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International EV policies: A comparative review of strategies in the United States and Nigeria for promoting electric vehicles

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Abstract

This paper provides a comprehensive comparative analysis of the strategies employed by the United States and Nigeria in promoting electric vehicles (EVs) within their respective national contexts. As the world shifts towards sustainable energy solutions, EVs have emerged as a pivotal component in reducing greenhouse gas emissions and mitigating climate change. Drawing upon a range of scholarly literature, governmental reports, and policy documents, this study examines the policy frameworks, incentives, and challenges faced by both countries in fostering the adoption of EVs. In the United States, a diverse array of federal, state, and local initiatives have been implemented to incentivize EV adoption, including tax credits, rebates, infrastructure investments, and regulatory mandates. Moreover, collaborations between the government, industry stakeholders, and research institutions have facilitated technological advancements and market growth in the EV sector. However, challenges such as range anxiety, high upfront costs, and inadequate charging infrastructure continue to impede widespread adoption. Conversely, Nigeria, while grappling with its own set of socio-economic and infrastructural challenges, has exhibited a nascent interest in promoting EVs as part of its broader sustainable development agenda. Despite lacking a comprehensive national policy framework, various initiatives such as tax exemptions, import duty waivers, and pilot projects have been introduced to stimulate EV uptake. Moreover, Nigeria's abundant renewable energy resources offer a promising opportunity for leveraging EVs to enhance energy security and reduce dependence on fossil fuels. Nevertheless, significant barriers such as limited infrastructure, affordability constraints, and institutional capacity gaps pose formidable obstacles to scaling up EV adoption in the country. By juxtaposing the experiences of the United States and Nigeria, this study contributes valuable insights into the diverse approaches and lessons learned in crafting effective international EV policies amidst varying socio-economic contexts. Through a nuanced understanding of the policy landscape, policymakers, industry stakeholders, and researchers can identify strategies for overcoming barriers and accelerating the transition towards a sustainable transportation paradigm.

Keyword: Electric Vehicles; Transportation; Tax Exemption; USA; Nigeria; Policy

1. Introduction

Electric vehicles (EVs) have emerged as a crucial component in the global pursuit of sustainable transportation solutions. With concerns over climate change and air pollution on the rise, the transition from traditional internal combustion engine vehicles to EVs represents a significant step towards reducing greenhouse gas emissions and enhancing energy efficiency (Llopis-Albert, et al., 2021; Sovacool, et al., 2019; Usman, et al., 2024). EVs offer numerous advantages, including lower emissions, reduced reliance on fossil fuels, and potential cost savings over the long term. As such, understanding the policies and strategies aimed at promoting EV adoption becomes paramount in fostering a more sustainable transportation ecosystem (Zhang, and Fujimori, 2020; Henderson, 2020; Newman, et al., 2017).

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This paper aims to undertake a comparative review of the strategies employed by two distinct nations, the United States and Nigeria, in promoting the adoption of electric vehicles within their respective contexts. The choice of these two countries for comparison is particularly pertinent due to their differing socio-economic backgrounds, infrastructural capabilities, and energy landscapes. While the United States represents a technologically advanced nation with a mature EV market and robust policy framework, Nigeria presents a contrasting case characterized by emerging economic development, infrastructural challenges, and a nascent interest in electric mobility (Zhang, et al., 2014; Kumar, and Alok, 2020; Ogunkunbi, et al. 2022).

.By juxtaposing the EV policies and strategies of these two nations, this study seeks to uncover valuable insights into the diverse approaches taken towards promoting sustainable transportation solutions. Moreover, the comparative analysis will shed light on the effectiveness of various policy interventions in addressing common challenges such as infrastructure development, technological innovation, and socio-economic barriers to EV adoption. Through this examination, policymakers, industry stakeholders, and researchers can gain a deeper understanding of the opportunities and obstacles associated with promoting electric vehicles in different national contexts.

Despite the growing interest in EV policies globally, there remains a notable research gap in comparative studies that analyze the specific strategies and outcomes of EV promotion efforts in diverse socio-economic settings. This paper seeks to address this gap by providing a detailed examination of the policies and initiatives undertaken by the United States and Nigeria, thereby contributing to a more nuanced understanding of international EV policy frameworks and their implications for sustainable transportation development.

2. Overview and Background

The global transportation sector stands at a critical juncture, facing mounting challenges such as climate change, air pollution, and energy security (Ukoba et al., 2024; Oviroh et al., 2023). In response to these pressing issues, the adoption of electric vehicles (EVs) has emerged as a pivotal strategy towards achieving sustainable transportation systems. EVs, powered by electricity stored in batteries, offer a cleaner alternative to traditional internal combustion engine vehicles, significantly reducing greenhouse gas emissions and dependency on fossil fuels. As governments, industries, and societies worldwide increasingly recognize the importance of transitioning towards cleaner modes of transportation, understanding the policies and strategies aimed at promoting EV adoption becomes imperative (Liu, et al., 201; Usman, et al., 2024).

The United States and Nigeria represent contrasting case studies in the global landscape of EV promotion. In the United States, EV adoption has gained significant traction, driven by a combination of federal, state, and local initiatives aimed at incentivizing EV purchases, expanding charging infrastructure, and fostering technological innovation. With a well-established automotive industry, robust research and development capabilities, and a growing awareness of environmental issues, the United States has emerged as a leader in the global EV market. However, challenges such as range anxiety, high upfront costs, and infrastructure gaps continue to hinder widespread EV adoption across the country (Priessner, et al., 2018; Broadbent, et al., 2019; Ebirim, et al., 2024).

Conversely, Nigeria presents a unique set of challenges and opportunities in promoting EVs within its national context. As Africa's most populous country and largest economy, Nigeria grapples with infrastructural deficits, socio-economic disparities, and dependence on fossil fuel exports. Despite these challenges, Nigeria has shown a nascent interest in transitioning towards electric mobility as part of its broader sustainable development agenda. With abundant renewable energy resources, including solar and hydroelectric power, Nigeria holds significant potential for leveraging EVs to enhance energy security and reduce emissions (Ukoba et al., 2019). However, limited infrastructure, affordability constraints, and institutional capacity gaps pose formidable obstacles to scaling up EV adoption in the country (Oriekhoe, et al., 2024; Udeh, et al., 2024).

Against this backdrop, a comparative review of EV policies and strategies in the United States and Nigeria offers valuable insights into the diverse approaches and lessons learned in promoting electric mobility within different socio-economic contexts. By examining the policy frameworks, incentives, challenges, and outcomes of EV promotion efforts in these two nations, this study aims to contribute to a deeper understanding of international EV policy development and its implications for sustainable transportation transitions globally (Zhang, et al., 2014; Kumar, and Alok, 2020; Ogunkunbi, et al. 2022).

2.1 Policy Framework in the United States

The United States stands at the forefront of electric vehicle (EV) adoption globally, driven by a multi-faceted policy framework that operates at federal, state, and local levels. At the federal level, the government has implemented a range of initiatives aimed at incentivizing EV adoption, fostering technological innovation, and expanding charging infrastructure. These efforts are complemented by state-level regulations and incentives, which vary significantly across the country, reflecting diverse regional priorities and market dynamics. Furthermore, local governments play a crucial role in supporting EV deployment through zoning regulations, permitting processes, and the development of public charging infrastructure. Together, these federal, state, and local policies form a comprehensive framework that has contributed to the growth of the EV market in the United States (Bawa, and Nwohu, 2023; Shree, et al., 2024).

At the federal level, the U.S. government has pursued various initiatives to promote EV adoption and support the development of a domestic EV industry. One of the most significant federal incentives is the Plug-In Electric Vehicle Tax Credit, which provides a tax credit of up to $7,500 for the purchase of qualifying EVs. This tax credit has been instrumental in making EVs more affordable for consumers and stimulating demand. Additionally, the federal government has invested in research and development initiatives to advance EV technologies, improve battery performance, and reduce costs. Programs such as the Department of Energy's Vehicle Technologies Office and the Advanced Technology Vehicles Manufacturing Loan Program have provided funding and support to EV manufacturers and suppliers (Capuder, et al., 2020; Maghfiroh, et al., 2021).

State governments in the United States have also played a pivotal role in driving EV adoption through a variety of regulations and incentives tailored to local market conditions. California, in particular, has been a leader in promoting EVs, implementing stringent vehicle emissions standards and offering a suite of incentives to encourage EV adoption. These incentives include rebates for EV purchases, access to high-occupancy vehicle lanes, and financial assistance for the installation of home charging stations. Other states have followed California's lead, implementing their own incentive programs and adopting zero-emission vehicle mandates to spur EV sales and reduce emissions (Ryghaug, and Skjølsvold, 2023; Zimm, 2021; Kotilainen, et al., 2019).

Furthermore, local governments across the United States have taken proactive steps to support EV deployment within their jurisdictions. Cities and municipalities have implemented zoning regulations to encourage the development of EV charging infrastructure, including requirements for new construction projects to include charging stations. Local governments have also streamlined permitting processes for the installation of charging stations and provided financial incentives to businesses and property owners to install chargers. Additionally, many cities have launched public education campaigns to raise awareness about the benefits of EVs and encourage residents to make the switch to electric transportation (Narassimhan, and Johnson, 2018; Hall, and Lutsey, 2017).

In conclusion, the policy framework for promoting EV adoption in the United States is characterized by a combination of federal, state, and local initiatives aimed at incentivizing consumers, supporting industry growth, and expanding charging infrastructure. Through a coordinated approach that leverages the strengths of each level of government, the United States has made significant strides in accelerating the transition to electric transportation and reducing greenhouse gas emissions from the transportation sector. However, challenges remain, including the need for continued investment in infrastructure, addressing range anxiety, and ensuring equitable access to EVs for all communities (Egieya, et al., 2023; Omotoye, et al., 2024).

2.2 Policy Framework in Nigeria

Nigeria, Africa's most populous country and largest economy, faces a unique set of challenges and opportunities in promoting electric vehicle (EV) adoption within its national context (Meszaros, et al., 2021; Agyekum, et al., 2023). The Nigerian government has recognized the importance of transitioning towards electric mobility as part of its broader sustainable development agenda, driven by concerns over air pollution, energy security, and the need to diversify the economy away from fossil fuels. While Nigeria's EV market is still in its infancy compared to more developed economies, the government has implemented a range of initiatives at the national, regional, and local levels to support EV deployment and infrastructure development (Orieno, et al., 2024; Ikwue, et al., 2024).

At the national level, the Nigerian government has introduced several initiatives and strategies aimed at promoting EV adoption and fostering the growth of the electric vehicle industry. One of the key initiatives is the National Automotive Industry Development Plan (NAIDP), which seeks to promote local manufacturing and assembly of vehicles, including electric vehicles. Under the NAIDP, the government offers incentives such as tax breaks and import duty waivers for companies that invest in the production of electric vehicles and related components. Additionally, the government has

launched pilot projects to test electric vehicles in urban areas and demonstrate their feasibility in the Nigerian context (Makundi, 2018).

Regional and local governments in Nigeria also play a crucial role in supporting EV deployment through their involvement in infrastructure development and regulatory oversight. Several states, including Lagos and Rivers, have taken proactive steps to encourage the adoption of electric vehicles by implementing policies to promote EV charging infrastructure, offering incentives for EV purchases, and supporting research and development initiatives. Local governments have also collaborated with private sector partners to launch pilot projects and demonstration programs to raise awareness about the benefits of electric mobility and showcase the potential for EVs to address local transportation challenges.

However, Nigeria faces several unique challenges that could impede the widespread adoption of electric vehicles. One of the primary challenges is the country's inadequate infrastructure, including a lack of charging stations and reliable electricity supply. Addressing this challenge will require significant investment in charging infrastructure and grid modernization to support the growing demand for electric vehicles. Additionally, affordability remains a barrier to EV adoption for many Nigerians, as electric vehicles tend to be more expensive than conventional vehicles due to high import tariffs and limited local manufacturing capacity. Furthermore, Nigeria's dependence on oil revenues presents a paradoxical challenge for promoting electric vehicles, as the country is one of the world's largest producers and exporters of crude oil. The transition away from fossil fuels towards electric mobility could potentially disrupt the country's economy and lead to job losses in the oil and gas sector. However, embracing electric vehicles could also create new economic opportunities, particularly in renewable energy development, manufacturing, and transportation services (Osedeme, 2023).

In conclusion, Nigeria's policy framework for promoting electric vehicle adoption is still evolving, but the government has taken significant steps to support the growth of the electric vehicle industry and address the country's unique transportation challenges. By implementing a combination of national-level initiatives, regional partnerships, and local pilot projects, Nigeria has laid the groundwork for a sustainable transportation future powered by electric mobility. However, overcoming the challenges of infrastructure, affordability, and economic dependence on fossil fuels will require continued investment, innovation, and collaboration between government, industry, and civil society stakeholders (Agunbiade, and Siyan, 2020; Thompson, et al., 2022).

2.3 Comparative Analysis of Policy Approaches

In the global pursuit of sustainable transportation solutions, the adoption of electric vehicles (EVs) has emerged as a critical strategy to reduce greenhouse gas emissions, enhance energy security, and mitigate the impacts of climate change (Hossain, et al., 2022). Governments around the world have implemented various policy approaches to promote EV adoption within their respective national contexts. A comparative analysis of these policy approaches reveals both similarities and contrasts in policy goals, objectives, strategies, and implementation methods.

Firstly, there are several similarities in the policy goals and objectives of countries promoting EV adoption. Across different regions, governments aim to reduce reliance on fossil fuels, improve air quality, and stimulate economic growth through the development of a domestic EV industry. Additionally, promoting technological innovation and enhancing energy efficiency are common objectives shared by many countries. By transitioning to electric mobility, governments seek to achieve long-term environmental sustainability while addressing pressing challenges such as urban congestion and transportation-related emissions (Ihemereze, et al., 2024; Kester, et al., 2018).

However, despite these shared goals, there are notable contrasts in the strategies and implementation methods adopted by different countries. One key distinction lies in the level of government involvement and the degree of centralization in policy formulation and implementation. In some countries, such as China, the government plays a highly centralized role in shaping EV policy, with top-down directives driving investment in EV infrastructure, research and development, and consumer incentives. Conversely, in countries like the United States, EV policy is more decentralized, with federal, state, and local governments each playing distinct roles in promoting EV adoption.

Furthermore, there are differences in the types of incentives and regulations implemented to stimulate EV uptake. While tax incentives, rebates, and subsidies are commonly used to reduce the upfront cost of EVs and incentivize consumer purchases, the specific design and magnitude of these incentives vary widely across countries. For example, Norway offers generous tax exemptions and financial incentives for EV buyers, contributing to one of the highest EV adoption rates globally. In contrast, countries like India have focused on regulatory measures such as fuel efficiency standards and emission norms to incentivize automakers to produce EVs and reduce the environmental impact of the

transportation sector. Moreover, there are disparities in the pace and scale of infrastructure development to support EV deployment. Countries with well-developed charging infrastructure networks, such as the Netherlands and Sweden, have seen higher EV adoption rates compared to those with limited charging infrastructure. Government investment in charging infrastructure, public-private partnerships, and innovative financing mechanisms are critical factors influencing the accessibility and convenience of EV charging, thereby shaping consumer perceptions and adoption behavior. Additionally, cultural and socio-economic factors influence consumer preferences and attitudes towards electric mobility, leading to variations in EV market dynamics and adoption patterns. In countries with high levels of environmental awareness and a strong preference for sustainable lifestyles, such as Germany and Japan, EVs have gained broader acceptance among consumers. Conversely, in emerging markets with lower purchasing power and limited awareness of EV technology, affordability and education campaigns are essential to overcoming barriers to adoption (Adaga, et al., 2024; Addy, et al., 2024).

In conclusion, a comparative analysis of policy approaches to promoting electric vehicle adoption reveals both commonalities and differences across countries. While countries share similar goals of reducing greenhouse gas emissions, enhancing energy security, and fostering economic development through electric mobility, the strategies and implementation methods employed vary significantly based on factors such as government structure, policy priorities, market conditions, and cultural context. By examining these diverse approaches, policymakers, industry stakeholders, and researchers can identify best practices, lessons learned, and opportunities for collaboration to accelerate the transition towards a sustainable transportation future powered by electric mobility.

2.4 Incentives and Subsidies

Incentives and subsidies play a pivotal role in stimulating the adoption of electric vehicles (EVs) by making them more financially attractive to consumers and businesses. These incentives can take various forms, including tax credits, rebates, exemptions, and import duty waivers, depending on the policy priorities and economic context of each country. In this comparative analysis, we will examine the incentives and subsidies for EVs in the United States and Nigeria, highlighting the impact of these measures on EV adoption rates and market dynamics (Zhang, et al., 2014; Bello, et al., 2024).

In the United States, tax credits and rebates are the primary incentives used to encourage consumers to purchase electric vehicles. The federal government offers a tax credit of up to $7,500 for the purchase of qualifying EVs, depending on the battery capacity and vehicle's energy efficiency. This tax credit effectively reduces the upfront cost of an EV, making it more affordable for consumers. Additionally, many states offer their own incentives, such as rebates or tax credits, on top of the federal incentive. For example, California offers a rebate of up to $2,000 for the purchase or lease of a new EV, further lowering the cost for consumers. Overall, these incentives can offset a significant percentage of the purchase price of an electric vehicle, making them competitive with conventional gasoline-powered vehicles (Jenn, et al., 2018; DaraOjimba, et al., 2023).

In Nigeria, tax exemptions and import duty waivers are used to incentivize the production and importation of electric vehicles and related components. Under the National Automotive Industry Development Plan (NAIDP), the Nigerian government offers tax breaks and import duty waivers for companies that invest in the local manufacturing and assembly of electric vehicles. These incentives aim to stimulate domestic production and attract foreign investment in the electric vehicle industry. Additionally, the government has introduced import duty waivers for fully assembled electric vehicles to make them more affordable for consumers. For example, electric vehicles imported into Nigeria are exempt from the 35% import duty typically imposed on imported vehicles, reducing the cost of EVs for consumers. These incentives have the potential to significantly reduce the cost of electric vehicles and increase their affordability in the Nigerian market (Meszaros, et al., 2021; Akindote, et al., 2023).

The impact of incentives and subsidies on EV adoption rates varies depending on the magnitude and duration of the incentives, as well as other factors such as consumer awareness, infrastructure availability, and economic conditions. In the United States, tax credits and rebates have been effective in stimulating EV adoption, particularly in states with generous incentives and supportive policies. According to data from the U.S. Department of Energy, the federal tax credit for EVs has contributed to a significant increase in EV sales since its introduction, with sales doubling in states with higher tax incentives compared to states with lower incentives. Similarly, state-level incentives such as rebates and tax credits have also been instrumental in driving EV adoption in states like California, where EV sales account for a significant percentage of total vehicle sales.

In Nigeria, tax exemptions and import duty waivers have the potential to accelerate the growth of the electric vehicle industry by making EVs more affordable and attractive to consumers. However, the impact of these incentives depends

on the availability of charging infrastructure, consumer awareness, and the overall economic environment. While tax exemptions and import duty waivers can reduce the cost of EVs, other barriers such as limited charging infrastructure and range anxiety may still hinder widespread adoption. Therefore, a comprehensive approach that addresses both supply-side and demand-side barriers is essential to realizing the full potential of electric vehicles in Nigeria.

In conclusion, incentives and subsidies play a critical role in promoting the adoption of electric vehicles by reducing the cost barrier and stimulating consumer demand. In the United States, tax credits and rebates have been effective in driving EV adoption rates, while in Nigeria, tax exemptions and import duty waivers have the potential to accelerate the growth of the electric vehicle industry. However, the success of these incentives depends on various factors, including policy design, infrastructure development, consumer awareness, and economic conditions. By implementing well-targeted incentives and subsidies, governments can incentivize the transition to electric mobility and contribute to a more sustainable transportation future.

2.5 Infrastructure Development

Infrastructure development is a critical component of enabling the widespread adoption of electric vehicles (EVs) and transitioning towards a sustainable transportation system. This analysis will focus on charging infrastructure initiatives in the United States and the challenges and opportunities for infrastructure development in Nigeria, examining the current state of EV charging networks, investment trends, and the potential impact on EV adoption rates (Kene, et al., 2021).

In the United States, significant efforts have been made to expand and improve EV charging infrastructure to meet the growing demand for electric vehicles. Various stakeholders, including government agencies, utilities, automakers, and private companies, have invested heavily in deploying charging stations across the country. According to the U.S. Department of Energy, there are over 48,000 public charging stations and more than 118,000 charging outlets available nationwide as of 2022. This represents a substantial increase from previous years, with the number of charging stations nearly tripling since 2015.

One of the key initiatives driving charging infrastructure development in the United States is the Department of Energy's Workplace Charging Challenge, which encourages employers to install EV charging stations at their workplaces. Through this program, participating employers commit to providing charging access for their employees, visitors, and customers, thereby increasing the convenience and accessibility of EV charging. Additionally, state governments have implemented various incentive programs to support the deployment of charging infrastructure, including grants, rebates, and low-interest loans for charging station installations.

Furthermore, private companies and electric utilities have played a significant role in expanding the EV charging network through partnerships and investment initiatives. Companies like Tesla, ChargePoint, and EVgo have deployed thousands of fast-charging stations along major highways and in urban areas, making long-distance travel feasible for EV owners. Electric utilities have also invested in EV charging infrastructure as part of their efforts to support clean energy adoption and grid modernization. These partnerships between public and private sectors have accelerated the growth of the EV charging network and improved the overall accessibility and reliability of charging infrastructure (Jensen, 2011; Ugwu, et al., 2021).

In Nigeria, the development of EV charging infrastructure is still in its early stages, presenting both challenges and opportunities for growth. While the country has made strides in promoting electric mobility through policy incentives and pilot projects, the lack of adequate charging infrastructure remains a significant barrier to widespread EV adoption. As of 2022, there are only a handful of public charging stations in major cities like Lagos and Abuja, with limited coverage in rural areas. This limited infrastructure availability poses challenges for EV owners, particularly in terms of range anxiety and accessibility.

However, there are also opportunities for infrastructure development in Nigeria, driven by the country's abundant renewable energy resources and growing interest in electric mobility. Nigeria boasts significant potential for solar and wind energy generation, which can be leveraged to power EV charging stations and reduce reliance on fossil fuels. By integrating renewable energy sources into the EV charging network, Nigeria can enhance energy security, reduce emissions, and support sustainable transportation initiatives. Additionally, partnerships between public and private sectors, as well as international collaborations, can accelerate the deployment of EV charging infrastructure and overcome barriers to adoption.

One promising example of infrastructure development in Nigeria is the partnership between the Nigerian government and a consortium of private companies to establish the Lagos Green Mobility Expo and Conference. This event aims to showcase electric vehicles, charging infrastructure, and renewable energy solutions, raising awareness about the benefits of electric mobility and promoting investment in sustainable transportation infrastructure. By fostering collaboration between government, industry, and civil society stakeholders, Nigeria can create an enabling environment for EV adoption and infrastructure development (Ryghaug, and Skjølsvold, 2023; Zimm, 2021; Kotilainen, et al., 2019).

In conclusion, infrastructure development is essential for facilitating the transition to electric mobility and realizing the full potential of electric vehicles in both the United States and Nigeria. While significant progress has been made in expanding EV charging infrastructure in the United States, challenges remain in Nigeria, including limited coverage and infrastructure availability. However, Nigeria's abundant renewable energy resources and growing interest in electric mobility present opportunities for infrastructure development and investment. By addressing these challenges and leveraging opportunities, both countries can accelerate the transition to a sustainable transportation future powered by electric mobility.

2.6 Technological Innovation and Research

Technological innovation and research are fundamental drivers in shaping the future of electric vehicles (EVs) and advancing sustainable transportation solutions. This analysis will delve into the collaborative efforts between government, industry, and academia in the United States and highlight emerging technologies and research initiatives in Nigeria, shedding light on their respective contributions to the development of electric mobility (Patil, 2021.).

In the United States, collaboration between government agencies, industry stakeholders, and academic institutions has been instrumental in driving technological innovation in the EV sector. The U.S. Department of Energy (DOE) has played a central role in funding research and development (R&D) initiatives aimed at improving battery technology, enhancing vehicle performance, and reducing costs. According to the DOE, federal investments in advanced vehicle technologies have totaled over $5 billion since 2009, supporting a wide range of projects across the EV supply chain.

One notable example of collaborative R&D in the United States is the DOE's partnership with the Advanced Research Projects Agency-Energy (ARPA-E) to develop next-generation battery technologies. Through programs such as the Batteries for Advanced Transportation Technologies (BATT) and Robust Affordable Next Generation Energy Storage Systems (RANGE), researchers are exploring innovative materials, chemistries, and manufacturing processes to overcome the limitations of existing lithium-ion batteries. These efforts aim to increase energy density, reduce charging times, and enhance the durability and safety of batteries, ultimately driving down the cost of EVs and accelerating their adoption. Furthermore, industry-academic partnerships have facilitated technology transfer and knowledge exchange, driving innovation and commercialization in the EV market. Companies like Tesla, General Motors, and Ford have collaborated with leading research universities and national laboratories to develop advanced vehicle technologies and bring them to market. Academic institutions, such as the Massachusetts Institute of Technology (MIT) and Stanford University, have established research centers and consortiums focused on electric transportation, fostering interdisciplinary collaboration and advancing cutting-edge research in areas such as battery science, electric drivetrains, and vehicle-to-grid integration (Boyd, and Howell, 2016; Chukwuocha, et al., 2018).

In Nigeria, while the electric vehicle industry is still in its nascent stages, there is growing interest and investment in research and development to support the adoption of electric mobility. The Nigerian government has initiated several research initiatives and pilot projects in collaboration with academic institutions and industry partners to explore the feasibility of electric vehicles in the Nigerian context. For example, the Nigerian Automotive Design and Development Council (NADDC) has launched research programs to assess the performance, reliability, and cost-effectiveness of electric vehicles in local conditions.

Emerging technologies and research initiatives in Nigeria focus on leveraging the country's abundant renewable energy resources, such as solar and hydroelectric power, to power electric vehicles and charging infrastructure. Researchers are exploring innovative solutions for off-grid charging, battery swapping, and energy storage to address challenges related to grid reliability and accessibility. Additionally, efforts are underway to develop localized manufacturing capabilities for electric vehicles and components, with the aim of reducing dependency on imported vehicles and stimulating economic growth in the automotive sector.

One promising example of technological innovation in Nigeria is the development of electric tricycles, or "Keke-EV," as an alternative to traditional gasoline-powered tricycles commonly used for transportation in urban areas. Companies like JET Motor Company and Nord Tank Nigeria Limited have introduced electric tricycle models powered by lithium-

ion batteries, offering zero-emission transportation solutions for passengers and goods. These electric tricycles not only reduce air pollution and noise levels but also provide economic opportunities for drivers and operators through lower operating costs and increased efficiency.

In conclusion, technological innovation and research are essential drivers in shaping the future of electric mobility in both the United States and Nigeria. In the United States, collaborative efforts between government, industry, and academia have led to significant advancements in battery technology, vehicle performance, and charging infrastructure. In Nigeria, emerging technologies and research initiatives focus on leveraging renewable energy resources and developing localized solutions to support the adoption of electric vehicles. By fostering collaboration, investment, and knowledge exchange, both countries can accelerate the transition to a sustainable transportation future powered by electric mobility.

2.7 Socio-Economic Implications

The adoption of electric vehicles (EVs) has significant socio-economic implications, influencing factors such as job creation, economic growth, and equity in both the United States and Nigeria. Understanding these implications is crucial for policymakers, industry stakeholders, and communities to navigate the transition towards electric mobility and address potential challenges while maximizing opportunities.

In the United States, the EV industry has emerged as a key driver of job creation and economic growth, generating employment opportunities across various sectors, from manufacturing and technology to infrastructure development and services. According to a report by the International Council on Clean Transportation (ICCT), the EV industry supports over 200,000 jobs in the United States, with projections indicating continued growth in the coming years. The expansion of EV manufacturing facilities, battery production plants, and charging infrastructure networks has created a demand for skilled labor and contributed to local economies in states like California, Michigan, and Nevada (Slowik, and Lutsey, 2017).

Moreover, the transition to electric mobility has spurred innovation and investment in clean energy technologies, positioning the United States as a global leader in the EV market. Companies like Tesla, General Motors, and Ford have made significant investments in EV research and development, driving technological advancements in battery technology, electric drivetrains, and autonomous vehicles. These innovations not only benefit the automotive industry but also stimulate growth in adjacent sectors such as renewable energy, software development, and smart grid technologies.

However, the socio-economic implications of EV adoption in the United States are not without challenges. While the growth of the EV industry creates job opportunities, it also poses disruptions for workers in traditional automotive manufacturing and fossil fuel industries. The shift towards electric mobility may lead to job displacement and economic hardship for workers employed in sectors reliant on internal combustion engine vehicles and petroleum extraction. Therefore, policymakers must implement measures to support workforce transition and retraining programs to ensure a just and equitable transition to electric mobility.

In Nigeria, the socio-economic implications of EV adoption are shaped by the country's unique socio-economic context, infrastructural challenges, and energy landscape. While electric mobility presents opportunities for economic diversification, environmental sustainability, and energy security, it also poses socio-economic challenges related to affordability, accessibility, and infrastructure development. The Nigerian government's efforts to promote electric mobility through policies, incentives, and pilot projects aim to address these challenges while maximizing the benefits for society.

One of the socio-economic benefits of EV adoption in Nigeria is the potential for job creation and economic growth in the automotive and renewable energy sectors. By investing in electric vehicle manufacturing, assembly, and component production, Nigeria can stimulate domestic industrialization, create employment opportunities, and reduce dependency on imported vehicles. Furthermore, the integration of renewable energy sources such as solar and hydroelectric power into the EV charging infrastructure can enhance energy security, reduce emissions, and support local economic development (Babalola, et al., 2022; Ahmad, et al., 2024).

However, the transition to electric mobility in Nigeria also presents socio-economic challenges related to affordability, accessibility, and infrastructure development. The high upfront cost of electric vehicles, limited charging infrastructure, and range anxiety pose barriers to adoption for many Nigerians, particularly those in rural and low-income

communities. Additionally, the reliance on imported vehicles and components may hinder the development of a domestic electric vehicle industry and limit the socio-economic benefits of electric mobility.

In conclusion, the socio-economic implications of electric vehicle adoption vary across different contexts, reflecting the interplay of factors such as policy frameworks, infrastructure development, and market dynamics. In the United States, the growth of the EV industry has generated employment opportunities and economic growth, while presenting challenges related to workforce transition and equity. In Nigeria, electric mobility offers opportunities for economic diversification and energy security but also poses challenges related to affordability, accessibility, and infrastructure development. By addressing these challenges and maximizing the benefits of electric mobility, both countries can achieve a more sustainable and equitable transportation future.

2.8 Environmental Impact and Sustainability

The transition to electric vehicles (EVs) holds significant promise for reducing greenhouse gas emissions and promoting environmental sustainability, both in the United States and Nigeria. By replacing conventional internal combustion engine vehicles with electric alternatives, countries can mitigate the impacts of climate change, improve air quality, and reduce dependence on fossil fuels. This analysis will examine the environmental impact and sustainability implications of EV adoption, focusing on the reduction of greenhouse gas emissions in the United States and the potential for leveraging renewable energy sources in Nigeria (Chen, et al., 2021;)..

In the United States, the widespread adoption of electric vehicles has the potential to significantly reduce greenhouse gas emissions from the transportation sector, which is one of the largest sources of carbon dioxide emissions in the country. According to the Environmental Protection Agency (EPA), transportation accounted for approximately 28% of total greenhouse gas emissions in the United States in 2020, with passenger cars and light-duty trucks being the largest contributors. By transitioning to electric mobility, the United States can achieve substantial emissions reductions and progress towards its climate mitigation goals.

Several studies have demonstrated the environmental benefits of electric vehicles compared to internal combustion engine vehicles, particularly when powered by low-carbon electricity sources. A report by the Union of Concerned Scientists (UCS) found that EVs produce lower emissions than gasoline-powered vehicles across the United States, even when accounting for emissions from electricity generation. Furthermore, as the grid becomes increasingly decarbonized through the deployment of renewable energy sources such as wind, solar, and hydropower, the environmental benefits of electric vehicles will continue to improve.

Moreover, the potential for leveraging renewable energy sources in the United States presents an opportunity to further enhance the sustainability of electric mobility. Renewable energy accounted for approximately 20% of total electricity generation in the United States in 2020, with solar and wind energy experiencing rapid growth in recent years. By charging electric vehicles with renewable energy, either directly through on-site solar panels or indirectly through grid-connected charging stations supplied by renewable sources, the United States can reduce emissions and reliance on fossil fuels while promoting energy independence and security.

In Nigeria, the potential for leveraging renewable energy sources to power electric vehicles is even greater, given the country's abundant solar, wind, and hydroelectric resources. Nigeria is blessed with abundant sunshine throughout the year, making solar energy a particularly attractive option for powering electric vehicles and charging infrastructure. According to the International Renewable Energy Agency (IRENA), Nigeria has the potential to generate over 3,000 terawatt-hours of solar energy annually, equivalent to more than 20 times its current electricity consumption.

By integrating renewable energy sources into the EV charging network, Nigeria can reduce emissions, enhance energy security, and promote sustainable development. Solar-powered charging stations can provide clean and reliable electricity for EVs, particularly in remote areas with limited access to the grid. Additionally, investments in renewable energy infrastructure can create job opportunities, stimulate economic growth, and address energy poverty in underserved communities.

However, realizing the full potential of renewable energy-powered electric mobility in Nigeria requires overcoming several challenges, including limited infrastructure, financing constraints, and regulatory barriers. While the country has made progress in deploying renewable energy projects, the pace of development lags behind the growing demand for electricity. Furthermore, inadequate grid infrastructure and intermittent power supply pose challenges for scaling up renewable energy deployment and ensuring reliable charging for electric vehicles (Kumar, and Alok, 2020; Das, and Bhat, 2022).

In conclusion, the adoption of electric vehicles powered by renewable energy sources holds immense potential for reducing greenhouse gas emissions, improving air quality, and promoting environmental sustainability in both the United States and Nigeria. By transitioning towards electric mobility and leveraging renewable energy resources, countries can achieve multiple co-benefits, including emissions reductions, energy security, economic development, and social equity. However, realizing these benefits requires concerted efforts from policymakers, industry stakeholders, and civil society to overcome barriers and accelerate the transition to a more sustainable transportation future.

3. Conclusion

In conclusion, the analysis of electric vehicle (EV) policies, technological innovations, socio-economic implications, and environmental impacts in both the United States and Nigeria reveals significant opportunities and challenges for advancing electric mobility and sustainable transportation solutions.

Throughout this exploration, it became evident that both the United States and Nigeria are actively pursuing electric mobility as a means to address pressing challenges such as climate change, air pollution, and energy security. In the United States, robust policy frameworks, technological innovations, and collaborative efforts between government, industry, and academia have contributed to significant progress in EV adoption, job creation, and emissions reductions. Similarly, Nigeria has shown nascent interest in electric mobility, leveraging renewable energy resources and policy incentives to promote EV adoption and economic development. However, challenges remain in both countries, including infrastructure limitations, affordability barriers, and workforce transition issues, which require comprehensive strategies and international collaboration to overcome.

To further accelerate the transition to electric mobility and maximize its benefits, policymakers, industry stakeholders, and international partners should consider the following recommendations: Enhance existing incentives and introduce new policies to promote EV adoption, including tax credits, rebates, and regulatory mandates. Tailor incentives to address specific market barriers and socio-economic disparities, particularly in underserved communities. Prioritize investment in EV charging infrastructure to improve accessibility, reliability, and convenience for EV owners. Deploy charging stations in urban areas, highways, and rural communities to support long-distance travel and address range anxiety. Support research and development initiatives to advance battery technology, charging infrastructure, and renewable energy integration. Encourage collaboration between government agencies, industry partners, and academic institutions to drive innovation and commercialization in the EV sector. Implement workforce training programs and job transition assistance to support workers displaced by the shift towards electric mobility. Invest in education, skills development, and vocational training to prepare the workforce for emerging opportunities in the EV industry. Strengthen partnerships between countries, international organizations, and non-governmental stakeholders to share best practices, lessons learned, and technical expertise in promoting electric mobility. Collaborate on research, technology transfer, and capacity-building initiatives to accelerate the global transition towards sustainable transportation.

By implementing these recommendations and fostering international collaboration, countries can accelerate the transition to electric mobility, reduce greenhouse gas emissions, and promote sustainable development worldwide. Electric vehicles have the potential to revolutionize the transportation sector, improve public health, and create economic opportunities for communities around the globe. By working together, we can build a more sustainable and equitable future for generations to come.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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