who bears the cost of maintenance and repairs even in cases of equipment misuse. • Unfavourable rent fee and conditions set by the owners.

[42] Siemens Stiftung (2020). *E-Mobility Solutions for Rural Sub-Saharan Africa: Leveraging Economic, Social and Environmental Change*. Munich: Siemens Stiftung, p. 20.



3. **Battery swapping:** A Nigerian EV expert has noted how popular battery swapping is in China (which is where the battery of an EV is swapped out with a fully charged one rather than waiting for their run-down battery to fully charge) as a means of charging is a better alternative to visiting charging stations. This is currently in use by Nio and Aulton New Energy in China.[43] This appears to be due to the need to avoid the wait times associated with directly charging at stations. This is therefore a viable business model for charging stations.

Advantages	*Disadvantages*
• Less time spent on charging the battery.	• Proximity of swapping stations

CONCLUSION AND RECOMMENDATIONS

The E-Mobility sector is very nascent and still at its budding stage with the private sector taking the lead in activities to push for its adoption.

The market for E-Mobility has grown globally and Nigeria is gaining grounds in penetration of its local market to increase demand. Also, plans are ongoing by both the private sector and NADDC to build charging infrastructure which will also foster the adoption of EVs. From the different research and interviews done, this market update recommends the following;

[43]Zeyi Yang (2022). Electric battery swap in China. Climate Protocol. https://www.protocol.com/climate/electric-vehicle-battery-swap-china

1. **Partnership**: There is room for partnerships to scale up the adoption of EVs. These partnerships are in different forms;

    a. Partnership between mini-grid solar companies and EV manufacturers where the mini-grid companies provide charging infrastructure just like in the case of Max.ng and Rubitec solar. This can also happen between charging infrastructure developers and the mini-grid companies.

    b. Partnership between the private sector and government agencies for proper policy implementation in the areas of taxation and enabling the environment for manufacturing.

2. **Awareness and Advocacy**: There is a need for proper advocacy and awareness around the existence and benefits attached to the adoption of E-Mobility. This can be on the local level before scaling it up. This will also boost the demand for EVs.

3. **Creation of Industry Association**: The coming together of all E-Mobility manufacturers and people involved in the value chain to build an ecosystem in order to nurture and build a strong sector.

There is a bright future for EVs in Nigeria, every action undertaken by both government and private sector is geared toward the tipping point after which EVs become the only form of mobility in the country.